iE 250 Marine

4189341396-D

Power Management

Designer's handbook

Improve
Tomorrow

5. Alarms and protections

11. HYBRID controller

12. SHAFT generator controller

13. SHORE connection controller

14. BUS TIE breaker controller

17. Glossary

1. About the Designer's handbook

1.1 Intended users of the Designer's handbook

The Designer's handbook is intended for the designer of the system where the controllers are installed. It can also be used during commissioning to check the design drawings and the controller parameters. Operators may find the Designer's handbook useful for understanding the system and for troubleshooting.

1.2 Symbols and conventions

Symbols for hazard statements

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

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

CAUTION
This shows low level risk situation. If the guidelines are not followed, these situations could result in minor or moderate injury.

NOTICE
This shows an important notice Make sure to read this information.

Symbols for general notes

NOTE This shows general information.

More information
This shows where you can find more information.

Example

This shows an example.

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

Functions

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

Function or parameter path notation

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

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

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

Inputs and outputs

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

Parameters

Parameters can be configured with either the display or PICUS.

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

Multi-function parameters and I/Os

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

> **Parameter used by more than one function example**
>
> For a **GENSET** controller:
>
> `Generator > Nominal settings > Nominal settings 1 > Voltage (V)`
>
> This parameter is for the genset *Nominal voltage* for the first set of nominal settings. The *Nominal voltage* is the basis for all of the voltage alarms.

General names

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

> **Use of square brackets examples**
>
> *[A-side]* represents the *Generator* for a **GENSET** controller.
>
> *[Hardware module]* represents the relevant controller hardware module.
>
> *[Breaker]* represents the *Generator breaker* for a **GENSET** controller.

Numbers

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

Example

Nominal settings #

Where the # could be 1 to 4.

1.3 Software versions

The information in this document relates to software versions:

Software	Details	Version
iE 250 Marine Core iE 250 Marine Power management	Controller application	2.0.18.x
CODESYS libraries	CODESYS	2.0.18.x
PICUS	PC software	1.0.27.x

1.4 Need more information?

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

DEIF website
Official DEIF homepage.

Give feedback
Help improve our documentation with your feedback.

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

Documentation
iE 250 Marine documentation.

Product
iE 250 Marine product page.

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

1.5 CAD drawings

DWG Drawings

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

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

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

DWG iE 7 Display

www.deif.com/rtd/ie7/dwg

STP STEP-file

STP | iE 250 Front-mounted with MIO
www.deif.com/rtd/ie250fmm/stp

STP | iE 250 Base-mounted with MIO
www.deif.com/rtd/ie250bmm/stp

STP | iE 250 Base-mounted without MIO
www.deif.com/rtd/ie250bm/stp

STP | iE 7 Display
www.deif.com/rtd/ie7/stp

2D PDF

2D PDF | iE 250 Front-mounted with MIO
www.deif.com/rtd/ie250fmm/2dpdf

2D PDF | iE 250 Base-mounted with MIO
www.deif.com/rtd/ie250bmm/2dpdf

2D PDF | iE 250 Base-mounted without MIO
www.deif.com/rtd/ie250bm/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 250 Front-mounted with MIO
www.deif.com/rtd/ie250fmm/3dpdf

3D PDF | iE 250 Base-mounted with MIO
www.deif.com/rtd/ie250bmm/3dpdf

3D PDF | iE 250 Base-mounted without MIO
www.deif.com/rtd/ie250bm/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.

Switchboard control (Marine)

In *Switchboard control*, the operator operates the equipment from the switchboard. When *Switchboard control* is activated:

- The controller trips the breaker and/or shuts down the engine, if an alarm situation arises that requires a trip and/or shutdown.
- The controller **does not** respond to a blackout.
- The controller **does not** provide power management.
- The controller **does not** accept operator commands.
- The controller cannot and **does not** prevent manual operator actions.

The switchboard design must protect the system when the controller is in *Switchboard control*.

DANGER!

Manual override of alarm action

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

An alarm may be active because it is latched, or because the alarm condition is still active. If the alarm action is manually overridden, the latched alarm provides no protection.

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.

Automatic and remote-controlled starts

CAUTION

Automatic genset start

The power management system automatically starts gensets when more power is needed. It can be difficult for an inexperienced operator to predict which gensets will start. In addition, gensets can be started remotely (for example, via an Ethernet connection, or a digital input).

To avoid personal injury, the genset design, the layout, and maintenance procedures must take this into account.

Electrostatic discharge

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

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

Shelving and taking alarms out of service

DANGER!

Shelved and out of service alarms are completely disabled.

These alarms cannot be activated by the operating conditions, and provide NO protection. Shelving or taking out of service also automatically acknowledges the alarm and resets the latch.

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

Do not circumvent active alarm actions

DANGER!

Circumventing a latched alarm action

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

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

Latched *Over-current* alarm example

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

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

Do not use unsupported hardware modules

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

Remote-controlled starts

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

1.7 Legal information

Third party equipment

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

Warranty

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

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2. System principles

2.1 About the controllers

2.1.1 About the controller types

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

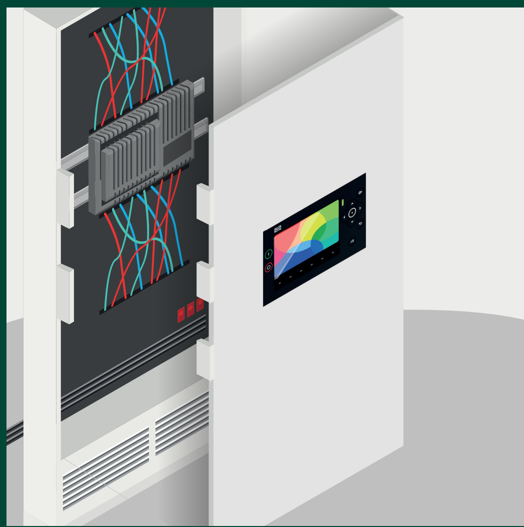
Available hardware versions:

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

Front-mounted controller with combined display

iE 250 Marine (7")

Base-mounted controller with or without display



iE 250 Marine (Base)

iE 7 display

An extensive range of control, protection and supervision features. Applications range from generator control and protection to engineered power management solutions.

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
Genset controller	A prime mover, generator, and generator breaker.
Emergency genset controller *	An emergency prime mover, generator, and both generator breaker and busbar tie breaker. There can only be 1 Emergency generator controller in each system.
Hybrid controller	An inverter with power source, and breaker.

Controller type	Controls and protects
Bus tie breaker controller	A bus tie breaker.
Shaft generator controller	The system when a shaft generator is connected.
Shore connection controller	The system and a shore connection breaker, when a shore connection is connected.

NOTE * Emergency genset controllers are only available with the Power management licence.

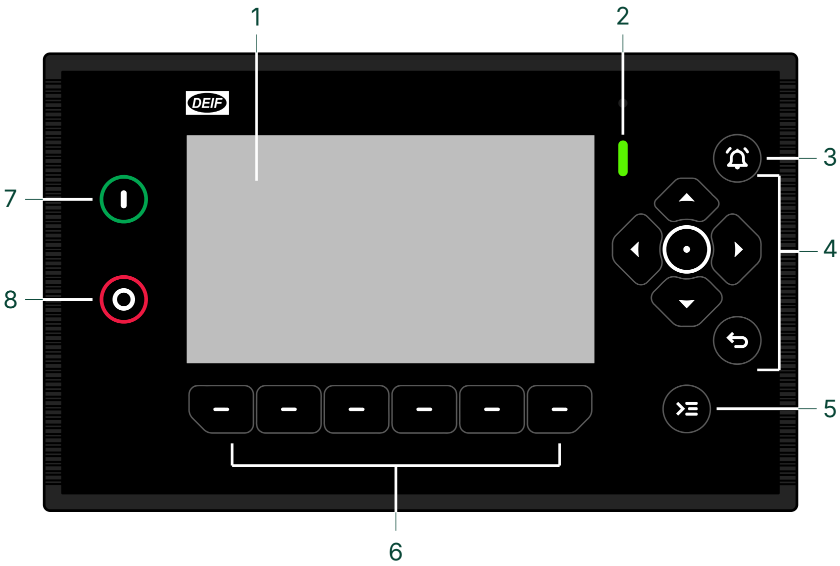
2.1.2 Software licences

The supported features depend on the software licence installed.

The standard license is the **Core** licence synchronising and load share, and support. Alternatively, you can select the **Power management** licence, which includes power management features and support.

2.1.3 Display layout

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



No.	Item	Notes
1	Display screen	7" colour touch screen.
2	Status LED	Multi-colour LED for status indication.
3	Notification centre button	Silences the alarm horn (deactivates the output), and opens the **Notification centre**, which shows alarms and events.
4	Navigation buttons	Up, down, left, and right arrows.
	Enter button	Confirms the selection.
	Back button	• Returns to the previous page • 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. In a Power management system and in AUTO mode, it starts the Power management.
8	Stop button **	In manual or local operation, it stops the asset. In a Power management system and in AUTO mode, it stops the Power management.

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. Idle run may not be permitted or approved by certain maritime classification societies.

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
- The non-essential loads (NEL)
- The heavy consumers (HC)

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

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.

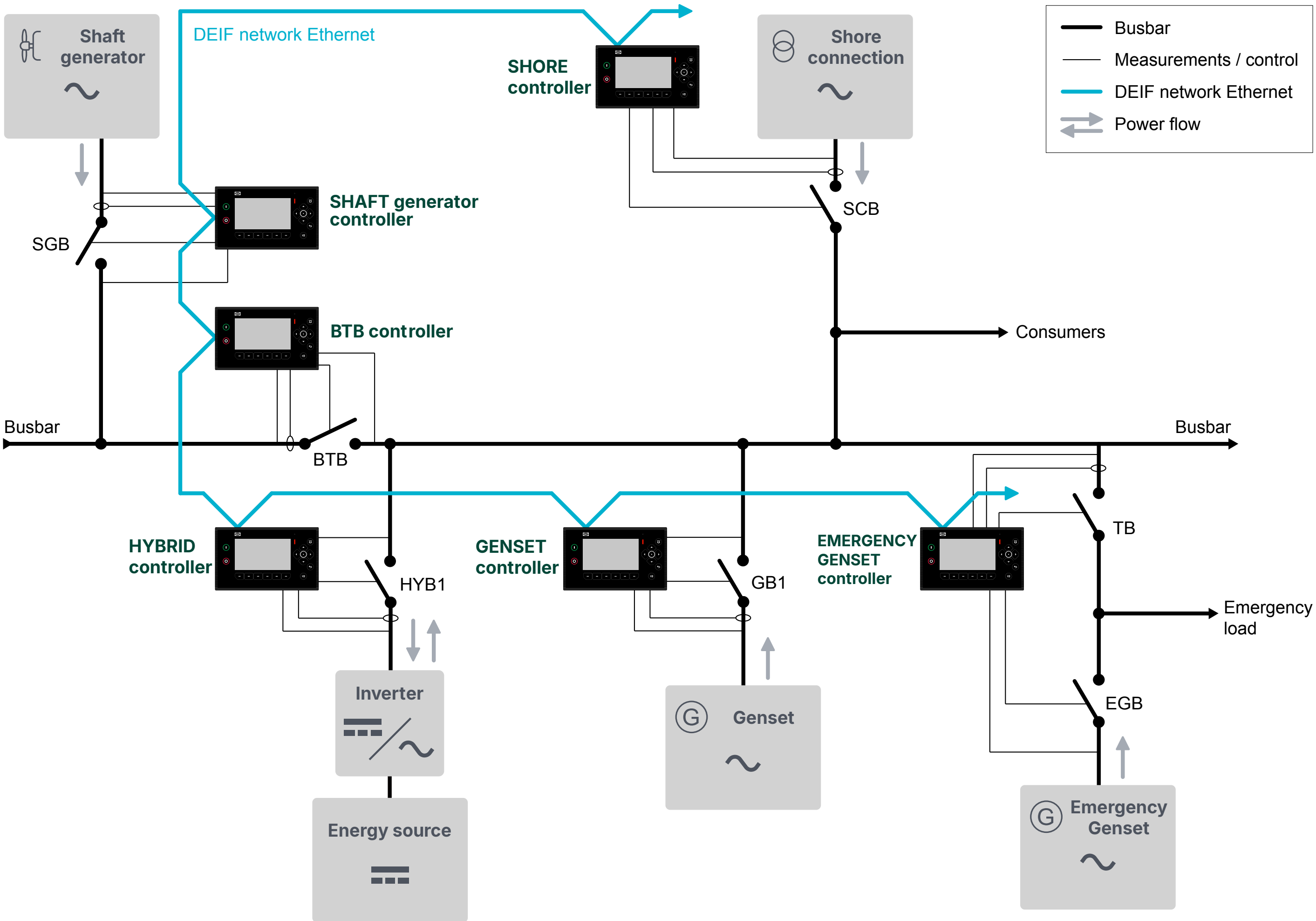
More information
See the PICUS manual for how to configure and write the Application drawing.

2.2.2 Applications

With power management, the controller can handle simple or advanced applications for a variety of marine and offshore industry projects. Applications include synchronising generators, critical power, emergency standby, and power production.

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 shore and busbars, and fuel consumption.

Example application with Power management



2.2.3 Application selector

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

DANGER!

Controller must not be in operation

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

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

`System > Application selector`

Parameter	Range
`Application selector`	• Core • Power management

2.2.4 Change controller type

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

The controller must be either safe for commissioning:

1. Any controlled equipment must be stopped.
2. All breakers must be open.
3. The controller must be in switchboard control.

or

1. The controller is in emulation mode.

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

NOTICE

Configuration reset

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

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

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

2.2.5 Maximum number of controllers

There can be up to a total of 32 controllers per **DEIF network Ethernet** ring. That is, you can assign up to 32 unique **Controller ID** numbers out of a possible range of 64.

A system can consist of several controllers in the same **DEIF network**.

Types	Possible	Notes
GENSET controller	1 to 32	There must be at least one **GENSET** controller.
EMERGENCY genset controller	0 to 1	Power management licence only.
HYBRID controller	0 to 32	
SHAFT generator controller	0 to 31	See Restrictions.
SHORE connection controller	0 to 31	See Restrictions.
BUS TIE breaker controller	0 to 31	

NOTE For Marine Power management applications, you can use any combination of iE 250 Marine Power management and iE 350 Marine Power management controllers.

2.2.6 Restrictions

The iE 250 is not suitable for all possible marine configurations. Some configurations, which require an engineered controller solution, like DEIF's Delomatic, are listed briefly below.

Shaft generators cannot run in parallel with each other

The iE 250 allows multiple **SHAFT generator** controllers. If the shaft generators must connect at the same time, then they **must** be on separate busbar sections. However, during power take home, one shaft generator **can** drive another shaft generator.

Shaft generator cannot run in parallel with a shore connection

The **shaft generator and shore connection cannot run in parallel** with each other. If they run at the same time, they must connect to separate busbar sections.

Redundant busbar is not supported

The iE 250 controllers **cannot control a system with a redundant busbar**. If you need to control a system with a redundant busbar, use the DEIF Delomatic controller.

2.2.7 Non-Essential Loads (NEL)

You **cannot** assign a non-essential load to a **BUS TIE breaker** controller.

NEL configuration options

Name	Details
`Label`	Customisable label for the non-essential load.
`NEL ID`	Select *NEL 1*, *NEL 2* or *NEL 3*. IDs that are already used are not shown.
`NEL trip signal #`	Select a controller from the list. Controllers that are not in the same section are not shown.
`New NEL trip signal(s)`	If there are other controllers in the section that the NEL trip signal can be connected to, you can select these in the *New NEL trip signal* list.

The NEL must be both connected and assigned to the controller on the application in order for the NEL functions to be visible under the controller inputs and outputs.

More information
See the PICUS manual for how to create the application and add a non-essential load.

2.2.7.1 Non-essential load trip (NEL) function

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

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

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

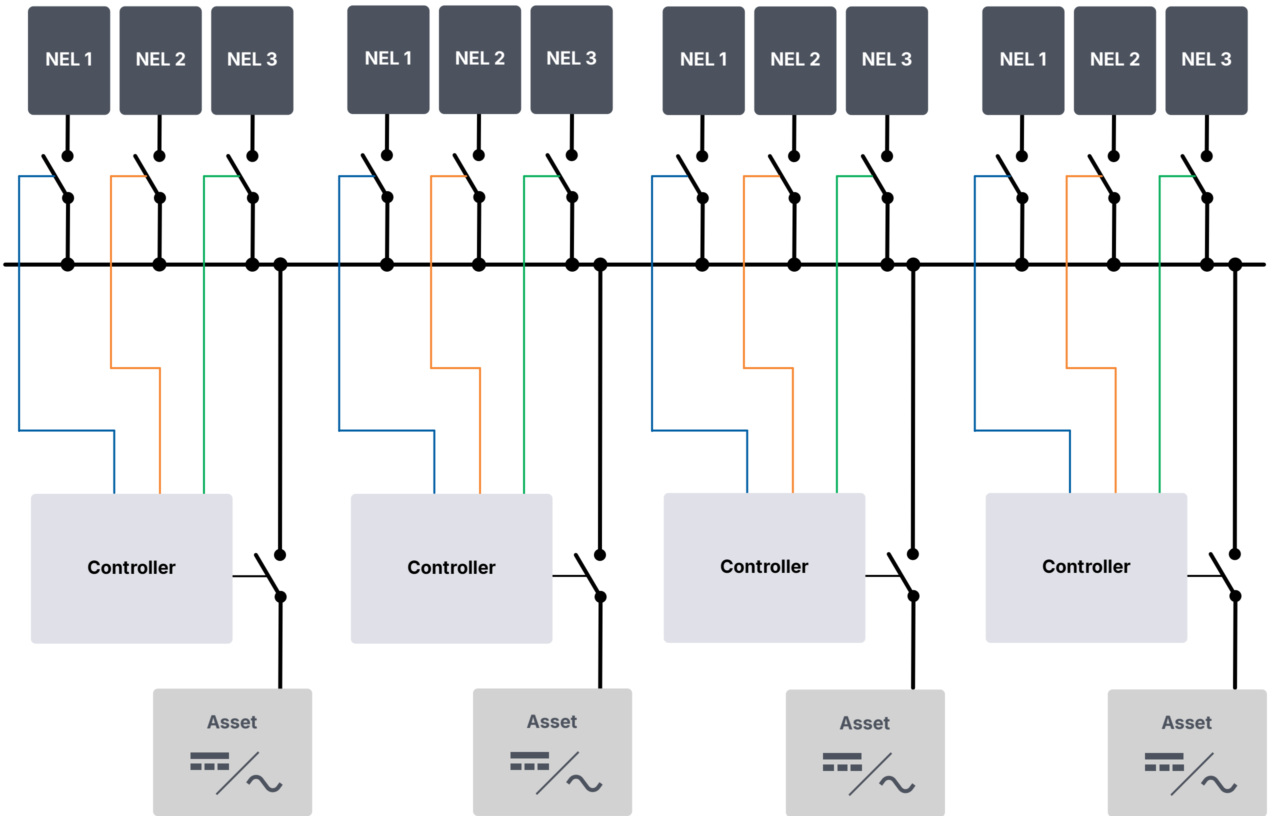
Up to three non-essential loads (NEL) can be defined per controller. The NELs are tripped individually, that is, a trip of NEL 1 does not directly influence NEL 2 or NEL 3. Inhibits are used to prevent a NEL trip when the breaker to the busbar is open.

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

NOTE In this description, # represents the *NEL ID* (# is 1 to 3).

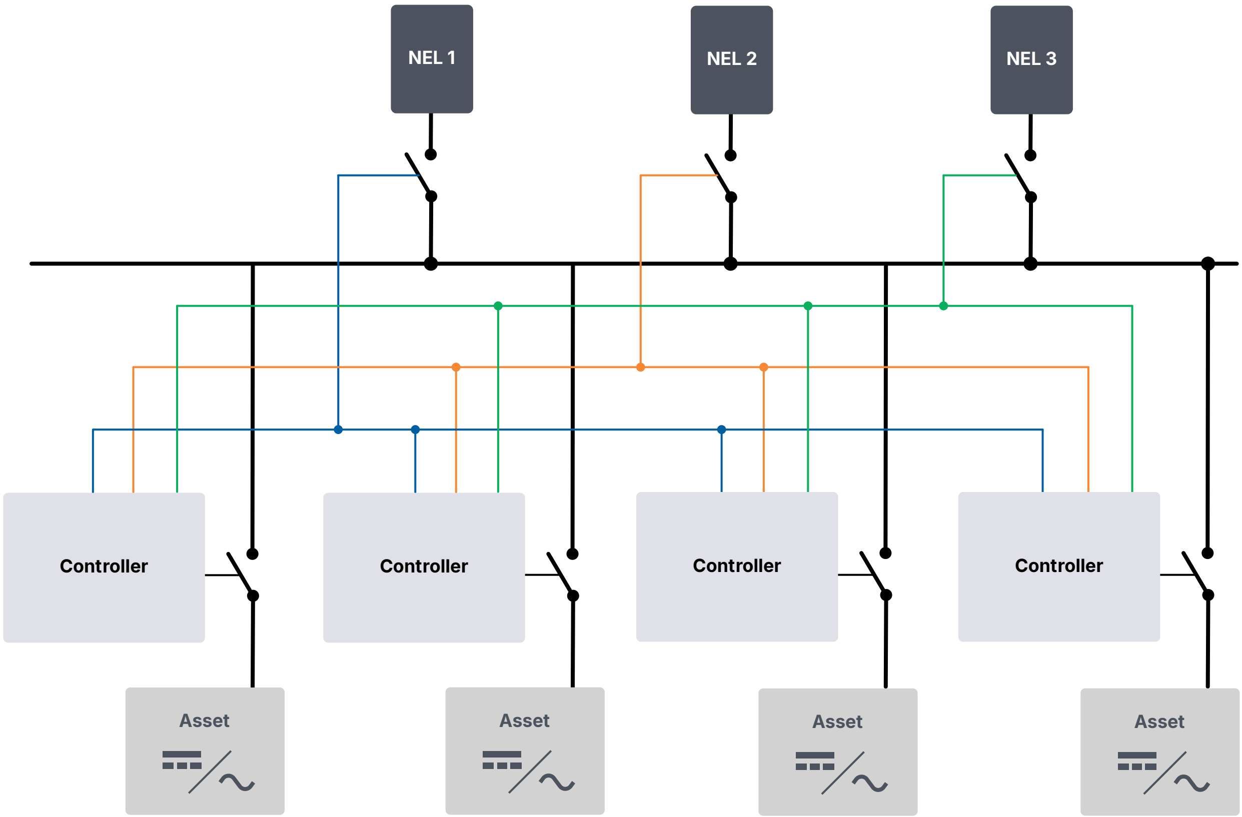
Wiring 12 non-essential loads with no redundancy

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



Wiring three non-essential loads with full redundancy

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



Digital output

For each controller assign the non-essential load outputs. The NEL must be added to the application single-line diagram before you can configure this digital output.

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

Parameter

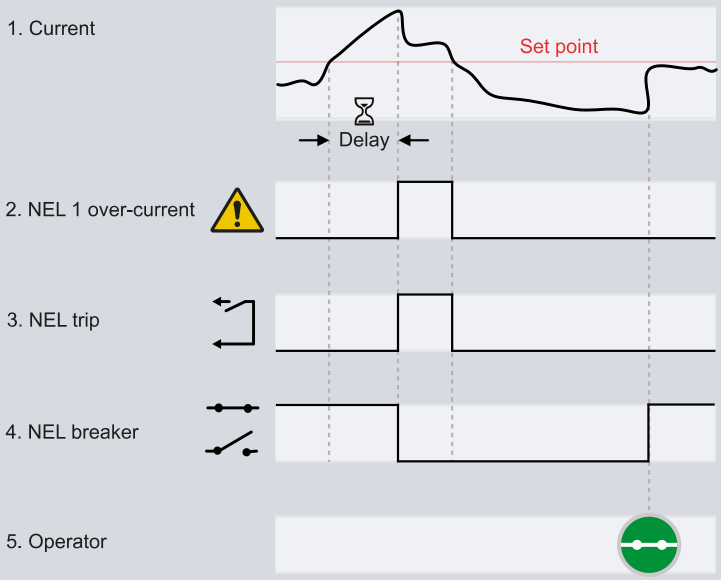
The non-essential load parameter is only visible when the *Non-essential load trip #* function is configured.

`Non-essential load trip > Trip # > Settings`

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

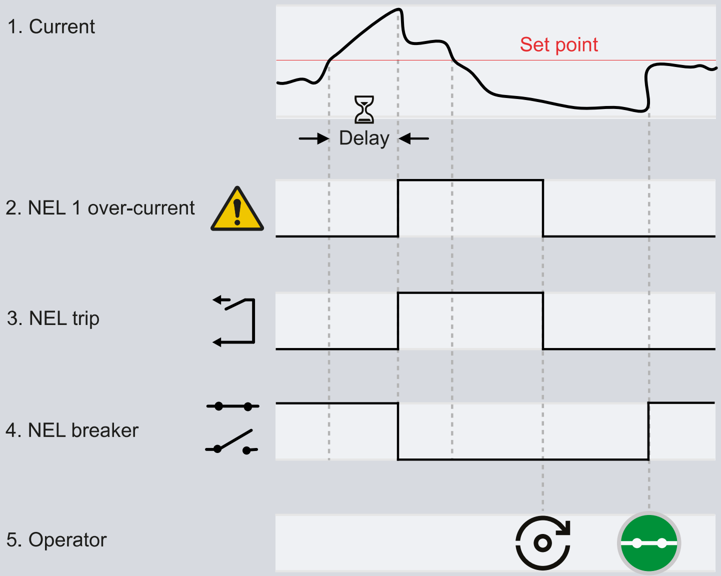
How the NEL function works

Example NEL 1 over-current, without a latch



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

Example NEL 1 over-current, with a latch



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

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:

- **AUTO - Automatic mode**
  - The controller can automatically start, stop, connect, and disconnect the asset. The operator cannot start a sequence manually, unless the local control setting is enabled for the controller or section. The controllers use the power management configuration to automatically select the power management action.
- **MANUAL - Manual 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.
- **Switchboard mode**
  - Each controller can operate in switchboard control. You can manually operate the genset speed and open and close the breakers. Use Switchboard control for troubleshooting, or to manually override the system.
  - In Switchboard control, all the controller functions are not available, but the controller protections stay active. The controller can trip breaker(s) and/or shut down the engine, if an alarm situation occurs. The controller does not accept operator commands. The controller cannot and does not prevent manual operator actions.
  - The controller does not respond to a blackout. The controller does not provide Power management.
  - The switchboard design must protect the system when the controller is in Switchboard mode.
- **TEST - Test mode**
  - The test sequence starts when an operator selects the test mode.

2.3.2 Power Management System (PMS) control

All of the controllers normally run in PMS control. The PMS is enabled and monitors the available power. Load sharing is active. AUTO mode and Manual mode both operate in PMS control.

Digital input

Function	I/O	Type	Details
`Local > Mode > PMS control`	Digital input	Continuous	If it is possible, the controller is put under PMS control when this input is activated. The controller will remain under PMS control for as long as the input is activated. If this input is configured but not activated, then the controller is forced to *Switchboard control*. If the *Switchboard control* digital input is also configured, when it is activated it overrides the *PMS control* digital input.

NOTE The *PMS control* input function acts as a safety function, by forcing the controller to switchboard control if the *PMS control* input is not activated.

2.3.3 Switchboard control

In *Switchboard control*, the operator controls and operates the equipment from the switchboard. The operator can manually regulate the frequency and voltage using digital inputs (if configured) or Modbus.

In *Switchboard control*, the controller does not accept any commands from the display or other external sources (for example, PLC and Modbus) to open or close the breaker. The **GENSET** controller does not accept any commands to start or stop the engine. However, the controller alarms can still trip the breaker, and the **GENSET** controller alarms can shut down the engine.

Input and output for switchboard control

Function	I/O	Type	Details
`Local > Mode > Switchboard control`	Digital input	Continuous	The controller is forced to *Switchboard control* when this input is activated.
`Power management > Force all controllers in section to SWBD control`	Digital input	Continuous	All the controllers in the section are forced to *Switchboard control* when this input is activated. This input function is **not** available in the BUS TIE breaker controller.
`Local > Mode > Under switchboard control`	Digital output	Continuous	Activated if the controller is under *Switchboard control*.

You can automatically activate *Switchboard control* when the digital input is deactivated, with the *PMS control* digital input.

Optional inputs for manual governor regulation

Function	I/O	Type	Details
`Regulators > GOV > Manual > Manual GOV increase`	Digital input	Continuous	This input only has an effect when the genset is in switchboard control. When this input is activated, the controller increases the output to the governor. This affects: `Regulators > GOV > Control > GOV increase` digital output or `Regulators > GOV > Control > GOV output [%]` analogue output Set the percentage change of the governor input per second with: `Configure > Parameters > Regulators > GOV analogue configuration > Manual slope`.
`Regulators > GOV > Manual > Manual GOV decrease`	Digital input	Continuous	This input only has an effect when the genset is in switchboard control. When this input is activated, the controller decreases the output to the governor. This affects: `Regulators > GOV > Control > GOV decrease` digital output or `Regulators > GOV > Control > GOV output [%]`analogue output Set the percentage change of the governor input per second with: `Configure > Parameters > Regulators > GOV analogue configuration > Manual slope`.
`Regulators > GOV > Command > Reset GOV to offset`	Digital input	Pulse	This input only has an effect when the regulator uses the analogue output for regulation. When this input is activated, the controller resets the governor output to the offset. This cancels the accumulated effect of the `Manual GOV increase` and/or `Manual GOV decrease` digital inputs.

Optional inputs for manual AVR regulation

Function	I/O	Type	Notes
`Regulators > AVR > Manual > Manual AVR increase`	Digital input	Continuous	This input only has an effect when the genset is in switchboard control. When this input is activated, the controller increases the output to the AVR. This affects: `Regulators > AVR > Control > AVR increase` digital output or `Regulators > AVR > Control > AVR output [%]` analogue output Set the percentage change of the AVR voltage per second with: `Configure > Parameters > Regulators > AVR analogue configuration > Manual slope`.
`Regulators > AVR > Manual > Manual AVR decrease`	Digital input	Continuous	This input only has an effect when the genset is in switchboard control. When this input is activated, the controller decreases the output to the AVR. This affects: `Regulators > AVR > Control > AVR decrease` digital output or `Regulators > AVR > Control > AVR output [%]` analogue output Set the percentage change of the AVR voltage per second with: `Configure > Parameters > Regulators > AVR analogue configuration > Manual slope`.
`Regulators > AVR > Command > Reset AVR to offset`	Digital input	Pulse	This input only has an effect when the regulator uses the analogue output for regulation. When this input is activated, the controller resets the AVR output to the offset. This cancels the accumulated effect of the `Manual AVR increase` and/or `Manual AVR decrease` digital inputs.

More information
See Regulation chapter for more information.

Manual slope

These parameters are active when the controller is in switchboard control, and the operator manually controls the regulator. They are only visible if a governor or AVR output is configured.

`[Regulator]` is either GOV or AVR.

`Regulators > [Regulator] analogue configuration > Manual slope`

Parameter	Range	Notes
`Manual GOV slope`	0.0 to 200.0 %/s of genset nominal power	The controller increases or decreases the analogue output by this amount when the digital input is activated. For relay outputs, depending on the relay output settings, the effect might not be linear.
`Manual AVR slope`	0.0 to 200.0 %/s of genset nominal reactive power	The controller increases or decreases the analogue output by this amount when the digital input is activated.

Parameter	Range	Notes
		For relay outputs, depending on the relay output settings, the effect might not be linear.

After switchboard control

This parameter only applies to the **GENSET**, **HYBRID**, and **EMERGENCY genset controllers**.

This parameter defines the controller mode after *Switchboard control*.

`Local power management > Return modes > After SWBD control`

Option	Notes
`No mode change`	The default. After *Switchboard control*, the controller returns to the mode it was in before it was under *Switchboard control*.
`Manual mode`	After *Switchboard control*, the controller mode is manual (Manual).
`AUTO mode`	After *Switchboard control*, the controller mode is automatic (AUTO).

Events that force controllers in switchboard control

The following events force all the controllers in the section to operate in *Switchboard control*:

- The `Power management > Force all controllers in section to SWBD control` command or digital input on ANY controller in the section.
- Any breaker position failure in the section.
- Any critical alarms in a connected controller (that is, a controller with a closed breaker) in the section:
  - *Duplicate controller ID*
  - *Missing all controllers*
  - *System not OK* alarm on any controller (that is, there is a problem with a hardware module in that controller)
  - ACM voltage measurement error alarms
    - *[Source] L1-L2-L3 wire break*
    - *[Busbar] L1-L2-L3 wire break*
    - *[Source] L1 wire break*
    - *[Source] L2 wire break*
    - *[Source] L3 wire break*
    - *[Busbar] L1 wire break*
    - *[Busbar] L2 wire break*
    - *[Busbar] L3 wire break*
- Power management system disabled, as shown by any of these alarms:
  - *PMS disabled due to an error*
  - *Network protocol incompatible*
  - *Different single-line configurations*
  - *Controller type mismatch*
  - *Single-line missing/none active*
  - *Priority network error*
  - *Different power management rules activated*
  - *Controller ID not configured*

The controllers return to power management system control when the cause is removed.

More information
See Forced to switchboard control alarm in Power management for more information about the alarm.

EMERGENCY genset controller and force to switchboard control

The events that force controllers to switchboard control (listed above) only apply to the **EMERGENCY genset** controller when it is in **Harbour operation**. If the **EMERGENCY genset** controller is not in **Harbour operation**, then none of the events force the controller to *Switchboard control*.

The **EMERGENCY genset** controller is not forced to *Switchboard control* by alarms that force the other types of controllers to *Switchboard control*. However, if the controller(s) in the same section with connected equipment are forced to switchboard control, then the **EMERGENCY genset** controller is forced to Manual mode.

The **EMERGENCY genset** controller is not forced to *Switchboard control* by the `Power management > Force all controllers in section to SWBD control` input. This allows the **EMERGENCY genset** controller to still respond to a blackout.

Remote breaker signals in switchboard control

You can configure remote breaker signals as inputs to the controller. You can configure an alarm on an external over-current detection input, so that the controller trips the breaker when the input is activated.

In *Switchboard control*, the controller will respond to the remote breaker signal IF the alarm action has an effect under *Switchboard control*. In the examples above, in *Switchboard control*, the controller will not respond to the under-voltage coil input. However, in *Switchboard control* the controller will trip the breaker if the over-current detection input is activated.

Effect of switchboard control in ALL controllers

The power management system is disabled when all the controllers are in *Switchboard control*. The controllers do not respond to blackouts or requests from heavy consumers.

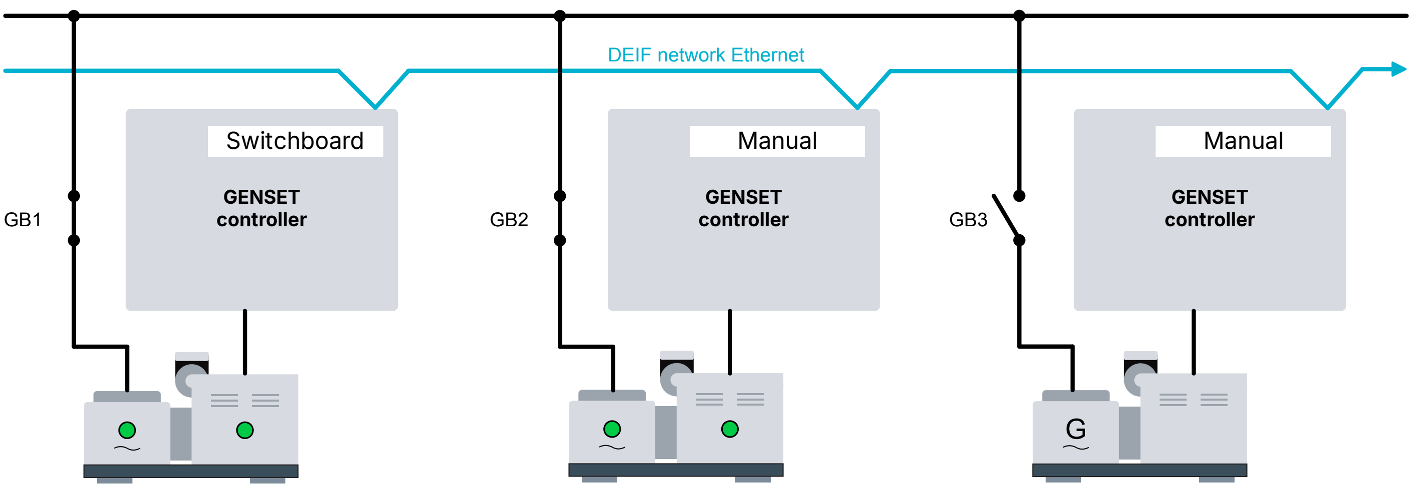
Effect of switchboard control in ONE controller

The controller in *Switchboard control* does not start or stop the engine, or open or close breakers. The controller in *Switchboard control* does not respond to a blackout.

If the controller in *Switchboard control* receives a request from a heavy consumer, and power is available from controllers in AUTO mode, then the controller acknowledges the request.

Effect of switchboard control on other controllers

If a connected **GENSET**, **SHAFT generator** or **SHORE connection** controller is in *Switchboard control*, all the other **GENSET** controllers go into Manual mode. Power management is disabled.



If a **BUS TIE breaker controller** is put in *Switchboard control*, then this has no effect on the other controllers.

If any **not connected** controller is put in *Switchboard control*, then this has no effect on the other controllers.

There can be a blackout while a connected controller is in *Switchboard control*. For the **GENSET**, **EMERGENCY genset**, **SHAFT generator**, and **SHORE connection** controllers, for the default under-voltage settings, the breaker will trip.

2.3.4 Automatic (AUTO) mode

Only applies to **GENSET**, **HYBRID**, and **EMERGENCY genset** controllers.

In AUTO mode, the **GENSET** controllers automatically start and stop gensets according to the power management requirements and the system settings. No operator actions are needed. In AUTO mode, power management includes load management, priority start, load sharing, and heavy consumer control.

External signals to start, stop, connect or disconnect gensets are ignored in AUTO mode.

For the power management system to operate, at least one **GENSET** controller must be in AUTO mode. However, it is not necessary for all the **GENSET** controllers to be in AUTO mode for the power management system to operate.

Inputs and outputs

Function	I/O	Type	Details
`Local > Mode > AUTO mode`	Digital input	Pulse	If it is possible, the controller is put into AUTO mode when this input is activated. This input has the same effect as pressing the AUTO push-button on the display.
`Power management > Force all gensets in section to AUTO mode`	Digital input	Pulse	If it is possible, each **GENSET** controller in the section is put into AUTO mode when this input is activated. This input has the same effect as pressing the AUTO push-button on the display of each **GENSET** controller.
`Local > Mode > In AUTO mode`	Digital output	Continuous	Activated if the controller is in AUTO mode.

2.3.5 Manual mode

Only applies to **GENSET**, **HYBRID**, and **EMERGENCY genset** controllers.

In Manual mode, the controller cannot automatically start, stop, connect or disconnect the genset. However, when a controller is in Manual mode, operator intervention (or an external signal) can start, stop, connect or disconnect the genset. In Manual mode, the controller automatically synchronises before closing a breaker, and automatically de-loads before opening a breaker.

Load sharing is active in Manual mode.

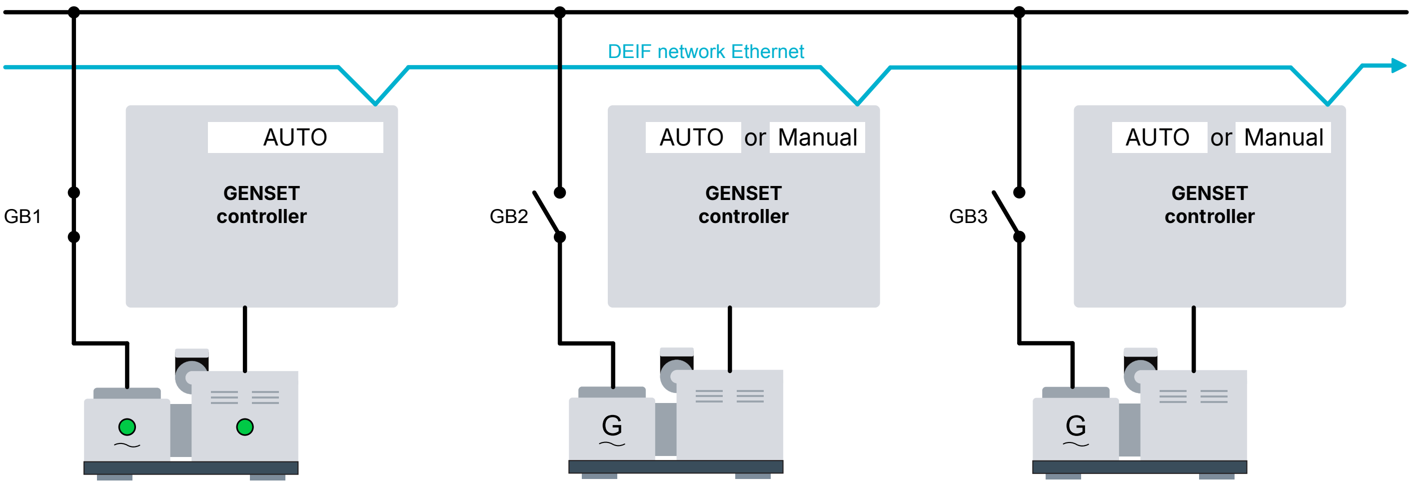
Non-essential load (NEL) trips are active in Manual mode. If local measurements show that the genset is overloaded, then the NEL(s) trip to protect the power supply to the main busbar.

Inputs and outputs

Function	I/O	Type	Details
`Local > Mode > Manual`	Digital input	Pulse	If it is possible, the controller is put into Manual mode when this input is activated. This input has the same effect as pressing the Manual push-button on the display unit.
`Power management > Force all gensets in section to Manual mode`	Digital input	Pulse	If it is possible, each **GENSET** controller in the section is put into Manual mode when this input is activated. This input has the same effect as selecting Manual on the display of each **GENSET** controller.
`Local > Mode > In Manual mode`	Digital output	Continuous	Activated if the controller is in Manual mode.

Effect of Manual mode on genset priority order

If only one **GENSET** controller is in AUTO mode, the PMS always starts the genset for that controller and connects the genset to the busbar. The PMS does this to have control over the system. The PMS starts the genset that is in AUTO even if there is enough power available from other controllers in Manual mode, and even if the genset has the lowest priority.



Event that forces controllers to Manual mode

If one or more controller in the section with **connected** equipment is in Switchboard control, then all the controllers in the section that are in AUTO mode are forced to Manual mode. The **EMERGENCY genset** controller equipment is **connected** if the generator breaker and the tie breaker are closed.

The controllers return to the return mode after switchboard when the cause is removed.

```
Local power management > Return modes > After SWBD control
```

More information
See Forced to Manual mode in Power management for the more information about the alarm.

2.3.6 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.

Parameters

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

`Local > Command sources > Active sources`

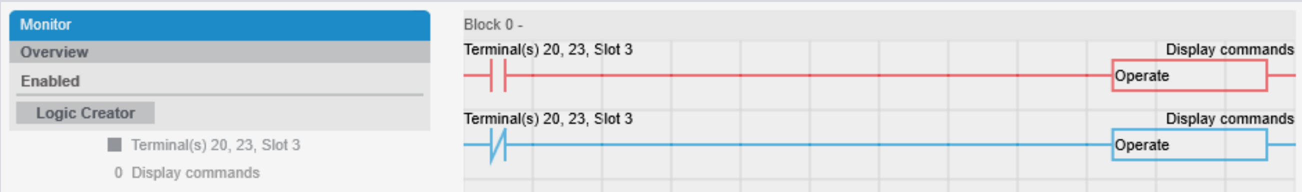
Parameter	Range	Push-button	Notes
`PICUS commands`	Not enabled, Enabled	-	Allow or prohibit PICUS commands.
`Modbus commands`	Not enabled, Enabled	-	Allow or prohibit Modbus commands.
`I/O commands`	Not enabled, Enabled	-	Allow or prohibit I/O commands to be used.
`CustomLogic commands`	Not enabled, 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	Manual/AUTO mode	-	Allow or prohibit the operator to use the display to change to Manual or AUTO mode.
	Mute alarm	-	Allow or prohibit the operator to mute alarms.
	Start/stop engine	I or O	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).
	First priority	-	Allow or prohibit the operator to select first priority.

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 and HYBRID controllers

Command	Bit	OPERATE value
Manual/AUTO	0	1
Mute alarm	1	2
Start/stop engine	2	4
Open/close breaker	3	8
First priority	4	16

EMERGENCY genset controller

Command	Bit	OPERATE value
Manual/AUTO	0	1
Mute alarm	1	2

Command	Bit	OPERATE value
Start/stop engine	2	4
Open/close breaker	3	8
Open/close tie breaker	4	16
Test engine	5	32

BUS TIE breaker , SHAFT generator, and SHORE connection controllers

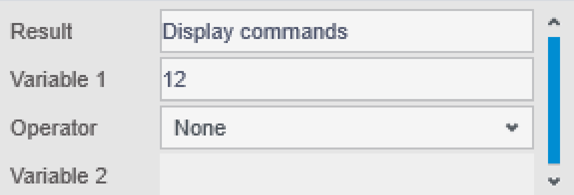
Command	Bit	OPERATE value
[Mode]	0	1
Mute alarm	1	2
Open/close breaker	2	4

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



Example 2

In this example, we enable all push-buttons with the exception of the *Test engine* push-button on a **EMERGENCY genset** controller.

Command	Bit	OPERATE value
Manual/AUTO	0	1
Mute alarm	1	2
Start/stop engine	2	4
Open/close breaker	3	8
Open/close tie breaker	4	16

Bit 0 + Bit 1 + Bit 2 + Bit 3 + Bit 4 = 1 + 2 + 4 + 8 + 16 = OPERATE value 31

2.3.7 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*

Effect of the unpowered controller hardware

DEIF Ethernet network links through the unpowered controller are broken. If a redundant **DEIF Ethernet network** link is not available, the controllers on either side of the unpowered controller cannot communicate with each other. If a redundant **DEIF Ethernet network** link is available, then the controllers on either side of the unpowered controller communicate through the redundant link.

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

NOTE

Maritime classification requires backup power supply

Maritime classification approval societies require that there is an independent backup power supply for the controller. This avoids having an unpowered 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**. This network is only for the controllers in the controller system.

Commands to start sequences

A controller can automatically start controller sequences. For example, if the available power is too low, then a **GENSET** controller in AUTO mode can automatically start and connect the genset.

Alternatively, the controller can receive external commands to start controller sequences. For example, a **GENSET** controller in Manual mode can respond to an external command to start the engine. If the controller is in AUTO mode, then the controller displays an info 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. The following table lists the various types of commands.

Commands to start sequences

Command	Mode	Type	Example
The controller starts the sequence.	AUTO	Internal	The controller parameters are set so that the controller starts the genset when the available power is too low. The controller calculates that the available power is too low, and starts the sequence to start the genset.
The operator presses a push-button on the display unit.	Manual	External	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.
A digital input, which is assigned an external command function, is activated.	Manual	External	A button on the switchboard is wired to a digital input on IOM3.1 in slot 6 (terminals 22 and 23) 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 unit push-button on the **Supervision** page in PICUS.	Manual	External	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.	Manual	External	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.
Using Modbus communication, an operator, a SCADA system, or a PLC sets a Modbus address in the function group *Command* to **1** (True).	Manual	External	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.

The controller ignores the command and displays an information message if the controller cannot execute the command. For example, if a **GENSET** controller is in *Switchboard control*, it ignores a *Start engine* command. The controller displays the info message *Engine start not possible in SWBD*.

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 power management for a **GENSET** controller in AUTO mode. Alternatively, if the **GENSET** controller is in Manual mode, an operator using the display, PICUS, a digital input, CustomLogic, CODESYS, or an external system using a Modbus command can initiate the generator breaker close. Similarly, the generator speed can be controlled using an analogue output, or CAN bus communication to the engine.

The **DEIF network** allows information from all the controllers to be used by any of the controllers. For example, with power management, the analogue and digital inputs and outputs for a heavy consumer can be connected to a **SHAFT generator** controller. The **SHAFT generator** controller shares the power management information with the rest of the system, even if the shaft generator itself is not connected while the heavy consumer is active.

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 power management and protections. Many protection settings are based on a percentage of the nominal settings.

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

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

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

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

Input and output functions

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

NOTE * # is 1 to 4.

Parameters

`Local > Nominal settings > Controller nominal setting`

Parameter	Range	Notes
`Selection`	• Nominal settings 1 • Nominal settings 2 • Nominal settings 3 • Nominal settings 4	The selected nominal setting group for the controller when **Source** is set to *Local*. Changing the nominal setting group using a digital input, analogue input, or external command changes this parameter.
`Source`	• Local • Power management rules	**Local**: The nominal setting selection is independent of the power management rules. The selected nominal setting is the same regardless of the active power management rule. Changing the nominal setting group with a digital input, analogue input, or external command, changes the nominal setting **Selection** parameter for the local settings. **Power management rules**: The nominal setting depends on the active power management rule. Each power management rule can determine which set of nominal settings should be active at a given time. Changing the nominal setting group with a digital input, analogue input, or external command, changes the nominal setting **Selection** parameter for the active power management rules.

Power management nominal setting parameter

`Power management rules > Configuration #* > Nominal settings > Controller nominal setting`

Parameter	Range	Notes
`Selection`	• Nominal settings 1 • Nominal settings 2 • Nominal settings 3 • Nominal settings 4	The selected nominal setting group for the controller when the **Source** parameter (`Local > Nominal settings > Controller nominal settings`) is set to *Power management rules*. Changing the nominal setting group using a digital input, analogue input, or external command changes this parameter.

NOTE * # is 1 to 8.

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.

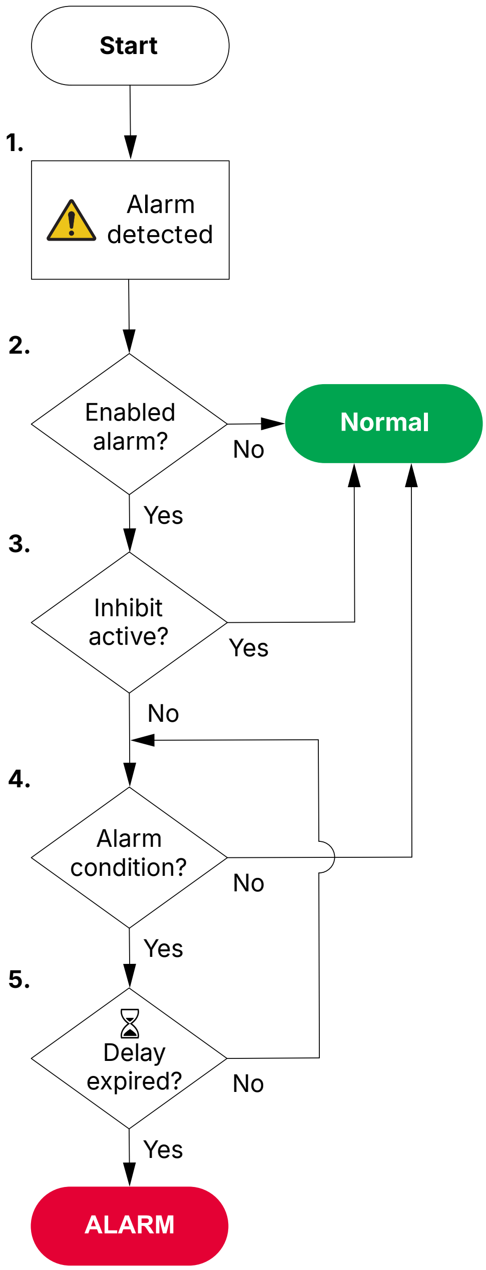
2.6 Alarms and protections

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. The Auto-acknowledge feature is not be approved for use by some Maritime classification societies.

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.

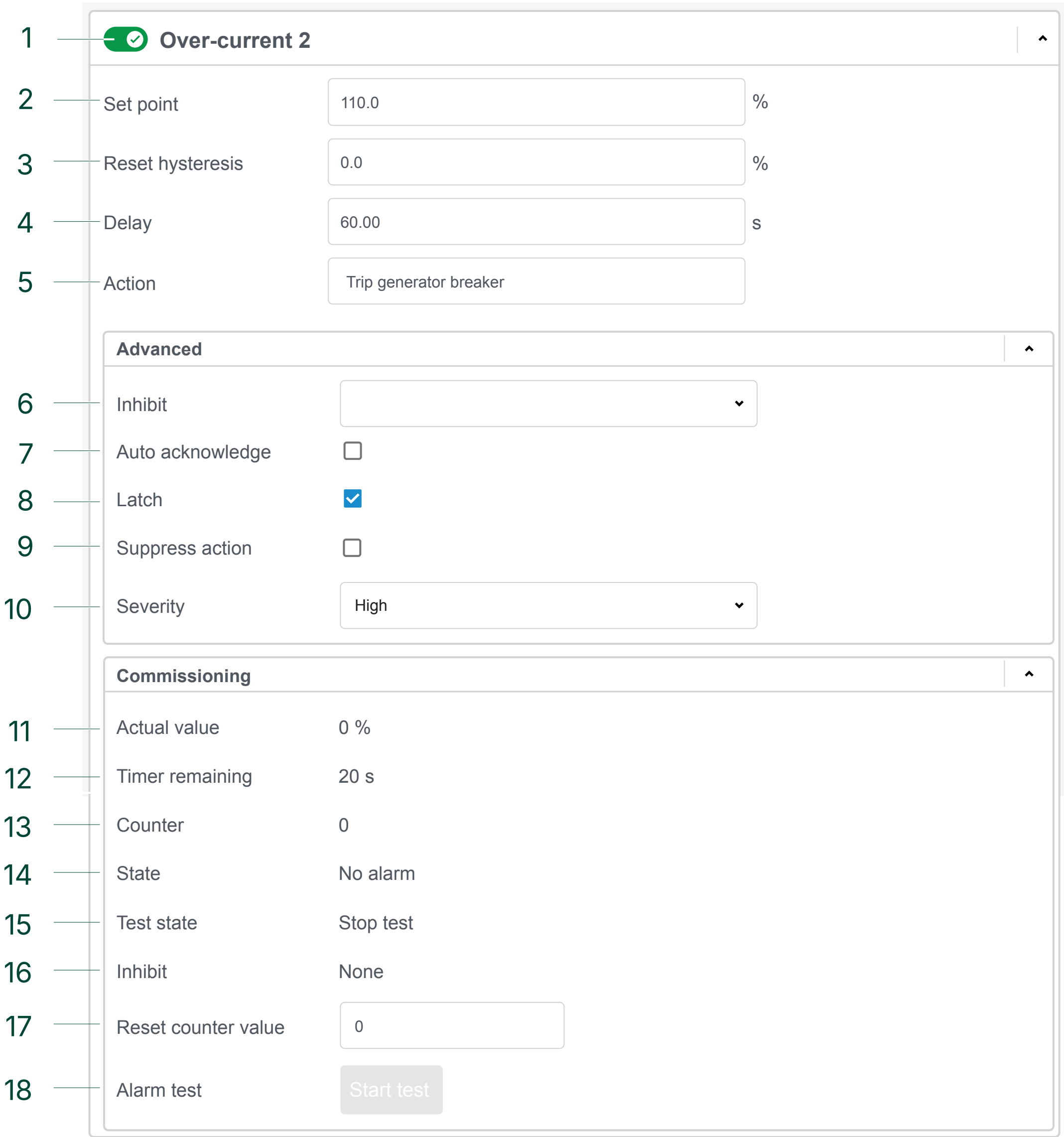
CAUTION

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.

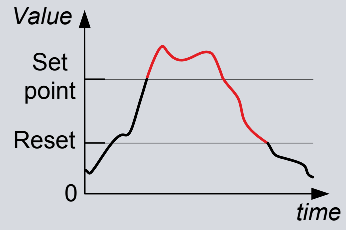
Reset hysteresis

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.

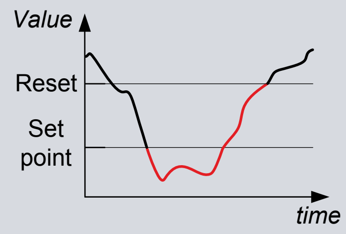
Overspeed example

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

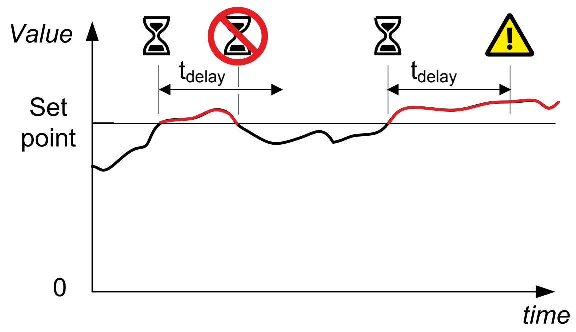
An *Under-speed* alarm with a *Set point* of 80 % of the nominal speed and a *Reset hysteresis* of 5.0 %. The alarm is only reset when the operating value is above 85.0 % of the nominal speed.



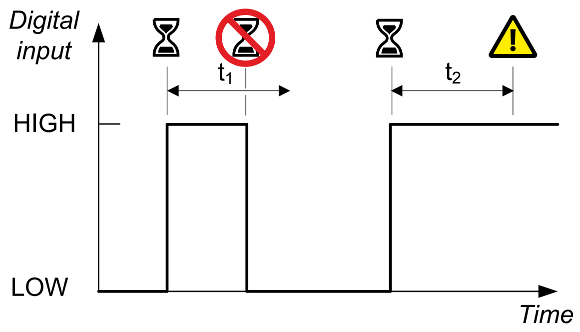
Delay

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*.

For **EMERGENCY genset** controllers: if there is a blackout, the controller must ensure that power is restored to the emergency busbar as soon as possible.

For the **EMERGENCY genset** controller, when *Suppress action* is selected for an alarm, the **Alarm action** is suppressed during the blackout recovery. The alarm is shown in the alarm handling system, but the **Alarm action** is only *Warning*.

More information
See Blackout in Power management for how blackout recovery works.

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.

NOTICE

Alarm tests activate alarm actions

Alarm tests activate alarm actions, some of which can force the system to switchboard control, trip breakers, create a blackout, and shut down engines. Use extreme care when performing alarm tests during normal operation.

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.

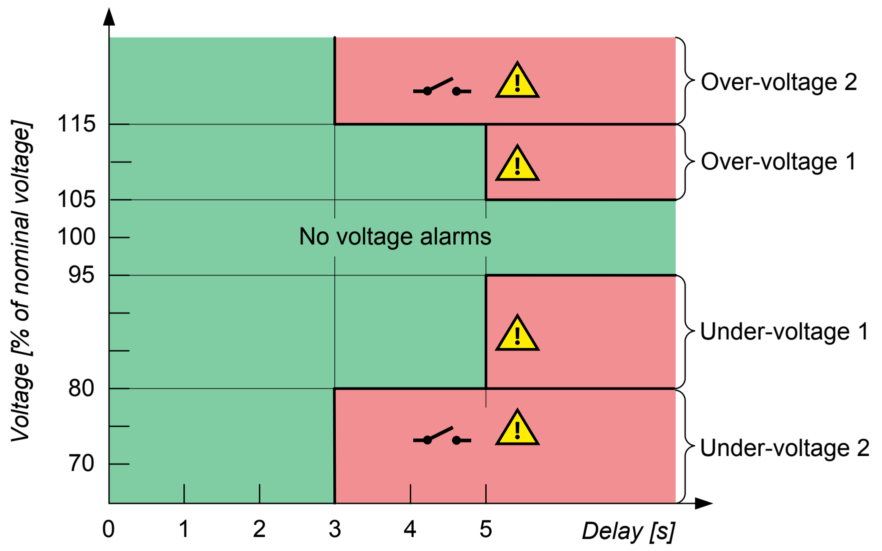
If the delay is **5.00 s**, the controller does the *Over-voltage 1* alarm action **5.10 s** after the alarm *set point* is exceeded.

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.

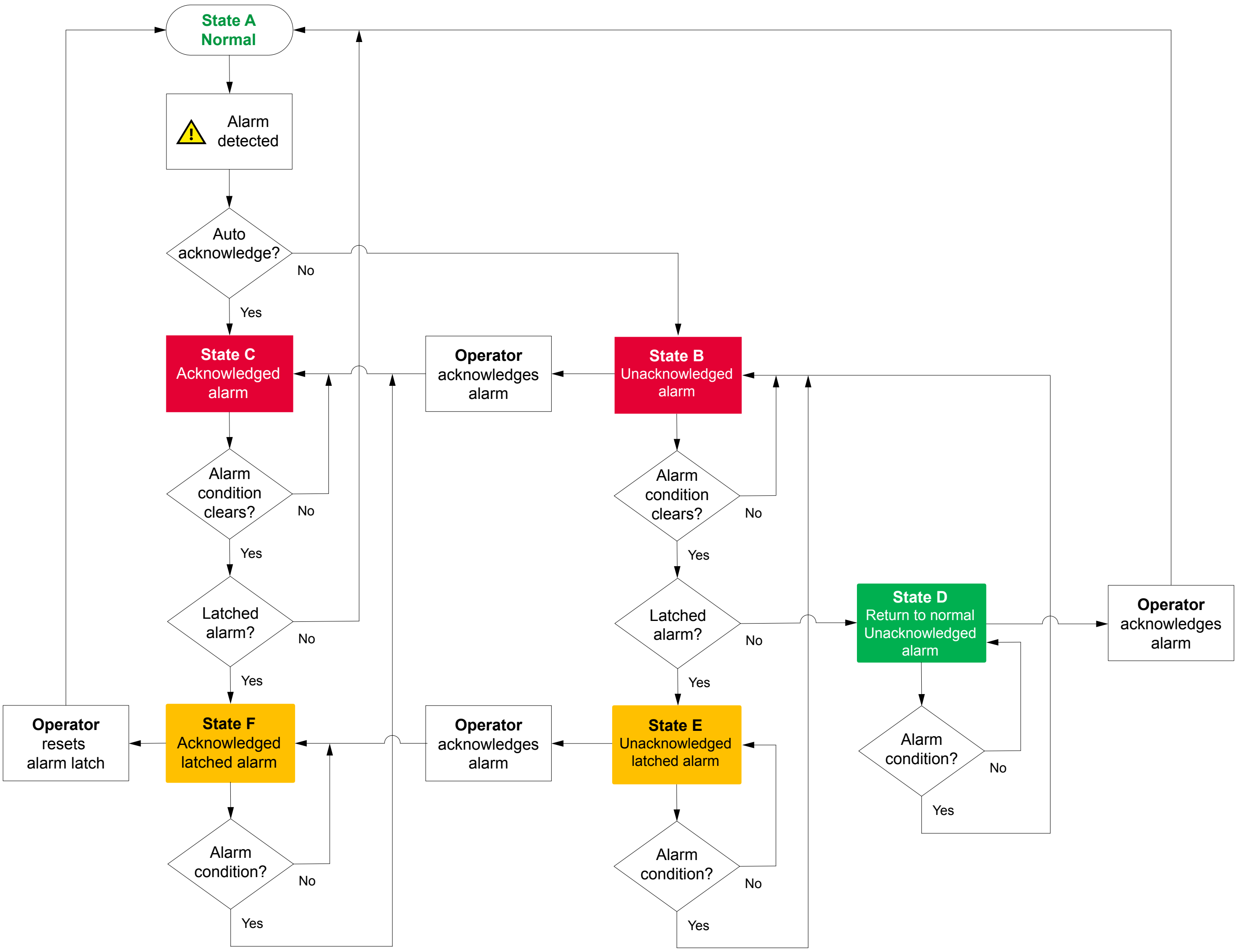
2.6.5 Alarm processing states

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	Symbol	Alarm condition	Alarm action	Acknowledge	Notes
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. • 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.)

PMS-controlled stop	
Controller types	**GENSET**, **HYBRID**, and **EMERGENCY genset** controllers
Priority	Medium
Effect	The breaker is de-loaded and then opened. The controller then initiates the stop sequence. If the power management system cannot de-load the breaker (for example, because there is not enough power), nothing happens. This alarm action **only** opens the breaker when it is de-loaded.

PMS-controlled open breaker	
Controller types	**SHAFT generator**, **SHORE connection** and **BUS TIE breaker** controllers
Priority	-
Effect	The breaker is de-loaded and then opened. If the power management system cannot de-load the breaker, nothing happens. This **Alarm action** only opens the breaker when it is de-loaded.

Trip generator breaker	
Controller types	**GENSET**, **EMERGENCY genset** and **SHAFT generator** controllers
Priority	High
Effect	The controller trips the genset or shaft generator breaker (that is, without de-loading).

Trip breaker	
Controller types	**HYBRID** controllers
Priority	High
Effect	The controller trips the inverter breaker (that is, without de-loading).

Trip tie breaker	
Controller type	**EMERGENCY genset** controller
Priority	High
Effect	The controller trips the tie breaker to the emergency busbar (that is, without de-loading).

Trip shore connection breaker	
Controller type	**SHORE connection** controller
Priority	High
Effect	The controller trips the shore connection breaker (that is, without de-loading).

Trip bus tie breaker	
Controller type	**BUS TIE breaker** controller
Priority	High
Effect	The controller trips the bus tie breaker (that is, without de-loading).

Trip generator breaker and stop engine	
Controller types	**GENSET** and **EMERGENCY 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 breaker and stop inverter	
Controller types	**HYBRID** controllers
Priority	High
Effect	The controller trips the inverter breaker (without de-loading) and stops the inverter at the same time.

Trip generator breaker and shutdown engine	
Controller types	**GENSET** and **EMERGENCY 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.

Trip AVR	
Controller types	**GENSET**, **HYBRID**, **EMERGENCY genset** and **SHAFT generator** controllers
Priority	High
Effect	The controller trips the AVR (that is, stops voltage or reactive power regulation).

Trip generator breaker + AVR	
Controller types	**GENSET**, **EMERGENCY genset** and **SHAFT generator** controllers
Priority	High
Effect	The controller trips the genset or shaft generator breaker (that is, without de-loading) and the AVR (that is, stops reactive power regulation).

Trip breaker + AVR	
Controller types	**HYBRID** controllers
Priority	High
Effect	The controller trips the inverter breaker (that is, without de-loading) and the AVR (that is, stops reactive power regulation).

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

Trip breaker and AVR and stop inverter	
Controller types	**HYBRID** controllers
Priority	High
Effect	The controller trips the inverter breaker (that is, without de-loading) and the AVR (that is, stops reactive power regulation). The controller stops the inverter.

Trip generator breaker + AVR + shutdown engine	
Controller types	**GENSET** and **EMERGENCY genset** controllers
Priority	Highest
Effect	The controller trips the genset breaker (that is, without de-loading) and the AVR (that is, stops reactive power regulation). The controller shuts down the engine, **without** a cooldown period.

Stop inverter	
Controller types	**HYBRID** controller
Priority	High
Effect	The controller stops the inverter without checking the breaker position.

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

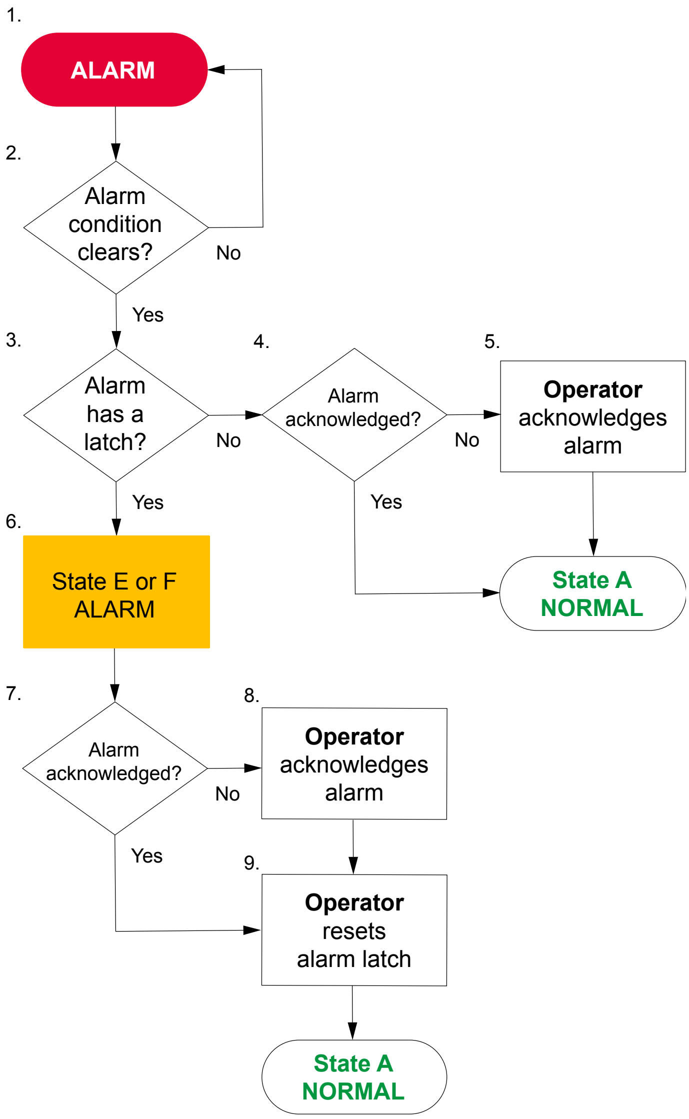
Function	I/O	Type	Details
`Alarm system > Command > Acknowledge all alarms`	Digital input	Pulse	When this input is activated, the controller acknowledges all its alarms.
`Power management > Acknowledge all alarms in system`	Digital input	Pulse	When this input is activated, the controller acknowledges all its own alarms, along with all the alarms in all the other controllers in the system.

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. The *Auto-acknowledge* feature is not be approved for use by some Maritime classification societies.

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*).

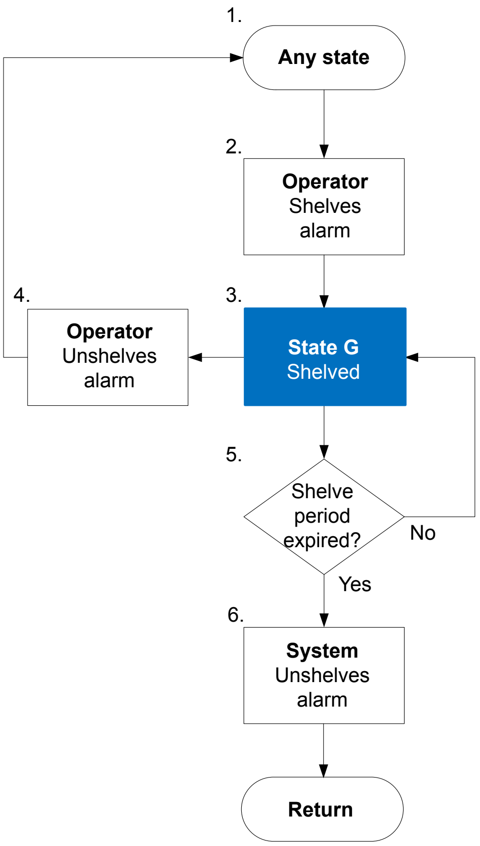
If an unacknowledged alarm is shelved, the alarm is automatically acknowledged. If a latched alarm is shelved, the latch on the alarm is reset. While the alarm is shelved, the alarm action is not active.

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.

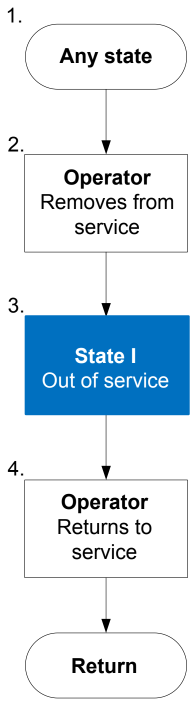
2.6.11 Out of service an alarm

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 will force the system under switchboard control, 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 Modbus

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

For example:

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

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

2.8 Engine interface communication

2.8.1 How it works

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

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

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

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

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

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

Not supported engines

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

2.8.2 ECU power configuration function

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

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

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

Digital output

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

Parameter

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

Range	Comment
Auto 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.

2.8.3 ECU reset input function

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

Digital input

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

2.8.4 Other EIC information

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

2.9 Custom parameters

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

Configure custom parameters under `Custom parameters`.

`Custom parameter # *`

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

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

2.10 CustomLogic

2.10.1 Use CustomLogic

CustomLogic is used in PICUS to create and configure customised logical operations for use in the system. These functions are built using ladder logic elements and can include interaction with external equipment, or more advanced logic interfaces.

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

2.10.2 Enable CustomLogic

Local > CustomLogic > Configuration

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

2.10.3 Digital inputs and outputs (optional)

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

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

2.10.4 Activate controller outputs

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

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

2.10.5 CustomLogic and Modbus

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

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

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

2.10.6 Constraints

CustomLogic reset on save

If you make a change to the CustomLogic and then save the change to the controller, all the CustomLogic states and timers are reset.

CustomLogic under switchboard control

CustomLogic remains enabled when the controller is in switchboard control.

However, the controller does not accept external commands in switchboard control. For example, if CustomLogic activates a command to open a breaker, the controller ignores the command.

If the logic should not be processed while the controller is in switchboard control, a open normally closed contact should be added to the logic lines where necessary. Set the normally closed contact to `Mode > Inputs > Under switchboard control`.

2.11 Date and time

2.11.1 About date and time settings

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

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

Time master

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

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

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

Synchronisation interval and performance

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

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

`Configure > Time settings`

Setting	Range	Notes
Date format	• YYYY-MM-DD • 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.

Setting	Range	Notes
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.

2.11.2 Set the time manually

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

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

2.12 Event and system logs

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

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

2.13 Test functions

2.13.1 Emulation

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

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

2.13.2 Lamp test

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

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

Digital inputs (optional)

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

Parameters

`Test functions > Lamp test`

Parameter	Range	Comment
`Activate`	Not enabled, Enabled	**Not enabled**: There is no lamp test. **Enabled**: When the parameter is saved, the lamp test starts. After the lamp test, the controller automatically changes the parameter to *Not enabled*. 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.

2.14 CODESYS (optional)

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

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

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

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

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

3. Cybersecurity

3.1 About Cybersecurity

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

To minimise the risk of data security breaches we recommend:

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

Admin password

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

3.2 Permissions

3.2.1 About permissions

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

Permission structure

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

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

Permissions access enables you to easily control which user can access which function. This provides a layer of control for the operation of the controller.

NOTICE

Permissions access

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

3.2.2 Role settings

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

Role information

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

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

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

Role permissions

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

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

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

Feature permissions	
Live Data	Live Data
Application	Plant configuration 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

Feature permissions	
	Notification configuration

3.2.3 User settings

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

3.2.4 Default user

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

User	Password	Role
admin	admin	Administrator for the system.

NOTICE

Secure your system

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

NOTICE

Lost passwords

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

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

3.2.5 Password strength verification

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

Entered passwords must:

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

3.3 Network communication

3.3.1 Ethernet port configuration

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

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

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

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

3.3.2 Untrusted networks

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

3.4 CODESYS

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

3.5 Activity logs

3.5.1 About activity logs

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

These are recorded in logs:
- Event log
- Live system log

3.5.2 Event log

This can be accessed with PICUS or the display.

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

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

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

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

3.5.3 System log

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

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

These logs include:
- System events and journal.
- Connected session access with WebConfig.
- CODESYS related information.

Download logs

You can select and download the system logs directly from the controller as text files.
1. Select **Download** from **Logs**.
2. Select the **Duration** (period) you want to download.
   - This can be **Latest**, **Day**, **Week**, or **All**.
3. Select the **Type** of log to download.
   - This can be **SYSLOG**.

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

SYSLOG

The system log (SYSLOG) archive includes:

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

4. AC configuration

4.1 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

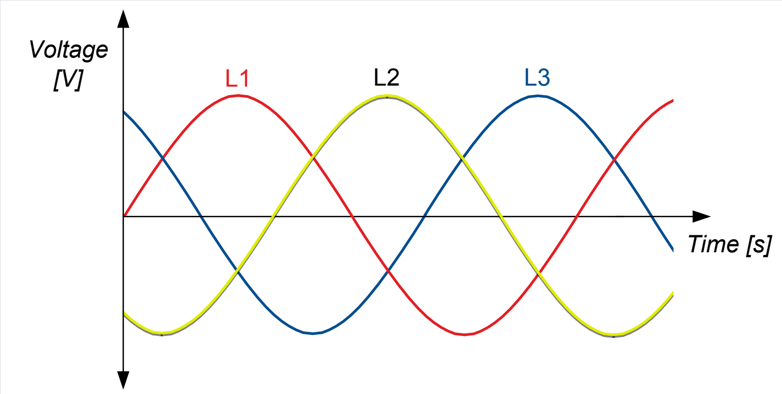
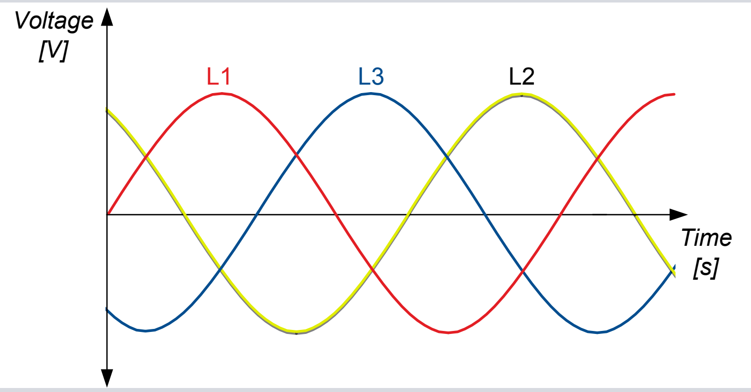
See **System AC configuration** in the **Installation instructions** for examples of three-phase, single-phase wiring, and split-phase wiring.

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.

4.1.1 [A-side] and [B-side] for each controller type

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

Controller type	[A-side] (MIO terminals 78 to 81)	[B-side] (MIO terminals 83 to 86)
GENSET	Generator	Busbar
HYBRID	Inverter	Busbar
EMERGENCY genset	Generator	Busbar
SHAFT generator	Generator	Busbar
SHORE connection	Shore connection	Busbar
BUS TIE breaker	Busbar A	Busbar B

4.1.2 [A-side] AC configuration

Voltage transformer

Set these parameters for the voltage transformer on the [A-side]'s voltage measurement.

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

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

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

Parameter	Range	Notes
`Primary`	10 V to 1500 kV AC	The voltage transformer primary side (asset side) value.
`Secondary`	17 to 690 V AC	The voltage transformer secondary side (controller side) value. **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

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

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

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

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

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

Voltage and frequency OK

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

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

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

Voltage and frequency OK (blackout)

For the **GENSET**, **EMERGENCY genset**, **SHAFT generator** or **SHORE connection** controllers.

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

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

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

Voltage or frequency not OK

For the **GENSET**, **EMERGENCY genset**, **SHAFT generator** or **SHORE connection** controllers.

`[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.

4.1.3 [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 s	After detecting the blackout, the controller does not respond, unless the 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.

4.1.4 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.

4.1.5 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.

4.2 AC measurement filters

4.2.1 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.

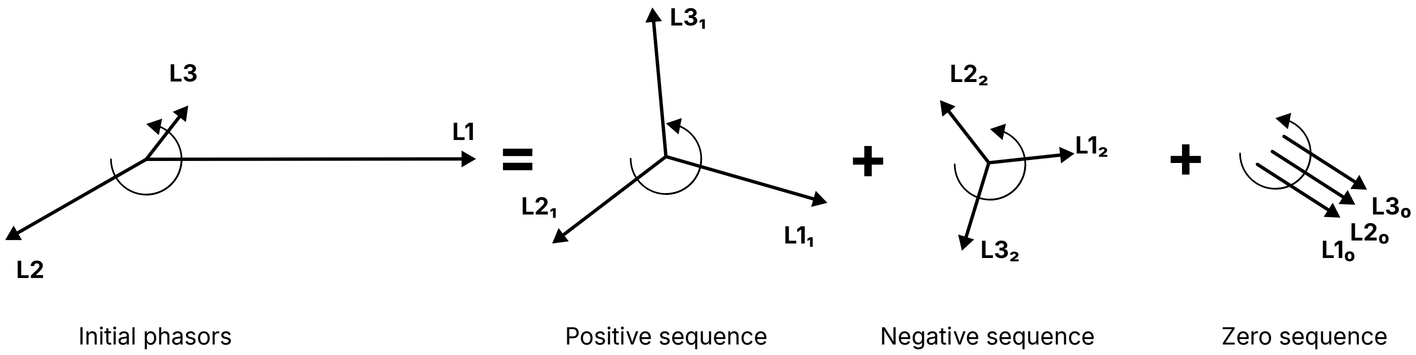
4.2.2 AC measurement filters

`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)

4.3 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.

4.4 AC measurements as analogue outputs

4.4.1 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.

4.4.2 [A-side] AC measurements

Function names

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

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

Example

```
Shore busbar > Phase angle > Shore | Phase angle L3-L1 [°]
```

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

Controller type	[A-side]	[Asset]
GENSET	Generator	Generator
HYBRID	Inverter	Inverter
EMERGENCY genset	Generator	Generator
SHAFT generator	Generator	Generator
SHORE connection	Shore busbar	Shore
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).

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

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

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

[A-side] current analogue output functions

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

Function	Details
`[Asset] | L1 [A]`	The controller outputs the L1 current from the A-side.
`[Asset] | L2 [A]`	The controller outputs the L2 current from the A-side.
`[Asset] | L3 [A]`	The controller outputs the L3 current from the A-side.
`[Asset] | N [A]`	The controller outputs the N current from the A-side, relative to the star point.
`[Asset] | Min. [A]`	The controller outputs the lowest phase current.
`[Asset] | Max. [A]`	The controller outputs the highest phase current.
`[Asset] | Unbalanced nominal [A]`	The controller outputs the unbalanced current from the A-side, calculated using the nominal method.
`[Asset] | Unbalanced average [A]`	The controller outputs the unbalanced current from the A-side, calculated using the average method.
`[Asset] | Positive sequence [A]`	The controller outputs the magnitude of the positive sequence current.
`[Asset] | Negative sequence [A]`	The controller outputs the magnitude of the negative sequence current.
`[Asset] | Zero sequence [A]`	The controller outputs the magnitude of the zero sequence current from the A-side.

[A-side] power analogue output functions

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

Function	Details
`[Asset] | L1 [kW]`	The controller outputs the L1 power.
`[Asset] | L2 [kW]`	The controller outputs the L2 power.
`[Asset] | L3 [kW]`	The controller outputs the L3 power.
`[Asset] | Min. [kW]`	The controller outputs the power of the phase with the lowest power.
`[Asset] | Max. [kW]`	The controller outputs the power of the phase with the highest power.

Function	Details
`[Asset]	Total [kW]`	The controller outputs the total power.
`[Asset]	Total [%]`	The controller outputs the total power, as a percentage of the A-side's nominal power.
`[Asset]	Available [kW]`	The controller outputs the available power for the A-side in kW. Available power = Nominal power - Total power
`[Asset]	Available [%]`	The controller outputs the available power for the A-side, as a percentage of the A-side's nominal power. Available power = Nominal power - Total power

[A-side] reactive power analogue output functions

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

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

[A-side] apparent power analogue output functions

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

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

[A-side] power factor analogue output functions

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

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

[A-side] phase angle analogue output functions

`[A-side] > Phase angle`

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

4.4.3 [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]
GENSET	Busbar	Busbar
HYBRID	Busbar	Busbar
EMERGENCY genset	Busbar	Busbar
SHAFT generator	Busbar	Busbar
SHORE connection	Ship 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.

Function	Details
[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.

4.4.4 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.

4.5 A-side AC protections

4.5.1 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]
GENSET	Diesel genset	GB
HYBRID	Inverter	Breaker
EMERGENCY genset *	Emergency diesel genset	EGB and TB *
SHAFT generator	Shaft generator	SGB
SHORE connection	Shore connection	SCB
BUS TIE breaker	Busbar A	BTB

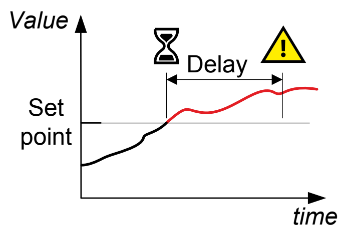
NOTE * The **EMERGENCY genset** controller also controls the tie breaker to the emergency busbar. The *Trip generator breaker* alarm action trips the emergency genset breaker (EGB), while *Trip tie breaker* trips the tie breaker.

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

4.5.2 [A-side] over-voltage (ANSI 59)

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

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



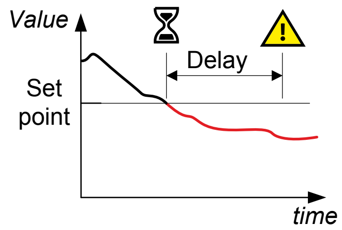
`[A-side] > Voltage protections > Over-voltage #`

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

4.5.3 [A-side] under-voltage (ANSI 27)

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

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



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

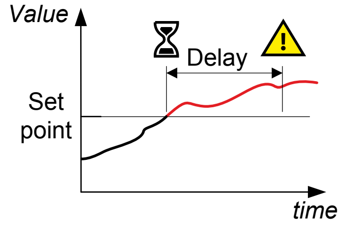
Parameter	Range
`AC setup`	Phase-phase, Phase-neutral
`Set point`	10.0 to 100.0 % of nominal voltage
`Reset hysteresis`	0.0 to 20.0 %
`Delay`	0.00 s to 2 h

4.5.4 [A-side] voltage unbalance (ANSI 47)

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

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

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



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

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

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

Voltage unbalance example

A **GENSET** controller controls a genset with a nominal voltage of 230 V. The L1-L2 voltage is 235 V, the L2-L3 voltage is 225 V, and the L3-L1 voltage is 210 V.

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

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

4.5.5 Positive sequence under-voltage (ANSI 27D)

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

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

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

Parameters

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

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

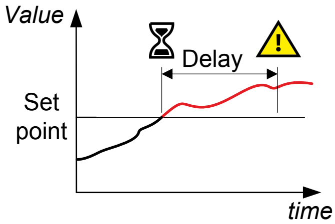
4.5.6 Negative sequence over-voltage (ANSI 47)

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

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

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

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



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

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

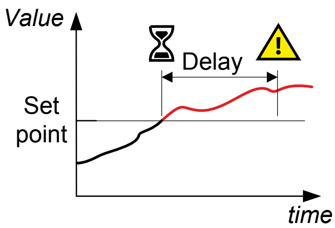
4.5.7 Zero sequence over-voltage (ANSI 59U_0)

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.



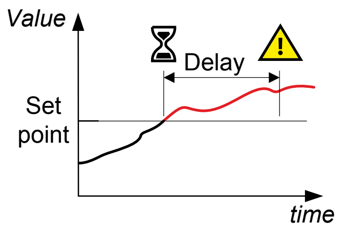
`[A-side] > Voltage protections > Zero sequence voltage`

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

4.5.8 Over-current (ANSI 50TD)

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

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



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

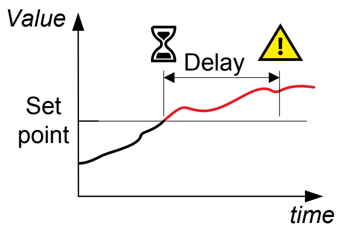
Parameter	Range
`Set point`	Variable. Depends on current transformer settings.
`Reset hysteresis`	0.0 to 20.0 %
`Delay`	0.00 s to 2 h

4.5.9 Fast over-current (ANSI 50/50TD)

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

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

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



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

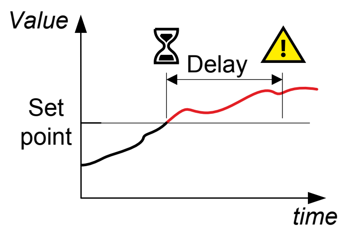
Parameter	Range
`Set point`	Variable. Depends on current transformer settings.
`Reset hysteresis`	0.0 to 20.0 %
`Delay`	0.00 s to 2 h

4.5.10 Current unbalance (ANSI 46)

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

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

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



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

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

Average method

The *Average method* is based on the ANSI C84.1-2016 calculation method to determine ***voltage*** unbalance. The controller calculates the average current for the three phases. The controller then calculates the difference between each phase current and the average current. Finally, the controller divides the maximum difference by the average current to get the current unbalance.

Average method example

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

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

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

Nominal method

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

Nominal method example

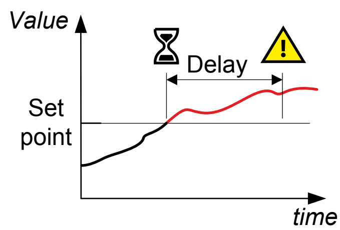
A **GENSET** controller controls a genset with a nominal current of 100 A. The L1 current is 80 A, the L2 current is 90 A, and the L3 current is 60 A.

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

4.5.11 Directional over-current (ANSI 67)

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

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



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

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

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

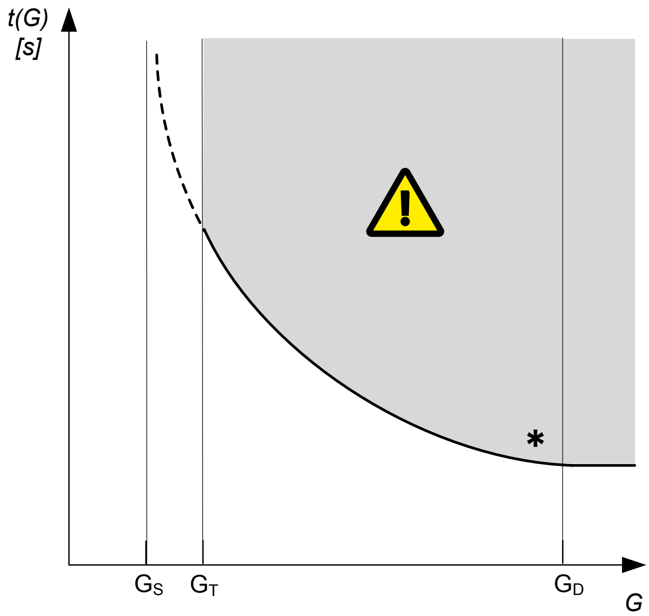
4.5.12 Inverse time over-current (ANSI 51)

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.

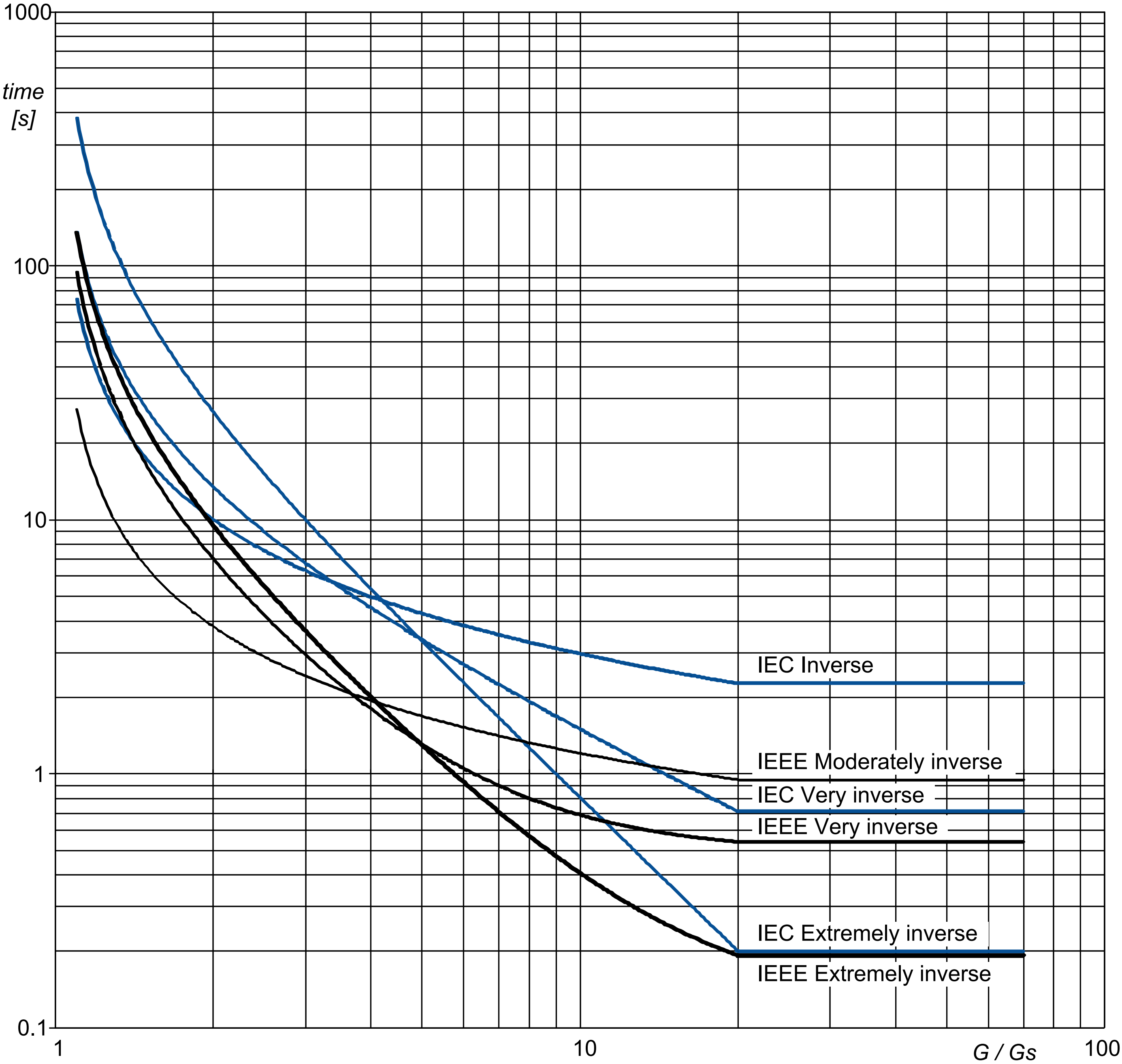
Standard inverse time over-current curves

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

Table 4.1 Parameters for the inverse time over-current curves

Curve name	k	c	alpha (α, or a)
IEC inverse	0.14 s	0 s	0.02
IEC very inverse	13.5 s	0 s	1
IEC extremely inverse	80 s	0 s	2
IEEE moderately inverse	0.0515 s	0.114 s	0.02
IEEE very inverse	19.61 s	0.491 s	2
IEEE extremely inverse	28.2 s	0.1217 s	2
Custom characteristic	Customisable	Customisable	Customisable

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



Definite time characteristic

G_D is the point where the alarm shifts from an inverse curve to a definite time characteristic, as the following graph shows. That is, after this point, the curve is flat, and a current increase does not have any effect on the alarm response time. In IEC 60255-151, this point is defined as $G_D = 20 \times G_S$.

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

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

Influence of the CT primary current rating on G_D example

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

G_D of the inverse time over-current characteristic graph according to IEC 60255-151 is 7000 A.

- $G_D = 20 \times G_S = 20 \times (I_{nom} \times (Limit / 100)) = 20 \times (350 \times (1 / 1)) = 7000$ A

However, the highest G_D value where measurements can be made is 2000 A.

- Because the secondary current rating is 5 A, the formula to calculate the measurable G_D is $G_D = 4 \times I_{CT\ primary}$.
- $G_D = 4 \times I_{CT\ primary} = 4 \times 500 = 2000$ A

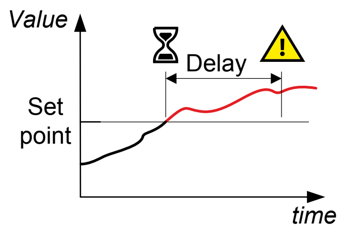
If the time performance at higher currents of the inverse time over-current protection is important, DEIF recommends using a current transformer that is rated for a 1 A secondary current (that is, -/1 A).

4.5.13 Negative sequence over-current (ANSI 46)

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

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

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



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

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

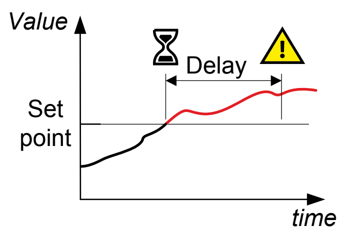
`[A-side] > Current protections > Negative sequence current`

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

4.5.14 Zero sequence over-current (ANSI $51I_0$)

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

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



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

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

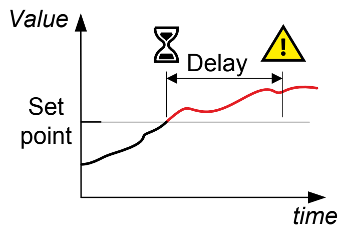
`[A-side] > Current protections > Zero sequence current`

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

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

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

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



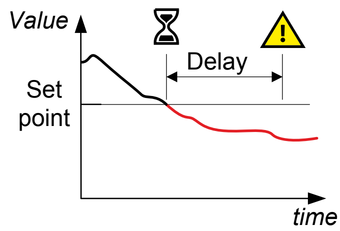
`[A-side] > Frequency protections > Over-frequency #`

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

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

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

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



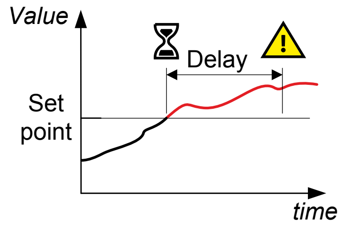
`[A-side] > Frequency protections > Under-frequency #`

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

4.5.17 Overload (power export) (ANSI 32)

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

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



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

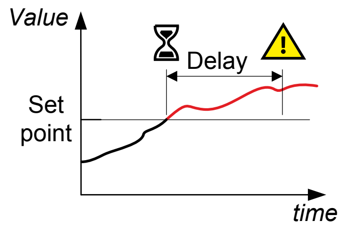
Parameter	Range
`Set point`	0.0 to 200.0 % of nominal power
`Reset hysteresis`	0.0 to 20.0 %
`Delay`	0.00 s to 2 h

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

4.5.18 Reverse power (power import) (ANSI 32R)

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

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



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

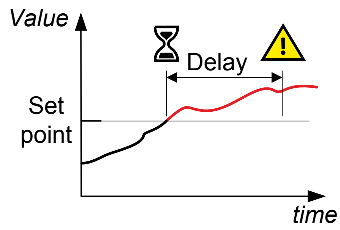
Parameter	Range
`Set point`	0.0 to 200.0 % of nominal power
`Reset hysteresis`	0.0 to 20.0 %
`Delay`	0.00 s to 2 h

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

4.5.19 Overload reverse power (ANSI 32R)

Protection	IEC symbol (IEC60617)	ANSI (IEEE C37.2)	Operate time
Overload reverse power		32R	< 100 ms

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



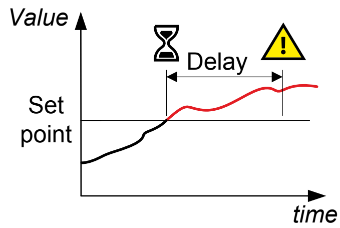
Inverter > Power protections > Overload reverse power #

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

4.5.20 Reactive power export (ANSI 40O)

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

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



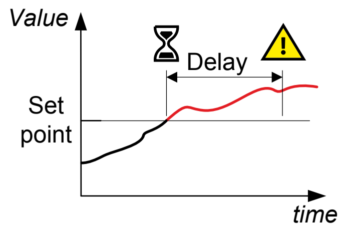
[A-side] > Reactive power protections > Reactive power export #

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

4.5.21 Reactive power import (ANSI 40U)

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

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



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

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

4.5.22 Active synchroniser (ANSI 25A)

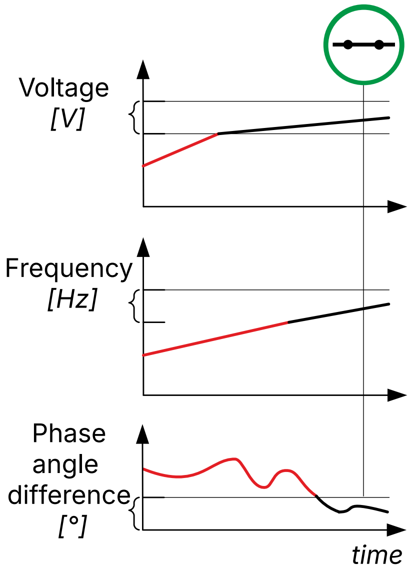
Protection	IEC symbol (IEC60617)	ANSI (IEEE C37.2)	Operate time
Active synchroniser (including blackout close)	-	25A	-

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`

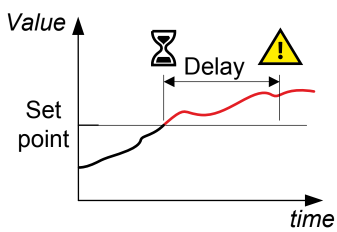
More information
See Blackout for blackout configuration and blackout closing.

4.6 B-side AC protections

4.6.1 [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.



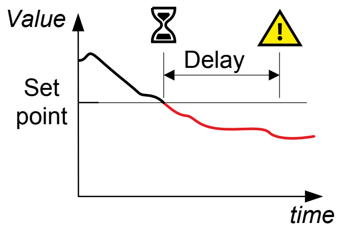
[B-side] > Voltage protections > Over-voltage #

Parameter	Range
Set point	90 to 120 % of nominal voltage
Delay	0.00 s to 2 h

4.6.2 [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
Set point	50 to 100 % of nominal voltage
Delay	0.00 s to 2 h

NOTE For the **EMERGENCY genset** controller, this alarm action trips the tie breaker to the main busbar. For other controllers: the controller trips the breaker to the equipment it controls.

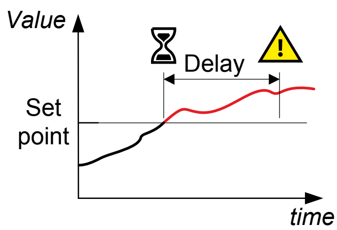
4.6.3 [B-side] voltage unbalance (ANSI 47)

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

Parameter	Range
`Reset hysteresis`	0.0 to 20.0 %
`Delay`	0.10 s to 2 h

B-side voltage unbalance example

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

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

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

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

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

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

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

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

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

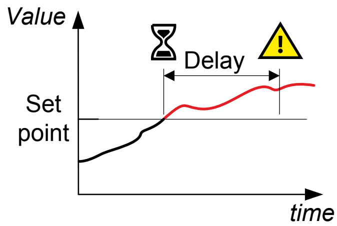
4.6.5 [B-side] negative sequence over-voltage (ANSI 47)

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

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

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

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



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

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

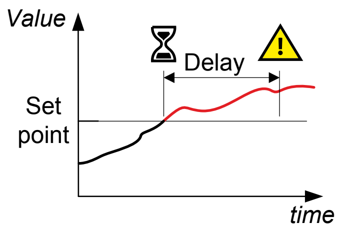
4.6.6 [B-side] zero sequence over-voltage (ANSI 59U$_0$)

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

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

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

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



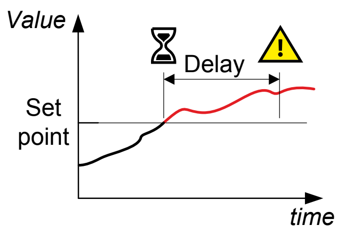
`[B-side] > Voltage protections > Zero sequence voltage`

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

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

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

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



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

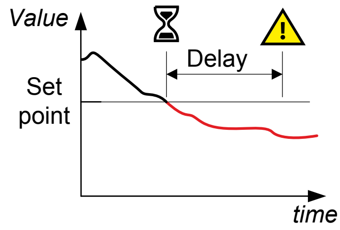
Parameter	Range
`Set point`	100.0 to 130.0 % of nominal frequency
`Reset hysteresis`	0.0 to 20.0 %
`Delay`	0.00 s to 2 h

NOTE For the **EMERGENCY genset** controller, this alarm action trips the tie breaker to the main busbar. For other controllers: the controller trips the breaker to the equipment it controls.

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

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

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



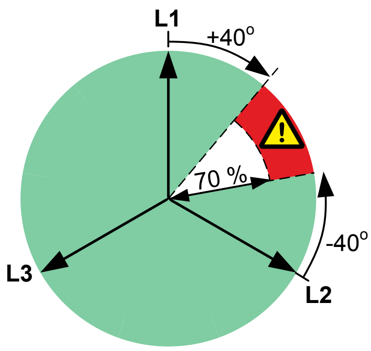
`[B-side] > Frequency protections > Under-frequency #`

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

4.7 Other AC protections

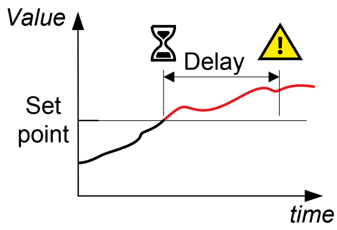
4.7.1 Phase sequence error

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.

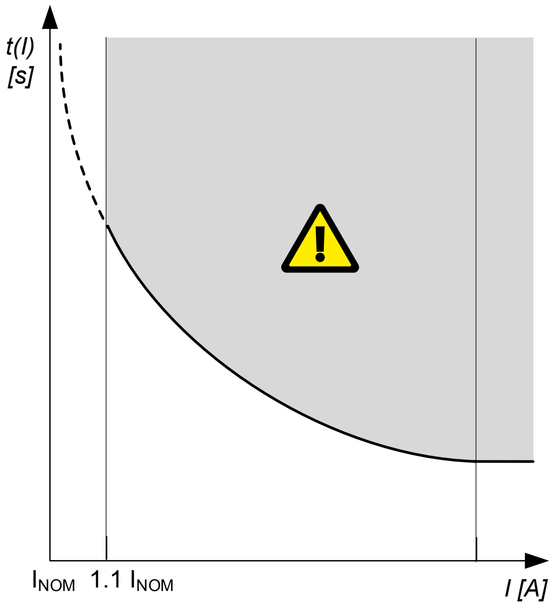
4.7.2 Earth inverse time over-current (ANSI 51G)

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

The alarm response is based on the earth current, as measured by the 4th current measurement filtered to attenuate the third harmonic (at least 18 dB; a 128 tap FIR low pass filter is applied). The A-side frequency, as measured by the controller (f), is used as the cutoff frequency. The filter has 0 dB attenuation at f0, and 33 dB attenuation at 3 × f0.

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

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



Wiring

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

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

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

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

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

NOTE * Only used if custom curve is selected.

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

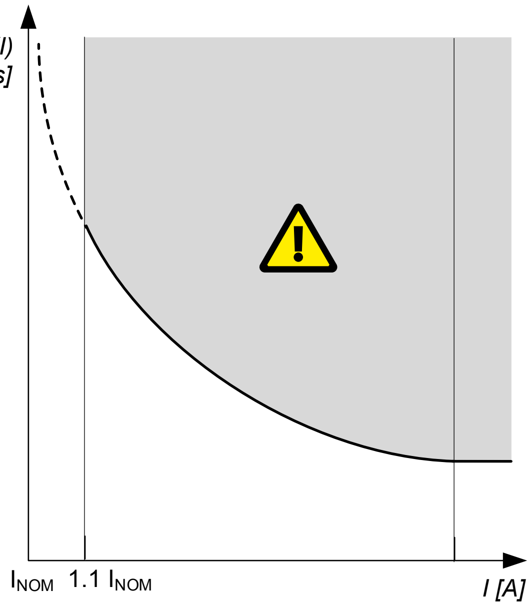
4.7.3 Neutral inverse time over-current (ANSI 51N)

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

The alarm response is based on the RMS neutral current, as measured by the 4th current measurement.

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

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



Wiring

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

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

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

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

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

NOTE * Only used if custom curve is selected.

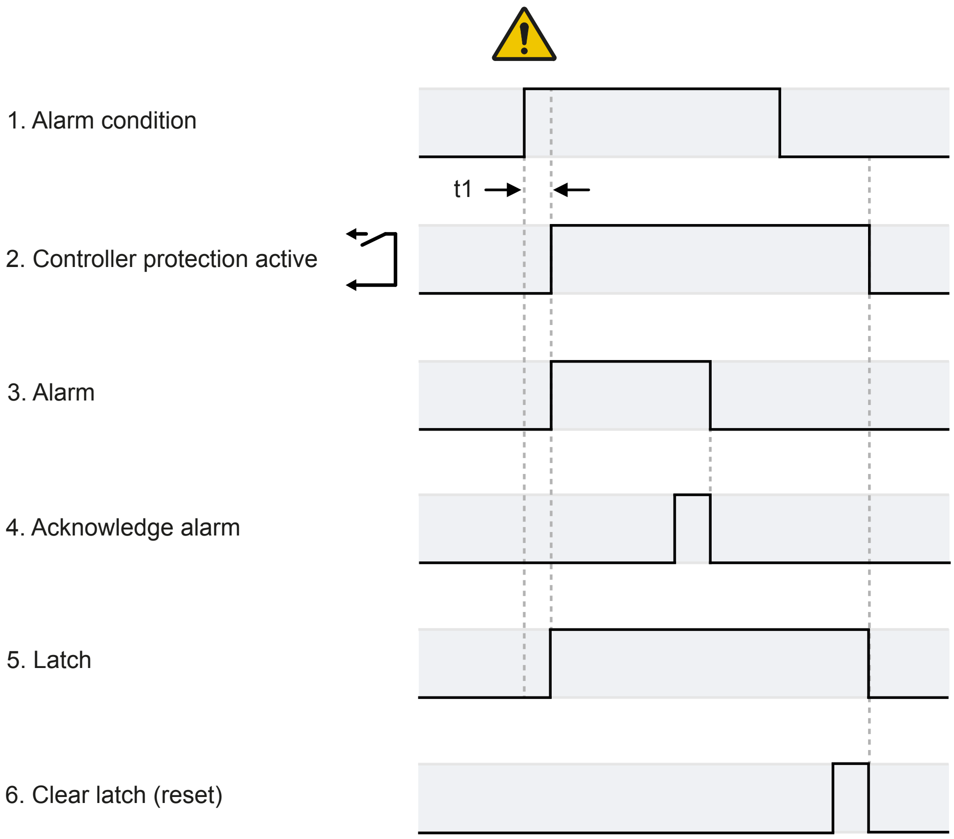
More information
See Inverse time over-current (ANSI 51) for the calculation method, the standard curves, and information about the definite time characteristic.

4.7.4 Lockout relay (ANSI 86)

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

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

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



1. **Alarm condition**
   - When an alarm condition occurs, an alarm-dependent delay timer activates.
   - If the alarm condition occurs for longer than the delay timer (t1), the protection activates.
2. **Controller protection active**
   - If a latch is enabled for the protection, the latch activates when the controller protection activates.
   - The protection will remain active until the latch is reset, even if the alarm condition clears.
3. **Alarm**
   - The alarm output, for example, an alarm horn, remains active until the alarm is acknowledged.
   - When the alarm is acknowledged, the protection remains active if a latch is enabled.
4. **Acknowledge alarm**
   - The alarm can be acknowledged while the alarm condition is still active, or when the alarm condition has cleared.
   - If a latch is active and the alarm is acknowledged after the alarm condition has cleared, the protection will remain active.
5. **Latch**

- If a latch is enabled for the alarm, the alarm latch will activate when the controller protection activates.
- While the latch is active, the alarm protection will also be active.

6. **Clear latch (reset)**
   - The alarm latch can only be removed once the alarm condition is no longer active and the alarm is acknowledged.
   - The protection will remain active until the latch is cleared.

For most alarms, a latch can be *Enabled* as a parameter under `[Alarm location] > [Alarm] > Latch`

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

`[Alarm]` is the alarm name.

NOTICE

Not powered controller opens digital outputs

If the controller is not powered, the controller opens the digital outputs.

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

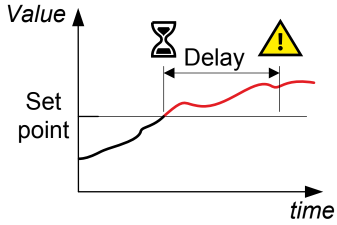
An external lockout relay with manual reset functionality can be connected to a digital output. The digital output activates if a specific alarm condition is triggered by the controller. For example: Under `Configure > Input/output`, a digital output can be configured to activate if *Any latched alarm* 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.

5.1 Non-essential loads

5.1.1 NEL # over-current

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



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

Up to three NEL trips are available.

`Non-essential load trip > Trip # * > Over-current`

These parameters are only visible if the non-essential loads are configured on the application single-line diagram.

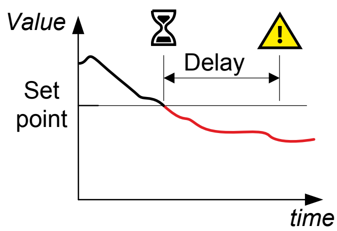
Parameter	Range
`Set point`	50 to 200 % of nominal current
`Delay`	0.1 s to 1 h

NOTE * # is 1 to 3.

The NEL function also trips NEL #. You cannot reconnect the NEL until the alarm is deactivated. The alarm action cannot be changed.

5.1.2 NEL # under-frequency

These NEL trips are for [B-side] under-frequency protection.



The trip response is based on the lowest frequency in the 3-phase voltage from the [B-side], as measured by the controller.

Up to three NEL trips are available.

`Non-essential load trip > Trip # * > Under-frequency`

These parameters are only visible if the non-essential loads are configured on the application single-line diagram.

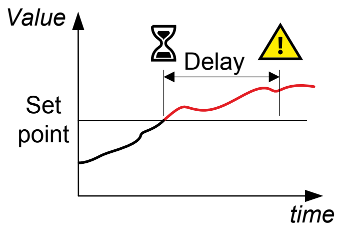
Parameter	Range
`Set point`	70 to 100 % of nominal frequency
`Delay`	0.1 s to 1 h

NOTE * # is 1 to 3.

The NEL function also trips NEL #. You cannot reconnect the NEL until the alarm is deactivated. The alarm action cannot be changed.

5.1.3 NEL # overload

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



The alarm response is based on the active power (all phases), supplied by the [A-side], as measured by the controller.

Up to six NEL trips are available. You can configure **Overload 1** for three overload trips, and **Overload 2** for three fast overload trips.

`Non-essential load trip > Trip # * > Overload [1 or 2]`

These parameters are only visible if the non-essential loads are configured on the application single-line diagram.

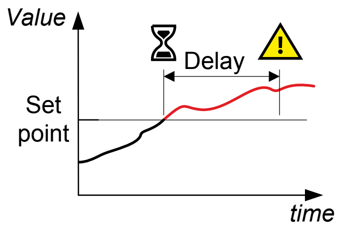
Parameter	Range
`Set point`	10 to 200 % of nominal power
`Delay`	0.1 s to 1 h

NOTE * # is 1 to 3.

The NEL function also trips NEL #. You cannot reconnect the NEL until the alarm is deactivated. The alarm action cannot be changed.

5.1.4 NEL # reactive overload

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



The alarm response is based on the reactive power (all phases), supplied by the [A-side], as measured by the controller.

Up to three NEL trips are available.

`Non-essential load trip > Trip # * > Reactive overload`

These parameters are only visible if the non-essential loads are configured on the application single-line diagram.

Parameter	Range
`Set point`	10 to 200 % of nominal reactive power
`Delay`	0.1 s to 1 h

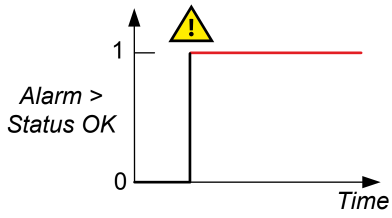
NOTE * # is 1 to 3.

The NEL function also trips NEL #. You cannot reconnect the NEL until the alarm is deactivated. The alarm action cannot be changed.

5.2 General system alarms

5.2.1 System not OK

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



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

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

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

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

`Local > Monitoring > System not OK`

This alarm is always enabled.

More information
See Alarm status digital outputs for how the *Status OK* alarm is configured.

5.2.2 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.

5.2.3 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.

5.2.4 System power management network error

Controller types: This alarm is present in all controllers.

This alarm communicates that the same *System power management* setting changed at the exact same time on two or more controllers. If the alarm activates, all the controllers where the setting changed at the same time are forced to switchboard control.

The alarm condition can be cleared by resetting the controllers on which the alarms occurred.

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

5.2.5 Power management rules network error

Controller types: This alarm is present in all controllers.

This alarm communicates that the same setting in *Power management rule 1 to 8* changed at the exact same time on two or more controllers. If the alarm activates, all the controllers where the setting changed at the same time are forced to switchboard control.

The alarm condition can be cleared by resetting the controllers on which the alarms occurred.

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

5.2.6 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.

5.2.7 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.

5.2.8 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.

5.2.9 Priority error

Controller types: This alarm is present in all controllers.

This alarm communicates that a number of controllers cannot synchronise the priorities in the network. If the alarm activates, the controller is forced to switchboard control.

This alarm activates when one of the following conditions are present:
- There is an error in the system.
- The wrong controller types are present in the system.

- The wrong controller IDs are present in the system.
- The single line application drawings for all the controllers in the system are not the same.

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

5.2.10 Controller ID not configured

This alarm communicates that the user has never configured the *Controller ID*. When this alarm is active, the controller is always under *Switchboard* control.

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

5.2.11 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.

5.2.12 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.

5.2.13 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.

5.2.14 Licence error

This alarm communicates that the controller's Application licence is not valid.

The alarm action is *Block* and the alarm is always enabled. The controller also activates the *System not OK* alarm. The alarm parameters are not visible.

It is unlikely that customers will see this alarm. If you do see this alarm take the following actions:

1. Restart the controller to see if the alarm clears.
2. If restarting does not help, check that the Application selector parameter is not configured to a licence not present or active on your controller.
   - You can use WebConfig and Licence manager to check the licences installed.
3. Contact DEIF for assistance.

5.2.15 Live power detected (emulation)

This alarm informs the operator that live power was detected during emulation.

The controller activates this alarm if `Test functions > Emulation > Emulation active` is *Enabled* and live power is detected on MIO2.1.

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

5.2.16 Emulation disabled (live power)

This alarm informs the operator that emulation has been disabled (because live power was detected during emulation).

The controller activates this alarm if `Test functions > Emulation > Emulation active` is *Enabled* and live power is detected on MIO2.1. The alarm changes the emulation parameter to *Not enabled* on all controllers in the system.

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

5.3 Custom input alarms

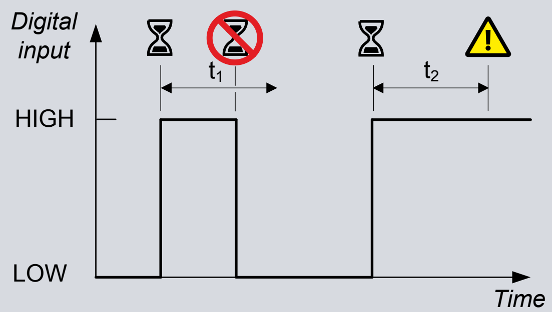
5.3.1 Digital input (DI) alarms

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.

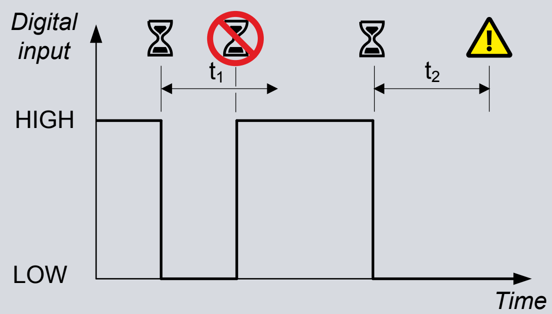
By default, a digital input (DI) is normally low, and the alarm is activated if the digital input is high for longer than the *Time delay*.



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	

5.3.2 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.

5.4 General hardware module alarms

5.4.1 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.

5.4.2 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.

5.4.3 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.

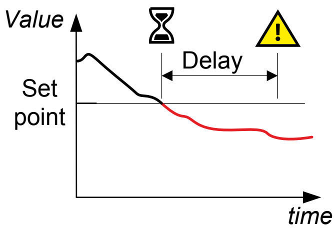
Contact DEIF product support for assistance and help identify the hardware issue. This may require a replacement hardware module.

5.5 Controller

5.5.1 PCM2.1 supply voltage low alarm

This default alarm is for power supply voltage protection.

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



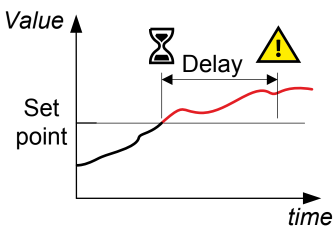
`Hardware > PCM2.1 > Low voltage alarm`

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

5.5.2 PCM2.1 supply voltage high alarm

This default alarm is for power supply voltage protection.

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



`Hardware > PCM2.1 > High voltage alarm`

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

5.5.3 Controller temperature too high

This is a built-in alarm for the controller internal temperature, as measured on the controller. The alarm is triggered when the controller internal temperature is higher than 80 °C (176 °F). The alarm action is *Warning*. The alarm parameters are not visible.

If the controller operates at internal temperatures higher than 80 °C (176 °F), the performance and the lifetime of the controller is significantly reduced.

5.5.4 Clock battery failure alarm

The *Clock battery failure* alarm is activated when the battery in controller needs to be replaced. The alarm action is *Warning*. The alarm parameters are not visible.

5.5.5 Network and communication alarms

5.5.5.1 Data loss from a controller

This alarm is for data loss detected from a controller. If there is more than 5% data loss for over 60 seconds, the alarm is activated. This can indicate a bad network or an overloaded controller.

The alarm is always enabled, and the alarm action is *Warning*. The alarm parameters are visible.

It is recommended to run network diagnostics of the network if this alarm is activated.

`System > Monitoring > Data loss from a controller`

Parameter	Range
`Set point`	0 to 100.0 %
`Delay`	0.0 s to 1 h

5.5.5.2 Data loss on DEIF network

This alarm is for data loss detected on the DEIF network. If there is more than 5% data loss for over 60 seconds, the alarm is activated. This can indicate a bad network or an overloaded controller.

The alarm is always enabled, and the alarm action is *Warning*. The alarm parameters are visible.

It is recommended to run network diagnostics of the network if this alarm is activated.

`System > Monitoring > Data loss on DEIF network`

Parameter	Range
`Set point`	0 to 100.0 %
`Delay`	0.0 s to 1 h

5.5.5.3 Unknown traffic on DEIF network

This alarm is for unknown traffic detected from on the DEIF network. If there is unknown data detected on the network, the alarm is activated without delay. This can indicate non-DEIF equipment sending data that may affect the DEIF communication.

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

It is recommended to check both cable wiring and remove any non-DEIF equipment from the network if this alarm is activated.

5.5.5.4 High traffic on DEIF network

The alarm is used to detect potential foreign noise or unwanted data traffic on the DEIF communication ring. If interference is suspected, the alarm can be enabled for diagnostic purposes. The alarm is disabled by default. When enabled, the alarm action is *Warning*, and the alarm parameters are visible.

NOTE This alarm is not intended to be active during normal operation.

Operational guidelines when the alarm is enabled

To reduce communication load on the PMS network when the alarm is active:

- Set all controllers to SWBD mode.
- 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

5.6 Measurement Input Output module MIO2.1

5.6.1 Relay # wire break alarms

These alarms are for MIO2.1 configured digital output channels. The wire break monitoring is only active when the digital output is open.

`Hardware > MIO2.1 > Relay # supervision` *

Parameter	Range
`Delay`	0.0 s to 1 h

NOTE * # is 9 to 16.

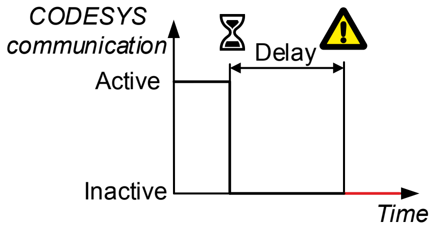
5.7 CODESYS alarms

5.7.1 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

5.7.2 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.

5.8 Event logging

5.8.1 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.

5.8.2 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.

5.9 Advanced blackout prevention

5.9.1 Advanced blackout prevention function

The Advanced Blackout Prevention (ABP) function stops a faulty genset from causing a blackout. ABP trips the BTB if a genset governor or AVR fails. ABP also trips the faulty genset's generator breaker. The ABP protections allow the system to run with the bus tie breaker (BTB) closed during critical operations. This saves fuel.

ABP is a set of protections, and therefore overrides the requirements of the power management system (PMS).

Requirements for ABP

If you want to use ABP, ensure that you have:

- At least one **GENSET** controller in each section.
- At least one **BUS TIE breaker** controller between the sections.
- ALL the ABP alarms enabled in the **BUS TIE breaker** controller(s).

Recommendations for ABP

Before closing the bus tie breaker during critical operation, DEIF recommends that you:

- Ensure that there is at least one connected genset in each section.
- Set the **GENSET** controller priorities so that the PMS does not disconnect and stop all of the gensets in one section.
- In each section, connect the `Power management > Available P in section [%]` analogue output to the heavy consumer(s), for example, the thruster. If ABP trips the BTB and the available power for a section is reduced, the heavy consumer can then reduce its load.
- Configure the timers for tripping the BTB and disconnecting the gensets so that the BTB trips first. The faulty genset's **GENSET** controller can then trip the generator breaker after the BTB trips.

Application single-line diagram

Configure ABP in the **BUS TIE breaker** controller(s) and the **GENSET** controllers.

If one or more ABP alarms are not enabled in a **BUS TIE breaker** controller, ABP is not enabled for that **BUS TIE breaker** controller.

For **BUS TIE breaker** controllers where all the ABP alarms are enabled, ABP trips the BTB based on the measurements from the connected **GENSET** controllers on the Busbar A section and Busbar B section.

ABP can be used with multiple **BUS TIE breaker** controllers and busbar sections. Each BUS TIE breaker controller with ABP enabled responds to the measurements from the closest connected **GENSET** controllers on its Busbar A section and Busbar B section.

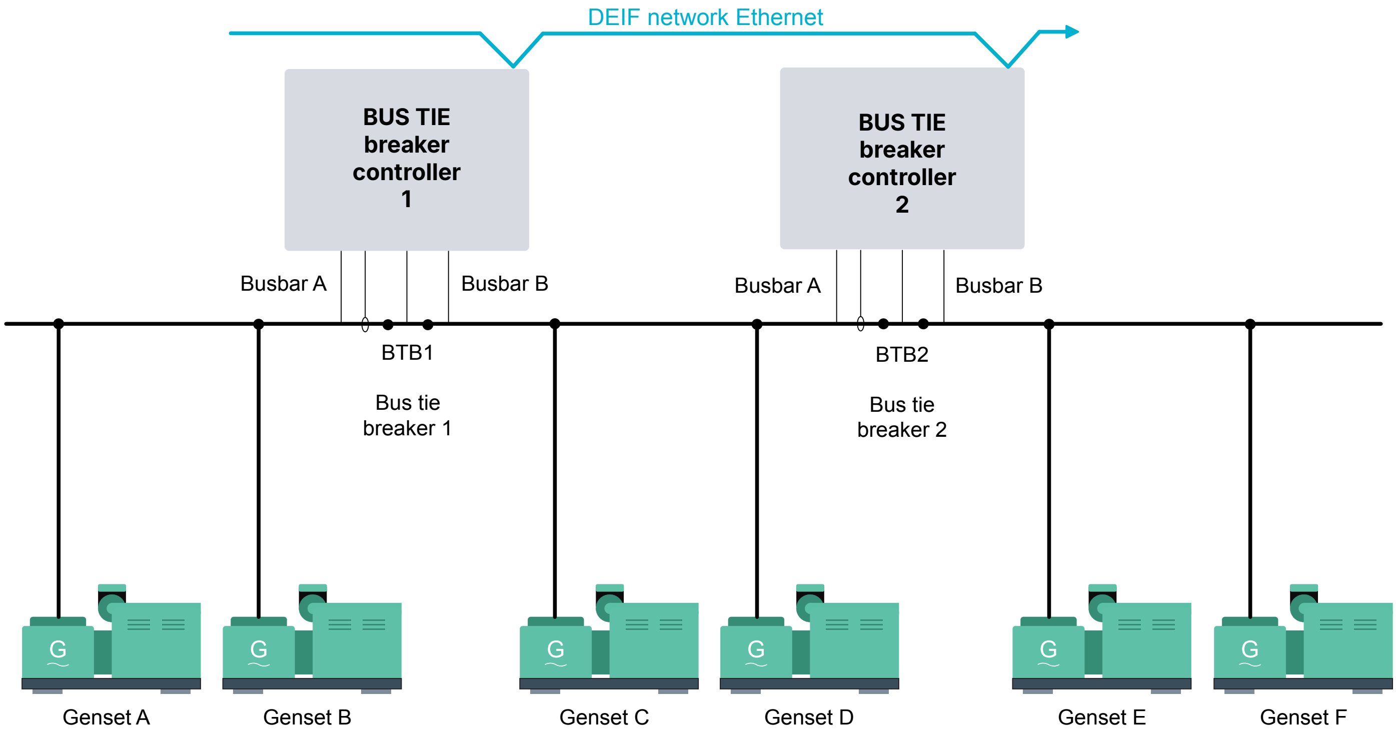
When a BTB is opened or closed, the busbar sections change.

The position of an externally controlled bus tie breaker affects the busbar sections. However, ABP cannot be configured for an externally controlled bus tie breaker.

More information
See Busbar sections for more information.

ABP is not designed for connected shaft generators and/or shore connections, and ignores their measurements.

Example of ABP with two bus tie breakers



If all the ABP protections are enabled in both **BUS TIE breaker** controller 1 and 2:

- If the governor/AVR fails on Genset A:
  - One of the ABP protections trips bus tie breaker 1, to protect the section with Gensets C, D, E and F.
  - Bus tie breaker 2 does not trip, because there is a closer bus tie breaker with ABP enabled (that is, bus tie breaker 1).
- If the governor/AVR fails on Genset C:
  - One of the ABP protections trips bus tie breaker 1, to protect the section with Gensets A and B.
  - One of the ABP protections trips bus tie breaker 2, to protect the section with Gensets E and F.

If all the ABP protections are only enabled on **BUS TIE breaker** controller 2:

- If the governor/AVR fails on Genset A:
  - One of the ABP protections trips bus tie breaker 2, to protect the section with Gensets E and F.
- If the governor/AVR fails on Genset C:
  - One of the ABP protections trips bus tie breaker 2, to protect the section with Gensets E and F.

If none of the ABP protections are enabled in the **BUS TIE breaker** controllers, but all of the ABP protections are enabled in the **GENSET** controllers:

- If the governor/AVR fails on Genset A:
  - One of the ABP protections can trip the Genset A generator breaker.
  - One of the AC protections can trip the Genset A generator breaker.
  - One of the AC protections can trip Genset B, C, D, E or F's generator breaker.

Parameter in the GENSET controllers

`Local power management > Advanced blackout prevention`

Parameter	Range	Comment
`Delay after load share changes`	0 s to 1 h	After any of the following changes in the busbar section, ABP is disabled for the configured delay: • A genset connects. • A genset disconnects. The timer starts when de-loading starts.

Parameter	Range	Comment
		• A BTB closes. • A BTB opens. The timer starts when de-loading starts. • Asymmetric load sharing is activated/deactivated in a **GENSET** controller. • An asymmetric load sharing parameter is changed in a **GENSET** controller. Use this delay to stop ABP from tripping the generator breaker due to normal load sharing changes. This delay timer must run out before the delay configured in an ABP protection can start. Note that a bus tie breaker trip caused by an ABP protection does NOT reset the ABP timer for the genset.

The **GENSET** controllers also include the following ABP alarms:

- P load sharing failure (low frequency) on DG
- P load sharing failure (high frequency) on DG
- Q load sharing failure (low voltage) on DG
- Q load sharing failure (high voltage) on DG

Parameter in the BUS TIE breaker controller

`Local power management > Advanced blackout prevention`

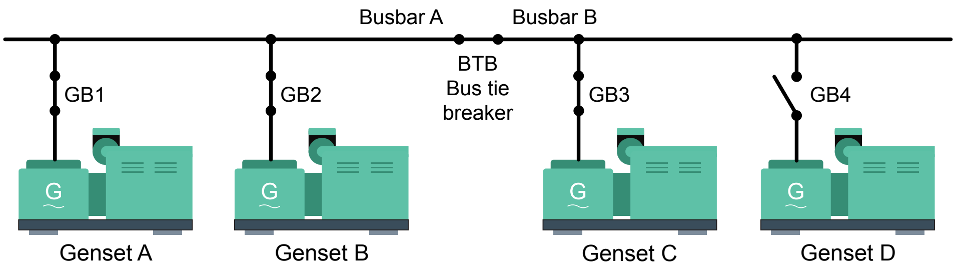
Parameter	Range	Comment
`Delay after load share changes`	0 s to 1 h	The conditions for this delay are the same as for the **GENSET** controllers. Use this delay to stop ABP from tripping the BTB due to normal load sharing changes. This delay timer must run out before the delay configured in an ABP protection can start.

The **BUS TIE breaker** controllers also include the following ABP alarms:

- P load sharing failure (low frequency) on a DG
- P load sharing failure (high frequency) on a DG
- Q load sharing failure (low voltage) on a DG
- Q load sharing failure (high voltage) on a DG
- Overload on a DG
- Reverse power on a DG
- Reactive power export on a DG
- Reactive power import on a DG
- Over-current on a DG

Examples of ABP

These examples are based on the following single-line drawing, and the default ABP parameters. All the ABP alarms are enabled.



For these examples:

- The system is running with the bus tie breaker closed.

- There are no recent load share changes, and so the "Delay after load share changes" timers are not relevant.
- Gensets A, B and C are connected, and have equal load sharing.

Genset A governor set point failure example

The *GOV increase* relay that regulates Genset A is stuck in a closed position. This drives up the load on Genset A, while the other gensets have less load. The busbar section frequency starts to increase.

One of the following ABP protections trips the BTB:
- P load sharing failure (high frequency) on a DG
- Overload on a DG
- Over-current on a DG

Genset A continues to draw load from Genset B. This ABP protection can trip the Genset A generator breaker:
- P load sharing failure (high frequency) on DG

Alternatively, one of the following AC protections can trip the Genset A generator breaker:
- Overload
- Over-current
- Directional over-current
- Fast over-current
- Inverse time over-current

The system now runs with a split busbar, and the generator with the faulty governor (Genset A) disconnected.

Genset C AVR excitation failure example

Genset C's AVR fails, and does not excite the generator as needed. Genset C takes less of the reactive load. The busbar section voltage starts to decrease.

One of the following protections trips the BTB:
- Q load sharing failure (low voltage) on DG
- Reactive power import on a DG

Genset C tries to supply the required reactive load for the busbar section, but cannot, and the voltage is low. The *Busbar under-voltage* alarm trips the generator breaker, and activates a precautionary genset start of Genset D.

The generator breaker trip causes a blackout on the busbar section. When Genset D is started, the power management system connects Genset D in order to recover from the blackout.

5.9.2 Calculating the load sharing error

For active power, the load sharing error is based on the difference between the measured power and the internal controller set point, as a percentage of the genset nominal power.

Load sharing error = (Measured power - Internal set point power) / (Nominal power)

Load sharing error example

Two gensets are connected to the busbar. Genset A has a nominal power of 1000 kW, while Genset B has a nominal power of 500 kW. The gensets are configured to each take an equal percentage (based on the genset nominal power) of the load.

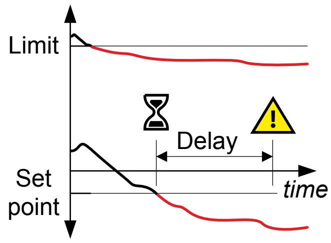
The total load is 900 kW. The internal controller set point Genset A is therefore 600 kW, and the set point for Genset B is 300 kW, that is, 60 % of nominal power.

	Genset A supplies 500 kW, and Genset B supplies 400 kW. For Genset A, the load sharing error is (500 kW - 600 kW) / (1 000 kW) = -0.1 = -10 % For Genset B, the load sharing error is (400 kW - 300 kW) / (500 kW) = 0.2 = 20 %

5.9.3 P load sharing failure (low frequency)

This advanced blackout prevention alarm can be activated if there is both a low frequency and a negative P load sharing error at a **GENSET** controller.

Controller types: This alarm is present in **GENSET**, **HYBRID**, and **BUS TIE breaker** controllers.



GENSET or HYBRID controllers

`Local power management > Advanced blackout prevention > P load sharing failure (low frequency)`

Parameter	Range
`Low frequency limit`	90 to 110 %
`Set point`	-100 to -0.1 %
`Delay`	0 s to 1 h

BUS TIE breaker controller

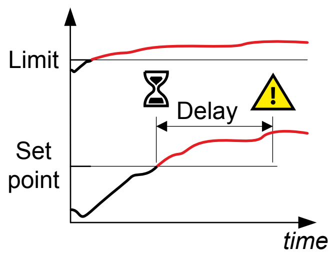
`Local power management > Advanced blackout prevention > P load sharing failure (low frequency)`

Parameter	Range
`Low frequency limit`	90 to 110 %
`Set point`	-100 to -0.1 %
`Delay`	0 s to 1 h

5.9.4 P load sharing failure (high frequency)

This advanced blackout prevention alarm can be activated if there is both a high frequency and a positive P load sharing error at the **GENSET** controller.

Controller types: This alarm is present in **GENSET**, **HYBRID**, and **BUS TIE breaker** controllers.



GENSET or HYBRID controllers

`Local power management > Advanced blackout prevention > P load sharing failure (high frequency)`

Parameter	Range
`High frequency limit`	90 to 110 %
`Set point`	0.1 to 100 %
`Delay`	0 s to 1 h

BUS TIE breaker controller

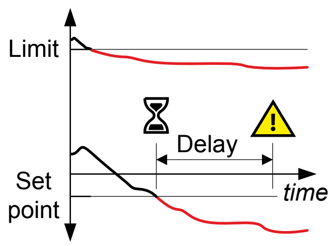
`Local power management > Advanced blackout prevention > P load sharing failure (high frequency)`

Parameter	Range
`High frequency limit`	90 to 110 %
`Set point`	0.1 to 100 %
`Delay`	0 s to 1 h

5.9.5 Q load sharing failure (low voltage)

This advanced blackout prevention alarm can be activated if there is both a low voltage and a negative Q load sharing error at the **GENSET** controller.

Controller types: This alarm is present in **GENSET**, **HYBRID**, and **BUS TIE breaker** controllers.



GENSET or HYBRID controllers

`Local power management > Advanced blackout prevention > Q load sharing failure (low voltage)`

Parameter	Range
`Low voltage limit`	90 to 110 %
`Set point`	-100 to -0.1 %
`Delay`	0 s to 1 h

BUS TIE breaker controller

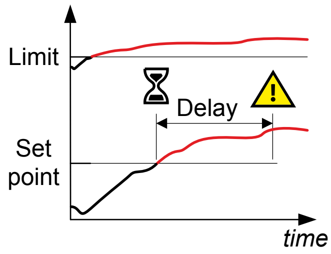
`Local power management > Advanced blackout prevention > Q load sharing failure (low voltage)`

Parameter	Range
`Low voltage limit`	90 to 110 %
`Set point`	-100 to -0.1 %
`Delay`	0 s to 1 h

5.9.6 Q load sharing failure (high voltage)

This advanced blackout prevention alarm can be activated if there is both a high voltage and a positive Q load sharing error at the **GENSET** controller.

Controller types: This alarm is present in **GENSET**, **HYBRID**, and **BUS TIE breaker** controllers.



GENSET or HYBRID controllers

`Local power management > Advanced blackout prevention > Q load sharing failure (high voltage)`

Parameter	Range
`High voltage limit`	90 to 110 %
`Set point`	0.1 to 100 %
`Delay`	0 s to 1 h

BUS TIE breaker controller

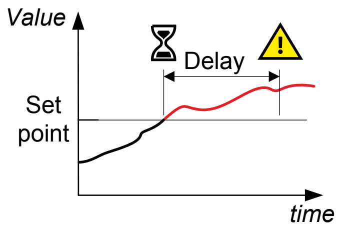
`Local power management > Advanced blackout prevention > Q load sharing failure (high voltage)`

Parameter	Range
`High voltage limit`	90 to 110 %
`Set point`	0.1 to 100 %
`Delay`	0 s to 1 h

5.9.7 Overload on DG

This advanced blackout prevention alarm can be activated if the load on any genset in the section exceeds the alarm set point.

Controller types: This alarm is present in **BUS TIE breaker** controllers.



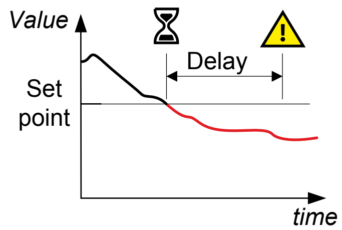
`Local power management > Advanced blackout prevention > Overload on a DG`

Parameter	Range
`Set point`	70 to 250 %
`Delay`	0 s to 1 h

5.9.8 Reverse power on DG

This advanced blackout prevention alarm can be activated if the reverse power to any genset in the section exceeds the alarm set point.

Controller types: This alarm is present in **BUS TIE breaker** controllers.



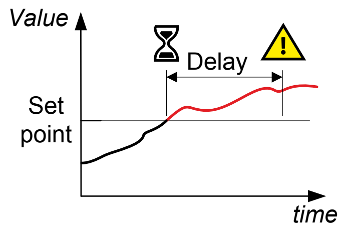
`Local power management > Advanced blackout prevention > Reverse power on a DG`

Parameter	Range
`Set point`	-25 to -0.1 %
`Delay`	0 s to 1 h

5.9.9 Reactive power export on DG

This advanced blackout prevention alarm can be activated if the reactive power export from any genset in the section exceeds the alarm set point.

Controller types: This alarm is present in **BUS TIE breaker** controllers.



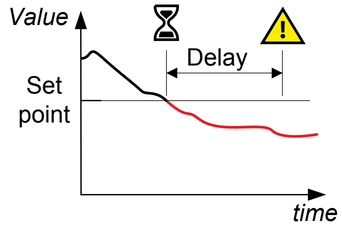
`Local power management > Advanced blackout prevention > Reactive power export on a DG`

Parameter	Range
`Set point`	0.1 to 250 %
`Delay`	0 s to 1 h

5.9.10 Reactive power import on DG

This advanced blackout prevention alarm can be activated if the reactive power import to any genset in the section exceeds the alarm set point.

Controller types: This alarm is present in **BUS TIE breaker** controllers.



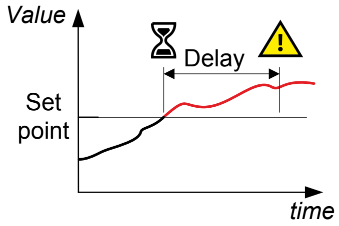
`Local power management > Advanced blackout prevention > Reactive power import on a DG`

Parameter	Range
`Set point`	-120 to -0.1 %
`Delay`	0 s to 1 h

5.9.11 Over-current on DG

This advanced blackout prevention alarm can be activated if the current from any genset in the section exceeds the alarm set point.

Controller types: This alarm is present in **BUS TIE breaker** controllers.



`Local power management > Advanced blackout prevention > Over-current on a DG`

Parameter	Range
`Set point`	70 to 250 %
`Delay`	0 s to 1 h

6. Breakers, synchronisation and de-loading

6.1 About

6.1.1 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.

Synchronisation is one of the controller's key functions. Power management synchronises the power sources by using the appropriate **GENSET** controller(s) to adjust the speed of the relevant genset(s).

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 Power management for information on the automatic actions to optimise the power supply.

See **each controller type** for information on each controller's breaker sequences.

6.1.2 Regulation required for synchronisation

For synchronisation, the controller must be able to adjust the genset frequency (by regulating the genset governor) and voltage (by regulating the genset AVR).

The power management can only regulate the voltage and frequency by using the **GENSET** controllers. The power management cannot regulate the voltage or frequency of the shaft generator, the shore connection, or (in some cases) the busbar. Where the power management must synchronise to equipment that is not regulated, the power management regulates the gensets to synchronise to the unregulated equipment.

It does not matter whether the energy sources are already connected to the busbar. The power management only regulates the gensets to synchronise.

The power management regulates the gensets to synchronise the power sources. The controller measures the conditions across its breaker(s). When the synchronisation is within the configured limits, the controller activates the `Breakers > [Breaker] > Controls > Close` output.

EMERGENCY genset controller

Most of the controller types control only one breaker. However, the **EMERGENCY genset** controller controls two breakers: the emergency genset breaker and the tie breaker to the emergency busbar. You can configure different synchronisation settings for each breaker.

6.1.3 Regulation required for de-loading

If possible, the breakers are de-loaded before they are opened, to reduce wear. A breaker is de-loaded by reducing the flow of power through the breaker to the configured level. In AUTO and MANUAL mode, the power management de-loads a breaker by regulating and/or starting the appropriate genset(s) to take the load off that breaker.

The power management does not normally disconnect loads to de-load breakers. A load is only disconnected if the conditions for a non-essential load (NEL) trip are met.

Regulation

For de-loading, the controller must be able to adjust the genset frequency (by regulating the genset governor).

De-loading uses the same principles as synchronisation. For synchronisation, the power management adjusts the genset speed(s) so that the frequencies on either side of the breaker match. For de-loading, the power management adjusts the genset speed(s) to minimise the flow of power through the breaker.

The power management can only regulate the voltage and frequency of the gensets, by using the **GENSET** controllers. The power management cannot regulate the voltage or frequency of the shaft generator, the shore connection, or (in some cases) the busbar. Where the power management must de-load assets that are not regulated, the power management therefore regulates the gensets to de-load to the unregulated assets.

Genset breaker de-loading in MANUAL mode

The controller only responds to operator and external breaker commands in MANUAL mode.

If the operator pushes the push-button **Open breaker** OPEN on the display unit of a **GENSET** controller in MANUAL mode, the power management checks whether opening the breaker would cause a blackout. If it would, the power management will not allow the breaker to open.

PMS-controlled stop

If a running genset has a *PMS-controlled stop* alarm action, the power management will start the next genset, synchronise it with the busbar, and close its breaker. The power management will then de-load and open the genset breaker, and stop the genset that had the *PMS-controlled stop* alarm action.

NOTE *PMS-controlled stop* does **not** ensure that the genset stops. *PMS-controlled stop* tries to stop the genset, but will not stop a genset that cannot be de-loaded.

6.2 Synchronisation in each controller mode

6.2.1 Synchronisation in AUTO mode

In AUTO mode, the power management automatically does the regulation required for synchronisation. When the power sources are synchronised, the controller automatically closes the breaker.

6.2.2 Synchronisation in MANUAL mode

In MANUAL mode, the controller must receive an external signal to synchronise and close the breaker. The power management then automatically regulates the gensets as required for synchronisation. When the power sources are synchronised, the controller automatically activates the output to close the breaker.

Synchronisation in MANUAL mode example

The operator presses **Close breaker** CLOSE on the display.

6.2.3 Synchronisation in switchboard control

If the controller is in switchboard control, the synchronisation must be done manually.

To get in switchboard control, the controller must receive an external signal. This is normally done using a switch on the switchboard that is connected to one of the controller's digital inputs. That digital input is then assigned the `Local > Mode > Switchboard control` function.

Switchboard control equipment

The following table lists the third party equipment (hardware not generally supplied by DEIF) that may be used for switchboard control. The switchboard buttons are connected directly to the genset or breaker, and are not connected to the controller.

Table 6.1 Example typical third party equipment

Name	Type	Details
Switchboard control selector	ON/OFF switch	The operator uses this to switch the controller to switchboard control.
GOV up *	Push-button	The operator sends a signal directly to the governor to increase the genset speed.
GOV down *	Push-button	The operator sends a signal directly to the governor to decrease the genset speed.
AVR up *	Push-button	The operator sends a signal directly to the AVR to increase the genset excitation.
AVR down *	Push-button	The operator sends a signal directly to the AVR to decrease the genset excitation.
Breaker close	Push-button	The operator sends a signal directly to the breaker to close the breaker.
Breaker open	Push-button	The operator sends a signal directly to the breaker to open the breaker.
Synchroscope	For example, DEIF's CSQ-3	The synchroscope shows the synchronisation across the breaker. The sync check relay in the synchroscope prevents the breaker from closing when it is not synchronised.

NOTE * These only apply to gensets. The AVR inputs are optional.

For stable operation during manual regulation under switchboard control, the governor and AVR must include the required amount of droop.

Manual regulation during switchboard control 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 switchboard control, when the operator presses the buttons, the controller adjusts the governor and/or AVR output.

More information
See Control and modes for more information.

Synchronising during switchboard control

During switchboard control, if the operator wants to synchronise and close a breaker, the operator must use the switchboard to operate the system. The operator manually adjusts the speed of the relevant equipment until the frequencies are almost the same. The operator then finely adjusts the speed until the power sources are in phase. The phase synchronisation of the power sources must be shown by a switchboard instrument, for example, a synchroscope. When the phases are within the synchronisation limits, the operator closes the breaker.

Protections during switchboard control

NOTICE

Operator errors during switchboard control

The controller protections will not protect the system against all possible operator errors during switchboard control.

The controller protections are active during switchboard control, but there are no proactive checks for the operator inputs. This means that while the controller is under switchboard control, it is possible for an operator to use switchboard operations to potentially damage or destroy equipment.

Operator error during switchboard control

In a slow system, an operator accidentally increases the generator speed above the recommended speed by repeatedly pressing the **GOV up** switchboard push-button.

If the speed increases past the set point for the *Overspeed 1* alarm, the timer for the alarm starts. If the generator speed stays above the set point for longer than the allowed time, the *Overspeed 1* alarm activates and the generator shuts down.

If the speed increases past the set point for the *Overspeed 2* alarm, the alarm activates and the generator shuts down.

In the example the damage to the generator was minimised due to the active protections in the controller. However a more dangerous situation could occur if a breaker is forced to close when the busbars are not synchronised.

For this reason, a well-designed switchboard (including a sync check relay) is essential for operating the system during switchboard control.

6.3 Configuring breakers

6.3.1 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.
`Breakers > [Breaker] > Command > Block [*B] close`	Digital input	Continuous	The controller does not allow the breaker to close while this input is active.

6.3.2 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.

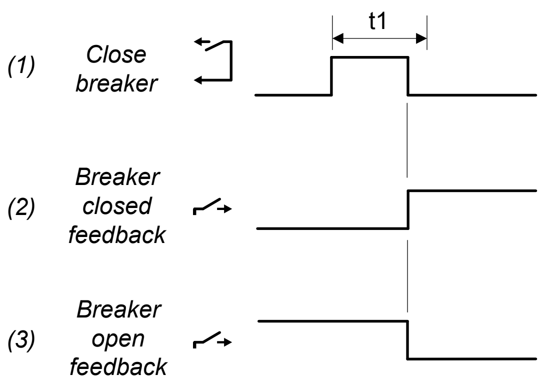
Parameters

`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 6.2 Closing a pulse breaker

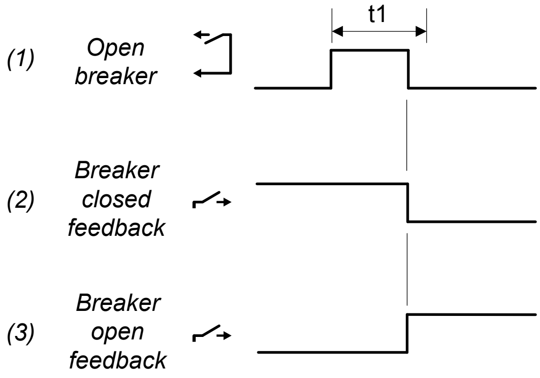


t1 Pulse on (`Parameters > Breakers > [Breaker] > Pulse time ON`)

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 6.3 Opening a pulse breaker

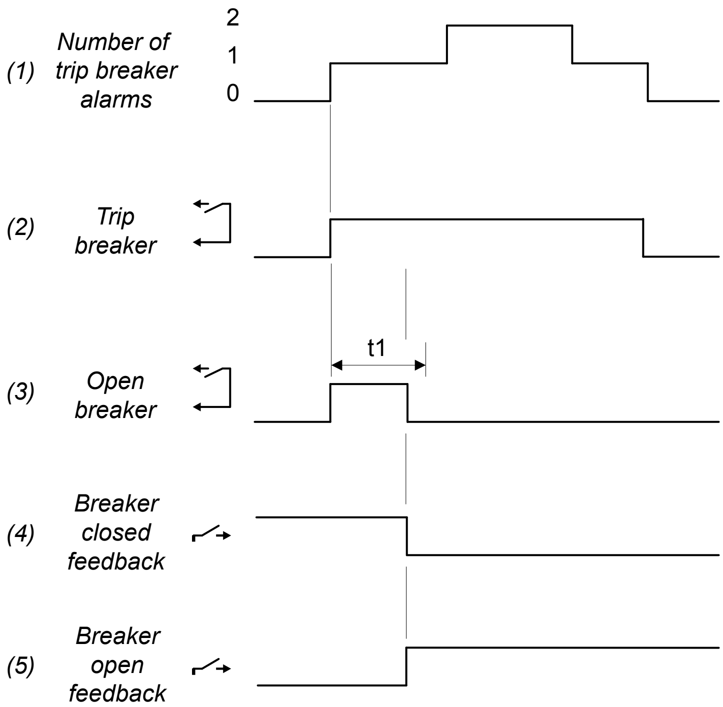


t1 Pulse on (`Parameters > Breakers > [Breaker] > Pulse time ON`)

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 6.4 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.

6.3.3 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.
`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

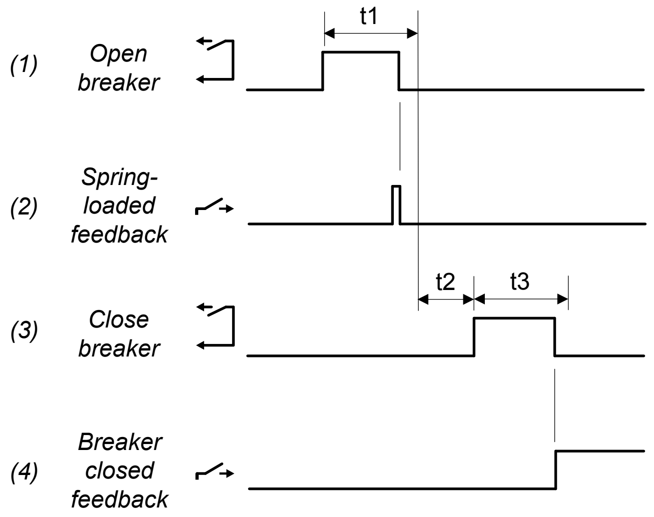
`Breakers > [Breaker] configuration > Configuration`

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.

Parameter	Range	Notes
`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 6.5 Closing a compact breaker

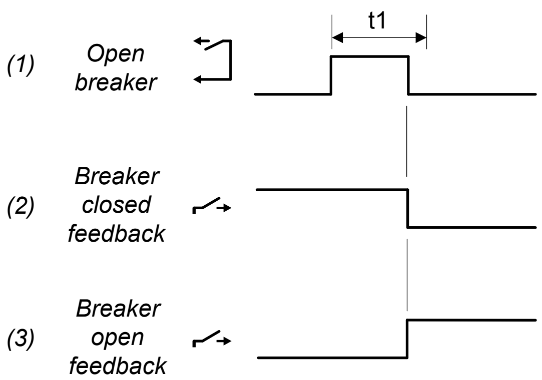


t1	Spring load time (`Breakers > [Breaker] configuration > Spring load time`)
t2	Wait after spring-loading (`Breakers > [Breaker] > Pulse time OFF`)
t3	Pulse on (`Breakers > [Breaker] > Pulse time ON`)

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 6.6 Opening a compact breaker

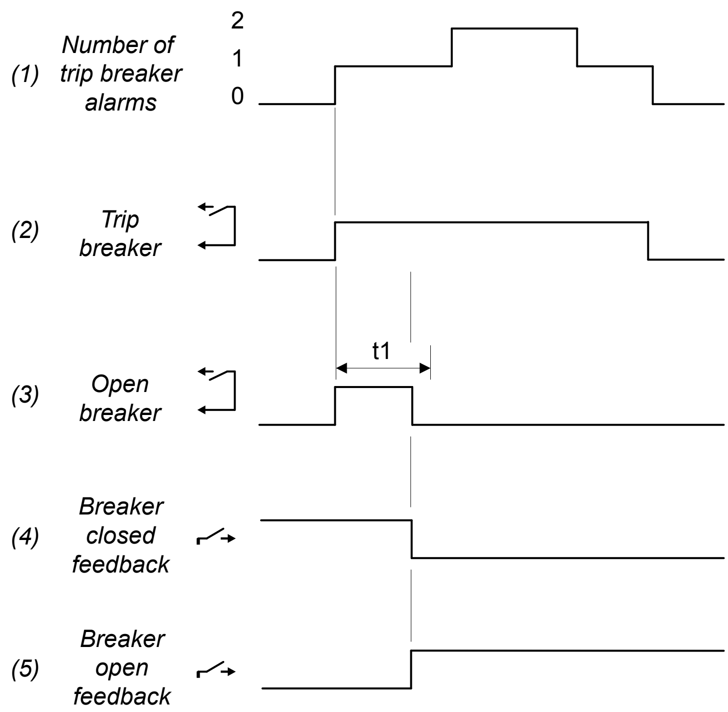


t1	Pulse on (`Breakers > [Breaker] > Pulse time ON`)

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 6.7 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.

6.3.4 Continuous breaker

NOTICE

Not suitable for marine use

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

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.

Function	I/O	Type	Details
`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. *
`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.

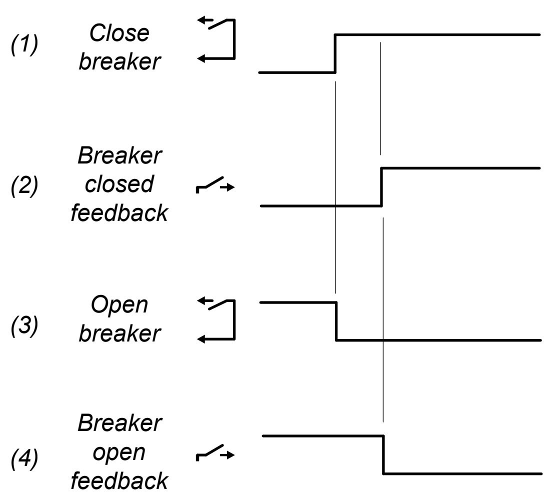
Parameters

`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. Due to class requirements, this breaker type is not suitable for marine use. This is because the ship would lose power if the controller failed.
`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].

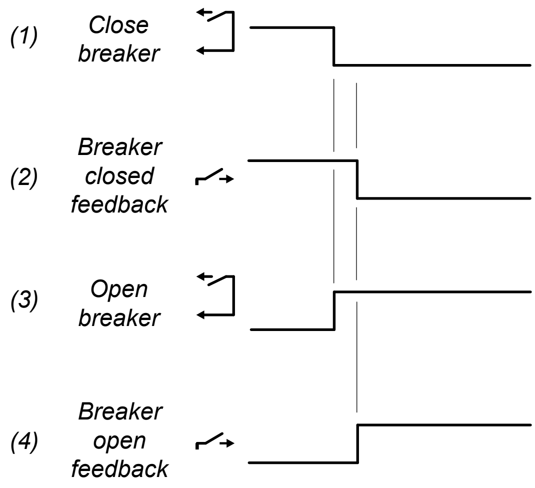
Sequence diagrams

Table 6.8 Closing a continuous breaker



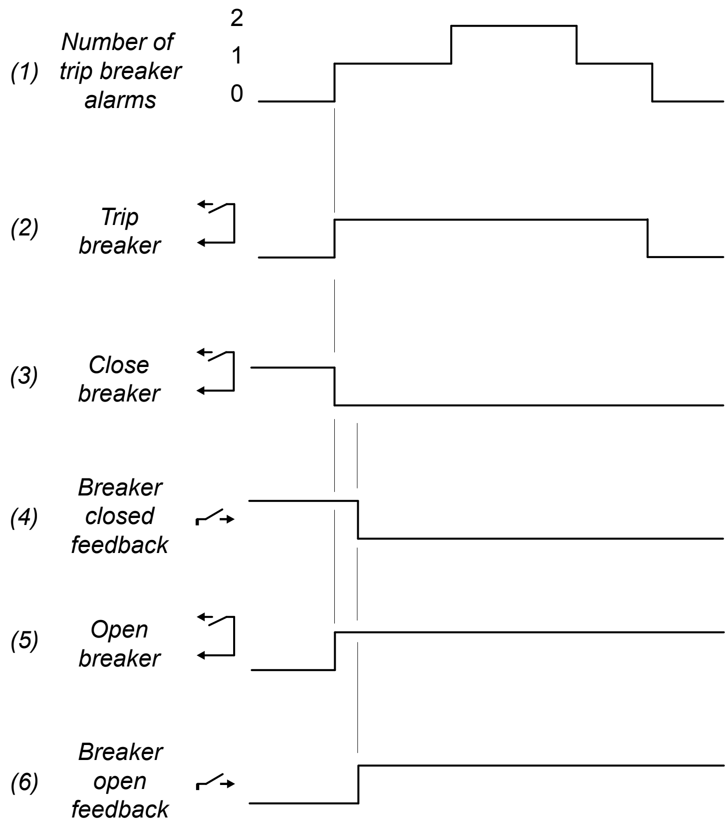
1. **Close breaker:** `Breakers > [Breaker] > Controls > [*B] close` (digital output). The controller activates this output to close the breaker.
2. **Breaker closed feedback:** `Breakers > [Breaker] > Feedback > [*B] closed` (digital input). This input is activated when the breaker is closed.
3. **Open 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 6.9 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 6.10 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.

6.3.5 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.

6.3.6 External breaker

More information
See Externally controlled breakers for how the external breaker works.

6.3.7 Short circuit, and short circuit close attempts

You can connect the breaker's short circuit detection to the controller.

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 .

Short circuit close attempt parameters

In exceptional circumstances, where a short circuit input is configured, this function allows a breaker to attempt to close during a blackout even though another breaker in the system was tripped by a short circuit. This may **only be done in systems that are designed for this type of operation**. If you choose to attempt to close the breaker even though a short circuit input was activated, **this is your own responsibility**.

DANGER!

Breaker close after short circuit

Closing a breaker after a short circuit is extremely dangerous.

`Power management rules > Configuration # > Blackout > Short circuit close attempts` *

The *Short circuit close attempts* function is only active when there is a blackout.

Parameter	Range	Notes
`Set point`	0 to 1	**0 close attempts**: The power management will not close a breaker to connect to a system where a short circuit was detected. The breaker must first be reset and the *[Breaker] short circuit* alarm deactivated and acknowledged. **1 close attempt**: **In exceptional circumstances**, you may change this parameter to allow a breaker to attempt to close once, even though a short circuit was detected by another breaker.

NOTE * # is 1 to 8.

6.3.8 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

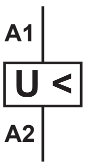
A digital output with a breaker state may be wired to a switchboard light, to help the operator.

For example, for a **SHAFT generator** controller, a digital output may have the `Shaft generator breaker > State > SGB is de-loading` function. A switchboard light is lit when the controller system is de-loading the shaft generator breaker.

6.3.9 Breaker under-voltage coil configuration

You can configure a breaker to use an under-voltage coil. The controller can then know that the breaker is open when there is a low voltage. This can be used in cases where there is no redundant breaker feedback connected and a blackout occurs.

Use PICUS to configure the under-voltage coil setting on the breaker.



More information
See the PICUS manual for how to configure the breaker for an under-voltage coil.

6.4 Synchronisation functions

6.4.1 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	*Dynamic* 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.

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.

For a **SHAFT generator** controller, the synchronisation settings for power take home (PTH) can be configured separately. These are under *Synchronisation setting (PTH)*.

More information
See Power take home (PTH) for how to configure these settings.

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:

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

Slip frequency bad example

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

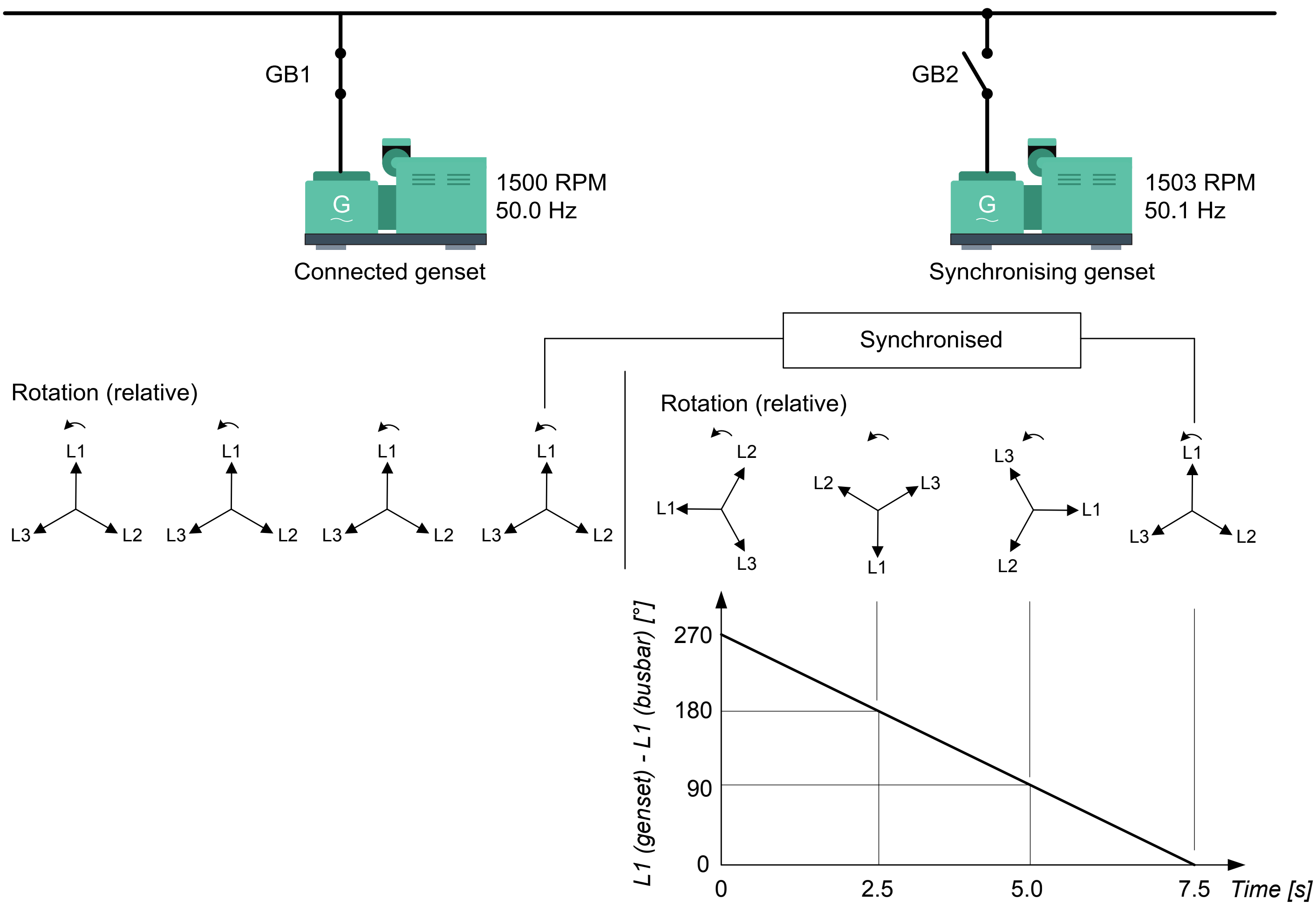
The slip frequency is **0.0 Hz**. There is a risk that there will be a long synchronisation time, because there is no change in the phase difference.

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.

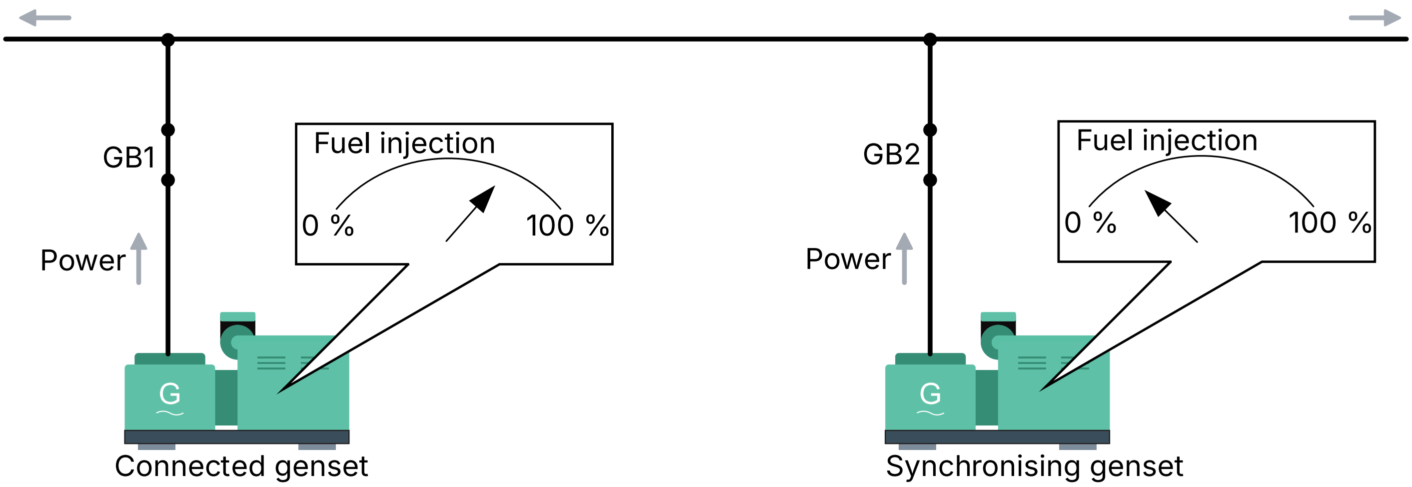
Load distribution after synchronisation

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.

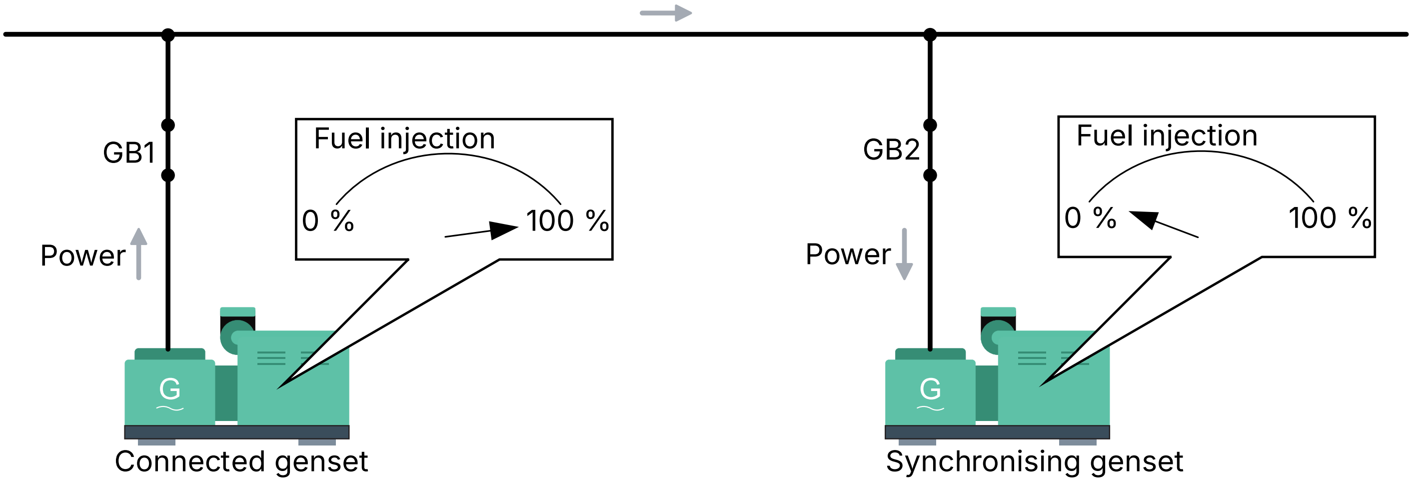
The following example shows that at a given *positive* slip frequency, the synchronising genset will *export* power to the load after the breaker closes.

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:

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

In this example, the controller activates the close breaker output 9 degrees before the phases are aligned.

6.4.2 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.

Parameters

`Breakers > [Breaker] configuration > Synchronisation setting`

Name	Range	Notes
`Sync. type`	• Dynamic • Static	*Static* 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.

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.

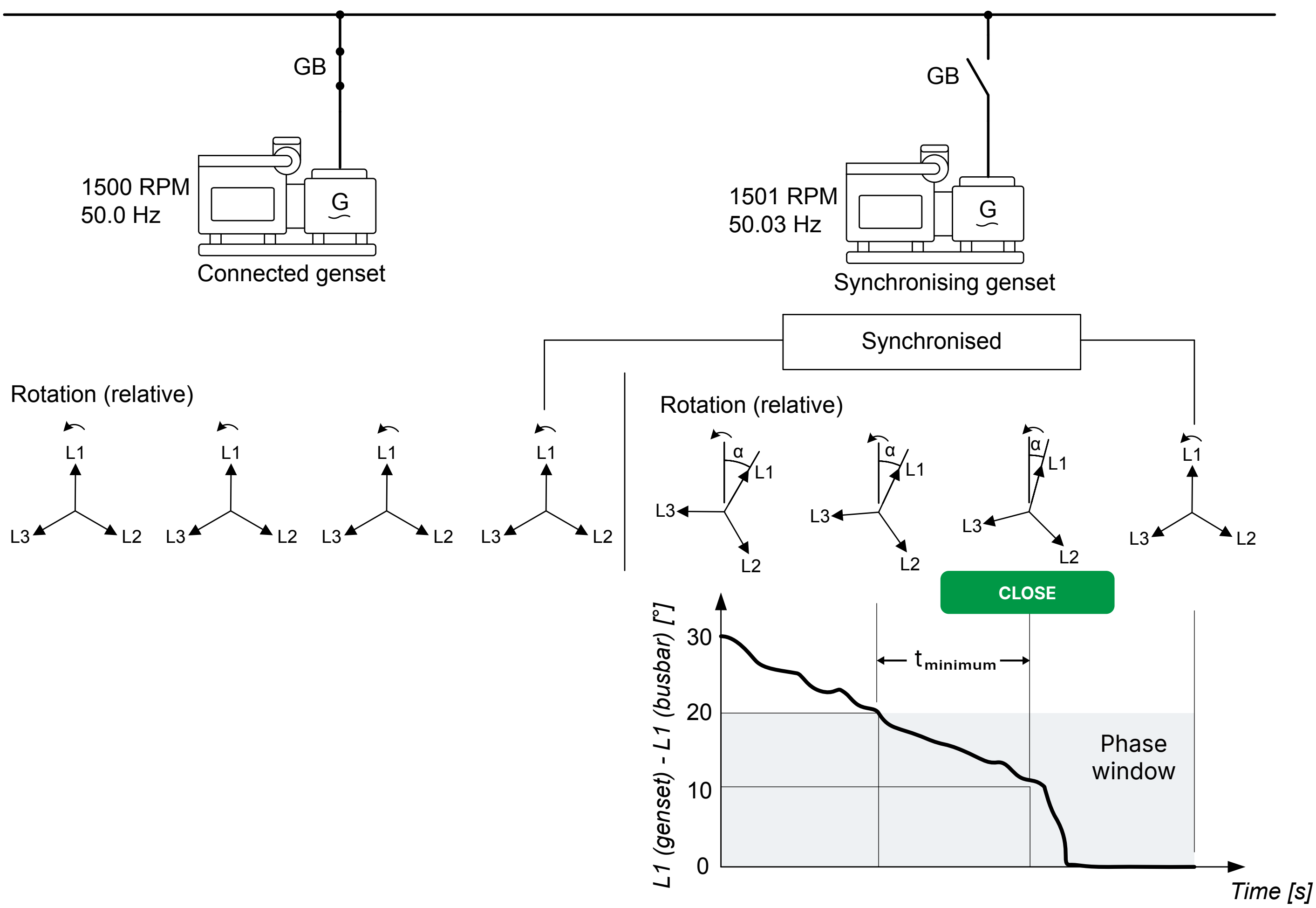
For a **SHAFT generator** controller, the synchronisation settings for power take home (PTH) can be configured separately. These are under *Synchronisation setting (PTH)*.

More information
See Power take home (PTH) for how to configure these settings.

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 6.1 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.

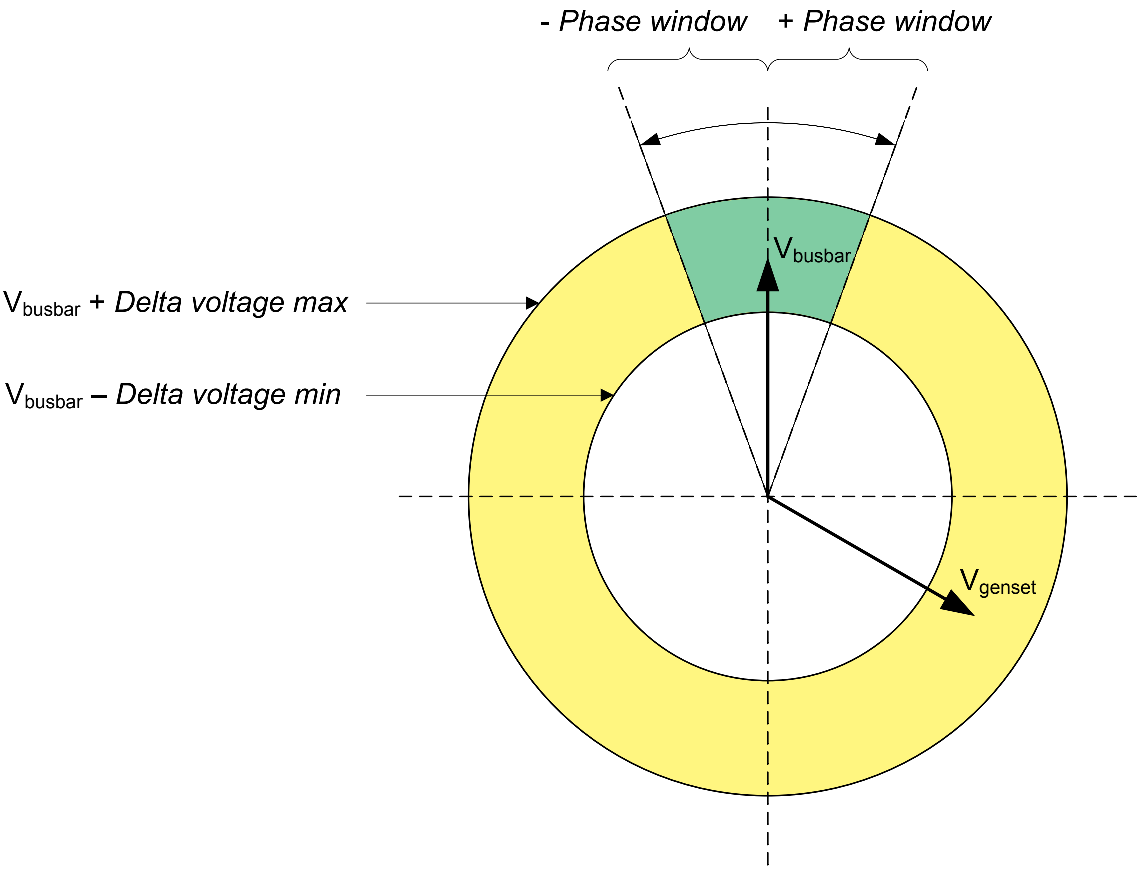
When the genset-busbar difference is 200 mHz, the phase synchronisation function takes over. The phase regulator for synchronisation aims to minimise the angle between the synchronising genset and the busbar.

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 6.2 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.

6.4.3 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.

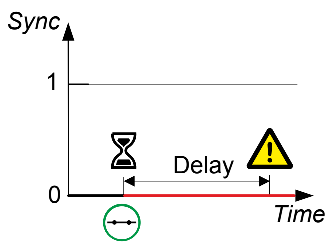
Parameter	Range	Notes
`Kp`	0.0 to 1000.0	The gain for the regulator.

6.5 Synchronisation and breaker alarms

6.5.1 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`

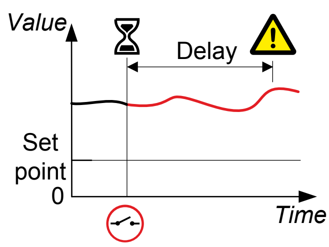
Parameter	Range
`Delay`	30.0 s to 5 min

6.5.2 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.

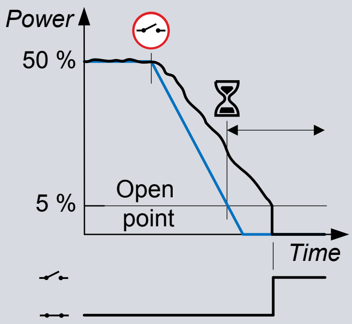
The *Open point (de-loading)* is configured under **Breakers > [Breaker] configuration > Configuration**.



Parameter	Range
Delay	0.0 s to 1 h

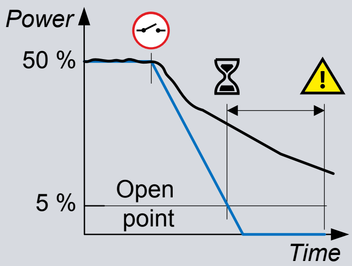
Effect of de-load ramp example

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.



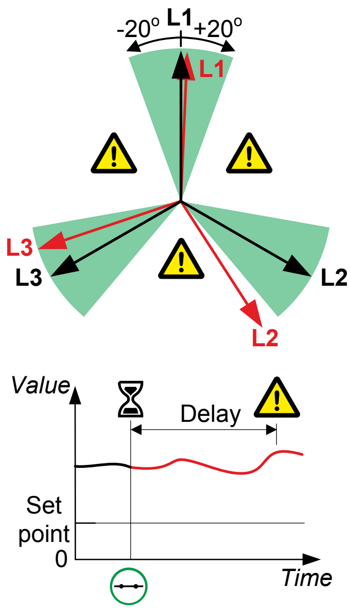
More information
See Regulation for more information about de-loading.

6.5.3 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.

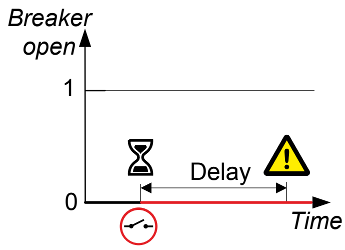
Frequency-based inhibit

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**.

6.5.4 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.

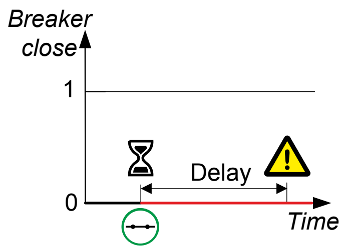
Breakers > [Breaker] monitoring > Opening failure

Parameter	Range
`Delay`	0.1 to 60.0 s

6.5.5 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

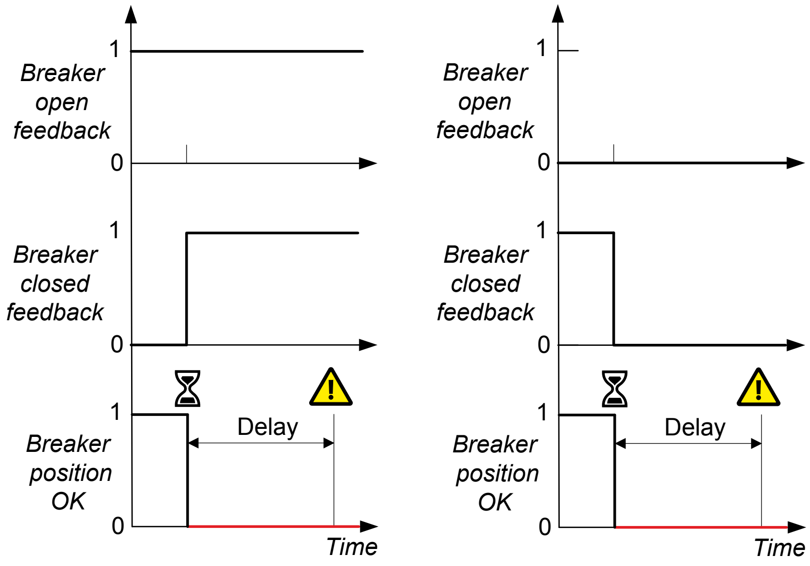
Parameter	Range
`Delay`	0.1 to 60.0 s

6.5.6 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

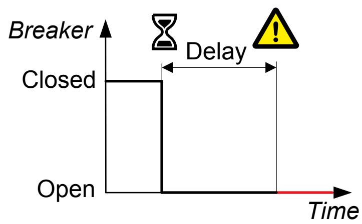
All controllers in section in switchboard control

If the *Breaker position failure* alarm is activated, the controller cannot be sure whether the breaker is open or closed. The power management therefore forces all the controllers in the section under switchboard control. The controllers remain under switchboard control until the position failure is fixed.

6.5.7 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.

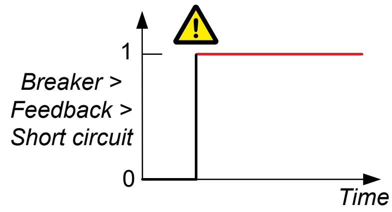


`Breakers > [Breaker] monitoring > Tripped (external)`

By default, the alarm has the *Latch enabled*. The delay is always 0.1 s.

6.5.8 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.

6.5.9 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.

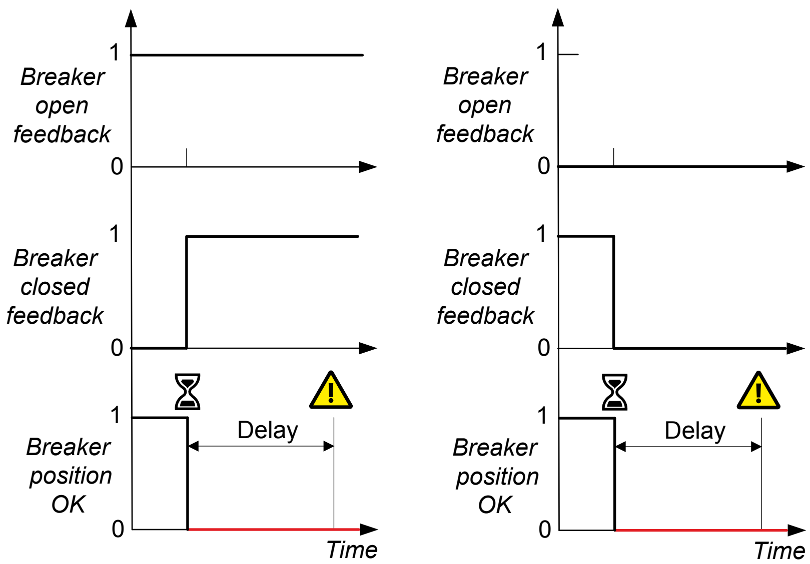
This alarm is always enabled, and has the alarm action *Block* with *Latch enabled*. You cannot see or change the parameters for this alarm.

6.5.10 Any tie breaker position failure

This alarm is for tie breaker position failure.

The alarm is based on the tie 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 tie breaker.



This alarm is always enabled. The alarm action is *Warning*. The parameters for this alarm are not visible.

All affected controllers under switchboard control

If the *Any tie breaker position failure* alarm is activated, the controller cannot be sure whether the breaker is open or closed. The power management therefore forces ALL of the controllers in the sections connected to the tie breaker under switchboard control. The controllers remain under switchboard control until the position failure is fixed.

If the controller should remain in switchboard control after the position failure has been fixed, then configure the latch on this alarm.

NOTE This alarm is only activated if the controller is in contact with the tie breaker's controller.

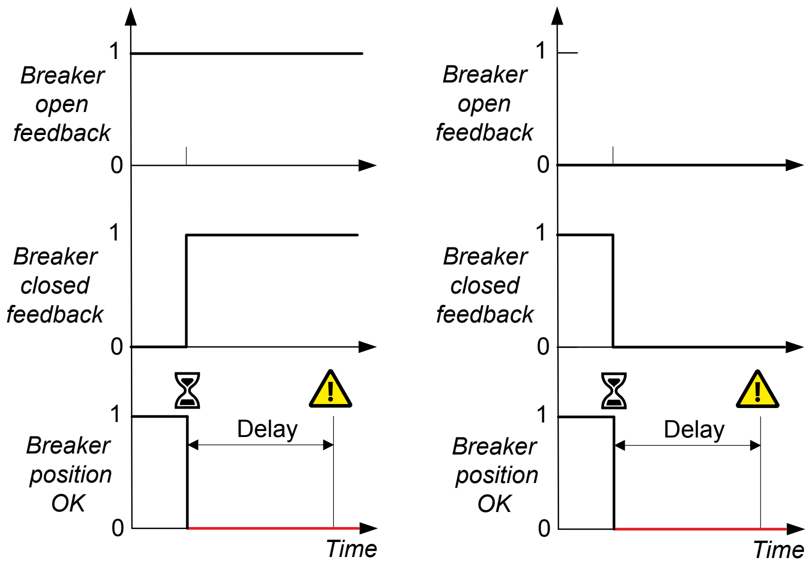
6.5.11 Any bus tie breaker position failure

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.

This alarm is always enabled.



System > Monitoring > Any bus tie breaker position failure

All affected controllers in switchboard control

If the *Any bus tie breaker position failure* alarm is activated, the controller cannot be sure whether the breaker is open or closed. The power management system therefore forces ALL the controllers in the sections connected to the bus tie breaker in switchboard control. The controllers remain in switchboard control until the position failure is fixed.

If the controller should remain in switchboard control after the position failure has been fixed, then configure the latch on this alarm.

NOTE This alarm is only activated if the controller is in contact with the bus tie breaker's controller.

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 all breaker feedbacks.

7. Regulation

7.1 About regulation

7.1.1 How it works

The **GENSET** and **EMERGENCY genset** controllers can use analogue and/or relay control functions for regulation.

The controller sets the regulation mode according to the system conditions.

When the controller is in *Switchboard control*, or when certain alarm conditions are active, regulation must be done manually.

More information
See Switchboard control for how to control the regulators manually through the controller.

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.

7.1.2 Analogue regulation

More information
See Analogue outputs for how to configure the analogue output(s) and PWM.

Configuring analogue outputs

Assign the analogue output regulation function(s) to the analogue output terminals under `Configure > Input/output`.

- `Regulators > GOV > GOV output [%]`
- `Regulators > AVR > AVR output [%]`

Configure the parameter to *Analogue* (where *[Regulator]* is *Governor* or *AVR*).

`Regulators > [Regulator] general configuration > Regulator output`

Parameter	Range
Output type	• Analogue / ECU (for GOV) • 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.

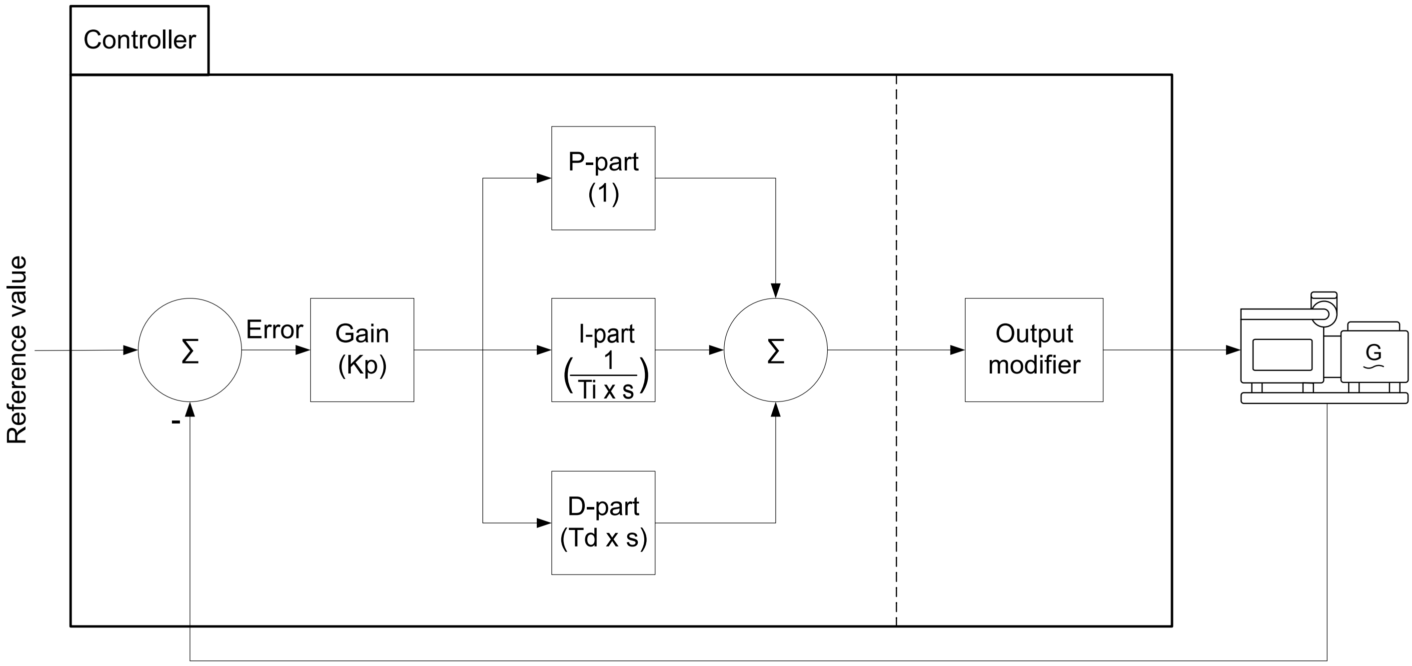
More information
See Pulse width modulation (PWM) output characteristics for the relationship between duty cycles and the PWM output.

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 7.1 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.

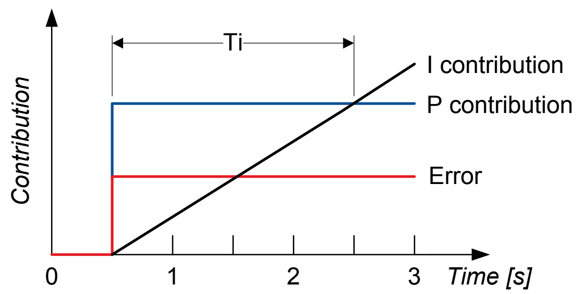
The integral part is determined by:
- The gain × error
- The integration time (*Ti*)
- The error history

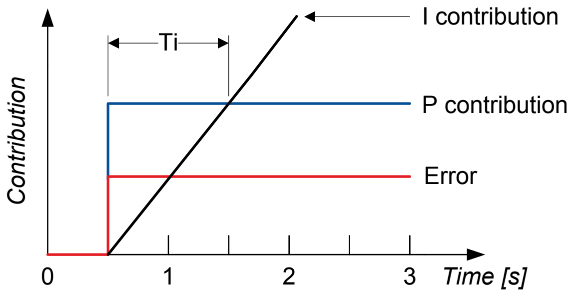
Ti is the time it takes for the contribution of the integral part to be equal to the contribution of the proportional part. If *Ti* is reduced, the contribution of the integral part is increased.

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.

7.1.3 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).

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 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.

Range	Relay position	Notes
		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 7.2 Up and down relay on time for different errors (deviations from the reference)

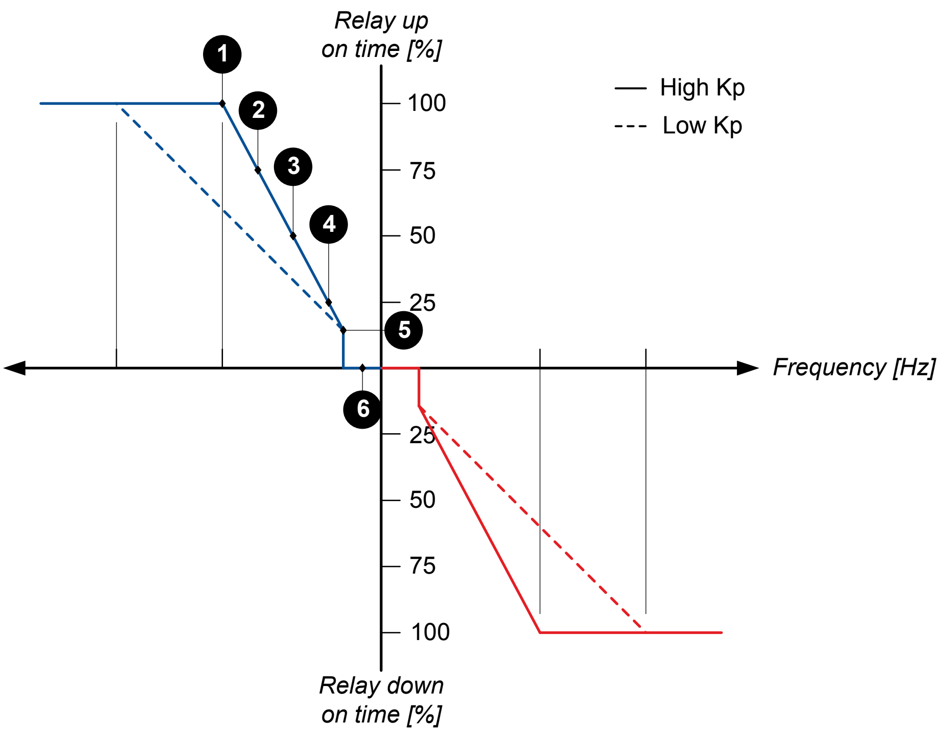
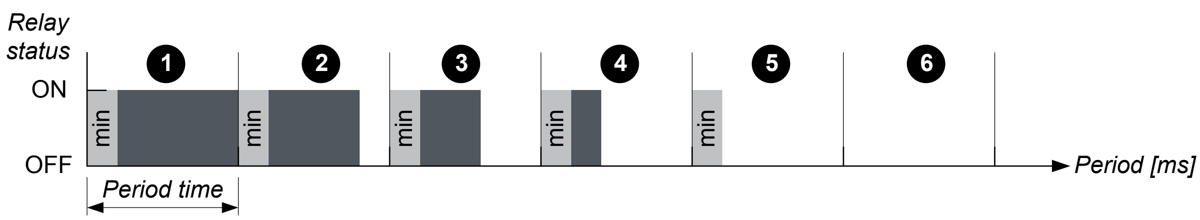


Figure 7.3 Relay action (based on measurements at the end of the period time)



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.

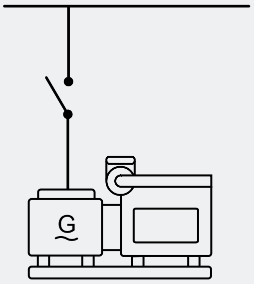
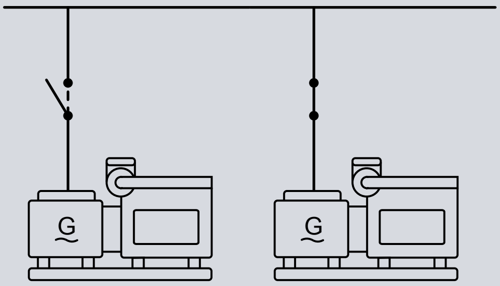
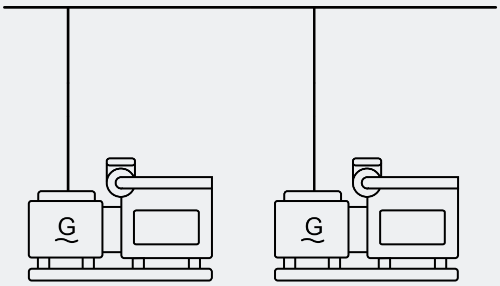
The *Maximum ON time* sets the maximum amount of time a relay is allowed to be closed when the regulation is in the constant range. The parameter is a percentage of the *Period time*.

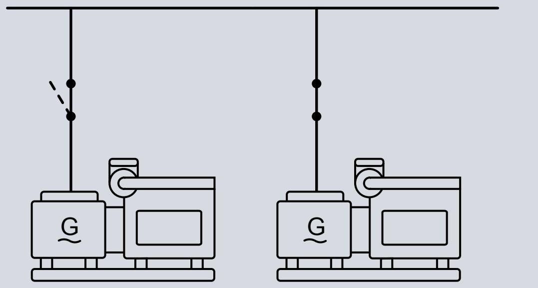
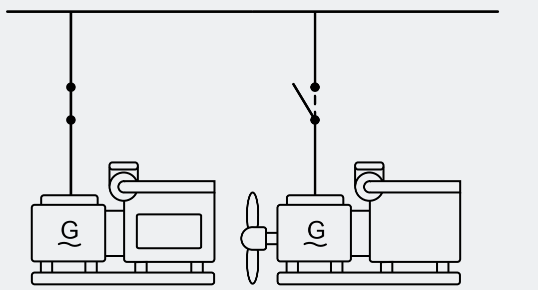
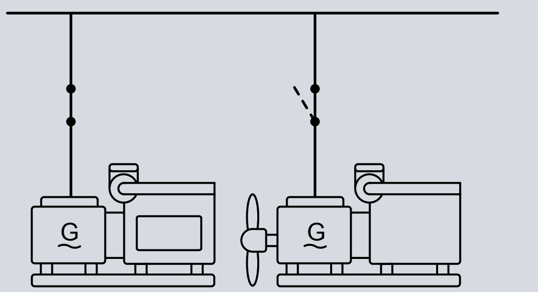
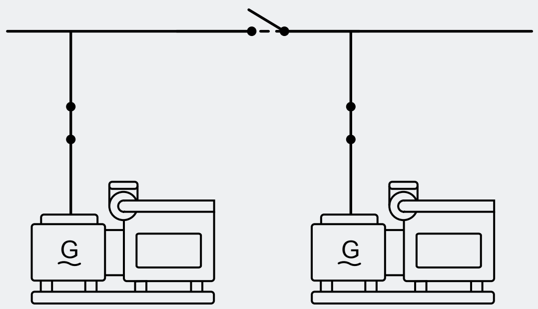
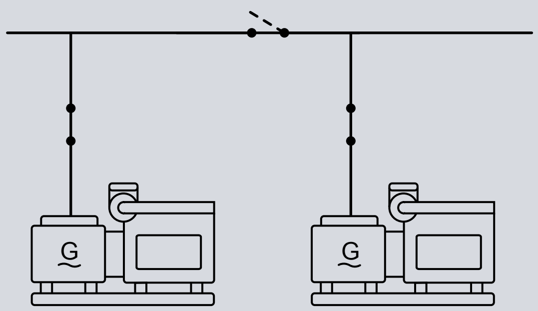
The pulse length is never shorter than the *Minimum ON time*. If the *Maximum ON time* is 100 %, when the pulse length is equal to or greater than the period time, the output is constant. The error where this shift occurs depends on *Kp* and the period time. As *Kp* increases, the variable range decreases. As *Kp* decreases, the variable range increases.

7.1.4 Regulation mode overview

The genset regulation system consists of a number of basic control modes for the governor, and 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 governor or AVR interface, and sent to the governor or AVR.

Active modes for different system conditions

Condition		Governor mode	AVR mode
 	The generator breaker is open and the genset is running. This can be a stand alone genset, or a genset in a system.	• Frequency regulation	• Voltage regulation
 	The generator breaker is open and the controller receives a close breaker command. The controller sends commands to synchronise the genset to the busbar frequency, voltage and phase (static synchronisation).	• Frequency synchronisation • Phase synchronisation (only for static synchronisation)	• Voltage regulation
 	The genset is connected to the busbar and is producing power. The genset can be a stand alone genset, or a genset running in parallel to another power producing component on the busbar.	• Power regulation • Power load share	• Reactive power regulation • Power factor regulation • Reactive power load share

Condition		Governor mode	AVR mode
	The genset is running in parallel with another power producing component on the same busbar. The genset controller receives a open breaker command. The controller sends commands to de-load the generator breaker.	• Power regulation	• Reactive power regulation
	There is at least one genset connected to the busbar. The **SHAFT generator** or **SHORE connection** controller receives a close breaker command. All the gensets connected to the same busbar that the equipment is connecting to, receive their set points from power management.	• Frequency synchronisation • Phase synchronisation (only for static synchronisation)	• Voltage regulation
	There is at least one genset connected to the busbar. The **SHAFT generator** or **SHORE connection** controller receives an open breaker command. All the gensets connected to the same busbar that the equipment is disconnecting from, receive their set points from the power management.	• Power regulation	• Reactive power regulation
	A bus tie breaker controller receives a close breaker command between two live busbars. All the connected gensets on both busbars receive their set points from the power management.	• Frequency synchronisation • Phase synchronisation (only for static synchronisation)	• Voltage regulation
	A bus tie breaker controller receives an open breaker command. All the connected gensets on the busbar that is splitting sections receive their set points from the power management.	• Power regulation	• Reactive power regulation

7.1.5 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*.

7.2 Governor regulation modes

7.2.1 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).

7.2.2 Frequency regulation

When a genset is running with an open generator breaker, the controller uses frequency regulation to keep the frequency at the nominal set point.

Alternatively the frequency set point can be configured using Modbus.

More information

See External communication using Modbus for how the frequency set point is configured using Modbus.

The frequency regulation parameters define the regulation when the controller regulates the frequency.

Analogue governor output: Frequency parameters

`Regulators > GOV > Analogue > Frequency regulation`

Parameter	Range	Notes
`Kp`	0.00 to 1000.00	The PID gain for the regulator.
`Ti`	0.00 to 1000.00 s	The PID regulator integral time. To turn off the integral component, set Ti to 0. This might cause unexpected regulator behaviour.
`Td`	0.00 to 1000.00 s	The PID regulator derivative.

Relay governor output: Frequency parameters

`Regulators > GOV > Relay configuration > Frequency regulation`

Parameter	Range	Notes
`Kp`	0.00 to 1000.00	This is the gain for the regulator.
`Deadband`	0.2 to 10.0 %	The deadband for the regulator, as a percentage of the nominal frequency.

7.2.3 Power regulation

When there is a genset (or emergency genset in harbour mode) connected to the busbar along with other gensets, and/or shaft generator, and/or shore connection, then the controller can use power regulation (that is, active power).

The controller also uses power regulation when ramping up the power to a genset (increasing the load), or ramping down the power of a genset (decreasing the load).

If multiple gensets are connected to the same busbar section, a **GENSET** controller can regulate the power from its genset. Connected gensets automatically run at the same engine speed. Therefore, decreasing the fuel to one genset automatically increases the active power from the other genset.

More information
See Regulation required for de-loading.

Alternatively the power set point can be configured using Modbus.

If a single genset is connected to the busbar, changing the governor input only changes the frequency of the genset and not the power.

More information
See External communication using Modbus for how the power set point is configured using Modbus.

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 configuration > 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. To turn off the integral component, set Ti to 0. This might cause unexpected regulator behaviour.
Td	0 to 2 s	The PID control derivative time.

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.

7.2.4 Power load sharing

Active power (kW) is shared in the system by controlling the fuel supply of the gensets.

During load sharing the controller regulates the governor output to the gensets. The power management calculates the **GENSET** controller load set point and communicates this over the DEIF network. By default, all gensets will share an equal portion of the load. Asymmetric power load sharing is also available. For asymmetric load sharing, some gensets can be prioritised to provide an optimum portion of the load per genset, while the other gensets absorb the varying load in the system.

More information
See Load sharing for information about asymmetric load sharing.

Analogue governor output power load sharing parameters

The power load sharing parameters define analogue regulation when the controller regulates the governor to control the genset active power output for load sharing.

`Regulators > GOV analogue configuration > 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.
`P weight`	0.0 to 100.0 %	If P weight is 100 %, the controller ignores the frequency set point to achieve the power set point. If P weight is 0 %, the controller ignores the power set point, to achieve the frequency set point. 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 new heavy consumer connects.

Relay governor output power load sharing parameters

The power load sharing parameters define relay regulation when the controller regulates the governor to control 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 10.0 %	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 weight`	0.0 to 100.0 %	If P weight is 100 %, the controller ignores the frequency set point to achieve the power set point. If P weight is 0 %, the controller ignores the power set point, to achieve the frequency set point. 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 new heavy consumer connects.
`P deadband`	0.2 to 10.0 %	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.

7.2.5 Frequency synchronisation

During the synchronisation sequence, the controller uses frequency synchronisation regulation to match the genset frequency to the frequency of the busbar.

More information
See Regulation required for synchronisation and Regulator synchronisation parameters.

7.2.6 Phase synchronisation

For static synchronisation, during the synchronisation sequence, the controller uses phase synchronisation regulation to match the genset phases to the phases of the busbar.

More information
See Regulation required for synchronisation and Regulator synchronisation parameters.

7.3 AVR regulation modes

7.3.1 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 the output configuration To see the parameters, you must have an AVR configured in the controller with relay outputs or analogue output.

7.3.2 Voltage regulation

The controller regulates and maintains the genset voltage at its nominal set point by sending a signal to the AVR to adjust the exciter current.

Before the generator breaker is closed, the controller uses voltage regulation to match the genset voltage with the voltage of the other gensets on the busbar. This minimises the circulating current in the system after gensets are connected to the busbar. The controller calculates the necessary values to eliminate the circulating current between the generators before the busbar is connected to a load. Then the controller uses the AVR output to send the adjusted values to the AVR. If a genset is already connected to a load, the controller must match the generator voltages before closing an additional generator breaker.

Alternatively the voltage set point can be configured using Modbus.

More information
See External communication using Modbus for how the voltage set point is configured using Modbus.

Analogue AVR output voltage parameters

The voltage regulation parameters define analogue regulation when the controller regulates AVR to change the voltage.

Regulators > AVR analogue configuration > Voltage 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.

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	0.0 to 10.0 %	The deadband for the regulator, as a percentage of the nominal voltage.

7.3.3 Reactive power regulation

By controlling the AVR current for the genset, the controller controls the reactive power (kvar) of the genset. The controller sends a signal to the AVR to change the excitation of the generator. 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 assets, the controller can use reactive power regulation to ensure that the genset provides the same amount of reactive power to the busbar.

The controller also uses reactive power regulation when ramping up the reactive power of a genset (increasing the load), and 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 the required amount of reactive power. Connected gensets automatically run at the same engine speed. Therefore, decreasing the excitation in the generator automatically decreases the reactive power that it provides, and increases the load on the other power generating assets. Increasing the excitation in the generator automatically increases the reactive power that the genset provides, and decreases the load on the other power generating assets.

Alternatively the reactive power set point can be configured using Modbus.

More information
See External communication using Modbus for how the reactive power set point is configured using Modbus.

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 configuration > Reactive power 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.

Parameter	Range	Notes
		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 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`	0.0 to 10.0 %	The deadband for the regulator, as a percentage of the nominal reactive power.

7.3.4 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. 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.

7.3.5 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 Load sharing under Power management.

Digital input

Function	I/O	Type	Details
`Regulators > AVR > Modes > Deactivate regulation`	Digital input	Pulse	The input disables any active AVR regulation mode.

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 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.

7.4 External communication

7.4.1 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).

7.4.2 External communication using an analogue input

To receive the controller regulation set points through the controller analogue inputs, the function must first be configured in **Input/output**. When the function is active, the controller ignores the internal set points that are calculated by the PMS and uses the set points it receives from the analogue input instead.

You can either activate the function under **Parameters**, or by activating a digital input that is configured to activate the function, or using Modbus.

Inputs

Function	I/O	Type	Details
`Regulators > GOV > Frequency offset [%]`	Analogue input	% of nominal frequency	When configured, the controller receives the frequency offset value from this analogue input. The 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	% of nominal power	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	% of nominal voltage	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	% of nominal reactive power	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.
`Regulators > GOV > External set points > Activate external f offset`	Digital input	Pulse	When activated, the controller changes `Regulators > GOV general configuration > External offset > Frequency offset enable` to *Enabled*.
`Regulators > GOV > External set points > Deactivate external f offset`	Digital input	Pulse	When activated, the controller changes `Regulators > GOV general configuration > External offset > Frequency offset enable` to *Not enabled*.

Function	I/O	Type	Details
`Regulators > GOV > External set points > Activate external P set point`	Digital input	Pulse	When activated, the controller changes `Regulators > GOV general configuration > External offset > P set point enable` to *Enabled*.
`Regulators > GOV > External set points > Deactivate external P set point`	Digital input	Pulse	When activated, the controller changes `Regulators > GOV general configuration > External offset > P set point enable` to *Not enabled*.
`Regulators > AVR > External set points > Activate external V offset`	Digital input	Pulse	When activated, the controller changes `Regulators > AVR general configuration > External offset > Voltage offset enable` to *Enabled*.
`Regulators > AVR > External set points > Deactivate external V offset`	Digital input	Pulse	When activated, the controller changes `Regulators > AVR general configuration > External offset > Voltage offset enable` to *Not enabled*.
`Regulators > AVR > External set points > Activate external Q set point`	Digital input	Pulse	When activated, the controller changes `Regulators > AVR general configuration > External offset > Q set point enable` to *Enabled*.
`Regulators > AVR > External set points > Deactivate external Q set point`	Digital input	Pulse	When activated, the controller changes `Regulators > AVR general configuration > External offset > Q set point enable` to *Not enabled*.
`Regulators > AVR > External set points > Activate external cos phi set point`	Digital input	Pulse	When activated, the controller changes `Regulators > AVR general configuration > External offset > Cos phi set point enable` to *Enabled*.
`Regulators > AVR > External set points > Deactivate external cos phi set point`	Digital input	Pulse	When activated, the controller changes `Regulators > AVR general configuration > External offset > Cos phi set point enable` to *Not enabled*.

Governor parameters

`Regulators > GOV general configuration > External offset`

To see these parameters, you must assign a governor output function.

These parameters allow analogue inputs to determine the genset's frequency or power set point.

If an analogue input is configured, the Modbus value for the external offset will reflect the analogue input value. The Modbus external offset cannot be configured until the analogue input for the external offset is cleared.

Parameter	Range	Default	Notes
`Frequency offset enable`	• Not enabled • Enabled	Not enabled	• **Not enabled**: The controller ignores the *Frequency offset [%]* analogue input and Modbus input. • **Enabled**: During frequency regulation, the controller uses the *Frequency offset [%]* analogue input or Modbus input to determine the frequency set point.
`Frequency offset source`	• External • External → Off	External	• **External**: The controller uses the *Frequency offset [%]* analogue input or Modbus input.

Parameter	Range	Default	Notes
			• **External → Off**: If the *Frequency offset [%]* analogue input and/or Modbus input fails (that is, when the input is outside the configured scale), then the controller ignores the input.
`P set point enable`	• Not enabled • Enabled	Not enabled	• **Not enabled**: The controller ignores the *Power set point [%]* analogue input and Modbus input. • **Enabled**: During power regulation, the controller uses the *Power set point [%]* analogue input or Modbus input as the power set point.
`P set point source`	• External • External → Off	External	• **External**: The controller uses the *Power set point [%]* analogue input or Modbus input. • **External → Off**: If the *Power set point [%]* analogue input and/or Modbus input fails (that is, when the input is outside the configured scale), then the controller ignores the input.

AVR parameters

`Regulators > AVR general configuration > External offset`

To see these parameters, you must assign an AVR output function.

These parameters allow analogue inputs to determine the genset's voltage, reactive power or cos phi set point.

If an analogue input is configured, the Modbus value for the external offset will reflect the analogue input value. The Modbus external offset cannot be configured until the analogue input for the external offset is cleared.

Parameter	Range	Default	Notes
`Voltage offset enable`	• Not enabled • Enabled	Not enabled	• **Not enabled**: The controller ignores the *Voltage offset [%]* analogue input and Modbus input. • **Enabled**: During voltage regulation, the controller uses the *Voltage offset [%]* analogue input or Modbus input to determine the voltage set point.
`Voltage offset source`	• External • External → Off	External	• **External**: The controller uses the *Voltage offset [%]* analogue input or Modbus input. • **External → Off**: If the *Voltage offset [%]* analogue input and/or Modbus input fails (that is, when the input is outside the configured scale), then the controller ignores the input.
`Q set point enable`	• Not enabled • Enabled	Not enabled	• **Not enabled**: The controller ignores the *Reactive power set point [%]* analogue input and Modbus input. • **Enabled**: During reactive power regulation, the controller uses the *Reactive power set point [%]* analogue input or Modbus input as the reactive power set point.
`Q set point source`	• External • External → Off	External	• **External**: The controller uses the *Reactive power set point [%]* analogue input or Modbus input. • **External → Off**: If the *Reactive power set point [%]* analogue input and/or Modbus input fails (that is, when the input is outside the configured scale), then the controller ignores the input.
`Cos phi set point enable`	• Not enabled • Enabled	Not enabled	• **Not enabled**: The controller ignores the *Cos phi set point* analogue input and Modbus input. • **Enabled**: During reactive power sharing, the controller uses the *Cos phi set point* analogue input or Modbus input as the cos phi set point.
`Cos phi set point source`	• External • External → Off	External	• **External**: The controller uses the *Cos phi set point* analogue input or Modbus input.

Parameter	Range	Default	Notes
			• **External → Off**: If the *Cos phi set point* analogue input and/or Modbus input fails (that is, when the input is outside the configured scale), then the controller ignores the input.

7.4.3 External communication using Modbus

If you want to send set point values over Modbus, instead of using the controller internal set points, then you must configure and activate the set point function on the controller. When the function is active, the controller ignores the internal set points configured in the parameters and uses the set points it receives over Modbus.

Digital inputs

These inputs are only visible if a regulation output (either relay or analogue) is configured.

Function	I/O	Type	Details
`Regulators > GOV > External set points > Activate external f offset`	Digital input	Pulse	When activated, the controller changes `Regulators > GOV general configuration > External offset > Frequency offset enable` to *Enabled*.
`Regulators > GOV > External set points > Deactivate external f offset`	Digital input	Pulse	When activated, the controller changes `Regulators > GOV general configuration > External offset > Frequency offset enable` to *Not enabled*.
`Regulators > GOV > External set points > Activate external P set point`	Digital input	Pulse	When activated, the controller changes `Regulators > GOV general configuration > External offset > P set point enable` to *Enabled*.
`Regulators > GOV > External set points > Deactivate external P set point`	Digital input	Pulse	When activated, the controller changes `Regulators > GOV general configuration > External offset > P set point enable` to *Not enabled*.
`Regulators > AVR > External set points > Activate external V offset`	Digital input	Pulse	When activated, the controller changes `Regulators > AVR general configuration > External offset > Voltage offset enable` to *Enabled*.
`Regulators > AVR > External set points > Deactivate external V offset`	Digital input	Pulse	When activated, the controller changes `Regulators > AVR general configuration > External offset > Voltage offset enable` to *Not enabled*.
`Regulators > AVR > External set points > Activate external Q set point`	Digital input	Pulse	When activated, the controller changes `Regulators > AVR general configuration > External offset > Q set point enable` to *Enabled*.
`Regulators > AVR > External set points > Deactivate external Q set point`	Digital input	Pulse	When activated, the controller changes `Regulators > AVR general configuration > External offset > Q set point enable` to *Not enabled*.
`Regulators > AVR > External set points > Activate external cos phi set point`	Digital input	Pulse	When activated, the controller changes `Regulators > AVR general configuration > External offset > Cos phi set point enable` to *Enabled*.
`Regulators > AVR > External set points > Deactivate external cos phi set point`	Digital input	Pulse	When activated, the controller changes `Regulators > AVR general configuration > External offset > Cos phi set point enable` to *Not enabled*.

It is also possible to activate and deactivate the external communication set points using Modbus. 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 fucnctions and their properties.

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 > GOV > Frequency offset`	8008	03; 06; 16	-100 to 100	1	%	If the operator activates *Activate external f offset*, the frequency offset is determined by the value set in Modbus. The value entered is the percentage of the nominal frequency that is added or subtracted from the nominal frequency to determine the new set point.
`Regulators > GOV > Power set point`	8009	03; 06; 16	0 to 100	0	%	If the operator activates *Activate external P set point*, the power set point is determined by the value set in Modbus. The value is a percentage of the controller nominal power.
`Regulators > AVR > Voltage offset`	8010	03; 06; 16	-100 to 100	1	%	If the operator activates *Activate external V offset*, the voltage offset is determined by the value set in Modbus. The value entered is the percentage of the nominal voltage that is added 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 Q set point*, the reactive power set point is determined by the value set in Modbus. The value is a percentage of the controller nominal reactive power.
`Regulators > AVR > Cos phi set point`	8012	03; 06; 16	60 to 100	2	-	If the operator activates *Activate external Cos phi 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.

7.5 Governor

7.5.1 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. 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.

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.

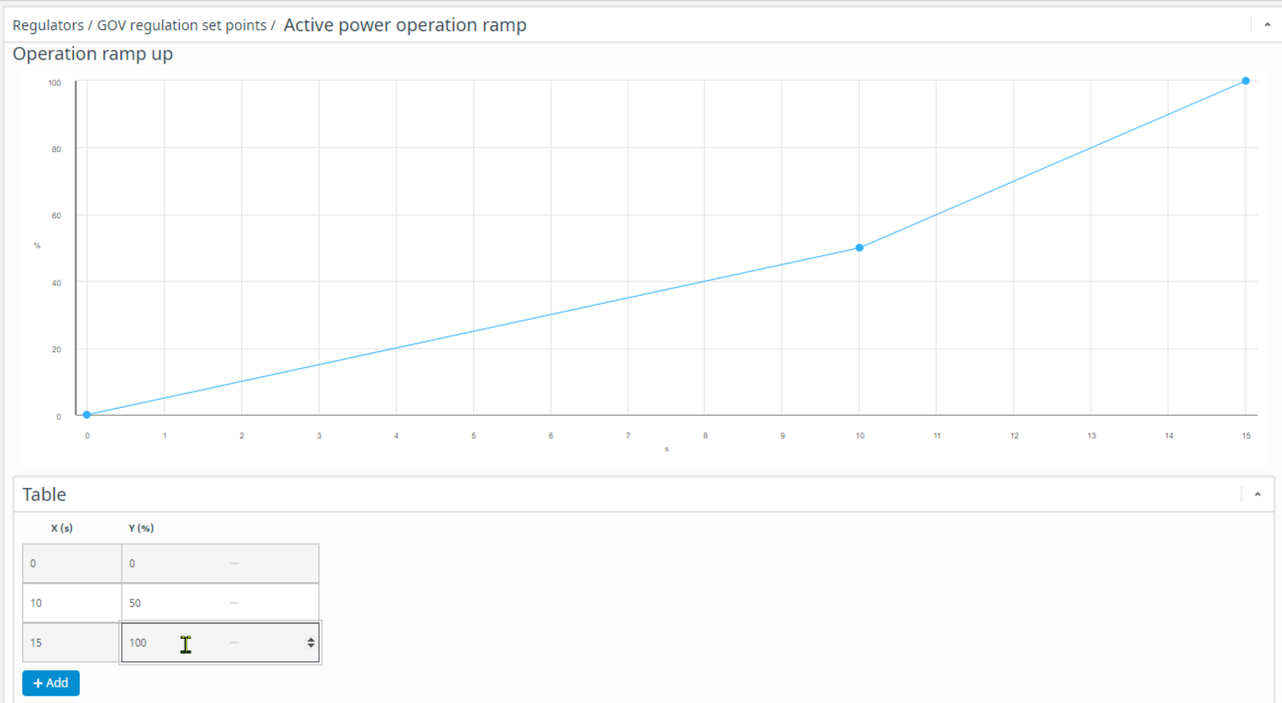
`Regulators > GOV regulation set points > Active power ramp up`

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.

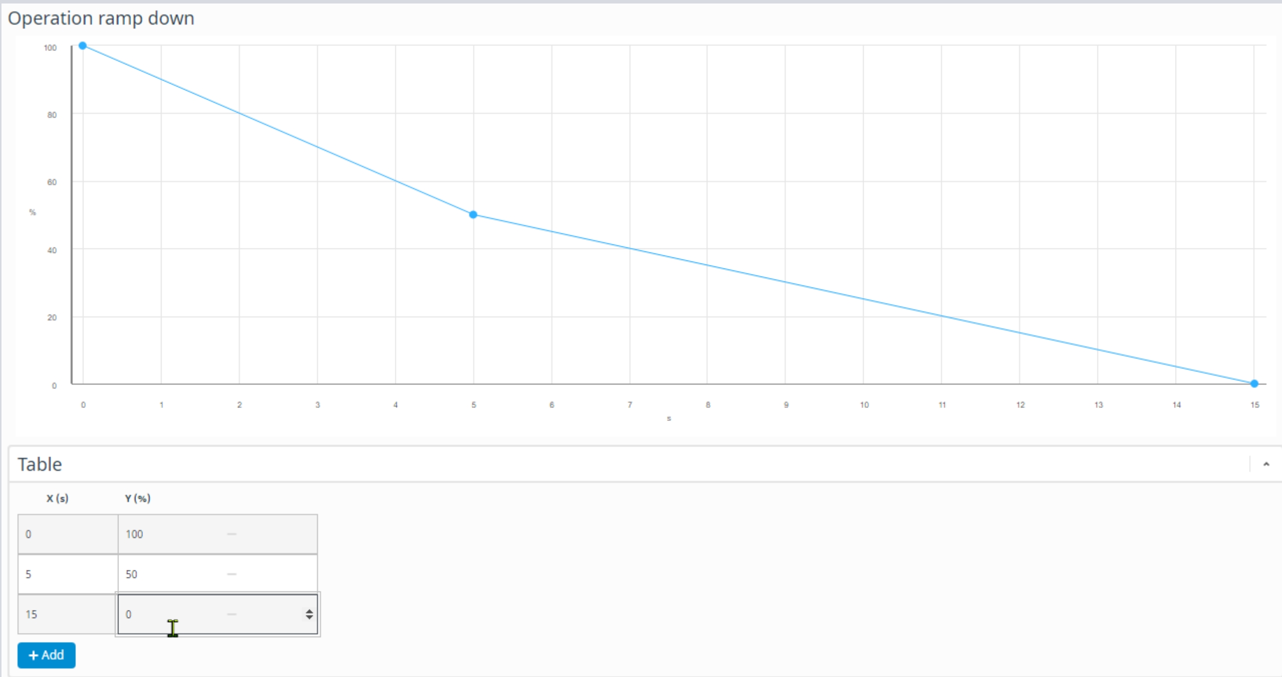
`Regulators > GOV regulation set points > Active power ramp down`

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.

7.5.2 Governor analogue regulation function

You can configure an analogue output on the controller to regulate the governor. You can also set a number of parameters for the governor analogue regulation function.

Inputs and Outputs

Function	I/O	Units	Details
`Regulators > GOV > Command > Reset GOV to offset`	Digital input	Pulse	When the operator activates this digital input, the analogue output is reset to the GOV output offset value.
`Regulators > GOV > GOV output [%]`	Analogue output	-100 to 100 %	The controller adjusts this output to regulate the governor. 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.

7.5.3 Governor relay regulation function

You can configure relay outputs on the controller to regulate the governor. You can also set a number of parameters for the governor relay regulation function.

Digital outputs

Function	I/O	Type	Details
`Regulators > GOV > Controls > GOV increase`	Digital output	Variable-length pulse	The controller activates this output to regulate the governor to increase the engine speed or power.
`Regulators > GOV > Controls > GOV decrease`	Digital output	Variable-length pulse	The controller activates this output to regulate the governor to decrease the engine speed or power.

Parameters

These parameters are only visible, if you assign the functions to digital outputs.

`Regulators > GOV > Relay configuration > Automatic configuration`

Parameter	Range	Notes
`Period time`	250 ms to 32.5 s	You can make the governor response faster by decreasing the *Period time*. However, if the rest of the system is slow anyway, you can reduce the wear on the relays by increasing the *Period time*. 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.

7.6 Automatic voltage regulator

7.6.1 AVR regulator

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 to increase or decrease voltage.

The AVR must allow external adjustment (digital inputs or analogue input), to let the genset controller bias the AVR internal set point.

The sections below describe the common input parameters for the automatic voltage regulator (AVR).

Parameters

The `AVR general configuration` and `AVR regulation set points` settings apply to all the controller's AVR regulation outputs (for example, relay or analogue).

To see these parameters, you must configure an AVR output function.

If an AVR analogue regulation output and both AVR relay regulation outputs are configured, then one output must be selected as the output that sends feedback to the AVR.

`Regulators > AVR general configuration > Regulator output`

Parameter	Range	Notes
`Regulator output`	• Off • Relay • Analogue / Digital AVR	**Off:** The controller does not attempt to regulate the AVR, and ignores any configured hardware. **Relay:** The controller uses the relay outputs to regulate the AVR (only visible if both relays for the AVR regulator are configured). **Analogue / Digital AVR**: The controller uses an analogue output or digital AVR to regulate the AVR (only visible if an analogue AVR regulator output is configured).

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.

`Regulators > AVR general configuration > Regulation delay`

Parameter	Range	Notes
`Regulator delay`	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.

The ramp up curve defines 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. 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 curve can consist of 2 to 10 coordinates for the time and the percentage of the genset nominal reactive power.

`Regulators > AVR regulation set points > Reactive power ramp up`

Parameter	Range	Notes
`[s]`	0.0 to 1 h	The time coordinate for the reactive power ramp up curve.
`[%]`	-100 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.

The ramp down curve 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 curve can consist of 2 to 10 coordinates for the time and the percentage of the genset nominal reactive power.

`Regulators > AVR regulation set points > Reactive power ramp down`

Parameter	Range	Notes
`[s]`	0 to 3600 s	The time coordinate for the reactive power ramp down curve.
`[%]`	-100 to 100 %	The percentage of nominal reactive power of the genset coordinate for the reactive power ramp down curve.

	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.

7.6.2 AVR analogue regulation function

You can configure an analogue output on the controller to regulate the AVR. You can also set a number of parameters for the AVR analogue regulation function.

Inputs and outputs

Function	I/O	Type	Details
`Regulators > AVR > Command > Reset AVR to offset`	Digital input	Pulse	When the operator activates this digital input, the output is set to the offset value.
`Regulators > AVR > AVR output [%]`	Analogue output	-	The controller adjusts this output to regulate the AVR.

NOTE The setup and parameters for AVR regulation using pulse width modulation (PWM) is exactly the same as for an analogue output.

Parameters

To see the AVR analogue control parameters, you must assign the `Regulators > AVR > AVR output [%]` function to an analogue output (that is, AO or PWM).

When you start and/or run a genset, you might want to adjust the starting point for analogue regulation. This is done by changing the output offset.

`Regulators > AVR > Analogue > Offset`

Parameter	Range	Notes

`AVR output offset 1`
`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.

7.6.3 AVR relay regulation parameters

You can configure relay outputs on the controller to regulate the AVR. You can also set a number of parameters for the AVR relay regulation function.

Digital outputs

Function	I/O	Type	Details
`Regulators > AVR > Controls > AVR increase`	Digital output	Variable-length pulse	The controller activates this output to send a signal to the AVR to increase the voltage or reactive power.
`Regulators > AVR > Controls > AVR decrease`	Digital output	Variable-length pulse	The controller activates this output to send a signal to the AVR to decrease the voltage or reactive power.

Parameters

These parameters adjust the controller's relay control output. To see these parameters, you must assign the functions to digital outputs.

`Regulators > AVR > Relay configuration > Automatic configuration`

Parameter	Range	Notes
`Period time`	50 ms to 15 s	You can make the AVR response faster by decreasing the *Period time*. However, if the rest of the system is slow anyway, then decreasing the *Period time* will provide no additional benefits. 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.

Parameter	Range	Notes
		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. 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.

7.7 Configuration alarms

7.7.1 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.

7.7.2 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.

7.7.3 GOV output selection failure

The controller activates the alarm if an output, either relay or analogue, was selected as the regulation output, but the selected output is then removed from the **Input/output** configuration.

The alarm remains active until either:

- The deleted output is added to the **Input/output** configuration
- The correct manual output is selected under `Regulators > GOV general configuration > Regulator output > Output type`

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

7.7.4 AVR output selection failure

The controller activates the alarm if an output, either relay or analogue, was selected as the regulation output, but the selected output is then removed from the **Input/output** configuration.

The alarm remains active until either:
- The deleted output is added to the **Input/output** configuration
- The correct manual output is selected under `Regulators > AVR: common settings > Regulator output > Output type`

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

7.8 Regulation alarms

7.8.1 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.

7.8.2 AVR regulation error

This alarm shows when there is an error with the AVR controlled regulation.

The alarm is based on the difference between the measured value and the required set point, as a percentage of the set point. The larger the set point, the more the measured value is allowed to differ from the set point.

The alarm activates if the measured value is outside of the permitted range for longer than the delay.

This alarm is not activated when the genset voltage swings in and out of the permitted range above and below the set point. This is because this alarm only activates when the measured value is constantly above the upper limit, or constantly below the lower limit for the entire delay period.

Parameters

Do not set the alarm set point lower than the deadband percentage for relay regulation. Doing so might activate the alarm in an area where regulation is not possible.

`Regulators > AVR > Monitoring > Regulation error`

Parameter	Range
`Set point` (absolute value)	1.0 to 100.0 % regulation deviation
`Delay`	10 s to 1 h

Alarm deviation examples

1. The controller is running fixed voltage regulation with a set point of 400 V, and the measured voltage is 250 V.
   - The deviation from the set point is $|(250 \text{ V} - 400 \text{ V})| / 400 \text{ V} \times 100 = 38$ %.
   - The deviation is more than the alarm set point. If the measured power is stays below 280 V for longer than the delay, then the alarm activates.
2. The controller is running fixed reactive power regulation with a set point of 0 % of nominal reactive power, and the measured value is 2 % of nominal reactive power.
   - The deviation from the set point is 2 %.
   - The deviation is less than the alarm set point, and the alarm is not activated.
3. The controller is running fixed cos phi regulation with a set point of 0.9 I, and the measured value is 0.95 C.
   - The deviation from the set point is $|(0.95 \text{ C} - 0.9 \text{ I})| / 0.9 \text{ I} \times 100 = 17$ %.
   - The deviation is less than the alarm set point, and the alarm is not activated.

8. Power management

8.1 Power management principles

8.1.1 How it works

Power Management makes sure that the required power is available. The power management system makes sure the system runs as efficiently as possible, and responds appropriately to changes. This requires the controllers to share information and work together.

Power management scope

The functions of the power management:

- Takes action to prevent blackouts
- Restores power after a blackout
- Automatically starts and stops gensets/inverters based on the load
- Shares the load between the generators or inverters
- Manages the genset or inverter priority
- Loads and de-loads generators or inverters
- Handles the inverter
- Handles the shaft generator
- Handles shore connection
- Handles the bus tie breaker
- Includes the position of externally controlled breakers in power management calculations
- Manages heavy consumers
- Calculates the available power in the system

Control and modes

The controllers should normally be in power management control. The **GENSET**, **HYBRID**, and **EMERGENCY genset** controllers can then be in either AUTO or MANUAL mode. The power management functions best when all the controllers are in AUTO mode. MANUAL mode allows operator or external system (for example, a PLC) commands. Controllers should not normally be in MANUAL mode.

A controller is in *Switchboard control* when the operator or an external signal activates the `Mode > Switchboard control` digital input, or deactivates the `Mode > PMS control` digital input. For certain errors, the power management can also force controllers in switchboard control.

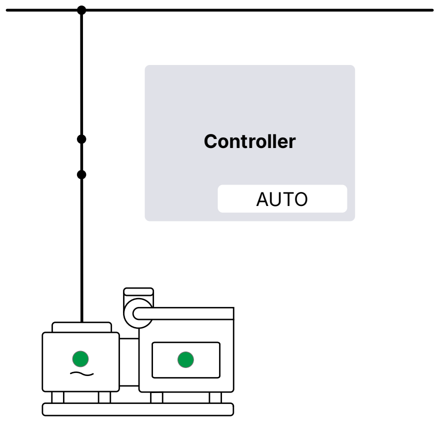
More information
See Control and modes in **System principles** for general mode information.

You can select that a mode change (AUTO/MANUAL) applies to only the controller, or to all controllers in the same busbar section.

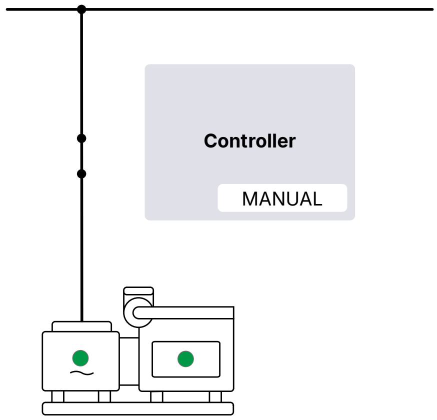
More information
See Mode change in section for how to configure this setting.

Power management and controller modes

AUTO The power managed when there is at least one **GENSET** controller in AUTO mode, and where that genset is either connected or ready to start. However, the power management is limited if there are not enough **GENSET** controllers in AUTO mode to supply the load.

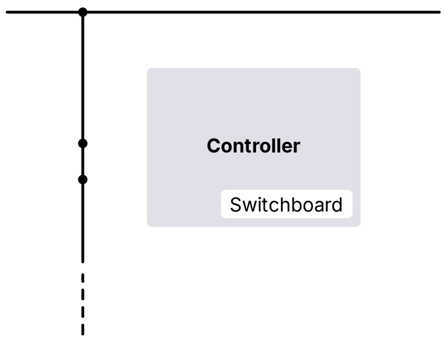


MANUAL The power cannot be managed automatically if all the **GENSET** controllers are in MANUAL mode. The controllers can share the load and restore power after a blackout. However, there is no automatic genset start or stop. The power management does not include the available power from connected **GENSET** controllers in MANUAL mode in the available power calculations.



Disabled Power management is **disabled** if a controller for **connected** equipment is under switchboard control. However, load sharing is still active in those controllers that the power management controls.

If there is a blackout, then the equipment under switchboard control is no longer connected automatically. The power management is then fully enabled for the controllers under PMS control and manages the blackout recovery.



Power availability

The controllers share information across the DEIF network, so that each controller can calculate the available power for the section.

The PMS power available calculation is used to determine when to start and stop gensets or inverters, and to respond appropriately to requests from heavy consumers.

More information
See Power calculations for more information.

Efficient operation

The power management with gensets, that is genset start, stop and load sharing, can be configured to maximise the system's fuel efficiency.

The power management with hybrid inverters, that is inverter start, stop, and load sharing, can be configured to maximise the system's use of the power source.

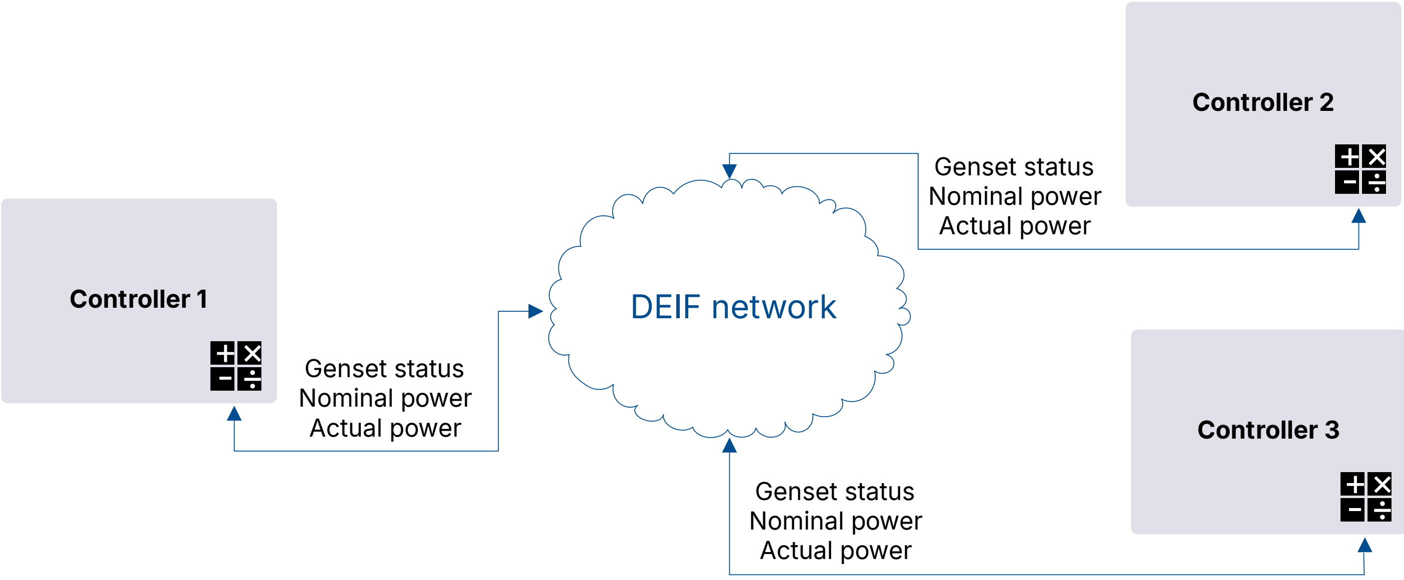
Multi-master control

The power management calculations are all done by each controller, for true multi-master control. This means that if a controller fails, the system can continue to function (as far as possible).

Protections

Most power management failures activate the standard controller alarms. Only the alarms that are specific to power management are described in this chapter.

Power management communication



For this example, the power management rules for the section specify the minimum *P available limit*.

Each controller calculates:

- Nominal power = ∑ Nominal power for connected gensets in the section
- Consumed power = ∑ Actual power from the connected gensets in the section
- Available power = Nominal power - Consumed power
- Genset priority order
- Genset start

How it works:

1. The controllers each communicate their status, nominal power, and the power that the controller measures.
2. Each controller does the power management calculations.
3. If the controllers calculate that the load-dependent start limit (*P available limit*) is exceeded, then the controller for the next genset in the priority order starts that genset.

8.1.2 Power management functions

These power management functions apply to the **GENSET** or **HYBRID** controller, and also to the other controllers working together as a system.

	Functions

Reliable power	• Blackout prevention
	  ◦ Precautionary genset/inverter start (either automatically or by operator action)
	  ◦ De-load before opening breakers
	  ◦ Genset/inverter breaker does not open if this would cause overload or a blackout
	• Fast load-reduction and configurable specific load reduction

	Functions
	• Configurable recovery after blackout
Efficient operation	• Intelligent load calculations • Advanced load-dependent start and stop calculations • Advanced (individually configurable) asymmetrical load sharing • Secured operation (power reservation)
Load control	• Load transfer (for synchronisation, de-loading and load sharing) • Load-dependent start (two sets of parameters available) ◦ For example, *Normal start* and *Faster start* (low available power) ◦ Based on active or apparent power, or on percentage of nominal power • Load-dependent stop (two sets of parameters available) ◦ For example, *Normal stop* and *Faster stop* (high available power) ◦ Based on active or apparent power, or on percentage of nominal power • Power management system calculates control set points ◦ Based on system configuration, controller modes, and load sharing ◦ Frequency, power, voltage, power factor and/or var • External analogue inputs as control set points
Genset priority selection	• Manual ◦ Set using the user-configured dashboard soft-key, or Modbus ◦ Delayed priority shift ◦ Modbus • Dynamic (first genset to connect has the highest priority) • Running hours
Heavy consumer management	• Up to 6 fixed and/or variable heavy consumers per controller • Pre-programmed heavy consumer management sequence (with configurable parameters) • Digital or analogue feedback from the heavy consumer *
Busbar section management	• Configurable power management rules for each section • Up to 4 externally-controlled breakers per controller ** ◦ Bus tie breakers and/or shore connection breakers • Ring busbar
Load sharing	• Active power (kW) load sharing (GOV) • Reactive power (kvar) sharing (AVR) • Load sharing between gensets ◦ Over the DEIF network • Load sharing options for each busbar section ◦ Equal load sharing (symmetrical) ◦ Asymmetric P load sharing for gensets ◦ Asymmetric Q load sharing for gensets ◦ **HYBRID** inverter with asymmetric load sharing with configurable constant discharge and genset start if required ◦ Shaft generator base load, with asymmetric load sharing for the gensets ◦ Shore connection base load, with asymmetric load sharing for the gensets ◦ One genset base load, with asymmetric load sharing for the other gensets

NOTE * For some controllers, the default hardware does not include analogue inputs. Extra hardware must be installed if analogue feedback from the heavy consumer is required.
** Up to 3 externally-controlled breakers per **EMERGENCY genset** controller.

8.1.3 Creating the power management application

Power management requires a single-line application drawing.

More information
See Single-line application drawing, and the **PICUS manual** for how to configure and write the single-line application drawing. See Change controller type if you need to change the controller type.

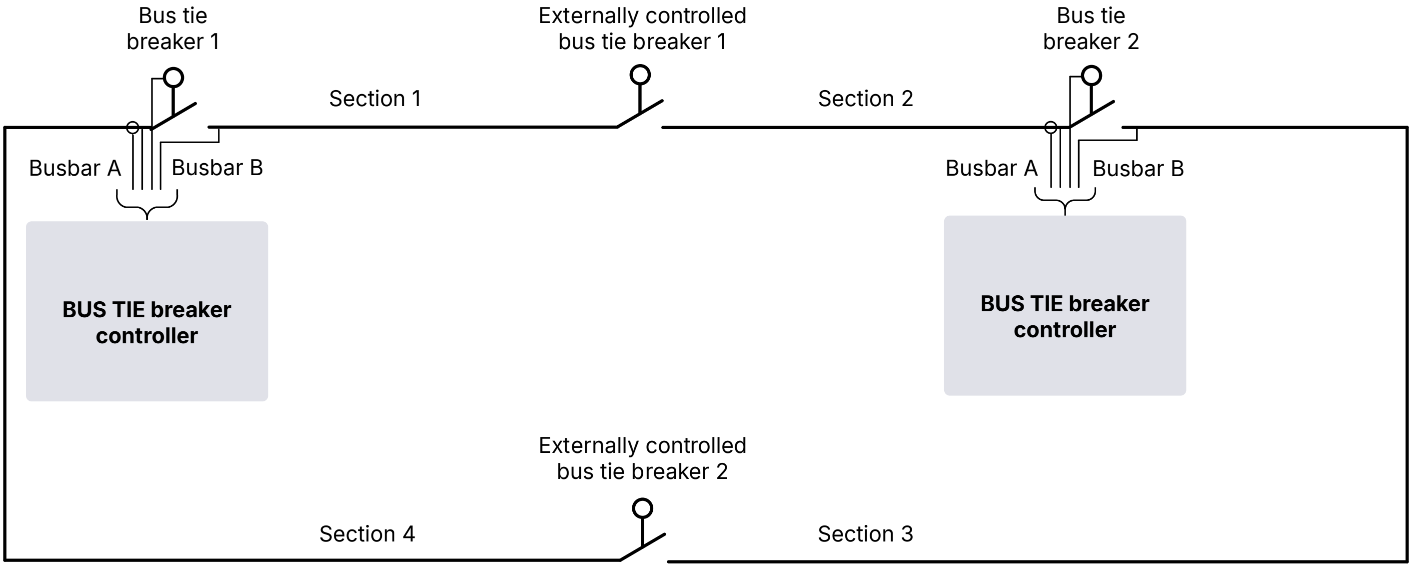
8.1.4 Busbar sections

There can be bus tie breakers in the single-line application drawing. When all the bus tie breakers are closed, the plant effectively has a single busbar. However, when one or more bus tie breakers are open, the power management has to manage busbar sections.

The power management manages the power for the busbar sections, according to a set of power management rules. The busbar sections are dynamic (that is, the busbar sections change whenever bus tie breakers are opened or closed).

Each **BUS TIE breaker** controller can create a new busbar section, as shown in the example below.

Example of busbar sections created by bus tie breakers and externally controlled bus tie breakers

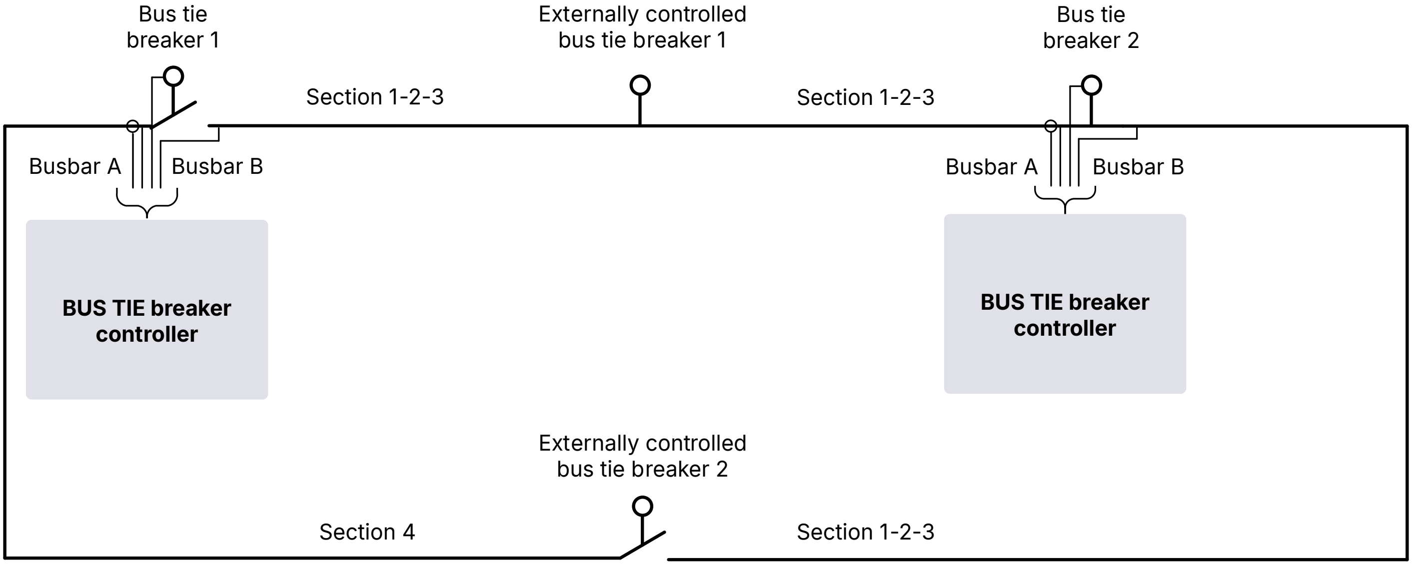


More information
See Externally controlled bus tie breaker how to configure and control an externally controlled bus tie breaker.

When the breaker(s) are open, each busbar section is independent from the other section(s). The controllers in the section manage the power independently for 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 manage the power for the combined busbar section.

Example of busbar sections created by closing a bus tie breaker and an externally controlled bus tie breaker



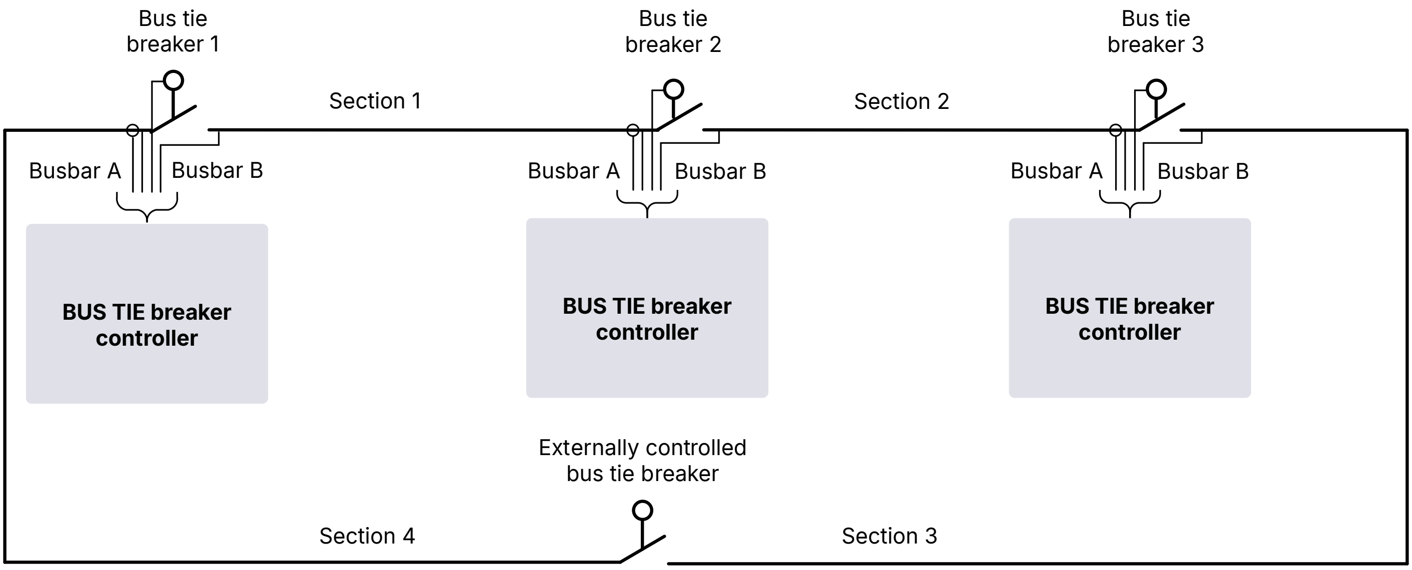
You can use CustomLogic to set conditions to determine the power management rules for a section. Alternatively, you can configure digital inputs to determine the power management rules for a section.

NOTE The busbar sections are numbered here to make it easier to understand sections. However, busbar section numbers are not used in PICUS. When CustomLogic is used to set the power management rules for one controller in the section, then all the controllers in that section start to use the same power management rules.

More information
See Section power management for the power management rules for each busbar section.

8.1.5 Ring busbar connection

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



NOTE 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.

Parameters

`System power management > Bus tie breaker > Closed ring`

Parameter	Range	Default	Comment
`Ring close allowed`	• Not enabled • Enabled	Not enabled	**Not enabled** • The power management does not allow the last open bus tie breaker to close to create a ring busbar. If the operator presses the close button, then an info message appears on the display unit. **Enabled** • The power management allows the last open bus tie breaker to close to create a ring busbar.

NOTICE
Externally controller bus tie breakers If externally controlled bus tie breaker(s) are present in the system and these are open, then the power management can close all the bus tie breakers controlled by the BUS TIE breaker controller, even though *Not enabled* is selected under *Close last BTB in a ring allowed*. After this, it is possible to manually close the externally controlled bus tie breaker(s) and create a ring, even though *Not enabled* is selected under *Close last BTB in a ring allowed*.

If all the bus tie breakers in a ring are closed, and the operator presses the open button for a **BUS TIE breaker** controller, then that bus tie breaker opens without de-loading.

8.1.6 Local parameters

Local parameters only apply to one controller. Configure them under `Local power management`. These parameters are not automatically shared with other controllers in the system.

8.1.7 Mode changes and sections

You can configure the mode change to apply to only the local controller or to all controllers in the same section.

NOTE This function also applies to applications without BTBs.

Parameters

`Local power management > Mode > Update`

Parameter	Range	Default	Notes
`Selection`	• Local update • Update all	Local update	Decides how change mode should be applied within the section. **Local update** • Only the local controller changes mode. **Update all** • All controllers in the section change mode.

NOTE Joining or splitting sections does not cause any mode changes.

8.1.8 Section power management

For each controller, you can configure parameters for the section power management rules. You can use up to eight sets of power management rules.

By default, all controllers use *Power management rules 1*. When the power management rules are changed for one controller, then all the controllers in the section automatically use the same power management rules.

You can use CustomLogic to assign a set of power management rules to a controller, based on the operating conditions. Alternatively, you can configure a digital input to activate a specific set of power management rules.

Inputs and outputs

Function	I/O	Type	Details
`Power management > Deactivate selected power management rule`	Digital input	Continuous	When this input is activated, the controller uses the same power management rules as the other controllers in the section are using. When activated, this input overrides any set of power management rules required by the controller's CustomLogic or a digital input.
`Power management > Activate power management rule #` *	Digital input	Continuous	The controller starts using the specified set of power management rules when this input is activated. As a result, the other controllers in the section also start using the specified set of power management rules. You can create a power management rule conflict in the section if this input function is active in two controllers for two different sets of power management rules at the same time. A conflict activates the *Different power management rules activated* alarm, and forces all the controllers in the section to switchboard control.
`Power management > Power management rule # active` *	Digital output	Continuous	The controller activates this relay when the controller is using the specified set of power management rules.

NOTE * # is 1 to 8.

Parameters

Configure the parameters under `Power management rules > Configuration #` (# is 1 to 8).

More information
The descriptions for the power management rules parameters are included in various topics in this chapter.

Power management rules within a section

All controllers in a section must use the same power management rules at the same time. If different power management rules are assigned to two or more controllers in the section, then the controllers activate the *Different power management rules activated* alarm.

Bus tie breaker example

Two sections may each use their own set of power management rules when the bus tie breaker between them is open. The sections must use the same set of power management rules when the bus tie breaker is closed.

Power management rules when splitting a section

The power management system (PMS) uses the section's power management rules when splitting a section. The PMS does not try to anticipate what the power management rules will be after the split.

Splitting a section example

If the `Power management rules # > Number of gensets connected > Maximum` is 2 before the split, then PMS will ensure that there are no more than 2 gensets connected to **each** section during the split.

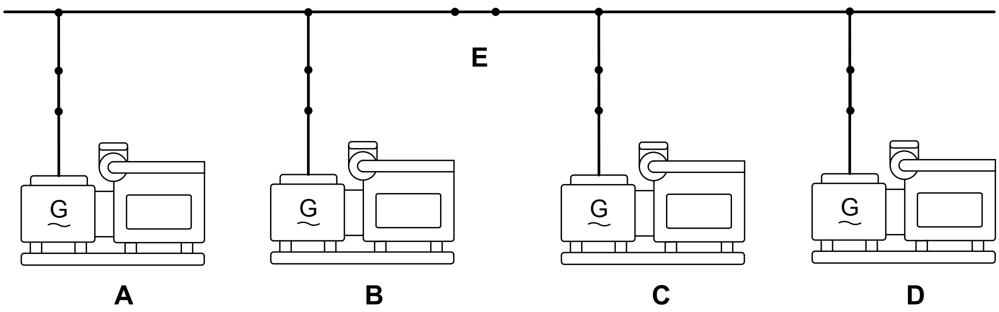
Power management rules when joining two sections

The PMS uses the least restrictive section's power management rules when joining two sections. The PMS does not try to anticipate what the power management rules will be after sections are joined.

> **Joining a section example**
>
> Section 1 uses *Power management rules 7*, and Section 2 uses *Power management rules 8*. *Power management rules 7 > Number of gensets connected > Maximum* is 2 and *Power management rules 8 > Number of gensets connected > Maximum* is 3. There must therefore be a maximum of 3 gensets connected in total before the join.

Section power management rules example

Figure 8.1 Single-line diagram for the example



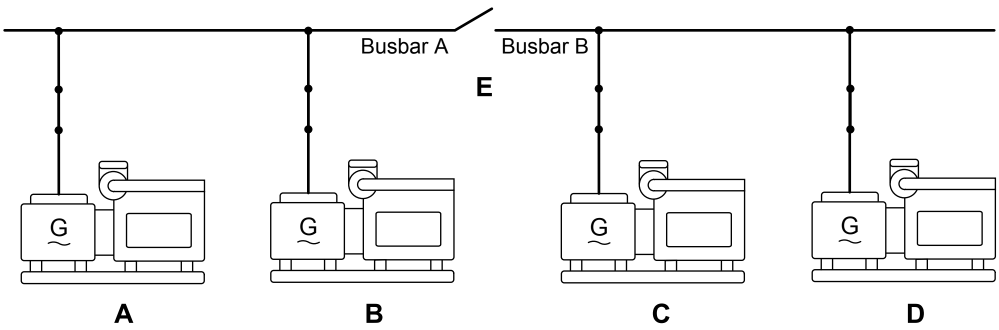
CustomLogic is configured as follows:

- When bus tie breaker E is closed, CustomLogic assigns *Power management rules 1* to controller A.
    - Since they are in the same section, the PMS applies *Power management rules 1* to controllers B, C and D too.
- When bus tie breaker E is open, CustomLogic assigns *Power management rules 2* to controller A.
    - Since it is in the same section, the PMS applies *Power management rules 2* to controller B too.
- When bus tie breaker E is open, CustomLogic assigns *Power management rules 3* to controller C.
    - Since it is in the same section, the PMS applies *Power management rules 3* to controller D too.

Based on this configuration, when bus tie breaker E is closed:

- All controllers (A to E) use *Power management rules 1*.

Figure 8.2 Split busbar operation for the example



When bus tie breaker E is open:

- **GENSET** controllers A and B and **BUS TIE breaker** controller E use *Power management rules 2*.
- **GENSET** controllers C and D use *Power management rules 3*.

More information
See **CustomLogic**, **Advanced examples** in the **PICUS manual** for detailed information on how to configure this.

Power management rules and BUS TIE breaker controllers

You can configure power management rules in a **BUS TIE breaker** controller.

If the bus tie breaker is closed, the power management rules for the **BUS TIE breaker** controller are treated in the same way as the power management rules for any other controller in the section.

If the bus tie breaker is open, the power management rules only apply to the section connected to Busbar A of the **BUS TIE breaker** controller.

8.1.9 System power management

System power management parameters apply to the whole application, and are configured under `System power management`. When you write changes in these parameters, the system power management parameters are automatically updated in **all** the controllers in the system.

8.1.10 Parallel operation

In general, parallel operation is when two or more power sources supply power to the same busbar. The frequency and voltage of the power sources must be synchronised in order for the breakers to close for parallel operation.

Rules for parallel operation

- Gensets or inverters can run in parallel with each other indefinitely.
- Generally, the shaft generator, shore connection and emergency genset run in parallel with the gensets or inverters for only the short time it takes to switch between them, and not for extended periods.
- Multiple shore connections can run in parallel with each other if multiple shore connections are enabled and they have the same power source.
- Shaft generators never run in parallel with each other if both are generating power.
- Multiple shaft generators can be connected to the same busbar if power take home is active.
- A shaft generator and a shore connection never run in parallel with each other.
  - The *SC-SG parallel* alarm trips the shore connection breaker if this ever occurs.
- The shaft generator can run in parallel with gensets or inverters indefinitely if a *Base load* control set point is used on the power from the shaft generator.
- The shore connection can run in parallel with gensets or inverters indefinitely if a *Base load* control set point is used on the power from the shore connection.

More information
See **each [Controller type]** for more information on parallel operation alarms.

Emergency genset: Test function

During the emergency genset test, the emergency genset can be configured to run in parallel with the rest of the system for a limited period. However, the emergency genset capacity is not included in the power management calculations while the test is running.

If a blackout occurs during an emergency genset test, the **EMERGENCY genset** controller ends the test immediately.

More information
See EMERGENCY genset test functions for how the test functions work.

Emergency genset: Harbour operation

When harbour operation is active in the **EMERGENCY genset** controller, the emergency genset is treated as if it is an ordinary genset, and can run in parallel with the other gensets indefinitely. During harbour operation, the **EMERGENCY genset** controller must be in AUTO mode. The emergency genset capacity is included in the power management calculations.

When harbour operation is active, the emergency genset is always first in the priority order. The power management system sends a start command to the emergency genset, if it is not running when harbour operation starts. The other gensets may be stopped, but the emergency genset keeps running to supply the busbar.

More information
See Harbour operation for how harbour operation works.

8.1.11 Manage missing controllers

For various reasons, communication may be lost with one or more of the controllers in the section. To protect the section, by default the power management automatically changes the remaining controllers to switchboard control. However, parameters are available so that you can configure a different response if one or more controllers are missing. You can set the minimum number of missing controllers before the mode is changed under `System > Monitoring > Missing controllers`.

NOTICE

Missing controllers

If controllers are missing, then the power management cannot know their operating information, including the breaker positions. Evaluate the risks before configuring these parameters.

Parameters

`System > Monitoring`

Parameter	Range	Notes
`Mode while controller missing`	• Switchboard control • No mode change	If the minimum number of controllers are missing: **Switchboard control** • The power management changes the mode of the remaining controllers to switchboard control. **No mode change** • The power management changes the mode of the remaining controllers to the mode specified in *PMS mode while controller missing*.
`PMS mode while controller missing`	• No mode change • MANUAL mode • AUTO mode	If the minimum number of controllers are missing, and *Switchboard control* is not specified in *Mode while controller missing*: **No mode change** • The power management does not change the mode of the remaining controllers. **MANUAL mode** • The power management changes the remaining controllers to MANUAL mode. **AUTO mode** • The power management changes the remaining controllers to AUTO mode.

8.2 Connected, consumed and available power

8.2.1 Power calculations

The controllers continuously calculate the **nominal**, **consumed** and **available power** for each section. The power management system (PMS) uses these values.

The controller uses two sets of power calculations:

- **PMS power**: The power sources that are under power management control and available for automatic power management functions in the section.
- **Connected power**: All the power sources in the section.

PMS power

PMS power is used for the power management calculations. PMS power only includes the power supplied by sources under PMS control.

The power is included in the PMS power calculations as follows:

- **GENSET** controller:
  - The controller is in AUTO mode.
  - The genset is running.
  - The generator breaker is closed (that is, the genset is connected).
- **HYBRID** controller:
  - The controller has PTO (Power Take Off) mode active.
    - Power is not included if the controller is in Standby or PTI mode.
  - The controller is in AUTO mode.
  - The inverter is running.
  - The inverter breaker is closed (that is, the inverter is connected).
- **EMERGENCY genset** controller:
  - The controller is in AUTO mode.
  - The genset is running.
  - The generator breaker and tie breaker are closed (that is, the genset is connected to the section).
- **SHAFT generator** controller:
  - The controller is under PMS control.
  - The breaker is closed.
    - **NOTE:** Power take home (PTH) is a load, and not included in the PMS power.
- **SHORE connection** controller:
  - The controller is under PMS control.
  - The breaker is closed.
    - **NOTE:** Ship-to-ship is a load, and not included in the PMS power.

Connected power

The connected power shows the overall supply and load situation for the section, without being restricted by the power management state of the power sources. It includes all the sources that are connected to the section (that is, breaker closed and supplying power).

The power from controllers under switchboard control is included in the connected power.

Nominal power

The nominal power (also called *P nom.*) is the power that the connected sources can supply.

For PMS power, the nominal power is the sum of the nominal power for the connected gensets in AUTO mode (and, if applicable, a shaft generator or shore connection under PMS control).

For connected power, the nominal power is the sum of the nominal power for the connected sources:

$$\text{Nominal power} = \Sigma \text{ Nominal power of connected sources}$$

Consumed power

The consumed power (also called *P used*) is produced by the gensets (and, if applicable, also the shaft generator and shore connection). The controllers can therefore use the sources' AC measurements to calculate the consumed power.

The consumed power calculations assume that no unknown power sources are connected to the busbar.

The consumed power is also the sum of the power consumed by all of the loads in the system, for example, motors, pumps and lighting.

For PMS power, the consumed power is the sum of the power produced by the connected sources in AUTO mode (and, if applicable, a shaft generator or shore connection under PMS control).

For connected power, the consumed power is the sum of the power produced by the connected sources.

Consumed power = Σ Power from sources

Available power

The available power (also called *P avail.*) is the difference between the nominal power and the consumed power.

For PMS power, the available power calculation uses the **connected consumed power**, and NOT the PMS consumed power. The PMS available power thus shows whether the PMS generators can meet the section's power needs. If a generator in MANUAL mode or under switchboard control is supplying the section, the PMS available power can be negative.

For connected power, the available power is the difference between the nominal power and the consumed power for the connected sources.

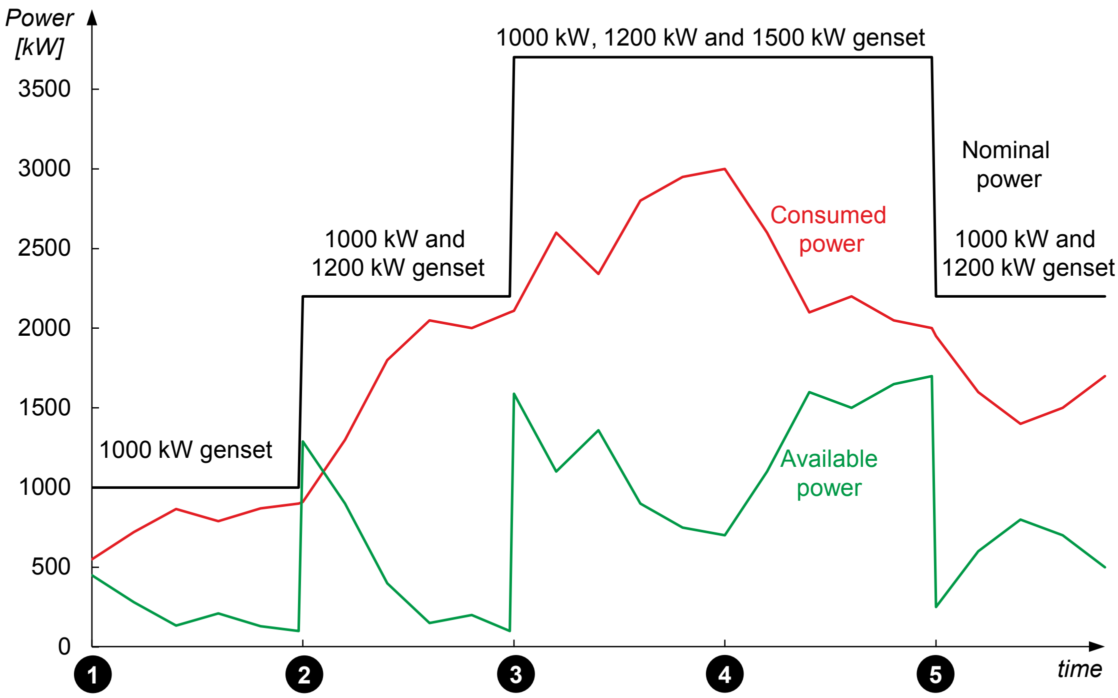
Available power = Nominal power - Total consumed power

The section can use the available power immediately, without starting more gensets. The section should always have some available power for sudden load increases.

Interaction between the power types

The following graph shows an example of how the nominal power, consumed power and available power could interact over time.

The example is a system with three gensets, with nominal powers of 1000 kW, 1200 kW and 1500 kW respectively.



1. At the start of the period, the 1000 kW genset is running.
2. The load gradually increases, and so the power management system starts the 1200 kW genset. The available power jumps up when the genset starts.
3. The load continues to increase, and so the power management system starts the 1500 kW genset.
4. The system runs, consuming power from all three gensets.
5. Towards the end of the period, the load decreases, so that the power management system stops the 1500 kW genset.

Available power delay

To avoid over-loading a connected genset when a new genset connects to the busbar, the power management system can communicate the new available power after a delay. When you delay communicating the new available power, the system has time to reduce the load on the genset that is already connected before the consumers increase the load on the busbar.

The Delay parameter delays the communication of the new available power to the display unit, CustomLogic, Modbus and other external components. The controllers in the system immediately know how much power is available and can perform load sharing immediately once a new genset connects.

`Local power management > Delays > P delay after genset connects`

Parameter	Range	Notes
`Delay`	0 to 30 s	The delay is not active for the first genset that connects to a busbar.

8.2.2 Power reservation

The power reservation inputs and parameters are used in the PMS available power calculation for the section. If these inputs and/or parameters are changed, the changes are broadcast to the rest of the section and also saved in the other controllers in the section.

NOTE Do not specify too much available power. The load-dependent start parameters ensure that the section normally has some available power. *Secured mode* and *Reserved power* each provide additional available power. Therefore *Secured mode* and *Reserved power* are not normally used simultaneously.

Secured mode

In *Secured mode*, the power management system (PMS) reduces the PMS power available by the nominal power of the largest connected genset:

Available power = Nominal power - Consumed power - Nominal power of the largest connected genset

Digital inputs

Function	I/O	Type	Details
`Power management > Activate secured mode`	Digital input	Pulse	Secured mode is activated in the section when this input is activated.
`Power management > Deactivate secured mode`	Digital input	Pulse	Secured mode is deactivated in the section when this input is activated.

If there have been conflicting secured mode digital input pulses in a section, then the most recent input is used.

Secured mode digital output (optional)

If you want the controller to activate a digital output when secured mode is activated, then assign this function to a digital output.

Function	I/O	Type	Details
`Power management > Secured mode active in section`	Digital output	Continuous	Activated when secured mode is active in the section.

Reserved power

For *Reserved power*, the power management reduces the PMS power available by the reserved power *Set point*:

Available power = Nominal power - Consumed power - Reserved power

Parameters

`Power management rules > Configuration # > Power reservation > Reserved power *`

Parameter	Range	Notes
`Enable`	Not enabled, Enabled	**Not enabled**: The PMS ignores the reserved power set point. Available power = Nominal power - Consumed power **Enabled**: The system subtracts the reserved power from the available power.
`Set point`	1 kW to 9 GW	The reserved power that the controller must subtract from the available power.

If this parameter is set too high, then heavy consumers might not be able to connect.

NOTE * # is 1 to 8.

8.2.3 Power analogue outputs

You can configure analogue outputs with functions for a power value in a section. The controller calculates these values from the information from all the controllers in the section.

Power value analogue outputs

Function	I/O	Units	Details
`Power management > Section | PMS P avail. [kW]`	Analogue output	0 kW to 10 MW	The available power to supply the total load in the section from gensets connected in AUTO mode.
`Power management > Section | PMS P used [kW]`	Analogue output	0 kW to 10 MW	The power used from gensets connected in AUTO in the section. Note: If you need the total power consumption in the section, use *Conn. P used*.

Function	I/O	Units	Details
`Power management > Section | PMS P nom. [kW]`	Analogue output	0 kW to 10 MW	The total nominal power for the gensets connected in AUTO mode in the section.
`Power management > Section | PMS P avail. [%]`	Analogue output	-100 to 100 %	The PMS available power as a percentage of the PMS nominal power in the section. This can be negative. For example, the gensets in AUTO mode cannot supply the whole load, and a generator under switchboard control is supplying power to the section.
`Power management > Section | PMS P used [%]`	Analogue output	-100 to 100 %	The PMS power used as a percentage of the PMS nominal power in the section.
`Power management > Section | Conn. P avail. [kW]`	Analogue output	0 kW to 10 MW	The total available power from all the connected generators in the section.
`Power management > Section | Conn. P used [kW]`	Analogue output	0 kW to 10 MW	The total load in the section.
`Power management > Section | Conn. P nom. [kW]`	Analogue output	0 kW to 10 MW	The total nominal power for the connected gensets in the section.
`Power management > Section | Conn. P avail. [%]`	Analogue output	-100 to 100 %	The total available power as a percentage of the connected nominal power in the section.
`Power management > Section | Conn. P used [%]`	Analogue output	-100 to 100 %	The load as a percentage of the connected nominal power in the section.
`Power management > Number of feeders connected in PMS`	Analogue output	Value	The number of feeders (DG or HYBRID) connected in PMS in AUTO mode to the busbar in the dynamic section.

Applications

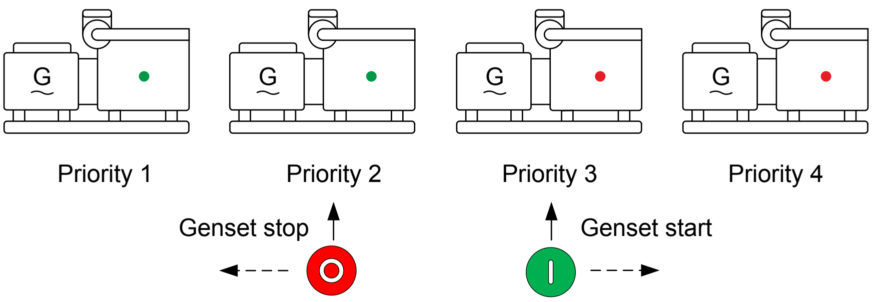
An analogue output with a power value may be wired to a switchboard instrument, to help with troubleshooting. For example, use `Section | PMS P avail. [%]` to troubleshoot load-dependent start and stop.

8.3 Genset priority

8.3.1 Genset start and stop priority order

Each genset has a priority that the power management can use to determine which genset to start (or stop) when a genset start (or stop) is needed. The operator can determine the genset priority. Alternatively, the power management can determine the genset priority.

The priorities are used to create a genset priority order, as shown in the following example. The gensets with priority 1 and 2 are running, while the gensets with priority 3 and 4 are stopped. All the **GENSET** controllers are in AUTO mode.



If a genset start is needed, the first non-running genset in the priority order is started. Note that the **GENSET** controller must also be in AUTO mode, and the genset must be *Ready for operation*.

In this example, the genset with priority 3 is started. If the genset fails to start, or if the power management needs another genset to start, the next genset in the order (the genset with priority 4) is started.

Similarly, if a genset stop is needed, the last running genset in the priority order is stopped. In this example, the genset with priority 2 is stopped.

NOTE Poorly selected genset priorities can lead to inefficient operation in a system that consists of gensets of different sizes. This is because the power management ensures that the gensets run according to their priority order, even if it is not the most efficient configuration.

Genset priority example

The system consists of genset A (1000 kW), genset B (500 kW) and genset C (200 kW). The system requires 800 kW.

- If genset A has priority 1, then only genset A will run to supply the load.
- However, if genset C has priority 1, and genset B priority 2, then all three gensets have to run. This is because the power management ensures that the gensets run according to their priority order to provide the power required by the load.

Priority in the system

The power management has one genset priority order, which includes all the **GENSET** controllers in the system. The genset priority order does not change when bus tie breakers open to create new sections. The order does not change when bus tie breakers close to join sections.

Priority in sections

Within a section, the power management uses the genset priority order for the **GENSET** controllers that are in the section.

If a bus tie breaker opens and splits the section, then the genset priority order for each section consists of only the **GENSET** controllers in each section.

Similarly, if a bus tie breaker closes to join two sections, then the genset priority order for the new section consists of all the **GENSET** controllers in the new section.

Priority in a section example

The system has six **GENSET** controllers. Gensets A, B and C are in section 1. Gensets D, E and F are in section 2. The bus tie breaker between sections 1 and 2 is open.

The genset priority order is:

- Genset F, priority 1
- Genset C, priority 2
- Genset D, priority 3
- Genset A, priority 4
- Genset B, priority 5
- Genset E, priority 6

For section 1, the genset priority order is: C, A, B. For section 2, the genset priority order is: F, D, E.

8.3.2 Priority selection method

`System power management > Priority > Selection`

Parameter	Range	Notes
`Method`	• Manual • Delayed priority shift • Dynamic • Running hours	**Manual**: The genset priority is defined using a digital input, a user-configured dashboard soft-key, or the Modbus interface. See Manual genset priority. **Delayed priority shift**: This is the same as *Manual priority*, however, after a change in priorities, the new priority order will not start (or stop) a genset until the next genset start (or stop) is required by power management. See Manual genset priority. **Dynamic**: Dynamic priority selection assigns the genset priority according to the order in which the gensets connect to the busbar. This genset priority selection method maximises system reliability by prioritising the gensets that start quickly and penalising slow starts and genset failure. See Dynamic genset priority . **Running hours**: The genset priority is assigned to ensure that the genset running hours are all within the same range or offset. The controller ignores the user-configured dashboard soft-key. See Running hours for genset priority.

8.3.3 Manual priority

The controller priorities are always synchronised. If you manually change the priority in one controller, then the priorities in all the other controllers are automatically updated.

If *Manual*, *Delayed priority shift* or *Dynamic* is selected as the priority selection method, then you can select the genset priorities manually. For *Manual* and *Delayed priority shift*, the priorities are only set by the operator, and the controllers do not automatically change the genset priorities.

A new genset priority order should be carefully considered, since it may cause genset starts and stops. You can select *Delayed priority shift* before changing the priority, to prevent genset starts and stops while changing the priority. If all the **GENSET** controllers are in MANUAL mode while you set the genset priority, this prevents unwanted automatic genset starts and/or stops.

Digital inputs (optional)

Function	I/O	Type	Details
`Power management > 1st priority`	Digital input	Pulse	This input makes the controller the first priority.
`Power management > Last priority`	Digital input	Pulse	The last priority request is a pulse signal. The controller becomes the last priority in the genset priority order.

More information
See **Last priority** for how this request works.

Setting the genset priority using the 1st priority input

You can set the genset priority manually by using the 1st priority input on the gensets in the reverse of the priority order you want. You can also use a user-configured dashboard soft-key or Modbus interface.

1st priority example

The system consists of gensets A, B, C and D. You want genset A to have priority 1, genset B to have priority 2, genset C to have priority 3 and genset D to have priority 4.

1. Activate the **1st priority** input or use a user-configured **1st priority** button on the dashboard on the controller in the following order: D, C, B, A. Wait about 10 seconds between each input activation.
2. The priority order is then A, B, C, D.

Alternatively, if a button is wired to a digital input, with the `Power management > 1st priority` function configured, then pressing this button has the same effect as as using a user-configured dashboard button.

Delayed priority shift

If *Delayed priority shift* is selected, then after a change, the new priority order only comes into effect during the next load-dependent start/stop. If this is not selected, changes to the priority order may immediately result in genset starts and stops, since the gensets that are running must correspond to the new genset priority order.

Delayed priority shift example

The priority order is A, B, C, D. The gensets are all the same size. Genset A is running.

The operator changes Genset A's priority to 3. The priority order is now B, C, A, D. When the power management requires a genset start, Genset B starts. At the same time, Genset C also starts. When Genset B and C are connected, and the load-dependent stop timer expires, then Genset A stops.

8.3.4 Dynamic priority

For *Dynamic* priority, the power management assigns the genset priority according to the order in which the gensets connect to the busbar. This genset priority selection method maximises system reliability by prioritising the gensets that start quickly and penalising slow starts and genset failure.

Manual genset priority inputs also change the dynamic genset priority.

There are no parameters specific to *Dynamic* priority.

Rules for dynamic genset priority selection

- Each genset's priority is according to the order in which it connects to the busbar. This applies to both AUTO and MANUAL mode. The first genset to connect gets priority 1, the second genset gets priority 2, and so on.
  - The controller also monitors the order in which the gensets connect during blackout recovery.
- If the operator puts a **GENSET** controller in MANUAL mode and opens the breaker, then that genset gets the lowest priority.
- If a genset breaker trips, then that genset gets the lowest priority. The gensets in the priority order behind that genset each move up one place.
- The dynamic genset priority also changes in response to inputs from the user-configured dashboard soft-key button on the **GENSET** controller display, as well as inputs from `Power management > 1st priority` digital input.

Dynamic genset priority example

The system consists of four gensets and the load requires one genset.

1. Genset A is running, and the priority order is A, B, C, D.
2. Genset A's breaker trips and there is a blackout.
3. The power management moves Genset A to the back of the priority order (because its breaker tripped). The new priority order is B, C, D, A.

4. The blackout recovery sequence sends commands to the first two gensets in the priority order to start (B and C). Genset C starts and connects to the busbar first. Genset B does not start. The blackout recovery sequence therefore starts and connects genset D.
5. The new priority order is C, D, A, B. This is because genset C connected first, and genset B did not start.

8.3.5 Running hours for priority

You can use running hours for priority to ensure that all the gensets have about the same running hours. This method checks the running hours at regular intervals. It places the gensets with the lowest running hours at the front of the priority order, while the gensets with the highest running hours are at the back of the priority order. If the genset priorities are different from the running gensets, the genset(s) with the lowest number of running hours is started, and the genset(s) with the highest number of running hours is stopped.

If two (or more) gensets have exactly the same number of running hours, the genset priority is decided using the controller *Controller ID* numbers. The controller with the lowest *Controller ID* has the first priority.

Parameters

`System power management > Priority > Running hours`

Parameter	Range	Notes
`Method`	• Total counter • Trip counter	**Total counter** • The priority is based on the total running hours for each genset. **Trip counter** • The priority is based on the running hours for each genset since the timer was last reset (similar to a trip meter in a car).
`Swap timer`	1 to 20000 h	The regular interval for re-evaluating the genset priority, based on running hours.

Total counter

By default, the priority order calculation is based on each genset's absolute running hours.

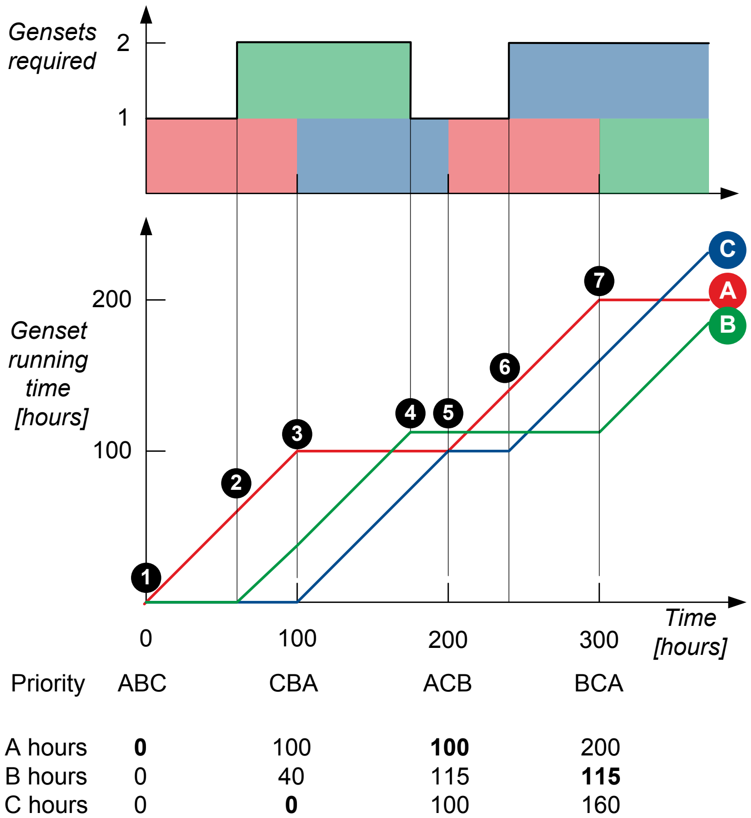
Trip counter

You can use `Trip counter` to avoid a situation where gensets with significantly different running times are over- or under-used. For example, if `Total counter` is used, then an older genset might not run at all until the newer gensets get up to the same number of running hours.

Example Swap timer for the Total and Trip methods

There are three gensets (A, B, C) in the system. The *Swap timer* is 100 hours. All the gensets have 0 running hours.

The following graph shows how the running hours priority determines which gensets run, as well as the effect when more than one genset is required.



The operation is as follows:

1. The genset priority is A, B, C. Genset A runs.
2. At 60 hours, the load increases, and an additional genset is required. Genset B starts.
3. The swap timer reaches 100 hours. The genset priority changes to C, B, A. Genset C starts. Genset A stops.
4. At 175 hours, the load decreases, and only one genset is required. Genset B stops.
5. The swap timer reaches 200 hours. The genset priority changes to A, C, B. Genset A starts. Genset C stops.
6. At 240 hours, the load increases, and an additional genset is required. Genset B starts.
7. The swap timer reaches 300 hours. The genset priority changes to B, C, A. Genset B starts. Genset A stops.

8.3.6 Priority digital outputs

This only applies to **GENSET** or **HYBRID** controllers.

You can configure a digital output with a function for the priority.

Digital outputs

Function	I/O	Type	Details
`Power management > Is first priority`	Digital output	Continuous	Activated when the controller has the first priority in the section.
`Power management > Is first standby`	Digital output	Continuous	Activated when the controller controls the first power source in the section that the power management system would attempt to connect when another power source is required.
`Power management > Is second standby`	Digital output	Continuous	Activated when the controller controls the second power source in the section that the power management system would attempt to connect when another power source is required.

8.3.7 Last priority

This only applies to **GENSET** or **HYBRID** controllers.

You can configure either a digital input or use a CustomLogic function to force the controller to be the last priority. Where multiple controllers get the command, then the last controller to get the command is the last priority. If another controller gets the command again after that, then the last controller becomes the last priority.

Digital input

Function	I/O	Type	Details
`Power management > Last priority`	Digital input	Pulse	The last priority request is a pulse signal. The controller becomes the last priority in the priority order.

8.4 Genset start and stop

8.4.1 How it works

The power management automatically starts and stops gensets. Gensets are started to ensure that the required power is always available. Gensets are stopped when enough power is available, for more efficient operation.

AUTO mode for automatic genset starts and stops

The load-dependent start function sends a genset start command when an additional genset is required to satisfy the system's power requirements. The load-dependent stop function sends a genset stop command when the system's power requirements will be satisfied even after that genset is stopped.

The load-dependent start function is active whenever at least one **GENSET** controller is in AUTO mode. However, the function will only start additional gensets when there are additional **GENSET** controllers are available in AUTO mode.

The load-dependent stop function is active whenever at two **GENSET** controllers are in AUTO mode. However, the power management will not stop the last connected genset.

Only **GENSET** controllers in AUTO mode are included in the available power calculations. Power from **GENSET** controllers that are in MANUAL mode is not included.

Section-based power management rules

The load-dependent start and stop function parameters are included in the section-based power management rules.

Overriding automatic genset stops

There may be times when you do not want the load-dependent stop function to be active (for example, during harbour manoeuvring). You can override load-dependent stops using a digital input (`Power management > Block load-dependent stop`).

Blackout and genset starts

The blackout recovery sequence responds immediately to a dead busbar. In contrast, a precautionary genset start responds to busbar instability.

More information
See Blackout recovery and Precautionary genset start.

The **EMERGENCY genset** controller response to a blackout is based on its own AC measurements. The **EMERGENCY genset** controller response is independent of the power management response.

More information
See EMERGENCY genset controller for more information on the **EMERGENCY genset** controller blackout response.

8.4.2 Load-dependent start configuration

Load-dependent start defines when the power management automatically starts gensets. The power management starts gensets when the section load increases, for example, if the operator starts some equipment. An additional *Protective start* setting can be configured to attempt to avoid unwanted starts of additional gensets due to a temporary situation. If you have heavy consumers that temporarily push the apparent power above 100% while starting, you might want to use active power instead.

If the PMS available power is negative, the power management starts another genset immediately, and does not wait for the load-dependent start timer.

These parameters apply to **GENSET** controllers in AUTO mode and **HYBRID** controllers in PTO mode.

You can configure up to 8 different configurations (# is 1 to 8).

Define the overall load-dependent start and stop configuration.

`Power management rules > Configuration # > Load-dependent start/stop > Configuration`

Parameter	Range	Notes
`Power selection`	• Calculation in P • Calculation in S	**Calculation in P** • The calculations are based on the active power (P). **Calculation in S** • The calculations are based on the apparent power (S).
`Method`	• Power • Percent	**Power** • The calculations are based on the PMS available active power in kW, or the PMS available apparent power in kVA. **Percent** • The calculations are based on the total consumed active (or apparent) power as a percentage of PMS nominal active (or apparent) power. **NOTE** The *Percent* method can be better if the genset sizes are very different.

Define the first set of start parameters. By default, the power management uses these parameters.

`Power management rules > Configuration # > Load-dependent start/stop > Start 1`

Parameter	Range	Notes
`Enable`	• Not enabled • Enabled	**Not enabled** • The power management ignores this set of parameters. **Enabled** • The power management uses this set of parameters.
`P available limit`	1 kW to 9 GW	*Calculation in P* and *Method* = *Power* must be selected, otherwise this parameter is ignored. If this amount of PMS power is not available for the delay period, the power management starts the next genset in the priority order.
`S available limit`	1 kVA to 9 GVA	*Calculation in S* and *Method* = *Power* must be selected, otherwise this parameter is ignored. If this amount of PMS apparent power is not available for the delay period, the power management starts the next genset in the priority order.

Parameter	Range	Notes
`Load limit`	1 to 100 %	*Method* = *Percent* must be selected, otherwise this parameter is ignored. The load percentage is the total power consumed, as a percentage of the PMS nominal power. If the load percentage exceeds this parameter for the *Delay* period, the power management automatically starts and connects another genset. If *Calculation in P* is selected, this limit is based on the percentage of active power. If *Calculation in S* is selected, this limit is based on the percentage of apparent power.
`Delay`	5 s to 1 h	If the load exceeds the limit for the whole of the delay period, then the power management starts the next genset in the priority order.

Define the second set of start parameters. By default, the power management ignores these parameters.

`Power management rules > Configuration # > Load-dependent start/stop > Start 2`

Parameter	Range	Notes
`Enable`	• Not enabled • Enabled	**Not enabled** • The power management ignores this set of parameters. **Enabled** • The power management uses this set of parameters for load-dependent start. The *Start 1* parameters can also be active. The controller starts an additional genset if this is required by either set of parameters.
`P available limit`	1 kW to 9 GW	*Calculation in P* and *Method* = *Power* must be selected, otherwise this parameter is ignored. If this amount of PMS power is not available for the delay period, then the power management starts another genset, according to the priority order.
`S available limit`	1 kVA to 9 GVA	*Calculation in S* and *Method* = *Power* must be selected, otherwise this parameter is ignored. If this amount of PMS apparent power is not available for the delay period, the power management starts another genset, according to the priority order.
`Load limit`	1 to 100 %	*Method* = *Percent* must be selected, otherwise this parameter is ignored. The load percentage is the total power consumed, as a percentage of the PMS nominal power. If the load percentage exceeds this parameter for the *Delay* period, then the power management automatically starts and connects another genset. If *Calculation in P* is selected, then this limit is based on the percentage of active power. If *Calculation in S* is selected, then this limit is based on the percentage of apparent power.
`Delay`	5 s to 1 h	If the load exceeds the limit for the whole of the delay period, the power management starts another genset, according to the priority order.

Example

Start load limit example

The system consists of three gensets. Genset A has a nominal power of 1000 kW. Gensets B and C each have a nominal power of 500 kW. The total power consumed in the system (that is, the load) is 900 kW. The *Power selection* is *Calculation in P*. The *Method* is *Percent*. The *Load limit* is 90 %.

Example 1: Gensets A and B are running. The total nominal power connected is Genset A nominal power + Genset B nominal power = 1500 kW.
The load percentage is 900 kW / 1500 kW = 0.6 = 60 %. The power management does not start another genset.

Example 2: Only Gensets B and C are running. The total power connected is 1000 kW. The load percentage is 900 kW / 1000 kW = 0.9 = 90 %. If the load percentage remains at 90 % (or more) for the *Delay* time, the power management starts another genset.

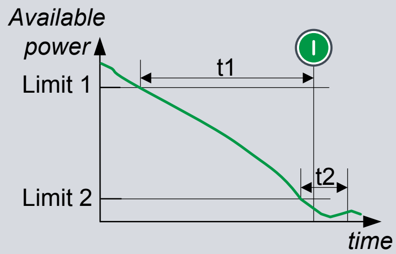
Two sets of load-dependent start parameters

You can use both sets of load-dependent start parameters:

- Configure one parameter set for low available power, with a long timer setting.
  - The timer period helps to ensure that the genset start really is needed.
- Configure the other parameter set with a low timer setting for very low available power.
  - This ensures that the power management responds quickly to a very low available power.

Two sets of start parameters example

The graph shows available power and time, with two sets of start parameters. In this example, Limit 1 is exceeded for Timer 1, and so the power management starts a genset.



Protective start

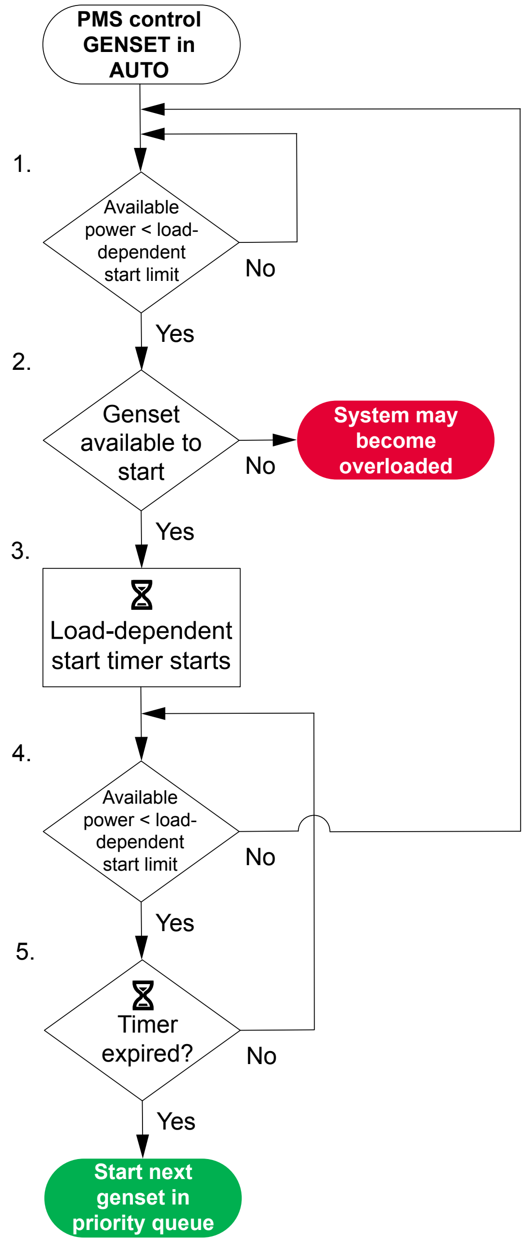
You can additionally configure a setting to use active power (kW), apparent power (kVA), or both. The default is both (kW and kVA).

In certain systems, you may want to avoid unwanted starts. For example, if you have heavy consumers that could push the apparent power above 100% while they are starting. In this situation, it might be useful to use active power (kW) for this setting.

`Power management rules > Configuration # > Load-dependent start/stop > Protective start`

Parameter	Range	Notes
`Protective start`	kW, kVA, kW and kVA	

8.4.3 Load-dependent start flowchart



1. The controller checks if the PMS available power is below the start limit.
2. The controller checks if a genset can be started.
   - If a genset cannot be started the system may become overloaded.
3. The controller starts the load-dependent start timer.
4. The controller checks if the PMS available power remains below the start limit.
5. If the timer expires the power management starts the next available genset in the priority order.

8.4.4 Load-dependent stop configuration

This configuration defines when the power management automatically stops gensets. The power management stops gensets when the section load decreases.

These parameters apply to **GENSET** controllers in AUTO mode and **HYBRID** controllers in PTO mode. You can configure up to 8 different configurations (# is 1 to 8).

Digital input (optional)

Name	I/O	Type	Details
`Power management > Block load-dependent stop`	Digital input	Continuous	The power management prevents load-dependent stops in the section while this input is activated.

Define the overall load-dependent start and stop configuration.

Power management rules > Configuration # > Load-dependent start/stop > Configuration

Parameter	Range	Notes
Power selection	• Calculation in P • Calculation in S	**Calculation in P** • The calculations are based on the active power (P). **Calculation in S** • The calculations are based on the apparent power (S).
Method	• Power • Percent	• **Power**: The calculations are based on the PMS available active power in kW, or the available apparent power in kVA. • **Percent**: The calculations are based on the total consumed active (or apparent) power as a percentage of PMS nominal active (or apparent) power. Note: The *Percent* method can be better if the genset sizes are very different.

Define the first set of stop parameters. By default, the power management uses these parameters.

Power management rules > Configuration # > Load-dependent start/stop > Stop 1

Parameter	Range	Notes
Enable	• Not enabled • Enabled	**Not enabled**: The power management ignores this set of parameters. **Enabled**: The power management uses this set of parameters.
P available limit	1 kW to 9 GW	*Calculation in P* and *Method* = *Power* must be selected, otherwise this parameter is ignored. If this amount of PMS power would be available for the *Delay* period if a genset was stopped, then the power management stops a genset, according to the priority order.
S available limit	1 kVA to 9 GVA	*Calculation in S* and *Method* = *Power* must be selected, otherwise this parameter is ignored. If this amount of PMS apparent power would be available for the *Delay* period if a genset was stopped, then the power management stops a genset, according to the priority order.
Load limit	1 to 100 %	*Method* = *Percent* must be selected, otherwise this parameter is ignored. For the stop *Load limit*, the load percentage is the total power consumed, as a percentage of the PMS nominal power that would be connected **if a genset was stopped**. If the load percentage is lower than this limit for the *Delay* period, then the power management automatically disconnects and stops a genset. If *Calculation in P* is selected, then this limit is based on the percentage of active power. If *Calculation in S* is selected, then this limit is based on the percentage of apparent power.
Delay	5 s to 1 h	If the load is less than the limit for the whole of the *Delay* period, then the power management stops a genset, according to the priority order.

Define the second set of stop parameters. By default, the power management ignores these parameters.

Power management rules > Configuration # > Load-dependent start/stop > Stop 2

Parameter	Range	Notes
Enable	• Not enabled • Enabled	**Not enabled**: The power management ignores this set of parameters.

Parameter	Range	Notes
		Enabled: The power management uses this set of parameters for load-dependent stop. The *Stop 1* parameters can also be active. The controller will stop a genset if either set of parameters allow the stop.
`P available limit`	1 kW to 9 GW	*Calculation in P* and *Method* = *Power* must be selected, otherwise this parameter is ignored. If this amount of PMS power would be available for the *Delay* period if a genset was stopped, then the power management stops a genset, according to the priority order.
`S available limit`	1 kVA to 9 GVA	*Calculation in S* and *Method* = *Power* must be selected, otherwise this parameter is ignored. If this amount of PMS apparent power would be available for the *Delay* period if a genset was stopped, then the power management stops a genset, according to the priority order.
`Load limit`	1 to 100 %	*Method* = *Percent* must be selected, otherwise this parameter is ignored. For the stop *Load limit*, the load percentage is the total power consumed, as a percentage of the PMS nominal power that would be connected **if a genset was stopped**. If the load percentage is lower than this limit for the *Delay* period, then the power management automatically disconnects and stops a genset. If *Calculation in P* is selected, then this limit is based on the percentage of active power. If *Calculation in S* is selected, then this limit is based on the percentage of apparent power.
`Delay`	5 s to 1 h	If the load would be less than the limit for the whole of the *Delay* period if a genset was stopped, the power management stops a genset, according to the priority order.

Example

Stop load limit example

The system consists of three gensets. Genset A has a nominal power of 1000 kW. Gensets B and C each have a nominal power of 500 kW. The priority is A, B, C. The total power consumed in the system (that is, the load) is 700 kW. The *Power selection* is *Calculation in P*. The *Method* is *Percent*. The *Load limit* is 60 %.

Example 1: Gensets A, B and C are running. For the load percentage calculation, the total nominal power connected if genset C was stopped is Genset A nominal power + Genset B nominal power = 1500 kW.
The load percentage is 700 kW / 1500 kW = 0.47 = 47 %. If the load percentage remains below the *Load limit* for the *Delay* time, the power management stops genset C.

Example 2: Only gensets A and B are running. For the load percentage calculation, the total nominal power connected if Genset B was stopped is Genset A nominal power = 1000 kW. The load percentage is 700 kW / 1000 kW = 0.7 = 70 %. The power management does not stop genset B.

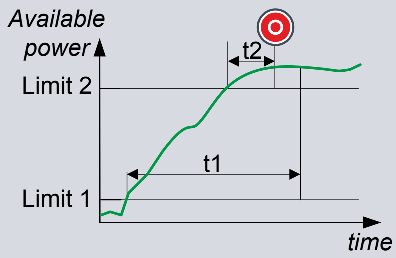
Two sets of load-dependent stop parameters

You can use both sets of load-dependent stop parameters:

- Configure one parameter set for high available power, with a long timer setting.
  - The timer period helps to ensure that the genset stop really is needed.
- Configure the other parameter set with a low timer setting for very high available power.
  - This ensures that the power management responds quickly to a very high available power.

Two sets of stop parameters example

The graph shows available power and time, with two sets of stop parameters. In this example, Limit 2 is exceeded for Timer 2, and so the power management stops a genset.

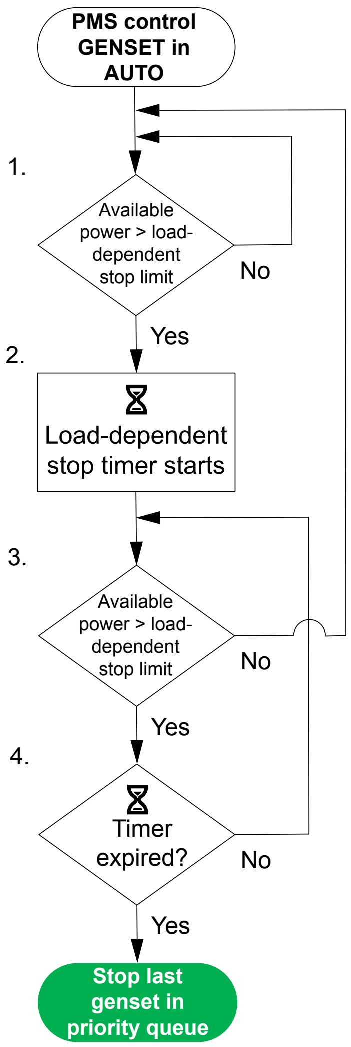


Conditions that block load-dependent stops

The following can block load-dependent stops in the section:

- The load-dependent stop will mean that the minimum number of gensets are not running
  - See `Power management rules > Configuration # > Number of gensets connected > Minimum`
- A heavy consumer is active, and *Block stop when active* is enabled.
  - See `Power management rules > Configuration # > Load dependent start/stop > Heavy consumer > Block stop when active`
- The digital input function *Block load dependent stop* is assigned, and the digital input is activated.
  - See `Power management > Block load-dependent stop`

8.4.5 Load-dependent stop flowchart



1. The controller checks if the PMS available power is more than the stop limit.
   - The load-dependent stop limit + the nominal power of the lowest priority running genset.
2. The controller starts the load-dependent start timer.
3. The controller checks if the PMS available power remains below the start limit.
4. If the timer expires the power management stops the last running genset in the priority order.

8.4.6 Power method for load-dependent start and stop

For the *Power* method, the power management starts or stops gensets with **GENSET** controllers in AUTO mode, based on the section's PMS available power.

The *Power* method may be based on active power (P, in kW) (*Calculation in P*) or apparent power (S, in kVA) (*Calculation in S*). The available power genset start and stop function calculations are the same for apparent power as they are for active power.

Calculation in S is typically selected if the connected load is inductive and the power factor is below 0.7.

The following example shows how the parameters interact with the PMS nominal power, connected consumed power and PMS available power.

Load-dependent start

If the PMS available power is less than the *Load-dependent start* limit for the specified time, then the first genset that is ready to start (in the priority order) is started and connected.

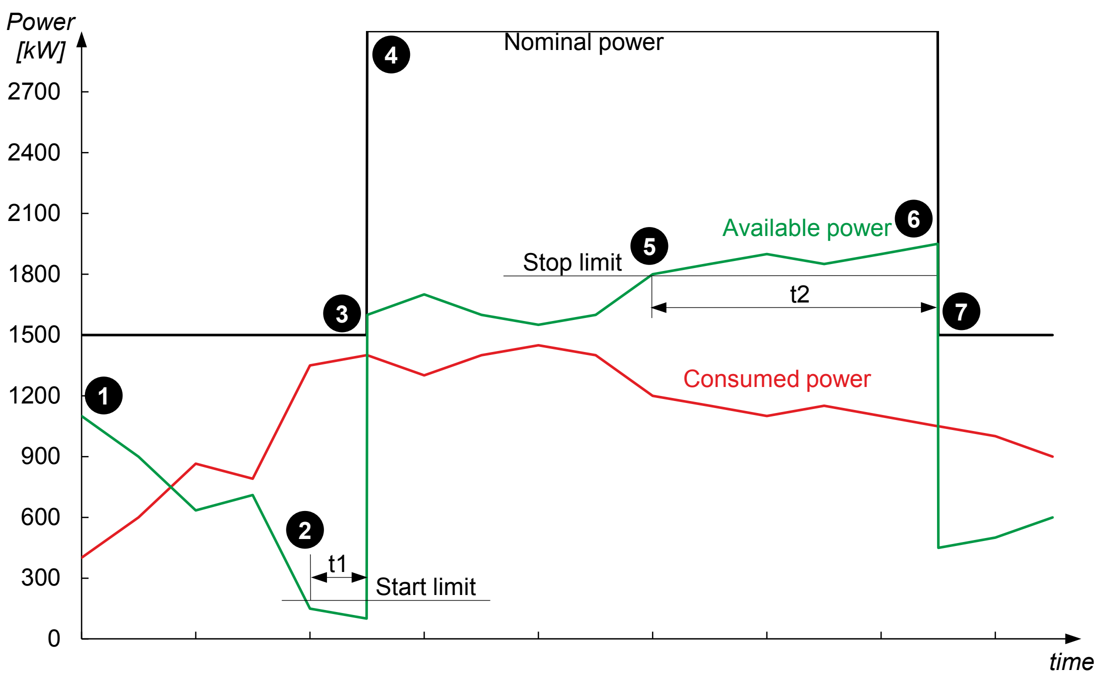
Load-dependent stop

The power management calculates what the PMS available power would be if the connected genset that is last in the priority order is stopped. If this is higher than the *Load-dependent stop* limit for the specified time, that genset will be stopped.

Example

The system consists of two gensets, each with a nominal power of 1500 kW. The load-dependent start set point is 150 kW. The load-dependent stop set point is 300 kW.

- The load-dependent start delay (t1) is 1 minute.
- The load-dependent stop delay (t2) is 5 minutes.



1. One genset is running and the PMS nominal power is 1500 kW. The consumed power rises, and so the PMS available power drops.
2. The PMS available power is 150 kW. The load-dependent start timer starts.
3. The PMS available power remains below 150 kW, and so the power management sends a command to the second genset to start.

4. The second genset starts, and both gensets supply the load.
5. The consumed power drops to 1200 kW. The PMS available power is now 1800 kW. This is equal to the nominal power of the genset that is last in the priority order plus the load-dependent stop set point. Therefore, the load-dependent stop timer starts.
6. The PMS available power remains above 1800 kW, and so the power management send a command to the second genset to stop.
7. The second genset stops, and the first genset supplies the load.

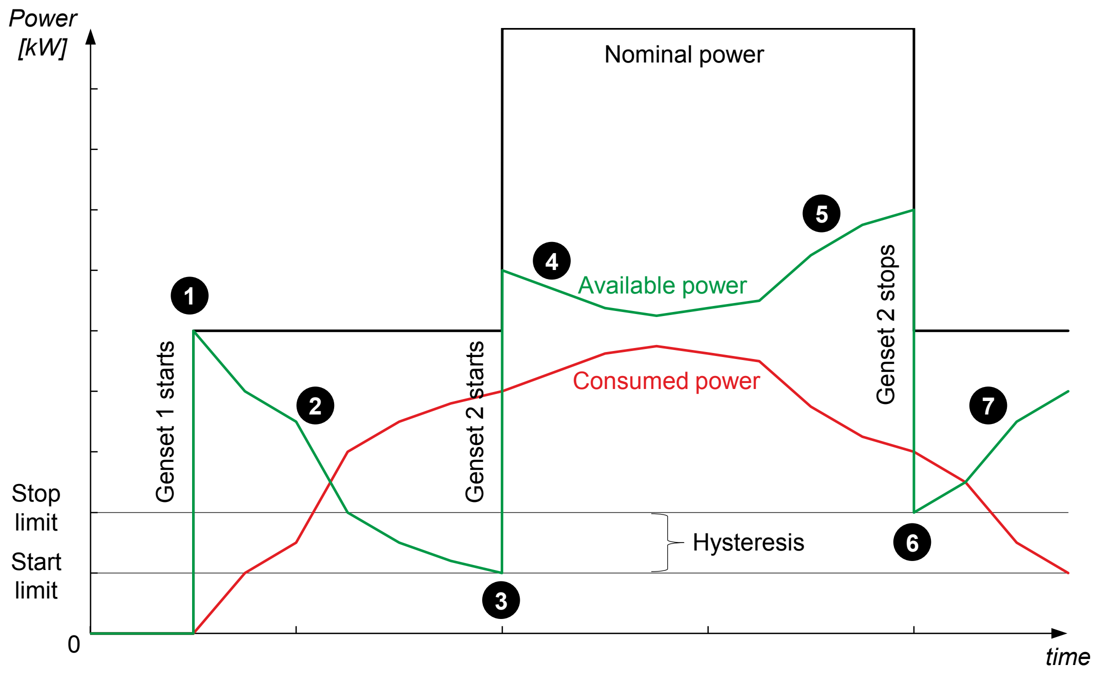
8.4.7 Power method and hysteresis

For the power method:

Hysteresis = Load-dependent stop limit - Load-dependent start limit

For stable operation, the load-dependent stop limit must be larger than the load-dependent start limit.

The following graph of PMS available power shows an example of the hysteresis between the stop and start for the power method. The section consists of two equally sized gensets. The start and stop delays are 0 seconds. At the beginning of the period shown on the graph, the section is not powered.



1. The PMS available power jumps up when genset 1 starts and connects to the busbar.
2. As time passes, the section load increases, which makes the PMS available power fall.
3. The PMS available power falls until it reaches the load-dependent start limit. Genset 2 is started.
4. The PMS available power jumps up when genset 2 starts, then drops as the section load continues to increase.
5. The section load decreases, and the available power increases, until PMS available power = genset 2 nominal power + load-dependent stop limit.
6. Genset 2 stops. The PMS available power drops to the load-dependent stop limit.
7. The section load continues to decrease, and the PMS available power continues to increase.

8.4.8 Percent method for load-dependent start and stop

For the *Percent* method, the power management starts/stops gensets with **GENSET** controllers in AUTO mode based on the load measured at each genset.

The controller calculates the genset load percentage:

Genset load percentage = Measured genset load / Nominal genset power

The *Percent* method is a simple, robust method. However, the available power is proportional to the section load. The available power may therefore be too low at low loads, and/or too high at high loads. If this is a problem, use the *Power* method.

Load-dependent start

If the genset load percentage is higher than the *Load-dependent start* limit, then the first genset that is ready to start (in the priority order) is started and connected.

Load-dependent stop

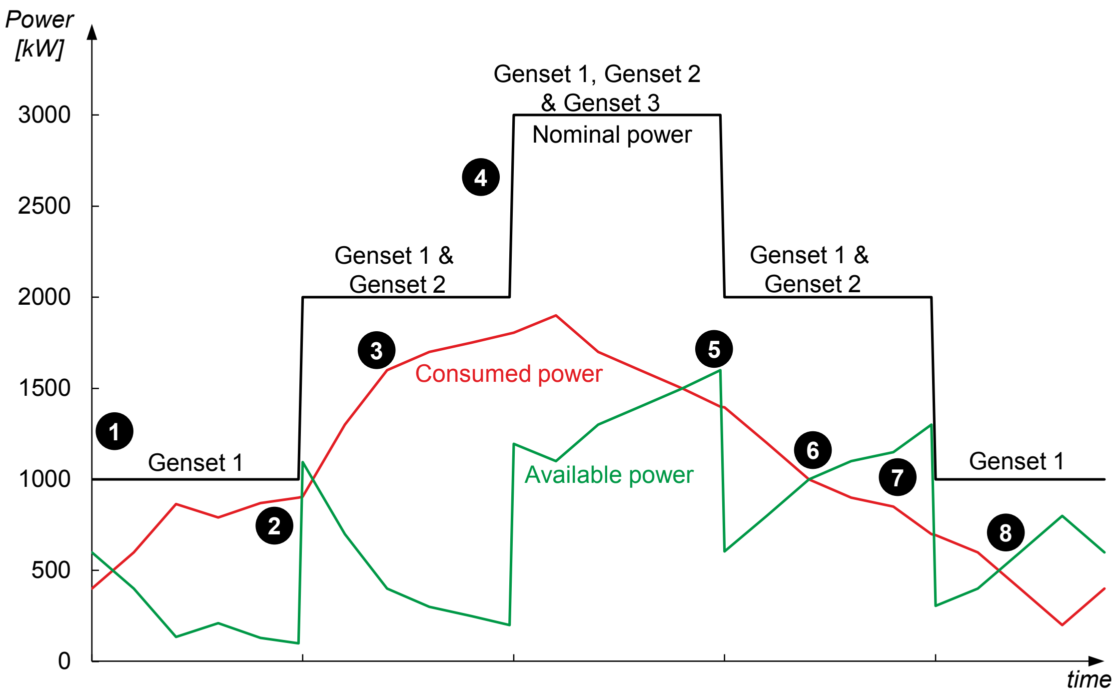
The power management calculates what the genset load percentage would be if the connected genset that is last in the priority order is stopped. If this is lower than the *Load-dependent stop* limit, that genset will be stopped.

Example

The following graph shows how the genset load percentage start and stop function works. The system consists of three 1000 kW gensets that use load sharing.

Genset load-dependent start limit: 90 %

Genset load-dependent stop limit: 70 %



1. Genset 1 is running.
2. The load builds up until it reaches 900 kW, which is 90 % of genset 1's nominal power. The power management starts the next genset in the priority order.
3. Genset 2 starts, and the load builds up until it reaches 1800 kW, which is 90 % of the nominal power for genset 1 and genset 2. The power management starts the next genset in the priority order.
4. Genset 3 starts, and gensets 1, 2 and 3 run. After a while the load starts to decrease.
5. The load reaches 1400 kW, which is 70 % of the nominal power for genset 1 and genset 2, after genset 3 is stopped. The power management therefore stops the last running genset in the priority order.
6. Genset 3 stops, and gensets 1 and 2 run. The load decreases.

7. The load reaches 700 kW, which is 70 % of the nominal power for genset 1, after genset 2 is stopped. The power management therefore stops the last running genset in the priority order.
8. Genset 2 stops, and genset 1 runs. The load is less than 90 %, so no additional gensets start. There are no other running gensets, so the genset stop function is inactive.

8.4.9 Percent method and hysteresis

For the percent method the load-dependent start and stop hysteresis depends on:

- The nominal power of the gensets
- The priority of the gensets
- The number of connected gensets
- The load-dependent stop limit must be LOWER than the load-dependent start limit.

Equally sized gensets example

The section has three 1000 kW gensets. The priority order is A, B, C. `Start 1 > Load limit` is 90 %, and `Stop 1 > Load limit` is 70 %.

Genset A always runs.
Genset B starts when the load is 900 kW, and stops when the load is 700 kW. The hysteresis is 200 kW.
Genset C starts when the load is 1800 kW, and stops when the load is 1400 kW. The hysteresis is 400 kW.

Different gensets example

Genset A has a nominal power of 2000 kW and has first priority. Genset B has a nominal power of 1000 kW and has second priority. Genset C has a nominal power of 500 kW and has third priority. `Start 1 > Load limit` is 90 %, and `Stop 1 > Load limit` is 70 %.

Genset A always runs.
Genset B starts when the load is 1800 kW, and stops when the load is 1400 kW. The hysteresis is 400 kW.
Genset C starts when the load is 2700 kW, and stops when the load is 2100 kW. The hysteresis is 600 kW.

8.4.10 Non-connected genset

The non-connected genset function stops a genset from running for too long without connecting. The function is only active when the controller is in AUTO mode. That is, if a genset is running with its breaker open, this function stops the genset when its timer expires.

The function may be needed in the following situations:

- The operator first starts the genset with the **GENSET** controller in MANUAL mode, and then switches to AUTO mode.
- There has been a precautionary genset start, but the busbar stabilised, and the started genset was not needed.

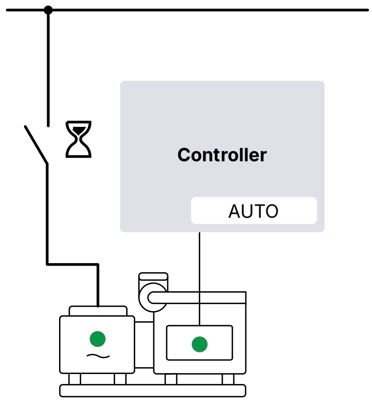
`Local power management > Non-connected genset > Stop timer`

Parameter	Range	Notes
`Delay`	10.0 s to 10 min	The timer starts when both of these conditions are met: 1. The genset start sequence is finished. 2. The genset is ready to connect. The timer resets if any of the following happens: • The breaker close sequence starts. • The stop sequence starts. • There is a genset alarm. When the timer expires, the controller stops the genset engine.

How the non-connected genset function works

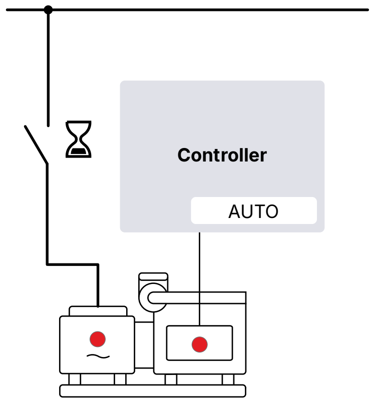
Non-connected genset running in AUTO

The timer starts ....



... the timer expires.

The power management stops the genset.



8.4.11 Precautionary genset start

During critical operations, you may want to have a genset running and ready to connect. You can therefore configure an input with the *Precautionary genset start* function.

In addition, for busbar frequency and voltage alarms, the power management system automatically starts a genset as a precaution.

There is a maximum of one precautionary genset start per section. That is, only one genset starts when the section has more than one activated *Precautionary genset start* inputs and/or multiple alarm conditions for a precautionary genset start. The display unit for the **GENSET** controller shows the controller status text: **Precautionary standby**.

How the precautionary genset start works

When a precautionary genset start is needed, the power management system automatically starts the first available genset in the priority order for the section. However, the power management system does not connect the genset (that is, the generator breaker does not close). This genset acts as a running standby.

If a precautionary genset start is needed, and the power management system or an operator closes the generator breaker of the running standby, then the power management system starts the next genset in the priority list as the running standby.

If the power management system disconnects a higher priority genset, then that genset becomes the running standby. The lower priority genset is treated as a non-connected genset.

When the input or the alarm is deactivated, then the running standby is not needed. The genset runs until the *Local power management > Non-connected genset > Stop timer > Delay* timer expires and the power management system stops the genset. Alternatively, an operator or external signal can put the controller into MANUAL mode and stop the genset.

NOTE Precautionary genset start does not start the emergency genset.

Precautionary genset start based on an input

You can wire this input to any **GENSET** controller(s) in the section.

Table 8.1 Digital input (optional)

Function	I/O	Type	Details
`Power management > Precautionary genset start`	Digital input	Continuous	When this digital input is activated, the power management system ensures that there is a running standby in the section.

Precautionary genset start in section digital output

Table 8.2 Digital output (optional)

Function	I/O	Type	Details
`Power management > Precautionary genset start in section`	Digital output	Continuous	Activated when the precautionary genset start is active in the section.

Precautionary genset start based on an alarm

When a controller activates a busbar voltage or frequency alarm, the power management system automatically starts the first available genset in the priority order. However, the power management system does not connect the genset. The genset start is a precaution, for rapid recovery if there is blackout, or if more power is needed.

By default, all the busbar alarms for a **GENSET** controller include the *Generator breaker open* inhibit. Therefore, only the connected gensets activate busbar alarms, and thus a precautionary genset start. Note that the power management system starts only one genset, even though there might be multiple busbar alarms.

Voltage alarms that activate a precautionary genset start

Voltage alarms
Busbar over-voltage 1
Busbar over-voltage 2
Busbar under-voltage 1
Busbar under-voltage 2

Frequency alarms that activate a precautionary genset start

Frequency alarms
Busbar over-frequency 1
Busbar over-frequency 2
Busbar under-frequency 1
Busbar under-frequency 2

The precautionary genset start is based on the busbar voltage and frequency alarms. You cannot disable the precautionary genset start based on an alarm. However, you can change the busbar voltage and frequency alarm parameters.

8.4.12 Number of gensets connected

These parameters determine the *Maximum* and *Minimum* number of connected gensets required for the section.

Maximum

Defines the maximum number of gensets connected for **GENSET** controllers in AUTO mode.

NOTICE
Blackout due to insufficient power. This parameter could cause a blackout due to insufficient power. If the maximum number of gensets are already connected, the controllers will not automatically connect additional gensets.

`Power management rules > Configuration # > Number of gensets connected > Maximum`

Parameter	Range	Notes
`Enable`	• Not enabled • Enabled	**Not enabled** • The power management system ignores this limit. **Enabled** • The power management system uses this limit.
`Set point`	1 to 64	In AUTO mode, the load-dependent start function will not start another genset if this would result in more gensets running than this set point. This parameter only applies to the number of connected **GENSET** controllers in AUTO mode. The system is limited to a maximum of 12 controllers.

Minimum

Defines the minimum number of gensets connected with their **GENSET** controllers in AUTO mode. Note that gensets with **GENSET** controllers in MANUAL mode or in switchboard control are not included. You can use these parameters to guarantee a minimum level of power available.

`Power management rules > Configuration # > Number of gensets connected > Minimum set [1/2]`

Parameter	Range	Notes
`Enable`	• Not enabled • Enabled	**Not enabled** • The power management system ignores this limit. **Enabled** • The power management system uses this limit.
`Set point`	0 to 32	The minimum set point. The power management system starts more gensets if fewer gensets are connected than this set point. The load-dependent stop function does not stop another genset if this would result in fewer connected gensets than this set point. The minimum number of gensets continue to run, even if the load is low and the load-dependent stop function otherwise would stop one or more gensets.

8.5 Blackout

8.5.1 Blackout and blackout recovery conditions

Blackout recovery is the power management system's attempt to recover from a blackout by connecting to another power source, or starting one or more gensets automatically, when a dead busbar is detected.

When there is at least one controller under power management control, the blackout recovery sequence always responds to a blackout and cannot be disabled.

Blackout conditions

A blackout is present if the following conditions are all met, **at all controllers** in the section *:

- The phase-to-phase voltage is less than 10 % of the nominal voltage (V_{L-L} < 10 % of V_{nom}).
  - This percentage is fixed.
  - If one or more controllers in the section do not detect a blackout, the controller(s) that detected the blackout activate the *Blackout detection mismatch* alarm.
- The generator breakers are open.
  - That is, there are no gensets, shaft generator or shore connections connected.
- The blackout detection delay timer has run out (`Busbar > AC setup > Blackout detection > Blackout delay`).

NOTE * If a controller cannot communicate with the other controllers in the section, then that controller is forced to switchboard control (and does not start blackout the blackout recovery sequence).

If one or more of the blackout conditions disappear, there is no longer a blackout.

Conditions that prevent blackout recovery

If any of the following conditions are present in the section, the power management will not start the blackout recovery sequence:

- A digital input is configured with the `Power management > Block blackout start` function, and activated.
- A breaker position is unknown.
- There is a short circuit.
  - A digital input with the function `Breakers > [Breaker] > Feedback > [*B] short circuit` was activated.
  - The parameter `Power management rules # > Blackout > Short circuit close attempts` *, allows at most one short circuit in the section. The controller that detected the short circuit cannot close its breaker. However, one other controller in the section can try once to close its breaker during blackout recovery.
- There is a blocking alarm.
  - The alarm action determines whether the alarm is a blocking alarm.
- All of the controllers that could be part of the blackout recovery are under switchboard control.

NOTE * # is 1 to 8.

More information

See Switchboard control for information on events that force controllers in switchboard control.

8.5.2 Blackout recovery configuration

When a blackout is detected, all **GENSET** controllers or **HYBRID** controllers in PTO that are in MANUAL mode are changed to AUTO mode.

Digital input (optional)

Function	I/O	Type	Details
`Power management > Block blackout start`	Digital input	Continuous	Blackout recovery is prevented in any section where this input is activated.

Parameters for GENSET or HYBRID controllers

`Local power management > Blackout`

Parameter	Range	Notes
`Allow blackout recovery`	• Not enabled • Enabled	**Not enabled** • The power management system does not attempt to close the inverter breaker if a blackout is detected. **Enabled**

Parameter	Range	Notes
		• When a blackout is detected, the inverter breaker can close automatically if the inverter voltage and frequency are okay. The blackout recovery sequence first tries to restore power by: 1. Closing the bus tie breaker with auto close. 2. Connecting inverters with allow blackout recovery. 3. Connecting gensets with allow blackout recovery. 4. Connecting shaft generator with auto close. 5. Connecting shore connection with auto close.

Parameters for SHAFT generator controllers

`Local power management > Blackout > Blackout close`

Parameter	Range	Notes
`Enable SG blackout close`	• Not enabled • Enabled	**Not enabled** • The power management system does not attempt to close the shaft generator breaker if a blackout is detected. **Enabled** • When a blackout is detected, the shaft generator breaker can close automatically if the shaft generator voltage and frequency are okay. The blackout recovery sequence first tries to restore power by: 1. Closing the bus tie breaker with auto close. 2. Connecting inverters with allow blackout recovery. 3. Connecting gensets with allow blackout recovery. 4. Connecting shaft generator with auto close. 5. Connecting shore connection with auto close.

Parameters for SHORE connection controllers

`Local power management > Blackout > Blackout close`

Parameter	Range	Notes
`Enable SC blackout close`	• Not enabled • Enabled	**Not enabled** • The power management system does not attempt to close the shore connection breaker if a blackout is detected. **Enabled** • When a blackout is detected, the shore connection breaker can close automatically if the shore connection voltage and frequency are okay. The blackout recovery sequence first tries to restore power by: 1. Closing the bus tie breaker with auto close. 2. Connecting inverters with allow blackout recovery. 3. Connecting gensets with allow blackout recovery. 4. Connecting shaft generator with auto close. 5. Connecting shore connection with auto close.

Parameters for BUS TIE breaker controllers

`Local power management > Blackout close`

Parameter	Range	Notes
`Enable BTB blackout close`	• Not enabled • Enabled	**Not enabled** • The power management system does not attempt to close the bus tie breaker if a blackout is detected. **Enabled** • When a blackout is detected on either busbar, the bus tie breaker can close automatically if the voltage and frequency are okay on one of the busbars. The blackout recovery sequence first tries to restore power by: 1. Closing the bus tie breaker with auto close. 2. Connecting inverters with allow blackout recovery. 3. Connecting gensets with allow blackout recovery. 4. Connecting shaft generator with auto close. 5. Connecting shore connection with auto close.

Other parameters

`Local power management > Return modes > After blackout`

This parameter is only visible in **GENSET** controllers. The **GENSET** controllers may each have different settings for this parameter.

Parameter	Range	Notes
`Mode`	• No mode change • MANUAL mode • AUTO mode	This parameter selects the controller mode after the blackout. **No mode change** • The **GENSET** controller mode is the same as before the blackout. **MANUAL mode** • The **GENSET** controller is changed to MANUAL mode after the blackout. **AUTO mode** • The **GENSET** controller remains in AUTO mode after the blackout.

`Power management rules > Configuration # > Blackout > Blackout recovery` *

Parameter	Range	Notes
`Number of gensets to start`	1 to 64	The power management system attempts to start this number of gensets, according to the priority order. The power management system connects all the gensets that start. If a genset fails to start, the power management system tries to start the next genset, until the required number of gensets have started. If more gensets are connected than the load requires, the load-dependent stop timer starts. When the timer runs out, the power management system automatically stops the gensets that are not required.

`Power management rules > Configuration # > Blackout > Short circuit close attempts` *

Parameter	Range	Notes
`Set point`	0 to 1	**0** close attempts • The power management system will not close any breakers to connect to a system where a short circuit was detected.

Parameter	Range	Notes
		• The tripped breaker must first be reset. • The *GB short circuit* alarm must be acknowledged and the latch reset. **1** close attempt: • **In exceptional circumstances**, you may change this parameter to allow one breaker to attempt to close, even though a short circuit was detected by another breaker. • The breaker that detected the short circuit cannot close. However, one other controller in the section can try (once) to close its breaker during the blackout recovery.

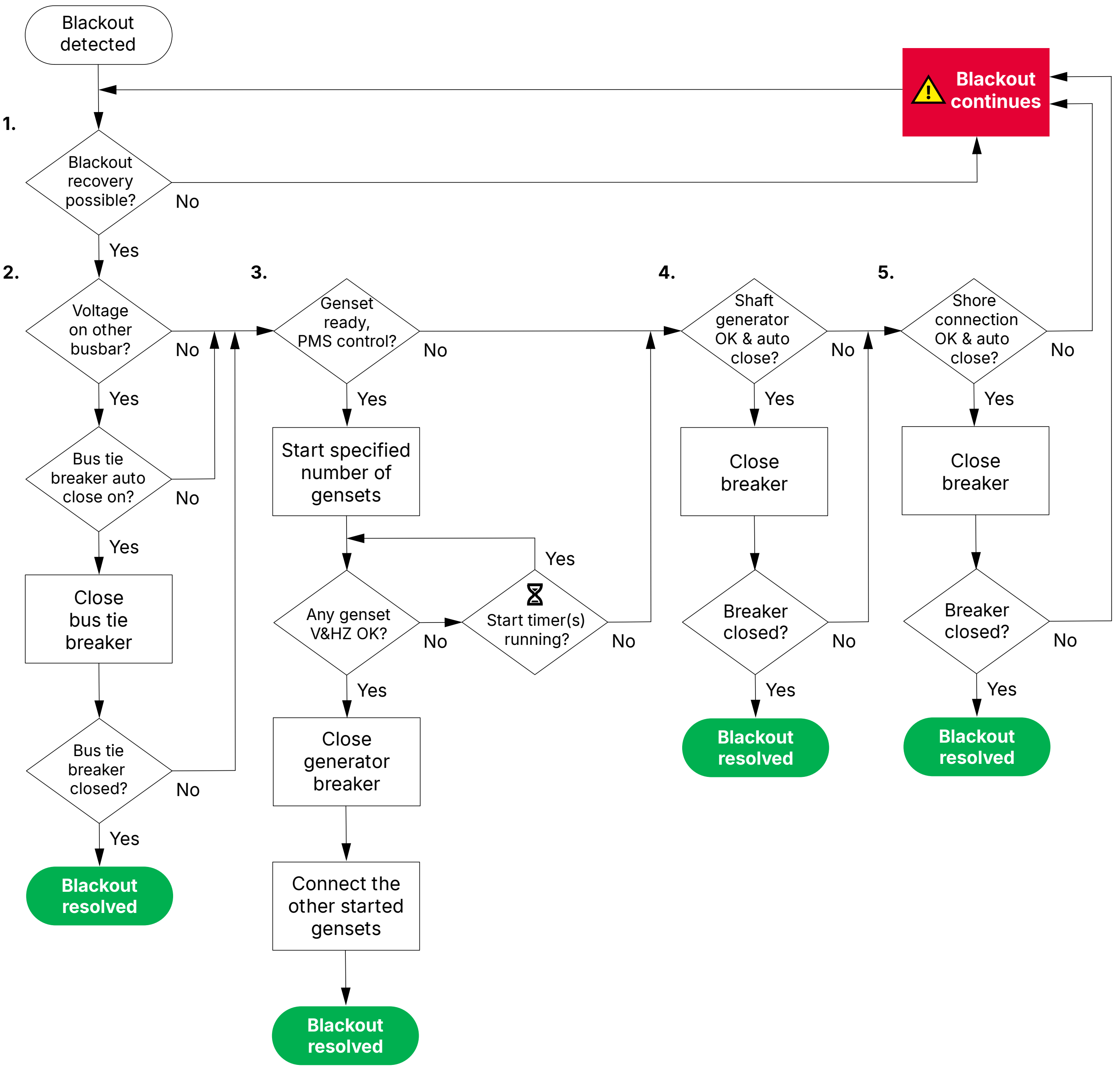
NOTE * # is 1 to 8.

Alarms

More information
See Blackout detection mismatch for more information about the alarm.

More information
See Action suppressed for information about suppressing alarm actions during blackout recovery.

8.5.3 Blackout recovery flowchart



1. After a blackout is detected, the power management checks whether blackout recovery is possible. If any conditions that prevent blackout recovery are present, then the blackout recovery is not attempted.
2. The power management checks whether there is power on another busbar.
   - If there is power on another busbar, and the bus tie breaker can be closed automatically, the controller sends the signal to the bus tie breaker to close. This resolves the blackout.
   - If there is no other busbar, or if the bus tie breaker cannot be closed automatically, or if the bus tie breaker fails to close, the controller attempts to use genset start to resolve the blackout.
3. The power management checks whether there are any **GENSET** controllers under power management control, with gensets ready to start.
   a. The power management changes all **GENSET** controllers in MANUAL mode to AUTO mode.
   b. The power management sends a start signal to the number of gensets specified, according to their position in the genset priority order. Gensets that are not ready to start are not sent a start signal.
   c. The power management sends the first genset that has running feedback and its voltage and frequency within range an acknowledge signal. The first genset closes its breaker immediately. If the breaker does not close within the *Closing failure* time, the breaker close signal is sent to the next genset to start.

d. Any other gensets that start are synchronised to the busbar, and their breakers are closed.
e. The blackout is resolved when a genset has successfully connected to the busbar. The power management controller switches back to normal operation. All the gensets that were sent a start signal are allowed to start and connect to the busbar. After the load-dependent stop timer expires, the power management controller will stop the lowest priority gensets if they are not required to power the load.

4. If the genset starts do not resolve the blackout, the power management checks whether a shaft generator with auto close ON is present and OK to supply power.
   - Yes: The power management sends a breaker close signal to the controller. If the breaker closes, the blackout is resolved.
5. The power management checks whether a shore connection with auto close ON is present and OK to supply power.
   - Yes: The power management sends a breaker close signal to the controller. If the breaker closes, the blackout is resolved.

More information
See Shaft generator breaker blackout close flowchart for how the SHAFT generator breaker closes in a blackout.

More information
See Shore connection breaker blackout close flowchart for how the SHORE connection breaker closes in a blackout.

8.6 Load sharing

8.6.1 How it works

When gensets operate in parallel, supplying power to the same busbar, the operation cannot be stable unless the loading on the gensets is controlled. To efficiently control the gensets' operation, the power management must perform **load sharing** for the gensets.

The voltage and frequency for paralleled gensets on the same busbar are forced to exactly the same values. As a result, the busbar voltage and genset speed alone do not provide the information needed for load sharing calculations.

The **load sharing** is achieved by using the **DEIF network**.

Load sharing possibilities

Load sharing connection	Asymmetric	Equal
DEIF network (DEIF Ethernet network)	●	●

8.6.2 Load sharing over the DEIF network

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

However, the **SHAFT generator** and **SHORE connection** controllers can only supply a base load (by adjusting the power from the gensets).

Load sharing over the **DEIF network** occurs automatically when the controllers are under power management control, provided all the necessary I/O settings and parameters are configured. The load sharing can be equal or asymmetrical.

NOTICE

DEIF network load sharing

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.

8.6.3 Equal load sharing

For equal load sharing, the gensets each run at the same percentage of nominal load. This allows differently sized gensets to share the load.

Hardware

Name	Type	Details
DEIF network	Ethernet	For load sharing (active and/or reactive power).
GOV control	Various	For active power load sharing.
AVR control	Various	Optional. For reactive power sharing.

Control type

If a controller is in switchboard control, then that controller does not control the governor or AVR. It cannot participate in load sharing.

For controllers in power management control (in AUTO and MANUAL mode), the power management shares the load equally between the connected equipment. The shared load may be the total system load. However, if a controller is under switchboard control, or if the **SHAFT generator** controller is supplying a base load, then the shared load is the remaining load.

Equal load sharing example

800 kW is required from two running gensets (nominals loads of 600 kW and 400 kW respectively).

Together, the gensets run at 800 kW / (600 kW + 400 kW) = 0.8 = 80 % of their nominal load. That is, the 600 kW genset supplies 480 kW, and the 400 kW genset supplies 320 kW.

8.6.4 Asymmetric P load sharing

Asymmetric power (P) load sharing allows you to select certain gensets to run at their optimum efficiency. The load on the other gensets then fluctuates to absorb variations. It can also be used in mixed systems with both gensets and hybrid controllers.

Asymmetric P load sharing can also be configured so that, as far as possible, a particular genset supplies a base load.

Asymmetric P load sharing can also be configured so that, if the asymmetric load sharing limit is exceeded, this can switch to either equal load sharing (default) or to adjust the set point.

Asymmetric P load sharing is done by power management over the **DEIF network**.

Hardware

The following hardware is required for asymmetric P load sharing.

Name	Details
DEIF network	The DEIF network is used for asymmetric P load sharing.
GOV control	The controller must control the genset governor for active power load sharing.

Control types

For controllers in power management control, if enabled, the power management uses asymmetric P load sharing to share the load between the connected assets. The shared load may be the total system load. However, if a connected controller is in switchboard control, or if the **SHAFT generator** controller is supplying a base load, then the shared load is the remaining load.

If a controller is in switchboard control, then that controller does not control its load, and therefore it cannot participate in load sharing.

Analogue and digital inputs (optional)

Function	I/O	Type	Details
`Local power management > Asymmetric load sharing > P set point [%]`	Analogue input	% of genset nominal power	When this input is configured, and `Local power management > Asymmetric load sharing > P configuration` is *Enabled* and **Source** is *External*, then the controller uses this analogue input as the set point for asymmetric P load sharing.
`Power management > Activate asymmetric P load sharing`	Digital input	Pulse	When this input is activated, the controller changes the parameter value under `Local power management > Asymmetric load sharing > P configuration > Enable` to *Enabled*.
`Power management > Deactivate asymmetric P load sharing`	Digital input	Pulse	When this input is activated, the controller changes the parameter value under `Local power management > Asymmetric load sharing > P configuration > Enable` to *Not enabled*.

Parameters

These parameters only apply to the selected **GENSET** or **HYBRID** controller. Other **GENSET** or **HYBRID** controllers can have different parameters.

`Local power management > Asymmetric load sharing > P configuration`

Parameter	Range	Notes
`Enable`	• Enabled • Not enabled	**Not enabled** • The **GENSET** controller shares the load equally with the other **GENSET** controllers. • If other **GENSET** controllers have asymmetric P load sharing enabled, then the **GENSET** controller without asymmetric P load sharing shares the load equally with the other gensets without asymmetric P load sharing. **Enabled** • Asymmetric P load sharing is active for the **GENSET** or **HYBRID** controller. • The power management runs the genset(s) with asymmetric P load sharing enabled at their set points while the remaining genset(s) supply a load that is between the asymmetric P load sharing *Minimum* and *Maximum*. • If more than one genset has asymmetric P load sharing enabled, then the genset with the highest priority also has the highest asymmetric P load sharing priority.
`Source`	• Parameter • External • External → Off • External → Parameter	The controller only uses these parameters when asymmetric P load sharing is enabled. **Parameter** • The controller uses the *Set point* parameter as the set point for asymmetric P load sharing. **External** • The controller uses the analogue input with `Local power management > Asymmetric load sharing > P set point [%]` as the set point for asymmetric P load sharing. **External → Off** • This is used if the asymmetric P load sharing set point from an analogue input fails. That is, when the input for `Local power management > Asymmetric load sharing > P set point [%]` is outside the configured scale. If the external set point fails, then the controller turns off asymmetric P load sharing. **External → Parameter**

Parameter	Range	Notes
		- ◦ This is used if the asymmetric P load sharing set point from an analogue input fails. That is, when the input for `Local power management > Asymmetric load sharing > P set point [%]` is outside the configured scale. If the external set point fails, then the controller ignores the analogue input and uses the *Set point* parameter as the set point for asymmetric P load sharing.
`Set point`	1 to 100 % of nominal active power	The asymmetric P load sharing set point for the genset. Whenever possible, the power management system adjusts the load of lower priority gensets, and gensets without asymmetric P load sharing enabled, so that the gensets with asymmetric P load sharing enabled can run at their set point.

These parameters apply to all the **GENSET** or **HYBRID** controllers in the section.

`Power management rules > Configuration # > Asymmetric load sharing > P configuration`

Parameter	Range	Notes
`Minimum`	1 to 100 % of nominal active power	This minimum reduces frequency control problems for gensets running at a low percentage of their nominal load. This minimum also reduces the risk of reverse power. If the load percentage for any genset is less than this minimum, the power management either system stops or adjusts the asymmetric P load sharing. The parameter **Limit exceeded** (see below) is used to determine if equal P load sharing is used or to adjust the set point.
`Minimum delay`	0 s to 1 h	To switch to equal load sharing, the load percentage must be less than the minimum for this period.
`Maximum`	1 to 100 % of nominal active power	This maximum reduces the risk of genset overloading. If the load percentage for any genset is more than this maximum, the power management either system stops or adjusts asymmetric P load sharing. The parameter **Limit exceeded** (see below) is used to determine if equal P load sharing is used or to adjust the set point.
`Maximum delay`	0 s to 1 h	To switch to equal load sharing, the load percentage must be more than the maximum for this period.
`Limit exceeded`	Switch to equal Adjust set point	This parameter controls how the load sharing is handled if either minimum or maximum are exceeded.

`Power management rules > Configuration # > Asymmetric load sharing > Start when an asymmetric set point is exceeded` *

Parameter	Range	Notes
`Enable`	• Enabled • Not enabled	If enabled then the power management system starts the genset or inverter if the asymmetric load sharing set point is exceeded.
`Delay`	0 s to 1 h	To start the genset or inverter, the asymmetric load sharing set point must be exceeded for this period.

NOTE * The load dependent stop is not blocked by this option. The limits should be considered to prevent unintended load dependent stop.

Base load

For a selected genset to supply a P **base load**, asymmetric P load sharing must be enabled in its **GENSET** controller. If asymmetric P load sharing is enabled in more than one controller, then the P **base load** genset must always have the highest priority in the section. To ensure a constant P base load and prevent equal P load sharing, the *Minimum* load parameter must not be too high.

How it works

When asymmetric P load sharing is enabled for gensets, then, whenever possible, these gensets run at their asymmetric P load sharing set points. If it is not possible for all the gensets with asymmetric P load sharing enabled to run at their set points, then only the highest priority genset(s) run at their set points. The lowest priority connected genset(s) supply the remaining, fluctuating load.

Asymmetric P load sharing is only possible when the remaining load on the low priority genset is between the minimum and maximum load percentage. If this is not possible, the parameter **Limit exceeded** is used to either change to equal P load sharing for ALL the gensets or to adjust the set point accordingly. All gensets not configured for base load will be kept at the minimum or maximum and the gensets running with base load will get their set point adjusted starting with the lowest priority.

Load-dependent start and stop

The load-dependent starts and stops are based on either active power (P, in kW) or apparent power (S, in kVA). The load-dependent start and stop parameters are independent of the asymmetric P load sharing parameters.

The load-dependent start and stop parameters determine how many gensets are connected. The asymmetric P load sharing parameters determine the load distribution among the connected gensets.

Active power and reactive power load sharing

Asymmetric P load sharing only applies to active power (P). The controllers can share the reactive power (Q) using either asymmetric Q load sharing, or equal Q load sharing.

If asymmetric P load sharing is enabled, but equal Q load sharing is enabled, then the generators each supply the same proportion of the reactive power (Q). When one genset has a small asymmetric P load, there can be a big difference between the power factors of the generators that supply the highest and lowest active power.

> **Power factor example for asymmetric P load sharing with equal Q load sharing**
>
> Three 100 kW gensets use asymmetric P load sharing to supply 165 kW. Genset A and Genset B each supply at 80 kW, while Genset C supplies at 5 kW.
>
> If the total system reactive power is 30 kvar, then, with equal Q load sharing, each genset supplies 10 kvar.
>
> The power factor for Genset A and Genset B is around 0.99, while the power factor for Genset C is 0.45.

If you enabled asymmetric P load sharing, you can make sure that the power factor is the same for each genset by enabling Asymmetric Q load sharing with the same set points.

More information

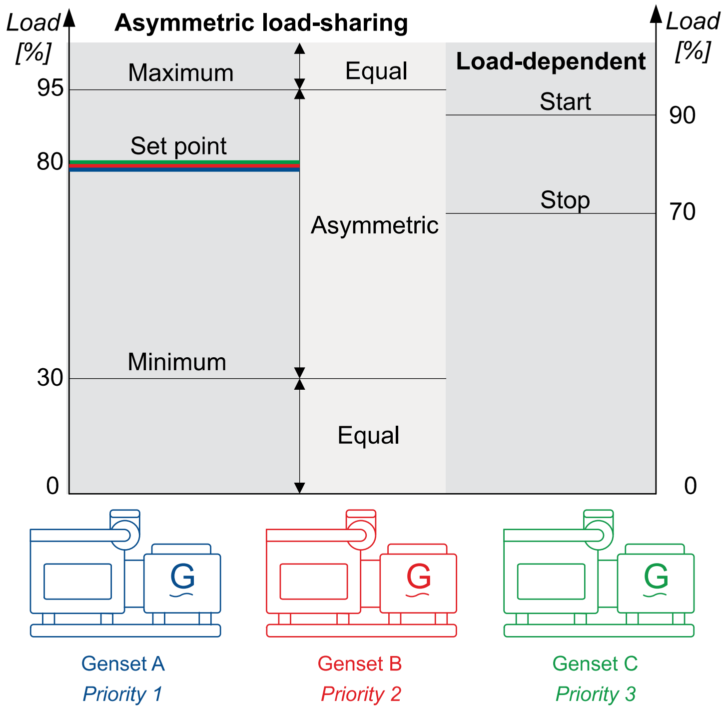
See Asymmetric Q load sharing for how to configure these settings.

8.6.5 Asymmetric P load sharing - Example 1

In this example, three **GENSET** controllers are configured so that when the asymmetric limits are exceeded, the load sharing is changed to equal load sharing.

The following example is based on this configuration:

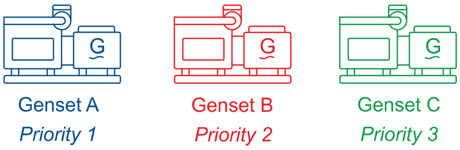
- Gensets A, B and C: Nominal load = 100 kW
- All the gensets are in the same section
- Asymmetric P load sharing
    - *Enabled* for all gensets
    - *Set point* = 80 % for all three gensets
    - *Minimum* = 30 % for the section *
    - *Maximum* = 95 % for the section
    - *Limit exceeded* = Switch to equal
- Genset A has the highest priority
- Genset C has the lowest priority
- Load-dependent start = 90 %
- Load-dependent stop = 70 %

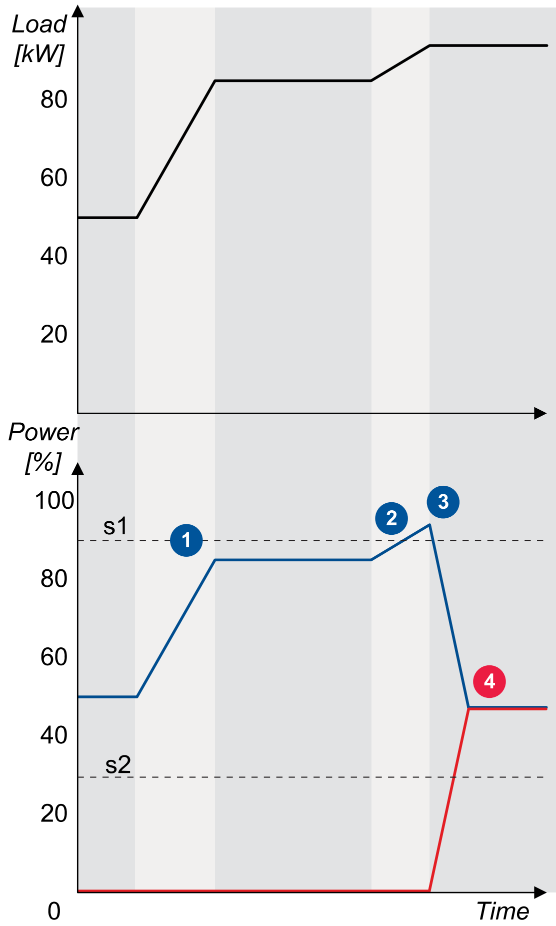


NOTE * To make the effect of asymmetric P load sharing clearer in this example, the asymmetric P load sharing *Minimum* is higher than the default (5 %).

The sequences in the examples show how the load sharing occurs over time. Each sequence follows on from each other. There are three load increases shown and in the last sequence how reduction of load is handled.

Sequence 1 of 4 : Load increase 1





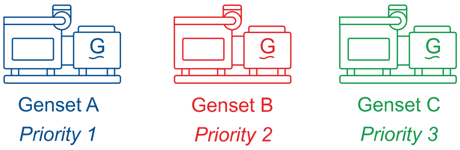
Parameters

s1 = Load-dependent start
s2 = Asymmetric P load sharing *Minimum*

Points on graph

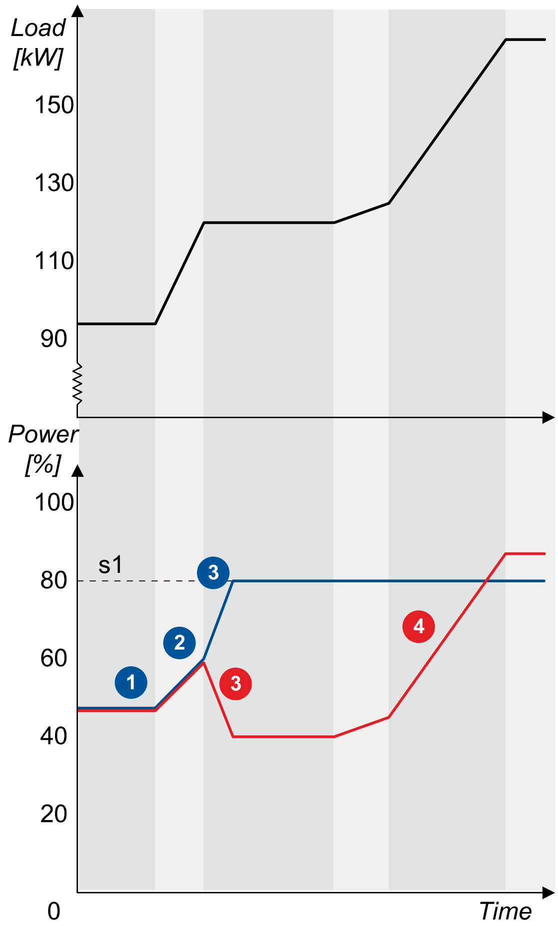
1. Genset A runs with load. The load increases but does not pass the load-dependent start set point. Asymmetric P load sharing is irrelevant, since there are no gensets to load share with.
2. Genset A reaches the load-dependent start set point. The controller starts Genset B.
3. Genset B is connected and starts taking load.
4. Genset A and Genset B share the load equally. Asymmetric P load sharing is not used because it would require Genset B to run under the asymmetric P load sharing minimum (set at 30 % in this example).

Sequence 2 of 4 : Load increase 2



Parameters

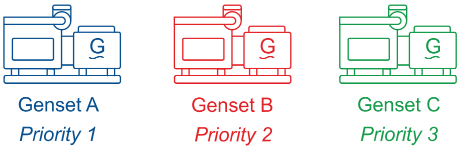
s1 = Asymmetric P load sharing *Set point*

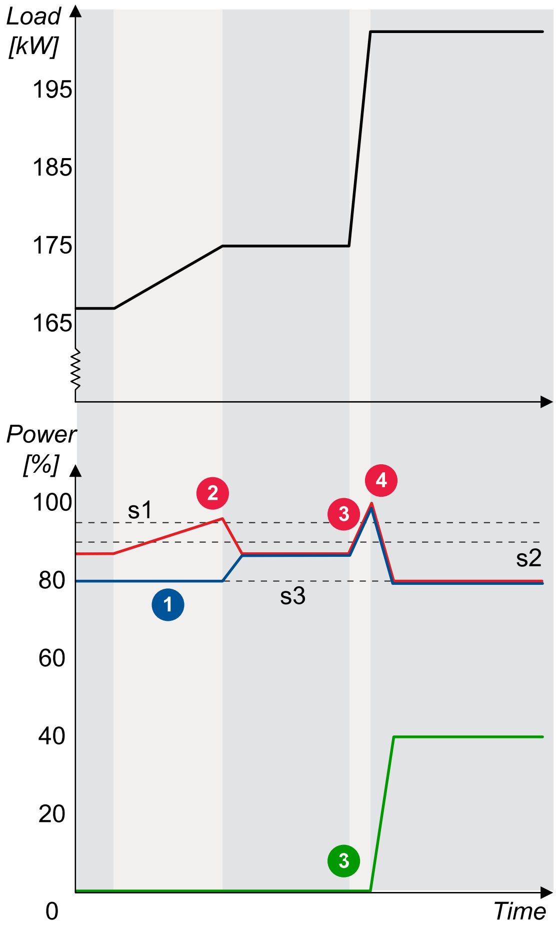


Points on graph

1. Genset A and Genset B share the load equally. Asymmetric P load sharing would required Genset B to run below the minimum.
2. The load increases.
3. The load on Genset B will be more than the minimum if Genset A uses asymmetric P load sharing. The power management system therefore increases the load on Genset A until it reaches its asymmetric P load sharing set point.
4. The load continues to increase. The power management system keeps Genset A at its asymmetric P load sharing set point, and adjusts the load on Genset B.

Sequence 3 of 4 : Load increase 3





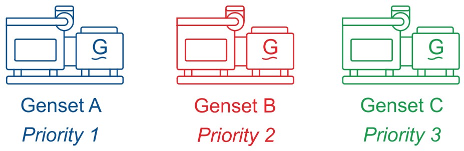
Parameters

s1 = Asymmetric P load sharing *Maximum*
s2 = Load-dependent start
s3= Asymmetric P load sharing *Set point*

Points on graph

1. Genset A runs at its asymmetric P load sharing set point, and the load on Genset B is adjusted.
2. Genset B reaches the asymmetric P load sharing maximum. The power management system shares the load equally between Genset A and Genset B.
3. The load increases. The load on the gensets exceeds the load-dependent start, and the power management system starts Genset C.
4. Genset C is connected and starts taking load. Genset A and Genset B can run at their asymmetric P load sharing set point, while the load on Genset C is adjusted.

Sequence 4 of 4 : Load decrease

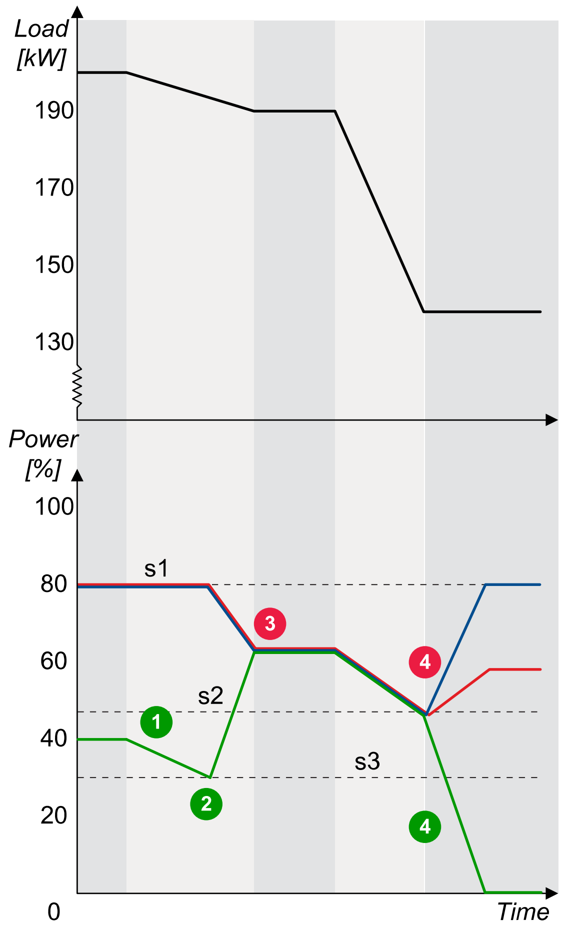


Parameters

s1 = Asymmetric P load sharing *Set point*
s2 = Load-dependent stop
s3 = Asymmetric P load sharing *Minimum*

Points on graph

1. The load decreases.
2. Genset C reaches the asymmetric P load sharing minimum.
3. The power management system shares the load equally between Genset A, Genset B and Genset C.
4. The load decreases, and so the power management system stops Genset C. Genset A runs at its asymmetric P load sharing set point and the load on Genset B is adjusted.

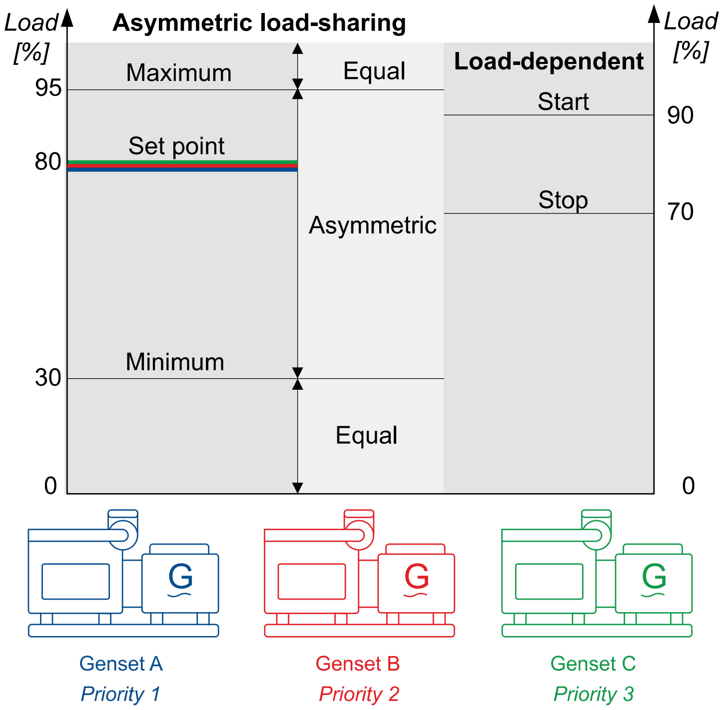


8.6.6 Asymmetric P load sharing - Example 2

In this example, three **GENSET** controllers are configured so that when the asymmetric limits are exceeded, the load sharing set point is adjusted.

The following example is based on this configuration:

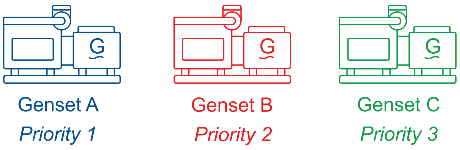
- Gensets A, B and C: Nominal load = **100 kW**
- All the gensets are in the **same** section
- Asymmetric P load sharing
  - *Enabled* for all gensets
  - *Set point* = 80 % for all three gensets
  - *Minimum* = 30 % for the section *
  - *Maximum* = 95 % for the section
  - *Limit exceeded* = Adjust set point
- Genset A has the highest priority
- Genset C has the lowest priority
- Load-dependent start = 90 %
- Load-dependent stop = 70 %



NOTE * To make the effect of asymmetric P load sharing clearer in this example, the asymmetric P load sharing *Minimum* is higher than the default (5 %).

The sequences in the examples show how the load sharing occurs over time. Each sequence follows on from each other. There are three load increases shown and in the last sequence how reduction of load is handled.

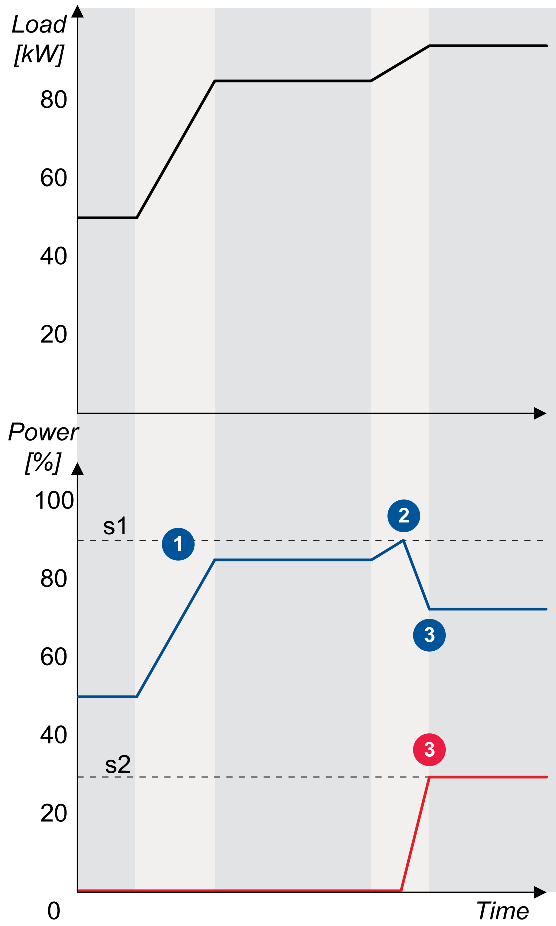
Sequence 1 of 4 : Load increase 1



Parameters

s1 = Load-dependent start

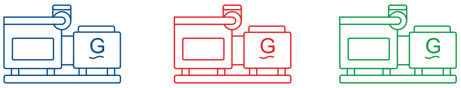
s2 = Asymmetric P load sharing *Minimum*



Points on graph

1. Genset A runs with load. The load increases but does not pass the load-dependent start set point. Asymmetric P load sharing is irrelevant, since there are no gensets to load share with.
2. Genset A reaches the load-dependent start set point. The controller starts Genset B.
3. Genset A drops 30 % and Genset B increases to the asymmetric P load sharing minimum (set at 30 % in this example).

Sequence 2 of 4 : Load increase 2

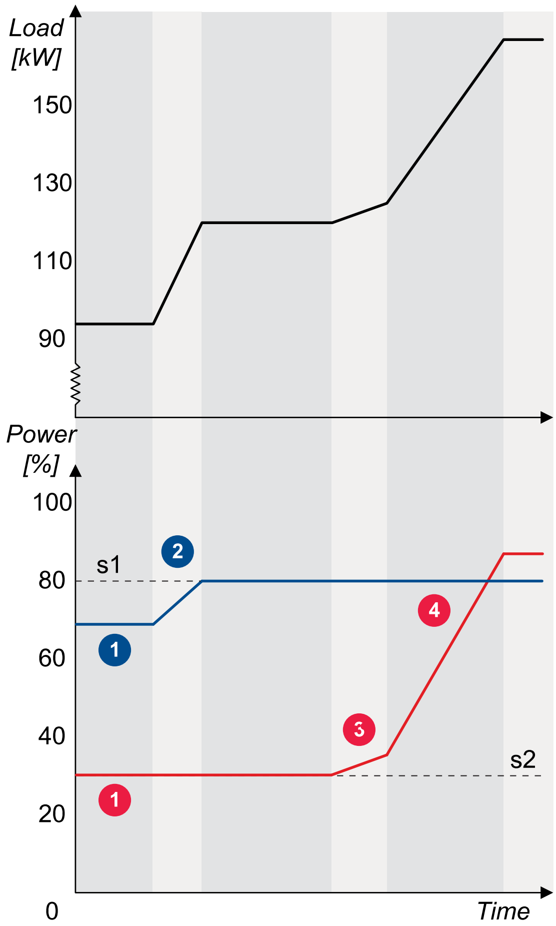


Parameters

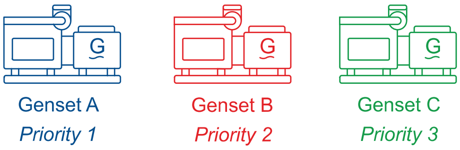
s1 = Asymmetric P load sharing *Set point*
s2 = Asymmetric P load sharing *Minimum*

Points on graph

1. Genset A and Genset B share the load.
2. The load rises. Genset A takes the increases load.
3. The load on Genset A has reached the asymmetric P load sharing set point. The power management system therefore increases the load on Genset B.
4. The load continues to increase. The power management system keeps Genset A at its asymmetric P load sharing set point, and increases the load on Genset B.



Sequence 3 of 4 : Load increase 3

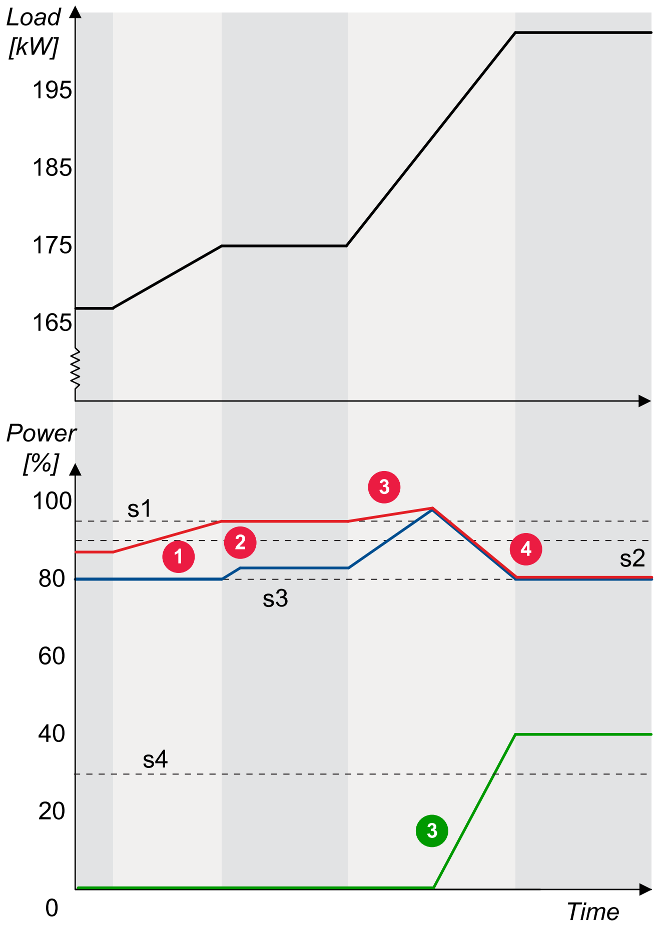


Parameters

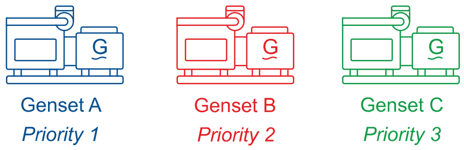
s1 = Asymmetric P load sharing *Maximum*
s2 = Load-dependent start
s3 = Asymmetric P load sharing *Set point*
s4 = Asymmetric P load sharing *Minimum*

Points on graph

1. Genset A runs at its asymmetric P load sharing set point, and the load increases on Genset B.
2. Genset B reaches the asymmetric P load sharing maximum. The load increases on Genset A.
3. The load increases. The load on the gensets A and B reach the load-dependent start, and the power management system starts Genset C.
4. Genset C is connected and starts taking load. Genset A and Genset B can run at their asymmetric P load sharing set point, while the load on Genset C is adjusted.

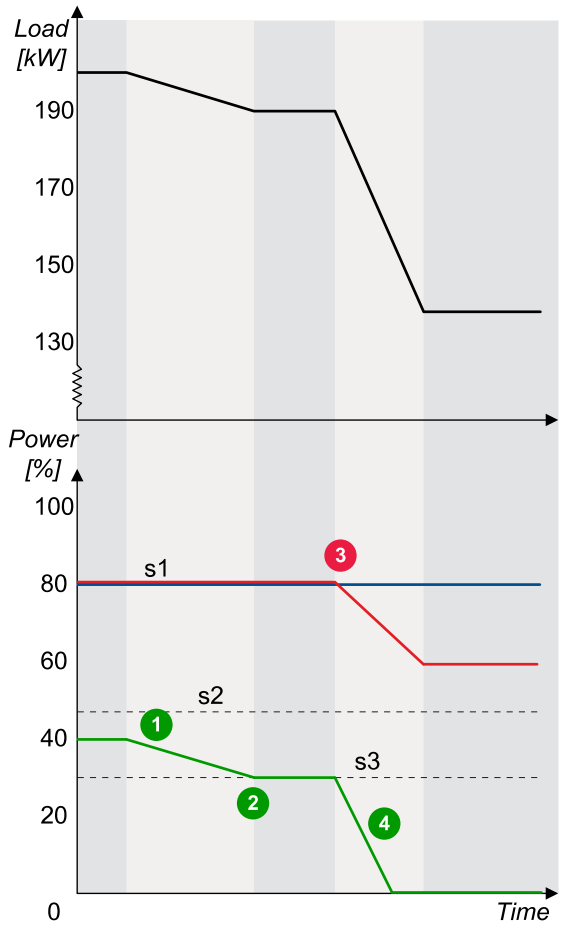


Sequence 4 of 4 : Load decrease



Parameters

s1 = Asymmetric P load sharing *Set point*
s2 = Load-dependent stop
s3 = Asymmetric P load sharing *Minimum*



Points on graph

1. The load decreases.
2. Genset C reaches the asymmetric P load sharing minimum.
3. Genset A remains at asymmetric set point, Genset B decreases load and Genset C.
4. The load decreases, the power management system performs a load dependant stop of Genset C. Genset A runs at its asymmetric P load sharing set point and the load on Genset B is adjusted.

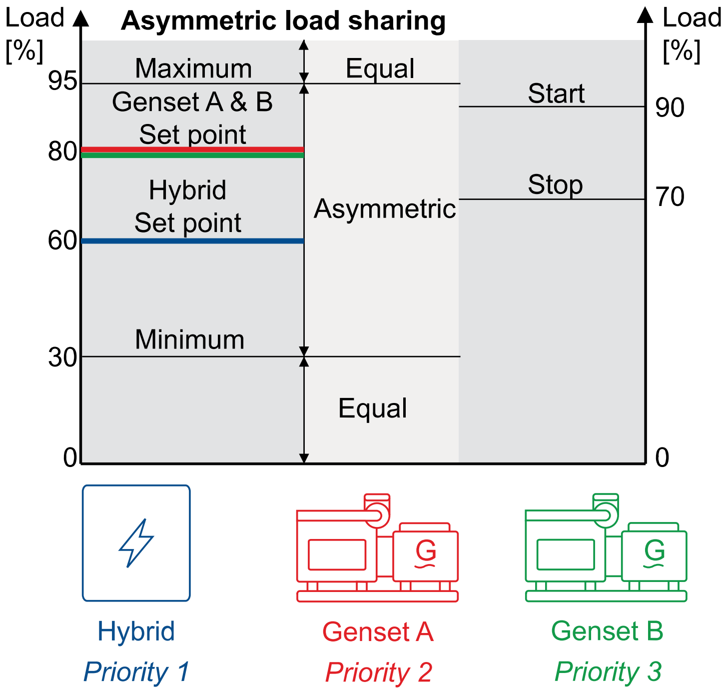
8.6.7 Asymmetric P load sharing - Example 3

In this example, three **GENSET** controllers are configured so that when the asymmetric limits are exceeded, the load sharing set point is adjusted.

In this example, one **HYBRID** controller with two **GENSET** controllers are configured so that when the asymmetric limits are exceeded, the load sharing set point is adjusted. The **HYBRID** controller is also configured to keep both a constant discharge at 60 % from PTO mode, and to automatically start gensets if necessary.

The following example is based on this configuration:

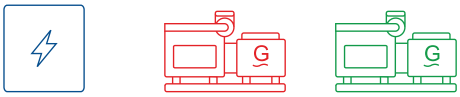
- Hybrid, Gensets A, B : Nominal load = 100 kW
- Hybrid is configured to give a constant discharge at 60 %
- All are in the same section
- Asymmetric P load sharing
  - *Enabled* for all
  - *Set point* = 60 % for hybrid with constant discharge
  - *Set point* = 80 % for gensets A and B
  - *Minimum* = 30 % for the section *
  - *Maximum* = 95 % for the section
  - *Limit exceeded* = Adjust set point
  - *Start when an asymmetric set point is exceeded* = Enabled
- Hybrid has the highest priority
- Genset B has the lowest priority
- Hybrid is in PTO mode
- Load-dependent start = 90 %
- Load-dependent stop = 70 %



NOTE * To make the effect of asymmetric P load sharing clearer in this example, the asymmetric P load sharing *Minimum* is higher than the default (5 %).

The sequences in the examples show how the load sharing occurs over time. Each sequence follows on from each other. There are three load increases shown and in the last sequence how reduction of load is handled.

Sequence 1 of 4 : Load increase 1



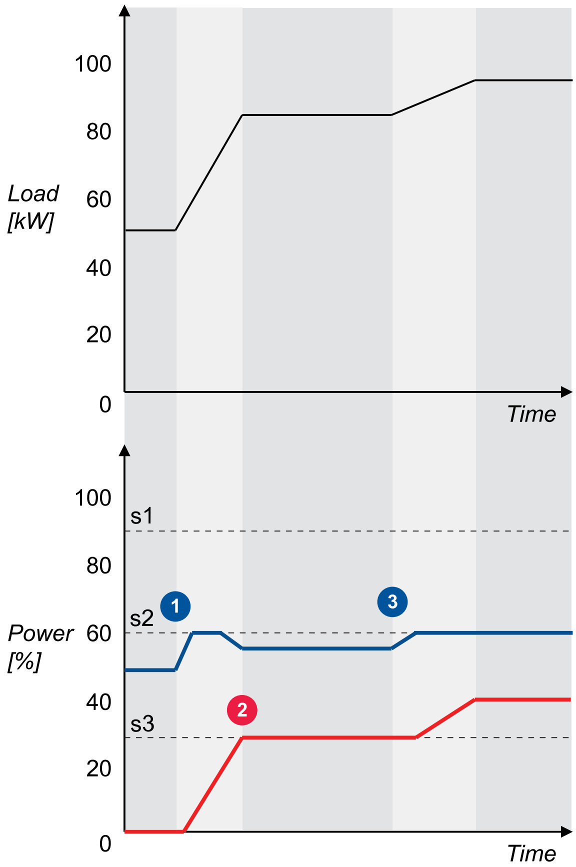
Hybrid Genset A Genset B
Priority 1 *Priority 2* *Priority 3*

Parameters

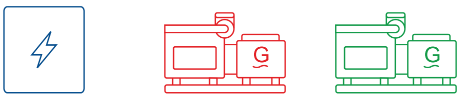
s1 = Load-dependent start
s2 = Hybrid load sharing set point (60 %)
s3 = Asymmetric P load sharing *Minimum* (30 %)

Points on graph

1. Hybrid runs with load. The load increases, reaching the Hybrid asymmetric load set point (60%) and Genset A starts to take the remaining load.
2. Genset A continutes at the asymmetric load share minimum (30%).
3. The load increases, Hybrid continues same discharge at the set point (60%), Genset A takes the rest.



Sequence 2 of 4 : Load increase 2



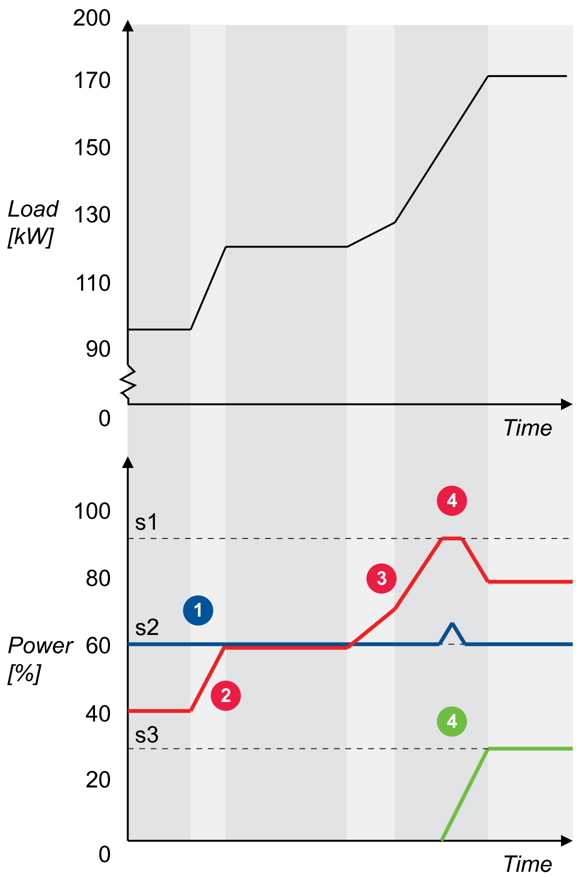
Hybrid Genset A Genset B
Priority 1 *Priority 2* *Priority 3*

Parameters

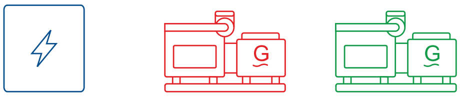
s1 = Load-dependent start
s2 = Hybrid load sharing set point (60 %)
s2 = Asymmetric P load sharing *Minimum* (30 %)

Points on graph

1. Hybrid continues discharge at 60%.
2. The load increases, Genset A takes more load.
3. The load increases, Genset A takes more load.
4. Genset A reaches maximum 95%, Hybrid takes initial extra load. As the *Start when an asymmetric set point is exceeded* is enabled, Genset B starts and takes over the load increase. Genset A returns back to set point 80%, Hybrid returns back to set point 60%, Genset B continues at 30 % minimum.



Sequence 3 of 4 : Load increase 3



Hybrid
Priority 1

Genset A
Priority 2

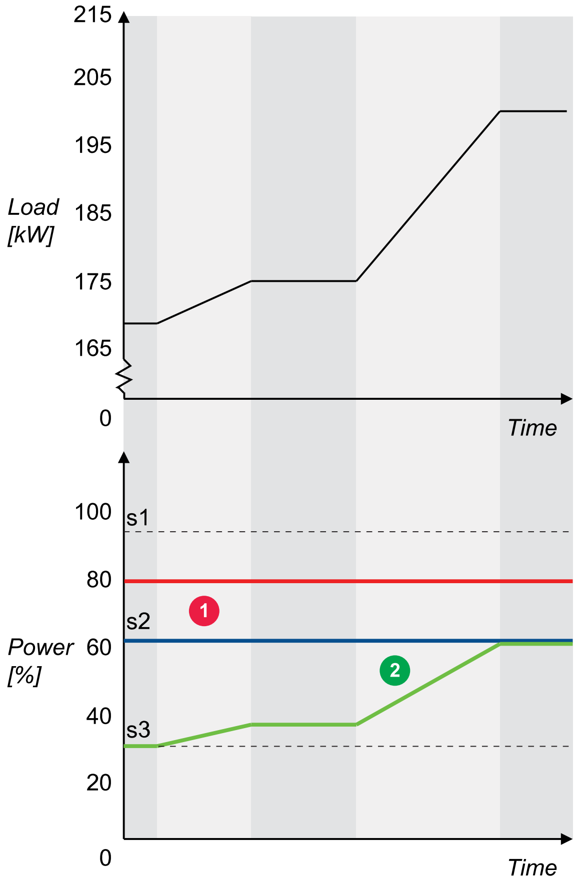
Genset B
Priority 3

Parameters

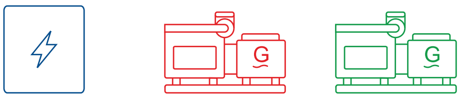
s1 = Asymmetric P load sharing *Maximum*
s2 = Load-dependent start
s3= Asymmetric P load sharing *Set point*

Points on graph

1. The load increases, Genset A reaches 80% set point and Genset B takes the remaining load.
2. The load increases, Genset B takes more load.



Sequence 4 of 4 : Load decrease



Hybrid
Priority 1

Genset A
Priority 2

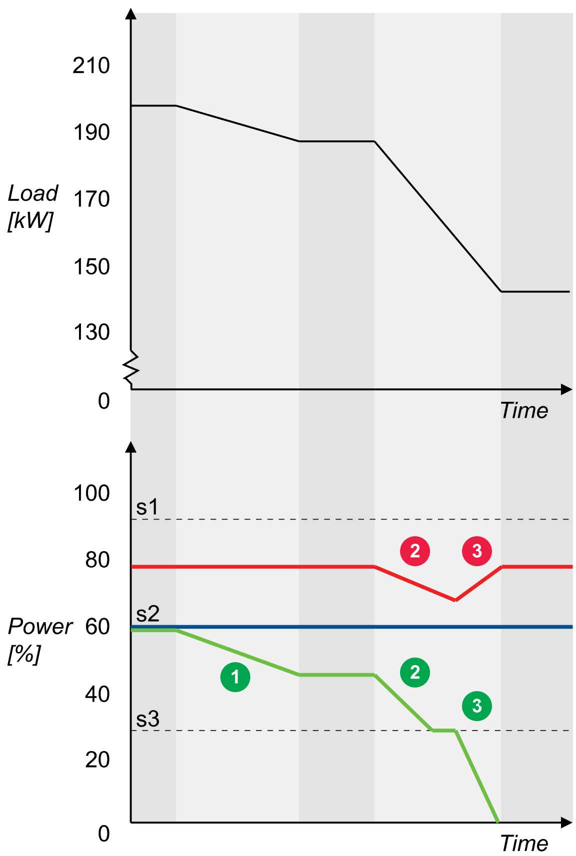
Genset B
Priority 3

Parameters

s1 = Asymmetric P load sharing *Set point*
s2 = Load-dependent stop
s3 = Asymmetric P load sharing *Minimum*

Points on graph

1. The load decreases, Genset B reduces load.
2. The load decreases, Genset A and B reduce load. Genset A reduces to preserve the minimum limit on Genset B.
3. The load decreases, Genset B stops and Genset A takes the remaining load.



8.6.8 Asymmetric Q load sharing

Asymmetric reactive power (Q) load sharing allows you to select certain gensets to run at their optimum reactive power load efficiency. The reactive power load on the other gensets then fluctuates to absorb variations.

You can configure Asymmetric Q load sharing so that:

- As far as possible, a particular genset supplies a base reactive power load.
- If the asymmetric load sharing limit is exceeded, this can switch to either equal load sharing (default) or to adjust the set point.
- Asymmetric Q load sharing is done by the Power Management System (PMS) over the DEIF Ethernet network.

Hardware

The following hardware is required for asymmetric Q load sharing.

Name	Details
DEIF network	The **DEIF Ethernet network** is used for asymmetric Q load sharing.
AVR control	The controller must control the genset AVR for reactive power load sharing.

Control types

For controllers in PMS control, if enabled, the PMS uses asymmetric Q load sharing to share the load between the connected equipment. The shared reactive load may be the total system reactive power load. However, if a connected controller is in switchboard control, then the shared reactive power load is the remaining reactive power load.

If a controller is in switchboard control, then that controller does not control its reactive load, and therefore it cannot participate in reactive power load sharing.

Analogue and digital inputs (optional)

Function	I/O	Type	Details
`Local power management > Asymmetric load sharing > Q set point [%]`	Analogue input	% of genset nominal reactive power	When this input is configured, and `Local power management > Asymmetric load sharing > Q configuration` is *Enabled* and **Source** is *External*, then the controller uses this analogue input as the set point for asymmetric Q load sharing.
`Power management > Activate asymmetric Q load sharing`	Digital input	Pulse	When this input is activated, the controller changes the parameter value under `Local power management > Asymmetric load sharing > Q configuration > Enable` to *Enabled*.
`Power management > Deactivate asymmetric Q load sharing`	Digital input	Pulse	When this input is activated, the controller changes the parameter value under `Local power management > Asymmetric load sharing > Q configuration > Enable` to *Not enabled*.

Parameters

`Local power management > Asymmetric load sharing > Q configuration`

These parameters only apply to the selected **GENSET** controller. Other **GENSET** controllers can have different parameters.

Parameter	Range	Notes
`Enable`	• Enabled • Not enabled	**Not enabled** • The **GENSET** controller shares the load equally with the other **GENSET** controllers. If other **GENSET** controllers have asymmetric Q load sharing enabled, then the **GENSET**

Parameter	Range	Notes
		controller without asymmetric Q load sharing shares the load equally with the other gensets without asymmetric Q load sharing. **Enabled** • Asymmetric Q load sharing is active for the **GENSET** controller. • The power management system runs the genset(s) with asymmetric Q load sharing enabled at their set points while the remaining genset(s) supply a load that is between the asymmetric Q load sharing *Minimum* and *Maximum*. • If more than one genset has asymmetric Q load sharing enabled, then the genset with the highest priority also has the highest asymmetric Q load sharing priority.
`Source`	• Parameter • External • External → Off • External → Parameter	The controller only uses these parameters when asymmetric Q load sharing is enabled. **Parameter** • The controller uses the *Set point* parameter as the set point for asymmetric Q load sharing. **External** • The controller uses the analogue input with `Local power management > Asymmetric load sharing > Q set point [%]` as the set point for asymmetric Q load sharing. **External → Off** • This is used if the asymmetric Q load sharing set point from an analogue input fails. That is, when the input for `Local power management > Asymmetric load sharing > Q set point [%]` is outside the configured scale. • If the external set point fails, then the controller turns off asymmetric Q load sharing. **External → Parameter** • This is used if the asymmetric Q load sharing set point from an analogue input fails. That is, when the input for `Local power management > Asymmetric load sharing > Q set point [%]` is outside the configured scale. • If the external set point fails, then the controller ignores the analogue input and uses the *Set point* parameter as the set point for asymmetric Q load sharing.
`Set point`	1 to 100 % of nominal reactive power	The asymmetric Q load sharing set point for the genset. Whenever possible, the power management system adjusts the load of lower priority gensets, and gensets without asymmetric Q load sharing enabled, so that the gensets with asymmetric Q load sharing enabled can run at their set point.

`Power management rules > Configuration # > Asymmetric load sharing > Q configuration`

These parameters apply to all the **GENSET** controllers in the section.

Parameter	Range	Notes
`Minimum`	1 to 100 % of nominal reactive power	This minimum reduces frequency control problems for gensets running at a low percentage of their nominal load. This minimum also reduces the risk of reverse power. If the load percentage for any genset is less than this minimum, the power management either system stops or adjusts asymmetric Q load sharing. The parameter **Limit exceeded** (see below) is used to determine if equal Q load sharing is used or to adjust the set point.
`Minimum delay`	0 s to 1 h	To stop asymmetric Q load sharing, the load percentage must be less than the minimum for this period.
`Maximum`	1 to 100 % of nominal reactive power	This maximum reduces the risk of genset overloading.

Parameter	Range	Notes
		If the load percentage for any genset is more than this maximum, the power management either system stops or adjusts asymmetric Q load sharing. The parameter **Limit exceeded** (see below) is used to determine if equal Q load sharing is used or to adjust the set point.
Maximum delay	0 s to 1 h	To stop asymmetric Q load sharing, the load percentage must be more than the maximum for this period.
Limit exceeded	Switch to equal Adjust set point	This parameter controls how the load sharing is handled if either minimum or maximum are exceeded.

`Power management rules > Configuration # > Asymmetric load sharing > Start when an asymmetric set point is exceeded`

Parameter	Range	Notes
`Enable`	• Enabled • Not enabled	**Enabled** • The power management system starts the genset or inverter if the asymmetric load sharing set point is exceeded.
`Delay`	0 s to 1 h	To start the genset or inverter, the asymmetric load sharing set point must be exceeded for this period.

How it works

When asymmetric Q load sharing is enabled for gensets, then, whenever possible, these gensets run at their asymmetric Q load sharing set points constantly. If it is not possible for all the gensets with asymmetric Q load sharing enabled to run at their set points, then only the highest priority genset(s) run at their set points constantly. The lowest priority connected genset(s) supply the remaining, fluctuating load.

Asymmetric Q load sharing is only possible when the remaining load on the low priority genset is between the minimum and maximum load percentage. If this is not possible, the parameter **Limit exceeded** is used to either change to equal Q load sharing for ALL the gensets or to adjust the set point accordingly.

Load-dependent start and stop

The load-dependent starts and stops are based on either power (P, in kW) or apparent power (S, in kVA). The load-dependent start and stop parameters are independent of the asymmetric Q load sharing parameters.

The load-dependent start and stop parameters determine how many gensets are connected. The asymmetric Q load sharing parameters determine the reactive power load distribution among the connected gensets.

Nominal reactive power

The asymmetric Q load sharing is based on the nominal reactive power. The nominal reactive power is calculated from the nominal apparent power, the nominal power and/or the nominal power factor.

More information
See Nominal power calculations in AC configuration for these settings.

Active power and reactive power load sharing

Asymmetric Q load sharing only applies to reactive power (Q). The controllers can share the active power (P) using either asymmetric P load sharing, or equal P load sharing.

If asymmetric Q load sharing is enabled, but equal P load sharing is enabled, there can then be a difference between the power factors of the generators that supply the highest and lowest reactive power.

Power factor example for asymmetric Q load sharing with equal P load sharing

Three 100 kW gensets use equal P load sharing to supply 180 kW. Each genset supplies 60 kW.

	The total system reactive power is 30 kvar. The asymmetric Q load sharing allocates 24 kvar to Genset A, while Genset B and C share the remaining reactive power load equally, with each genset supplying 3 kvar. The power factor for Genset A is around 0.93, while the power factor for Genset B and Genset C is around 1.00.

If you enable asymmetric Q load sharing, you can ensure that the power factor is the same for each genset by enabling asymmetric P load sharing with the same set points.

Example of asymmetric Q load sharing

For an example of asymmetric Q load sharing, replace kW with kvar in the asymmetric P load sharing example.

More information
See **Asymmetric P load sharing example** for the example.

NOTE The load-dependent starts and stops (which are based on the power or apparent power load) do not necessarily correspond to the reactive power (Q) load.

8.6.9 SHAFT generator base load

A **SHAFT generator** controller can only be assigned a base load.

The power management system distributes the load to keep the shaft generator at the base load set point. The **GENSET** controllers share the rest of the load. You can optionally configure the shaft to be the only generator online, if the actual load is below the set point.

Parameters

These parameters are only in a **SHAFT generator** controller.

`Local power management > Shaft generator base load > Enable`

Parameter	Range	Default	Notes
`Base load`	• Off • Active • Active with priority	Off	**Off:** • The shaft generator cannot run in long-term parallel with the gensets. **Active:** • Base load is active for the **SHAFT generator** controller. • The GENSET-SHAFT parallel timer protection is not enabled. **Active with priority:** • Base load is active for the **SHAFT generator** controller. • The GENSET-SHAFT parallel timer protection is not enabled. • If the **SHAFT generator** controller is priority 1, and the base load is below the set point, only the shaft generator continues to operate.

`Local power management > Shaft generator base load > Power set point`

Parameter	Range	Default	Notes
`Set point`	10 to 120 %	90 %	The set point for the base load, as a percentage of the shaft generator's nominal power. If the system load is lower than this set point: • Base load setting **Active**: ◦ The power management system deloads the gensets to the *Minimum limit* so that the shaft generator can run as close to this set point as possible. • Base load setting **Active with priority**:

Parameter	Range	Default	Notes
			◦ The power management system deloads the gensets with priority order. If the shaft generator is priroity 1, it takes all the system load. If the system load is higher than this set point: • The power management system transfers the load to the gensets so that the shaft generator runs at the *Set point*. If the gensets are running at the *Maximum limit*, the power management system increases the load on the shaft generator.

`Local power management > Shaft generator base load > Min. set point`

Parameter	Range	Default	Notes
`Minimum limit`	1 to 100 %	5 %	The minimum limit for the load on each genset (while using base load), as a percentage of the genset nominal power.

`Local power management > Shaft generator base load > Max. set point`

Parameter	Range	Default	Notes
`Maximum limit`	1 to 120 %	95 %	The maximum limit for the load on each genset (while using base load), as a percentage of genset nominal power. This maximum limit prevents genset overload.

NOTICE

Long-term parallel configuration

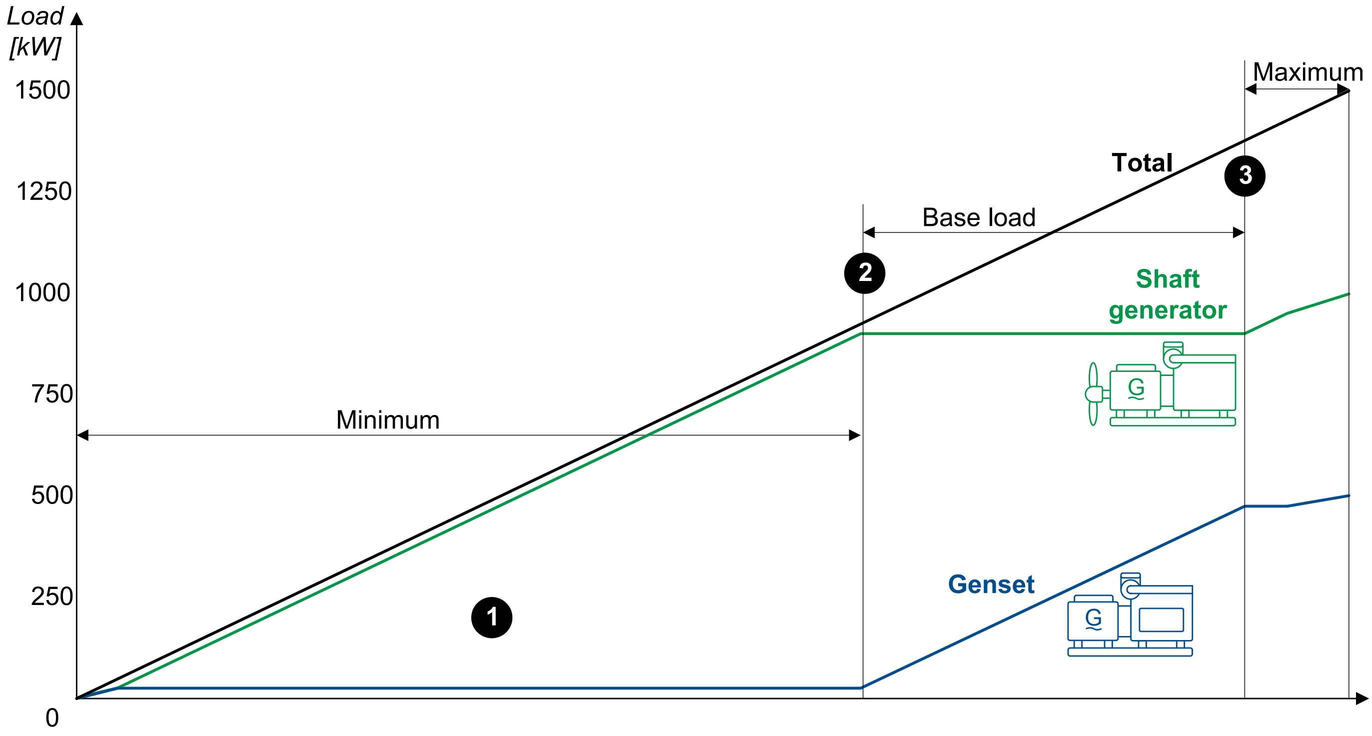
The only way to run the shaft generator in long-term parallel with gensets is by enabling and configuring a base load for the shaft generator.

Example

The following graph shows the relationship between the total load, and the load supplied by a shaft generator and a genset. In the example, the shaft generator has a nominal power of 1000 kW, and the genset has a nominal power of 500 kW. Base load is enabled, and the default settings are used.

Points on the graph

1. Total load: 0 to 925 kW: The *Minimum* setting is used. The genset supplies 25 kW, and the shaft generator supplies the remainder.
2. Total load: 925 to 1375 kW: The base load *Set point* is used. The shaft generator runs at 90 % of its nominal power (900 kW), and the genset supplies the remainder.
3. Total load: 1375 to 1500 kW: The *Maximum* setting is used. The generators share the load.



8.6.10 SHORE connection base load

A SHORE connection controller can only be assigned a base load.

The power management system distributes the load to keep the shore connection at the base load set point. The GENSET controllers share the rest of the load.

Parameters

These parameters are only visible in a SHORE connection controller.

`Local power management > Shore connection base load > Enable`

Parameter	Range	Default	Notes
`Enable SC base load`	• Not enabled • Enabled	Not enabled	**Not enabled** • The shore connection cannot run in long-term parallel with the gensets. **Enabled** • Base load is active for the SHORE connection controller. The GENSET-SHORE parallel timer protection is disabled.

`Local power management > Shore connection base load > Power set point`

Parameter	Range	Default	Notes
`Set point`	10 to 120 %	90 %	The set point for the base load, as a percentage of the shore connection's nominal power. If the system load is lower than this set point, the power management system de-loads the gensets to the *Minimum limit* so that the shore connection can run as close to this set point as possible. If the system load is higher than this set point, the power management system transfers the load to the gensets so that the shore connection runs at the *Set point*.

Parameter	Range	Default	Notes
			If the gensets are running at the *Maximum limit*, the power management system increases the load on the shore connection.

Local power management > Shore connection base load > Min. set point

Parameter	Range	Default	Notes
Minimum limit	1 to 100 %	5 %	The minimum limit for the load on each genset (while using base load), as a percentage of the genset nominal power.

Local power management > Shore connection base load > Max. set point

Parameter	Range	Default	Notes
Maximum limit	1 to 120 %	95 %	The maximum limit for the load on each genset (while using base load), as a percentage of genset nominal power. This maximum limit prevents genset overload.

NOTICE

Long-term parallel configuration

The only way to run the shore connection in long-term parallel with gensets is by enabling and configuring a base load for the shore connection.

8.6.11 DEIF network load sharing failure

The *P load sharing failure* and *Q load sharing failure* alarms alert the operator to the failure of the DEIF network load sharing. Other alarms are also activated if communication is lost in the DEIF network.

More information
See Regulation alarms for the load sharing failure alarms.

8.7 Load reduction

8.7.1 Load reduction function

Use the Load reduction function to reduce the total load on the system. It can be activated when there is low available power. Like the NEL function, load reduction helps to prevent the system from overloading and keeps the system healthy.

This function requires a load that is capable of reducing its power consumption from the system.

Configure the function to activate based on 1 or more set points:

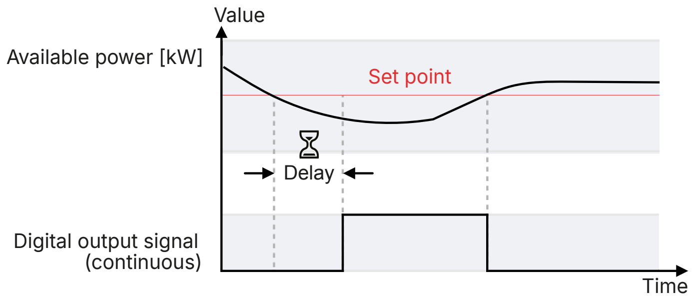
- Low power available [kW]
- Low power available [%]
- Under-frequency

Example load reduction function sequence

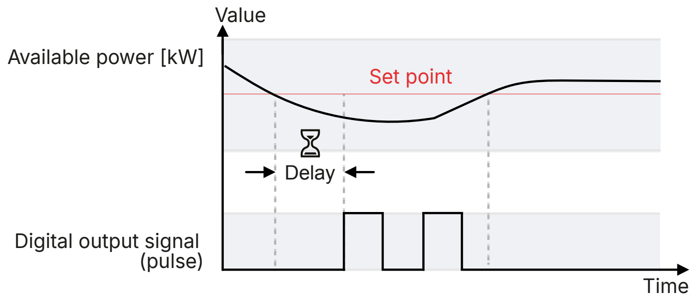
These examples use the set point for *Low power available [kW]*. The *Period time* and *Pulse time* are configured as either *Continuous* or *Pulse*.

If the *Available power [kW]* is below the set point the delay timer starts. If the *Available power [kW]* continues below the set point after the delay timer expires, the output is activated.

With continuous signal



With pulse signal



Digital output

Wire the digital output to the receiving load's hardware input.

Function	I/O	Type	Details
`Load reduction > Load reduction output # *`	Digital output	Continuous or Pulse	The controller activates the output if any of the load reduction conditions are met, and the delay timer expires. The output stays activate as long as at least one of the load reduction conditions are met. The digital output signal can be configured as either a continuous or a pulse signal.

NOTE * # is 1 or 2.

Parameters

These parameters are only visible when the digital output is configured. Configure the *Period time* and *Pulse time* with the same value for a Continuous signal.

`Load reduction > Reduction output # > Settings *`

Parameter	Range	Default	Notes
`Power available method`	AUTO mode, AUTO or Manual mode, Connected	AUTO or Manual mode	Select the mode where the load reduction function can be active. Connected includes all power providers (AUTO, Manual and Switchboard control).
`Period time`	0.04 to 3600.00 s	2.00 s	The period of time for each output operation.
`Pulse time`	0.04 to 3600.00 s	1.00 s	The length of each pulse for each output operation.

NOTE * # is 1 or 2.

`Load reduction > Reduction output # > Low power available [kW] *`

Parameter	Range	Default	Notes
`Enable`	Not enabled, Enabled	Not enabled	When enabled, compares the Available power [kW] with the configured limit set point.

Parameter	Range	Default	Notes
			If the Available power [kW] is less than the set point, the controller activates the digital output after the delay timer expires.
`Limit`	-1.5 GW to 1.5 GW	100 kW	The low power set point in kW. If there is less power available than the set point, the delay timer starts.
`Delay`	0.00 to 3600.00 s	0.00 s	The delay time for the limit set point. When this delay timer expires, the digital output is activated. This timer can be used to make the system more stable if consumption is close to the limit.

NOTE * # is 1 or 2.

`Load reduction > Reduction output # > Low power available [%]` *

Parameter	Range	Default	Notes
`Enable`	Not enabled, Enabled	Not enabled	When enabled, compares the Available power [%] with the configured limit set point. If the Available power [%] is less than the set point, the controller activates the digital output after the delay timer expires.
`Limit`	-50.0 to 100.0 %	0.0 %	The low power set point in %. If there is less power available than the set point, the delay timer starts.
`Delay`	0.00 to 3600.00 s	0.00 s	The delay time for the limit set point. When this delay timer expires, the digital output is activated. This timer can be used to make the system more stable if consumption is close to the limit.

NOTE * # is 1 or 2.

`Load reduction > Reduction output # > Under-frequency` *

Parameter	Range	Default	Notes
`Enable`	Not enabled, Enabled	Not enabled	When enabled, compares the power frequency [%] with the configured limit set point. If the power frequency [%] is less than the set point, the controller activates the digital output after the delay timer expires.
`Limit`	80.0 to 100.0 %	98.0 %	The Under-frequency set point in %. If power frequency is less than the set point, the delay timer starts.
`Delay`	0.00 to 3600.00 s	0.00 s	The delay time for the limit set point. When this delay timer expires, the digital output is activated. This timer can be used to make the system more stable if consumption is close to the limit.

NOTE * # is 1 or 2.

NOTICE

No effect on other similar functions

The load reduction function has no effect on the Fast load-reduction function or to the heavy consumer reservation.

8.8 Heavy consumer management

8.8.1 How it works

The heavy consumer function ensures that enough power is available when the heavy consumers need it. In addition, heavy consumer management minimises the disruption to the rest of the system when the heavy consumers connect. Each controller can manage up to six heavy consumers. The controller manages the heavy consumer function across the **DEIF network Ethernet**.

A heavy consumer can be assigned to any controller.

For the heavy consumer function, the power from connected gensets in Manual mode is included in the available power. However, for load-dependent start, this power is not included in the PMS available power. The power management system may therefore start additional gensets after the heavy consumer connects.

The heavy consumers must be assigned to the controller on the single-line diagram in order for the heavy consumer functions to be visible under the controller inputs and outputs.

The heavy consumer functions may be assigned to any inputs and outputs on the controller. The inputs and outputs do not have to be on the same hardware module.

8.8.2 Configure heavy consumers

Heavy consumer application configuration options

Name	Details
System ID	The unique heavy consumer number in the system. Range = 1 to 64.
Feedback type	**Fixed** • The heavy consumer provides load feedback to a controller digital input. **Variable** • The heavy consumer provides load feedback to a controller analogue input.
Controller ID	Drop-down list of the controllers in the system. The heavy consumer must be assigned to a controller. After writing the single-line diagram, you can configure the heavy consumer input and output functions on that controller.
Label	Customisable label for the heavy consumer.

Heavy consumer priority

If two or more heavy consumers send requests at the same time, the PMS uses the *System ID* to determine the priority. The heavy consumer with the lowest *System ID* has the highest priority.

The PMS acknowledges the highest priority heavy consumer first. However, once the controller has acknowledged a heavy consumer request, then the acknowledged heavy consumer is not displaced by a higher priority heavy consumer.

Wiring examples

More information
See **Wiring for controller functions** in the **Installation instructions** for examples of heavy consumer wiring.

Inputs and outputs

Function	I/O	Type	Details
`Heavy consumers > [Heavy consumer #] > Request` *	Digital input	Pulse/ Continuous	Required for each heavy consumer. The controller starts the heavy consumer connection function when this input is activated.
`Heavy consumers > [Heavy consumer #] > Acknowledge` *	Digital output	Pulse	Required for each heavy consumer. The controller energises this relay when the required power is available, and then the heavy consumer can connect.
`Heavy consumers > [Heavy consumer #] > Feedback` *	Digital input	Continuous	Required if *Fixed* is selected for the *Feedback type*. When the heavy consumer request is activated, but this input is not activated, the power management system (PMS) reserves 100 % of the power required for the heavy consumer at the busbar.
`Heavy consumers > [Heavy consumer #] > Feedback [%]` *	Analogue input	% of the heavy consumer nominal load	Required if *Variable* is selected for *Feedback type*. For example, this can be connected to a power transducer with a 4 to 20 mA output, and configured so that 4 to 20 mA corresponds to 0 to 100 % of the heavy consumer nominal load. if the heavy consumer nominal load is 500 kW, but the heavy consumer is only using 200 kW, the power transducer output is 4 mA + (200 kW / 500 kW × 16 mA) = 10.4 mA. Alternatively, the analogue input may be configured for another type of input, or another input range.

NOTE * By default [Heavy consumer #] is HC #, where # represents the *System ID*. [Heavy consumer #] can be replaced with the *Controller label* entered in the single line diagram for the heavy consumer.

Analogue outputs (optional)

Function	I/O	Units	Details
`Heavy consumers > [Heavy consumer #] > Load [%]` *	Analogue output	0 to 100 % of the heavy consumer nominal load	The controller outputs the actual heavy consumer load, as a percentage of the heavy consumer nominal load. For this to work, you must configure an analogue input with `[Heavy consumer #] > Feedback`.
`Heavy consumers > [Heavy consumer #] > Load [kW]` *	Analogue output	0 kW to 9 GW	The controller outputs the actual heavy consumer load. For this to work, you must configure an analogue input with `[Heavy consumer #] > Feedback`.

NOTE * By default [Heavy consumer #] is HC #, where # represents the *System ID*. [Heavy consumer #] can be replaced with the *Controller label* entered in the single line diagram for the heavy consumer.

Parameters

The parameters are only visible in the controller to which the heavy consumer is assigned. By default [Heavy consumer #] is HC #, where # represents the *System ID*. [Heavy consumer #] can be replaced with the *Controller label* entered in the single line diagram for the heavy consumer.

`Heavy consumers > [Heavy consumer #] > Nominal settings` **

Parameter	Range	Comment
`Initial load`	100 to 500 %	The available power required in the system (as a percentage of the heavy consumer nominal load) for the PMS to activate the heavy consumer acknowledge.

Parameter	Range	Comment
		Use this parameter to allow a high connection current.
`Nominal load`	0 kVA to 1 GVA	The heavy consumer nominal load.
`Power factor`	0.1 to 1.0	The heavy consumer power factor.

NOTE ** # is 1 to 6.

`Heavy consumers > [Heavy consumer #] > Acknowledge` **

Parameter	Range	Comment
`Pulse width`	1 to 10 s	The heavy consumer acknowledge digital output is activated for this period.
`Delay`	0 to 30 s	The time the controller waits before activating the heavy consumer acknowledge digital output. If the acknowledge signal is delayed, the generators have time to stabilise the load on the busbar before the heavy consumer connects.

NOTE ** # is 1 to 6.

`Heavy consumers > [Heavy consumer #] > Request signal` **

Parameter	Range	Comment
`Type`	• Pulse • Continuous	**Pulse** • The heavy consumer request is a pulse signal. • The heavy consumer request cannot be cancelled when the request is a pulse signal. **Continuous** • The heavy consumer request is a continuous signal. • The heavy consumer request is cancelled when the request signal becomes low before the delay timer expires for the *Feedback timeout* alarm.

NOTE ** # is 1 to 6.

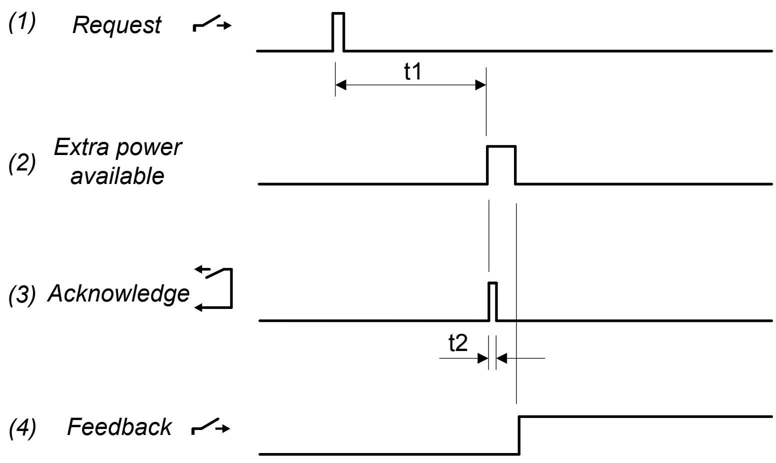
`Power management rules > Configuration # > Load-dependent start/stop > Heavy consumer` ***

Parameter	Range	Notes
`Block stop when active`	• Not enabled • Enabled	**Not enabled** • This parameter has no effect on load-dependent stops. **Enabled** • If any heavy consumers are active, load-dependent stops are blocked. This may lead to inefficient operation. • If you only need this function for some heavy consumers, configure the `Power management > Block load-dependent stop` digital input function and use it for these heavy consumers.

NOTE *** # is 1 to 8.

8.8.3 Heavy consumer sequence

Fixed heavy consumer sequence

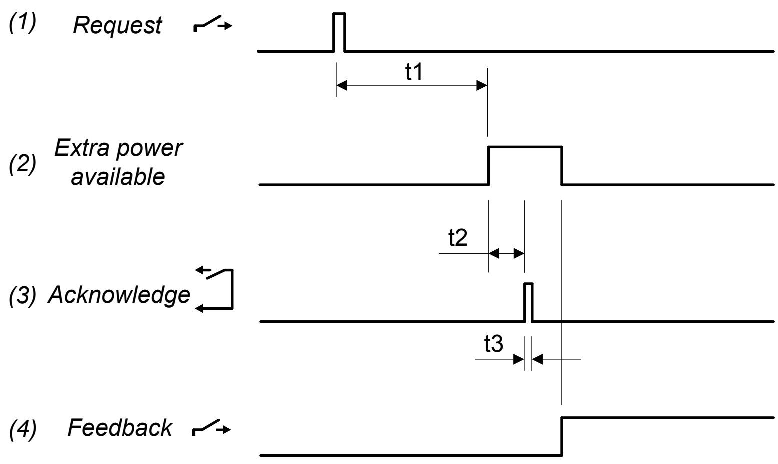


t1 = Time required to start extra genset(s) for the heavy consumer

t2 = Pulse width (`Heavy consumers > [Heavy consumer #] > Acknowledge`, where # is 1 to 6 and [Heavy consumer #] can be replaced by the heavy consumer *Controller label*)

1. **Request**: `Heavy consumers > [Heavy consumer #] > Request` (digital input). An operator or an external signal activates this input.
2. **Extra power available**: The PMS starts genset(s), until enough extra power is available for the heavy consumer.
3. **Acknowledge**: `Heavy consumers > [Heavy consumer #] > Acknowledge` (digital output). When enough extra power is available, the controller activates this output.
4. **Feedback**: `Heavy consumers > [Heavy consumer #] > Feedback` (digital input). The heavy consumer detects the *Acknowledge*, then connects, takes load, and activates this input.

Fixed heavy consumer sequence with acknowledge delay



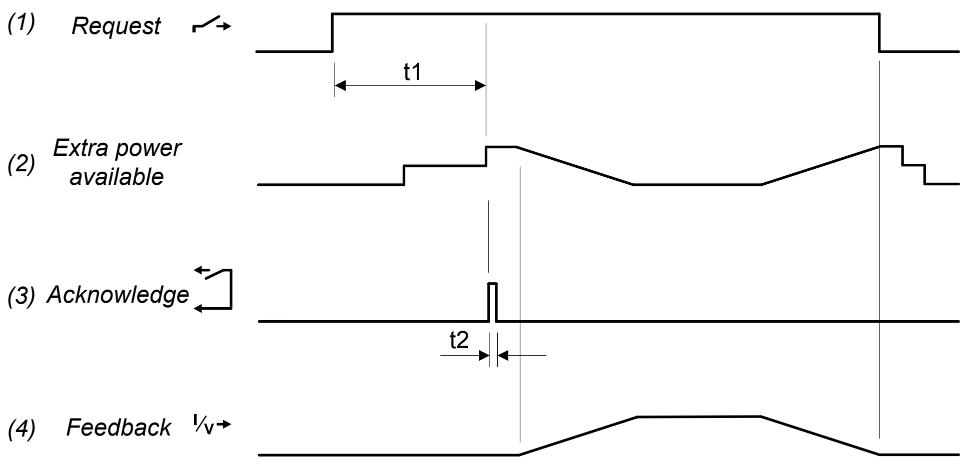
t1 = Time required to start extra genset(s) for the heavy consumer

t2 = Acknowledge delay

t3 = Pulse width (`Heavy consumers > [Heavy consumer #] > Acknowledge`, where # is 1 to 6 and [Heavy consumer #] can be replaced by the heavy consumer *Controller label*)

1. **Request**: `Heavy consumers > [Heavy consumer #] > Request` (digital input). An operator or an external signal activates this input.
2. **Extra power available**: The PMS starts genset(s), until enough extra power is available for the heavy consumer.
3. **Acknowledge**: `Heavy consumers > [Heavy consumer #] > Acknowledge` (digital output). When enough extra power is available, the controller waits for the time specified by the acknowledge delay parameter before the controller activates the *Acknowledge* digital output.
4. **Feedback**: `Heavy consumers > [Heavy consumer #] > Feedback` (digital input). The heavy consumer detects the *Acknowledge*, then connects, takes load, and activates this input.

Variable heavy consumer sequence



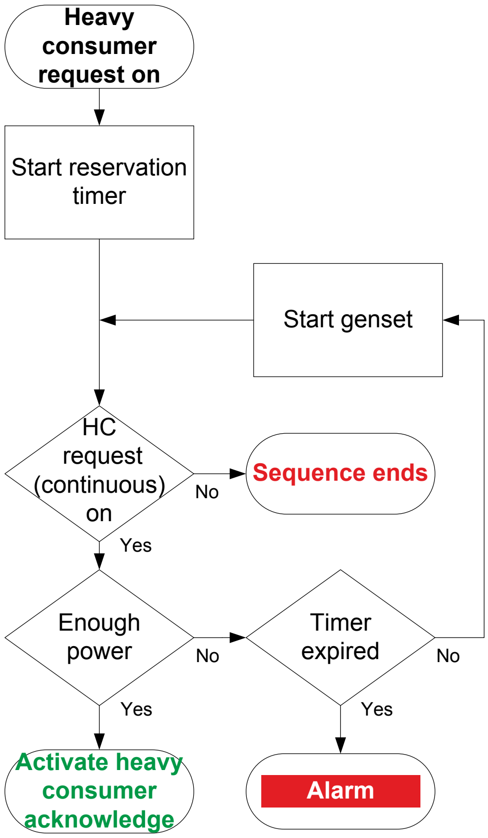
t1 = Time required to start extra genset(s) for the heavy consumer

t2 = Pulse width (`Heavy consumers > [Heavy consumer #] > Acknowledge`, where # is 1 to 6 and [Heavy consumer #] can be replaced by the heavy consumer *Controller label*)

1. **Request**: `Heavy consumers > [Heavy consumer #] > Request` (digital input). An operator or an external signal activates this input.
   - If the *Request* digital input is deactivated after the *Feedback* is above 2 %, then the heavy consumer power is reserved until the *Feedback* falls below 1 %.
2. **Extra power available**: The PMS starts genset(s), until enough extra power is available for the heavy consumer.
3. **Acknowledge**: `Heavy consumers > [Heavy consumer #] > Acknowledge` (digital output). The controller activates this output.
4. **Feedback**: `Heavy consumers > [Heavy consumer #] > Feedback`(analogue input). The heavy consumer detects the *Acknowledge*, then connects, and takes load. This input must show how much load is taken.

8.8.4 Heavy consumer flowcharts and example

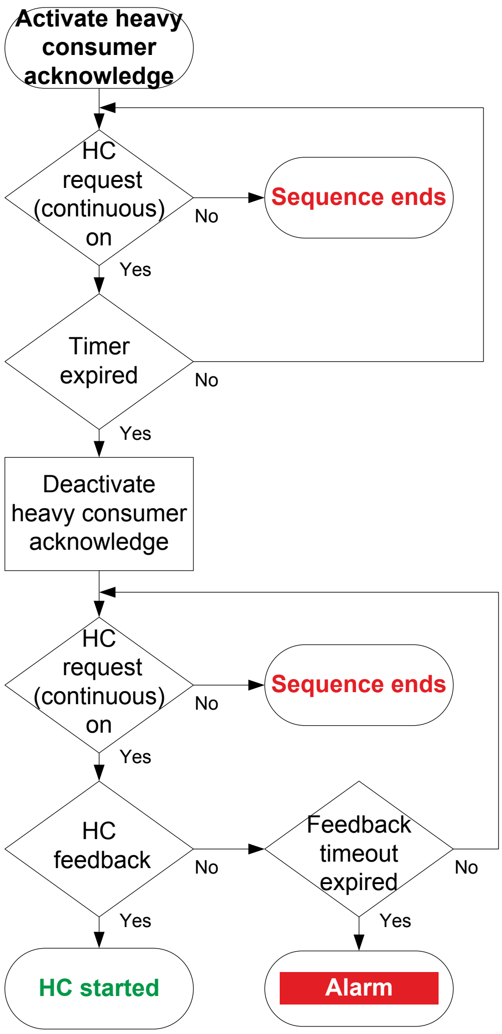
Heavy consumer request flowchart



1. When a heavy consumer needs to start, a request is sent to the controller by activating the `Heavy consumers > [Heavy consumer #] > Request` digital input.
2. The PMS starts the *Heavy consumer reservation not possible* timer.
3. The PMS uses the heavy consumer *Initial load* to calculate whether there is enough power for the heavy consumer to connect.
4. The PMS starts additional genset(s) if needed (that is, if the PMS available power after the heavy consumer connects is less than the load-dependent start limit).
   - If power reservation is impossible, or if the *Heavy consumer reservation not possible* timer runs out, then the controller activates the *Heavy consumer reservation not possible* alarm.

NOTE If you use a pulse request signal, then the heavy consumer request sequence can only stop when there wasn't enough power for the heavy consumer to connect and the *Heavy consumer reservation not possible* timer runs out. If you use a continuous signal, then the heavy consumer request sequence can be stopped at any time.

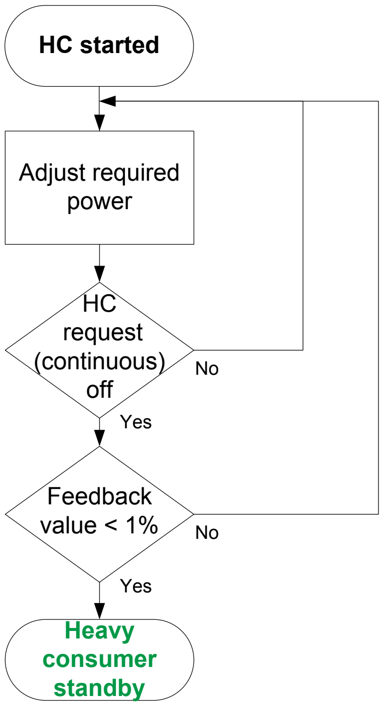
Heavy consumer acknowledge and feedback flowchart



1. When enough power is available, the controller activates the `Heavy consumers > [Heavy consumer #] > Acknowledge` output for the *Pulse width*. The *Feedback timeout > Delay* timer starts running.
2. Feedback:
   - For a fixed load heavy consumer, when the heavy consumer connects, it must activate the `Heavy consumers > [Heavy consumer #] > Feedback`. As long as this feedback is not activated, the PMS reserves the heavy consumer's full nominal power at the busbar. When this feedback is activated, the heavy consumer draws power as part of the system load, and the PMS does not reserve any extra power.
   - For a variable load heavy consumer, the power reserved for the heavy consumer changes according to the heavy consumer load feedback. For example, when the load feedback is 80 % of the nominal load, the power reserved at the busbar is 20 % of the nominal load.
   - If feedback is not received before the feedback timeout expires, the PMS activates the *Heavy consumer feedback timeout* alarm.

NOTE If the heavy consumer request signal is a pulse, then the state of the signal is not checked in this procedure.

Connected heavy consumer and disconnect flowchart

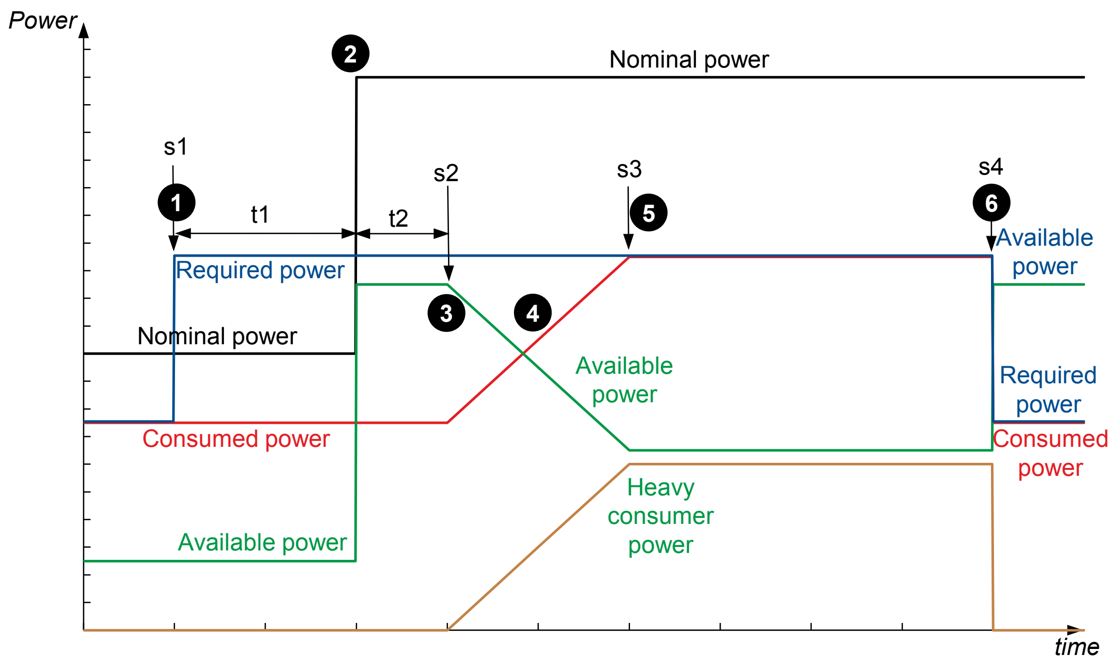


1. When the heavy consumer is connected, the controller adjust the power requirements for the system.
2. When the heavy consumer is no longer required, the operator (or an external signal) must:
   - **Pulse request signal**: Reduce the heavy consumer power consumption.
   - **Continuous request signal**: Turn off the `Heavy consumers > [Heavy consumer #] > Request` digital input.
3. The sequence ends when:
   - **Variable load heavy consumer**: The *Request* is not activated and the feedback falls below 1 %.
   - **Fixed load heavy consumer**: The *Request* is not activated and there is no longer any feedback from the heavy consumer.

Variable load example

The following graph shows the effect of a heavy consumer with a variable load.

Figure 8.3 Example of heavy consumer with variable load



s1 = Heavy consumer request on

s2 = Heavy consumer starts

s3 = Heavy consumer full power

s4 = Heavy consumer request off

t1 = Genset start time

t2 = Delay

Points on graph

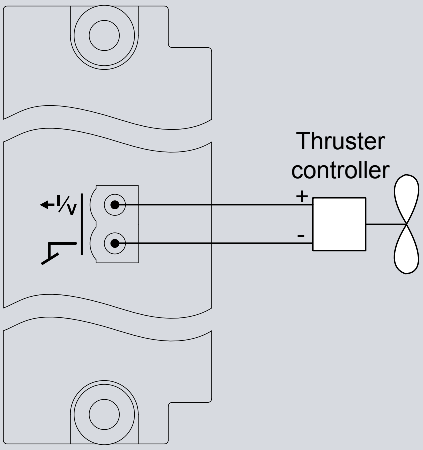
1. An operator or an external signal activates the `Heavy consumers > [Heavy consumer #] > Request`. The required power is more than the nominal power, so the PMS sends a start command to a genset.
2. The genset starts and connects, so that the nominal power is more than the required power. The controller activates the `Heavy consumers > [Heavy consumer #] > Acknowledge`.
3. The heavy consumer connects and starts taking load.
4. The heavy consumer power consumption increases. This increases the consumed power, and decreases the available power.
5. The heavy consumer runs at full power.
6. The heavy consumer disconnects and the operator or an external signal deactivates the heavy consumer request. The consumed power and required power drop, and the available power rises.

8.8.5 Fast load-reduction

The power management system uses the AC measurements to calculate the system's available power. The available power is available as an analogue output, with an operate time of less than 100 milliseconds. You can connect this output to a load controller, for example, a thruster or a crane, to have fast load-reduction when the available power is too low.

Example wiring

Fast load-reduction using a thruster controller



The thruster controller can reduce the load by reducing the frequency of a frequency drive. Alternatively, the thruster controller could change the propeller pitch.

Inputs and outputs

Function	I/O	Units	Details
`Power management > Section | PMS P avail. [kW]`	Analogue output	0 kW to 10 MW	Configure this output with a suitable scale. The output can be an input for a load controller, for fast load-reduction when the available power is low.
`Power management > Section | PMS P avail. [%]`	Analogue output	-100 to 100 %	
`Power management > Section | Conn. P avail. [kW]`	Analogue output	0 kW to 10 MW	
`Power management > Section | Conn. P avail. [%]`	Analogue output	-100 to 100 %	

Use *PMS P avail.* to ensure that there is power available from **GENSET** controllers in AUTO mode. Use *Conn. P avail.* to include the **GENSET** controllers in Manual mode and any controllers in switchboard control in the available power.

8.8.6 Protections

More information
See Heavy consumer reservation not possible and Heavy consumer feedback timeout for more information about the power management protections for heavy consumers.

8.9 Externally controlled breakers

8.9.1 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 **Wiring for controller functions** in the **Installation instructions** for an example of external breaker wiring.

Digital inputs

Function	I/O	Type	Details
`Breakers > Breaker feedback # > Feedback > Breaker # feedback closed` *	Digital input	Continuous	The feedback ensures that the controller system knows when the external breaker is closed.
`Breakers > Breaker feedback # > Feedback > Breaker # feedback 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 > Breaker feedback # > State > Breaker # feedback is open` *	Digital output	Continuous	Activated when the breaker is open.
`Breakers > Breaker feedback # > State > Breaker # feedback is closed` *	Digital output	Continuous	Activated when the breaker is closed.

NOTE * # represents the external breaker number. Up to four 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 must put the system under switchboard control. The operator must then manually synchronise the busbar sections and then manually close the external breaker.

For an externally controlled bus tie breaker, the power management system does not synchronise the busbar sections. The power management system does not close the breaker either. Similarly, the power management system does not de-load an externally controlled bus tie breaker, or open the breaker.

More information
See Regulation required for synchronisation for more information about synchronising busbars.

Alarm

More information
See Breaker # feedback position failure for information about the alarm settings.

8.9.2 Externally controlled shore connection

The externally controlled shore connection function allows an externally controlled shore connection 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.

Digital inputs

Function	I/O	Type	Details
`Breakers > Breaker feedback # > Feedback > Breaker # feedback closed` *	Digital input	Continuous	The feedback ensures that the controller system knows when the external breaker is closed.
`Breakers > Breaker feedback # > Feedback > Breaker # feedback 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 > Breaker feedback # > State > Breaker # feedback is open` *	Digital output	Continuous	Activated when the breaker is open.
`Breakers > Breaker feedback # > State > Breaker # feedback is closed` *	Digital output	Continuous	Activated when the breaker is closed.

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

Manually synchronising to an externally controlled shore connection

To close the externally controlled shore connection, the operator must put the system in switchboard control. The operator must then manually synchronise and afterwards manually close the external breaker.

For an externally controlled shore connection, the power management system (PMS) does not synchronise the ship busbar with the shore connection. The PMS does not close the breaker either. Similarly, the PMS does not de-load an externally controlled shore connection, or open the breaker.

More information
See Regulation required for synchronisation for more information about synchronising.

Creating a blackout to connect to an externally controlled shore connection

The PMS is designed to never stop the last genset, and to restore power if there is a blackout. To create a blackout and close the externally controlled shore connection:

1. There must be a digital input with the `Power management > Block blackout start function`. Activate this digital input.
2. Disconnect all the gensets: Put each **GENSET** controller in switchboard control, and then open the generator breaker.
   - There should now be a blackout.
3. Close the breaker to the externally controlled shore connection.

Alarm

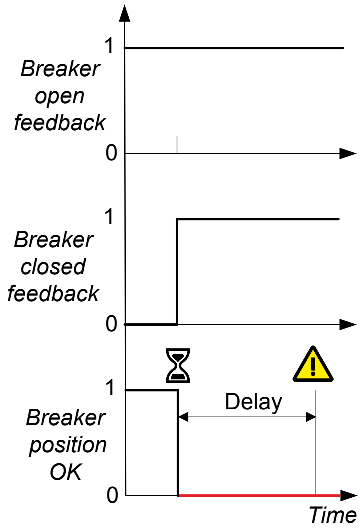
More information
See Breaker # feedback position failure for more information about the alarm settings.

8.10 Power management alarms

8.10.1 Breaker # feedback position failure

This alarm is for an externally controlled breaker or redundant breaker feedback 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	Default
`Delay`	1 s to 1 h	1 s

All controllers in the busbar sections in switchboard control

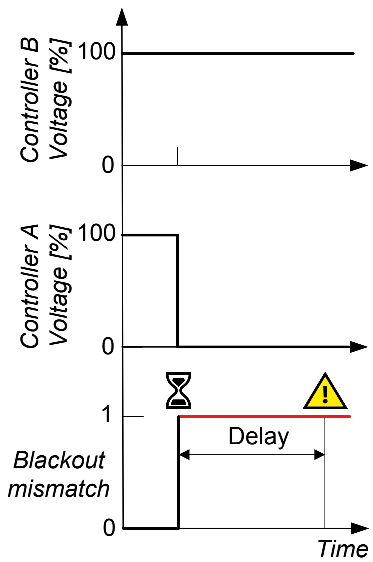
If the *Breaker # feedback position failure* alarm is activated for an externally controlled bus tie breaker without redundant breaker feedback, the controller cannot be sure whether the breaker is open or closed. The power management system therefore puts all the controllers in the sections on either side of the externally controlled bus tie breaker under switchboard control. The controllers remain under switchboard control until the position failure is fixed.

8.10.2 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.

This alarm is present in **GENSET**, **HYBRID**, **SHAFT generator** and **SHORE connection** controllers.



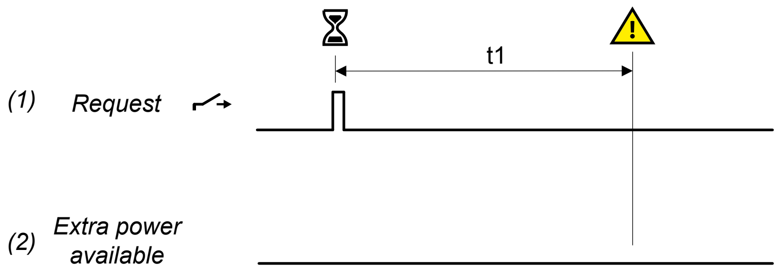
`System > Monitoring > Blackout detection mismatch`

Parameter	Range
`Delay`	0.0 s to 1 h

8.10.3 Heavy consumer reservation not possible

This alarm communicates that there is not enough power available in the PMS to start the heavy consumer.

The timer starts when the `Heavy consumers > [Heavy consumer #] > Request` is activated. The timer runs until the power management system confirms that the required power is available. If the *Delay* (t1) is exceeded, the controller activates the alarm, and the heavy consumer request is cancelled. If reservation is impossible the alarm is activated immediately, without waiting for the timer to expire.



The required power can be too low if the system is already under heavy load, or if the available gensets fail to start. When the alarm is activated, the power management system ignores heavy consumer requests.

`Heavy consumers > [Heavy consumer #] > Reservation not possible` *

This alarm is always enabled.

NOTE * # is 1 to 6 and [Heavy consumer #] can be replaced with the *Controller label* of the heavy consumer.

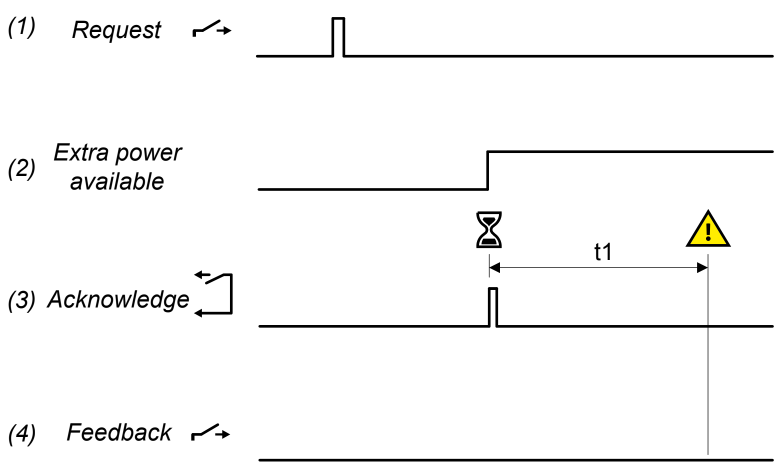
Parameter	Range	Default
`Delay`	1 s to 1 h	2 min
`Action`		Warning, Latch enabled

8.10.4 Heavy consumer feedback timeout

This alarm communicates that the requested heavy consumer did not give feedback within the configured time after the request was acknowledged.

The timer starts when the controller activates the `Heavy consumers > [Heavy consumer #] > Acknowledge` output. The timer runs until the controller receives `Heavy consumers > [Heavy consumer #] > Feedback`. For variable feedback, the timer is cancelled when the feedback is above 2 %.

For a continuous request signal, the feedback timer stops and resets when the request signal becomes low before the *Delay* (t1) is exceeded.



If the *Delay* (t1) is exceeded, the controller activates the alarm and the heavy consumer reservation is cancelled.

When the alarm is activated, it is not possible to request power reservation for this heavy consumer. The *Feedback* must be reset, and the alarm acknowledged, before the heavy consumer sequence can be restarted.

`Heavy consumers > [Heavy consumer #] > Feedback timeout` *

This alarm is always enabled.

Parameter	Range
`Delay`	1 s to 1 h

NOTE * # is 1 to 6 and [Heavy consumer #] can be replaced by the heavy consumer *Controller label*.

8.10.5 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. This alarm also forces the controller in switchboard control.

This alarm is always enabled.

`System > Monitoring > Missing all controllers`

8.10.6 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, the alarm action is *Warning*. The alarm also forces all the controllers in the section under switchboard control. The alarm parameters are not visible.

8.10.7 Duplicate controller ID

Each controller is delivered with this default alarm to communicate 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. The affected controllers are also forced in switchboard control.

This alarm is always enabled.

`System > Monitoring > Duplicate controller ID`

8.10.8 Missing any controller

This alarm informs the operator that there is a communication failure with one or more controllers.

The alarm is based on the network between the controllers included in the single-line application drawing. The controller activates the alarm if there is at least one controller in the single-line application drawing that it cannot communicate with. This alarm is not suppressed by *Missing all controllers*.

This alarm is always enabled.

`System > Monitoring > Missing any controller`

8.10.9 Missing controllers

This alarm informs the operator that there is a communication failure with one or more controllers. The alarm is based on the network between the controllers included in the single-line application drawing. The controller activates the alarm when the number of missing controllers in the section reaches the set point. This alarm is not suppressed by *Missing all controllers*.

When the alarm is activated, the power management system changes the mode of the remaining controllers in the section according to the parameters in `System > Monitoring > Mode while controller missing` and `PMS mode while controller missing`.

NOTICE

Missing controllers

If controller(s) are missing, then the power management cannot know their operating information, including the breaker positions. Evaluate the risks before configuring this set point.

`System > Monitoring > Missing controllers`

Parameter	Range
`Set point`	1 to 5

8.10.10 Forced to switchboard control

This alarm communicates that a critical alarm has forced the controller to switchboard control.

The alarm is based on the conditions that can force the controller to switchboard control. The alarm is not activated if the controller is already under switchboard control because the *Switchboard control* digital input is activated.

`Local power management > Alarms > Forced to switchboard control`

Parameter	Range	Default
`Enable`	• Not enabled • Enabled	Not enabled

More information

See Switchboard control for the conditions that can force the controller in switchboard control.

8.10.11 Forced to Manual mode

This alarm communicates that an alarm has forced the controller into Manual mode.

The alarm is based on the conditions that can force the controller to Manual mode. When the condition(s) that activated the alarm are resolved, the controller remains in Manual mode. An external signal (for example, an operator selects AUTO on the display) is required to change the controller to AUTO mode.

This alarm is present in the **GENSET** and **EMERGENCY genset** controllers.

`Local power management > Alarms > Forced to Manual mode`

Parameter	Range	Default
`Enable`	• Not enabled • Enabled	Enabled
`Action`		Warning

8.10.12 BTB # position failure

This alarm is activated when BTB # has a breaker position failure.

`System > Monitoring > BTB # position failure`

Name	Range	Details
Delay	1.0 to 5.0 s	To activate the alarm, the position failure must be present while the delay timer runs.

8.10.13 DEIF network redundancy broken

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

This alarm action is always *Warning*.

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

`Communication > DEIF network > DEIF network redundancy broken`

8.10.14 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`

8.10.15 DEIF network fork detected

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

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
```

8.10.16 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 in PICUS. When the alarm is activated, the controller is forced in switchboard control.

8.10.17 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 also forces the controller in switchboard control. The alarm parameters are not visible in PICUS.

8.10.18 Controller not part of system

This alarm communicates that the controller has a *Controller ID* that is not included in the single-line application drawing. Check the Application single-line application drawing in PICUS.

The alarm is always *Enabled*, and the action is *Warning*. The controller will also be forced in switchboard control. The alarm parameters are not visible in PICUS.

8.10.19 Controller type mismatch

This alarm communicates when a controller's type does not match the controller type with its *Controller ID* in the single-line application drawing.

This alarm is activated when the *Controller ID* is assigned to an incorrect controller type in the single-line application drawing, and the single-line application drawing is written to the controller. The controller is also forced under switchboard control. The alarm parameters are not visible in PICUS.

Controller type mismatch example

A **GENSET** controller has *Controller ID* 1, but on the single-line application drawing *Controller ID* 1 is assigned to an **EMERGENCY genset** controller. The alarm is activated when the single-line application drawing is written to the controller.

8.10.20 Different power management rules activated

This alarm communicates that different power management rules apply to the same section.

The alarm is activated when two or more sets of power management rules apply to the section. A warning is displayed, and all the controllers in the section are forced to switchboard control.

The alarm is always enabled. The alarm parameters are not visible in PICUS.

8.10.21 Network protocol incompatible

The alarm communicates that the controller has a different network protocol from the rest of the controllers in the system.

The alarm can for example activate when a controller with a newer software version than the other controllers is added to the network. This includes different DEIF products in the same system, for example, iE 250 controllers and iE 350 controllers.

Update all the controllers in the system to the latest software.

The alarm action is *Warning*. You cannot see or change the alarm parameters.

8.10.22 PMS disabled due to an error

This alarm communicates that there is an internal error in the power management software. Power management is disabled, and all the controllers in the system are also forced into switchboard control.

The alarm action is *Warning*.

The alarm parameters are not visible in PICUS.

9. GENSET controller

9.1 About the GENSET controller

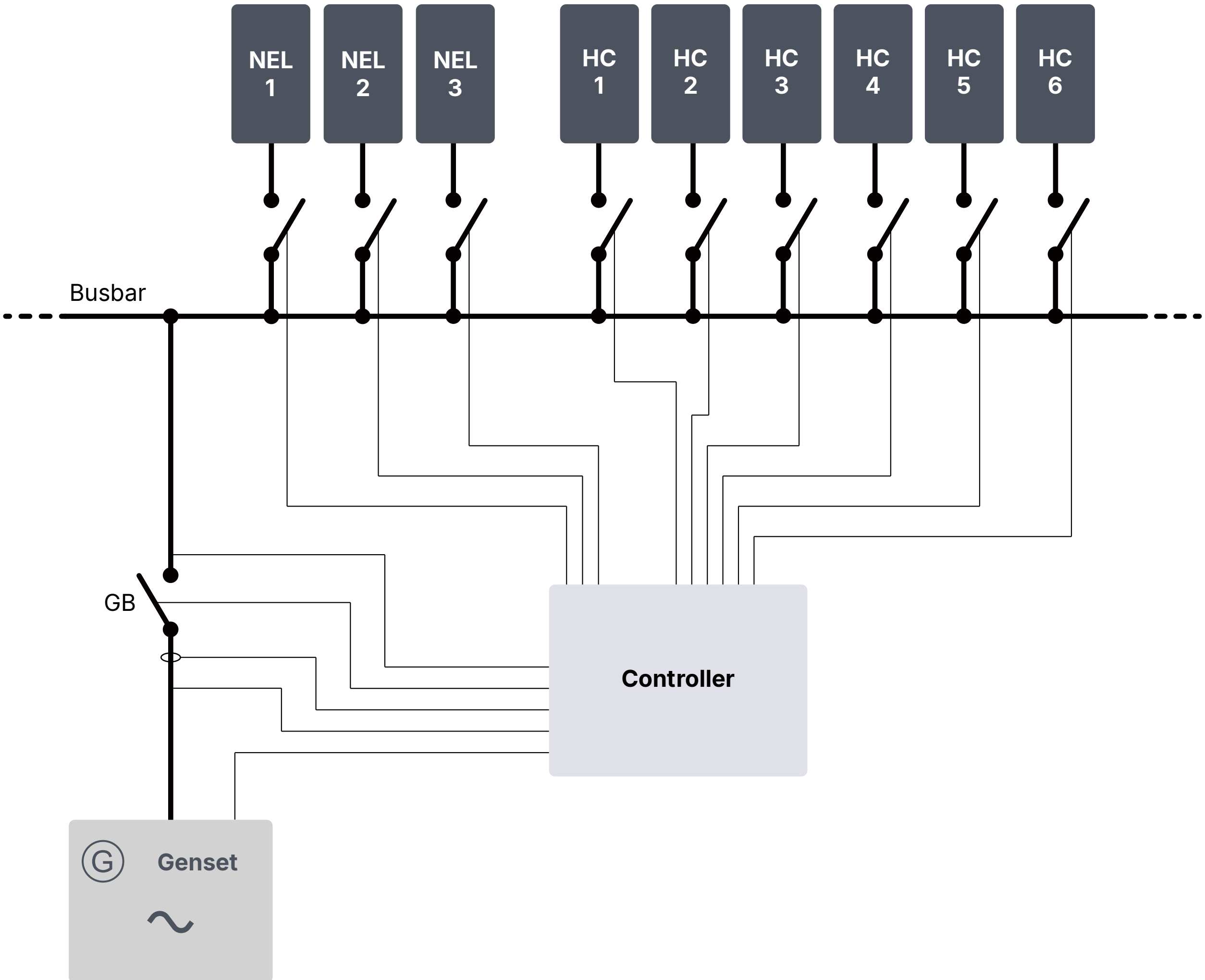
A **GENSET** controller controls and protects a prime mover (for example, a diesel engine) and generator, as well as the generator breaker. A system can include a number of **GENSET** controllers.

The **GENSET** controllers work together to ensure effective power management. This includes load-dependent start and stop, and may include setting the genset priority order, managing heavy consumers, and, if necessary, tripping non-essential loads.

The system must have at least one **GENSET** controller.

Each **GENSET** controller can control up to six heavy consumers (HC) and connect up to three non-essential load groups (NEL).

Example application with Heavy consumers (HC) and non-essential loads (NEL)



9.1.1 Functions

	Functions
Pre-programmed sequences	• Genset start and stop sequences • Breaker sequences

	Functions
	• Generator breaker blackout close

Regulation	• PID regulators for analogue outputs
	• P regulators for relay outputs
	• Set point selection using digital input, Modbus, and/or CustomLogic
	• Governor
	  ◦ Frequency regulation
	  ◦ Frequency and phase synchronisation
	  ◦ Active power load sharing
	  ◦ Fixed power
	• AVR
	  ◦ Voltage regulation
	  ◦ Reactive power load sharing
	  ◦ Fixed reactive power
	  ◦ Fixed cos phi
	• External set point from analogue input or Modbus
	• Configurable power ramp up/down
	• Three sets of temperature-dependent power derate settings

Counters	• Display unit counters, to edit or reset
	  ◦ Start attempts
	  ◦ Running hours (total and trip)
	  ◦ Breaker operations and trips
	  ◦ Power export (active and reactive)
	  ◦ External breaker operations
	• Energy counters with configurable digital outputs for external counters

Control types	• Power management system (PMS) control • Switchboard control

Control modes	• AUTO mode
	  ◦ Automatic power management
	  ◦ Automatic load-dependent genset start & stop
	  ◦ Automatic synchronisation & de-loading, and breaker control
	• MANUAL mode
	  ◦ Operations only on operator command
	  ◦ Operator-initiated synchronisation and de-loading
	  ◦ Display push-buttons for genset start/stop, and breaker open/close
	• Change control mode (AUTO/MANUAL) from the display, from PICUS, or via Modbus

9.2 GENSET controller principles

9.2.1 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)`	1.0 kW to 900 MW	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.

9.2.2 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. Marine classification societies generally require stop coil systems. A set of controller digital output terminals must be connected to and configured for either the run coil output, or the stop coil output.

Run coil and stop coil outputs

Function	I/O	Type	Details
`Engine > Controls > Run coil`	Digital output	Continuous	If all power to the controller is lost, then the genset stops. 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*.

9.2.3 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 is connected to an MPU mounted on the engine.
W	HSDI	Continuous	Optional. The W input is connected to the battery recharging generator and measures the engine speed. Alternatively, the W input can be connected to an NPN/PNP sensor.
`Engine > Measurements > Lube oil > Engine oil pressure [bar]`	Analogue input	Pressure in bar	Optional. This set of analogue input terminals are connected to a transducer for the engine oil pressure.

Parameters

Engine > Running detection > MPU setup

Parameter	Range	Comment
Number of MPU teeth	1 to 10000	The controller uses the number of teeth to calculate the engine speed from the MPU/W/NPN/PNP measurement signal.

Engine > Running detection > Feedback type

Parameter	Range	Comment
Primary running feedback	The available running feedbacks (depends on hardware)	Select one of the inputs as the primary running feedback. If the *Primary running feedback* does not detect running, but any other running feedback detects running, then the controller activates the *Primary running feedback failure* alarm.

Engine > Running detection > RPM running detection

Parameter	Range	Comment
RPM	0.0 to 50000.0 RPM	Running detection is ON when the engine speed measured by the MPU/W/NPN/PNP input is above this set point.
Use engine speed	Not enabled, Enabled	**Not enabled:** The MPU/W/NPN/PNP measurement is ignored and not used for running detection. **Enabled:** The MPU/W/NPN/PNP measurement is used as a running detection input.

Engine > Running detection > Frequency running detection

Parameter	Range	Comment
Frequency	10.0 to 100.0 Hz	Running detection is ON when the frequency measured by the generator voltage measurements is above this set point. For example: For a 60 Hz system, you can use a detection set point of 45 Hz.

Engine > Running detection > Oil pressure running detection

Parameter	Range	Comment
Oil pressure *	0.0 to 10.0 bar	Running detection is ON when the engine oil pressure is above this set point.
Use oil pressure *	Not enabled, Enabled	**Not enabled:** The engine oil pressure is ignored and not used for running detection. **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.

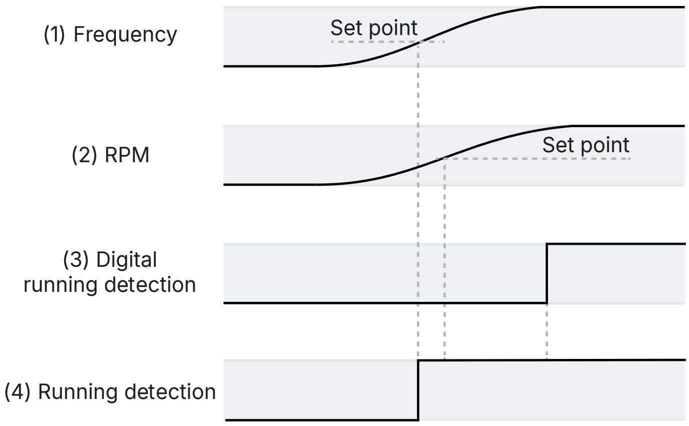
Oil pressure running detection hysteresis

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

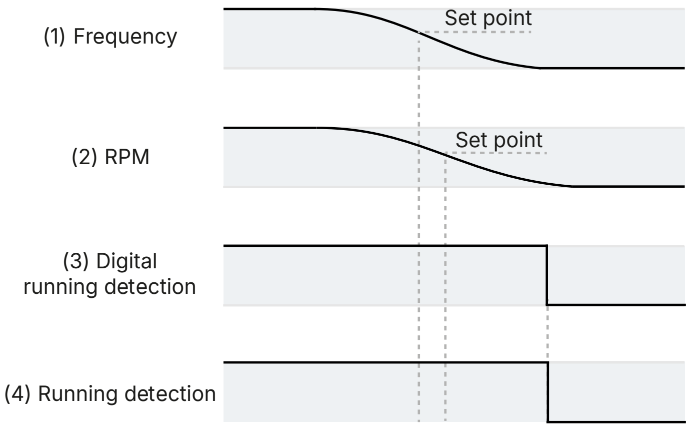


1. **Frequency**: The engine starts and the frequency rises above the set point.
2. **RPM**: (MPU/W/NPN/PNP input). The engine starts and the RPM rises above the set point.
3. **Digital running detection**: *Engine > Feedback > Digital running detection* (digital input). In the example, the response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

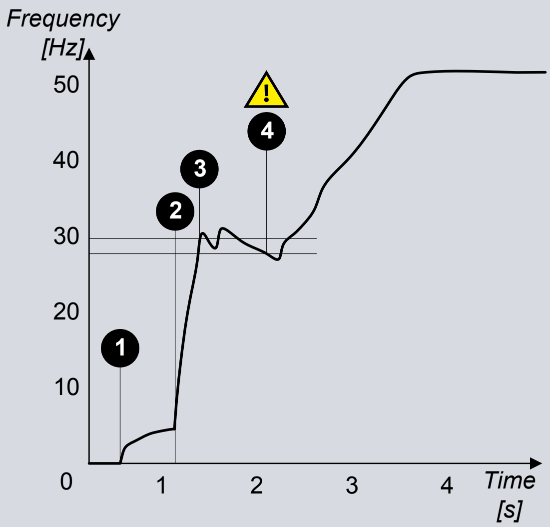
It is possible to only use frequency for running detection. However, using only frequency for running detection increases the risk of not detecting that the genset is running.

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.

9.2.4 Regulation

The GENSET controller can regulate both a governor (GOV) and an AVR.

More information
See Regulation for how regulation works.

9.2.5 Power management

The **GENSET** controller works together with the other controllers in the system to provide efficient power management. This includes blackout prevention and blackout recovery.

More information
See Power management for how power management works.

9.2.6 Load sharing

When a **GENSET** controller is under PMS control, it shares the load with other DEIF controllers using the DEIF network.

More information
See Power management and Load sharing for how it works.

9.2.7 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 **GENSET** controller is in PMS control.

9.2.8 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.

9.2.9 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.

9.3 Engine start

9.3.1 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

In AUTO and MANUAL mode, the **GENSET** controller uses these inputs and outputs, and parameters to start the genset. See the following sections for the engine start flowcharts and sequences.

When the operator starts the genset under switchboard control, the **GENSET** 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. 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 AUTO and MANUAL mode. However, the input will not prevent an engine start when the controller is under switchboard control.
`Engine > Command > Start engine and close generator breaker`	Digital input	Pulse	Optional. 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.

Idle run may not be allowed with certain maritime classification societies.

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.

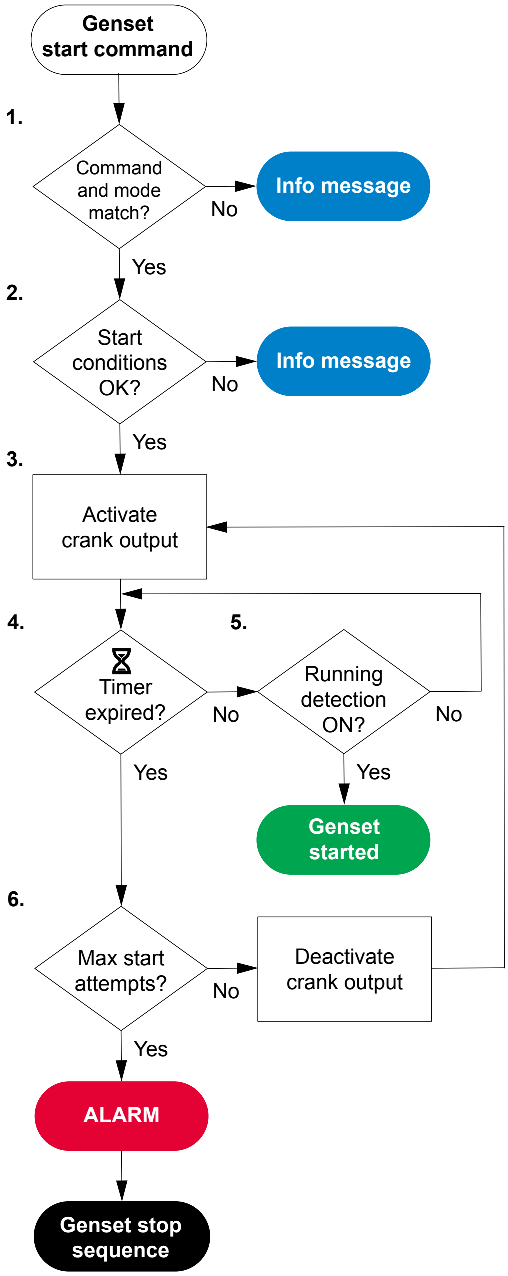
`Engine > Idle run start > Maximum`

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.

9.3.2 Engine start flowchart

This flowchart does not apply to switchboard control. Under switchboard control, if the operator presses the push-button **Start** on the display, the controller ignores the command and shows an info message.

Both *Start prepare* and *Idle run start* functions are not included on this diagram.



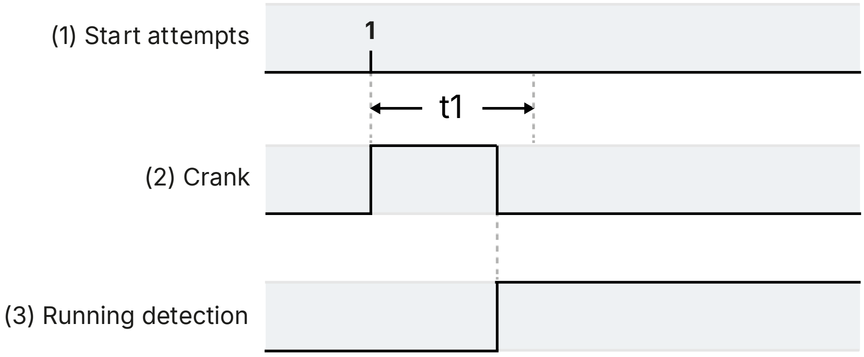
1. **Command and mode match:** The controller checks that the command source and the controller mode match:
   - In AUTO mode, the power management system must send the command to start the genset. The controller ignores all other external commands.
   - In MANUAL mode, the command to start the genset can come from the following:
     - The operator can press **Start** on the display.
     - The operator can use PICUS to send a genset start command.
     - The command can come from an external source, for example, a relay output from a PLC.
2. **Start conditions OK:** The controller checks whether the start conditions are OK:
   - For a power management command, the controller is in AUTO mode.
   - 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*
     - *PMS-controlled stop*
     - *Trip generator breaker and stop engine*
     - *Trip generator breaker and shutdown engine*
3. **Activate crank output:** 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.
5. **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.
6. **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.

9.3.3 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*.

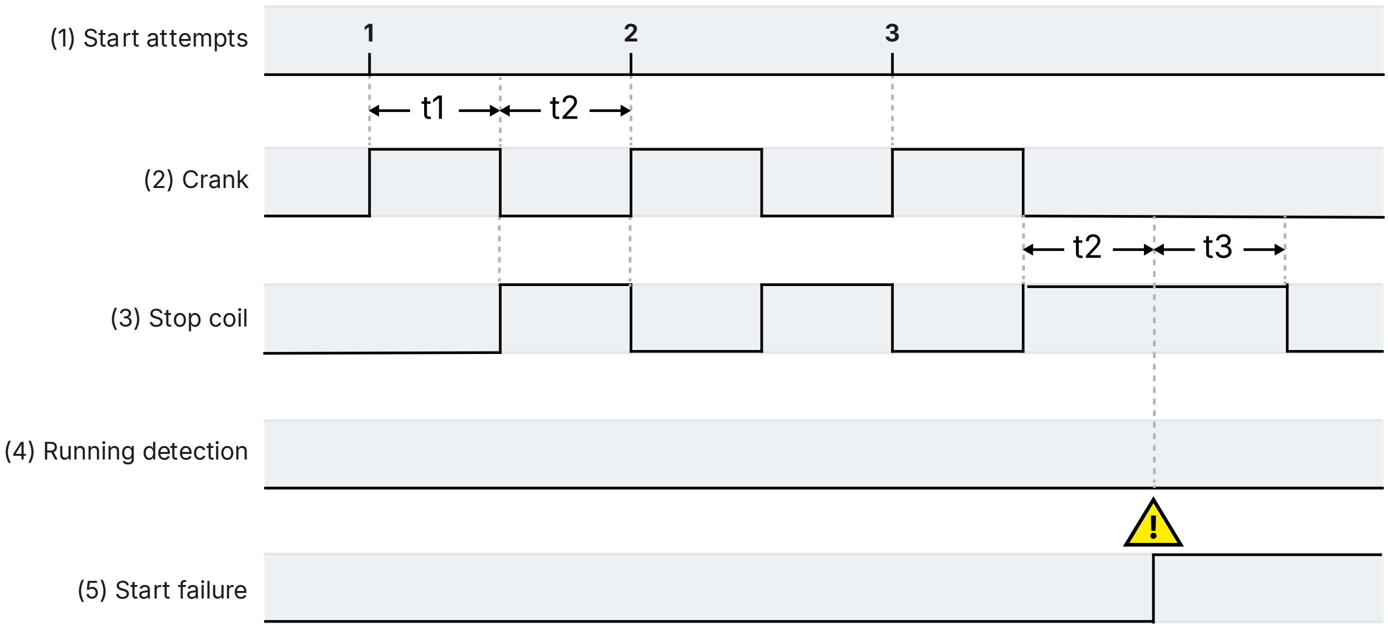
Successful engine start sequence for a stop coil system



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)

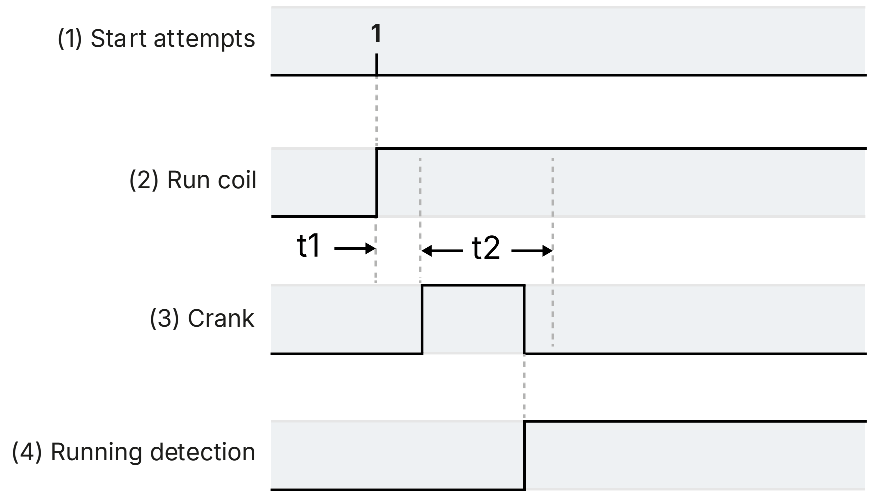
Failure of engine start sequence for a stop coil system:

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*.

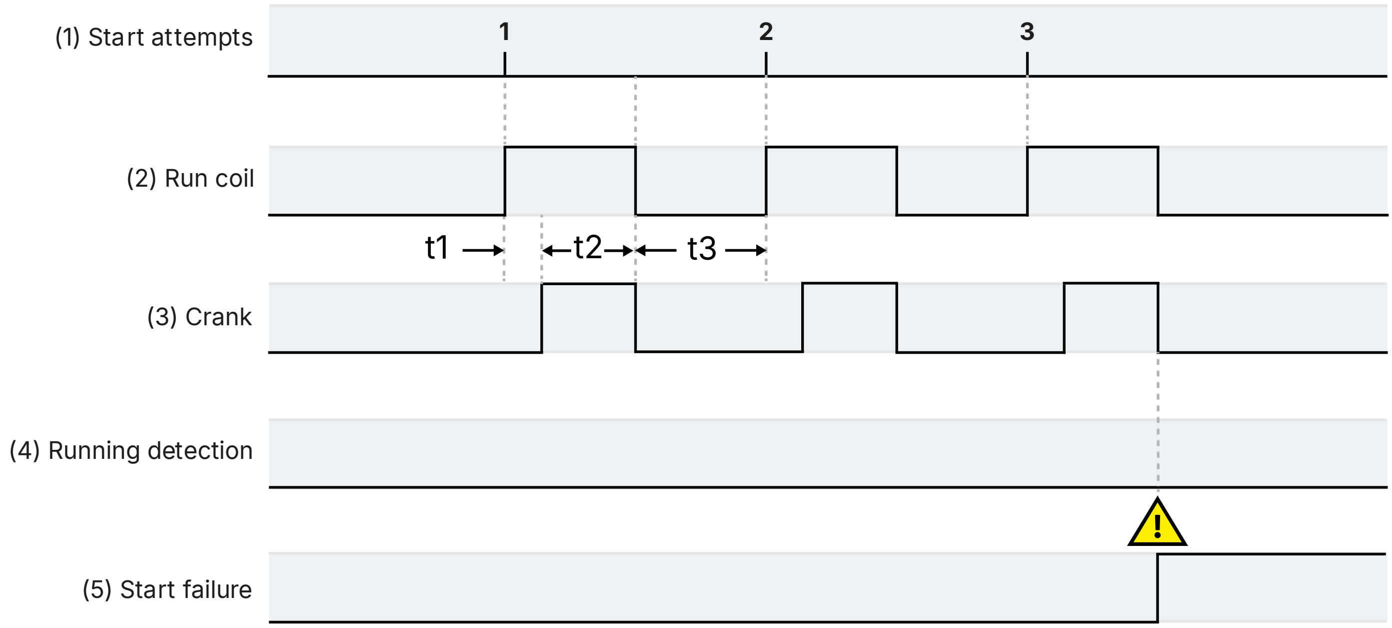
Successful engine start sequence for a run coil system



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`)

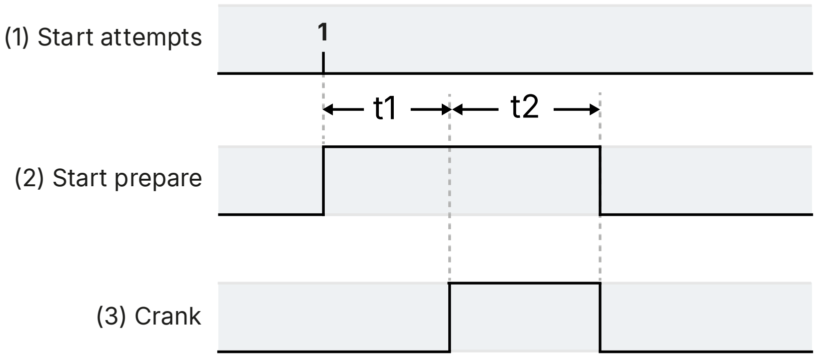
1. **Start attempts**: `Parameters > Engine > Start sequence > Start attempts > Normal` = 3.
2. **Run coil**: `Engine > Controls > Run coil` (digital output). The controller activates the *Run coil* at the time in the *Run coil before crank* parameter. If *Running detection* is still OFF after cranking, 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.

9.3.4 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)
- When the controller is in MANUAL mode, there is a *Stop engine* command. For example: The operator pushes the push-button **Stop** on the display unit.
- The following alarm actions:
  - *PMS-controlled stop*
  - *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.
- 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.

9.4 Engine stop

9.4.1 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

In AUTO and MANUAL mode, the GENSET 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 in MANUAL mode, 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 in MANUAL mode, 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. 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.

`Engine > Idle run stop > Maximum`

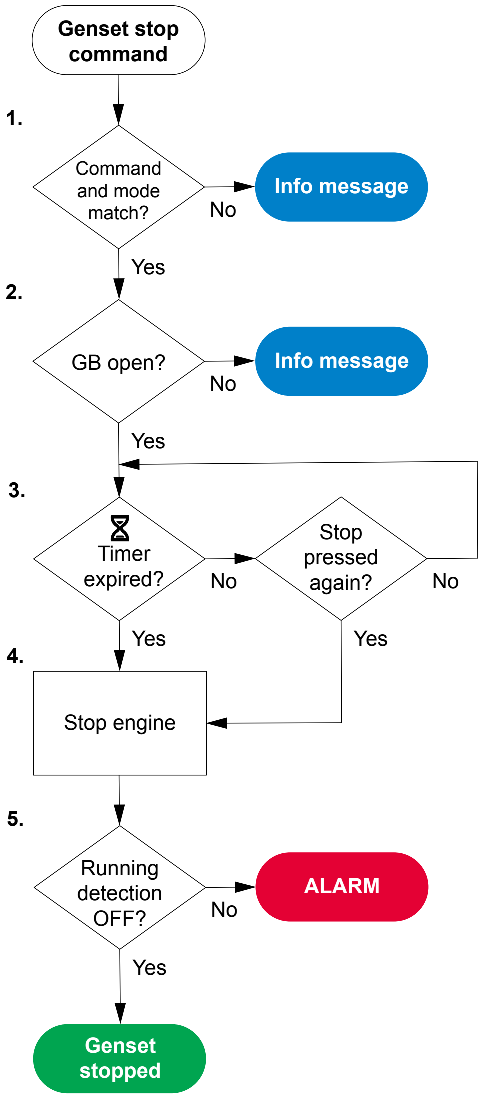
Parameter	Range	Comment
`Use`	Not enabled, Enabled	Uses maximum set point to determine if the engine is ready to stop.
`Delay`	1 s to 120 min	This is the maximum time the idle run stop can operate.

9.4.2 Engine stop flowchart

The following flowchart shows how the controller normally stops a genset. An engine shutdown is described later.

This flowchart does not apply to switchboard control. When the controller is under switchboard control, it will not stop the genset. If, for example, the operator presses the push-button **Stop** on the display unit, the controller ignores this command, and the controller display unit shows an info message.

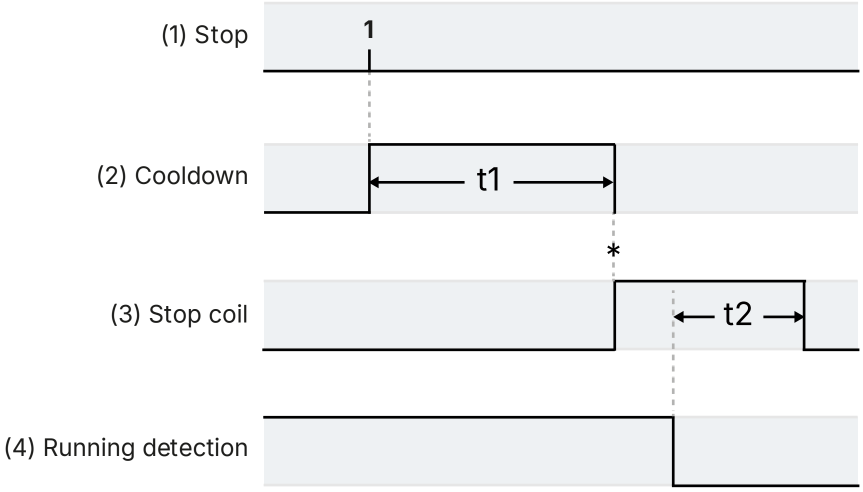
Idle run stop function is not included on this diagram.



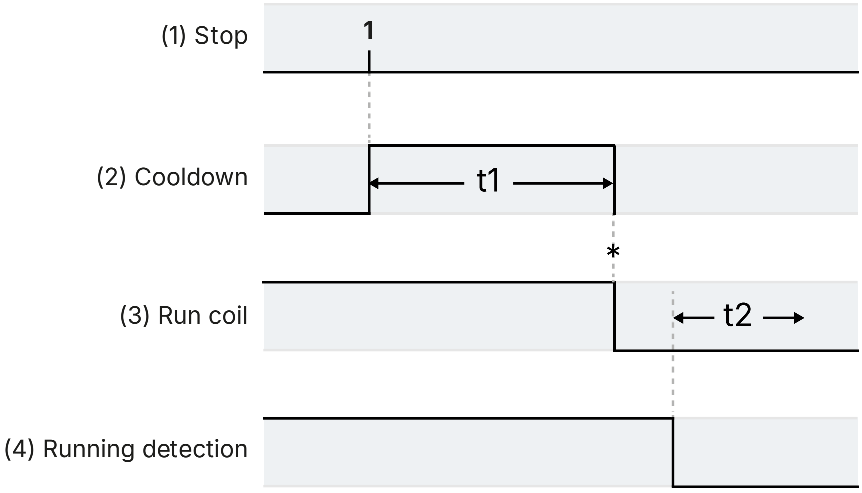
1. **Command and mode match:** The controller checks that the command source and the controller mode match:
   - In AUTO mode, the power management system must send the command to stop the genset. The controller ignores all other external commands.
   - In MANUAL mode, the command to stop the genset can come from the following:
     - The operator can press **Stop** on the display unit.
     - The operator can use PICUS to send an engine stop command.
     - The command can come from an external source, like a PLC.
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 is 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.

9.4.3 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.

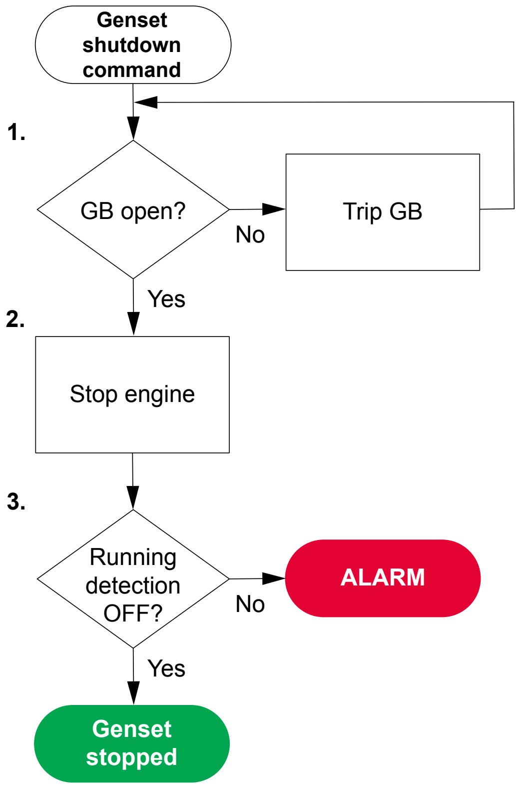
9.4.4 Engine shutdown flowchart

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.

9.5 Generator breaker

9.5.1 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

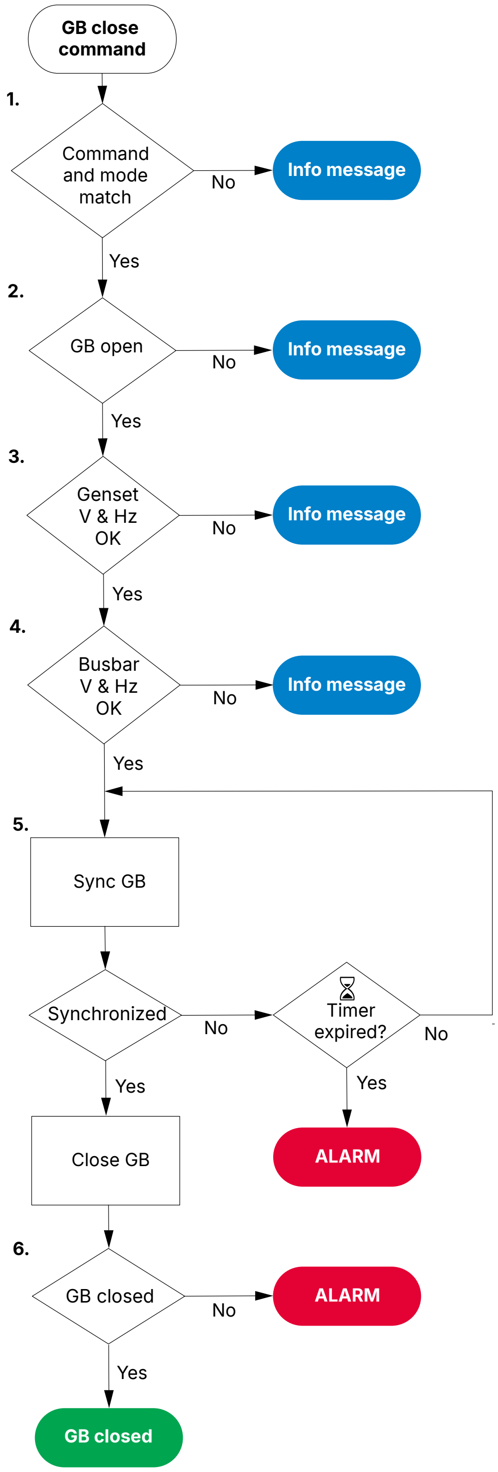
More information
See Breakers, synchronisation and de-loading for how synchronisation and breakers work. This includes the inputs and output functions and the parameters to configure.

[Breaker] refers to *Generator breaker*. The breaker abbreviation (*[*B]*) is *GB*.

9.5.2 Generator breaker close flowchart

This flowchart does not apply to switchboard control. When the controller is in switchboard control, it will not close the breaker. If, for example, the operator presses **Close breaker** on the display, the controller ignores this command.

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:
   - In AUTO mode, the power management system must send the command to close the generator breaker. The controller ignores all other external commands.
   - In MANUAL mode, the command to close the generator breaker can come from the following:
     - The operator can press the push-button **Close breaker** on the display unit.
     - The operator can use PICUS to send a close breaker command.
     - An external source, like a PLC.
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.

9.5.3 Generator breaker blackout close flowchart

The power management system can automatically close the generator breaker as part of the blackout response.

More information
See Blackout in Power management for more information.

Manual blackout close not possible

During a blackout, the **GENSET** controller is forced into AUTO mode. Since the **GENSET** controller is not in MANUAL mode, the operator cannot close the breaker by pushing **Close breaker** on the display.

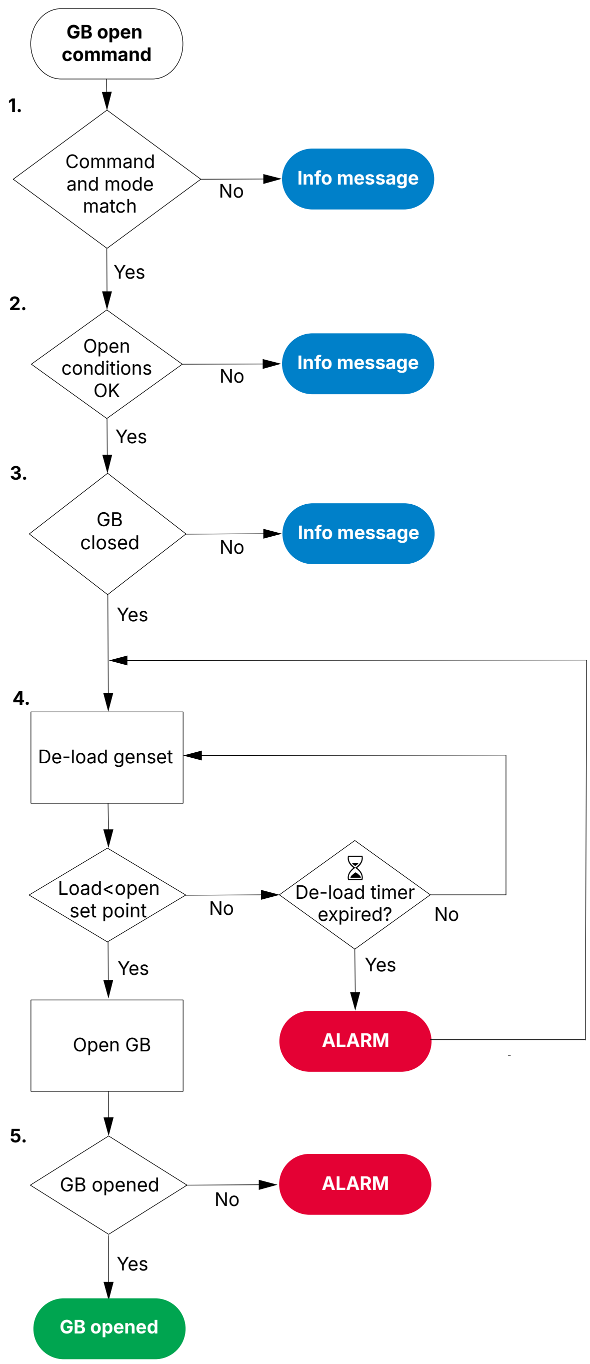
9.5.4 Generator breaker open flowchart

The flowchart shows the sequence that the controller normally uses to open the generator breaker. This sequence is also used for the alarm action *PMS-controlled stop*.

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.

This flowchart does not apply to switchboard control. When the controller is under switchboard control, it will not open the breaker (except for a trip). If, for example, the operator presses **Open breaker** on the display unit, the controller ignores this command.



1. **Command and mode match:** The controller checks that the command source and the controller mode match:
   - In AUTO mode, the power management system must send the command to open the generator breaker. The controller ignores all other external commands.
   - In MANUAL mode, the command to open the genset breaker can come from the following:
     - The operator can press **Open breaker** on the display.
     - The operator can use PICUS to send an open breaker command.
     - The command can come from an external source, like a PLC.
2. **Open conditions OK:** The controller checks whether the open conditions are OK. The following conditions must be met:
   - The system must have at least one other source of power running and connected to the busbar (for example, another genset, a shaft generator or a shore controller).
   - The remaining gensets must not be overloaded after the breaker opens.
3. **GB closed:** The controller checks whether the generator breaker is closed. If the generator breaker is open, the sequence ends.
4. **Deload genset:** The power management system de-loads the genset:
   - When the load is less than the set point for the breaker to open, the controller activates the *Breakers > Generator breaker > Controls > 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.
   - In MANUAL mode the de-loading of the genset can be stopped by sending a 'GB Close' command.
     - The de-loading sequence will stop and the breaker will remain closed.
     - An info message will show GB Open cancelled.
     - The system returns to the state before the 'GB Open' command.
5. **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.

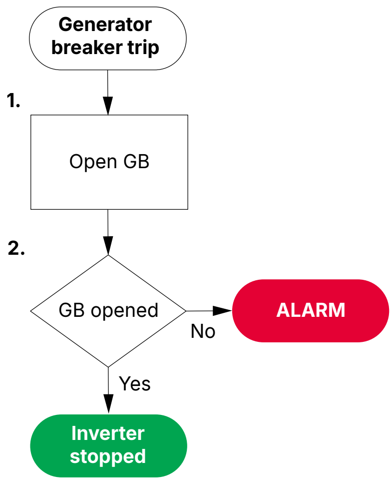
9.5.5 Generator breaker trip flowchart

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.

9.6 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/%

9.6.1 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`.

9.6.2 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.

9.7 Other GENSET controller functions

9.7.1 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.

Function	I/O	Type	Details
`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.

9.7.2 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.

9.7.3 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

By default, the genset nominal power is 100 % for temperatures up to 90 °C. If there is a *Derate temperature* input, then the power is derated linearly to 80 % at 130 °C. However, you can create a customised curve for each temperature input.

Power derate affects load sharing, since load sharing is 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.

9.7.4 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.

9.7.5 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

9.7.6 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.

Function	I/O	Units	Details
`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.
`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.

9.7.7 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.
`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.

9.7.8 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.

9.7.9 Trip AVR

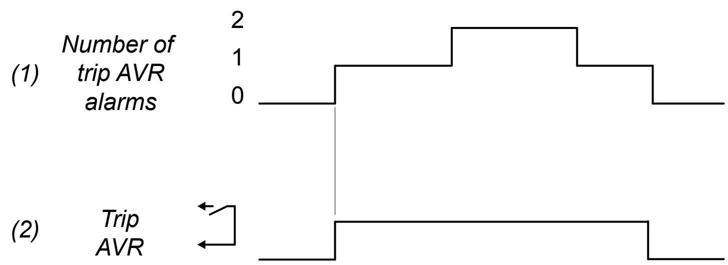
The *Trip AVR* output ensures that excitation is stopped when an alarm activates with a *Trip AVR* alarm action. In cases where there is high voltage present, stopping the excitation reduce the time required to stop an engine in case of an emergency.

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.

9.8 GENSET controller alarms

9.8.1 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)
	Governor regulation error
	Power ramp up error
	Power ramp down error
	Crank failure
	Primary running feedback failure
	Start failure
	Stop failure
	Engine stop (external)
	Engine start (external)
	Start enable removed during start
	Total running hours notification
	Trip running hours notification
	Magnetic pickup wire break
Generator	Voltage or frequency not OK
	AVR regulation error
Load sharing	P load sharing failure
	Q load sharing failure
Regulator configuration	GOV output selection failure
	GOV output setup failure
	GOV relay setup incomplete
	AVR output selection failure
	AVR output setup failure
	AVR relay setup incomplete
Maximum parallel time	DG-SG max. parallel time
	DG-SC max. parallel time
Power management	Heavy consumer feedback timeout (1 alarm for each heavy consumer)
	Heavy consumer reservation not possible (1 alarm for each heavy consumer)

	Alarms
Non-essential load (NEL)	• Up to 3 non-essential loads per controller • Can connect each controller to the same 3 non-essential load breakers
	NEL # over-current (1 alarm for each non-essential load)
	NEL # under-frequency (1 alarm for each non-essential load)
	NEL # overload 1 and 2 (2 alarms for each non-essential load)
	NEL # reactive overload (1 alarm for each non-essential load)
Advanced blackout prevention	P load sharing failure (low frequency)
	P load sharing failure (high frequency)
	Q load sharing failure (low voltage)
	Q load sharing failure (high voltage)
Other	Forced to Manual mode
	Trip AVR output not configured

9.8.2 Alarm actions

The controller has the following alarm actions:

- Warning
- Block
- PMS-controlled stop
- 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.

9.8.3 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.
Controller under SWBD control	The `Local > Mode > Switchboard control` digital input is activated, OR a system problem forced the controller under switchboard control.

Inhibit	Disables the alarm when ...
Engine stopping	The engine is in the stop sequence.
Idle run active	The engine idle run is active.
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.

9.8.4 Breaker alarms

More information
See Breakers, synchronisation and de-loading for breaker handling and alarms in general.

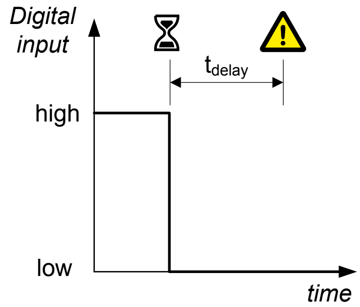
GENSET alarm	Parameters	General name
GB synchronisation failure	`Breakers > Generator breaker monitoring > Synchronisation failure`	Breaker synchronisation failure
GB de-load failure	`Breakers > Generator breaker monitoring > De-load failure`	Breaker de-load failure
Vector mismatch	`Breakers > Generator breaker monitoring > Vector mismatch`	Vector mismatch
GB opening failure	`Breakers > Generator breaker monitoring > Opening failure`	Breaker opening failure
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

9.8.5 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.

9.8.6 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.

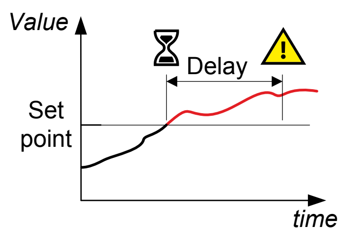
`Engine > Emergency stop > Emergency stop`

Parameter	Range
`Delay`	0.0 s to 1 min

9.8.7 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.

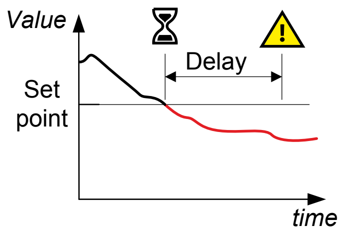
Parameter	Range
`Set point`	10.0 to 150.0 % of nominal speed
`Delay`	0.0 s to 3 min

NOTE * # is 1 or 2.

9.8.8 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.

9.8.9 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.

9.8.10 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.

9.8.11 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.

9.8.12 Coolant level

This alarm is activated if the coolant level is under the set point.

`Engine > Protections > Level > Coolant level #*`

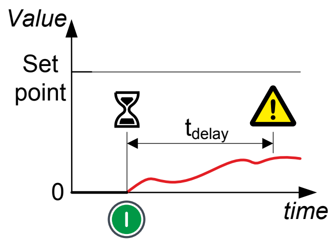
Parameter	Range
`Set point`	0.0 to 100.0 %
`Delay`	0.0 s to 3 min

NOTE * # is 1 to 3.

9.8.13 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`

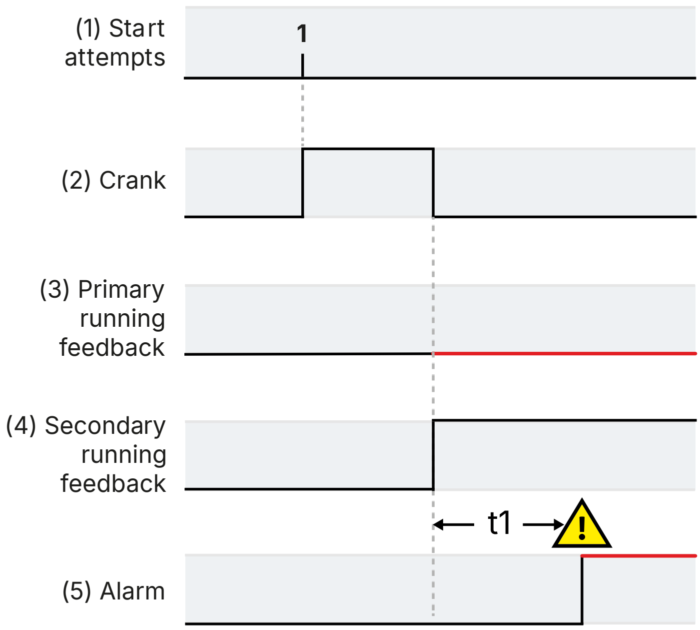
Parameter	Range
`Set point` (lower than)	1.0 to 400.0 RPM
`Delay`	0.0 to 20.0 s

9.8.14 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`

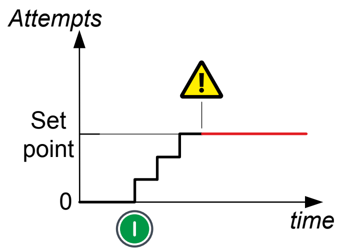
This alarm is always *Enabled*.

Parameter	Range
`Delay`	0.0 s to 3 min

9.8.15 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`

9.8.16 Start enable removed during start

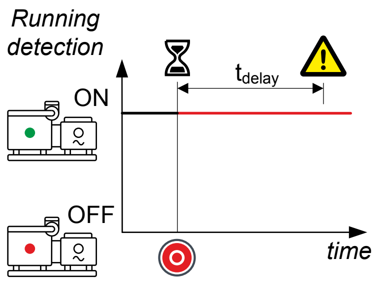
The alarm response is based on the engine start-up sequence. This alarm is activated if the engine start-up procedure is interrupted by the loss of the *Start enable* input before the engine has started.

`Engine > Start sequence > Start enable remove during start`

9.8.17 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.



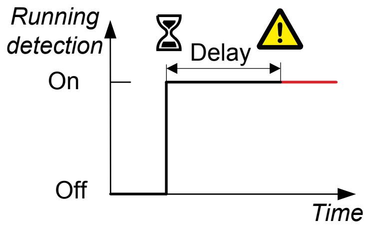
`Engine > Stop sequence > Stop failure`

Parameter	Range
`Delay`	10.0 s to 2 min

9.8.18 Engine started (external)

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

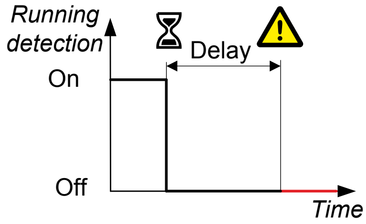
The alarm is activated if the controller did not initiate an engine start, but *Running detection* shows that the engine is running.



9.8.19 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.



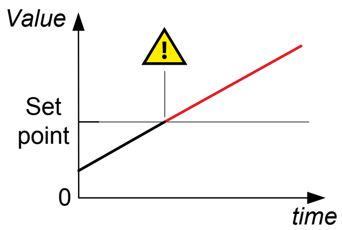
Engine > Stop sequence > Externally stopped

Parameter	Range
Delay	1 to 1200 s

9.8.20 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 # *

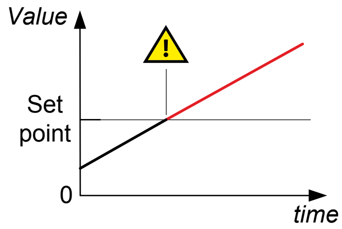
Parameter	Range
Set point	0 to 9000 h

NOTE * # is 1 to 4.

9.8.21 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

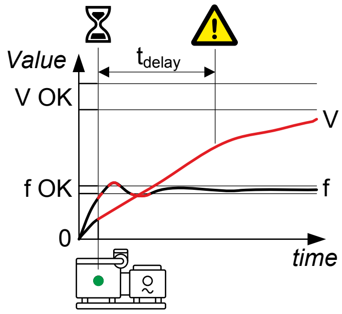
Parameter	Range
Set point	0 to 1,000,000 hours

9.8.22 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*.

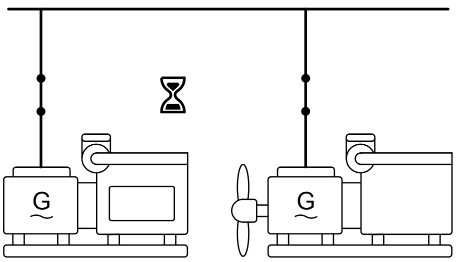
Parameter	Range
`Delay`	1 s to 1 h

9.8.23 DG-SG max. parallel time

This alarm limits the time that a genset may run in parallel to a shaft generator.

The timer starts when the genset or emergency genset are synchronised with the shaft generator.

Controller types: If a SHAFT generator controller is present in the system, these alarms are present in GENSET and EMERGENCY genset controllers.



Configure the parameters under:

```
Local power management > Parallel timers > DG-SG max parallel time
```

The alarm action is always *Trip generator breaker,* latch enabled.

Table 9.1 Default parameters

Parameter	Range	Default
Delay	0.1 s to 1 h	1 min
Enable	Not enabled, Enabled	Enabled

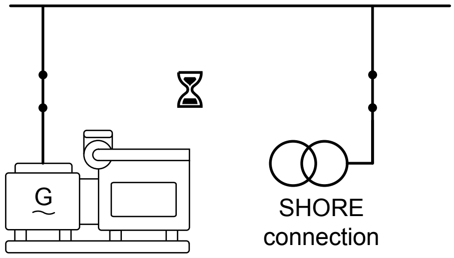
More information
See **SHAFT generator controller**, **SHAFT generator controller protections**, **SG-DG max. parallel time** for the alarm in the SHAFT generator controller that trips the shaft generator breaker.

9.8.24 DG-SC max. parallel time

This alarm limits the time that a genset may run in parallel to a shore connection.

The timer starts when the genset or emergency genset are synchronised with the shore connection.

Controller types: If a SHORE connection controller is present in the system, this alarm is present in GENSET and EMERGENCY genset controllers.



Configure the parameters under:

```
Local power management > Parallel timers > DG-SC max parallel time
```

The alarm action is always *Trip generator breaker*, latch enabled.

Table 9.2 Default parameters

Parameter	Range	Default
Delay	0.1 s to 1 h	1 min
Enable	Not enabled, Enabled	Enabled

More information
See **SHORE connection controller**, **SHORE connection controller protections**, **SC-DG max. parallel time** for the alarm in the SHORE connection controller that trips the shore connection breaker.

9.8.25 Other GENSET controller alarms

The following alarms are also included on the **GENSET** controller:
- Magnetic pickup wire break
- P load sharing failure
- Q load sharing failure

10. EMERGENCY genset controller

10.1 About the EMERGENCY genset controller

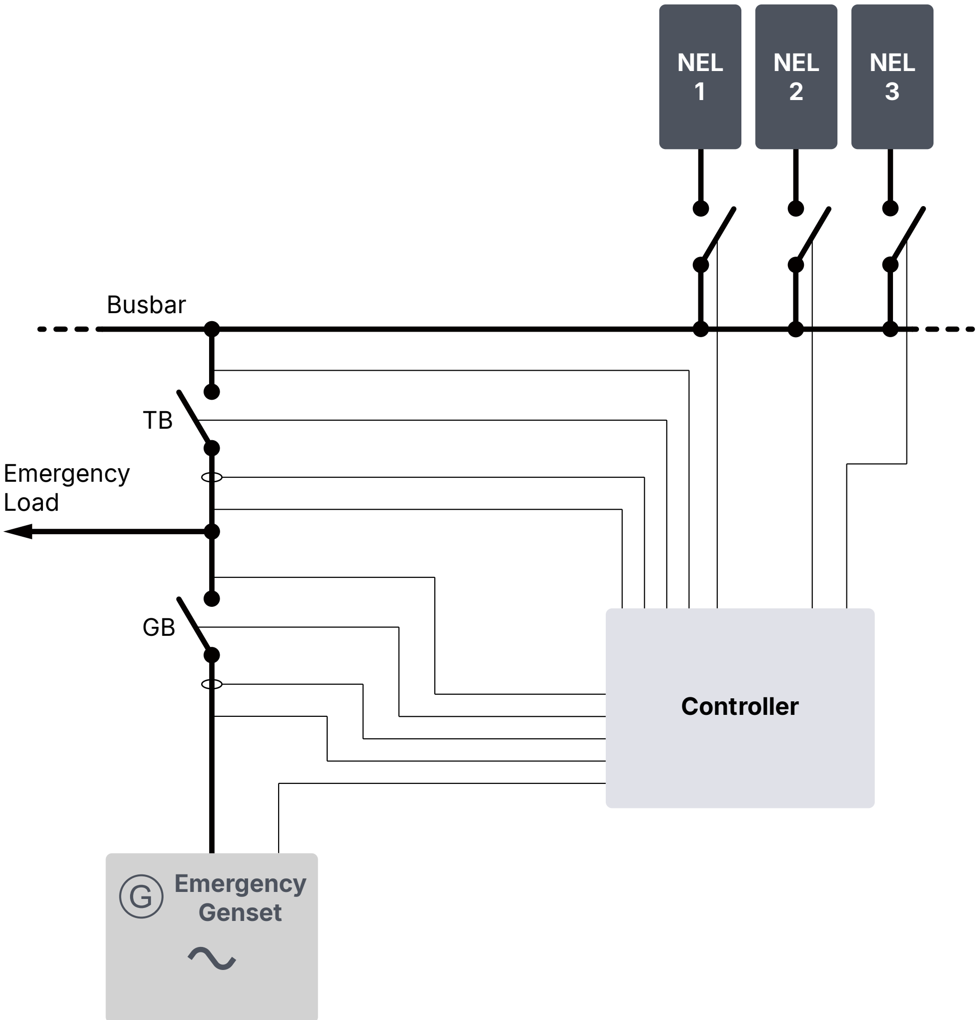
An **EMERGENCY genset** controller controls and protects an emergency genset (both the engine and the generator), as well as the generator breaker, and the emergency busbar tie breaker. By default, the **EMERGENCY genset** controller automatically starts the emergency generator when there is no voltage on the busbar.

The **EMERGENCY genset** controller includes a test function, to make regular testing of the emergency generator easier.

The **EMERGENCY genset** controller allows harbour operation, so that the genset can be used as the ship generator when in harbour. Apart from this, the emergency genset does not normally supply power to the system.

The system can have 0 or 1 **EMERGENCY genset** controllers. Each **EMERGENCY genset** controller can connect up to three non-essential load groups (NEL).

Example application with non-essential loads (NEL)



10.1.1 EMERGENCY genset controller functions

	Functions
Pre-programmed sequences	• Blackout start • Genset start sequence and genset stop sequence ◦ Running detection

	Functions
	◦ Stop coil and/or run coil for engine control ◦ Temperature-dependent cooldown • Generator breaker open sequence (with de-loading) • Generator breaker close sequence (with synchronisation) • Tie breaker open sequence (with de-loading) • Tie breaker close sequence (with synchronisation) • Load transfer between emergency and main busbar without synchronisation ◦ Uses short blackout, with configurable delay ◦ Tie breaker close sequence and generator breaker close sequence • Test sequence • Harbour mode start and stop sequences
Emergency functions	• Blackout start and handling (immediate or delayed), from AUTO or Manual mode • Selectively disable protections using the *EDG handling blackout* inhibit • *Main busbar is OK* digital input
Test functions	• Engine test ◦ Emergency genset start (does not synchronise or connect to the busbar) • Load take-over test ◦ Emergency-load (supplies the emergency busbar, tie breaker opened) • Parallel test ◦ Base-load (synchronises and connects to the busbar, tie breaker closed)
Harbour operation	• Emergency genset powers the ship. • Economic operation for low loads, for example, in harbour. • Confirm harbour operation from display.
Regulation	• PID regulators for analogue outputs • P regulators for relay outputs ◦ *Relay period time* and *Minimum ON time* configurable • Set point selection ◦ Activate external offsets or set points using DI, CustomLogic, or Modbus • Governor ◦ Frequency regulation ◦ Frequency and phase synchronisation ◦ Load sharing (active power) ◦ Fixed power • AVR ◦ Voltage regulation ◦ Load sharing (reactive power) ◦ Fixed reactive power ◦ Fixed cos phi • External set point ◦ From an analogue input ◦ From Modbus • Configurable: Power ramp up, power ramp down • Optional inputs: Manual regulation • Three sets of temperature-dependent power derate settings
Counters	• Display unit counters, to edit or reset ◦ Start attempts ◦ Running hours (total and trip)

	Functions
	◦ Generator breaker operations and trips ◦ Tie breaker operations and trips ◦ Power export (active and reactive) ◦ External breaker operations • Energy counters with configurable digital outputs (for external counters) ◦ Power export (active and reactive)
Other	• Priming
Control types	• Power management system (PMS) control ◦ AUTO mode ◦ Manual mode • Switchboard control ◦ Operator controls the system from the switchboard ◦ Only the controller protections are active • Stand-alone emergency genset ◦ Not part of the rest of the system ◦ Controller AC measurements independently detect blackout
Control modes	• AUTO mode ◦ Harbour operation active: Automatic power management ◦ Automatic load-dependent genset start/stop ◦ Automatic synchronisation/de-loading and breaker control • Manual mode ◦ Operations only on operator command ◦ Automatic synchronisation and de-loading ◦ Display unit push-buttons for genset start/stop, breaker open/close, and test • Test function ◦ Run the pre-configured test • Display unit push-buttons ◦ Change control mode (AUTO/Manual/test function) ◦ Push-button functions also possible using inputs, PICUS, and/or Modbus ◦ Intuitive, one-touch sequences using the display unit for genset start/stop, and breaker open/close, in Manual mode

10.2 EMERGENCY genset controller principles

10.2.1 EMERGENCY 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.

[Source] nominal settings

`[Source] > Nominal settings > Nominal settings # *`

Nominal setting	Range	Default	Notes
`Voltage (V)`	10 V to 150 kV	400 V	The phase-to-phase ** nominal AC voltage for the genset.
`Current (I)`	1 A to 9 kA	867 A	The maximum current flow in one phase (that is, L1, L2 or L3) from the genset during normal operation.
`Frequency (f)`	48 to 62 Hz	50 Hz	The system nominal frequency, typically either 50 Hz or 60 Hz. All the controllers in the system should have the same nominal frequency.

Nominal setting	Range	Default	Notes
`Power (P)`	1 kW to 900 MW	480 kW	The nominal active power may be on the genset nameplate.
`Apparent power (S)`	1 kVA to 1 GVA	600 kVA	The nominal apparent power should be on the genset nameplate.
`Power factor (PF)`	0.6 to 1	0.8	The power factor should be on the genset nameplate.

NOTE * # is 1 to 4.

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

Nominal setting calculation method

`[Source] > Nominal settings # > Calculation method` *

Calculation method	Options	Default
`Reactive power (Q) nominal`	Q nominal calculated Q nominal = P nominal Q nominal = S nominal	Q nominal calculated
`P or S nominal`	No calculation P nominal calculated S nominal calculated	No calculation

NOTE * # is 1 to 4.

More information

See Nominal power calculations for how these are used.

Busbar nominal settings

`Busbar > Nominal settings > Nominal settings #`

Nominal setting	Range	Default	Notes
`Nominal value source`	• Use generator nominal voltage • User defined	Use generator nominal voltage	**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 V to 150 kV	400 V	The phase-to-phase nominal voltage for the busbar. If there are no transformers between the genset and the busbar, the nominal voltage for the busbar will be the same as the nominal voltage for the genset.

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.

10.2.2 Running detection

The controller can be configured to receive engine running feedback from a variety of measurements.

More information

See Running detection in GENSET controller.

10.2.3 Regulation

The **EMERGENCY genset** controller regulates the engine governor (GOV) and can also regulate the generator AVR.

More information
See Regulation for how it works.

10.2.4 Power management

The **EMERGENCY genset** controller works together with the other controllers in the system to provide efficient power management.

More information
See Power management for how it works.

10.2.5 Load sharing

During *Harbour mode*, the **EMERGENCY genset** controller shares the load with other DEIF controllers using the DEIF Ethernet network.

More information
See Load sharing in Power management for how it works.

10.2.6 AC configuration

AC configuration for the EMERGENCY genset controller

EMERGENCY genset	General name
Generator	[Source]
Busbar	[Busbar]

More information
See AC configuration and Nominal settings for the general AC configuration.

10.2.7 Breaker configuration

Breaker names for EMERGENCY genset controller

EMERGENCY genset	[Breaker] name
Generator	Generator breaker
Busbar	Tie breaker

More information
See Breakers, synchronisation and de-loading for breaker configuration.

10.3 Engine start

10.3.1 Engine start function

The controller software includes pre-programmed genset start sequences.

More information
See Engine start in GENSET controller for how it works.

More information
See EMERGENCY genset controller protections .

10.4 Engine stop

10.4.1 Engine stop function

The controller software includes pre-programmed emergency genset stop sequences.

More information
See **GENSET controller**, **Engine stop** for more information.

More information
See **EMERGENCY genset controller**, **EMERGENCY genset controller protections** for more information.

10.5 Emergency genset breakers

10.5.1 Introduction

The generator breaker (GB) connects the emergency genset to the emergency busbar and the tie breaker (TB) connects the emergency busbar to the main busbar. The tie breaker is an important part of the system safety, and trips to protect the genset from problems on the busbar. The generator breaker trips to stop genset problems from disturbing the busbar.

More information
See **EMERGENCY genset controller breaker parameters** in this chapter for information about how the emergency genset can connect.

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 EMERGENCY genset controller, the breaker abbreviation (*[*B]*) is *GB* or *TB*. *[Breaker]* refers to *Generator breaker* or *Tie breaker*.

10.5.2 EMERGENCY genset controller breaker parameters

Generator breaker parameter

`Breakers > Generator breaker configuration > Configuration`

Parameter	Range	Default	Comment
`Generator breaker transfer delay`	0 to 10 s	0.5 s	This parameter only has an effect if *Tie breaker sync. enabled* is *Not enabled*. The controller starts the timer when it detects tie breaker open feedback. The generator breaker cannot close while the delay timer is running.

Tie breaker parameters

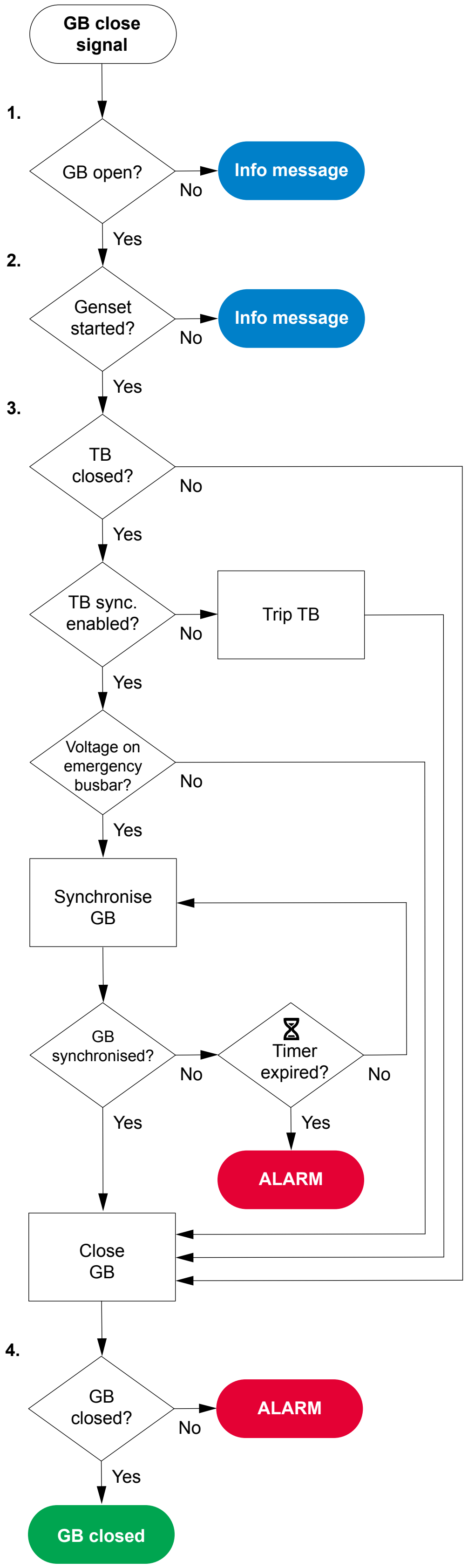
`Breakers > Tie breaker configuration > Configuration`

Parameter	Range	Default	Comment
`Tie breaker sync. enabled`	Not enabled, Enabled	Enabled	**Not enabled**: The tie breaker and the generator breaker can never be closed at the same time. The controller uses a short blackout to do a quick change from one supply to the other. The operator may hear "click-clack" as the one breaker opens and then the other breaker closes.

Parameter	Range	Default	Comment
			• *Main busbar to emergency genset supply*: The generator breaker closes as soon as the tie breaker open feedback is detected, unless there is a *Generator breaker transfer delay*. • *Emergency genset to main busbar supply*: The tie breaker closes as soon as the generator breaker open feedback is detected, unless there is a *Tie breaker transfer delay*. **Enabled**: The controller adjusts the speed of the emergency genset to synchronise the tie breaker. The tie breaker and generator breaker can both be closed at the same time. If the emergency genset controller does not control the governor, then the generator breaker can only close if there is a blackout on the emergency busbar.
`Tie breaker transfer delay`	0 to 10 s	0.5 s	This parameter only has an effect if *Tie breaker sync. enabled* is *Not enabled*. The controller starts the timer when it detects generator breaker open feedback. The tie breaker cannot close while the delay timer is running.

10.5.3 Generator breaker close flowchart

This flowchart does not apply to switchboard control. When the controller is in switchboard control, it will not close the breaker. For example, if the operator presses the push-button **Close breaker** on the display, the controller ignores this command.



1. **GB open:** After getting the GB close signal, the controller checks whether the generator breaker is open. If the generator breaker is already closed, the sequence stops.
2. **Genset started:** The controller checks whether the emergency genset started successfully. If not, the controller display unit shows an info message.
3. **TB closed:** The controller checks whether the breaker can be closed without synchronisation.
   - If the tie breaker is open, the controller closes the generator breaker without synchronisation.
   - If *Tie breaker sync. enabled* is not enabled, the controller trips the tie breaker and closes the generator breaker without synchronisation.
   - If there is no voltage on the emergency busbar, the controller closes the generator breaker without synchronisation.
   - Otherwise, the controller synchronises the genset to the busbar. If the synchronisation timer expires before the synchronisation is completed, the *Synchronisation failure* alarm is activated.
4. **GB closed:** The controller checks whether the generator breaker has closed.
   - If the generator breaker has not closed the *GB close failure* alarm is activated.
   - If the generator breaker has closed, the generator breaker close sequence has been completed successfully.

10.5.4 Generator breaker open flowchart

The opening sequence of the generator breaker for the emergency genset is the same as for a standard genset generator breaker.

More information
See **GENSET controller**, **Generator breaker**, **Generator breaker open flowchart** for more information.

10.5.5 Generator breaker trip flowchart

The trip sequence of the generator breaker for the emergency genset is the same as for a standard genset generator breaker.

More information
See **GENSET controller**, **Generator breaker**, **Generator breaker trip flowchart** for more information.

10.5.6 Tie breaker close flowchart

The tie breaker close sequence is determined by the configuration of the EMERGENCY genset controller, and by the EMERGENCY genset controller breaker parameters.

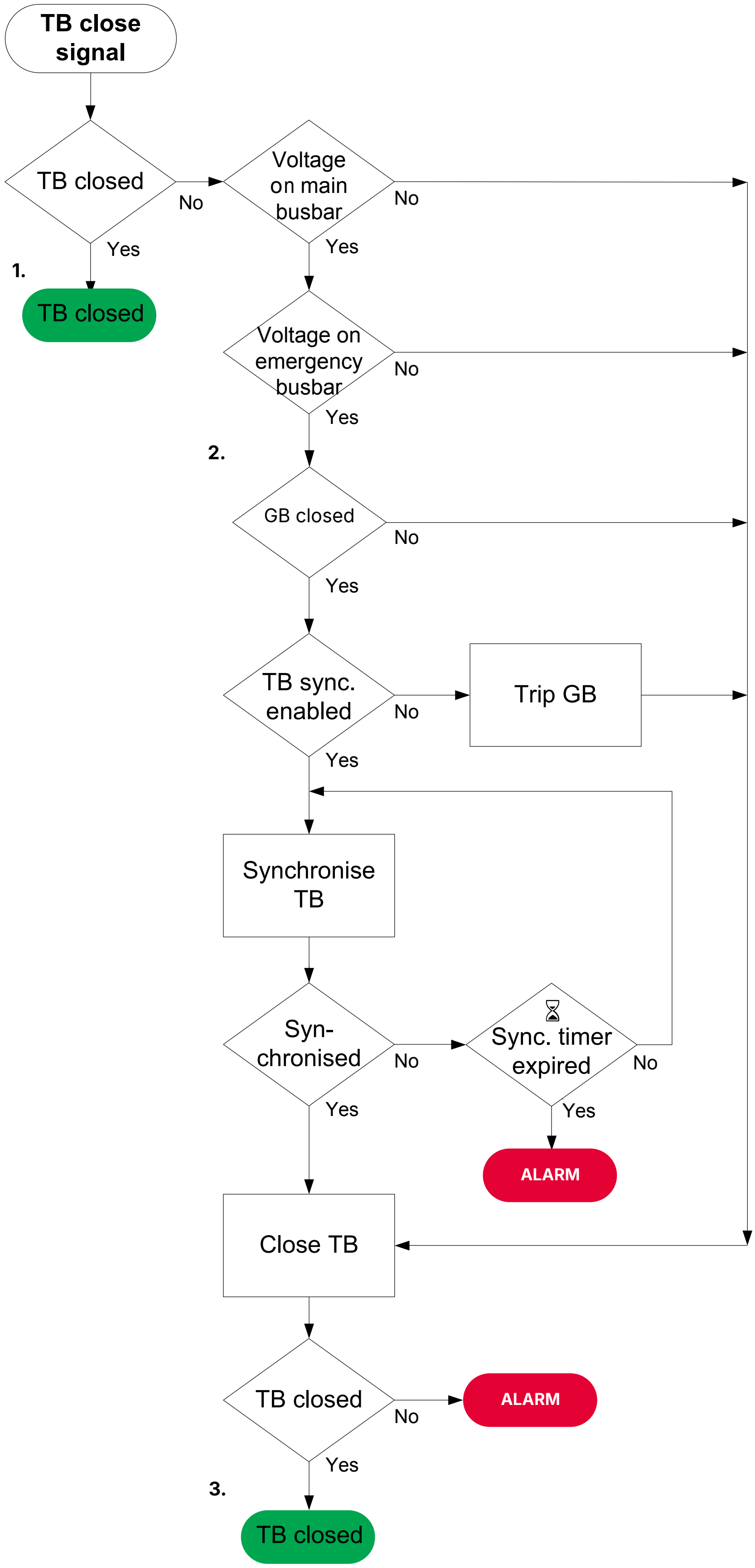
More information
See **Other EMERGENCY genset controller functions**, **Emergency genset configurations** in this chapter for more information about the configuration of the EMERGENCY genset controller.

More information
See **EMERGENCY genset controller**, **Emergency genset breakers**, **EMERGENCY genset controller breaker parameters**, for more information about the EMERGENCY genset controller parameters.

Tie breaker close sequence

The following flowchart below shows the sequence that the controller uses to close the tie breaker.

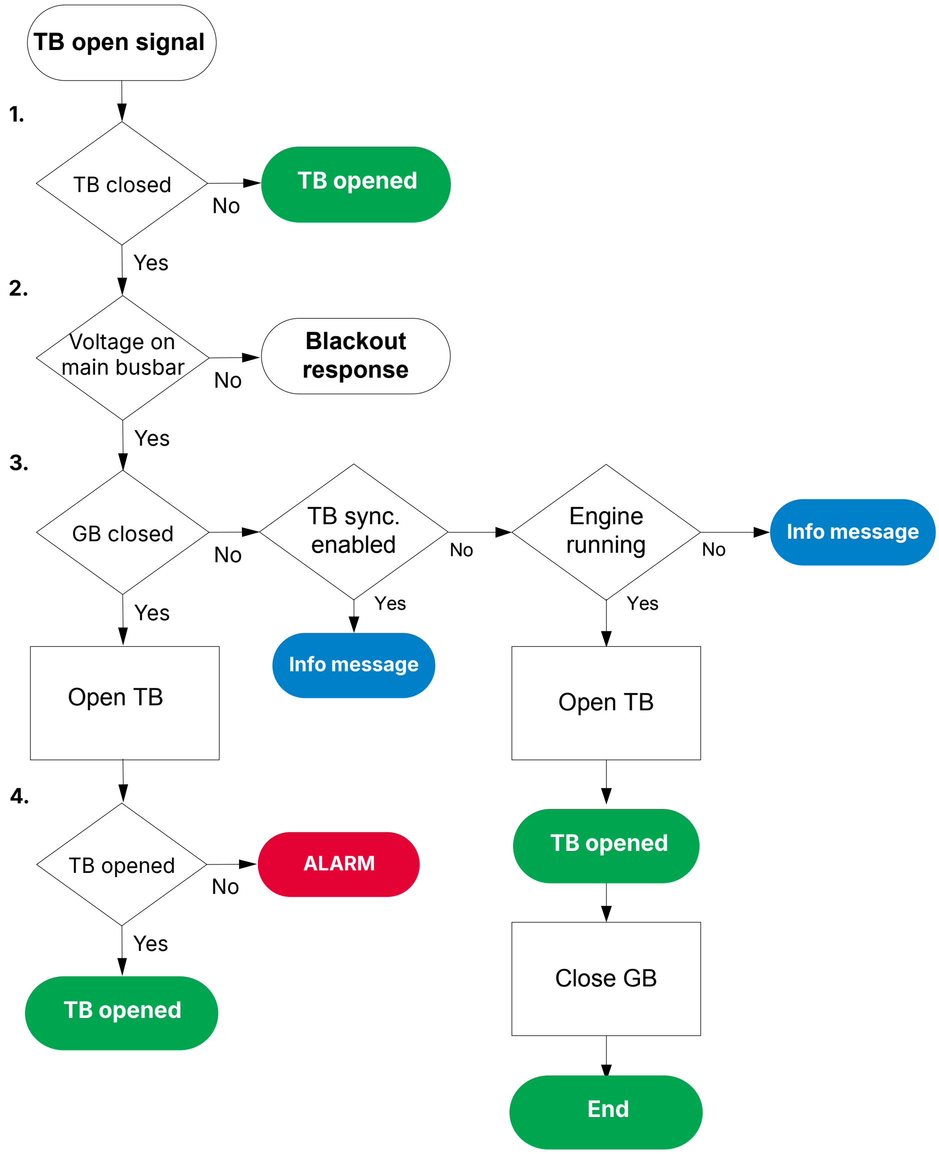
This flowchart does not apply to switchboard control. When the controller is under switchboard control, it will not close the breaker. If, for example, the operator presses the push-button **Close breaker** on the display unit, the controller ignores this command.



1. **TB closed:** After getting the TB close signal, the controller checks whether the tie breaker is closed. If the tie breaker is already closed, the sequence stops.
2. **GB closed:** The controller checks whether direct closing is okay (no voltage on the main busbar, no voltage on the emergency busbar, and the generator breaker is open).
   - If direct closing is OK, the controller closes the tie breaker.
   - If direct closing is not OK, the controller checks whether *Tie breaker sync. enabled* is enabled.
     - If *Tie breaker sync. enabled* is enabled, the controller synchronises across the tie breaker by regulating the emergency genset. When the busbars are synchronised, the controller closes the tie breaker.
     - If *Tie breaker sync. enabled* is not enabled, the controller trips the generator breaker. When the generator breaker is open, the controller closes the tie breaker.
3. **TB closed:** The controller checks whether the tie breaker has closed.
   - If the tie breaker has closed, the tie breaker close sequence has been completed successfully.
   - If the tie breaker is not closed, the *TB closing failure* alarm is activated.

10.5.7 Tie breaker open flowchart

The following flowchart shows the sequence that the controller uses to open the emergency busbar tie breaker.



1. **TB closed:** After getting the emergency busbar tie breaker open signal, the controller checks whether the tie breaker is open.
   - If the tie breaker is open, the sequence ends.
   - If the tie breaker is not open, the sequence continues.
2. **Voltage on main busbar:** The controller checks whether there is voltage on the main busbar.
   - If there is voltage on the main busbar, the controller continues with the sequence. (Note that if a *Main busbar is OK* digital input is configured, this must also be activated.)
   - If there is not voltage on the main busbar, the controller uses the blackout response.
3. **GB closed:** The controller checks whether the genset breaker is closed.
   - If the genset breaker is closed, the controller opens the tie breaker immediately.
   - If the genset breaker is open, the controller checks whether *Tie breaker sync. enabled* is enabled.
     - If *Tie breaker sync. enabled* is enabled, then the display unit shows an info message (GB open). The operator must first close the generator breaker before the tie breaker can be opened.
     - If *Tie breaker sync. enabled* is not enabled, then the controller checks whether the engine is running.
       - If the engine is running, the controller opens the tie breaker. When the tie breaker position feedback confirms that the tie breaker is open, then the controller closes the generator breaker.
       - If the engine is not running, then the display unit shows an info message.

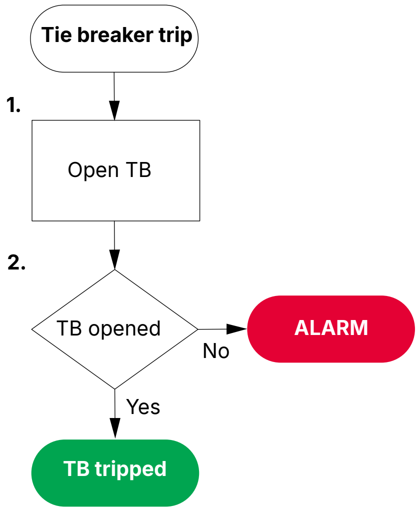
10.5.8 Tie breaker trip flowchart

The controller automatically trips the tie breaker (TB) for this alarm action:

- Trip tie breaker

The controller does not require the tie breaker open conditions to be met for a breaker trip. Similarly, the tie breaker is not de-loaded for a trip.

Table 10.1 Tie breaker trip flowchart



1. **Open TB:** When a trip is required, the controller activates the *Tie breaker > Control > 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.

10.6 Emergency genset test functions

10.6.1 Emergency genset test function

The EMERGENCY genset controller includes a test function so that the operator can easily test the emergency genset. Only the EMERGENCY genset controller has the test function.

The test function can be started from Manual mode from a digital input. If activated when the controller is not in Manual mode, then the info message *Not in Manual mode* is displayed.

When the test procedure starts, the test continues until the testing time is finished. If a blackout occurs while the test is running, then the EMERGENCY genset controller stops the test and resolves the blackout. When the blackout is resolved, the test does not automatically continue.

Digital input

Function	I/O	Type	Details
`Engine > Command > Test genset`	Digital input	Pulse	When this input is activated, the controller runs the genset test selected in the controller parameters. This input has the same effect as pressing the TEST push-button on the display unit.

Parameters

`Local power management > Emergency generator`

Parameter	Range	Default	Comment
`Test delay > Test time`	10 s to 1 h	30 s	The time the test runs from the moment the generator is started.
`Test base load > Base load`	10.0 to 100.0 % of nominal power	50 %	The load the genset will ramp up to during the parallel test.
`Test type > Type`	• Engine test • Parallel test • Load take-over test	Engine test	**Engine test**: Starts, runs and stops the emergency genset. **Parallel test**: Starts and runs the emergency genset. The power management system synchronises and closes the generator breaker. The emergency genset runs parallel to other power suppliers on the busbar, then de-loads and opens the generator breaker. The power management system then stops the emergency genset. **Load take-over test**: Similar to the parallel test, but after the emergency genset is in parallel to the other power suppliers, the tie breaker is de-loaded and opened. The power management system synchronises and closes the tie breaker. Then de-loads and opens the generator breaker before stopping the emergency genset.

`Local power management > Return modes`

Parameter	Range	Default	Comment
`After EDG test > Mode`	• No mode change • Manual mode • AUTO mode	AUTO mode	This parameter determines to which power management mode the controller should return to when the EMERGENCY genset controller test is finished.

Test function

The EMERGENCY genset controller has three test functions. The availability of the test functions for a stand-alone system depends whether the controller is able to control the emergency genset governor.

Table 10.2 Test function availability

Test function	Governor control possible	Governor control not possible
Engine test	●	●
Parallel test	●	-
Load take-over test	●	*See note

*Note: If the controller cannot synchronise with the main busbar, then for the load take-over test, the EMERGENCY genset controller opens the tie breaker, and immediately after that closes the generator breaker.

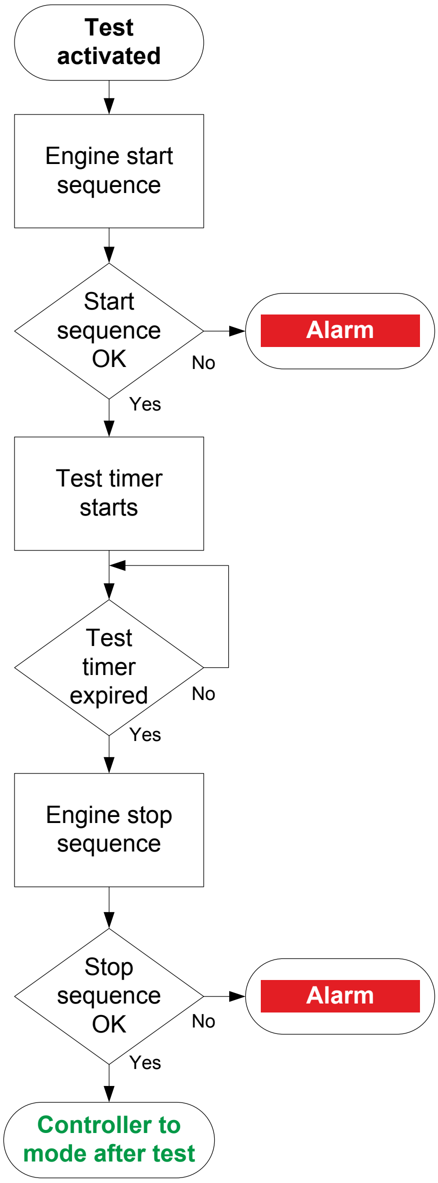
Emergency genset test and blackout

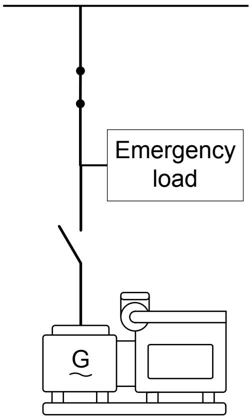
If there is a blackout during the emergency genset test, then the controller stops the test immediately, and starts the blackout response.

More information
See **EMERGENCY genset controller**, **Other EMERGENCY genset controller functions**, **Blackout response (emergency busbar blackout)** for more information.

10.6.2 Engine test

For the engine test, the controller starts the emergency genset, and runs it for the specified time with the genset breaker open.

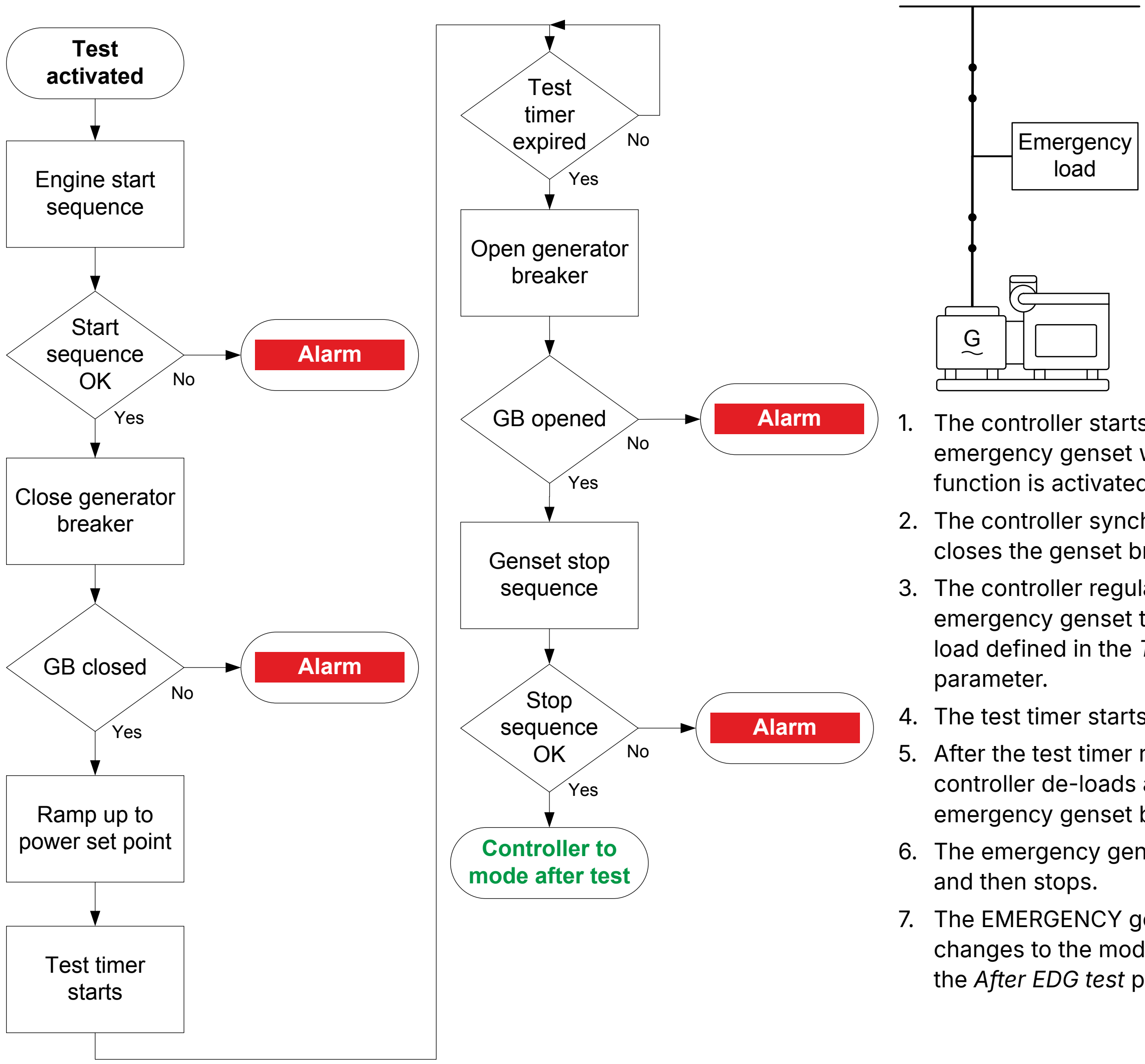




1. The controller starts the emergency genset when the TEST function is activated.
2. The test timer starts when the emergency genset has started.
3. The emergency genset runs at its nominal frequency (without synchronising or closing the genset breaker) until the test timer runs out.
4. After the test timer runs out, the emergency genset cools down and then stops.
5. The EMERGENCY genset controller changes to the mode specified in the *After EDG test* parameter.

10.6.3 Parallel test

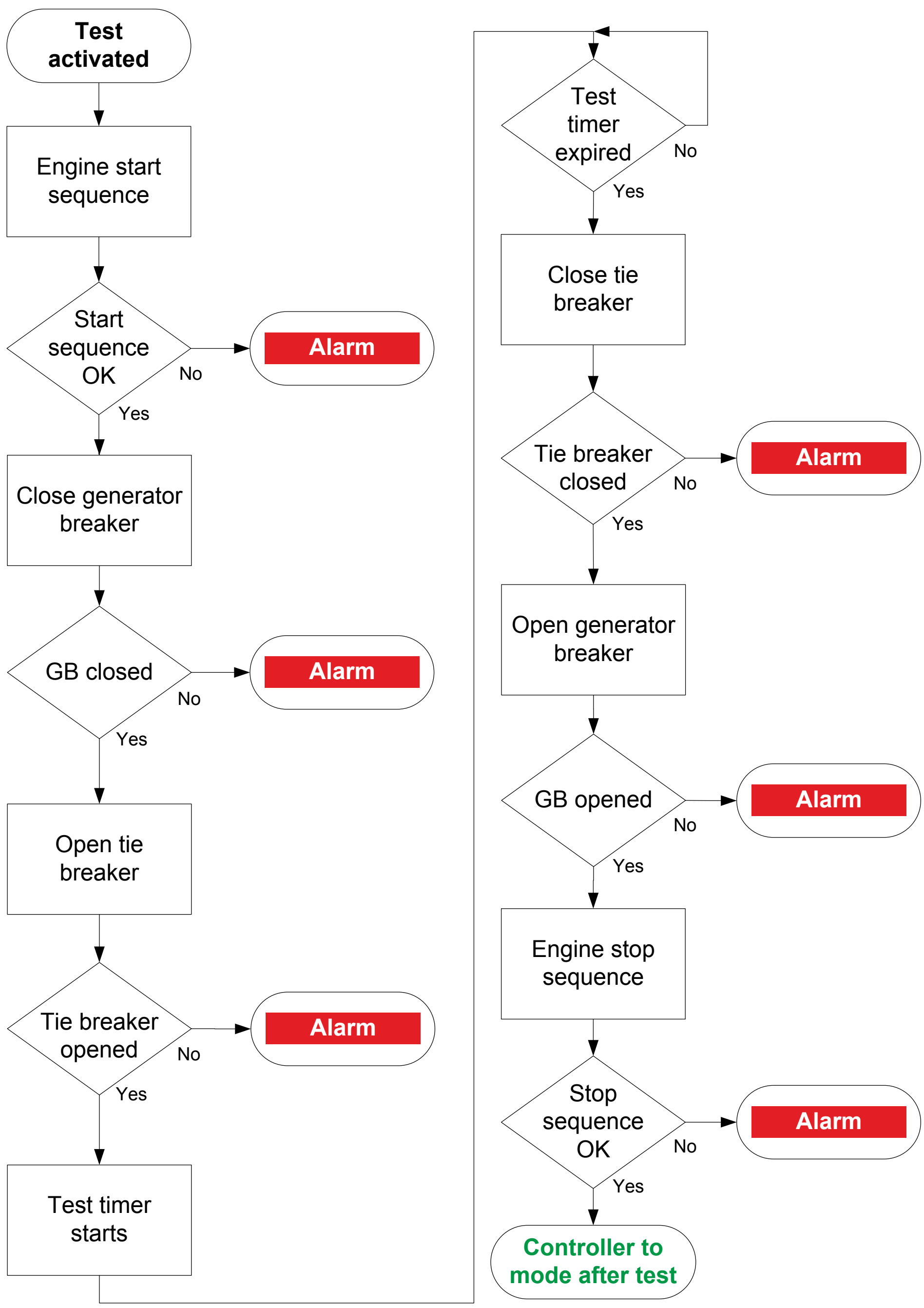
For the parallel test, the controller starts the emergency genset, and closes the genset breaker. The controller runs the genset at the specified test base load for the specified time, then opens the genset breaker and stops the emergency genset. The tie breaker is closed for this test.

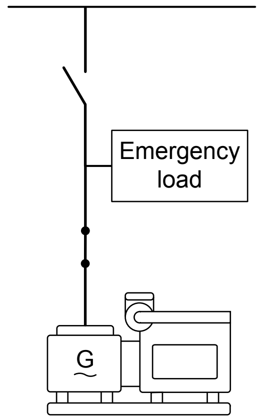


1. The controller starts the emergency genset when the TEST function is activated.
2. The controller synchronises and closes the genset breaker.
3. The controller regulates the emergency genset to supply the load defined in the *Test base load* parameter.
4. The test timer starts.
5. After the test timer runs out, the controller de-loads and opens the emergency genset breaker.
6. The emergency genset cools down and then stops.
7. The EMERGENCY genset controller changes to the mode specified in the *After EDG test* parameter.

10.6.4 Load take-over test

For the load take-over test, the controller starts the emergency genset, and closes the genset breaker. The controller then opens the tie breaker and runs the genset for the specified time. At the end of the test, the controller closes the tie breaker, opens the generator breaker and stops the emergency genset.





1. The controller starts the emergency genset when the TEST function is activated.
2. The controller synchronises and closes the genset breaker.
3. The controller opens the tie breaker between the emergency busbar and the main busbar.
4. The controller starts the test timer.
5. After the test timer runs out, the controller synchronises and closes the tie breaker.
6. The controller de-loads and opens the emergency genset breaker.
7. The emergency genset cools down and then stops.
8. The EMERGENCY genset controller changes to the mode specified in the *After EDG test* parameter.

No governor control

The load take-over test is modified if the controller does not control the governor (and therefore cannot synchronise with the main busbar). Instead of synchronising, the EMERGENCY genset controller opens the tie breaker, and immediately after that closes the generator breaker.

10.7 Emergency genset configurations

10.7.1 About configurations

The emergency genset can either be part of the power management system, or a stand-alone genset.

The single-line diagram for the EMERGENCY genset controller determines whether the emergency genset is part of the power management system or stand-alone.

The emergency genset controller configuration affects the response of the system after a blackout. This response also depends on whether the controller controls the emergency genset governor.

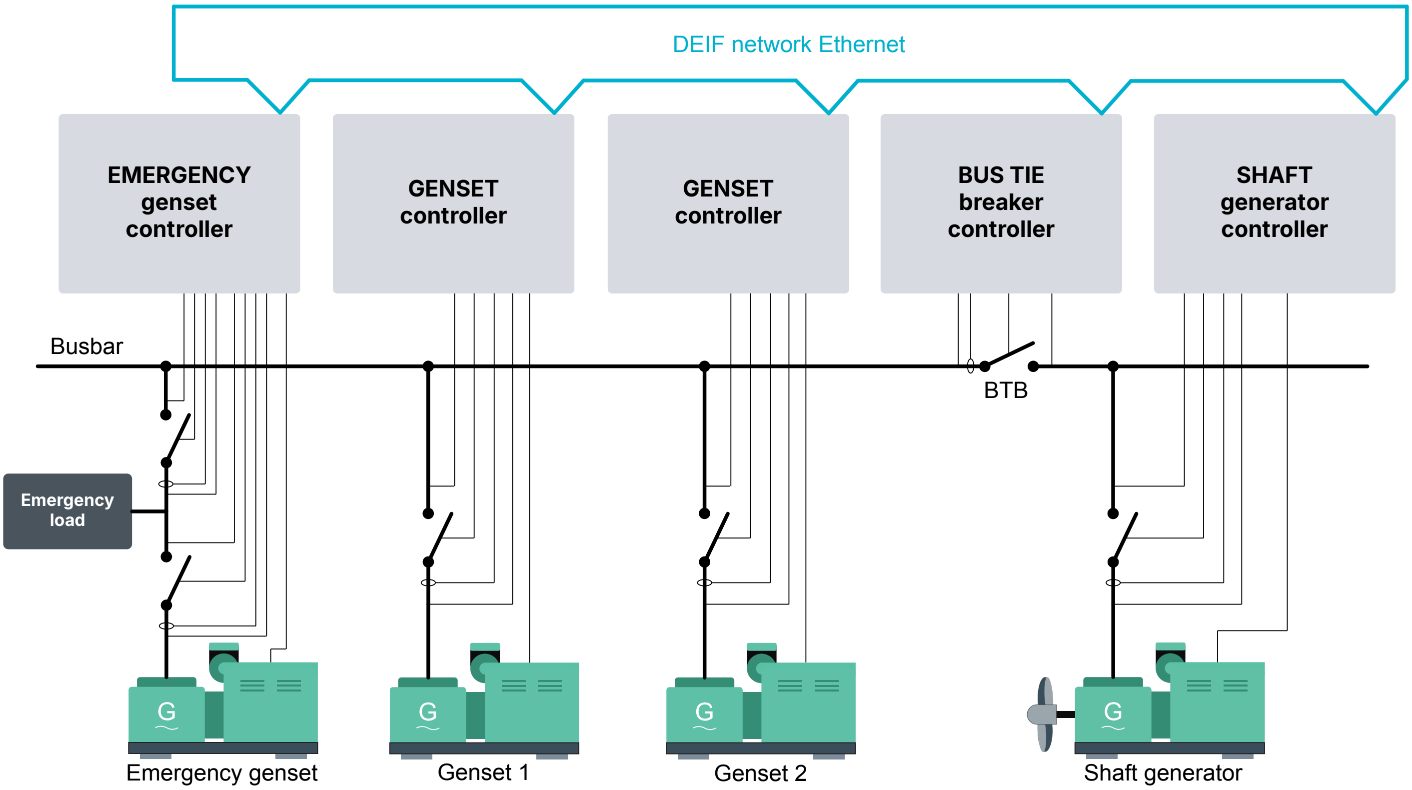
10.7.2 Emergency genset as part of the system

When the EMERGENCY genset controller is part of the power management system, it shares information with the other controllers over the DEIF network.

As part of the system, the emergency genset can operate in parallel to the busbar. This can be for short periods (load take-over), or for extended periods (harbour operation).

More information
See **Other EMERGENCY genset controller functions**, **Harbour operation** in this chapter for more information.

An example of an emergency genset as part of a system



10.7.3 Stand-alone emergency genset

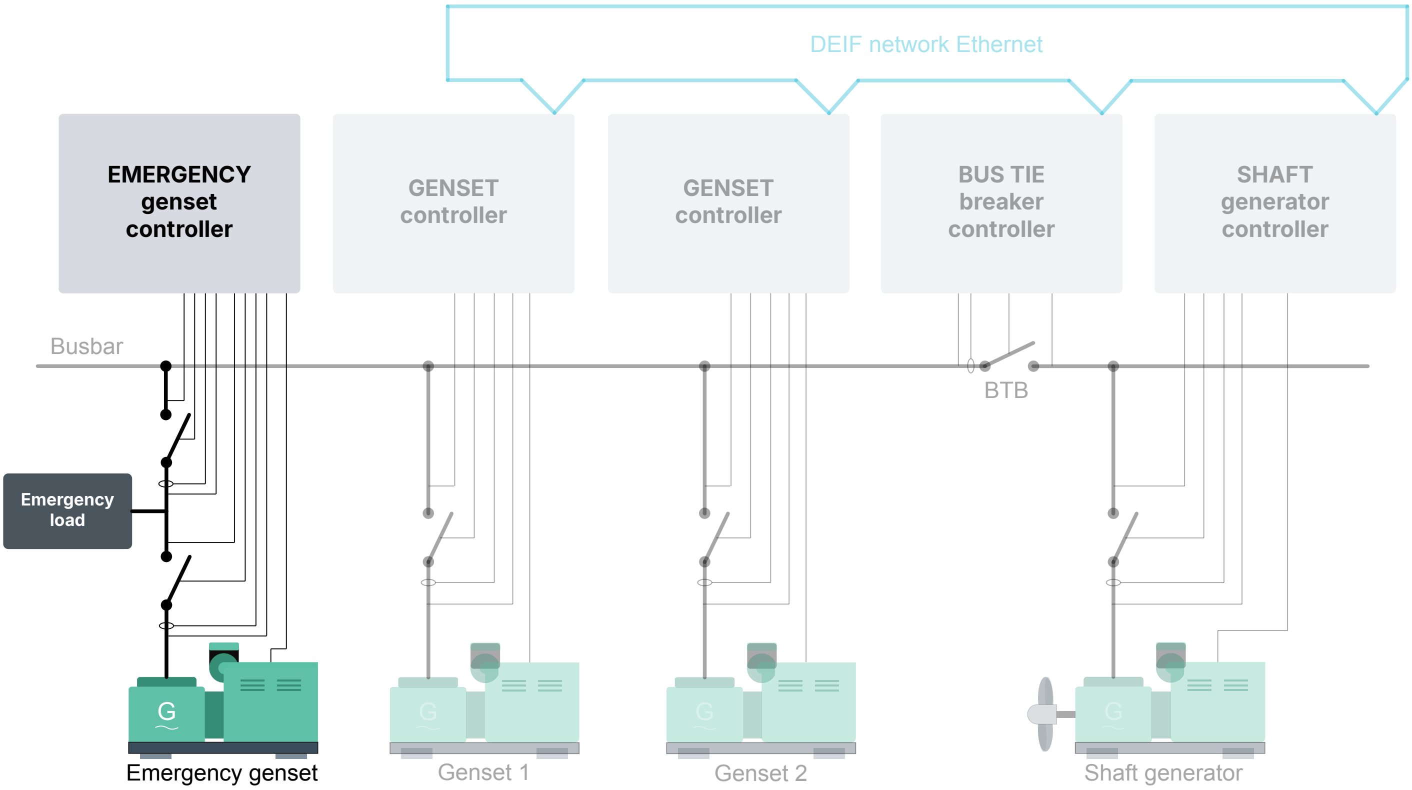
For some applications, the emergency genset must be a stand-alone genset. For a stand-alone genset, the EMERGENCY genset controller is not connected to the DEIF network.

Application single-line diagram

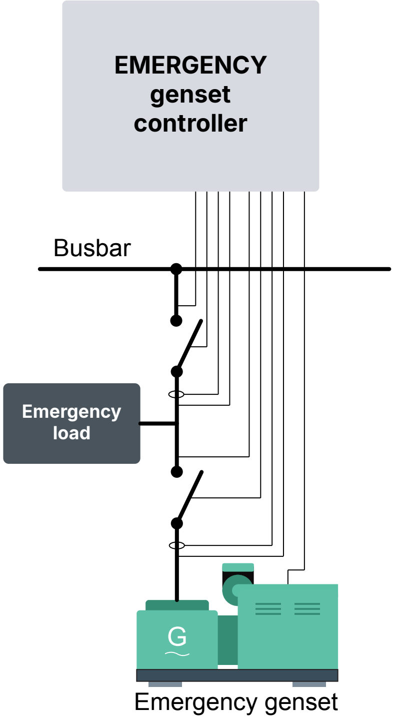
For a stand-alone emergency genset, the emergency genset must be the only component shown in the EMERGENCY genset controller single-line diagram. The stand-alone emergency genset must not be included in the rest of the system's single-line diagram.

NOTE For a stand-alone emergency genset application, do not include the EMERGENCY genset controller in the *Broadcast* when broadcasting the single-line diagram from another controller. Similarly, do not *Broadcast* the single-line diagram to other controllers for a stand-alone emergency genset application.

Example of a stand-alone emergency genset application



Stand-alone emergency genset



Input

Optional: You can configure the *Main busbar is OK* digital input.

More information

See **EMERGENCY genset controller**, **Emergency genset configurations**, **Main busbar is OK** for more information.

AUTO mode

The controller uses its AC measurements (from the ACM) and, if configured, the *Main busbar is OK* digital input, to determine whether there is power on the main busbar. If there is power on the main busbar, in AUTO mode the controller ensures that the tie breaker is closed and the generator breaker is open.

A stand-alone EMERGENCY genset controller does NOT regard itself as the last power source. In AUTO mode, the controller can therefore open the generator breaker and stop the engine when there is power on the main busbar.

Manual mode

You can connect stand-alone emergency genset to the main busbar in Manual mode if *Tie breaker sync. enabled* is *Enabled*. Start the genset, then close the genset breaker. Be aware that if the *EDG max. parallel time* alarm is *Enabled*, the controller will trip the tie breaker after the *Delay*.

To open the generator breaker for a connected stand-alone emergency genset, the following conditions are met:

- The EMERGENCY genset controller AC measurements must show that there is power on the main busbar
- If the controller has a *Main busbar is OK* digital input, it must be activated

If the conditions are met, you can use the generator breaker open push-button on the display unit to open the generator breaker.

Blackout response

More information
See **EMERGENCY genset controller**, **Other EMERGENCY genset controller functions**, **Blackout response (emergency busbar blackout)** for information on how the stand-alone EMERGENCY genset controller responds to a blackout.

Harbour operation

Harbour operation is not possible for a stand-alone emergency genset.

10.7.4 Main busbar is OK

You can configure a *Main busbar is OK* digital input as an extra check. After a blackout, when power is restored, the input allows the controller to disconnect and stop the emergency genset. The input also allows the tie breaker to connect to the main busbar.

Digital input

Function	I/O	Type	Details
`Power management > Main busbar is OK`	Digital input	Continuous	If this digital input function is configured, then this digital input must be activated for the controller to close the tie breaker.

10.8 Other EMERGENCY genset controller functions

10.8.1 Blackout response (emergency busbar blackout)

The emergency genset blackout response starts after all the blackout conditions have been met:

- The voltage on the main busbar is below a set level (that is, a black busbar).
- The emergency generator breaker is OPEN.

When a blackout is detected on the busbar, the **EMERGENCY genset** controller starts the *Blackout delay* timer (see below) to give other gensets a chance to resolve the blackout. When the timer expires, the controller responds according to the *Blackout control* parameter (see below).

If the **EMERGENCY genset** controller is running a *Test* when the blackout occurs, the controller automatically stops the test, goes into the mode specified for after the test, and starts the blackout response.

When power is restored to the main busbar, the controller may stop the emergency genset, depending on the emergency genset configuration and the **EMERGENCY genset** controller mode.

The **EMERGENCY genset** controller does NOT start the blackout response if:

- The **EMERGENCY genset** controller is in switchboard control.
- Harbour operation is active.
- The *EDG not ready for blackout* alarm is active.
- The *Extended stop* timer is running.
- There is a stop coil failure.

More information
See Emergency genset configurations.

Parameters

`Busbar > AC setup > Blackout detection`

Parameter name	Range	Default	Comment
`Blackout delay`	0 s to 1 h	15 s	The time the **EMERGENCY genset** controller waits before starting the emergency genset during a blackout.

`Local power management > Emergency generator > Blackout handling`

Parameter name	Range	Default	Comment
`Blackout control`	• Open TB and start engine • Start engine and open TB	Open TB and start engine	• **Open TB and start engine**: When a blackout is detected, open the TB after the *Blackout delay*. Then, when the TB is open, start the emergency genset engine. • **Start engine and open TB**: When a blackout is detected, start the emergency genset engine after the *Blackout delay*. Then, when the engine is running, open the TB.

`Busbar > AC setup > Voltage and frequency OK`

Parameter name	Range	Default	Comment
`Frequency and voltage OK`	0 s to 1 h	5 s	The time the EMERGENCY genset controller waits before closing the tie breaker after a blackout.

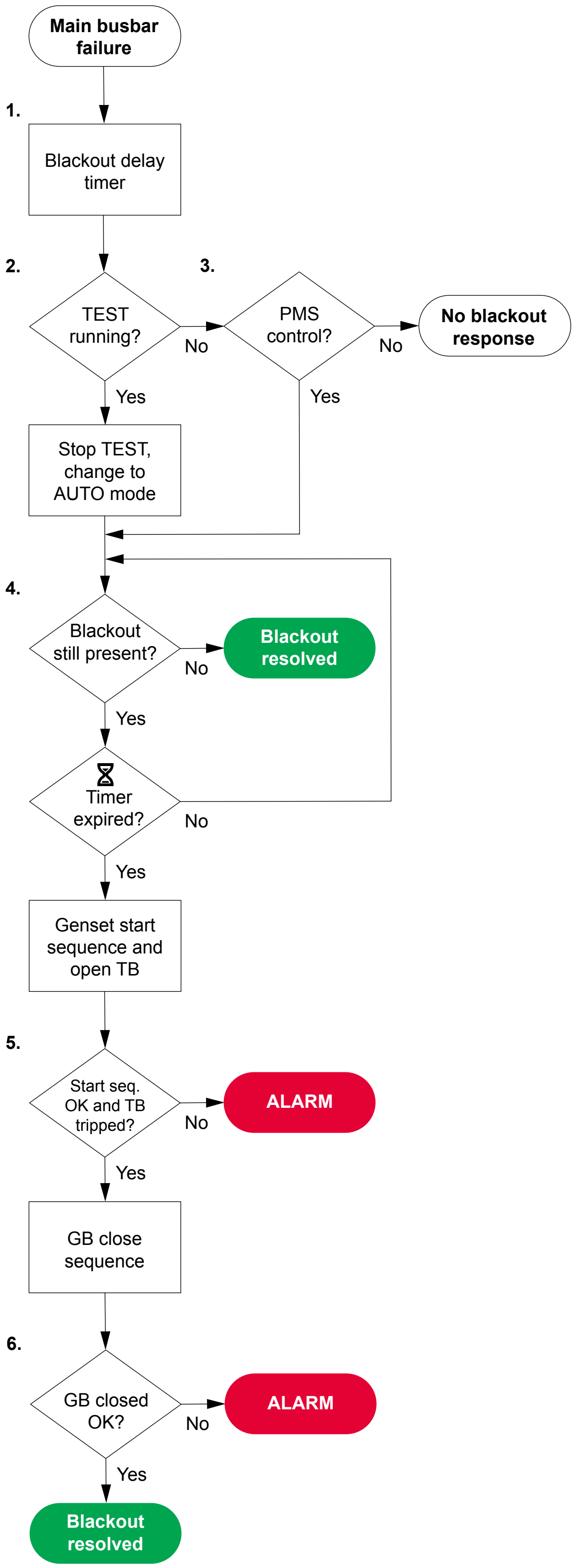
Switchboard control and blackout

An activated `Mode > Switchboard control` digital input on the **EMERGENCY genset** controller forces the controller in switchboard control. In this case, the emergency genset will not start automatically during a blackout.

Some system alarms can also force the **EMERGENCY genset** controller in switchboard control. For example: *Controller not part of system* and *Different single-line configurations*.

Apart from these, the **EMERGENCY genset** controller is not forced in switchboard control by the alarms that force the other controllers in switchboard control, or by the `Power management > Force all controllers in section to SWBD control` input. This means that the **EMERGENCY genset** controller is always ready to handle a blackout.

Blackout response flowchart

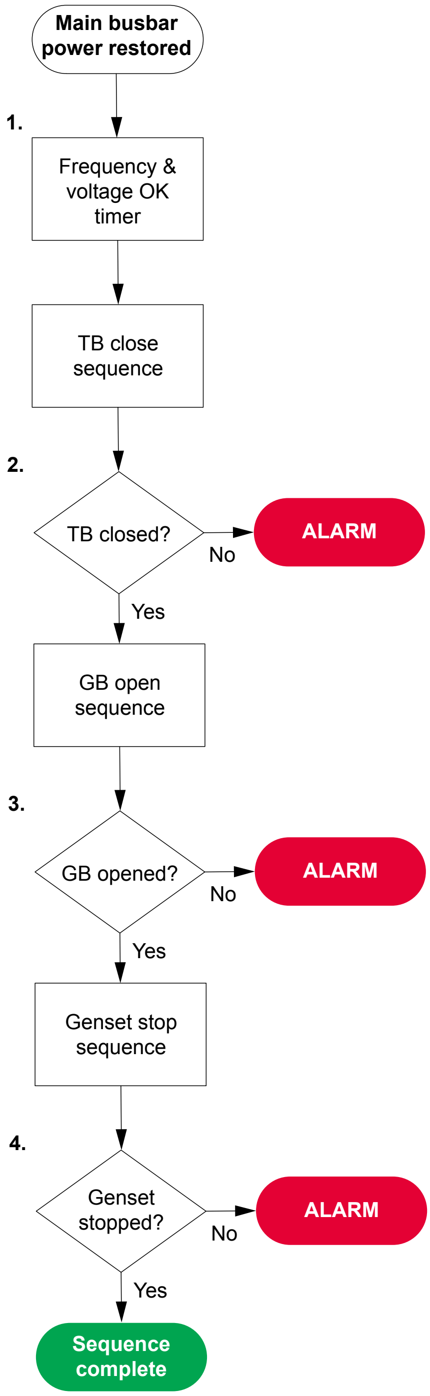


1. **Blackout delay timer:** If the main busbar fails, and the blackout response is possible, then the *Blackout delay* timer starts.
2. **TEST running:** The controller checks whether a *Test* is running. If a test is running the controller stops the test and changes to AUTO mode.
3. **PMS control:** If a test is not running, the controller checks whether *PMS control* is active. If the controller is under *Switchboard control* there is no blackout response.
4. **Blackout still present:** The controller checks whether the blackout is still present, and the status of the *Blackout delay* timer.
   - If the blackout is resolved before the timer expires, the sequence stops.
   - When the timer expires, the genset start sequence and TB trip sequence start. The order of these sequences depends on the *Blackout control* parameter. If the genset start sequence fails, the controller activates the *Start failure* alarm. If the TB trip sequence fails, the controller activates the *TB open failure* alarm.
5. **Start sequence OK & TB tripped:** After the emergency genset is started and the tie breaker is open, the controller starts the generator breaker close sequence.
6. **GB closed OK:** If the generator breaker is closed, the emergency busbar blackout is resolved.

Power restored

When power is restored on the main busbar, the controller stops the emergency genset according to the flowchart below.

The flowchart is based on *Tie breaker sync. enabled* being *Enabled*. If this parameter is *Not enabled*, then the controller first opens the generator breaker, then closes the tie breaker.



1. **Frequency & Voltage OK timer:** When power is restored to the main busbar, the power management system waits for the *Frequency and voltage OK* timer before starting the *TB close sequence*. This happens automatically when the controller is in AUTO mode.
2. **TB closed:** When the tie breaker is closed, the controller starts the *GB open* sequence.
3. **GB opened:** When the generator breaker is open, the controller starts the *Genset stop* sequence.
4. **Genset stopped:** The sequence is complete when the emergency genset stopped. The controller returns to the mode in `Local power management > Return modes > After blackout`.

10.8.2 Harbour operation

Harbour operation allows you to use the emergency genset as the ship generator when in harbour. You must get class approval for the ship to use harbour operation.

Harbour operation is only available for the EMERGENCY genset controller, and only when it is connected to the DEIF network. Harbour operation allows the emergency genset to supply the main busbar with power for an extended period. This is typically used while the ship is docked in harbour, since the emergency genset is typically much smaller than the other gensets, and can therefore run more efficiently at lower loads.

While harbour operation is activated, either by a digital input or a signal from CustomLogic, the operation overrides the *EDG max. parallel time*. During harbour operation the emergency genset is treated as an ordinary genset with the first priority and all normal GENSET controller protections.

During harbour operation, the EMERGENCY genset controller can be forced under switchboard control by alarms that force the other controllers under switchboard control, or by the *Power management > Force all controllers in section to SWBD control* input. In this case, the EMERGENCY genset controller stays under switchboard control, and does not automatically start the emergency genset during a blackout.

Digital input

Function	I/O	Type	Details
`Power management > Harbour operation`	Digital input	Continuous	The controller can run the emergency genset in long time parallel with the main busbar when this input is activated. The emergency genset will have the same protections as a standard genset when activated.

Table 10.3 Optional digital inputs and output

Function	I/O	Type	Details
`Power management > Harbour operation active`	Digital output	Continuous	Activated when the *Harbour operation* digital input is activated.
`Power management > Allow harbour operation`	Digital input	Pulse	This digital input only has an effect if the *Operator confirms harbour operation* parameter is *Enabled*. After the *Harbour operation* digital input is activated, activate this digital input to confirm that harbour operation is allowed. This has the same effect as pressing the **Allow** soft key then **OK** on the display unit.
`Power management > Reject harbour operation`	Digital input	Pulse	If the emergency genset controller is in harbour operation and this input is activated, then harbour operation is cancelled and the genset returns to normal operation. If the *Operator confirms harbour operation* parameter is *Enabled*, then after the *Harbour operation* digital input is activated, this digital input has the same effect as pressing the **Reject** soft key then **OK** on the display unit. Note: This is a pulse function. If this digital input is continuously activated, it will NOT prevent or stop harbour operation.

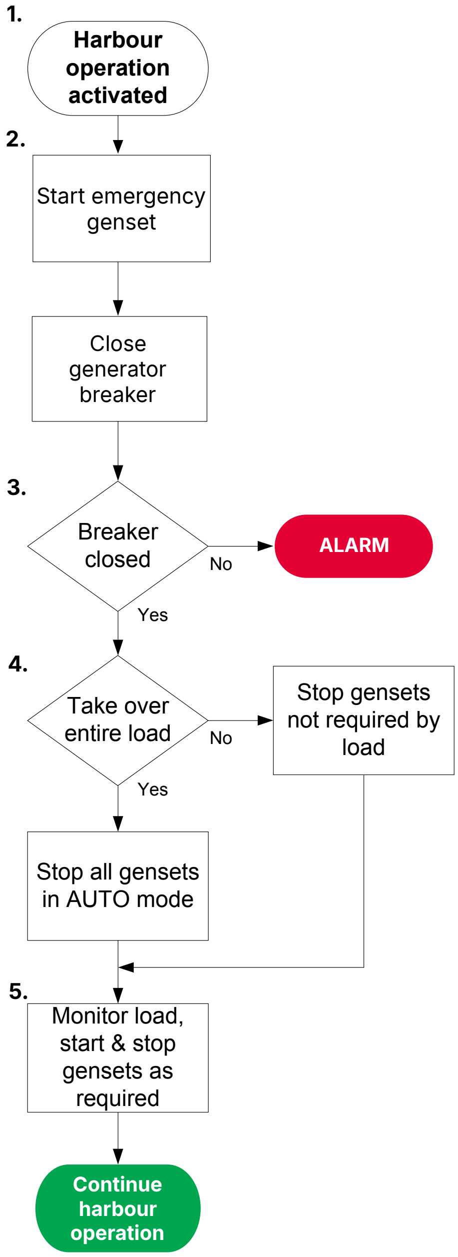
Parameter

`Local power management > Emergency generator`

Parameter name	Range	Default	Comment
`Operator confirms harbour operation`	Not enabled, Enabled	Enabled	**Not enabled**: No confirmation is required for harbour operation. **Enabled**: The operator must use the display unit or *Allow harbour operation* digital input to confirm harbour operation.

Harbour operation

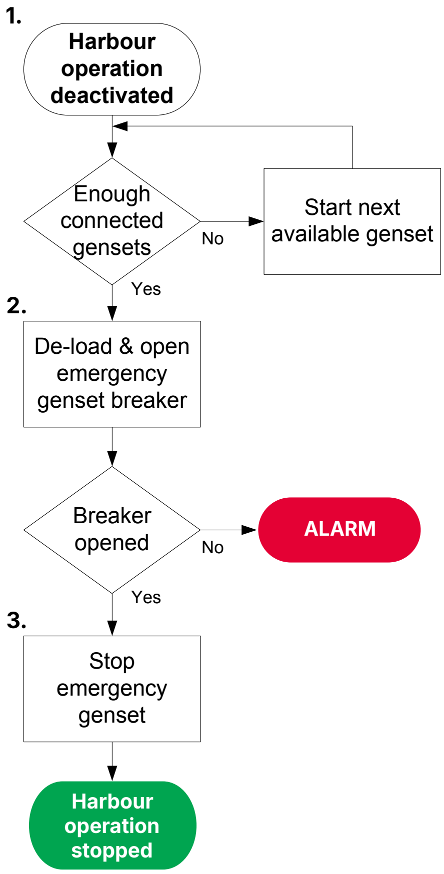
The harbour operation activation sequence is described below.



1. **Harbour operation activated:** The *Harbour operation* digital input is activated.
    - If the parameter *Operator confirms harbour operation* is *Enabled*, then the controller requires confirmation to start harbour operation.
2. **Start emergency genset:** The controller starts the emergency genset.
3. **Breaker closed:** Once the emergency genset is running, the controller closes the generator breaker.
4. **Take over entire load:** If the generator breaker has closed, the controller checks whether the emergency genset can take the entire load.
    - If the emergency genset can take the entire load, all the gensets that are in AUTO mode are stopped.
    - If the emergency genset cannot take the entire load, gensets in AUTO mode that are not needed are stopped according to their priority and the load-dependent stop parameters.
5. **Monitor load, start & stop gensets as required:** The controller continues to monitor the load on the busbar, and starts and stops gensets in AUTO mode as required. Harbour operation continues until the *Harbour operation* digital input is deactivated (or the *Reject harbour operation* digital input is activated).

Harbour operation deactivation

The harbour operation deactivation sequence is described below.



1. **Harbour operation deactivated:** After the *Harbour operation* digital input is deactivated (or the *Reject harbour operation* digital input is activated), then the controller checks whether the connected gensets can take the load.
   - If the connected gensets cannot take the entire load, the next available genset is started.
2. **De-load & open emergency genset breaker:** When the connected gensets can take the load, the controller de-loads and opens the generator breaker for the emergency genset.
3. **Stop emergency genset:** Once the breaker is open, the controller stops the emergency genset, and harbour operation stops.

10.8.3 Parallel timers

In some cases there may be a restriction on the time that the emergency genset is allowed to run in parallel with other power sources. This might be because the emergency genset requires a short paralleling time. The parallel timer allows the operator to define very short paralleling times between the gensets on the ship and the emergency genset, for a smooth transition from an emergency genset supply to on-ship electricity generation by the gensets.

Configure the parallel timer on the GENSET controller to define a short paralleling time for a smooth transition from on-ship electricity generation by the gensets to an emergency genset supply.

Parallel timer parameters can be configured under:

```
Local power management > Parallel timers
```

More information
See **EMERGENCY genset controller**, **EMERGENCY genset controller protections**, **EMERGENCY-main busbar maximum parallel time** for more information.

10.8.4 Temperature-dependent power derating

More information
See **GENSET controller**, **Other GENSET controller functions**, **Temperature-dependent power derating** for a description of this function.

10.8.5 Priming

More information
See **GENSET controller**, **Other GENSET controller functions**, **Priming** for a description of this function.

10.8.6 Temperature-dependent start/stop

More information
See **GENSET controller**, **Other GENSET controller functions**, **Temperature-dependent start/stop** for a description of this function.

10.8.7 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.

More information
See **GENSET controller**, **Other GENSET controller functions**, **Engine states as digital outputs** for more information.

10.8.8 Engine operating values as analogue outputs

You can configure an analogue output with a function for an engine operating value. The controller receives this value from an engine measurement. The controller then adjusts the analogue output to reflect the engine operating value.

More information
See **GENSET controller**, **Other GENSET controller functions**, **Engine operating values as analogue outputs** for more information.

10.8.9 Counters

The **EMERGENCY genset** controller includes the same counters as the **GENSET** controller.

More information
See Counters under **GENSET** controller for more information.

In addition, the **EMERGENCY genset** controller includes counters for tie breaker operations and trips.

10.8.10 EMERGENCY genset controller without regulation

In some cases it might not be possible to regulate the emergency genset speed using the controller. For these situations you can set up your controller to synchronise and de-load your generator breaker and/or tie breaker over the network.

To send synchronisation information over the network, the analogue or relay governor inputs must not be configured. To synchronise with the busbar, the controller sends the synchronisation information over the network to the available genset controllers. The GENSET controllers synchronise over the breaker and the EMERGENCY genset controller closes the breaker once the busbars are synchronised.

To de-load and open the breaker, the EMERGENCY genset controller sends a de-load request to the available GENSET controllers. The GENSET controllers de-load the breaker, and the EMERGENCY genset controller opens the breaker.

10.8.11 Trip AVR

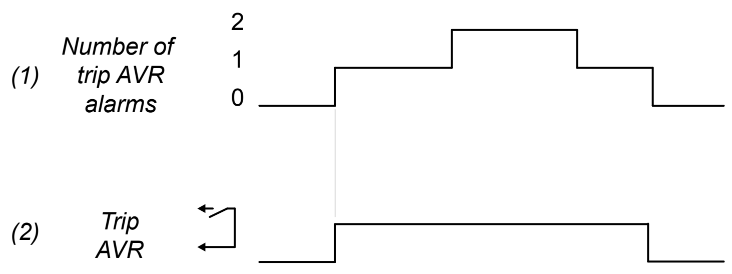
The *Trip AVR* output ensures that excitation is stopped when an alarm activates with a *Trip AVR* alarm action. In cases where there is high voltage present, stopping the excitation reduce the time required to stop an engine in case of an emergency.

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.

10.9 EMERGENCY genset controller protections

10.9.1 EMERGENCY genset controller protections

These alarms are in addition to the AC protections and other alarms for the controller.

During a blackout, the suppressed alarms are shown as *Warnings*.

	Alarms and protections
Engine	Emergency stop
	Overspeed (2 alarms)
	Under-speed (2 alarms)
	Governor regulation error
	Power ramp up error
	Power ramp down error
	Crank failure
	Primary running feedback failure
	Start failure
	Stop failure
	Engine stop (external)
	Engine start (external)
	Start enable removed during start
	Total running hours notification
	Trip running hours notification
	Magnetic pickup wire break
Generator	Voltage or frequency not OK
	AVR regulation error
Maximum parallel time	EDG max. parallel time

	Alarms and protections
Load sharing	P load sharing failure
	Q load sharing failure
Regulator configuration	GOV output selection failure
	GOV output setup failure
	GOV relay setup incomplete
	AVR output selection failure
	AVR output setup failure
	AVR relay setup incomplete
Non-essential load (NEL)	• Up to 3 non-essential loads per controller • Can connect each controller to the same 3 non-essential load breakers
	NEL # over-current (1 alarm for each non-essential load)
	NEL # under-frequency (1 alarm for each non-essential load)
	NEL # overload NEL 1 and 2 (2 alarms for each non-essential load)
	NEL # reactive overload (1 alarm for each non-essential load)
Other	EDG not ready for blackout
	Forced to Manual mode
	Trip AVR output not configured

10.9.2 Alarm actions

The **EMERGENCY genset** controller has the following alarm actions:

- Warning
- Block
- PMS-controlled stop
- Trip generator breaker
- Trip tie 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.

10.9.3 Inhibits

Inhibit	Disables the alarm when ...
Engine running	Running detection is ON.
Engine not running	Running detection is OFF.
Generator breaker closed	The *Generator breaker > Feedback > Closed* digital input is activated.
Generator breaker open	The *Generator breaker > Feedback > Open* digital input is activated.
Tie breaker closed	The *Tie breaker > Feedback > Closed* digital input is activated.
Tie breaker open	The *Tie breaker > Feedback > Open* digital input is activated.

Inhibit	Disables the alarm when ...
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.
EDG in parallel	The generator breaker and the tie breaker are closed at the same time.
Controller under SWBD control	The *Mode > Switchboard control* digital input is activated, OR a system problem forced the controller under switchboard control.
EDG handling blackout	The emergency genset is supplying power to the emergency busbar due to a blackout on the main busbar.
Engine stopping	
Inhibit 1	The *Inhibits > Activate inhibit 1* digital input is activated.
Inhibit 2	The *Inhibits > Activate inhibit 2* digital input is activated.
Inhibit 3	The *Inhibits > Activate inhibit 3* digital input is activated.

10.9.4 Breaker alarms

EMERGENCY genset alarm	Parameter	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
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
TB synchronisation failure	`Breakers > Tie breaker configuration > Synchronisation failure`	Breaker synchronisation failure
TB de-load failure	`Breakers > Tie breaker monitoring > De-load failure`	Breaker de-load failure
Vector mismatch	`Breakers > Tie breaker monitoring > Vector mismatch`	Vector mismatch
TB opening failure	`Breakers > Tie breaker monitoring > Opening failure`	Breaker opening failure
TB closing failure	`Breakers > Tie breaker monitoring > Closing failure`	Breaker closing failure
TB position failure	`Breakers > Tie breaker monitoring > Position failure`	Breaker position failure

EMERGENCY genset alarm	Parameter	General name
TB trip (external)	`Breakers > Tie breaker monitoring > Tripped (external)`	Breaker trip (external)
TB short circuit	`Breakers > Tie breaker monitoring > Short circuit`	Breaker short circuit
TB 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

More information
The Breakers, synchronisation and de-loading for breaker handling and alarms.

10.9.5 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.

10.9.6 Non-essential loads

You can connect up to three non-essential load trips (NEL) to the **EMERGENCY genset** controller. However, the NEL trips are inhibited when either the generator breaker or the tie breaker is open.

NELs cannot be connected to the emergency busbar. The NELs must be connected to the section that the tie breaker connects to.

If `Non-essential load trip > Trip # > Settings > Trip when breaker trips` is *Enabled*, then, if either the generator breaker or the tie breaker trips, the controller activates the *Non-essential load trip #* output.

More information
See Non-essential loads for alarm information.

10.9.7 EDG not ready for blackout

This alarm is activated if the emergency genset is not ready to respond to a blackout.

The alarm is not activated under the following conditions:
- Harbour operation.
- Under switchboard control, with the engine running, the generator breaker closed and the tie breaker open.

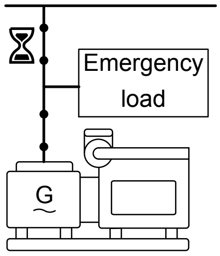
Parameter

`Local power management > Emergency generator > EDG not ready for blackout`

Parameter	Range	Default
`Delay`	1 s to 3 min	7 s *
`Enable`	Not enabled, Enabled	Enabled
`Action`		Warning

NOTE * If the parameter `Engine > Stop sequence > Extended stop` is increased, an engine stop can activate this alarm. To avoid this, increase the `EDG not ready for blackout > Delay` too.

10.9.8 Emergency-main busbar maximum parallel time



This alarm is for the maximum time that the emergency genset may run in parallel to the main busbar.

The timer starts when the emergency genset is synchronised with the main busbar. The alarm action is *Trip tie breaker* and the alarm is latched.
This alarm is ONLY present in the **EMERGENCY genset** controller.

`Local power management > Parallel timers > EDG max. parallel time`

This alarm is disabled during the parallel test.

Parameter	Range	Default
`Delay`	0.1 s to 1 h	30.0 s
`Enable`	Not enabled, Enabled	Enabled

10.9.9 Other EMERGENCY genset controller alarms

The following alarms are included on both the **GENSET** and **EMERGENCY genset** controllers:

- Emergency stop
- Primary running feedback failure
- Crank failure
- Start failure
- Engine started (external)
- Voltage or frequency not OK
- Stop failure
- Engine stopped (external)
- Overspeed
- Underspeed
- Start enable removed during start
- Total running hours notification
- Trip running hours notification
- Magnetic pickup wire break *

More information
* These alarms are in general Alarms and protections and the other alarms are in GENSET controller alarms.

11. HYBRID controller

11.1 About the HYBRID controller

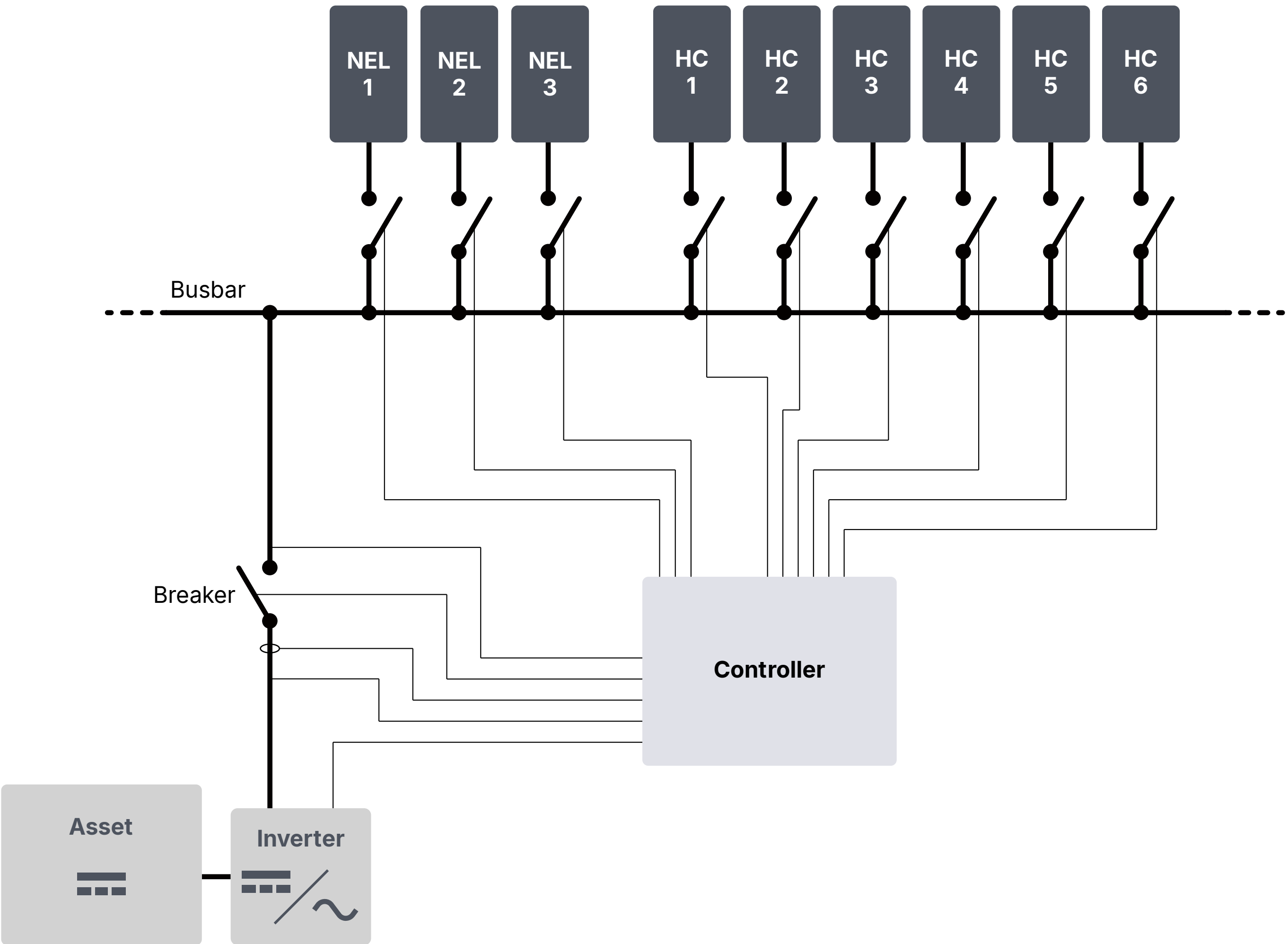
A **HYBRID** controller controls an inverter with power source, and the inverter breaker. A system can include a number of **HYBRID** controllers.

The **HYBRID** controllers work together to ensure effective power management. Power Take Off (PTO) mode, running only on the power source if needed and available, asymmetric load sharing with configurable constant discharge and genset start if required. The **HYBRID** controller accepts Power Take In (PTI) and but does not control it.

The **HYBRID** controller only directly controls an inverter and the inverter breaker. It does not control or provide any management of the actual power source, for example a Battery Management System (BMS). The customer must ensure that the necessary management system for the power source is installed and approved, according to the applicable Maritime classification societies.

Each **HYBRID** controller can control up to six heavy consumers (HC) and connect up to three non-essential load groups (NEL).

Example application with heavy consumers and non-essential loads



11.1.1 HYBRID controller functions

	Functions
Pre-programmed sequences	• Inverter start sequence and inverter stop sequence

	Functions
	◦ Running detection (Digital input) ◦ Start inverter and/or stop inverter for inverter control • Breaker sequences ◦ Inverter breaker close sequence (with synchronisation). ◦ Inverter breaker open sequence (with de-loading). • Inverter breaker blackout close
Inverter modes	• Power Take Off (PTO) ◦ Supply power to the system alone or with gensets or other source. ◦ Asymmetric load sharing with configurable constant discharge and genset start if required. • Power Take In (PTI) ◦ Recharge power source from the system. • Standby ◦ In standby mode, with breaker closed, the impedance of the inverter can ensure load peaks are taken on the busbar. This is only possible if the inverter supports this feature.
Counters	• Display unit counters, to edit or reset ◦ Start attempts. ◦ Running hours (total and trip). ◦ Inverter breaker operations and trips. ◦ Power export (active and reactive). ◦ External breaker operations. • Energy counters with configurable digital outputs (for external counters) ◦ Power export (active and reactive). ◦ Power import (active and reactive).
Control types	• Power management system (PMS) control ◦ AUTO mode ◦ Manual mode • Switchboard control ◦ Operator controls the system from the switchboard. ◦ Only the controller protections are active.
Control modes	• AUTO mode ◦ Automatic power management, only in PTO mode. ◦ Automatic load-dependent inverter start & stop, only in PTO mode. ◦ Automatic synchronisation & de-loading, and breaker control, only in PTO mode. • Manual mode ◦ Operations only on operator command. ◦ Operator-initiated synchronisation and de-loading. ◦ Inverter start and stop with the start/stop push-buttons, and the breaker is controlled by the close/open push-buttons. ◦ Display buttons for inverter start & stop, breaker open & close, and 1st priority. • Display unit push-buttons ◦ Change control mode (AUTO & Manual) ◦ Push-button functions also possible using inputs, PICUS, and/or Modbus ◦ Intuitive, one-touch sequences using the display unit for inverter start & stop, and breaker open & close in Manual mode

11.2 HYBRID controller principles

11.2.1 HYBRID 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.

`Inverter > 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 inverter.
`Current (I)`	1.0 A to 9 kA	The maximum current flow in one phase (that is, L1, L2 or L3) from the inverter 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 may be on the inverter nameplate.
`Apparent power (S)`	1.0 kVA to 1 GVA	The nominal apparent power should be on the inverter nameplate.
`Power factor (PF)`	0.6000 to 1.0000	The power factor should be on the inverter nameplate.

NOTE * # is 1 to 4.
NOTE ** In a single-phase set up the nominal AC voltage is phase-to-neutral.

Calculation method

`Inverter > 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 and calculated.

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 inverter 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 inverter and the busbar, the nominal voltage for the busbar will be the same as the nominal voltage for the inverter.

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.

11.2.2 Start inverter or stop inverter

Digital outputs

Function	I/O	Type	Details
`Inverter > Controls > Start`	Digital output	Pulse	Requests the inverter to start using the configured inverter start sequence.
`Inverter > Controls > Stop`	Digital output	Pulse	Requests the inverter to stop using the configured inverter stop sequence.

11.2.3 Running detection

The controller uses digital running detection to receive inverter running feedback.

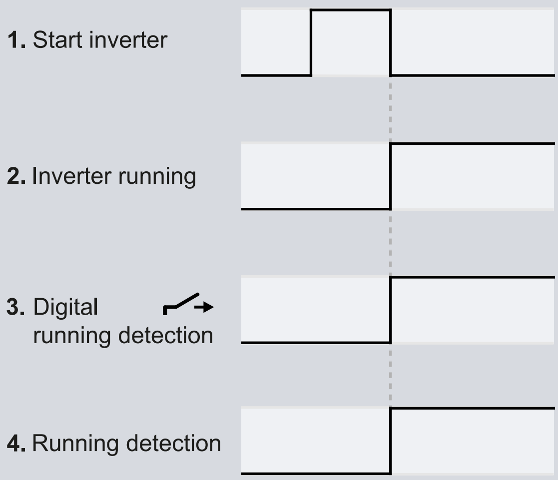
Running detection is a state calculated by the controller, and used by a number of functions. It is either OFF or ON. If digital running detection shows that the inverter is running, then *Running detection* is ON.

Digital input

Function	I/O	Type	Details
`Inverter > Feedback > Digital running detection`	Digital input	Continuous	Required to show the inverter is running.

Example: Running detection ON

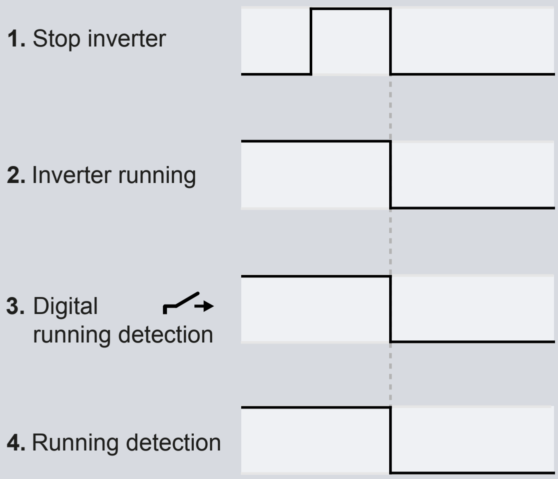
The following sequence diagram is an example of how *Running detection* changes during an inverter start. *Running detection* changes from OFF to ON when running feedback detects that the inverter is running.



1. **Start inverter**: Request to start the inverter.
2. **Inverter running**: The inverter starts running after the start request.
3. **Digital running detection:** `Inverter > Feedback > Digital running detection` (digital input).
4. **Running detection**: Running detection changes from OFF to ON.

Example: Running detection OFF

The following sequence diagram is an example of how *Running detection* changes during an inverter stop. *Running detection* changes from ON to OFF when running feedback detects that the inverter is not running.



1. **Stop inverter**: Request to stop the inverter.
2. **Inverter running**: The inverter stops running after the stop request.
3. **Digital running detection:** `Inverter > Feedback > Digital running detection` (digital input).
4. **Running detection**: Running detection changes from ON to OFF.

11.2.4 Regulation

The HYBRID controller regulates the inverter only in PTO mode.

11.2.5 Power management

The HYBRID controller works together with the other controllers in the system to provide efficient power management. This includes blackout prevention and blackout recovery.

More information
See Power management for how power management works and is configured.

11.2.6 HYBRID transition modes

The HYBRID controller can change mode based upon ready *, request, and running digital inputs.

Digital inputs

Function	I/O	Type	Details
`Power management > PTO ready`	Digital input	Continuous	Required to show the inverter is ready for PTO mode. *
`Power management > PTI ready`	Digital input	Continuous	Required to show the inverter is ready for PTI mode. *
`Power management > Standby ready (Hybrid)`	Digital input	Continuous	Required to show the inverter is ready for Standby mode. *
`Power management > PTO request`	Digital input	Pulse	Required to request mode change to PTO mode.
`Power management > PTI request`	Digital input	Pulse	Required to request mode change to PTI mode.
`Power management > Standby request (Hybrid)`	Digital input	Pulse	Required to request mode change to Standby mode.
`Power management > PTO running`	Digital input	Pulse/Continuous	Required to show the inverter is running in PTO mode.
`Power management > PTI running`	Digital input	Pulse/Continuous	Required to show the inverter is running in PTI mode.

NOTE * The **Ready input** is optional, but if the ready input is configured, it must be active before a request can be made.

PTO parameters

`Local power management > Hybrid modes > PTO (power take off) > Configuration`

Parameter	Range	Default	Notes
`Acknowledge pulse length`	0 to 3600 s	1 s	

`Local power management > Hybrid modes > PTO (power take off) > Request failure`

Parameter	Range	Default	Notes
Delay	0 to 3600 s	30 s	
Action		Warning	
Latch	Not enabled, Enabled	Enabled	

`Local power management > Hybrid modes > PTO (power take off) > Acknowledge timeout`

Parameter	Range	Default	Notes
Delay	0 to 3600 s	30 s	
Action		Warning	
Latch	Not enabled, Enabled	Enabled	

PTI parameters

`Local power management > Hybrid modes > PTI (power take in) > Configuration`

Parameter	Range	Default	Notes
Acknowledge pulse length	0 to 3600 s	1 s	
Nominal load	0 to 1000000 kW	0 kW	PTI sequence is similar to Heavy consumer (HC) sequence. When requesting PTI mode the nominal load has to be available on the busbar before the acknowledgement is given.

`Local power management > Hybrid modes > PTI (power take in) > Request failure`

Parameter	Range	Default	Notes
Delay	0 to 3600 s	30 s	
Action		Warning	
Latch	Not enabled, Enabled	Enabled	

`Local power management > Hybrid modes > PTI (power take in) > Acknowledge timeout`

Parameter	Range	Default	Notes
Delay	0 to 3600 s	30 s	
Action		Warning	
Latch	Not enabled, Enabled	Enabled	

Standby parameters

`Local power management > Hybrid modes > Standby > Request failure`

Parameter	Range	Default	Notes
Delay	0 to 3600 s	30 s	
Action		Warning	
Latch	Not enabled, Enabled	Enabled	

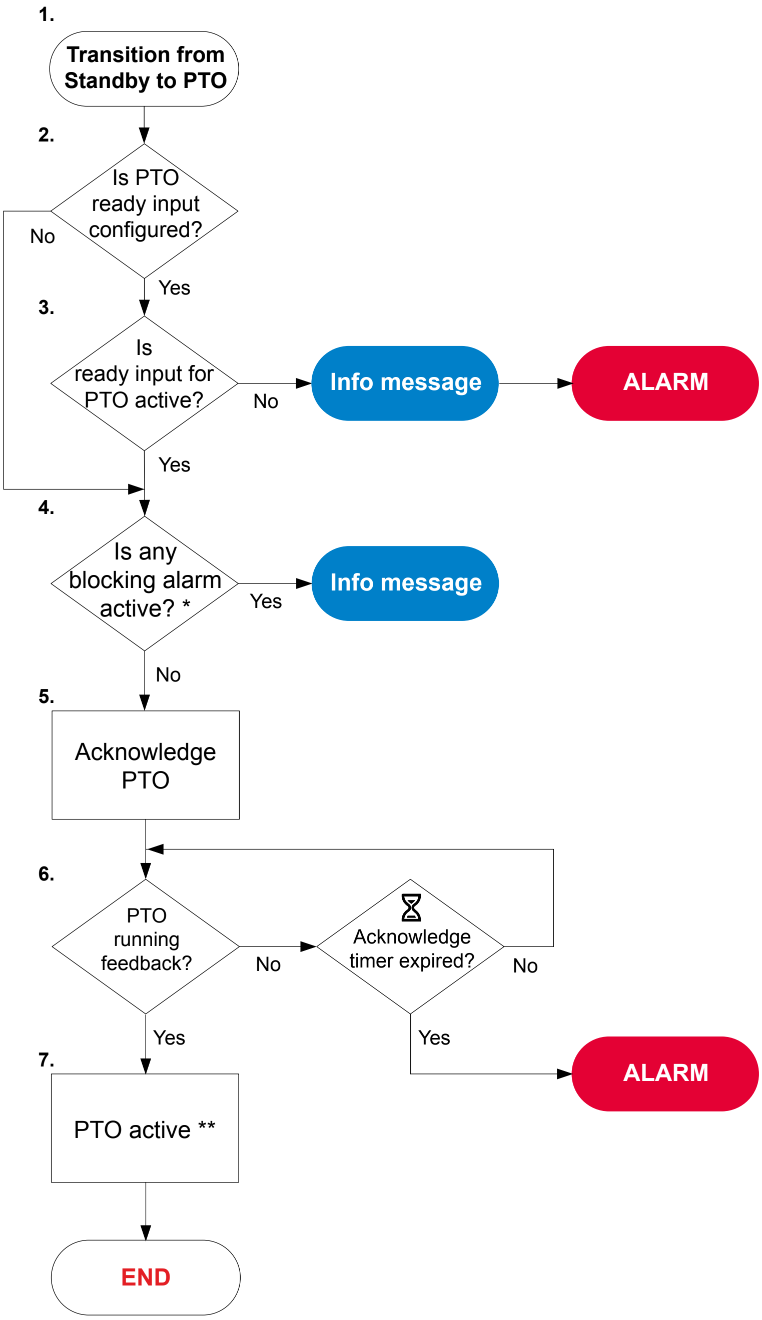
`Local power management > Hybrid modes > Standby > Acknowledge timeout`

Parameter	Range	Default	Notes
Delay	0 to 3600 s	30 s	
Action		Warning	
Latch	Not enabled, Enabled	Enabled	

Digital outputs

Function	I/O	Type	Details
`Power management > PTO acknowledge`	Digital output	Pulse	Activates when conditions for transition are OK.
`Power management > PTO active`	Digital output	Continuous	Activates when PTO mode is successfully activated.
`Power management > PTI acknowledge`	Digital output	Pulse	Activates when conditions for transition are OK.
`Power management > PTI active`	Digital output	Continuous	Activates when PTI mode is successfully activated.
`Power management > Standby acknowledge (Hybrid)`	Digital output	Pulse	Activates when conditions for transition are OK.
`Power management > Standby active (Hybrid)`	Digital output	Continuous	Activates when Standby mode is successfully activated.

Transition from Standby to PTO

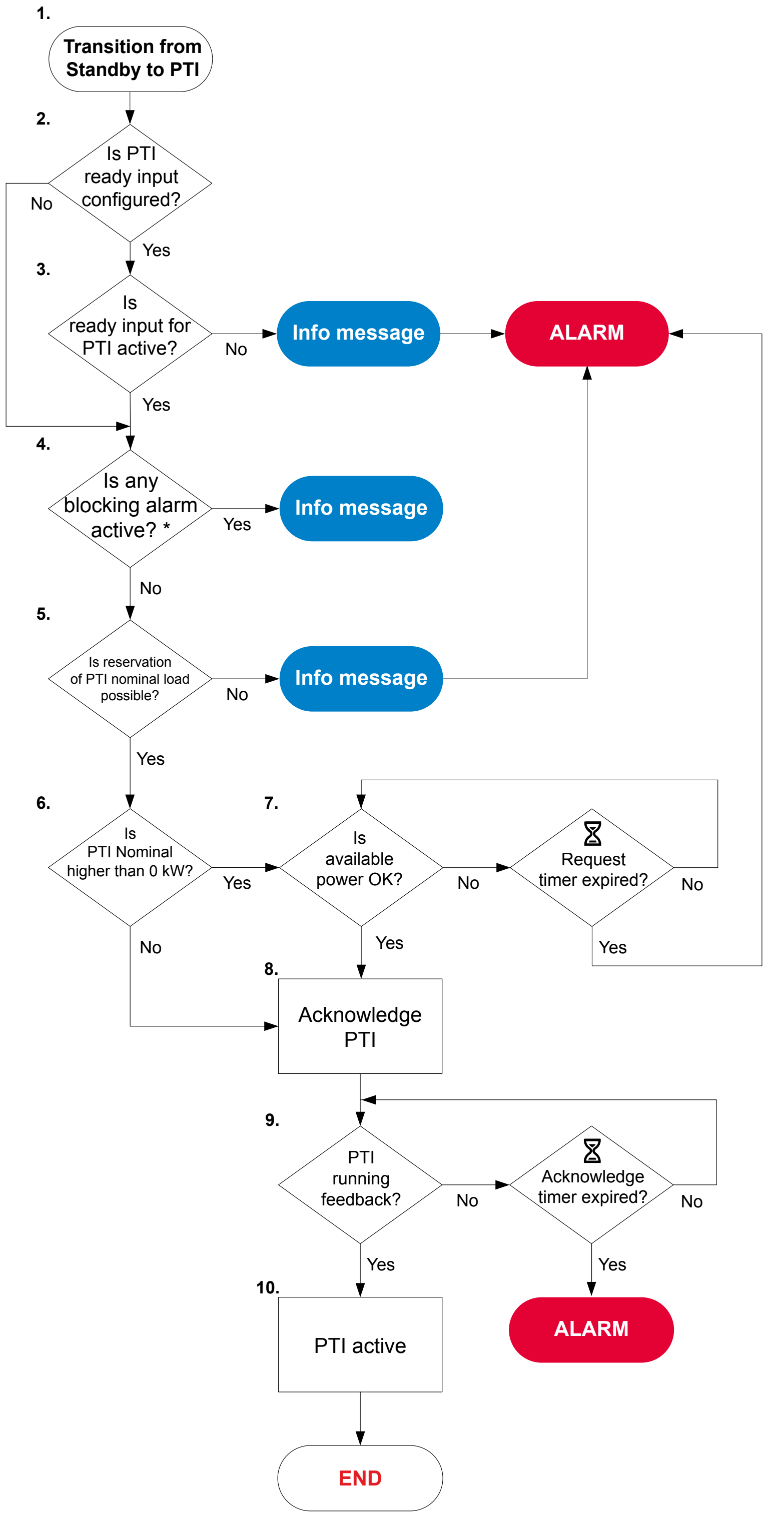


1. The controller receives a **PTO request** while in Standby mode.
2. The controller checks if the **PTO ready** input is configured:
   - The **PTO ready** input is optional, but if the ready input is configured, it must be active before a request can be made.
   - If this is not configured the controller skips the ready input check.
3. The controller checks if the **PTO ready** input is active.
   - If the **PTO ready** input is not active:
     - The controller displays an information message.
     - The controller activates the alarm **PTO request failure**.
4. The controller checks if any blocking alarm is active: *
   - If there is a blocking alarm:
     - The controller displays an information message.
5. The controller activates the **PTO acknowledge** digital output.
6. The controller checks if the **PTO running** input is active and starts the acknowledge timer:
   - If the acknowledge timer expires and the **PTO running** input is not active, a **PTO acknowledge timeout** alarm is activated.
7. The controller activates the **PTO active** digital output.

NOTE * Blocking alarms are **PTO request failure** or **PTO acknowledge timeout**.

NOTE ** PTO running state is independent of the inverter running state and the inverter breaker state. If the HYBRID controller is in AUTO mode if will now start and stop load depending after priority.

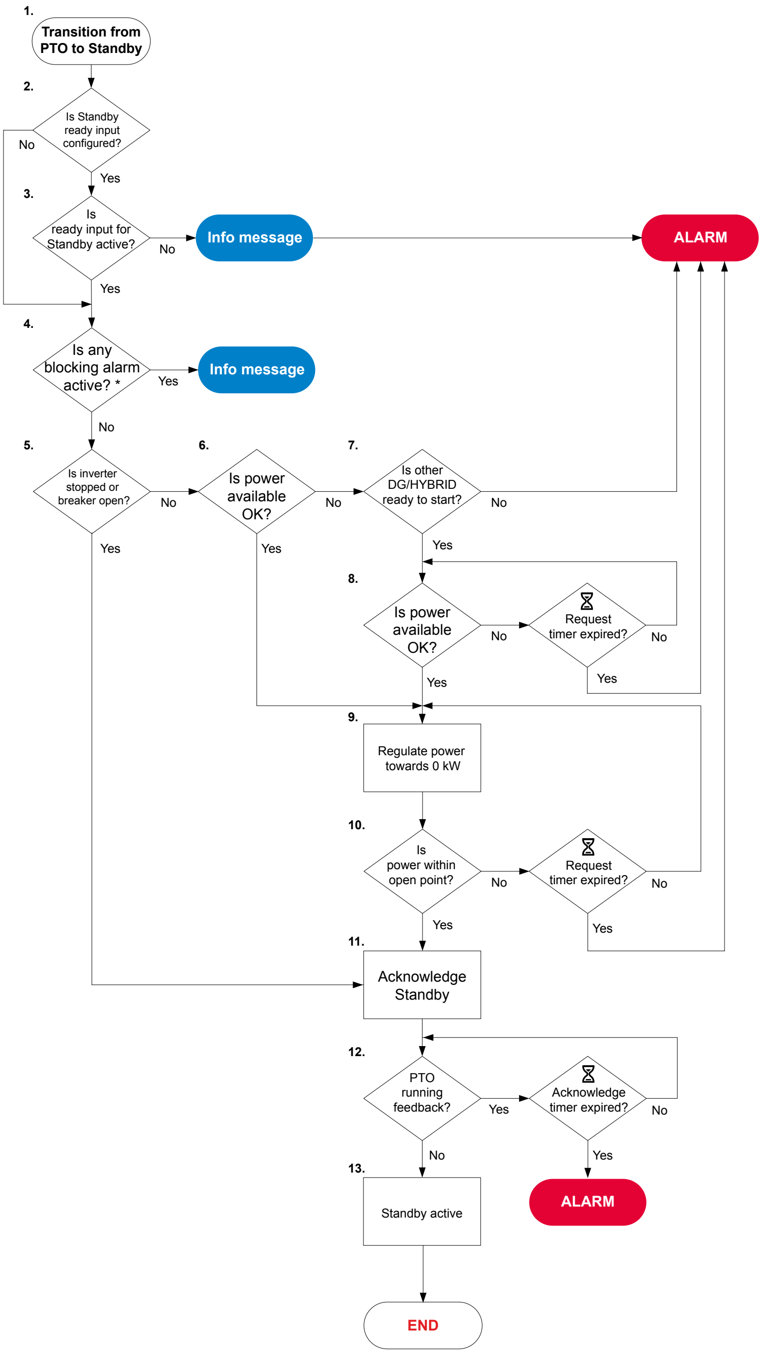
Transition from Standby to PTI



1. The controller receives a **PTI request** while in Standby mode.
2. The controller checks if the **PTI ready** input is configured:
   - The **PTI ready** input is optional, but if the ready input is configured, it must be active before a request can be made.
   - If the **PTI ready** input is not configured then the controller continues from step 4.
3. The controller checks if the **PTI ready** input is active.
   - If the **PTI ready** input is not active:
     - The controller displays an information message.
     - The controller activates the alarm **PTI request failure**.
4. The controller checks if any blocking alarms are active: *
   - If there is a blocking alarm:
     - The controller displays an information message.
5. The controller checks if reservation of the PTI nominal load is possible:
   - If the nominal load cannot be reserved
     - The controller displays an information message.
     - The controller activates the alarm **PTI request failure**.
6. The controller checks if the PTI nominal load is higher than 0 kW:
   - If PTI nominal load is not set higher than 0 kW, then the controller continues from step 8.
7. The controller checks if there is enough available power:
   - If there is not enough available power, the controller starts DGs and HYBRIDs and starts a request timer.
   - If request timer expires, or there is a start failure or failure to reserve, the controller activates the alarm **PTI request failure**.
8. The controller activates the **PTI acknowledge** digital output.
9. The controller checks if the **PTI running** input is active and starts the acknowledge timer:
   - If acknowledge timer expires and the **PTI running** input is not active, the controller activates the alarm **PTI acknowledge timeout**.
10. The controller activates the **PTI active** digital output.

NOTE * Blocking alarms are **PTI request failure** or **PTI acknowledge timeout**.

Transition from PTO to Standby



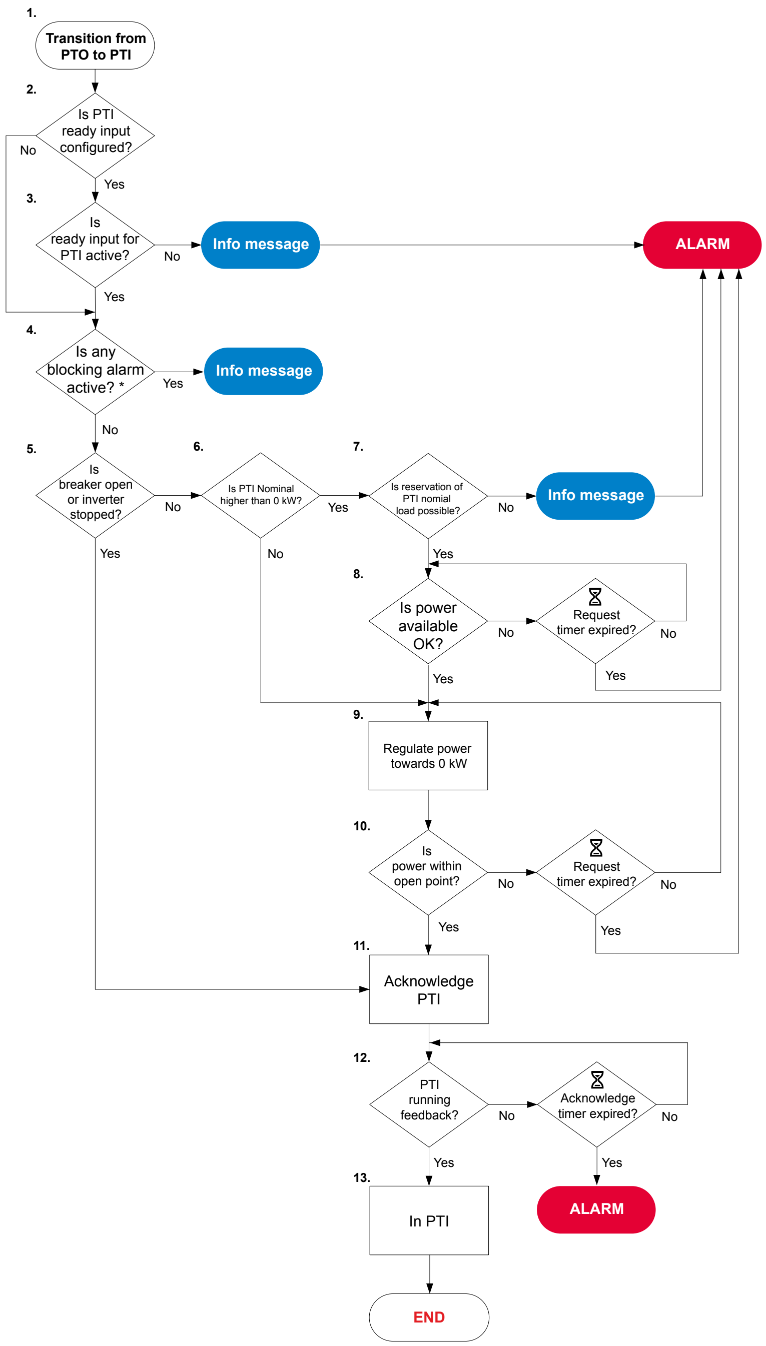
1. The controller receives a **Standby request** while in PTO mode.
2. The controller checks if the **Standby ready** input is configured:
   - The **Standby ready** input is optional, but if the ready input is configured, it must be active before a request can be made.
   - If this is not configured the controller skips the ready input check.
3. The controller checks if the **Standby ready** input is active.
   - If the **Standby ready** input is not active:
     - The controller displays an information message.
     - The controller activates the alarm **Standby request failure**.
4. The controller checks if any blocking alarm is active: *
   - If there is a blocking alarm:
     - The controller displays an information message.
5. The controller checks if the inverter is stopped or the breaker is open:
   - If the inverter is stopped or the breaker is open, the controller continues checking from step 11.
6. The controller checks if there is enough available power.
   - If there is enough available power the controller continues checking from step 9.
7. The controller checks if the other DG/HYBRID ready to start.
   - If the other DG/HYBRID is not ready to start:
     - The controller activates the alarm **Standby request failure**.
8. The controller checks if there is enough available power and starts the request timer:
   - If request timer expires or there is not enough available power:
     - The controller activates the alarm **Standby request failure**.
9. The controller starts to deload and regulate towards 0 kW.
10. The controller checks if the power is within the breaker open point:
    - If request timer expires and the power is not within the breaker open point:
      - The controller activates the alarm **Standby request failure**.
11. The controller activates the **Standby acknowledge** digital output.
12. The controller checks that the PTO running feedback and starts the acknowledge timer:

- If the acknowledge timer expires or PTO running remains active:
  - The controller activates the alarm **Standby Acknowledge timeout**.

13. The controller activates the **Standby active** digital output.

NOTE * Blocking alarms are **Standby request failure** or **Standby acknowledge timeout**.

Transition from PTO to PTI

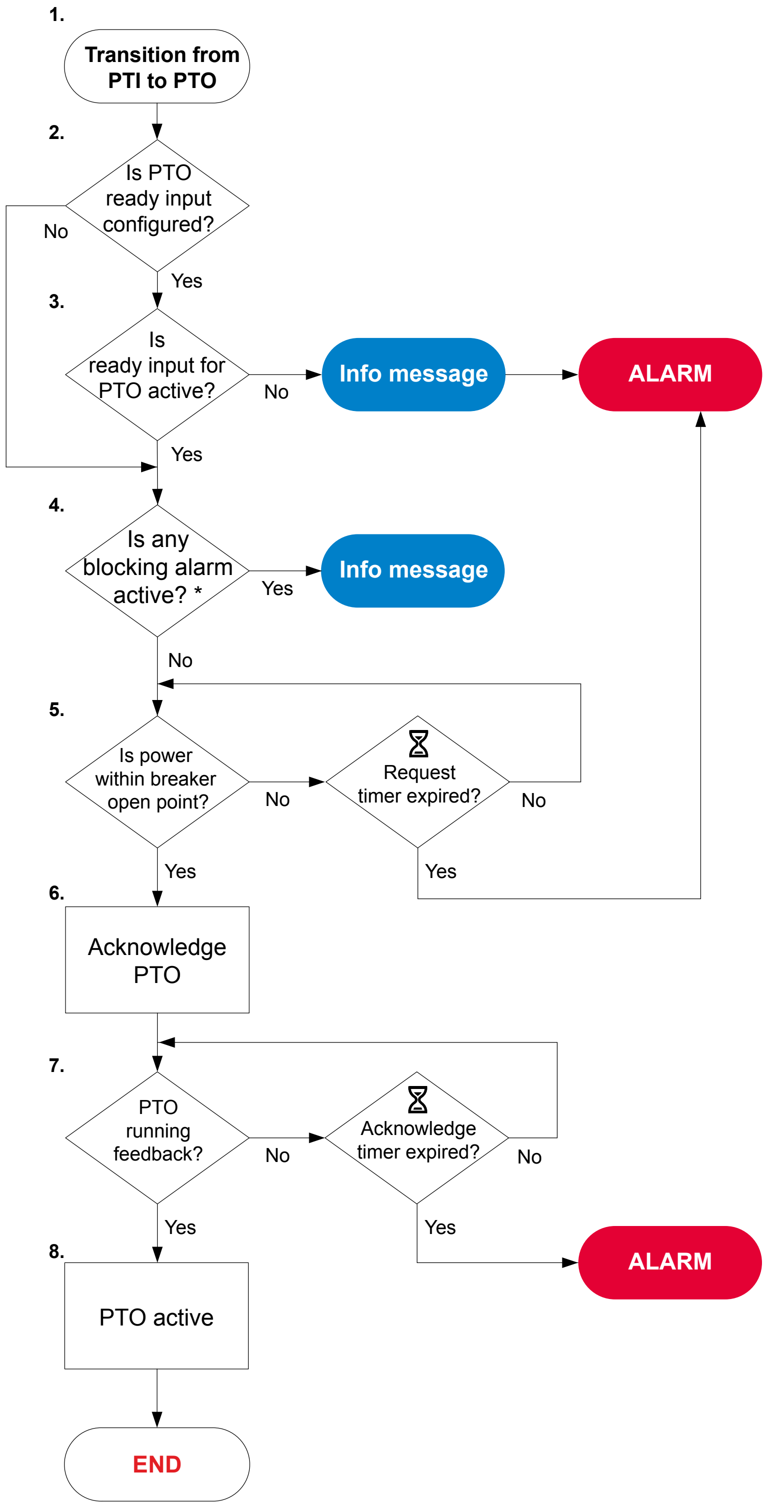


1. The controller receives a **PTI request** while in PTO mode.
2. The controller checks if the **PTI ready** input is configured:
   - The **PTI ready** input is optional, but if the ready input is configured, it must be active before a request can be made.
   - If this is not configured the controller skips the ready input check.
3. The controller checks if the **PTI ready** input is active.
   - If the **PTI ready** input is not active:
     - The controller displays an information message.
     - The controller activates the alarm **PTI request failure**.
4. The controller checks if any blocking alarm is active: *
   - If there is a blocking alarm:
     - The controller displays an information message.
5. The controller checks if the breaker is open or the inverter is stopped.
   - If the breaker is open or the inverter is stopped, the controller continues checking from step 11.
6. The controller checks if the PTI nominal is higher than 0 kW:
   - If PTI nominal load is not higher than 0 kW, then the controller continues on step 9.
7. The controller checks if reservation of the PTI nominal load is possible:
   - If the nominal load cannot be reserved:
     - The controller displays an information message.
     - The controller activates the alarm **PTI request failure**.
8. The controller checks if the available power is OK and starts the request timer:
   - If the request timer expires or there is a start failure or failure to reserve:
     - The controller displays an information message.
     - The controller activates the alarm **PTI request failure**.

9. The controller starts to deload and regulate towards 0 kW.
10. The controller checks if the power is within the open point:
    - If the request timer expires and the power is not within open point:
        - The controller activates the alarm **PTI request failure**.
11. The controller activates the **PTI acknowledge** digital output.
12. The controller checks if the **PTI running** input is active and starts the acknowledge timer:
    - If the acknowledge timer expires and the **PTI running** input is not active:
        - The controller activates the alarm **PTI Acknowledge timeout**.
13. The controller activates the **PTI active** digital output.

NOTE * Blocking alarms are **PTI request failure** or **PTI acknowledge timeout**.

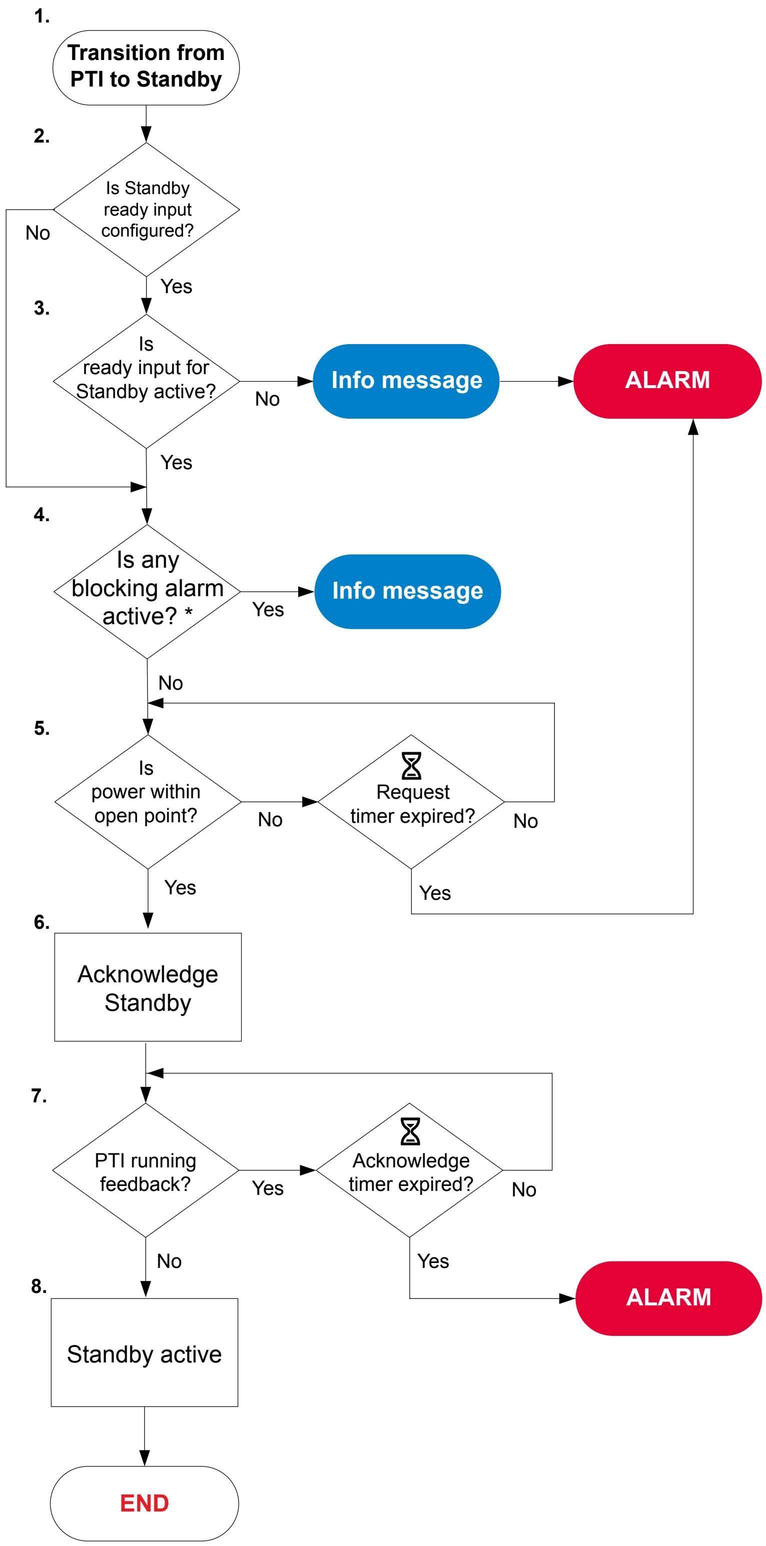
Transition from PTI to PTO



1. The controller receives a **PTO request** while in PTI mode.
2. The controller checks if the **PTO ready** input is configured:
   - The **PTO ready** input is optional, but if the ready input is configured, it must be active before a request can be made.
   - If this is not configured the controller skips the ready input check.
3. The controller checks if the **PTO ready** input is active.
   - If the **PTO ready** input is not active:
     - The controller displays an information message.
     - The controller activates the alarm **PTO request failure**.
4. The controller checks if any blocking alarm is active: *
   - If there is a blocking alarm:
     - The controller displays an information message.
5. The controller checks if the power within the breaker open point:
   - If the power is not within the breaker open point:
     - The controller activates the alarm **PTO request failure**.
6. The controller activates the **PTO acknowledge** digital output.
7. The controller checks if the **PTO running** input is active and starts the acknowledge timer:
   - If the acknowledge timer expires and the **PTO running** input is not active, a **PTO acknowledge timeout** alarm is activated.
8. The controller activates the **PTO active** digital output.

NOTE * Blocking alarms are **PTO request failure** or **PTO acknowledge timeout**.

Transition from PTI to Standby



1. The controller receives a **Standby request** while in PTI mode.
2. The controller checks if the **Standby ready** input is configured:
   - The **Standby ready** input is optional, but if the ready input is configured, it must be active before a request can be made.
   - If this is not configured the controller skips the ready input check.
3. The controller checks if the **Standby ready** input is active.
   - If the **Standby ready** input is not active:
     - The controller displays an information message.
     - The controller activates the alarm **Standby request failure**.
4. The controller checks if any blocking alarm is active: *
   - If there is a blocking alarm:
     - The controller displays an information message.
5. The controller checks if the power is within the open point and starts the request timer:
   - If the request timer expires and the power is not within the open point:
     - The controller activates the alarm **Standby request failure**.

   .
6. The controller activates the **Standby acknowledge** digital output.
7. The controller checks that PTI is not running and starts the acknowledge timer:
   - If the acknowledge timer expires and the PTI running remains active:
     - The controller activates the alarm **Standby Acknowledge timeout**.
8. The controller activates the **Standby active** digital output.

NOTE * Blocking alarms are **Standby request failure** or **Standby Acknowledge timeout**.

11.2.7 Load sharing

When a HYBRID controller is in PTO mode and under PMS control, it shares the load with other DEIF controllers using the DEIF network.

More information
See Load sharing for how it works and is configured.

11.2.8 Ready for operation

The inverter associated with a HYBRID controller is ready for operation when the following conditions are met:

- There are no alarms blocking the start.
- The HYBRID controller is in PTO mode and in PMS control.

11.2.9 AC configuration

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

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

HYBRID	General name
Inverter	[A-side]
Busbar	[B-side]

11.2.10 Breaker configuration

More information
The Breakers, synchronisation and de-loading chapter describes breaker configuration in general. For the HYBRID controller, replace "[Breaker]" with "Inverter breaker" in these descriptions.

11.3 Inverter start

11.3.1 Inverter start function

The controller software includes a pre-programmed inverter start sequence. For the inverter's start function, you must configure these inputs and outputs, and parameters.

More information
See Start failure for how the inverter start alarm works, and how to configure it.

Controller modes

In AUTO and Manual mode, the HYBRID controller uses these inputs and outputs, and parameters to start the inverter. See the following sections for the inverter start flowcharts and sequences.

When the operator starts the inverter in switchboard control, the HYBRID controller is not involved. These sequences do not apply to starting an inverter in switchboard control.

Required inverter start and run digital outputs

Function	I/O	Type	Details
`Inverter > Controls > Start`	Digital output	Pulse	Connect this output to the inverter start.
`Inverter > Controls > Run`	Digital output	Continuous	This output is high when the inverter should run.

Optional inverter start digital inputs

Function	I/O	Type	Details
`Inverter > Command > Start inverter`	Digital input	Pulse	Optional. When the controller is in Manual mode, the operator or another system can activate this input to request the controller to start the inverter.
`Inverter > Command > Block inverter start`	Digital input	Continuous	Optional. The operator or another system can activate this input so that the controller cannot start the inverter. The input blocks the start in both AUTO and Manual mode. However, the input will not prevent an inverter start when the controller is under switchboard control.
`Inverter > Command > Connect (inverter/breaker)`	Digital input	Pulse	Optional. When the controller is in Manual mode, the operator or another system can activate this input to request the controller to connect the inverter, synchronise and close the breaker.

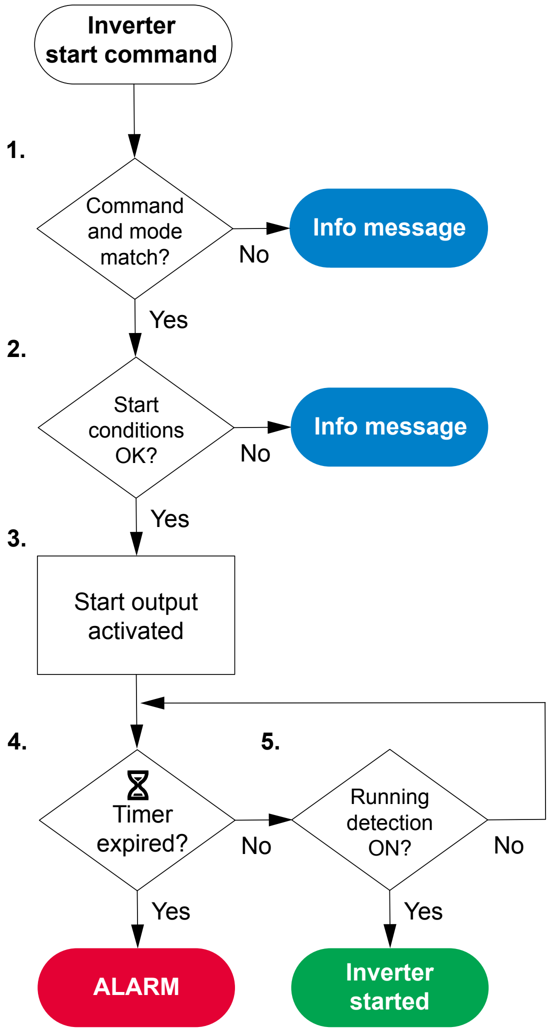
Required parameters

`Inverter > Start sequence`

Parameter	Range	Comment
`Restrictions > Allow start when`	Breaker is open, Breaker is closed, Breaker in any state	The controller allows the start of the inverter only if the inverter breaker is in the state required.
`Start > Start on`	1.0 s to 3 min	If there is no running detection during the inverter start, then a start failure is activated.

11.3.2 Inverter start flowchart

This flowchart does not apply to switchboard control. In switchboard control, if the operator presses the push-button **Start** on the display unit, the controller ignores the command and shows an info message.

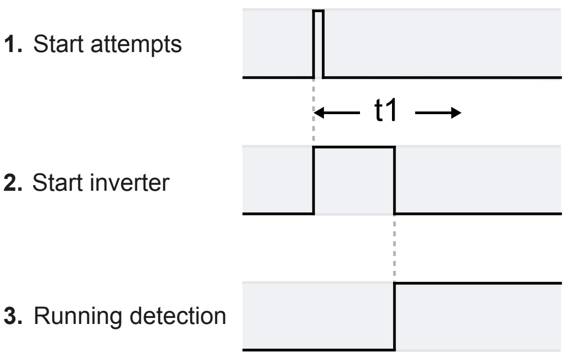


1. The controller checks if the command and mode match:
   - In AUTO mode, the power management system must send the command to start the inverter. The controller ignores all other external commands.
   - In Manual mode, the command to start the inverter can come from the following:
     - The operator can press the push-button **Start** on the display unit.
     - The operator can use PICUS to send an inverter start command.
     - The command can come from an external source, for example, a relay output from a PLC.
2. The controller checks if the start conditions are OK:
   - For a power management command, the controller is in AUTO mode.
   - There are no active or unacknowledged alarms to prevent the inverter start. These alarm actions prevent a inverter start:
     - *Block*
     - *PMS-controlled stop*
     - *Trip breaker and stop inverter*
     - *Trip breaker and AVR and stop inverter*
     - *Stop inverter*
   - Inverter start sequence restrictions are OK:
     - If configured as *Breaker is open*, breaker must be open.
     - If configured as *Breaker is closed*, breaker must be closed.
     - If configured as *Breaker in any state*, breaker can be open or closed.
3. The controller activates the *Start* output and a timer.
4. The controller checks if the *Start on timer* has expired:
   - If timer has expired, the controller activates the *Start failure* alarm.
5. The controller checks the inverter *Running detection*:
   - If *Running detection* is ON, the inverter has started.
   - If *Running detection* is OFF, the controller continues checking while the *Start on timer* has not expired.

11.3.3 Inverter start sequence

t1 = Start on (`Inverter > Start sequence > Start > Start on`)

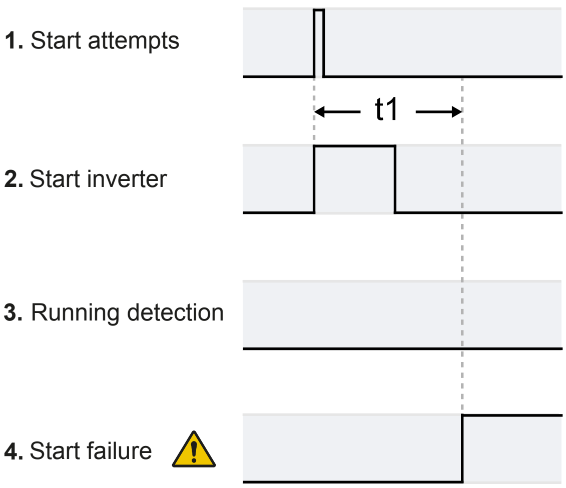
Successful inverter start sequence



1. **Start attempts**: The inverter starts during the first start attempt.
2. **Start inverter**: The inverter starts before the *Start on* timer expires.

3. **Running detection**: The inverter is regarded as started when *Running detection* is ON.

Failure of inverter start sequence



1. **Start attempts**: The inverter start attempt.
2. **Start inverter**: The inverter is requested to start.
3. **Running detection**: There is no running detection.
4. **Start failure**: The controller activates the *Start failure* alarm after the unsuccessful start attempt.

11.3.4 Interruption of the start sequence

These actions interrupt the inverter start sequence:

- The *Emergency stop* digital input is activated (for example, from the operator, or a PLC)
- When the controller is in Manual mode, there is a *Stop inverter* command. For example: The operator pushes the push-button **Stop** on the display.
- The following alarm actions:
  - *PMS-controlled stop*
  - *Trip breaker and stop inverter*

The *Block* alarm action will not interrupt the inverter start sequence after it has begun. However, the *Block* alarm action prevents a new inverter start sequence from starting.

If *Running detection* is ON, the controller regards the inverter as started. When the inverter has started, the actions listed here do not interrupt the inverter start sequence, but result in a inverter stop instead.

11.4 Inverter stop

11.4.1 Inverter stop function

The controller software includes pre-programmed inverter stop sequences. For the inverter's stop function, you must configure these inputs and outputs, and parameters.

More information
See Stop failure for how the inverter stop alarm works, and how to configure it.

Controller modes

In AUTO and Manual mode, the HYBRID controller uses these inputs and outputs, and parameters to stop the inverter.

When the operator stops the inverter under switchboard control, the controller is not involved. These sequences do not apply to stopping an inverter in switchboard control.

Required inverter stop digital outputs

Function	I/O	Type	Details
`Inverter > Controls > Stop`	Digital output	Pulse	Connect this output to the inverter stop.
`Inverter > Controls > Run`	Digital output	Continuous	This output is low when the inverter is stopped.

Optional inverter stop digital inputs

Function	I/O	Type	Details
`Inverter > Command > Stop inverter`	Digital input	Pulse	Optional. When the controller is in Manual mode, the operator or another system can activate this input to request the controller to start the inverter.
`Inverter > Command > Disconnect (inverter/breaker)`	Digital input	Pulse	Optional. When the controller is in Manual mode, the operator or another system can activate this input to request the controller to disconnect the inverter; deload and open the breaker.

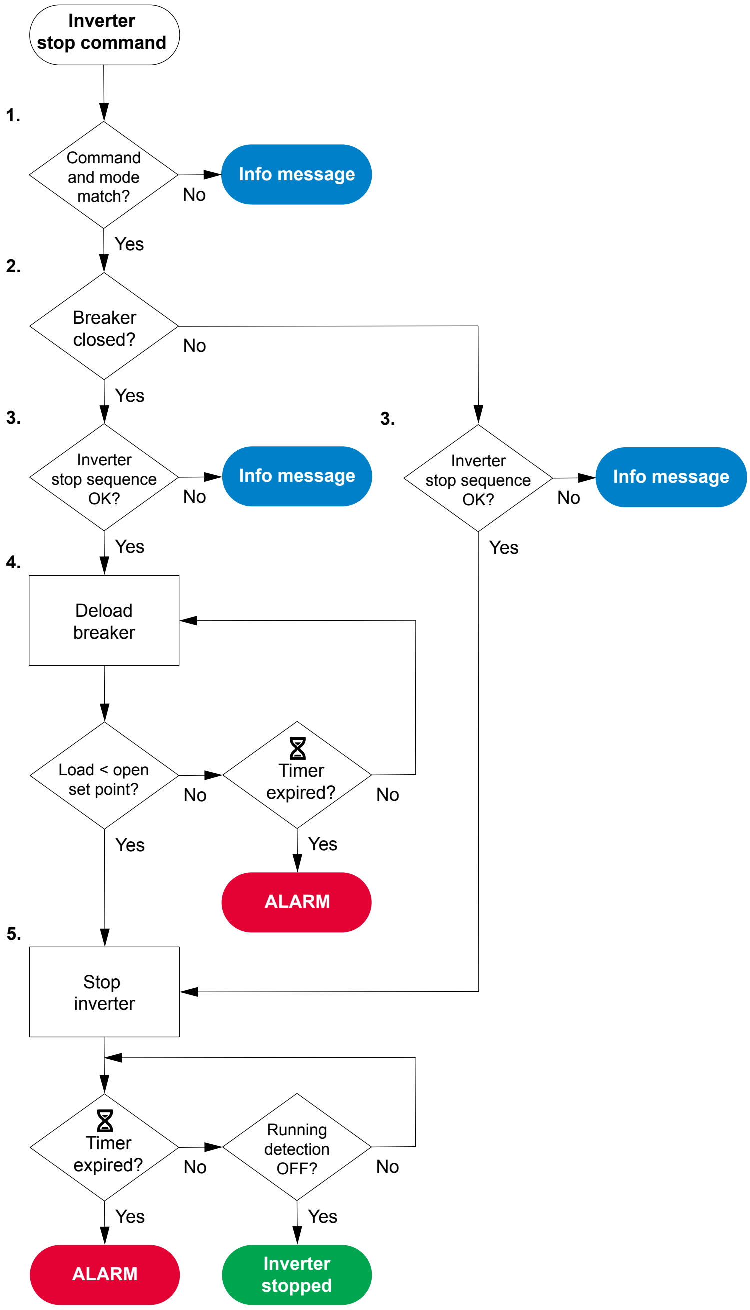
Required parameters

`Inverter > Stop sequence`

Parameter	Range	Comment
`Restrictions > Allow stop when`	Breaker is open, Breaker is closed, Breaker in any state	The controller allows the stop of the inverter only if the inverter breaker is in the state required.
`Stop failure`	0 s to 5 min	If there is running detection during the inverter stop, then a stop failure is activated.

11.4.2 Inverter stop flowchart

This flowchart does not apply to switchboard control. When the controller is under switchboard control, it will not stop the inverter. If, for example, the operator presses the push-button **Stop**  on the display unit, the controller ignores this command, and the controller display unit shows an info message.

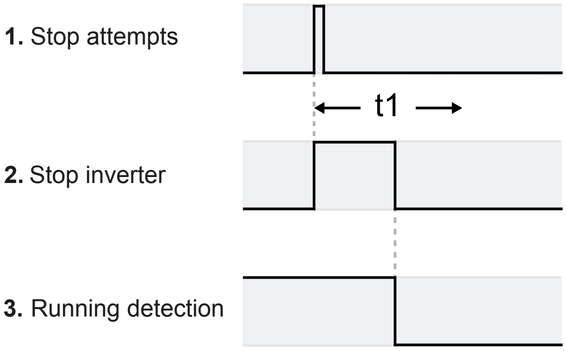


1. The controller checks that the command source and the controller mode match:
   - In AUTO mode, the power management system must send the command to stop the inverter. The controller ignores all other external commands.
   - In Manual mode, the command to stop the inverter can come from the following:
     - The operator can press the push-button **Stop** on the display unit.
     - The operator can use PICUS to send an inverter stop command.
     - The command can come from an external source, like a PLC.
2. The controller checks the break state.
3. The controller checks whether the stop sequence restriction on the breaker state is OK:
   - If configured as *Breaker in any state*
     - Breaker can be open or closed and the controller either deloads or stops the inverter.
   - If configured as *Breaker is open*
     - Breaker must be open to start deloading otherwise an information message.
   - If configured as *Breaker is closed*
     - Breaker must be closed and then deloaded otherwise an information message.
4. The controller starts deloading the breaker.
   - The controllers checks if the load has reached the open set point.
   - **Deload timer:**
     - If the deload timer has not expired, the controller continues to deload the breaker.
     - If the deload timer has expired and load has not reached the open set point, an alarm is activated.
     - The controller continues attempt to deload the breaker.
5. The controllers attempts to stop the inverter and starts the stop timer.
   - If the stop timer has expired and running detection is ON, the controller activates the *Stop failure* alarm.
   - If the stop timer has not expired, the controller checks if running detection is OFF.
     - If running detection is OFF the inverter is stopped.
     - If running detection is ON, the timer continues.

11.4.3 Inverter stop sequence

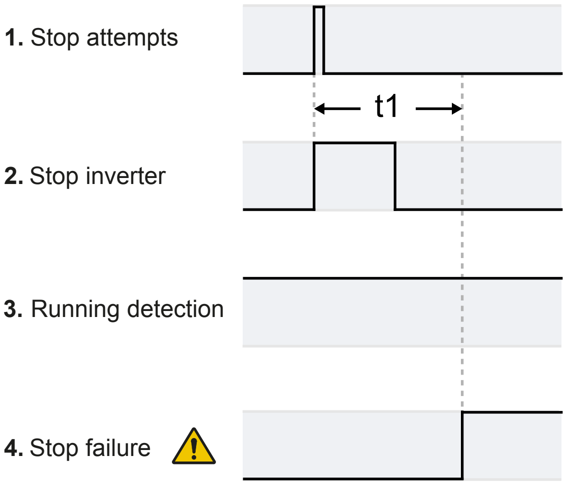
t1 = Stop failure (`Inverter > Stop sequence > Stop failure`)

Successful inverter stop sequence



1. **Stop attempts**: The inverter stops during the first stop attempt.
2. **Stop inverter**: The inverter stops before the Stop failure timer expires.
3. **Running detection**: When the running detection is OFF, the controller regards the inverter as stopped.

Failure of inverter stop sequence

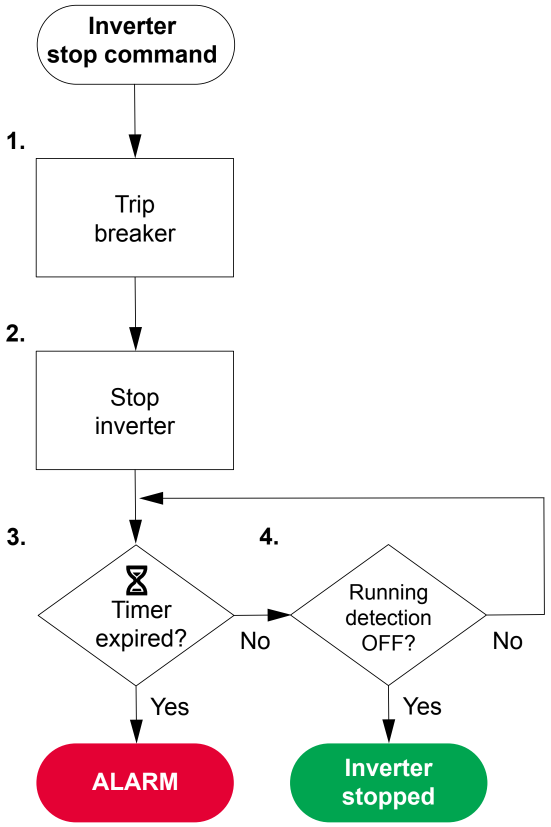


1. **Stop attempts**: The inverter stop attempt.
2. **Stop inverter**: The inverter is requested to stop.
3. **Running detection**: There is running detection.
4. **Stop failure**: The controller activates the *Stop failure* alarm after the unsuccessful stop attempt.

11.4.4 Inverter trip and stop flowchart

The inverter breaker is tripped and the inverter stopped if either:

- Any alarm with action: **Trip breaker and stop inverter**
- The controller's *Emergency stop* input is deactivated.



1. The controller checks whether the inverter breaker is open.
   - If the breaker is closed, the controller trips the inverter breaker.
2. The controller stops the inverter.
3. The controller checks if the **Stop failure timer** has expired:
   - If the **Stop failure timer** has expired, the controller activates the *Stop failure* alarm.
4. The controller checks if running detection is OFF:
   - If **Running detection** is OFF the inverter is stopped.
   - If **Running detection** is ON, the **Stop failure timer** continues.

11.5 Inverter breaker

11.5.1 About the Inverter breaker

The inverter breaker connects the inverter to the busbar. The inverter breaker is an important part of the system safety, and trips to protect the inverter from problems on the busbar. The inverter breaker also trips to stop inverter problems from disturbing the busbar.

Configure the inverter breaker parameters and the open and close conditions.

`Breakers > Inverter breaker configuration > Configuration`

Function	Range	Details
Allow breaker close when	Inverter is started, Inverter is stopped, Inverter is in any state	• **Inverter started** : The inverter must be running and synchronised with the busbar, before the inverter breaker can close. • **Inverter stopped** : The inverter must not be running, before the inverter breaker can close. • **Inverter is in any state** : The state of the inverter does not stop the breaker closing.
Allow breaker open when	Inverter is started, Inverter is stopped, Inverter is in any state	• **Inverter started** : The inverter must be running and synchronised with the busbar, before the inverter breaker can open. • **Inverter stopped** : The inverter must not be running, before the inverter breaker can open. • **Inverter is in any state** : The state of the inverter does not stop the breaker opening.

General breaker information

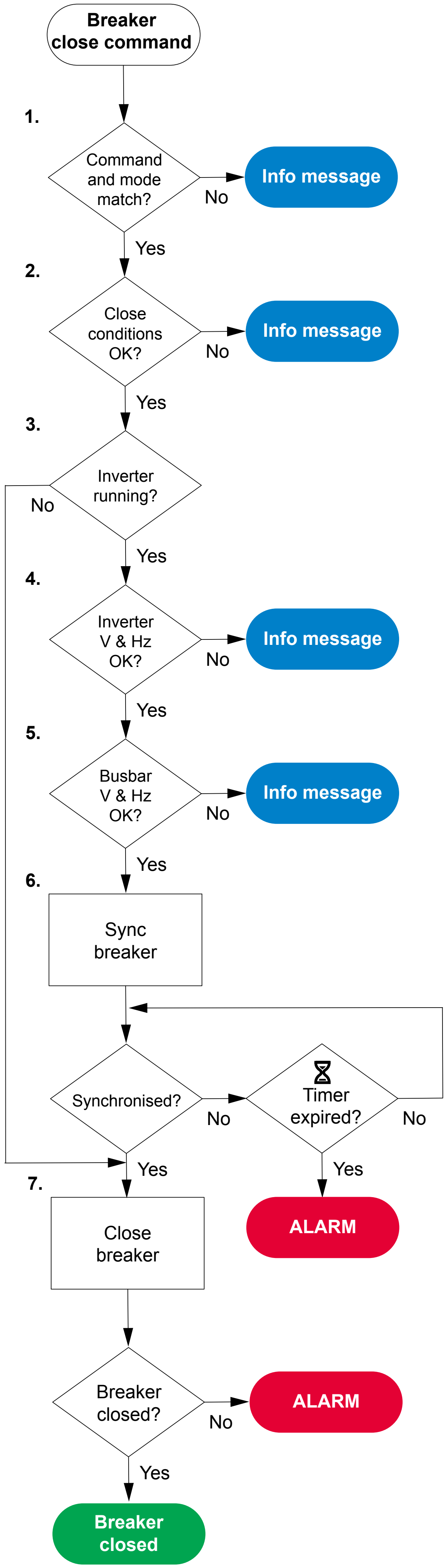
[Breaker] refers to *Inverter breaker*. The breaker abbreviation (*[*B]*) is *Breaker*.

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.

11.5.2 Inverter breaker close flowchart

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** on the display unit, the controller ignores this command.



1. The controller checks that the command source and the controller mode match:
   - In AUTO mode, the power management system must send the command to close the breaker. The controller ignores all other external commands.
   - In Manual mode, the command to close the breaker can come from the following:
     - The operator can press the push-button **Close breaker** on the display unit.
     - The operator can use PICUS to send a close breaker command.
     - An external source, like a PLC.
2. The controller checks if the close conditions are OK. The following conditions must be met:
   - The controller checks whether the inverter breaker is open. If the inverter breaker is already closed, the sequence stops, and an info message is shown.
   - Inverter breaker configuration restrictions for *Allow breaker close when* are OK:
     - If configured as *Inverter is started*, inverter must be running.
     - If configured as *Inverter is stopped*, inverter must be stopped.
     - If configured as *Inverter in any state*, inverter can be running or stopped.
   - If the digital input *Inverter breaker > Command > Block breaker close* is activated, an info message is shown.
3. The controller checks if the inverter is running.
   - If the inverter is not running, the controller continues from step 7.
4. The controller checks if the voltage and frequency from the inverter are in the allowed range *. If these are not in the range, then the controller cancels the close command and displays an info message.
5. The controller checks if the voltage and frequency on the busbar are in the allowed range **. If these are not in the range, then the controller cancels the close command and displays an info message.
6. The controller attempts to synchronise the inverter to the busbar.
   - When the inverter and busbar are synchronised, the controller activates the `Breakers > Inverter breaker > Controls > Breaker close` output to close the breaker.
   - If the inverter and busbar do not synchronise within the time allowed, the controller activates a *Breaker synchronisation failure* alarm.
7. The controller checks if the inverter breaker is closed:
   - If the inverter breaker has closed, the inverter breaker close sequence has been completed successfully.
   - If the inverter breaker has not closed, the controller activates the *Breaker closing failure* alarm.

NOTE * See `Inverter > AC setup > Voltage and frequency OK` for the Inverter ranges.
** See `Busbar > AC setup > Voltage and frequency OK` for the Busbar ranges.

11.5.3 Inverter breaker blackout close

The power management system can automatically close the inverter breaker as part of the blackout response.

More information
See **Power management**, **Blackout** for more information.

Manual blackout close not possible
During a blackout, if the HYBRID controller is in PTO mode, the controller is forced into AUTO mode. Since the HYBRID controller is not in Manual mode, the operator cannot close the breaker by pushing the push button **Close breaker** on the display.

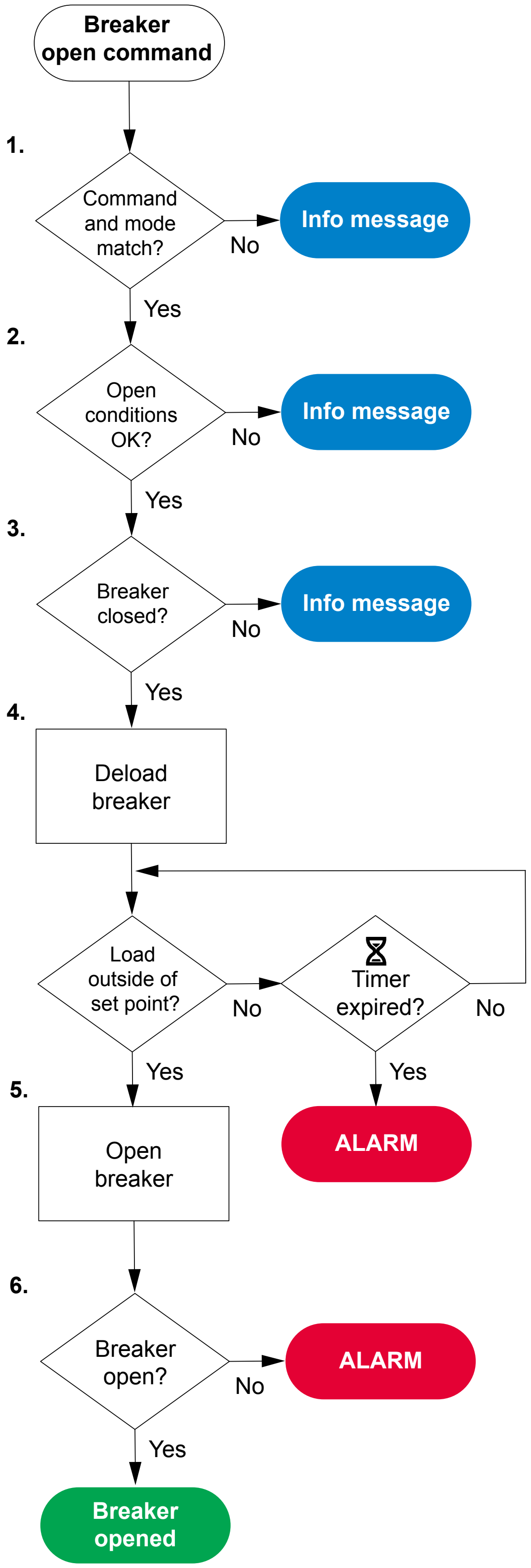
11.5.4 Inverter breaker open flowchart

The following flowcharts shows the sequence that the controller normally uses to open the inverter breaker. The sequence depends upon the active mode. This sequence is also used for the alarm action *PMS-controlled stop*.

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 Breaker open command while *Block* is active, the controller uses this sequence.

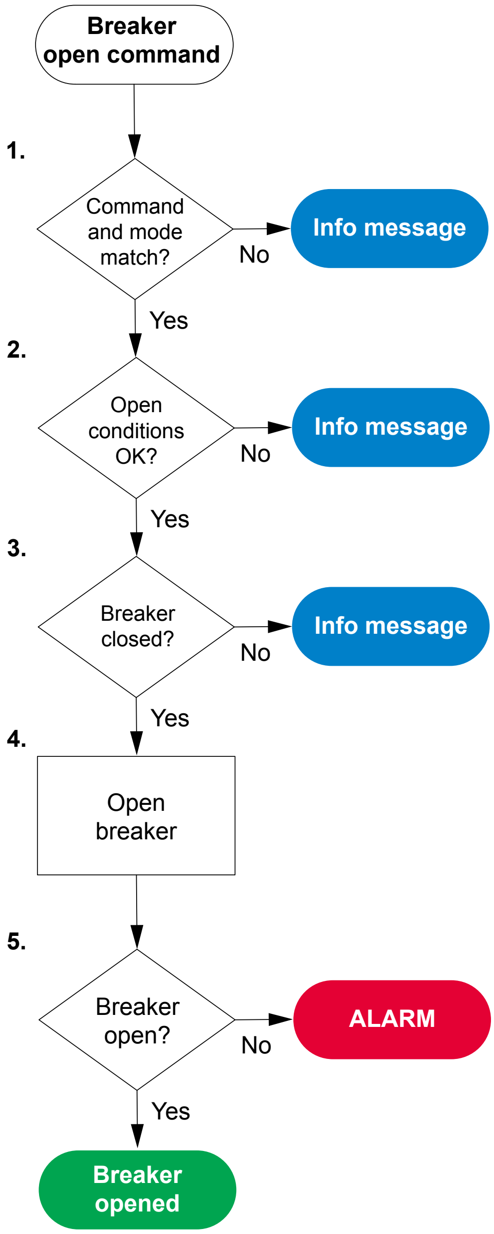
This flowchart does not apply to switchboard control. When the controller is under switchboard control, it will not open the breaker (except for a trip). If, for example, the operator presses the push-button **Open breaker** on the display unit, the controller ignores this command.

PTO mode



1. The controller checks that the command source and the controller mode match:
   - In AUTO mode, the power management system must send the command to open the breaker. The controller ignores all other external commands.
   - In Manual mode, the command to open the breaker can come from the following:
     - The operator can press the push-button **Open breaker** on the display unit.
     - The operator can use PICUS to send an open breaker command.
     - The command can come from an external source, like a PLC.
2. The controller checks whether the open conditions are OK. The following conditions must be met:
   - The system must have at least one other source of power running and connected to the busbar (for example, another genset, a shaft generator or a shore controller).
   - The remaining gensets must not be overloaded after the breaker opens.
   - Inverter breaker configuration restrictions for *Allow breaker open when* are OK:
     - If configured as *Inverter is started*, inverter must be running.
     - If configured as *Inverter is stopped*, inverter must be stopped.
     - If configured as *Inverter in any state*, inverter can be running or stopped.
   - If the digital input `Inverter breaker > Command > Block breaker open` is activated, an info message is shown.
3. **Breaker closed:** The controller checks whether the breaker is closed. If the breaker is open, the sequence ends.
4. **Deload inverter:** The system de-loads the inverter:
   - When the load is less than the set point for the breaker to open, the controller activates the *Breaker > Controls > Breaker open* output.
   - If the controller cannot de-load the breaker before the de-load timer expires, the controller activates the *Breaker de-load failure* alarm. The controller continues to try to de-load the breaker.
5. **Breaker opened:** The controller checks whether the breaker has opened:
   - If the breaker has opened, the breaker open sequence has been completed successfully.
   - If the breaker has not opened, the controller activates the *Breaker opening failure* alarm.

PTI or standby mode



1. **Command and mode match:** The controller checks that the command source and the controller mode match:
   - In AUTO mode, the power management system must send the command to open the breaker. The controller ignores all other external commands.
   - In Manual mode, the command to open the breaker can come from the following:
     - The operator can press the push-button **Open breaker** on the display unit.
     - The operator can use PICUS to send an open breaker command.
     - The command can come from an external source, like a PLC.
2. The controller checks whether the open conditions are OK. The following conditions must be met:
   - Load is below open breaker set point.
   - Inverter breaker configuration restrictions for *Allow breaker open when* are OK:
     - If configured as *Inverter is started*, inverter must be running.
     - If configured as *Inverter is stopped*, inverter must be stopped.
     - If configured as *Inverter in any state*, inverter can be running or stopped.
   - If the digital input `Inverter breaker > Command > Block breaker open` is activated, an info message is shown.
3. The controller checks whether the breaker is closed.
   - If the breaker is open, an info message is shown.
4. The controller checks whether the breaker has opened:
   - If the breaker has opened, the breaker open sequence has been completed successfully.
   - If the breaker has not opened, the controller activates the *Breaker opening failure* alarm.

11.5.5 Inverter breaker trip flowchart

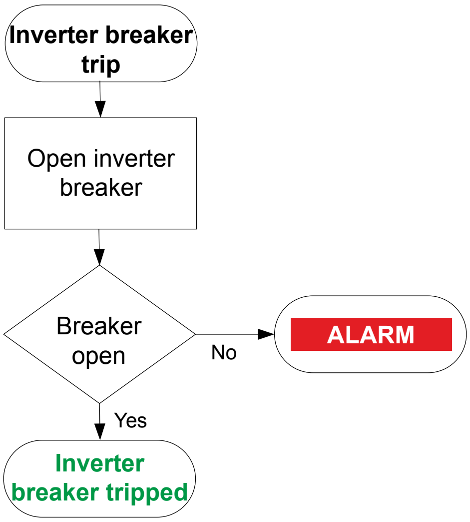
The controller automatically trips the inverter breaker for these alarm actions:

- Trip breaker
- Trip breaker and stop inverter
- Trip AVR*
- Trip breaker + AVR *
- Trip breaker + AVR + stop inverter *

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

NOTE * These alarm actions are only available if the *Trip AVR* digital output is configured.

Table 11.1 Inverter breaker trip flowchart



1. **Open breaker**: When a trip is required, the controller activates the *Breakers > Inverter breaker > Controls > Breaker open* output to open the breaker.
2. **Breaker 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 *Opening failure* alarm.

11.6 Other HYBRID controller functions

11.6.1 Temperature-dependent power derating

The temperature-dependent power derating function reduces the inverter nominal load by reducing the inverter nominal power used by load sharing. The derating function can be configured for up to three temperature measurements.

Analogue input

Function	I/O	Type	Details
`Inverter > Power derate > Temperature > Derate # temperature [C]`	Analogue input	The measurement must be in °C.	This can measure any temperature.

NOTE * # is 1, 2 or 3.

Parameters

The analogue input(s) must be configured to see the power derate parameter and curve.

`Inverter > Power derate #` *

Parameter	Range	Comment
`Enable derate`	Not enabled, Enabled	**Not enabled**: The load sharing uses the inverter 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.
`Setup`		Use this section to set up the power derate curve.

NOTE * # is 1, 2 or 3.

How it works

By default, the inverter nominal power is 100 % for temperatures up to 90 °C. If there is a *Derate temperature* input, then the power is derated linearly to 80 % at 130 °C. However, you can create a customised curve for each temperature input.

Power derate affects load sharing, since load sharing is based on a percentage of nominal power.

The derating does **not** affect the alarms.

11.6.2 Percentage-dependent power derating

The percentage-dependent power derating function reduces the inverter nominal load by reducing the inverter nominal power used by load sharing.

Analogue input

Function	I/O	Type
`Inverter > Power derate > Percentage > Derate percentage [%]`	Analogue input	The measurement must be in %.

Parameters

The analogue input(s) must be configured to see the power derate parameter and curve.

`Inverter > Power derate > Percentage`

Parameter	Range	Comment
`Enable derate`	Not enabled, Enabled	**Not enabled**: The load sharing uses the inverter nominal power, no matter what the derate percentage is. **Enabled**: The controller uses the power derating curve to derate the power for load sharing within the configured range.
`Setup`		Use this section to set up the power derate curve.

11.6.3 Inverter operating values as analogue outputs

You can configure an analogue output with a function for an inverter operating value. The controller receives this value from an inverter measurement. The controller then adjusts the analogue output to reflect the inverter operating value.

Analogue output

Function	I/O	Units	Details
`Inverter > Power derate > Percentage > Derate percentage [%] > Derate # temperature [C]`*	Analogue output	-50 to 200 °C	The controller outputs the derate temperature. For this function to work, there must be an analogue input to the controller with the inverter derate temperature.

NOTE * # is 1 to 3.

11.6.4 Inverter states as digital outputs

You can configure a digital output with a function for an inverter state. The controller activates the digital output if the inverter state is present. These can be useful for troubleshooting.

Digital outputs

Function	I/O	Type	Details
`Inverter > State > Running`	Digital output	Continuous	Activated if there is running detection for the inverter.
`Inverter > State > Ready to start`	Digital output	Continuous	Activated if there are no conditions that would block the controller from starting the inverter.
`Inverter > State > Starting`	Digital output	Continuous	Activated while the controller works through the pre-programmed start inverter sequence.

Function	I/O	Type	Details
`Inverter > State > Stopping`	Digital output	Continuous	Activated while the controller works through the pre-programmed stop inverter sequence.
`Inverter > State > Voltage and frequency OK`	Digital output	Continuous	Voltage and frequency are within range.
`Inverter > State > No voltage and frequency`	Digital output	Continuous	Voltage and frequency are not present or not measurable.

11.6.5 Counters

You can view, edit and reset all the counters with PICUS or the display.

The counters include:
- Start attempts.
- Total running hours and minutes.
- Trip running hours and minutes.
- Inverter 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. You must configure the digital output function to see the parameters.

Digital outputs

You must configure the digital output function to see the parameters.

Function	I/O	Type
`Inverter > Production counters > Active energy export pulse`	Digital output	Pulse
`Inverter > Production counters > Reactive energy export pulse`	Digital output	Pulse
`Inverter > Production counters > Active energy import pulse`	Digital output	Pulse
`Inverter > Production counters > Reactive energy import pulse`	Digital output	Pulse

Parameters

`Inverter > 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.

`Inverter > 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.

`Inverter > Production counters > Active 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.

`Inverter > 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.

Table 11.2 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.

11.6.6 Trip AVR

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

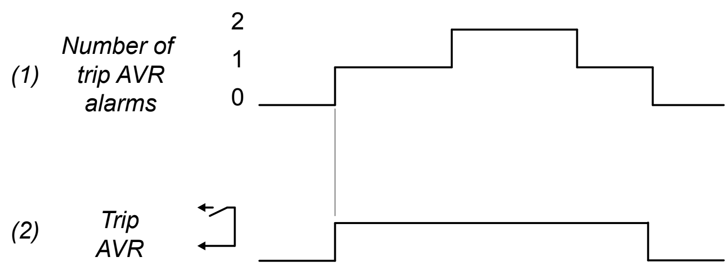
The *Trip AVR* output and alarm action does not initiate a breaker trip. To trip the breaker and the AVR, digital outputs for both actions must be configured and the correct alarm action must selected. For example, the *Trip breaker + AVR* alarm action.

Inputs and outputs

Assign the *Trip AVR* output under **Input/output**. Select the hardware module, then select the output to configure.

Function	I/O	Type	Details
Inverter > 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.

Table 11.3 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**: *Inverter > AVR > Trip AVR* (digital output). The controller activates this output until all alarms with a *Trip AVR* (or similar) alarm action are not active.

11.7 HYBRID controller protections

11.7.1 HYBRID controller alarms

These alarms are in addition to the AC protections and other alarms for the controller.

	Alarms and protections
Inverter	Emergency stop
	Start failure
	Stop failure
	Total running hours notification
	Trip running hours notification
	Standby request failure
	Standby acknowledge timeout
	PTI request failure
	PTI acknowledge failure
	PTO request failure
	PTO acknowledge failure
Load sharing	P load sharing failure
	Q load sharing failure
Regulator configuration	GOV output selection failure
	GOV output setup failure
	GOV relay setup incomplete
	GOV regulator error
	AVR output selection failure
	AVR output setup failure
	AVR relay setup incomplete

	Alarms and protections
Maximum parallel time	Hybrid-SG max. parallel time
	Hybrid-SC max. parallel time
Power management	Heavy consumer feedback timeout (1 alarm for each heavy consumer)
	Heavy consumer reservation not possible (1 alarm for each heavy consumer)
Non-essential load (NEL)	• Up to 3 non-essential loads per controller • Can connect each controller to the same 3 non-essential load breakers
	NEL # over-current (1 alarm for each non-essential load)
	NEL # under-frequency (1 alarm for each non-essential load)
	NEL # overload 1 and 2 (2 alarms for each non-essential load)
	NEL # reactive overload (1 alarm for each non-essential load)
Advanced blackout prevention	P load sharing failure (low frequency)
	P load sharing failure (high frequency)
	Q load sharing failure (low voltage)
	Q load sharing failure (high voltage)
Other	Forced to Manual mode
	Trip AVR output not configured

11.7.2 Alarm actions

The HYBRID controller has the following alarm actions:

- Warning
- Block
- PMS-controlled stop
- Trip breaker
- Trip breaker and stop inverter
- Trip AVR *
- Trip breaker + AVR *
- Trip breaker + AVR + stop inverter *

NOTE * These alarm actions are only available if the *Trip AVR* digital output is configured.

11.7.3 Inhibits

The controller includes the following inhibits:

Inhibit	Disables the alarm when ...
Inverter running	*Digital running detection* is ON.
Inverter not running	*Digital running detection* is OFF.
Inverter breaker closed	The *Breakers > Inverter breaker > Feedback > Breaker closed* digital input is activated.
Inverter breaker open	The *Breakers > Inverter breaker > Feedback > Breaker open* digital input is activated.
Inverter voltage present	The inverter voltage is above 10 % of the nominal voltage.
No inverter voltage	The inverter voltage is below 10 % of the nominal voltage.
Inverter frequency present	The inverter frequency is above 10 % of the nominal frequency.

Inhibit	Disables the alarm when ...
No inverter frequency	The inverter frequency is below 10 % of the nominal frequency.
Controller under SWBD control	The *Local > Mode > Switchboard control* digital input is activated, OR a system problem forced the controller under switchboard control.
ACM wire break	All these conditions are met: • The inverter 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
Operating mode PTI (Power take in)	The inverter is running in PTI mode.
Operating mode PTO (Power take out)	The inverter is running in PTO mode.
Operating mode standby	The inverter is running in Standby mode.
Inhibit 1	The *Alarm system > Inhibits > Activate inhibit 1* digital input is activated.
Inhibit 2	The *Alarm systems > Inhibits > Activate inhibit 2* digital input is activated.
Inhibit 3	The *Alarm systems > Inhibits > Activate inhibit 3* digital input is activated.

11.7.4 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 HYBRID controller, as well as which general alarm corresponds to each HYBRID controller alarm.

Table 11.4 Breaker alarm names for the HYBRID controller

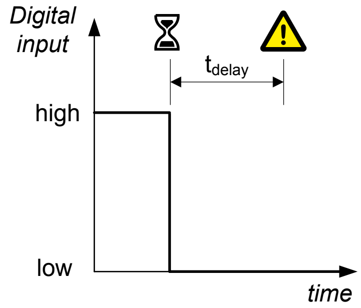
HYBRID alarm	Parameters	General name
Breaker synchronisation failure	`Breakers > Inverter breaker monitoring > Synchronisation failure`	Breaker synchronisation failure
Breaker de-load failure	`Breakers > Inverter breaker monitoring > De-load failure`	Breaker de-load failure
Vector mismatch	`Breakers > Inverter breaker monitoring > Vector mismatch`	Vector mismatch
Breaker opening failure	`Breakers > Inverter breaker monitoring > Opening failure`	Breaker opening failure
Breaker closing failure	`Breakers > Inverter breaker monitoring > Closing failure`	Breaker closing failure
Breaker position failure	`Breakers > Inverter breaker monitoring > Position failure`	Breaker position failure
Breaker trip (external)	`Breakers > Inverter breaker monitoring > Tripped (external)`	Breaker trip (external)
Breaker short circuit	`Breakers > Inverter breaker monitoring > Short circuit`	Breaker short circuit
Breaker configuration failure	-	Breaker configuration failure
Inverter phase sequence error	`Inverter > AC setup > Phase sequence error`	Phase sequence error
Busbar phase sequence error	`Busbar > AC setup > Phase sequence error`	Phase sequence error

11.7.5 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.

11.7.6 Emergency stop

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



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

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 controller activates 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.

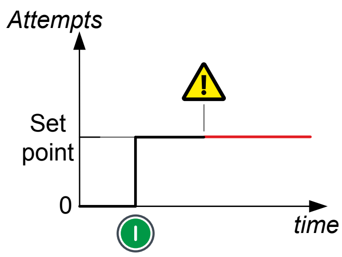
`Engine > Emergency stop > Emergency stop`

Parameter	Range
`Delay`	0.0 s to 1 min

11.7.7 Start failure

This alarm is for inverter start failure.

If the inverter has not started after the *Start on* delay and/or the restriction on breaker state is not correct, the controller activates this alarm.



Configure the start failure alarm parameters under `Inverter > Start sequence > Start failure`. By default, the latch is enabled.

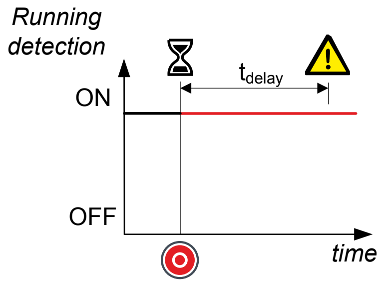
Table 11.5 Other parameters

Parameter	Range
`Inverter > Start sequence > Start > Start on`	1 s to 3 min
`Inverter > Start sequence > Restrictions > Allow start when`	Breaker is open, Breaker is closed, Breaker in any state

11.7.8 Stop failure

This alarm is for inverter stop failure.

The controller attempts to stop the inverter. If *Running detection* is still ON after the delay time and/or the restriction on breaker state is not correct, the controller activates this alarm.



`Inverter > Stop sequence > Stop failure`

Parameter	Range
Delay	0 s to 5 m

Other parameters

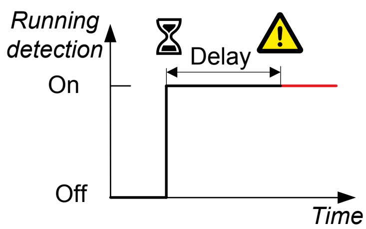
`Inverter > Stop sequence > Restrictions`

Parameter	Range
Allow stop when	Breaker is open, Breaker is closed, Breaker in any state

11.7.9 Inverter started (external)

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

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

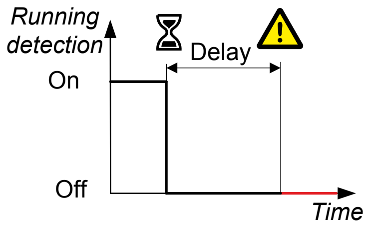


Configure the parameters under `Inverter > Start sequence > Externally started`.

11.7.10 Inverter stopped (external)

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

The alarm is activated if the controller did not initiate an inverter stop, but *Running detection* shows that the inverter has stopped.

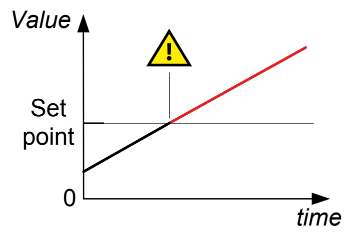


Configure the parameters under `Inverter > Stop sequence > Externally stopped`.

11.7.11 Total 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.



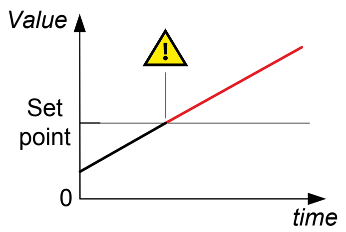
Inverter > Maintenance > Running hours total

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

11.7.12 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.



Inverter > Maintenance > Running hours trip

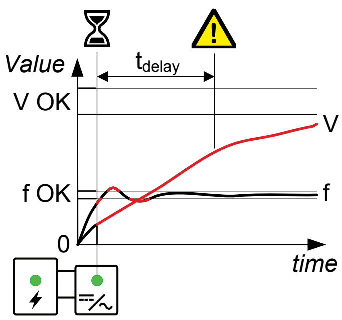
Parameter	Range
Set point	0 to 1,000,000 hours

11.7.13 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 inverter.



The parameters that the alarm is based on are under **Inverter > AC setup > Voltage and frequency OK**. The alarm action is always *Block*.

Table 11.6 `Inverter > AC setup > Voltage or frequency not OK`

Parameter	Range
Delay	1 s to 1 h

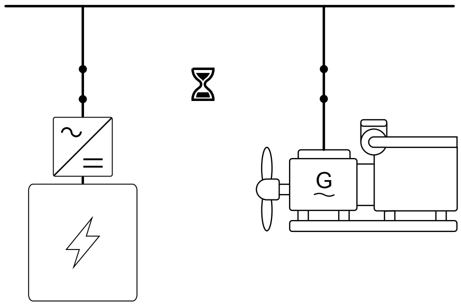
11.7.14 HYBRID-SG max. parallel time

Only when the HYBRID controller is in PTO mode.

This alarm limits the time that an inverter may run in parallel to a shaft generator.

The timer starts when the inverter is synchronised with the shaft generator.

Controller types: If a SHAFT generator controller is present in the system, these alarms are present in HYBRID controller.



Configure the parameters under **Configure** > **Parameters** > **Local power management** > **Parallel timers** > **HYBIRD-SG max parallel time**. The alarm action is always *Trip breaker,* latch enabled.

Table 11.7 Default parameters

Parameter	Range	Default
Delay	0.1 s to 1 h	1 min
Enable	Not enabled, Enabled	Enabled

More information
See **SHAFT generator controller**, **SHAFT generator controller protections**, **SG-HYBRID max. parallel time** for the alarm in the SHAFT generator controller that trips the shaft generator breaker.

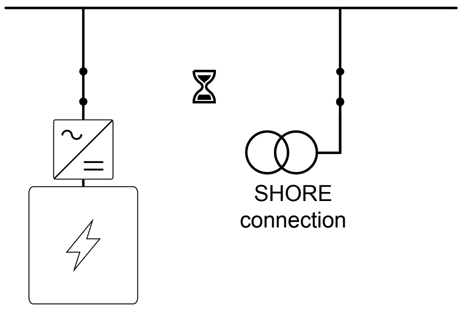
11.7.15 HYBRID-SC max. parallel time

Only when the HYBRID controller is in PTO mode.

This alarm limits the time that an inverter may run in parallel to a shore connection.

The timer starts when the inverter is synchronised with the shore connection.

Controller types: If a SHORE connection controller is present in the system, this alarm is present in HYBRID controllers.



Configure the parameters under **Configure** > **Parameters** > **Local power management** > **Parallel timers** > **HYBRID-SC max parallel time**. The alarm action is always *Trip breaker*, latch enabled.

Table 11.8 Default parameters

Parameter	Range	Default
Delay	0.1 s to 1 h	1 min
Enable	Not enabled, Enabled	Enabled

More information
See **SHORE connection controller**, **SHORE connection controller protections**, **SC-HYBRID max. parallel time** for the alarm in the SHORE connection controller that trips the shore connection breaker.

12. SHAFT generator controller

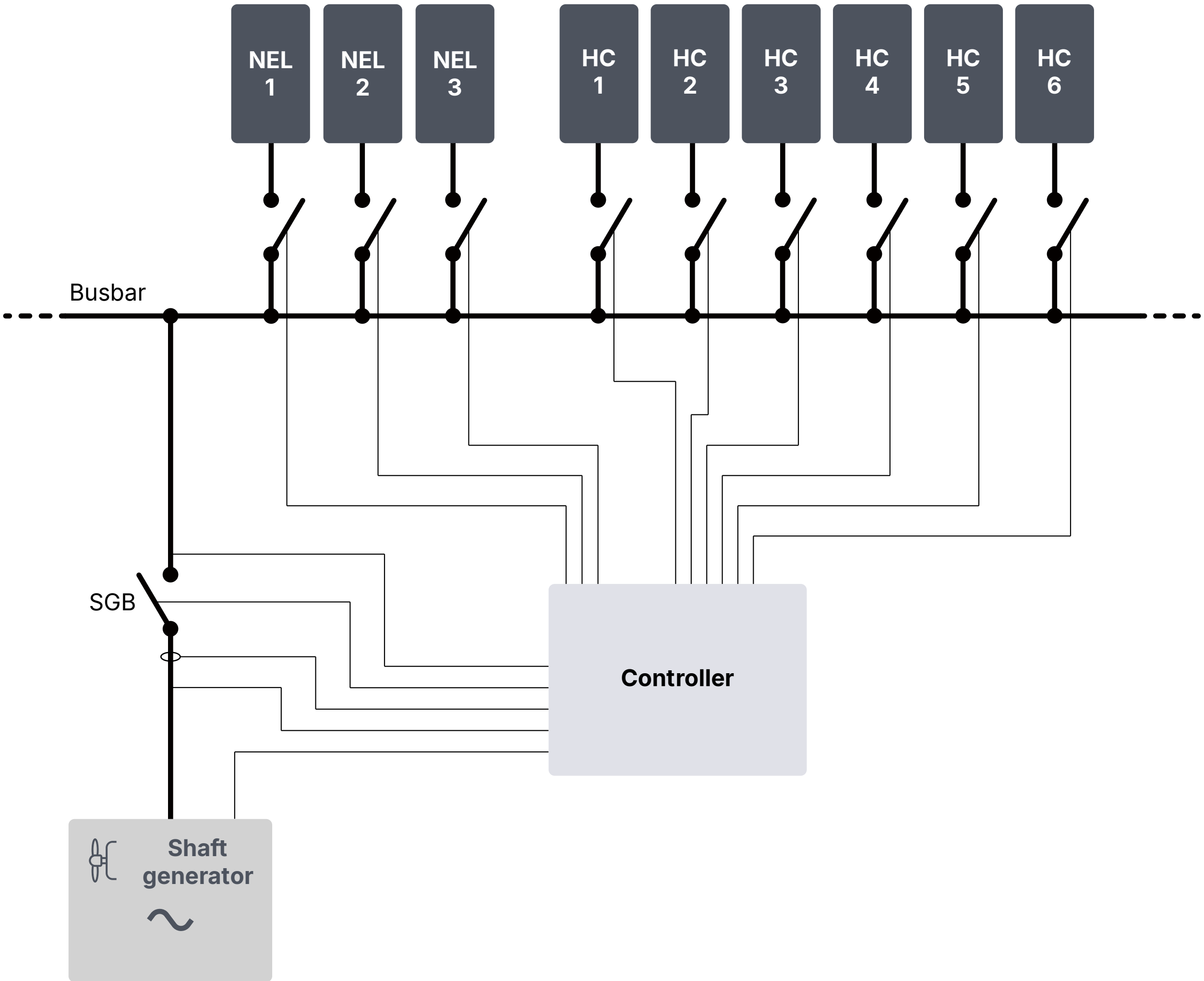
12.1 About the SHAFT generator controller

A **SHAFT generator** controller controls and protects the system when a shaft generator is connected. The **SHAFT generator** controller also controls and protects the shaft generator breaker.

When the shaft generator is connected, it is normally the ship's only power source. However, it is possible for the shaft generator to run in parallel with the gensets and supply a base load for an extended period (long-time parallel). The **SHAFT generator** controller then works together with the **GENSET** controllers to ensure effective power management.

There is no restriction on the number of **SHAFT generator** controllers.

Example application with heavy consumers and non-essential loads



12.1.1 SHAFT generator controller functions

	Functions
Pre-programmed sequences	• Shaft generator breaker open sequence (with de-loading) • Shaft generator breaker close sequence (with synchronisation) ◦ Running detection • Blackout close • Load transfer from one shaft generator to another (using gensets) • Load transfer from the shaft generator to a shore connection (using gensets)

	Functions
	• Frequency variation: Genset(s) automatically start and connect
Load control	• Load transfer between shaft generator and genset(s) • Base load from shaft generator; genset(s) load responds to demand fluctuations • Three sets of temperature-dependent power derate settings for each controller

Power take home (PTH)	• Power take home (PTH) start and stop sequences
	• Use the shaft generator as a motor to drive the ship's shaft .
	  ◦ Genset(s) drive the ship's shaft
	  ◦ Another shaft generator drives the ship's shaft
	• Power requirement to drive the ship's shaft treated as a load
	• Propeller zero pitch digital input
	• Shaft generator fixed speed digital input

Counters	• Display unit counters, to edit or reset
	  ◦ Running hours (total, and trip)
	  ◦ Shaft generator breaker operations and trips
	  ◦ Energy export (active and reactive) (to the busbar)
	  ◦ Energy import (active and reactive) (to the shaft generator)
	  ◦ External breaker operations
	• Energy counters with configurable digital outputs (for external counters)
	  ◦ Energy export (active and reactive) (to the busbar)
	  ◦ Energy import (active and reactive) (to the shaft generator)

Control types	• Power management system (PMS) control
	  ◦ Display unit push-buttons for breaker operations
	  ◦ Synchronisation, de-loading, and breaker control
	  ◦ Push-button functions also possible using inputs, PICUS, and/or Modbus
	• Switchboard control
	  ◦ Operator controls the system from the switchboard
	  ◦ Only the controller protections are active

12.2 SHAFT generator controller principles

12.2.1 Nominal settings

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 voltage for the shaft generator.
`Current (I)`	1.0 A to 9 kA	The maximum current flow in one phase (that is, L1, L2 or L3) from the shaft generator 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 may be on the shaft generator nameplate.
`Apparent power (S)`	1.0 kVA to 1 GVA	The nominal apparent power should be on the shaft generator nameplate.
`Power factor (PF)`	0.6000 to 1.0000	The power factor should be on the shaft generator nameplate.

The controller uses the nominal settings to calculate the nominal reactive power (nominal Q) for the shaft generator. 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.

NOTE * # is 1 to 4.

More information
See Nominal power calculations.

Busbar nominal settings

`Busbar > Nominal settings > Nominal settings #*`

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.

12.2.2 Power management

The **SHAFT generator** controller works together with the other controllers in the system to provide efficient power management.

More information
See Power management.

12.2.3 Running detection

The controller can be configured to receive engine running feedback from a variety of measurements.

The **SHAFT generator** controller uses running detection for:
- The controller status texts (in the display unit and PICUS)
- The *Engine running* and the *Engine not running* inhibits

More information
See Running detection.

12.2.4 AC configuration

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

AC configuration for the SHAFT generator controller

SHAFT generator	General name
Generator	[Source]
Busbar	[Busbar]

More information
The AC configuration and nominal settings for description of the AC configuration in general.

12.2.5 Breaker configuration

More information
The Breakers, synchronisation and de-loading for description of breaker configuration in general.

For the **SHAFT generator** controller, replace "[Breaker]" with "Shaft generator breaker" in these descriptions.

12.3 Shaft generator breaker

12.3.1 About the Shaft generator breaker

The shaft generator breaker (SGB) connects the shaft generator to the busbar. For the shaft generator breaker to close, the shaft generator must be running, and the busbar must be synchronised with the shaft generator. The shaft generator breaker is an important part of the system safety, and trips to protect the shaft generator from problems on the busbar. The shaft generator breaker also trips to stop shaft generator problems from disturbing the busbar.

More information
See Breakers, synchronisation and de-loading for information about synchronisation and breakers. This includes the inputs and output functions and the parameters to configure.

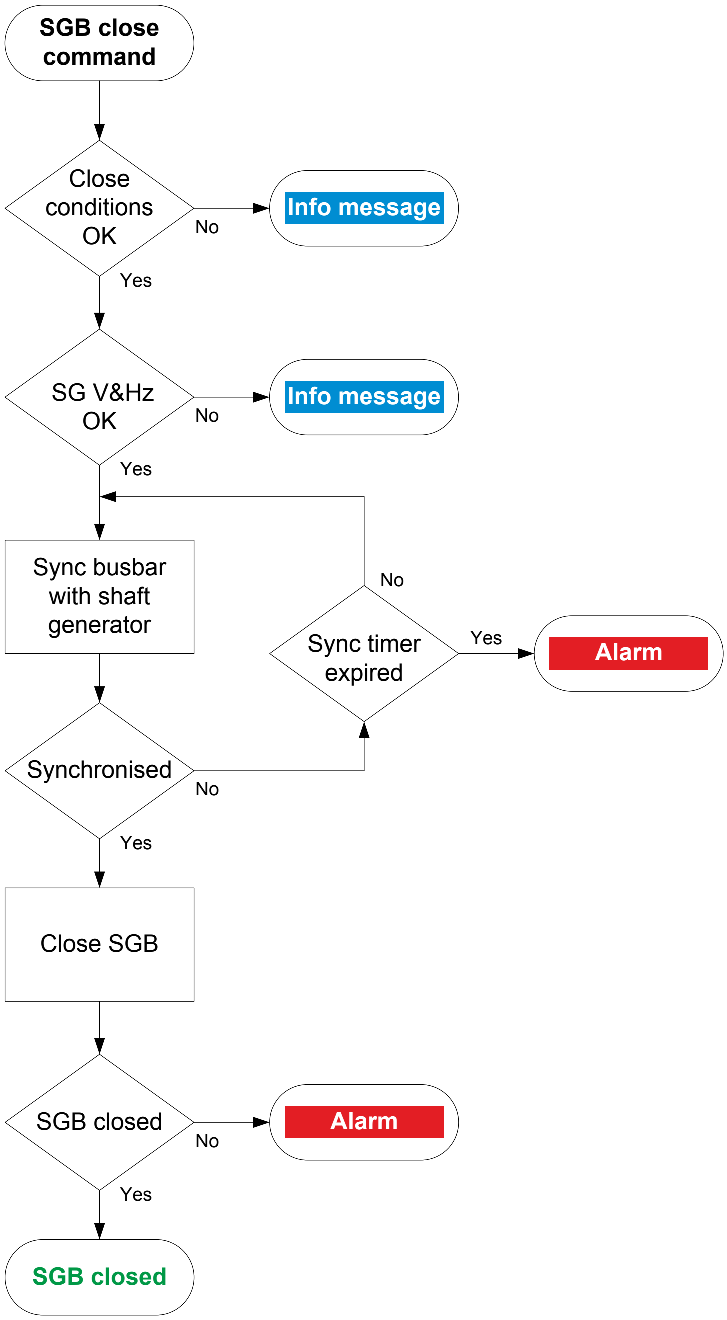
For the **SHAFT generator** controller, the breaker abbreviation (*[*B]*) is *SGB*. *[Breaker]* refers to *Shaft generator breaker*.

12.3.2 Shaft generator breaker close flowchart

More information
See Shaft generator breaker blackout close flowchart for how to allow the shaft generator to 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** on the display, the controller ignores this command.

Shaft generator breaker (SGB) close flowchart



1. **SGB close command:** The shaft generator breaker (SGB) close command can come from the following:
   - The operator can press the push-button **Close breaker** on the display.
   - The operator can use PICUS to send a close breaker command.
   - The command can come from an external source.
2. **Close conditions OK:** The controller checks that the close conditions are okay:
   - The SHAFT generator controller must not be under SWBD control.
   - All connected GENSET controllers must be under PMS control (that is, there must be no connected GENSET controllers under switchboard control).
   - The busbar voltage and frequency must be within the nominal range.
   - The nominal power of the shaft generator must be more than the required power.
3. **SG V&Hz OK:** The controller checks whether the voltage and frequency from the shaft generator are within the allowed range. If not, the controller display unit shows an info message.
4. **Sync busbar with shaft generator:** The Power Management System tries to synchronise the busbar to the shaft generator.
   - When the shaft generator and busbar are synchronised, the controller activates the close shaft generator breaker output to close the breaker.
   - If the genset and busbar do not synchronise within the time allowed, the controller activates a *SGB synchronisation failure* alarm and the breaker close sequence stops.
5. **SGB closed:** The controller checks whether the SGB has closed.
   - If the SGB has closed, the SGB close sequence has been completed successfully.
   - If the SGB has not closed an *SGB close failure* alarm is activated.

Changing from genset supply to shaft generator

The operator can start the change from genset supply to shaft generator by activating the close breaker sequence of the shaft generator breaker. The **SHAFT generator** controller must not be under SWBD control.

If the **GENSET** controllers are in AUTO mode, after the shaft generator is connected, the **GENSET** controllers will disconnect and stop the gensets.

If the **GENSET** controllers are in Manual mode, after the shaft generator is connected, the **GENSET** controllers will not disconnect the gensets. However, the parallel timer starts when the shaft generator is connected. The **GENSET** controller trips the generator breaker when the maximum parallel timer expires.

Connected shaft generator or shore connection

Activating the *Close breaker* command if a shaft generator is already connected to the busbar and *Power take home* is not activated will start a load transfer from the connected shaft generator to gensets under PMS control. After the load is transferred, the controller will follow the procedure described in the table above to close the shaft generator breaker.

Activating the *Close breaker* command is a shore connection is already connected to the busbar will start a load transfer from the shore connection to gensets under PMS control. After the load is transferred, the controller will follow the procedure described in the table above to close the shaft generator breaker.

More information
See Shaft generator load transfer without parallel.

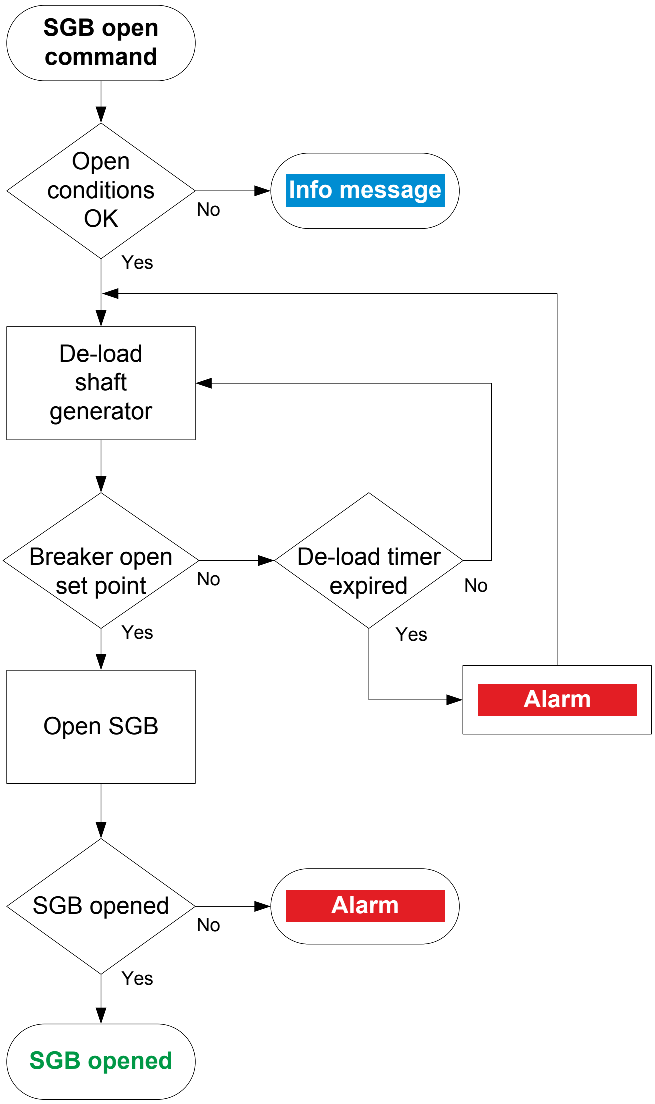
12.3.3 Shaft generator breaker open flowchart

The following flowchart shows the sequence that the controller normally uses to open the shaft generator breaker (SGB). This sequence is also used for the alarm action *PMS-controlled open breaker*.

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 SGB open command while *Block* is active, the controller uses the shaft generator breaker open sequence, shown below, to open the SGB.

This flowchart does not apply to switchboard control. When the controller is under switchboard control, it will not open the breaker (except for a trip). If, for example, the operator presses the push-button **Open breaker** on the display, the controller ignores this command.

Shaft generator breaker (SGB) open flowchart



1. **SGB open command:** The shaft generator breaker (SGB) open command can come from the following:
   - The operator can press the push-button **Open breaker** on the display.
   - The operator can use PICUS to send an open breaker command.
   - The command can come from an external source.
2. **Open conditions OK:** The controller checks that the open conditions are present:
   - There must be enough gensets in AUTO mode, and/or connected in Manual mode, to take over the shaft generator load when the SGB opens. Opening the SGB must not cause a blackout.
3. **De-load shaft generator:** The Power Management System de-loads the shaft generator until the load is less than the set point for the breaker to open. The controller then opens the breaker.
   - When the de-load timer expires, the *SGB de-load failure* alarm is activated. After the alarm is activated the controller will continue to try to de-load the SGB until it succeeds.
4. **SGB opened:** The controller checks whether the SGB has opened.
   - If the SGB has opened, the SGB open sequence has been completed successfully.
   - If the SGB has not opened, the controller activates an *SGB open failure* alarm.

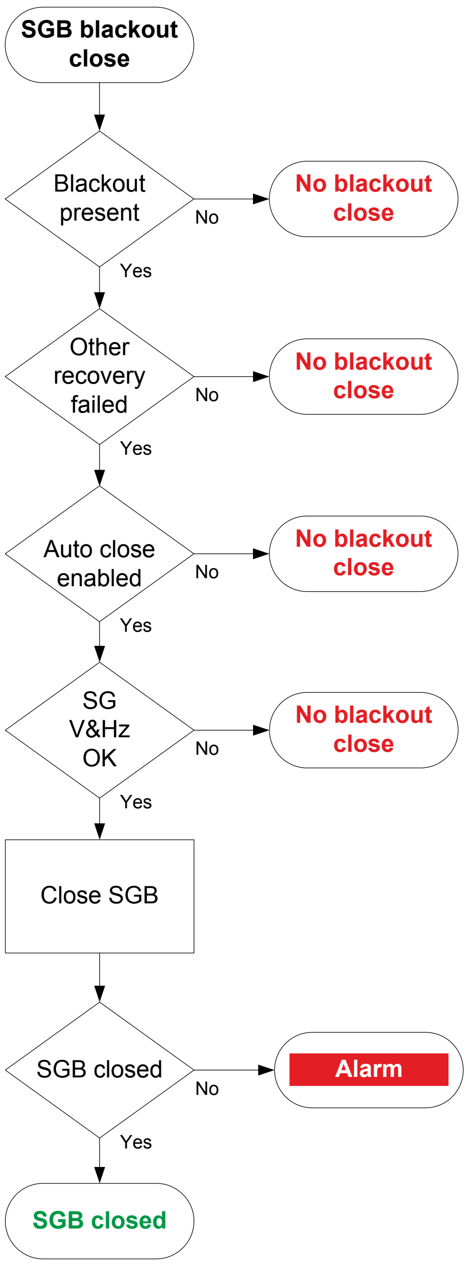
Activate network set point for all the **GENSET** controllers on the busbar section. If the network set point is only activated for one **GENSET** controller, that controller tries to take the whole load.

12.3.4 Shaft generator breaker blackout close flowchart

The following flowchart shows the sequence that the controller uses to connect the shaft generator to a dead busbar.

More information
See Blackout in Power management.

Shaft generator breaker (SGB) blackout close flowchart



1. **SGB blackout close:** The shaft generator breaker (SGB) blackout close command comes from the blackout close sequence.
2. **Blackout present:** The controller checks that the blackout close conditions are present:
   - There must be a blackout.
   - The other blackout recovery options on the main busbar have failed (that is, recovery by genset connection, and auto close of the bus tie breaker). Note that the emergency genset is not included in the blackout recovery options.
   - *Auto close* must be *Enabled* (that is, `Configure > Parameters > Local power management > Blackout > Blackout close > Enable SG blackout close`). If *Enable SG blackout close* is *Not enabled*, the breaker does not close automatically.
   - The shaft generator voltage and frequency from the shaft generator must be within the allowed range.
3. **Close SGB:** The controller activates the output to close the breaker.
4. **SGB closed:** The controller checks whether the SGB has closed.
   - If the SGB has closed, the SGB blackout close sequence has been completed successfully.
   - If the SGB has not closed, an *SGB close failure* alarm is activated.

Manual blackout close

During a blackout, the operator can manually close the shaft generator breaker by pushing the push button **Close breaker** on the display unit if there are no gensets available that can solve the blackout, and `Blackout close > Enabled SG blackout close` is *Not enabled*.

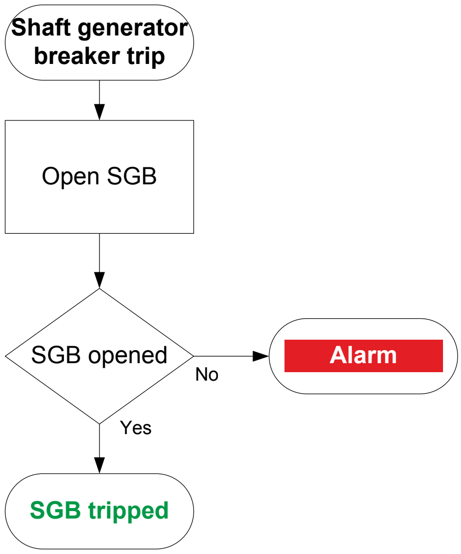
12.3.5 Shaft generator breaker trip flowchart

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

- Trip shaft generator breaker

The controller does not require the shaft generator breaker open conditions to be met for a breaker trip. Similarly, the breaker is not de-loaded for a trip.

Shaft generator breaker trip flowchart



1. **Open SGB:** When a trip is required, the controller activates the `Breakers > Shaft generator breaker > Controls > SGB open` output to open the breaker.
2. **SGB 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 *SGB opening failure* alarm.

12.4 Other SHAFT generator controller functions

12.4.1 Power take home (PTH)

Power take home (PTH) provides limited propulsion capacity to a ship by using the shaft generator as a motor to drive the shaft propeller. For PTH, the reverse power alarms are inhibited. PTH allows the main engine to be turned off when the ship's propulsion requirements are low. Alternatively, if the main engine fails, PTH allows propulsion and manoeuvrability according to the system setup.

For PTH, the main engine must be disconnected from the propeller shaft, for example, by using a clutch.

PTH can only be activated in a **SHAFT generator** controller, and only when the shaft is running at nominal frequency. When PTH is activated, the shaft generator consumes power, as it functions as a motor to drive the shaft propeller.

The PTH function can be configured to be activated by a digital input to the **SHAFT generator** controller.

Inputs and outputs

Function	I/O	Type	Details
`Breakers > Shaft generator breaker > Command > PTH mode`	Digital input	Continuous	When the input is activated, the shaft generator can be used as a motor to drive the shaft propeller. Once the shaft generator breaker closes, the PTH function is active until the breaker opens (even if the *PTH mode* input is deactivated). Power take home can only be activated when the shaft generator breaker is open. The input is ignored if the shaft generator breaker is closed.
`Breakers > Shaft generator breaker > Command > Zero pitch`	Digital input	Continuous	Optional. If the *Zero pitch* input function is configured, then the shaft generator breaker (SGB) can only open during PTH if the *Zero pitch* input is activated. The zero pitch input should come from the propeller-pitch control system. Configure the input so that the propeller blades must be at zero pitch

Function	I/O	Type	Details
			before the input is activated. This ensures the minimum load when opening the shaft generator breaker.

Parameters

`Local power management > Shaft generator PTH mode > Open point`

Parameter	Range	Default	Notes
`Open point enabled`	Not enabled, Enabled	Not enabled	**Not enabled**: The SGB may open at any load. **Enabled**: The SGB will not open if the load on the breaker is more than *Open when power below*.
`Open when power below`	2 to 100 % of nominal power	5 %	

`Local power management > Shaft generator PTH mode > Connect load`

Parameter	Range	Default	Notes
`PTH connect load`	1 kW to 900 MW	100 kW	The minimum available power required when the SGB closes.

For PTH the shaft generator breaker synchronisation parameters can be different from the normal shaft generator breaker synchronisation settings.

`Breakers > Shaft generator breaker configuration > Synchronisation setting (PTH)`

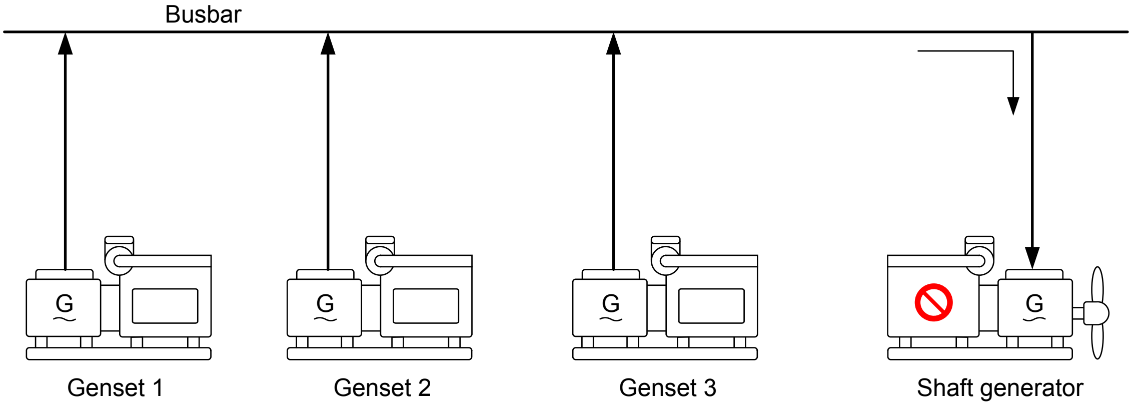
Name	Range	Default	Comment
`Sync. type`	• Dynamic • Static	Dynamic	The synchronisation type to be performed by controller to close the breaker.
`Delta frequency min.`	-0.5 to 0.3 Hz	-0.3 Hz	Add *Delta frequency min.* to the busbar frequency, for the **minimum** frequency from the synchronising generator for the breaker to close.
`Delta frequency max.`	0.0 to 2.0 Hz	0.1 Hz	Add *Delta frequency max.* to the busbar frequency, for the **maximum** frequency from the synchronising generator for the breaker to close. *Delta frequency max.* must always be higher than *Delta frequency min.*
`Delta voltage min.`	2 to 10 % of nominal voltage	5 %	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 to 10 % of nominal voltage	5 %	The maximum that the voltage of the synchronising generator may be above the voltage of the busbar for the breaker to close.
`Breaker close time`	40 to 300 ms	50 ms	The time between when the close breaker signal is sent and when the breaker actually closes.

Applications

The electricity required for PTH can be supplied by diesel generators, as shown in the following drawing.

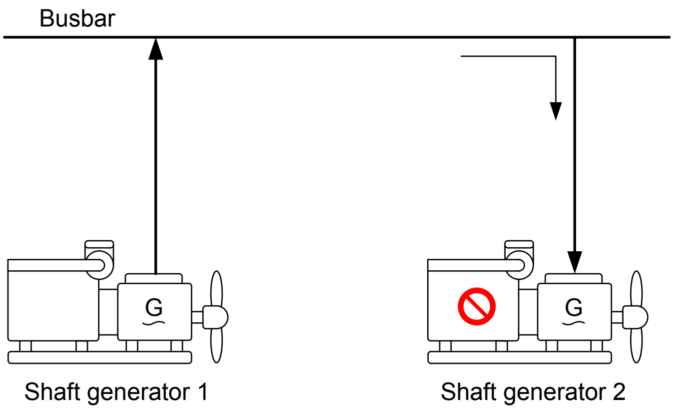
The gensets can also be used to provide power for two shaft generators, both running power take home, if required.

Power from diesel gensets used for PTH



If two shaft generators are present, the power from one shaft generator can be used for PTH by the other SHAFT generator controller, as shown in the following drawing.

Power from one shaft generator used for PTH by the other SHAFT generator controller



> **NOTICE**
>
> **Do not use both shaft generators as power source in parallel.**
>
> Do not use both shaft generators as power sources and run them in parallel. It is impossible to keep the shaft generators synchronised.

PTH as an inhibit

When the *PTH* input is activated in a SHAFT generator controller, these protections are deactivated by the *Power take home* inhibit in the **SHAFT generator** controller:

- Reverse power 1 and 2
- SG-SG max. parallel time
- SG-DG max. parallel time

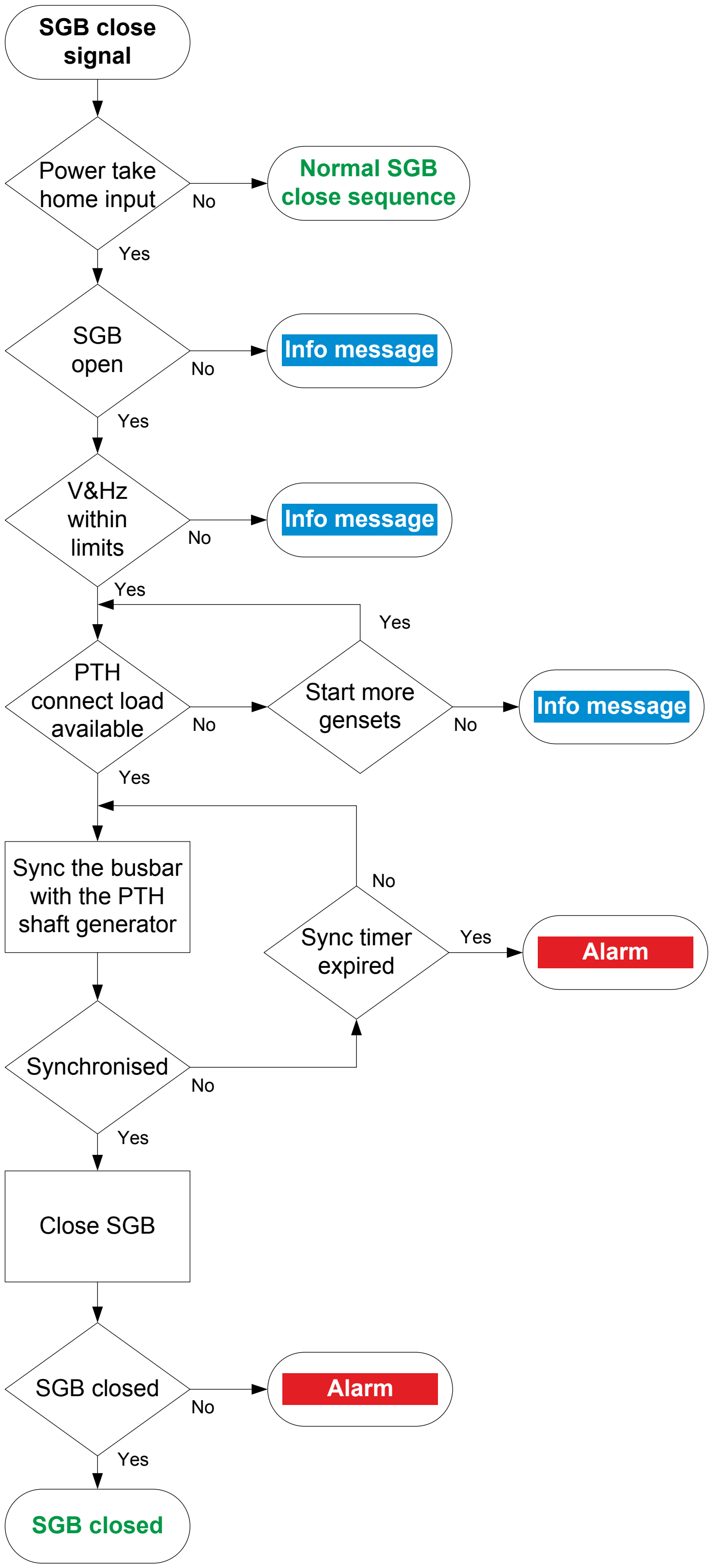
This protection is deactivated by the *Power take home* inhibit in all the connected **GENSET** controllers:

- DG-SG max. parallel time

Conditions for starting PTH

PTH is started when the *Power take home* digital input is activated and the shaft generator breaker receives a *Close* command. The *Close* command could be a digital input, or an input from the breaker close push-button on the **SHAFT generator** controller display.

Shaft generator breaker close sequence for starting PTH



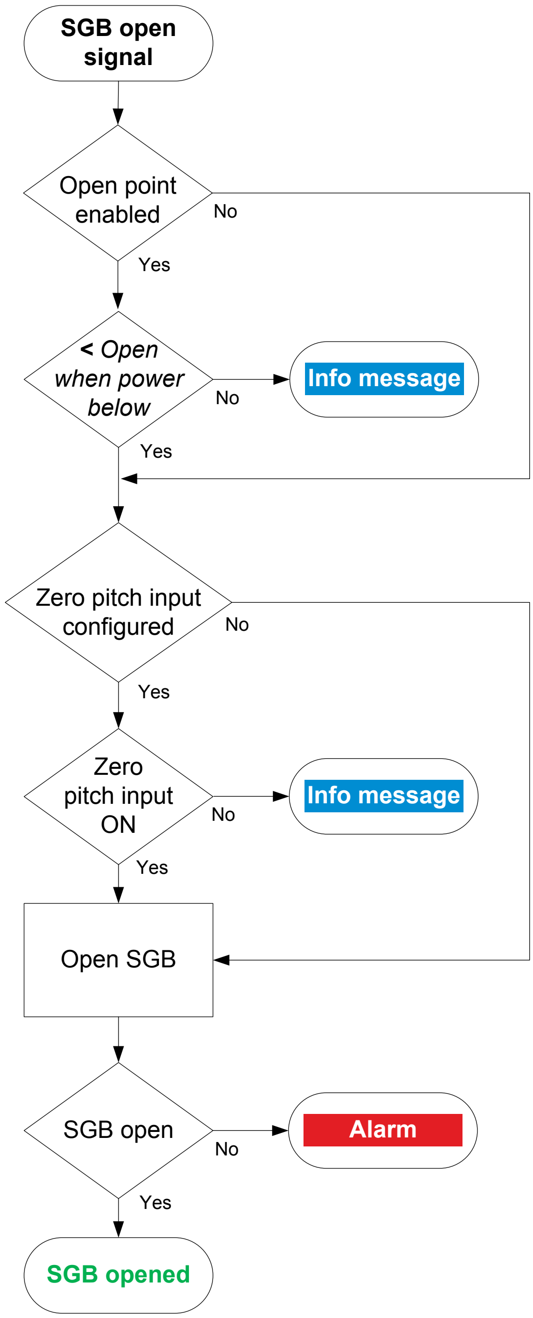
The following conditions must be met to successfully start PTH:

1. **Power take home input:** The *Power take home* input must be activated and the shaft generator breaker must be open.
2. **V&Hz within limits:** The controller checks that the busbar and shaft generator voltage and frequency are within the required range.
3. The operator must ensure that the shaft generator frequency is within the nominal frequency range. This may, for example, be done by engaging an electric pony motor controlled by a frequency converter on the main drive.
4. **PTH connect available:** The *PTH connect load* must be available.
5. **Synchronised:** The power management system synchronises the busbar with the shaft generator, and closes the shaft generator breaker.

Conditions for stopping PTH

PTH is stopped when the shaft generator breaker receives an *Open* command. The *Open* command could be a digital input, or an input from the breaker open push-button on the **SHAFT generator** controller display.

Shaft generator breaker open sequence for PTH



1. **Open point enabled:** The controller checks the *Open point enabled* parameter:
   - **Enabled**: Is the PTH power less than *Open when power below*?
     - *Yes*: The controller continues the sequence.
     - *No*: The controller displays the *Load on SG too high* info text, and stops the sequence.
   - **Not enabled**: The controller continues the sequence.
2. **Zero pitch input configured:** The controller checks whether the *Zero pitch* input is configured:
   - **Configured**:
     - *Activated*: The controller continues the sequence.
     - *Not activated*: The controller displays the *Pitch not zero* info text, and stops the sequence.
   - **Not configured**: The controller continues the sequence.
3. **Open SGB:** The controller activates the breaker *Open* output.
4. **SGB open:** The controller checks whether the SGB has opened.
   - If the SGB has opened, the sequence has been completed successfully.
   - If the SGB has not opened, then the *SGB open failure* alarm is activated.

The PTH function stops if an alarm condition (for example, over-current) trips the shaft generator breaker. In this case, the breaker trip will occur even if the zero pitch input is configured and is not activated.

NOTICE
Open point setting Be careful when setting the *Open point* parameter, since driving the ship transmission and propeller (even at zero pitch) requires a significant amount of power.

12.4.2 Shaft generator base load

The **SHAFT generator** controller allows the ship to generate power from a ship's main engine, while topping up the power requirement by running one or more generators in parallel.

Enable this function with: `Local power management > Shaft generator base load`.

When *Shaft generator base load* is enabled, then these alarms are not active:
- SG-DG max. parallel time (in the **SHAFT generator** controller)
- DG-SG max. parallel time (in the **GENSET** controllers)

More information
See SHAFT generator base load.

12.4.3 Shaft generator load transfer without parallel

If two power sources cannot be synchronised, then you cannot transfer the load directly from the one to the other without interrupting the supply. For example, you cannot transfer the load directly from a shaft generator to another shaft generator, or from a shaft generator to a shore connection.

However, the power management system includes a pre-programmed sequence to automatically transfer load. It does this by using the gensets in AUTO mode to supply the load during the transition (if they can supply the load). The sequence starts when the operator presses **Close** on the non-connected **SHAFT generator** or **SHORE connection** controller display.

For a load transfer using gensets from a shaft generator to another shaft generator, the steps of the sequence are:
1. The operator presses **Close** on the second **SHAFT generator** controller display.
2. The power management system starts and connects enough gensets to take the load from the first shaft generator.
3. The power management system regulates the gensets so that they de-load the first shaft generator.
4. The power management system opens the first shaft generator breaker.
5. The power management system synchronises the gensets to the second shaft generator.
6. The power management system closes the second shaft generator breaker.
7. The power management system regulates the gensets to transfer the load to the shaft generator.
8. The power management system disconnects and stops the gensets.

12.4.4 Shaft generator frequency variation

If the shaft generator frequency exceeds a set point (that is, too high or too low), then the power management system (PMS) starts the first priority genset. If the frequency exceeds the next set point, then the genset(s) synchronise, connect, and take over the load from the shaft generator.

You can use the parameters to customise the PMS response to frequency variation. The display unit shows an operator information message when the frequency exceeds the set points and the function is activated. The events are also recorded in the log.

Parameters

`Local power management > Shaft generator f [Hz] variation > Frequency [Hz] variation`

Parameter	Range	Default	Notes
`Enable`	Not enabled, Enabled	Enabled	**Not enabled**: Frequency variations do not activate this function. **Enabled**: The function is activated when the shaft generator frequency exceeds a set point.

`Local power management > Shaft generator f [Hz] variation > Engine start`

Parameter	Range	Default	Notes
`Low frequency limit`	90 to 100 % of the nominal frequency	91 %	The function starts the first priority genset if the shaft generator frequency is below this set point for the *Delay* time.
`High frequency limit`	100 to 110 % of the nominal frequency	109 %	The function starts the first priority genset if the shaft generator frequency is above this set point for the *Delay* time.
`Delay`	0 to 10 s	0.5 s	The delay time for the frequency set point.

`Local power management > Shaft generator f [Hz] variation > Connect gensets`

Parameter	Range	Default	Notes
`Low frequency limit`	90 to 100 % of the nominal frequency	90 %	The function synchronises and connects gensets to take over the load if the shaft generator frequency is below this set point for the *Delay* time.
`High frequency limit`	100 to 110 % of the nominal frequency	110 %	The function synchronises and connects gensets to take over the load if the shaft generator frequency is above this set point for the *Delay* time.
`Delay`	0 to 10 s	0.5 s	The delay time for the frequency set point.

How it works

This function is only active when the **SHAFT generator** controller is in PMS control.

The *Engine start* parameters have the same effect as a **Precautionary genset start**.

The *Connect genset* parameters have the same effect as pressing the **SHAFT generator** controller *Open breaker* button.

The sequence is as follows:

1. The shaft generator frequency exceeds the *Connect genset* limit for the delay time.
2. The PMS starts the required number of gensets.
   - The **SHAFT generator** controller and the **GENSET** controllers show operator information messages.
3. The gensets synchronise and connect, despite the shaft generator frequency.
4. The PMS regulates the gensets to de-load the shaft generator breaker.
5. The shaft generator breaker opens.
6. The PMS regulates the gensets so that the frequency returns to the nominal value.

12.4.5 Temperature-dependent power derating

More information
See Temperature-dependent power derating under **GENSET** controller for a description of this function.

12.4.6 Shaft generator fixed speed

Some shaft generators are capable of both variable and fixed speed. For these shaft generators, it is good practise to confirm that the shaft generator is operating at fixed speed before connecting the shaft generator to the busbar. You can therefore configure a digital input with the *SG fixed speed* function, to prevent the shaft generator breaker from closing if the shaft generator is not running at fixed speed.

Digital input

Function	I/O	Type	Details
`Breakers > Shaft generator breaker > Command > SG fixed speed`	Digital input	Continuous	If this digital input function is configured, then this digital input must be activated in order to close the shaft generator breaker.

12.4.7 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.

12.4.8 Engine operating values as analogue outputs

You can configure an analogue output with a function for an engine operating value. The controller receives this value from an engine measurement. The controller then adjusts the analogue output to reflect the engine operating value.

Analogue outputs

Function	I/O	Units	Details
`Engine > Running detection > Oil [bar]`	Analogue output	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 > Running detection > MPU [RPM]`	Analogue output	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.

Applications

An analogue output with an engine operating value may be wired to a switchboard instrument, to help the operator. For example, the oil pressure can be displayed.

12.4.9 Counters

You can view some counters on one of the live data pages in the display unit and PICUS.

You can view, edit and reset all the counters on the display unit under `Configure > Counters`. The counters include breaker operations and trips, active and reactive power export, and active and reactive power import. There are also counters for the associated 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
`Generator > Production counters > Active energy export pulse`	Digital output	Pulse
`Generator > Production counters > Reactive energy export pulse`	Digital output	Pulse

Parameters

You must configure the digital output function to see these 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.

`Generator > 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.

`Generator > 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.

Table 12.1 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.

12.4.10 Trip AVR

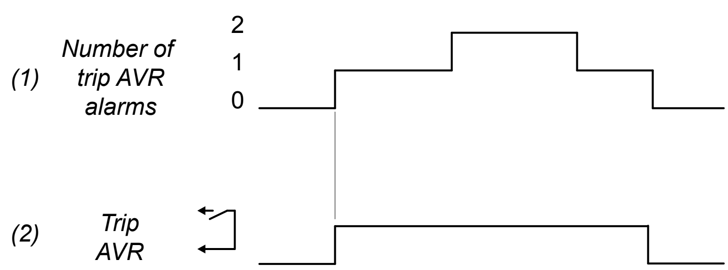
The *Trip AVR* output ensures that excitation is stopped when an alarm activates with a *Trip AVR* alarm action. In cases where there is high voltage present, stopping the excitation reduce the time required to stop an engine in case of an emergency.

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.

12.5 SHAFT generator controller protections

12.5.1 SHAFT generator controller protections

These alarms are in addition to the AC protections and other alarms for the controller.

	Alarms and protections
Shaft generator	Overspeed (2 alarms on the speed measurement)
	Under-speed (2 alarms)
	Primary running feedback failure
	Voltage or frequency not OK
	Total running hours notification
	Trip running hours notification
Maximum parallel time	SG-DG maximum parallel time
	SG-SG maximum parallel time
	SG-Hybrid maximum parallel time

	Alarms and protections
Power management	Heavy consumer feedback timeout (1 alarm for each heavy consumer)
	Heavy consumer reservation not possible (1 alarm for each heavy consumer)
Non-essential load (NEL)	• Up to 3 non-essential loads per controller • Can connect each controller to the same 3 non-essential load breakers
	NEL # over-current (1 alarm for each non-essential load)
	NEL # under-frequency (1 alarm for each non-essential load)
	NEL # overload 1 and 2 (2 alarms for each non-essential load)
	NEL # reactive overload (1 alarm for each non-essential load)

12.5.2 Alarm actions

The controller has the following alarm actions:

- Warning
- Block
- Trip generator breaker
- 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.

12.5.3 Inhibits

SHAFT generator controller inhibits

Inhibit	Disables the alarm when ...
Engine running	*Running detection* is ON.
Engine not running	*Running detection* is OFF.
Shaft breaker closed	The `Breakers > Shaft generator breaker > Feedback > SGB closed` digital input is activated.
Shaft breaker open	The `Breakers > Shaft generator breaker > Feedback > SGB open` digital input is activated.
Generator voltage present	The shaft generator voltage is above 10 % of the nominal voltage.
No generator voltage	The shaft generator voltage is below 10 % of the nominal voltage.
Generator frequency present	The shaft generator frequency is above 10 % of the nominal frequency.
No generator frequency	The shaft generator frequency is below 10 % of the nominal frequency.
Power take home active	The *Breakers > Shaft generator breaker > Command > PTH mode* digital input is activated.
Controller under SWBD control	The `Local > Mode > Switchboard control` digital input is activated, OR a system problem forced the controller under switchboard control.
Engine stopping	
ACM wire break	All these conditions are met: • The shaft generator 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 systems > Inhibits > Activate inhibit 1` digital input is activated.
Inhibit 2	The `Alarm systems > Inhibits > Activate inhibit 2` digital input is activated.
Inhibit 3	The `Alarm systems > Inhibits > Activate inhibit 3` digital input is activated.

12.5.4 Breaker alarms

More information
See Breakers, synchronisation and de-loading for a description of breaker handling and alarms in general.

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

Breaker alarm names for the SHAFT generator controller

SHAFT generator alarm	Parameters	General name
SGB synchronisation failure	`Breakers > Shaft breaker monitoring > Synchronisation failure`	Breaker synchronisation failure
SGB de-load failure	`Breakers > Shaft breaker monitoring > De-load failure`	Breaker de-load failure
Vector mismatch	`Breakers > Shaft breaker monitoring > Vector mismatch`	Vector mismatch
SGB opening failure	`Breakers > Shaft breaker monitoring > Opening failure`	Breaker opening failure
SGB closing failure	`Breakers > Shaft breaker monitoring > Closing failure`	Breaker closing failure
SGB position failure	`Breakers > Shaft breaker monitoring > Position failure`	Breaker position failure
SGB trip (external)	`Breakers > Shaft breaker monitoring > Tripped (external)`	Breaker trip (external)
SGB short circuit	`Breakers > Shaft breaker monitoring > Short circuit`	Breaker short circuit
SGB 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

12.5.5 AC alarms

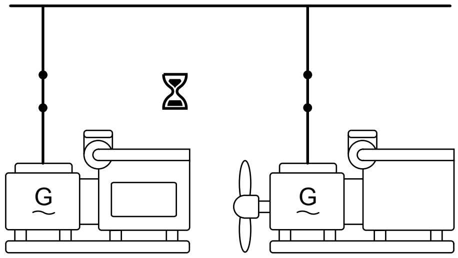
More information
See the **Data sheet** for the AC alarms for this controller type. See the **AC configuration** chapter for descriptions of the AC protections.

12.5.6 SG-DG max. parallel time

This alarm limits the time that a shaft generator may run in parallel to a genset.

The timer starts when the genset or emergency genset is connected to the same busbar as the shaft generator.

Controller type: **SHAFT generator** controller only.



`Local power management > Parallel timers`

This alarm is inhibited by *Power take home active*. The action is *Trip shaft generator breaker*, *Latch enabled*.

Parameter	Range	Default
`Delay`	0.1 s to 1 h	3 min
`Enable`	Not enabled, Enabled	Enabled

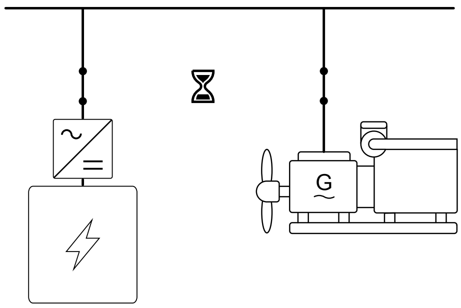
More information
See DG-SG max. parallel time for the alarm in the **GENSET** controller that trips the generator breaker.

12.5.7 SG-HYBRID max. parallel time

This alarm limits the time that a shaft generator may run in parallel to an inverter.

The timer starts when the inverter is in PTO mode and connected to the same busbar as the shaft generator.

Controller type: **SHAFT generator** controller only.



`Local power management > Parallel timers`

This alarm is inhibited by *Power take home active*. The action is *Trip shaft generator breaker*, *Latch enabled*.

Parameter	Range	Default
`Delay`	0.1 s to 1 h	3 min
`Enable`	Not enabled, Enabled	Enabled

More information
See HYBRID-SG max. parallel time for the alarm in the **HYBRID** controller that trips the inverter breaker.

12.5.8 SG-SG max. parallel time

DANGER!

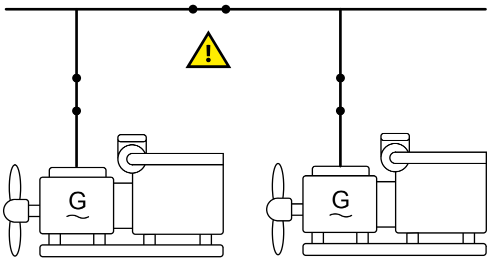
Two connected running shaft generators

Connecting two running shaft generators can release a large amount of energy. This can kill people and destroy equipment.

This alarm sets the maximum time that a shaft generator may run in parallel to a shaft generator.

The power management system normally prevents two shaft generators from connecting in the same section. This alarm is a safety feature, since it is possible to for an operator to manually connect two shaft generators. This can occur if the second shaft generator's breaker is closed manually, or if the tie breaker between the two sections is closed manually.

This alarm is activated when two shaft generators are connected to the same busbar for longer than the delay time. The alarm delay timer starts when the second shaft generator is connected.



The alarm has a delay of 0.1 s. The alarm is always enabled. The alarm action is *Trip shaft generator breaker*, *Latch enabled*. The alarm parameters are not visible in PICUS.

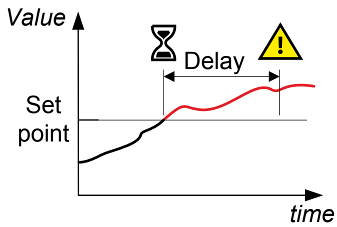
The alarm is inhibited in the **SHAFT generator** controller if *Power take home active* is activated.

To prevent a blackout, only the **SHAFT generator** controller with the highest *Controller ID* trips its breaker.

12.5.9 Overspeed

These two alarms are for overspeed protection.

The alarm response is based on the shaft generator speed, as measured by the MPU/W/NPN/PNP input.



`Engine > Protections > Overspeed # *`

Parameter	Range	Overspeed 1	Overspeed 2
`Set point`	10 to 150 % of nominal speed	110 %	120 %
`Delay`	0 s to 3 min	5 s	1 s
`Enable`	Not enabled, Enabled	Not enabled	Not enabled
`Latch`	Not enabled, Enabled	Nort enabled	Enabled
`Action`		Warning	Trip generator breaker

NOTE * # is 1 or 2.

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.

12.5.10 Other SHAFT generator controller alarms

The following alarms are also included on the **SHAFT generator** controllers:

- Under-speed
- Primary running feedback failure
- Voltage or frequency not OK
- Magnetic pickup wire break
- Total running hours notification
- Trip running hours notification

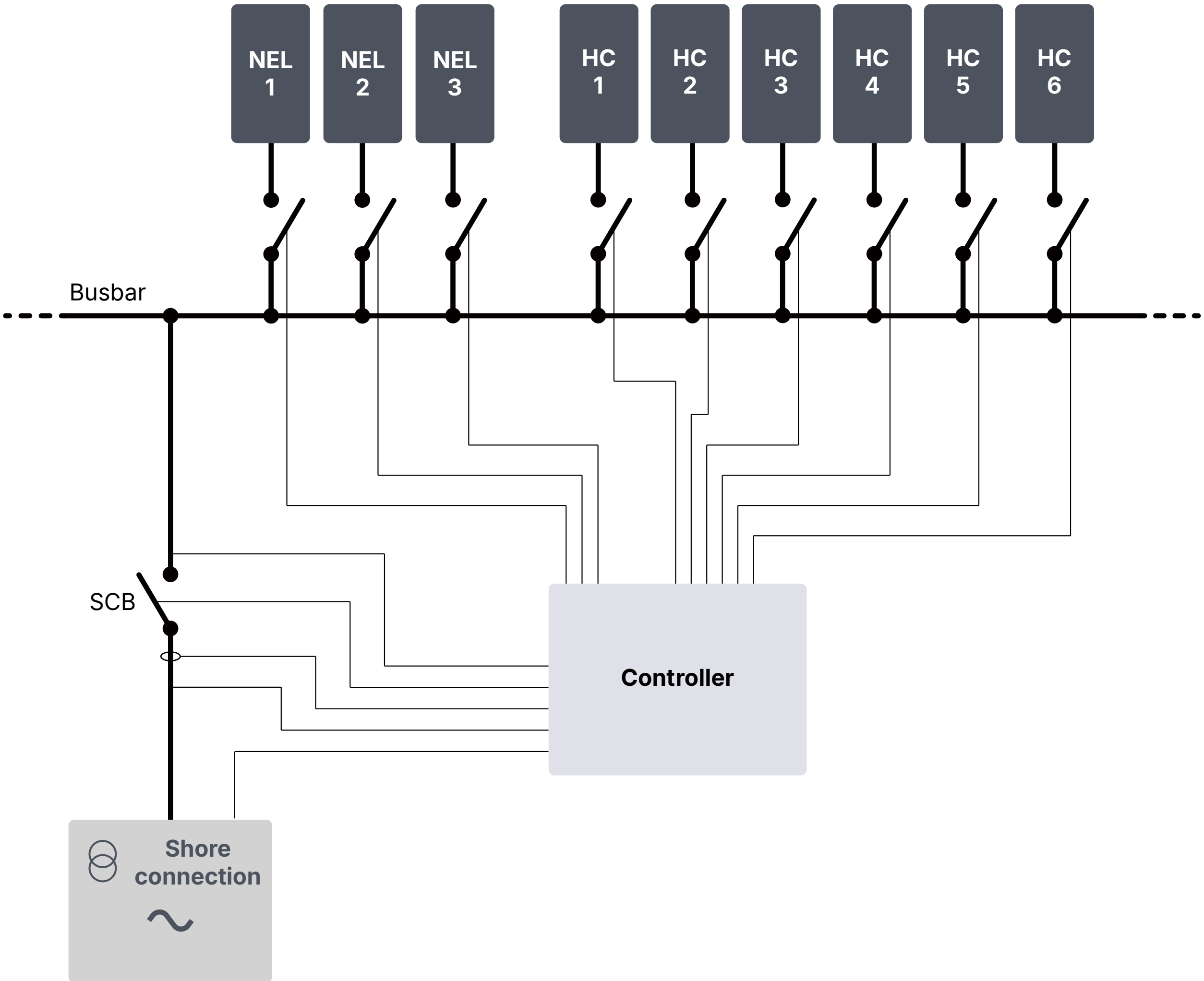
13. SHORE connection controller

13.1 About the SHORE connection controller

A **SHORE connection** controller controls and protects the system and the shore connection breaker when a shore connection is connected. When the shore connection is in use, it is normally the ship's only power source. However, the gensets may run in parallel with the shore connection for a limited time.

There is no restriction on the number of **SHORE connection** controllers.

Example application with heavy consumers and non-essential loads



13.1.1 SHORE connection controller functions

	Functions
Pre-programmed sequences	• Shore connection breaker open sequence (with or without de-loading) • Shore connection breaker close sequence (with synchronisation) • Blackout close • Load transfer from one shore connection to another (using gensets) • Load transfer from the shore connection to a shaft generator (using gensets)
Load control	• Load transfer between shore connection and genset(s) • Base load possible from shore connection; genset(s) load responds to demand fluctuations

	Functions
	• Connect multiple shore connections from the same source (configurable) • Connect multiple ship-to-ship supplies (configurable) • Shore connection close load • Sensitive shore connection (overlap)

Counters	• Display unit counters, to edit or reset
	  ◦ Shore connection breaker operations and trips
	  ◦ Power export (active and reactive) (to the shore connection)
	  ◦ Power import (active and reactive) (to the ship busbar)
	  ◦ External breaker operations
	• Energy counters with configurable digital outputs (for external counters)
	  ◦ Power export (active and reactive) (to the shore connection)
	  ◦ Power import (active and reactive) (to the ship busbar)

Control types	• Power management system (PMS) control
	  ◦ Display unit push-buttons for breaker operations
	  ◦ Synchronisation, de-loading, and breaker control
	  ◦ Push-button functions also possible using inputs, PICUS, and/or Modbus
	• Switchboard control
	  ◦ Operator controls the system from the switchboard
	  ◦ Only the controller protections are active

Redundancy	• Redundant breaker feedback on externally controlled shore connection breakers

13.2 SHORE connection controller principles

13.2.1 Nominal settings

Shore connection nominal settings

`Shore connection > Nominal settings > Nominal settings #*`

Nominal setting	Range	Notes
`Voltage (V)`	10.0 V AC to 1.5 MV AC	The phase-to-phase nominal voltage for the shore connection.
`Current (I)`	1.0 A to 9 kA	The maximum current from the shore connection 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 shore connection. Set the value to ensure the shore connection over-power alarm is triggered at the correct time.
`Apparent power (S)`	1.0 kVA to 1 GVA	Shore connection apparent power.
`Power factor (PF)`	0.6000 to 1.0000	Shore connection power factor.

NOTE * # is 1 to 4.

The controller uses the nominal settings to calculate the nominal reactive power (nominal Q) for the shore 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.

Ship busbar nominal settings

`Busbar > Nominal settings > Nominal settings # *`

Nominal setting	Range	Notes
`Nominal value source`	Use shore busbar nominal voltage User defined	**Use shore busbar nominal voltage:** • The phase-to-phase nominal voltage for the busbar is the same as the shore connection 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 shore connection and the busbar, the nominal voltage for the busbar will be the same as the nominal voltage for the shore connection.

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.

13.2.2 Power management

The **SHORE connection** controller works together with the other controllers in the system to provide efficient power management.

More information
See Power management for more information about how power management works.

13.2.3 AC configuration

More information
See AC configuration and nominal settings for a description of the AC configuration in general.

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

AC configuration for the SHORE connection controller

SHORE connection	General name
Shore busbar	[Source]
Ship busbar	[Busbar]

13.2.4 Breaker configuration

More information
See Breakers, synchronisation and de-loading for breaker configuration in general. For the **SHORE connection** controller, replace "[Breaker]" with "Shore connection breaker" in these descriptions.

The following inputs and parameters are in addition to the general breaker configuration.

Optional digital inputs

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 > Shore connection breaker >`	Digital input	Pulse	This input starts the breaker de-load and opening procedure.

Function	I/O	Type	Details
`Command > SCB action open`			This input can also be used to confirm the selection, when *Operator select* is selected under **Breaker action**. If the **Breaker action** parameter is set to *Open without de-loading*, or *Operator select*, then activating this input overrides the parameter selection.
`Breakers > Shore connection breaker > Command > SCB action open without de-loading`	Digital input	Pulse	This input checks if it is allowed to open the breaker without de-loading the breaker first, and starts the breaker open without de-loading procedure. This input can also be used to confirm the selection, when *Operator select* is selected under **Breaker action**. If the **Breaker action** parameter is set to *Open shore connection breaker*, or *Operator select*, then activating this input overrides the parameter selection.

Additional shore connection parameters

`Shore breaker configuration > Configuration`

Parameter	Range	Default	Notes
`Overlap`	• Not enabled • Enabled	Not enabled	See **Sensitive shore connection (overlap)** later in this chapter for more information about the **Overlap** function.
`Breaker action`	• Open shore connection breaker • Open without de-loading • Operator select	Open shore connection breaker	**Open shore connection breaker**: When the operator activates the open breaker command, the controller starts the open breaker sequence. If more than one shore connection is connected, the power management system de-loads and opens all the closed shore connection breakers. **Open without de-loading**: When the operator activates the open breaker command, the controller checks if it is safe to open the breaker without de-loading it first, and then opens the breaker if it is safe to do so. If more than one shore connection is connected, the controller only opens the shore connection breaker it is connected to. **Operator select**: When the operator activates the open breaker command, the operator receives a message in PICUS or on the display unit to select whether to open the breaker, open without de-loading, or cancel the action. After an action is selected, the controller performs the selected action to open the breaker it is connected to, or to open the breaker it is connected to without de-loading it first.

13.3 Shore connection breaker

13.3.1 About Shore connection breaker

The shore connection breaker (SCB) connects the shore connection to the ship busbar. For the shore connection breaker to close, the shore connection must be live, and the ship busbar must be synchronised with the shore connection. The shore connection breaker is an important part of the system safety, and trips to protect the shore connection from problems on the ship busbar. If it is configured correctly, the shore connection breaker also trips to stop shore connection problems from disturbing the ship busbar.

More information

See Breakers, synchronisation and de-loading for more information about synchronisation and breakers. This includes the inputs and output functions and the parameters to configure.

For the **SHORE connection** controller, the breaker abbreviation (*[*B]*) is *SCB*. *[Breaker]* refers to *Shore connection breaker*.

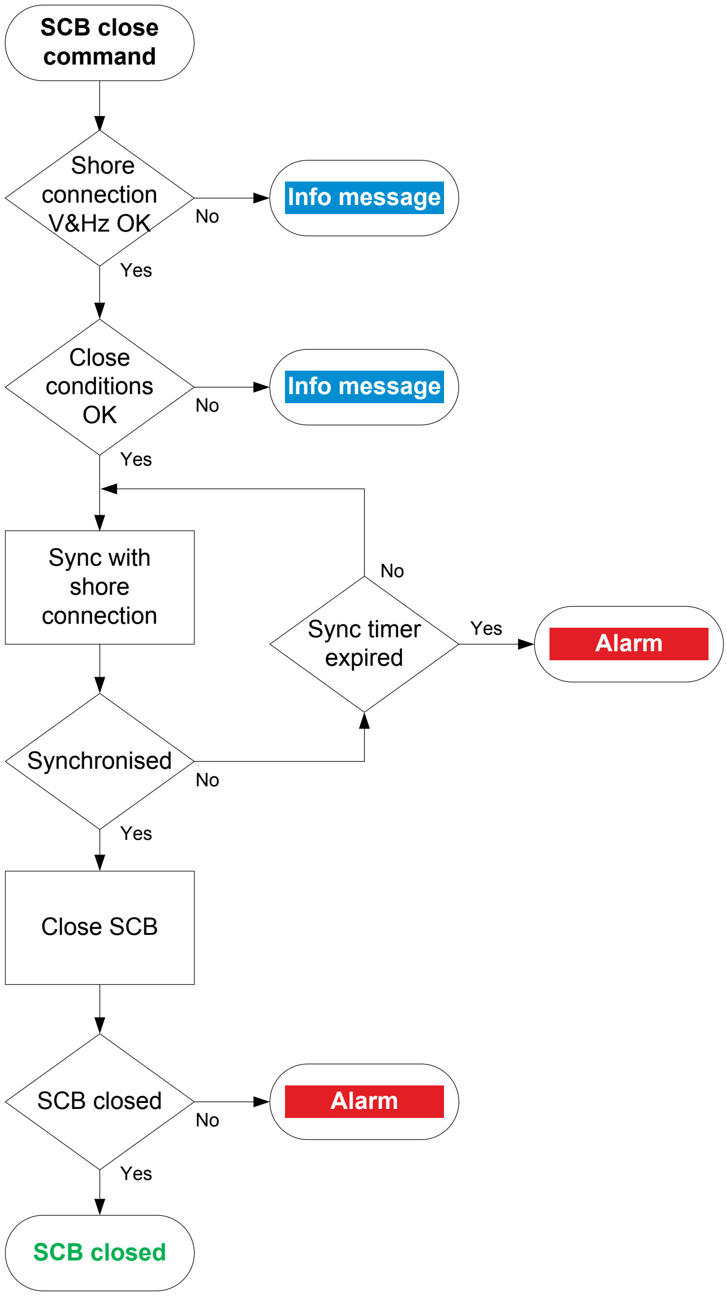
13.3.2 Shore connection breaker close flowchart

More information

See Shore connection breaker blackout close flowchart for how to allow the shore connection to connect to a dead ship 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** on the display unit, the controller ignores this command.

Shore connection breaker (SCB) close flowchart



1. **SCB close command:** The shore connection breaker (SCB) close command can come from the following:
   - The operator can press the push-button **Close breaker** on the display.
   - The operator can use PICUS to send a close breaker command.
   - The command can come from an external source.
2. **Shore connection V&Hz OK:** The controller checks whether the voltage and frequency from the shore connection are within the allowed range. If not, the controller display unit shows an info message.
3. **Close conditions OK:** The controller checks that the close conditions are okay:
   - The **SHORE connection** controller must not be under SWBD control.
   - The ship busbar voltage and frequency must be within the nominal range.
   - All connected **GENSET** controllers must be under PMS control (that is, there must be no connected GENSET controllers under switchboard control).
   - The nominal power of the shore connection must be more than the required power.
   - The load on the ship busbar must be more than the load required by the *Minimum load on ship busbar* parameter.
   - Another shore connection must not be connected to the same busbar section, unless *Multiple shore connections allowed* is enabled.
   - A shaft generator must not be connected to the same busbar section.
4. **Sync with shore connection:** The Power Management System tries to synchronise the ship busbar to the shore connection.
   - When the shore connection and busbar are synchronised, the controller activates the close shore connection breaker output to close the breaker.
   - If the shore connection and the busbar do not synchronise within the time allowed, the controller activates a *SCB sync failure* alarm and the sequence ends.

5. **SCB closed:** The controller checks whether the SCB has closed.
   - If the SCB has closed, the SCB close sequence has been completed successfully.
   - If the SCB has not closed, the *SCB close failure* alarm is activated.

Changing from genset supply to shore connection

The operator can start the change from genset supply to shore connection by activating the close breaker sequence of the shore connection breaker. The **SHORE connection** controller must not be in SWBD control.

If the **GENSET** controllers are in AUTO mode, after the shore connection is connected, the **GENSET** controllers will disconnect and stop the gensets after the cooldown period.

If the **GENSET** controllers are in Manual mode, after the shore connection is connected, the **GENSET** controllers will not disconnect the gensets. However, the parallel timer starts when the shore controller is connected. For the default configuration, the **GENSET** controller trips the genset breaker when the timer expires.

Connected shore connection or shaft generator

Activating the *Close breaker* command if a shore connection is already connected to the busbar and *Multiple shore connections allowed* is not activated will start a load transfer from the connected shore connection to gensets in PMS control. After the load is transferred, the controller will follow the procedure described in the table above to close the shore connection breaker.

Activating the *Close breaker* command if a shaft generator is already connected to the busbar will start a load transfer from the shaft generator to gensets in PMS control. After the load is transferred, the controller will follow the procedure described in the table above to close the shore connection breaker.

13.3.3 Shore connection breaker open flowchart

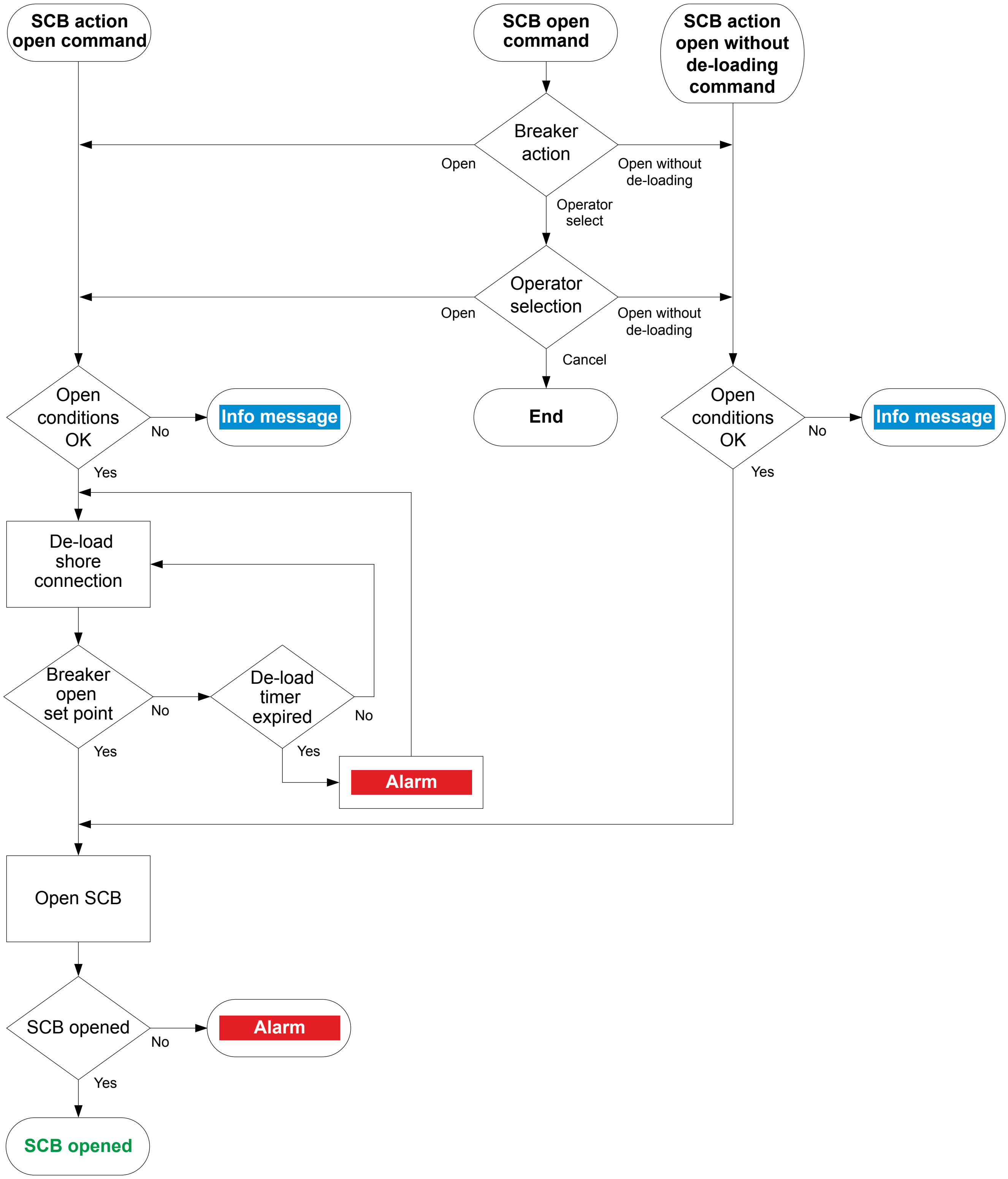
The following flowchart shows the sequence that the controller normally uses to open the shore connection breaker (SCB). This sequence is also used for the alarm action *PMS-controlled open breaker*.

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 SCB open command while *Block* is active, the controller uses this sequence.

This flowchart does not apply to switchboard control. When the controller is in switchboard control, it will not open the breaker (except for a trip caused by an alarm). If, for example, the operator presses the push-button **Open breaker** on the display, the controller ignores this command.

CAUTION
Possible over-load of remaining breakers If the **Breaker action** parameter is set to *Open without de-loading* or if the operator selects to open the breaker without de-loading, it is possible to over-load the remaining breakers after the selected breaker opens. It is recommended to only open breakers without de-loading them first, if the operator understands all of the risks and consequences of this action.

Shore connection breaker (SCB) open flowchart



1. **SCB open command:** The shore connection breaker (SCB) open command can come from the following:
   - The operator can press the push-button **Open breaker** on the display. If *Operator select* is selected under **Breaker action**, then the operator must also select *Open* from the information pop-up.
   - The operator can use PICUS to send an open breaker command. If *Operator select* is selected under **Breaker action**, then the operator must also select *Open* from the information pop-up.
   - The command **SCB action open** is activated by digital input or from an external source. If *Operator select* is selected under **Breaker action**, then the operator must also select *Open* from the information pop-up.
   - The command **SCB action open without de-loading** is activated by digital input or from an external source. The PMS opens the SCB without de-loading.

- The command can come from an external source.

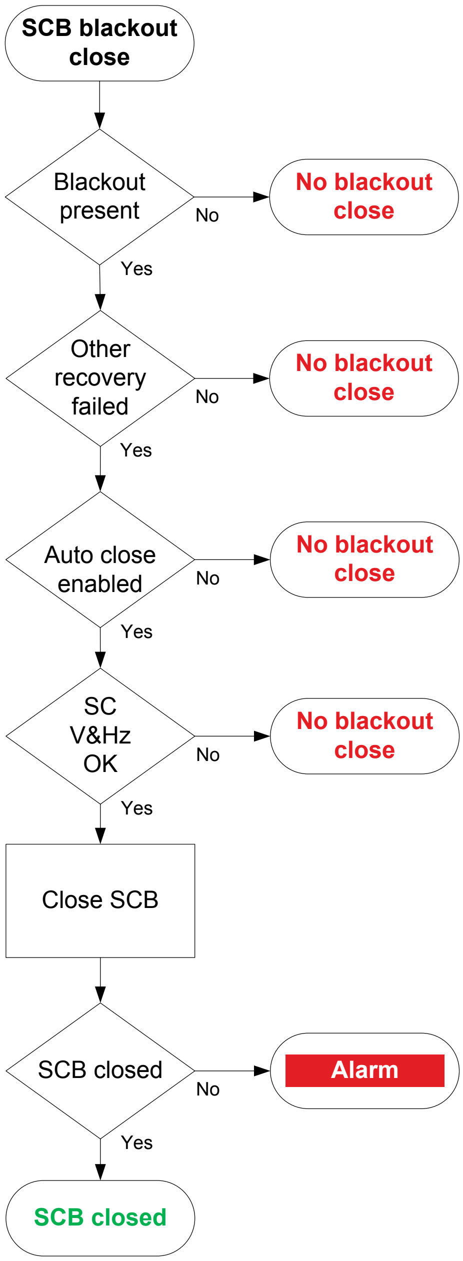
2. **Open conditions OK:** The power management system (PMS) checks that the open conditions are present:
   - There must be enough gensets in AUTO mode, and/or connected in Manual mode, to take over the shore connection load and/or de-load the SCB when the SCB opens.
   - A second shore connection or genset must be connected to the busbar to trip the SCB during the breaker open sequence.
3. **Open breaker** selected
   - **De-load shore connection:** The PMS de-loads the shore connection until the load is less than the set point for the breaker to open. The controller then opens the breaker.
     - When the de-load timer expires, the *De-load failure* alarm is triggered. After the alarm is triggered the controller will continue to try to de-load the SCB until it succeeds.

   Open without de-loading selected
   - The controller opens the breaker without de-loading.
4. **SCB opened:** The controller checks whether the SCB has opened.
   - If the SCB has opened, the SCB open sequence has been completed successfully.
   - If the SCB has not opened, an *SCB open failure* alarm is activated.

13.3.4 Shore connection breaker blackout close flowchart

More information
See Blackout in Power management.

Shore connection breaker (SCB) blackout close flowchart



1. **SCB blackout close:** The shore connection breaker (SCB) blackout close command comes from the blackout close sequence.
2. **Blackout present:** The controller checks that the blackout close conditions are present:
   - There must be a blackout.
   - The other blackout recovery options on the main busbar have failed (that is, recovery by genset connection, auto close of the bus tie breaker, and auto close of the shaft generator breaker). Note that the emergency genset is not included in the blackout recovery options.
   - *Auto close* must be *Enabled* (that is, `Configure > Parameters > Local power management > Blackout > Blackout close > Enable SC blackout close`). If *Enable SC blackout close* is *Not enabled*, the breaker does not close automatically.
   - The shore connection voltage and frequency must be within the allowed range.
3. **Close SCB:** The controller activates the output to close the breaker.
4. **SCB closed:** The controller checks whether the SCB has closed.
   - If the SCB has closed, the SCB blackout close sequence has been completed successfully.
   - If the SCB has not closed, an *SCB close failure* alarm is activated.

Manual blackout close

During a blackout, the operator can manually close the shore connection breaker by pushing the push button **Close breaker** on the display unit if there are no gensets available that can solve the blackout.

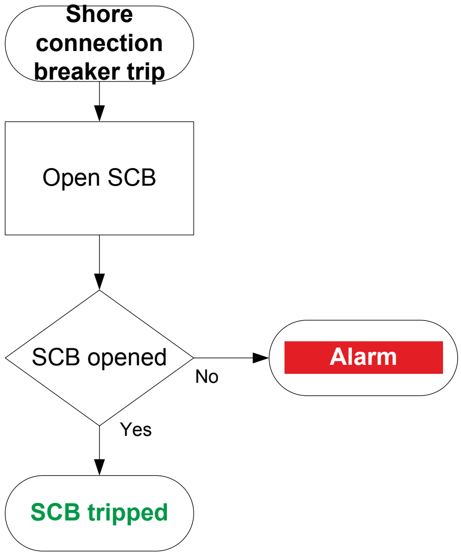
13.3.5 Shore connection breaker trip flowchart

The controller automatically trips the shore connection breaker (SCB) for this alarm action:

- Trip shore connection breaker

The controller does not require the shore connection breaker open conditions to be met for a breaker trip. Similarly, the breaker is not de-loaded for a trip.

Shore connection breaker trip flowchart



1. **Open SCB:** When a trip is required, the controller activates the `Breakers > Shore connection breaker > Controls > SCB open` output to open the breaker.
2. **SCB 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 *SCB opening failure* alarm.

13.4 Other SHORE connection controller functions

13.4.1 Ship-to-ship

A **SHORE connection** controller can be used to supply power to another ship using the ship-to-ship function. This may be useful where quay space is limited.

The ship-to-ship function can be active in several **SHORE connection** controllers in the section at the same time. These ship-to-ship functions operate independently.

Digital input

Function	I/O	Type	Details
`Power management > Ship-to-ship supply`	Digital input	Continuous	When the input is activated, the shore connection can supply another ship with power. The controller also activates the *Ship-to-ship active* inhibit. Note: Once the SCB closes, the ship-to-ship function remains activated until the breaker opens (even if this input is deactivated).

Parameters

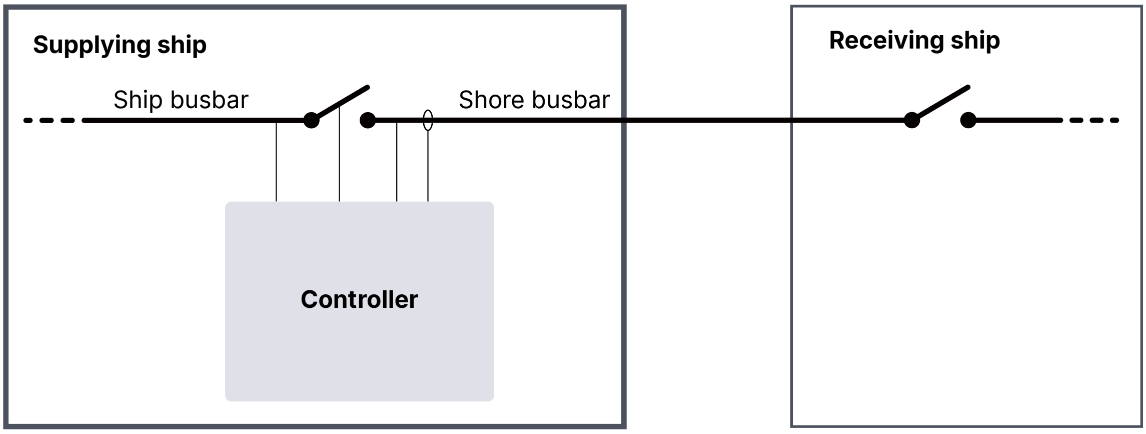
`Local power management > Shore connection ship-to-ship > Open point`

Parameter	Range	Default	Comment
`Open point enabled`	Not enabled, Enabled	Not enabled	**Not enabled**: The power management system can open the shore connection breaker (SCB) at any load. **Enabled**: For the power management system to open the SCB, the load on the SCB must be less than the value in *Open when power below*.
`Open when power below`	2 to 100 % of the shore connection nominal power	5 %	For the power management system to open the SCB, the receiving ship has to decrease the load until it is below this value.

`Local power management > Shore connection ship-to-ship > Connect load`

Parameter	Range	Default	Comment
`Ship-to-ship connect load`	1 kW to 900 MW	100 kW	When a request for synchronising the SCB with the receiving ship is send to the controller, then the power management system reserves this power until the SCB is closed.

Ship-to-ship function only applies to the supplying ship



On the **supplying** ship, the **SHORE connection** controller uses the ship-to-ship function. The controller regards the ship-to-ship connection as a load.

On the **receiving** ship, the connection acts like a shore connection (and does not use the ship-to-ship function). This shore connection can be manually controlled, controlled by a iE 250 Marine, or controlled by any other controller.

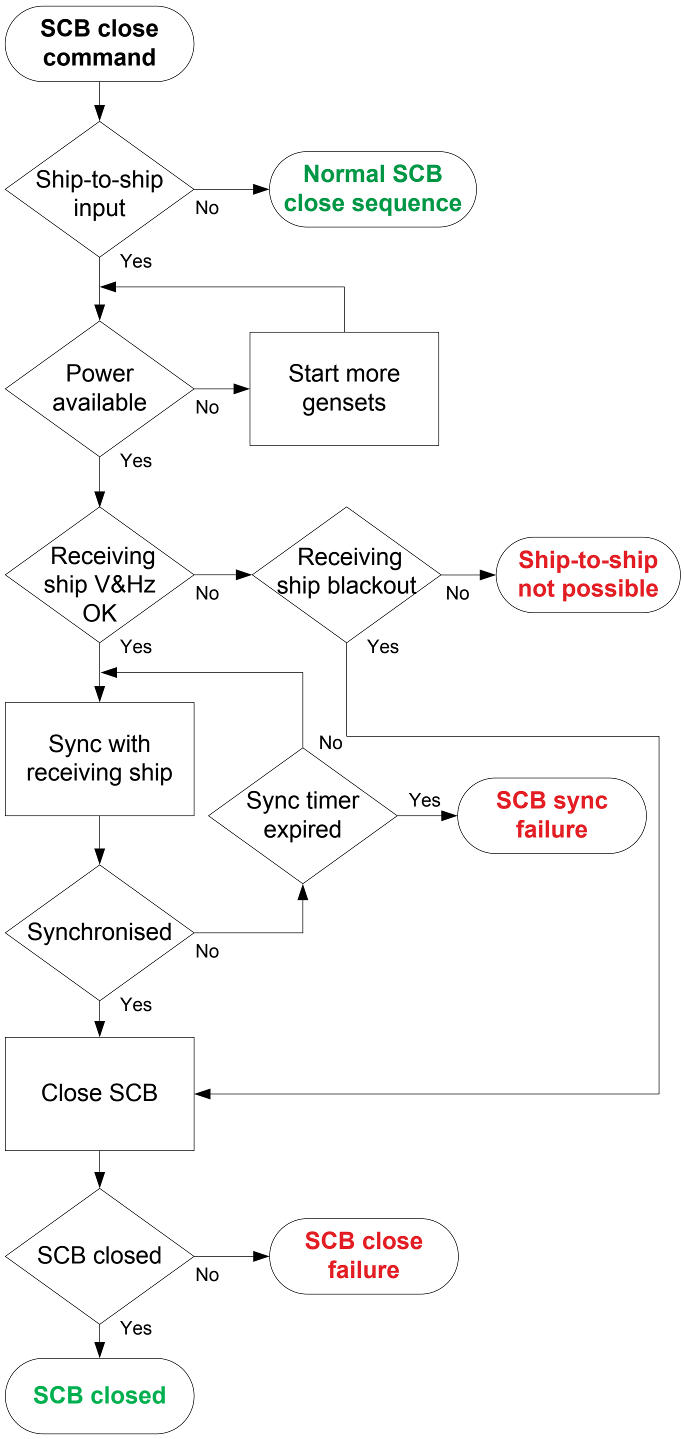
The **SHORE connection** controller on the supplying ship uses the AC measurements to detect the conditions on the receiving ship. There is no other communication between the **SHORE connection** controller on the supplying ship and the receiving ship.

Effect of shore connection(s) and shaft generator

You can use the ship-to-ship function even if shore connection(s) are connected in the same section. However, if one or more shore connections are connected, then synchronisation with the receiving ship is not possible. The receiving ship has to have a blackout to connect, or be powered from the same source as the shore connection(s).

Similarly, if a shaft generator is connected in the same section, then synchronisation with the receiving ship is not possible. The receiving ship has to have a blackout to connect.

Flowchart for the shore connection breaker close for ship-to-ship



1. **SCB close command:** The shore connection breaker (SCB) close command can come from the following:
   - The operator can press the push-button **Close breaker** on the display.
   - The operator can use PICUS to send a close breaker command.
   - The command can come from an external source.
2. **Ship-to-ship input:** If the *Ship-to-ship supply* input is not active, then the controller uses the standard SCB close sequence.
3. **Power available:** The controller checks that the close conditions are okay:
   - The **SHORE connection** controller must not be under SWBD control.
   - Enough power must be available.
   - All connected **GENSET** controllers must be under PMS control (that is, there must be no connected **GENSET** controllers under switchboard control).
   - The load for the receiving ship must be less than the shore connection nominal power.
4. **Receiving ship V&Hz OK:** The controller checks whether the voltage and frequency on the receiving ship are within the allowed range.
   - If there is a blackout on the receiving ship, the controller closes the breaker.
   - If there is not a blackout on the receiving ship, but the voltage and frequency are not within range, then ship-to-ship is not possible.
   - If the voltage and frequency are within range, the PMS tries to synchronise.
     - When the ship busbar and receiving ship are synchronised, the controller activates the `Breakers > Shore connection breaker > Control > SCB close` output to close the breaker.
     - If the ship busbar and the receiving ship do not synchronise within the time allowed, then the controller activates an *SCB sync failure* alarm, and the sequence ends.
5. **SCB closed:** The controller checks whether the SCB has closed.
   - If the SCB has closed, the ship-to-ship SCB close sequence has been completed successfully.
   - If the SCB has not closed, an alarm is activated.

Ship-to-ship active as an inhibit

When the ship-to-ship function is active in a **SHORE connection** controller, the following protections are deactivated by the *Ship-to-ship active* inhibit:

- Reverse power 1 and 2
- Reactive power import

13.4.2 Shore connection base load

The **SHORE connection** controller lets the ship use power from a land-based source, while topping up the power requirement by running one or more generators in parallel.

Enable this function with parameter: `Local power management > Shore connection base load`.

When *Shore connection base load* is enabled, then these alarms are not active:

- SC-DG max. parallel time (in the SHORE connection controller)
- DG-SC max. parallel time (in the GENSET controllers)

More information
See SHORE connection base load in Power management.

13.4.3 Minimum load to close shore connection

The controller only attempts to close the shore connection if the load on the ship busbar is above the specified minimum load. The shore connection breaker close sequence always checks the load as a percentage of the shore connection nominal power before trying to close the shore connection breaker.

`Local power management > Shore connection close load > Shore connection breaker`

Parameter	Range	Default	Notes
`Minimum load on ship busbar`	0 to 100 % of the shore connection nominal power	5.0 %	The controller only attempts to close the shore connection breaker if the load on the ship busbar is higher than this set point.

Shore connection close load example

The nominal power of the shore connection is 480 kW and the *Minimum load on ship busbar* is 5 %

To close the shore connection breaker, the ship busbar load must be at least 24 kW.

13.4.4 Connect multiple shore connections

If multiple **SHORE connection** controllers are installed, then these can potentially connect at the same time. Use the following parameter to determine how the multiple shore connections function.

`Power management rules > Configuration # > Shore connection > Parallel *`

Parameter	Range	Default	Notes
`Multiple shore connections allowed`	• Max. one SC may connect • One close command connects corresponding SC • One close command connects all SCs	Max. one SC may connect	**Max. one SC may connect**: The power management system (PMS) does not allow more than one shore connection breaker (SCB) to close at any one time. If a command is given to close another SCB, the PMS must de-load the first SCB, before opening it. Then the PMS synchronises the system to the second SCB, before it closes. **One close command connects corresponding SC**: When there is a close command for an SCB, the PMS closes that SCB. An operator can, for example, use the push-button **Close breaker** on the display units of the SHORE connection controllers to connect all the required shore connections. **One close command connects all SCs**: When there is a close command for an SCB, the PMS closes ALL the SCBs in the section,

Parameter	Range	Default	Notes
			starting with the SHORE connection controller that was given the close command. If an SCB cannot close, then the PMS stops trying to close that SCB. The PMS then tries to close the next SCB.

NOTE * # is the power management rule number.

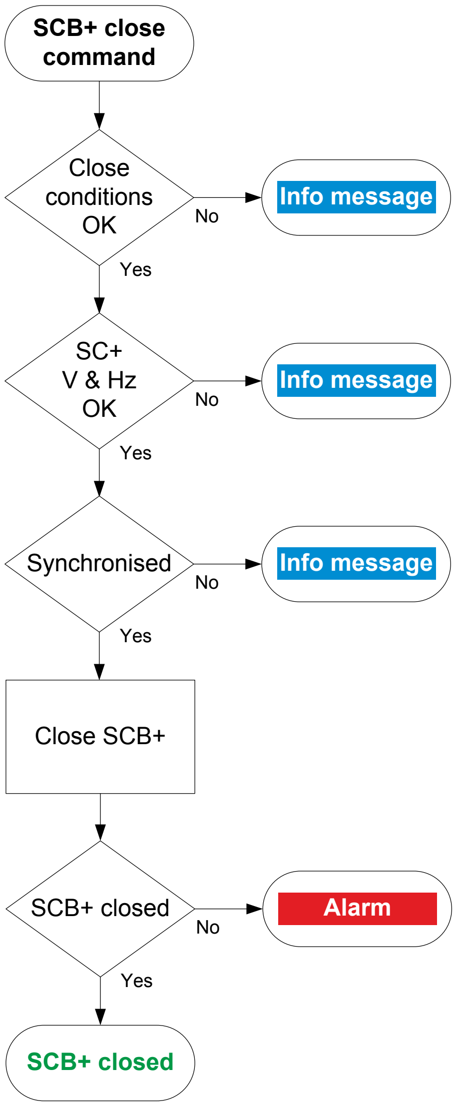
Connecting additional shore connections

The sequence for connecting to the first shore connection in a section is shown in the Shore connection breaker close flowchart. The PMS uses **Dynamic synchronisation** to connect to the first shore connection.

The sequence for connecting additional shore connections in a section is shown in the following flowchart.

The controller uses the **Static synchronisation** parameters for connecting additional shore connections. If the additional shore connection is from a different source, then static synchronisation is impossible, and the controller does not close the breaker.

Flowchart for connecting an additional shore connection



1. **SCB+ close command:** The additional shore connection breaker (SCB+) close command can come from the following:
   - The operator can press the push-button **Close breaker** on the display.
   - The operator can use PICUS to send a close breaker command.
   - The command can come from an external source.
2. **Close conditions OK:** The controller checks that the close conditions are okay:
   - The SHORE connection controller is not under switchboard control.
   - Multiple shore connections are allowed.
3. **SC+ V&Hz OK:** The controller checks that the voltage and frequency from the additional shore connection are within range. If not, the controller display unit shows an info message and the sequence stops.
4. **Synchronised:** The controller checks whether the additional shore connection is synchronised with the ship busbar. If not, the display unit shows an info message and the sequence stops.
5. **Close SCB+:** When all the conditions are met, the controller activates the `Breakers > Shore connection breaker > Control > SCB close` output to close the breaker.
6. **SCB+ closed:** The controller checks whether the additional SCB has closed.
   - If the SCB is closed, the additional SCB close sequence has been completed successfully.
   - If the SCB is not closed, the *SCB close failure* alarm is activated.

Blackout close

You can enable blackout auto close (`Local power management > Blackout > Blackout close`) for multiple **SHORE connection** controllers. The response to a blackout then follows the *Multiple shore connections allowed* parameter.

Table 13.1 Effect of parameter on blackout close

Selected parameter	Effect
Max. one SC may connect One close command connects corresponding SC	The PMS closes the SCB of the **SHORE connection** controller with the lowest *Controller ID*.
One close command connects all SCs	The PMS closes ALL the SCBs where blackout auto close is enabled, starting with the **SHORE connection** controller with the lowest *Controller ID*.

Effect of ship-to-ship

Whenever **Ship-to-ship** is active for a **SHORE connection** controller, then that controller is not included as one of the shore connections.

Opening multiple shore connections

For multiple shore connections, if there is a command to open any SCB, then the PMS checks the **Multiple shore connections** parameter to determine which actions to take to open one or more shore connections.

Table 13.2 Shore connection parallel parameter effect on the breaker open sequence

Parameter setting	Controller action
Max. one SC may connect	The PMS uses gensets to de-load the corresponding SCB. When the SCB is de-loaded, the PMS opens the SCB.
One close command connects corresponding SC	The controller opens or trips the corresponding SCB, based on the shore connection **Breaker action** parameter setting.
One close command connects all SCs	The PMS uses gensets to de-load all the SCBs in the section. When the SCBs are de-loaded, the PMS opens all the SCBs in the section. There is no particular order in which the SCBs are opened.

If an SCB trips, the other SCBs are not necessarily affected, and can remain closed.

13.4.5 Sensitive shore connection (overlap)

Some shore connections cannot tolerate running in parallel with gensets or de-loading, for example, because the shore supply is an inverter. The sensitive shore connection function (also known as the overlap) ensures that de-loading is not attempted, and that the relevant breaker opens in less than 100 ms.

NOTICE

Multiple shore connections with one configured as sensitive shore connection

If you have multiple shore connections but only one is configured as a sensitive shore connection, all connected shore connections will open without de-loading at the same time as the sensitive shore connection.

Parameters

`Breakers > Shore connection configuration > Configuration`

Parameter	Range	Default	Notes
`Overlap`	Not enabled, Enabled	Not enabled	**Not enabled**: The sensitive shore connection function is not active. All controllers use their standard breaker open sequences. **Enabled**: The sensitive shore connection function is active. The relevant breaker is opened in less than 100 ms, and de-loading is not attempted.

How it works

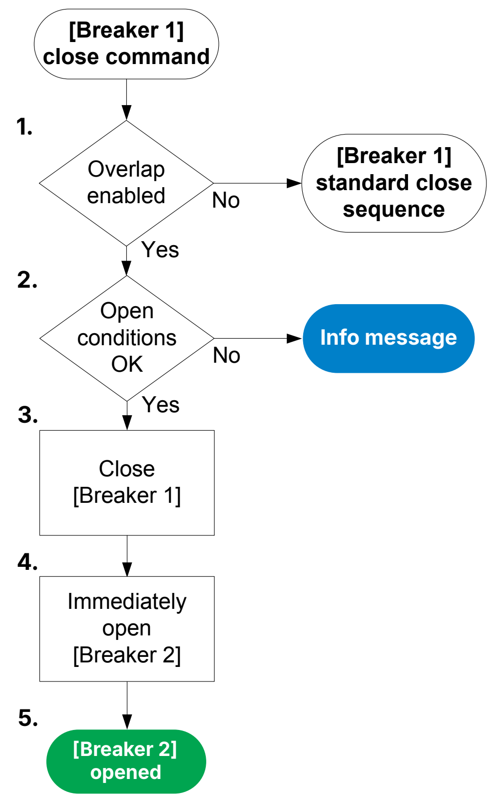
In the description below, the connecting equipment can either be a genset that connects to a busbar powered by one or more shore connections, or a shore connection that connects to a busbar powered by one or more gensets. The connecting equipment controller controls *Breaker 1*, while the connected equipment controller controls *Breaker 2*.

When the *Overlap* function is enabled on a shore connection controller, the controller checks whether the connecting equipment can take over the load from the busbar. If the connecting equipment can take over the load from the busbar, the controller closes the breaker (*Breaker 1*). The breaker(s) that would normally de-load and open after the connecting equipment takes over the load from the busbar (*Breaker 2*), opens immediately without de-loading the breaker. It is only possible for a controller to open *Breaker 2*, if the controller is under PMS control.

If a system has multiple shore connections and only one has the *Overlap* function enabled, then all the connected shore connections open without de-loading when the sensitive shore connection opens. For example, shore connection 1 (SC1) and shore connection 2 (SC2) are connected to the same busbar. SC1 has the *Overlap* function enabled. If there is a request to open the breaker of either SC1 or SC2, then both breakers open without de-loading when the genset connects to the busbar.

If a controller is under switchboard control, the breaker is not opened when a sensitive shore connection connects to the busbar. However, after the timer for the DG-SC max. parallel time protection expires, the controller trips the generator breakers that are closed to protect the gensets.

Sensitive shore connection breaker close and open flowchart



1. **Overlap enabled:** The controller of the connecting equipment checks whether *Overlap* is enabled on the shore connection controller. If *Overlap* is not enabled, then a standard breaker close sequence is followed.
2. **Open conditions OK:** The controller of the connecting equipment checks if the open conditions for the connected equipment (*Breaker 2*) are OK. The following conditions must be met:
   - The section must have at least one other source of power ready to connect to the busbar (for example, a running genset or shore connection).
   - The connecting equipment must not be overloaded when it takes over the load on the busbar.
3. **Close [Breaker 1]:** The controller of the connecting equipment activates the *Breakers > [Breaker] > Control > [*B] Close* output.
4. **Immediately open [Breaker 2]:** If the breaker has closed, then each controller of all the connected equipment that is under PMS control immediately activates the *Breakers > [Breaker] > Control > [*B] Open* output.
5. **[Breaker 2] opened:** Each controller of all the connected equipment that is under PMS control checks whether the breakers have opened.
   - If the breaker has opened, the sensitive shore connection breaker sequence has been completed successfully.

Note: In the flowchart *[Breaker 1]* refers to the breaker of the connecting equipment, and *[Breaker 2]* refers to the breaker of the connected equipment.

13.4.6 Shore connection load transfer without parallel

If two power sources cannot be synchronised, then you cannot transfer the load directly from the one to the other without interrupting the supply. For example, you cannot transfer the load directly from a shore connection to an unsynchronised shore connection, or from a shore connection to a shaft generator, or to a synchronised shore connection if the parameters only allow one shore connection.

However, the power management system includes a pre-programmed sequence to automatically transfer load. It does this by using gensets in AUTO mode to supply the load during the transition (if they can supply the load). The sequence starts when the operator presses **Close** on the non-connected **SHAFT generator** or **SHORE connection** controller display.

For a load transfer using gensets from a shore connection to an unsynchronised shore connection, the steps of the sequence are:
1. The operator presses **Close** on the second **SHORE connection** controller display.
2. The power management system starts and connects enough gensets to take the load from the first shore connection.
3. The power management system regulates the gensets so that they de-load the first shore connection.
4. The power management system opens the first shore connection breaker.
5. The power management system synchronises the gensets to the second shore connection.
6. The power management system closes the second shore connection breaker.
7. The power management system regulates the gensets to transfer the load to the shore connection.
8. The power management system disconnects and stops the gensets.

13.4.7 Counters

You can view, edit and reset all the counters on the display or with PICUS.

The counters include:
- Shore connection breaker operations and trips
- Active and reactive energy export (to the shore connection)
- Active and reactive energy import (to the ship busbar)
- 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.

Digital outputs
You must configure the digital output function to see the parameters.

Function	I/O	Type
`Shore connection > Production counters > Active energy export pulse`	Digital output	Pulse
`Shore connection > Production counters > Reactive energy export pulse`	Digital output	Pulse
`Shore connection > Production counters > Active energy import pulse`	Digital output	Pulse
`Shore connection > Production counters > Reactive energy import pulse`	Digital output	Pulse

Parameters
`Shore connection > 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.

`Shore connection > 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.

`Shore connection > 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.

`Shore connection > 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.

13.5 SHORE connection controller protections

13.5.1 SHORE connection controller protections

These alarms are in addition to the AC protections and general alarms for the controller.

	Alarms and protections
Maximum parallel time	SC-DG maximum parallel time
	SC-SC maximum parallel time
	SC-SG maximum parallel time
	SC-Hybrid maximum parallel time

	Alarms and protections
Power management	Heavy consumer feedback timeout (1 alarm for each heavy consumer)
	Heavy consumer reservation not possible (1 alarm for each heavy consumer)
Non-essential load (NEL)	• Up to 3 non-essential loads per controller • Can connect each controller to the same 3 non-essential load breakers
	NEL # over-current (1 alarm for each non-essential load)
	NEL # under-frequency (1 alarm for each non-essential load)
	NEL # overload 1 and 2 (2 alarms for each non-essential load)
	NEL # reactive overload (1 alarm for each non-essential load)

13.5.2 Alarm actions

The controller has the following alarm actions:

- Warning
- Block
- PMS-controlled open breaker
- Trip shore connection breaker

13.5.3 Inhibits

The **SHORE connection** controller includes the following inhibits:

Inhibit	Disables the alarm when ...
Shore connection breaker closed	The `Breakers > Shore connection breaker > Feedback > SCB closed` digital input is activated.
Shore connection breaker open	The `Breakers > Shore connection breaker > Feedback > SCB open` digital input is activated.
Shore voltage present	The shore connection voltage is above 10% of the nominal voltage.
No shore voltage	The shore connection voltage is below 10% of the nominal voltage.
Shore frequency present	The shore connection frequency is above 10% of the nominal frequency.
No shore frequency	The shore connection frequency is below 10% of the nominal frequency.
Controller under SWBD control	The `Local > Mode > Switchboard control` digital input is activated, OR a system problem forced the controller under switchboard control.
Ship-to-ship active	
ACM wire break	All these conditions are met: • The shore connection 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.

13.5.4 Breaker alarms

More information
See Breakers, synchronisation and de-loading for breaker handling and alarms in general.

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

Table 13.3 Breaker alarm names for the SHORE connection controller

SHORE connection alarm	Parameters	General name
SCB synchronisation failure	`Breakers > Shore breaker monitoring > Synchronisation failure`	Breaker synchronisation failure
SCB de-load failure	`Breakers > Shore breaker monitoring > De-load failure`	Breaker de-load failure
Vector mismatch	`Breakers > Shore breaker monitoring > Vector mismatch`	Vector mismatch
SCB opening failure	`Breakers > Shore breaker monitoringr > Opening failure`	Breaker opening failure
SCB closing failure	`Breakers > Shore breaker monitoring > Closing failure`	Breaker closing failure
SCB position failure	`Breakers > Shore breaker monitoring > Position failure`	Breaker position failure
SCB trip (external)	`Breakers > Shore breaker monitoring > Tripped (external)`	Breaker trip (external)
SCB short circuit	`Breakers > Shore breaker monitoring > Short circuit`	Breaker short circuit
SCB configuration failure	-	Breaker configuration failure
Shore phase sequence error	`Shore connection > AC setup > Phase sequence error`	Phase sequence error
Busbar phase sequence error	`Busbar > AC setup > Phase sequence error`	Phase sequence error

13.5.5 AC alarms

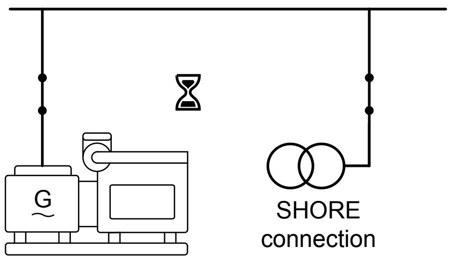
More information
See the **Data sheet** for the AC alarms for this controller type. See the **AC configuration** chapter for descriptions of the AC protections.

13.5.6 SC-DG max. parallel time

This alarm limits the time that a shore connection may run in parallel to a genset.

The timer starts when the genset or emergency genset is connected to the same busbar as the shore connection.

Controller type: **SHORE connection** controller only.



`Local power management > Parallel timers`

The action is *Trip shore connection breaker*, *Latch enabled*.

Parameter	Range	Default
`Delay`	0.1 s to 1 h	3 min
`Enable`	Not enabled, Enabled	Enabled

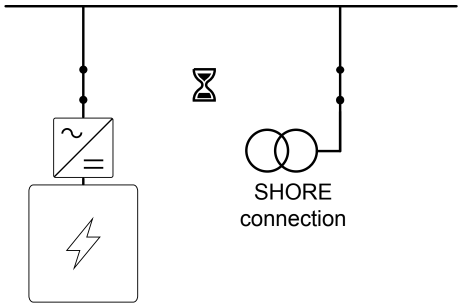
More information
See DG-SC max. parallel time for the alarm in the **GENSET** controller that trips the generator breaker.

13.5.7 SC-HYBRID max. parallel time

This alarm limits the time that a shore connection may run in parallel to an inverter.

The timer starts when the inverter is in PTO mode and is connected to the same busbar as the shore connection.

Controller type: **SHORE connection** controller only.



`Local power management > Parallel timers`

The action is *Trip shore connection breaker*, *Latch enabled*.

Parameter	Range	Default
`Delay`	0.1 s to 1 h	3 min
`Enable`	Not enabled, Enabled	Enabled

More information
See HYBRID-SC max. parallel time for the alarm in the **HYBRID** controller that trips the inverter breaker.

13.5.8 SC-SG max. parallel time

DANGER!

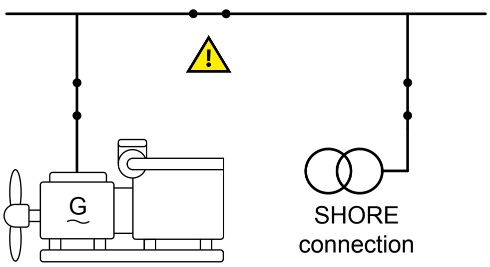
Connecting a shaft generator to a shore connection

Connecting a shaft generator to a shore connection can release a large amount of energy. This can kill people and destroy equipment.

This alarm sets the maximum time that a shore connection may be connected in parallel to a shaft generator.

The power management system normally prevents a shore connection and a shaft generator from connecting in the same section. This alarm is a safety feature, since it is possible to for an operator to manually connect a shore connection and a shaft generator. This can occur if the second equipment's breaker is closed manually, or if the tie breaker between the two sections is closed manually.

This alarm is triggered when a shore connection and a shaft generator are connected to the same busbar for longer than the delay time. The alarm delay timer starts when the second equipment connects.



The alarm has a delay of 0.1 s. The alarm is always enabled. The alarm action is *Trip shore connection breaker*, *Latch enabled*. The alarm parameters are not visible in PICUS.

13.5.9 SC-SC max. parallel time

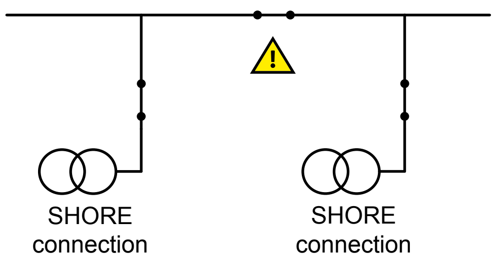
This alarm is not active when *Multiple shore connections allowed* is *Enabled*.

DANGER!

Connecting two shore connections

Connecting two shore connections from different sources can release a large amount of energy. This can kill people and destroy equipment.

This alarm sets the maximum time that a shore connection may run in parallel to another shore connection.



If *Multiple shore connections allowed* is *Not enabled*, then the power management system normally prevents two shore connections from connecting in the same section. This alarm is a safety feature, since it is possible to for an operator to manually connect two shore connections. This can occur if the second shore connection's breaker is closed manually, or if the tie breaker between the two sections is closed manually.

This alarm is activated when two shore connections are connected to the same busbar for longer than the delay time. The alarm delay timer starts when the second shore connection is connected.

The alarm has a delay of 0.1 s. If *Multiple shore connections allowed* is *Not enabled*, the alarm is always enabled. The alarm action is *Trip shore connection breaker*, *Latch enabled*. The alarm parameters are not visible in PICUS.

NOTE To prevent a blackout, only the **SHORE connection** controller with the highest *Controller ID* trips its breaker.

14. BUS TIE breaker controller

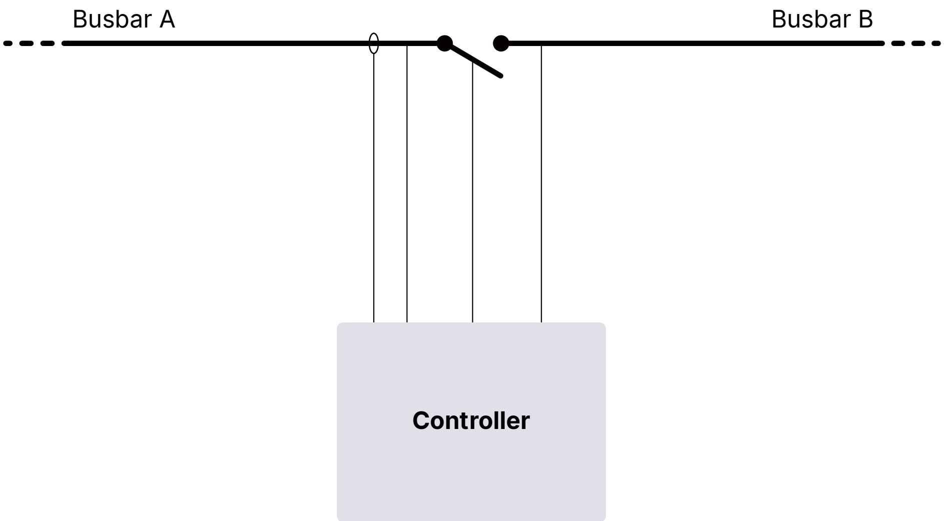
14.1 About the BUS TIE breaker controller

Each **BUS TIE breaker** controller controls one bus tie breaker. Before closing the bus tie breaker, the power management system synchronises the busbar sections.

Before opening the bus tie breaker, the power management system de-loads the bus tie breaker. The power management system also ensures that enough power is available on each busbar section after the bus tie breaker opens.

There can be a ring busbar connection.

Example application



14.1.1 BUS TIE breaker controller functions

	Functions
Pre-programmed sequences	• Bus tie breaker open sequence (with de-loading), to split the busbar into sections • Bus tie breaker close sequence (with synchronisation), to connect the busbar sections

Busbar section management	• Busbar split and connection (configurable)
	• Busbar section management
	  ◦ For example, independent busbars for dynamic positioning (DP) vessels
	  ◦ A busbar section can be under switchboard control without affecting other busbar sections
	• Configure up to eight sets of power management rules for busbar sections
	  ◦ Use CustomLogic to determine when to use the power management rules
	  ◦ For example, when the bus tie breaker is open, the rules can specify the minimum and/or maximum number of running gensets
	• 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)

	Functions
	◦ Energy import (active and reactive) (to busbar A)
Control types	• Power management system (PMS) control ◦ Display unit push-buttons for breaker operations ◦ Synchronisation, de-loading, and breaker control ◦ Push-button functions also possible using inputs, PICUS, and/or Modbus • Manual control ◦ Operator controls the system from the switchboard ◦ Only the controller protections are active
Redundancy	• Redundant breaker feedback on bus tie breakers and externally controlled bus tie breakers

14.2 BUS TIE breaker controller principles

14.2.1 Sections

By opening or closing, bus tie breakers create or join busbar sections in the application.

More information
See **Busbar sections** in the **Power management** chapter.

14.2.2 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 in the **Power management** chapter for how the bus tie breakers create busbar sections.

14.2.3 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.

Nominal setting	Range	Notes
`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.

14.2.4 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.

14.2.5 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*.

14.3 BUS TIE breaker controller sequences

14.3.1 Splitting the busbar

The busbar can be split into two busbar sections which operate independently by opening the bus tie breaker. The signal to open the bus tie breaker can come from:

- The operator can press the push-button **Open breaker** on the **BUS TIE breaker** controller display.
- The operator can use PICUS to send an open breaker command.
- A digital input with the `Breakers > Bus tie breaker > Command > BTB open` function.
- An external source, like a PLC.

The power management system then ensures that there is enough power available for each busbar section so that they can run independently. If there is enough power on each busbar section, the power management system de-loads the bus tie breaker. When the bus tie breaker is de-loaded, the **BUS TIE breaker** controller opens the bus tie breaker.

Requirements

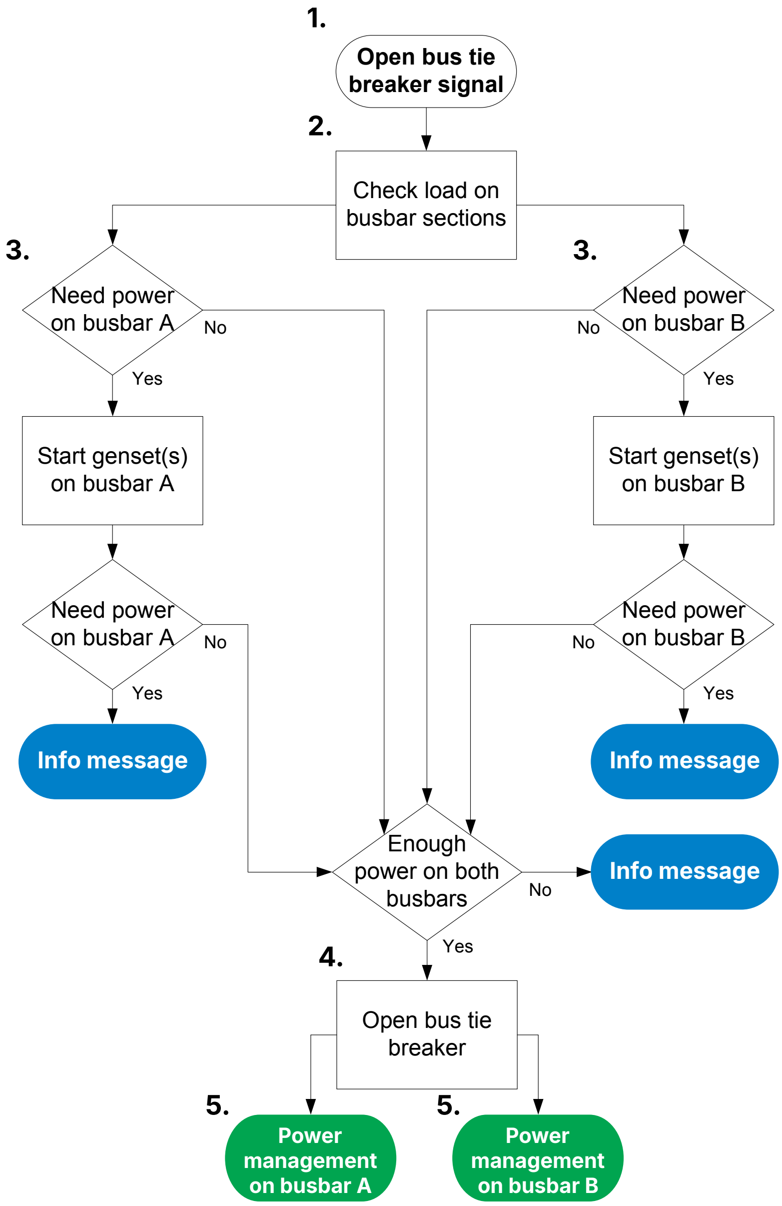
The power management system can only split the busbar if:

- The following controllers are under PMS control (that is, they are not under switchboard control):
  - **BUS TIE breaker** controller
  - All connected **GENSET** controller(s)
  - Connected **SHAFT generator** controller(s) (if present)
  - Connected **SHORE connection** controller(s) (if present)
- There are enough gensets available under PMS control to supply the required power to each busbar section.
  - If the required **GENSET** controllers are in MANUAL mode, then their gensets must be **connected**.
  - **GENSET** controllers in AUTO mode need not be connected. The power management system can start and connect them as necessary.
- If the only power supply to a busbar section is a shaft generator, then that shaft generator must be **connected**.
- If the only power supply to a busbar section is a shore connection, then that shore connection must be **connected**.

How it works

The following flowchart shows the sequence that the controller normally uses to open the bus tie breaker (BTB). This sequence is also used for the alarm action *PMS-controlled open breaker*.

Splitting the busbar flowchart



1. **Open bus tie breaker signal:** The BUS TIE breaker controller gets a signal to open the bus tie breaker.
2. **Check load on busbar sections:** The **BUS TIE breaker** controller checks the load on the busbars that would be created if the bus tie breaker is opened.
3. **Need power on busbar #:** If more power is needed on a busbar, more gensets are started. If there is still not enough power, the **BUS TIE breaker** controller display unit shows the info message *Busbar split not possible*.
4. **Open bus tie breaker:** If there is enough power on both of the busbars, then the controller opens the bus tie breaker.
5. **Power management on busbar #:** After the bus tie breaker is opened, the busbar sections operate independently, with separate power management on each busbar section.

14.3.2 Connecting busbar sections

The busbar sections can be connected to form one busbar section by closing the bus tie breaker. The signal to close the bus tie breaker can come from:

- The operator can press the push-button **Close breaker** on the **BUS TIE breaker** controller display.
- The operator can use PICUS to send an close breaker command.
- A digital input with the `Breakers > Bus tie breaker > Command > BTB close` function.
- An external source, like a PLC.

The power management system then synchronises the busbar sections on either side of the breaker. When the busbars are synchronised, the controller closes the bus tie breaker.

When you close a bus tie breaker, then the two sections on either side of the bus tie breaker are joined into one section. The supply mode after closing is required if a shaft generator or shore connection was supplying power to one of the sections before the bus tie breaker closed.

You can set the supply mode after closing either by configuring the function on a digital input, or by selecting the option in a parameter. The controller uses the last written value. That is, when the digital input is activated, that changes the parameter in the controller. Similarly, the parameter is updated when it is changed and written in the controller.

Requirements

The power management system can only connect the busbar sections if, for at least one of the sections, all of the following controllers are in PMS control (that is, they are not in switchboard control):

- **BUS TIE breaker** controller
- **SHAFT generator** controller (if present and **connected**)
- **SHORE connection** controller (if present and **connected**)
- **GENSET** controllers for the gensets that are **connected** to the busbar

NOTE If one or more controllers in the one section are under switchboard control and connected, then the connected **GENSET** controllers in the other section are forced into MANUAL mode after the sections are joined.

The controller will not allow the bus tie breaker to close in any of these situations:

- In the sections to be joined, there are one or more unknown breaker positions.
- Shaft generators are **connected** on both sides of the breaker.
- Shore connections are connected on both sides of the breaker, and *Multiple shore connections allowed* is *Not enabled*.

If only gensets are connected to both sections, the power management system can connect the sections, even if *Stay on SG/SC supply* is selected.

Optional digital inputs

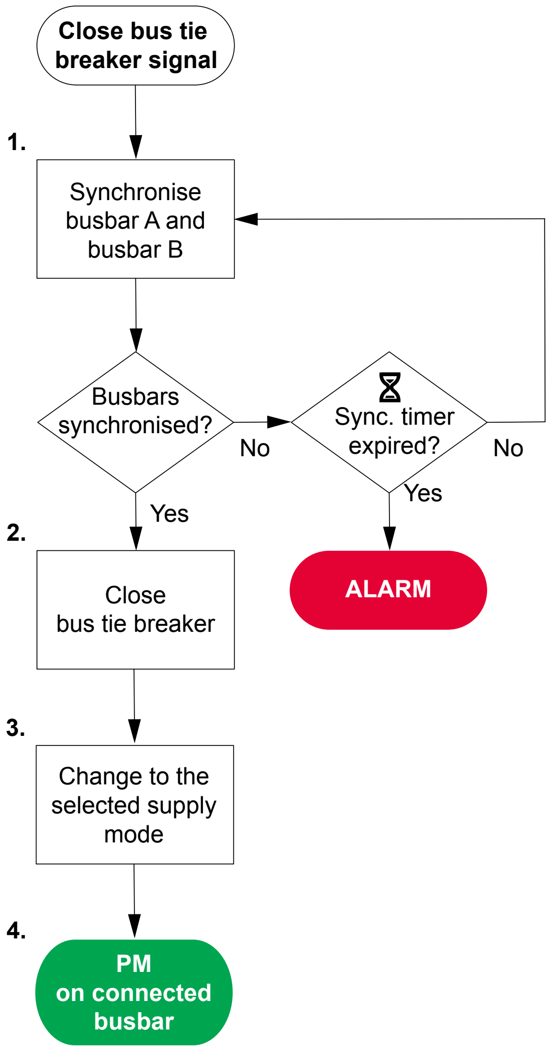
Function	I/O	Type	Details
`Additional functions > Supply mode > Stay on DG supply after BTB close`	Digital input	Pulse	When this input is activated, the controller changes the parameter value under `Local power management > Bus tie breaker > Supply mode after BTB close > Supply mode after connecting` to *Stay on DG supply* (see below).
`Additional functions > Supply mode > Stay on SG/SC supply after BTB close`	Digital input	Pulse	When this input is activated, the controller changes the parameter value under `Local power management > Bus tie breaker > Supply mode after BTB close > Supply mode after connecting` to *Stay on SG/SC supply* (see below).

Parameters

`Local power management > Bus tie breaker > Supply mode after BTB close`

Parameter	Range	Default	Comment
`Supply mode after connecting`	• Stay on DG supply • Stay on SG/SC supply	Stay on DG supply	• **Stay on DG supply**: After the bus tie breaker is closed, the power management system automatically de-loads any shaft generator or shore connection supply. The power management system then automatically opens the shaft generator breaker or shore connection breaker. In this way, the connected busbar runs on a genset supply. • **Stay on SG/SC supply**: After the bus tie breaker is closed, the power management system automatically de-loads the gensets. The power management system then automatically opens the genset breakers. In this way, the connected busbar runs on only a shaft generator or shore connection supply.

How it works



1. **Synchronise busbar A and busbar B:** After getting the signal to close the bus tie breaker, the power management system regulates the gensets on either side of the bus tie breaker.
   - If a shaft generator or shore connection is **connected** to one of the busbars, the power management system only regulates the gensets on the other busbar.
2. **Busbars synchronised:** When the busbars are synchronised, the power management system automatically closes the bus tie breaker. If the busbars do no synchronise within the time available, the controller activates a *BTB synchronisation failure* alarm.
3. **Change to selected supply mode:** If a shaft generator or shore connection was connected to one of the busbar sections, then the power management system regulates the system and opens breakers so that the connected busbar sections run on the supply selected in the parameter described above.
4. **Power management on connected busbar:** The power management system controls the connected busbar sections as one busbar section.

14.3.3 Bus tie breaker blackout close flowchart

More information
See Blackout for the sequence that the controller uses to close the bus tie breaker if there is a blackout on one of the busbars.

Manual blackout close

During a blackout, the operator can manually close the bus tie breaker by pushing the push button **Close breaker** on the display unit.

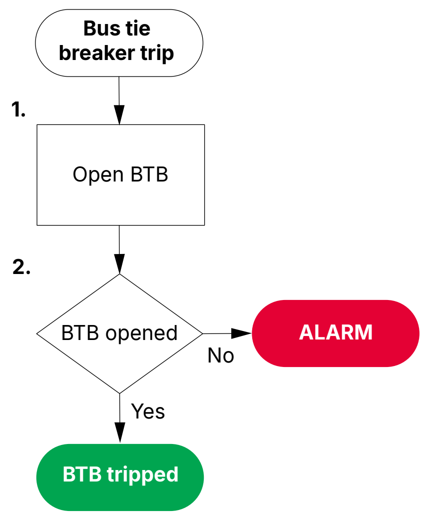
14.3.4 Bus tie breaker trip flowchart

The controller automatically trips the bus tie breaker (BTB) for this alarm action:

- Trip bus tie breaker

The controller does not require the bus tie breaker open conditions to be met for a breaker trip. Similarly, 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.

14.4 Other BUS TIE breaker controller functions

14.4.1 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.

14.4.2 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	

14.5 BUS TIE breaker controller alarms and protections

14.5.1 BUS TIE breaker controller protections

These alarms are in addition to the AC protections and general alarms for the controller.

	Alarms and protections
Power management	Heavy consumer feedback timeout (1 alarm for each heavy consumer)
	Heavy consumer reservation not possible (1 alarm for each heavy consumer)

	Alarms and protections
Advanced blackout prevention	P load sharing failure on DG (low frequency)
	P load sharing failure on DG (high frequency)
	Q load sharing failure on DG (low voltage)
	Q load sharing failure on DG (high voltage)
	Overload on a DG
	Reverse power on a DG
	Reactive power export on a DG
	Reactive power import on a DG
	Over-current on a DG

14.5.2 Alarm actions

The controller has the following alarm actions:

- Warning
- Block
- PMS-controlled open breaker
- Trip bus tie breaker

14.5.3 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.
Controller under SWBD control	The `Mode > Switchboard control` digital input is activated, OR a system problem forced the controller under switchboard control.
ACM wire break	All these conditions are met: • The bus tie 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.

14.5.4 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

BUS TIE breaker alarm	Parameter	General name
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.

14.5.5 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.

15. WebConfig

15.1 About WebConfig

You can configure and manage the controller system-settings direct with any HTML-capable browser. With WebConfig you can configure both advanced settings and see more detailed logs and information.

Use the **Admin** user to access and configure the WebConfig. To use a different user, that user must have the **Provisioner** role.

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

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

We would love to hear from you.

Help us improve our documentation by giving us feedback.

Click here

15.2 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.

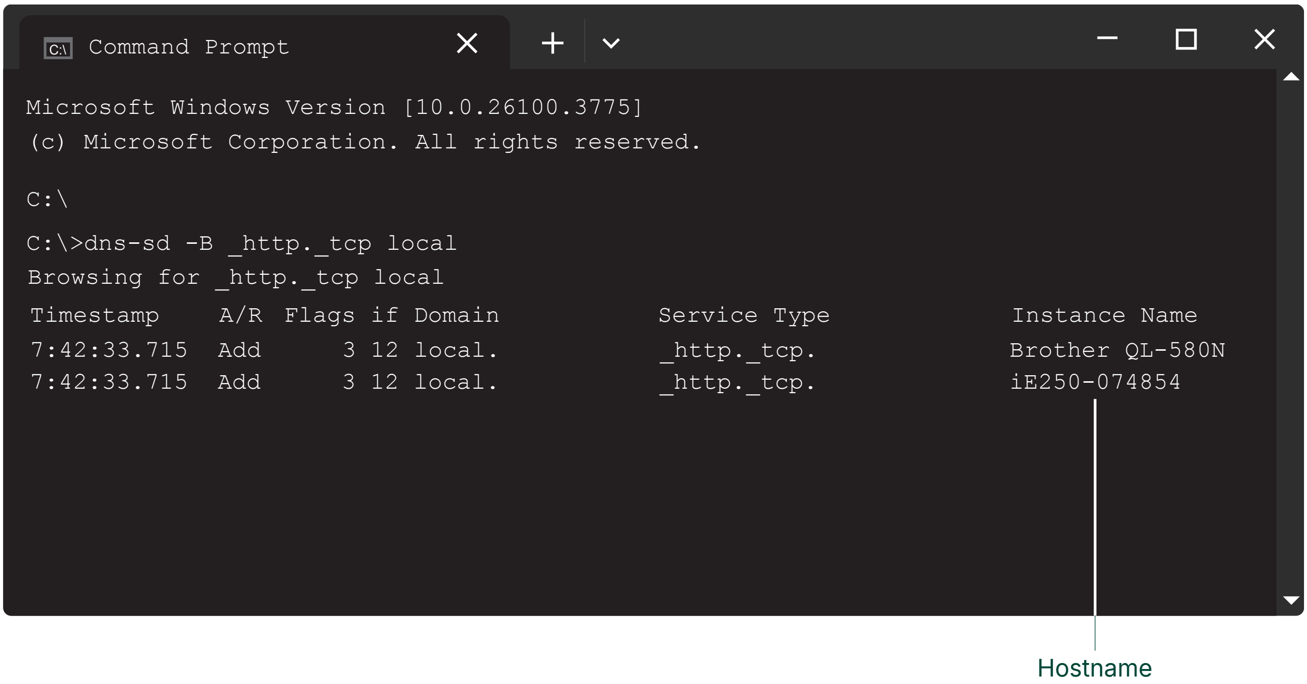
You can connect to the controller with *Hostname*, *IPv6*, or *IPv4* (if configured):

- **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.

15.2.1 Users

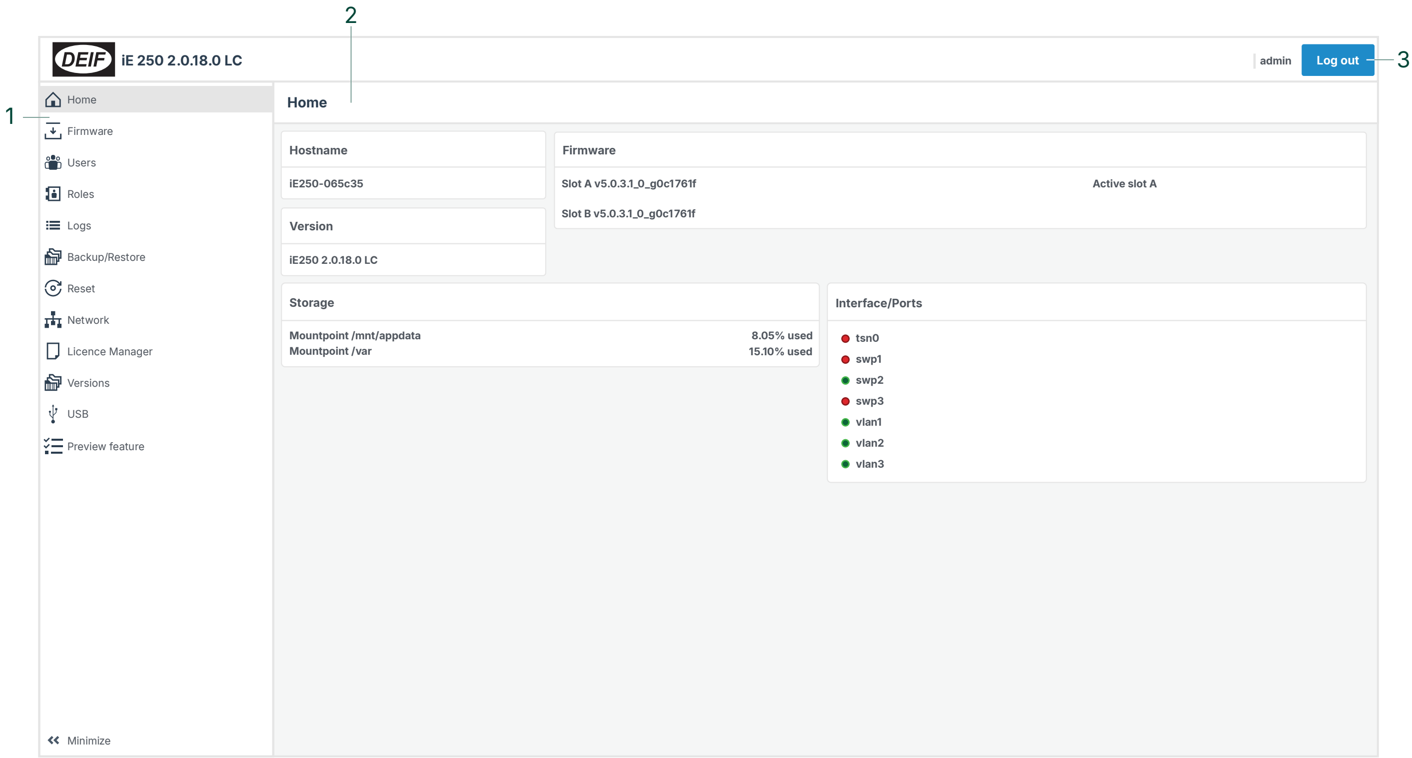
Use the **admin** user to access the WebConfig and configure the controller settings initially. New users must have the **Provisioner** permission to access the WebConfig features.

You can configure new users directly with WebConfig or by using PICUS.

More information
See About Permissions in Cybersecurity.

15.3 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.

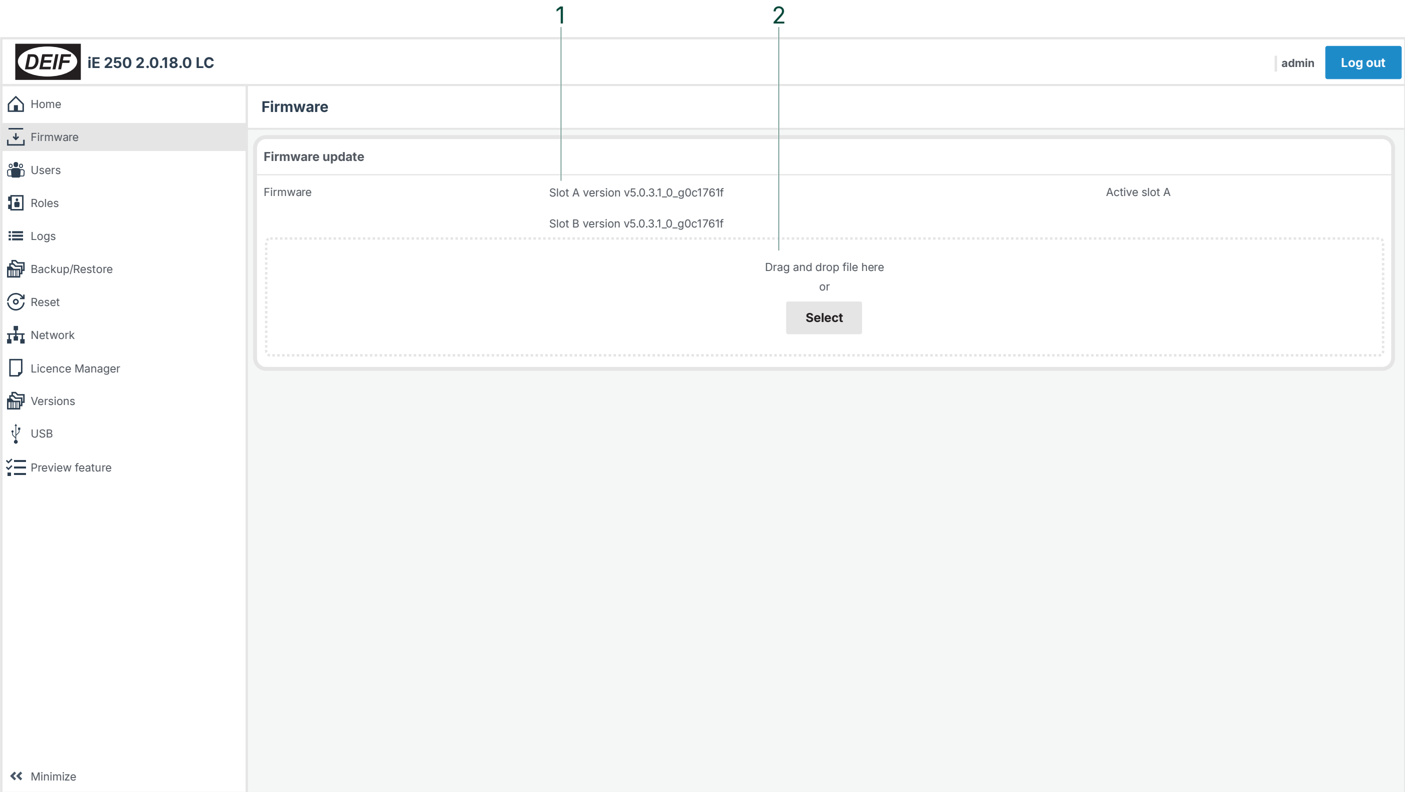


No.	Item	Notes
1	Features	Available features and pages.
2	Page	Selected page.
3	User	Log in / Log out. Logged in user is shown.

15.4 Firmware

15.4.1 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.

15.4.2 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.

Mode constraint (Marine applications)

The controller must be in Switchboard control.

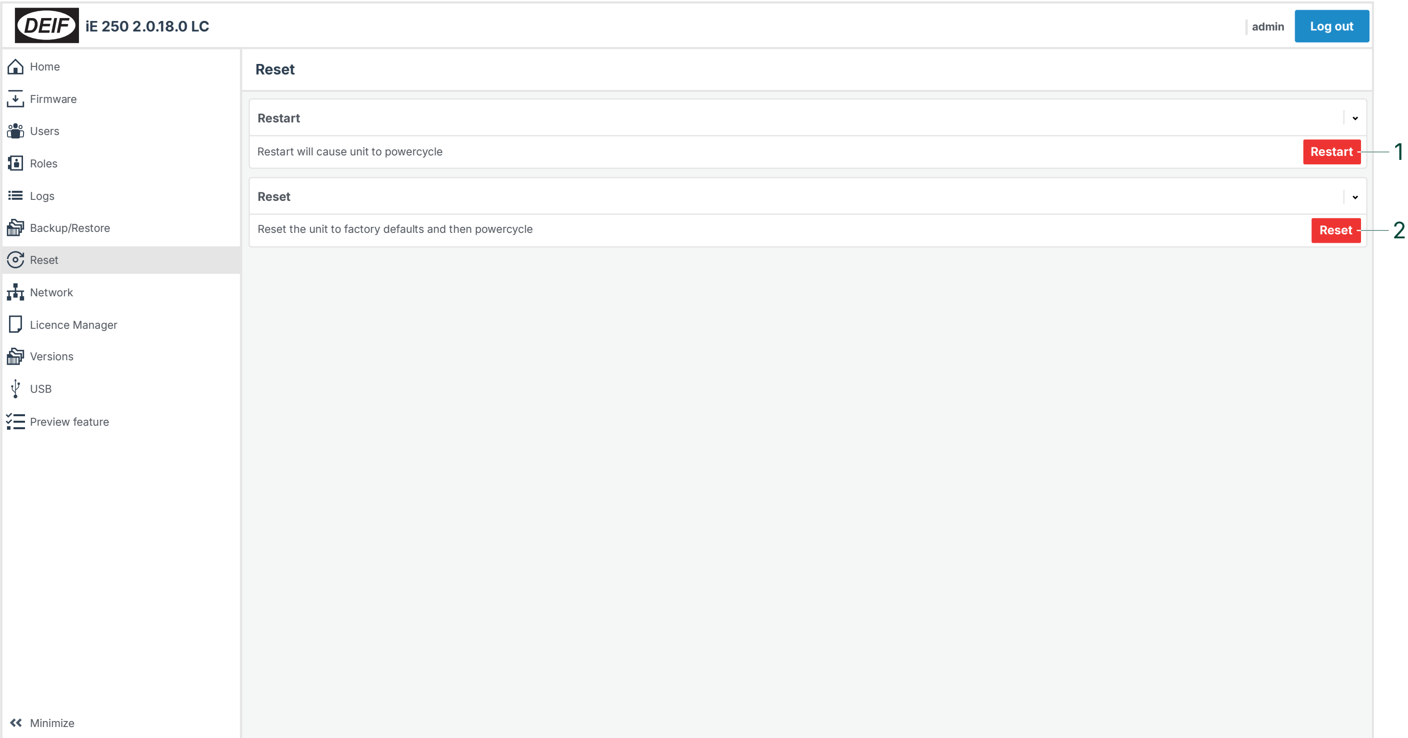
15.4.3 Download firmware

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

Download the software	
iE 250 Marine	https://www.deif.com/software/?product=20133

15.5 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.

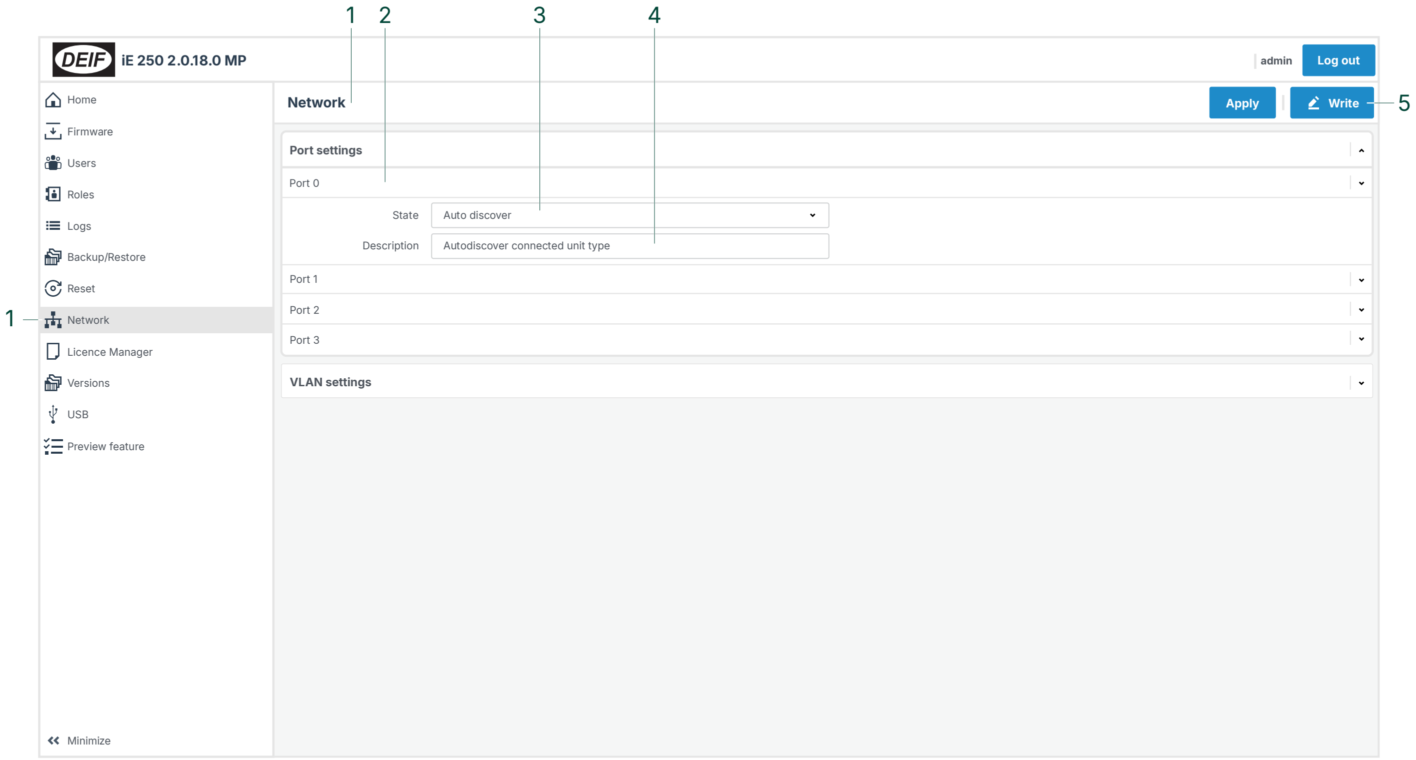
More information
See Factory reset for the location of the **Factory reset** button.

15.6 Communication settings

15.6.1 Network communication

15.6.1.1 Network settings

You can configure the communication settings for both Ethernet and VLAN configuration.



No.	Item	Notes
1	Network	Network settings page.
2	Port #	Configuration for each port.
3	State	Log in / Log out. Logged in user is shown.
4	Description	Description for the port configuration.
5	Apply / Write	Apply the changes immediately. Write the changes to the controller.

15.6.1.2 Ethernet ports

You can configure how the Ethernet ports are allowed to operate.

This is for ring topology networks and uses the Media Redundancy Protocol (MRP). The network master is connected to both ends of the network, forming a loop. This configuration allows the master to send and receive data from both directions, which is essential for detecting and compensating for a cable break.

With Auto discover selected, the devices connected in the loop are automatically discovered. It is not possible to connect multiple rings together.

DEIF recommends that you do not use Port 0 (Eth 0) for Auto discover. This is because Auto discover is for ring protocols.

Network > Port settings > Port # *

Parameter	Range	Notes
State	• Auto discover • 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 * Where # is 0 to 3 for iE 250 or 0 to 4 for iE 350.

15.6.2 USB communication

15.6.2.1 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.

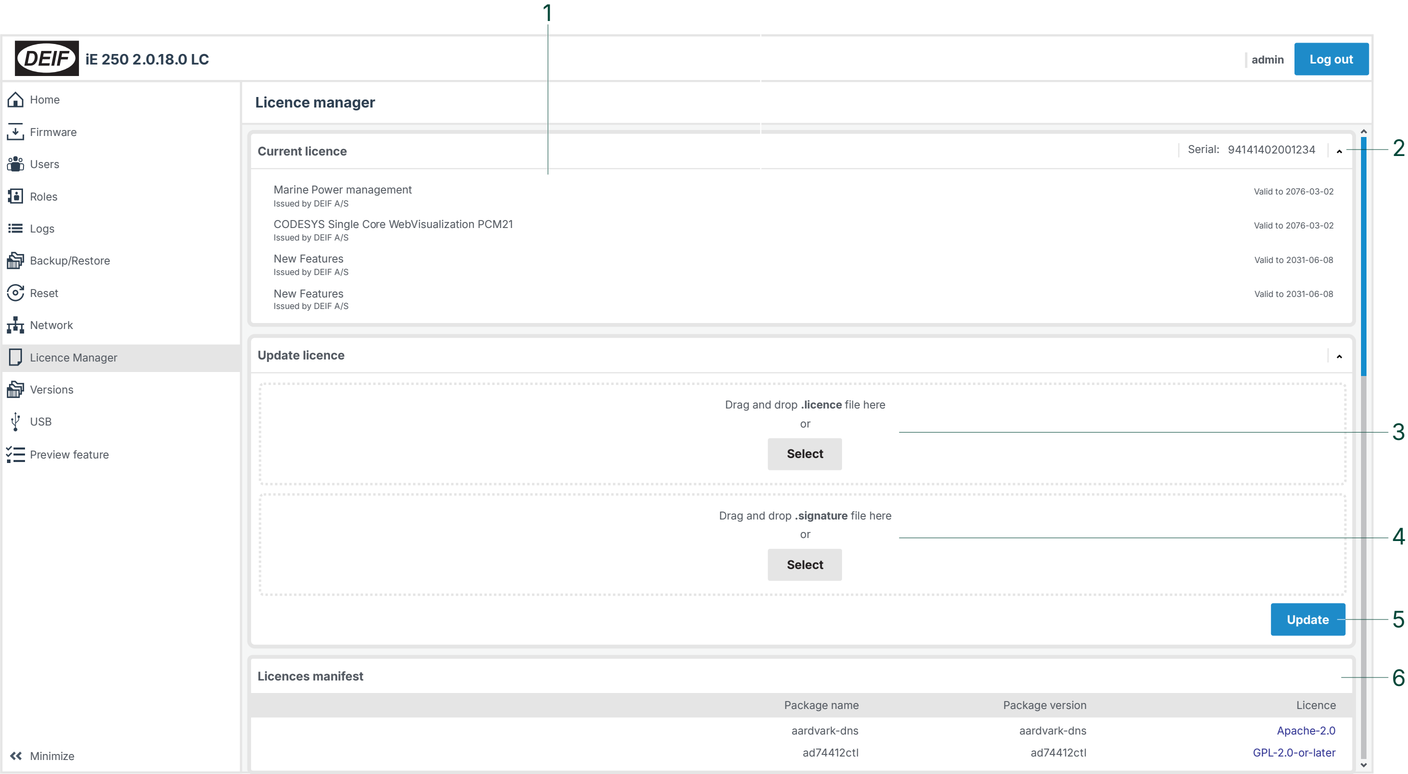
NOTICE
iE 7 display uses USB port The iE 7 display uses both the USB and DisplayPort for communication with the base mounted controller. If the USB port is not enabled, the display cannot send control signals to the controller.

15.7 Licences

15.7.1 About Licence manager

Use the **Licence manager** to view or install licences on the controller.

Contact DEIF with your controller serial number to order a new licence.



No.	Item	Notes
1	Current licences	Shows the installed DEIF application licences on the controller, this includes the expiry date.
2	Serial number	Shows the controller's serial number. This is required when ordering new licences, as the licences are linked to the serial number.
3	Licence file	Drag and drop a new **.licence** file or select the file from your computer.
4	Signature file	Drag and drop a new **.signature** file or select the file from your computer.
5	Update	Update the controller with the new **.licence** and **.signature** files.
6	Licences manifest	Shows all other installed licences on the controller. Use the link to view further information about the licence.

15.7.2 Update licence

After sending your serial number to DEIF, you will receive an email with your new licence files.

You will receive two files:

Table 15.1

File	Description
.licence	This is the licence for the application / features.
.signature	This is the DEIF-certified signature file.

Both files are required to successfully update your controller's licence.

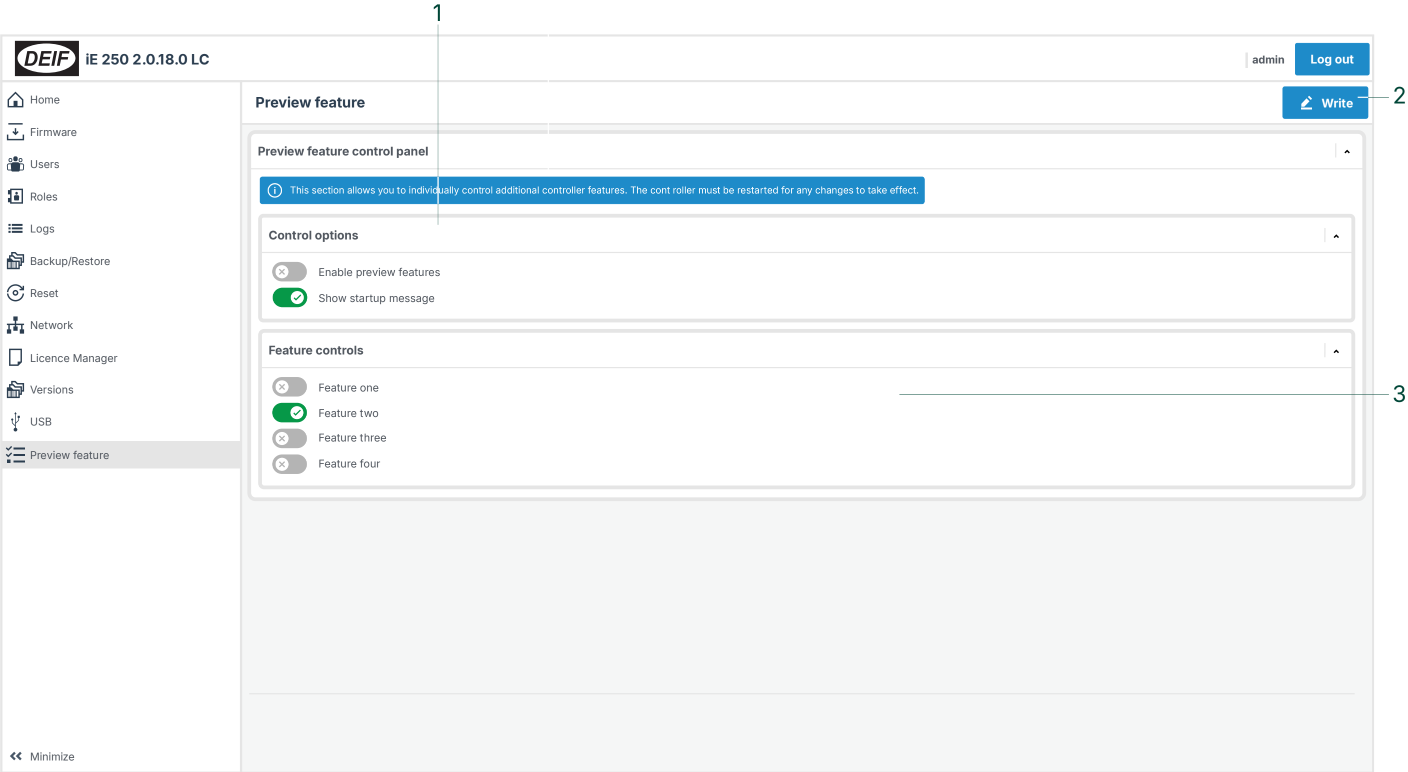
How to update the licence

1. Extract the two files, **.licence** and **.signature**, to your local PC or drive.
2. Open the Controller's WebConfig settings with your HTML-browser.
3. Select the Licence manager section.
4. In the Licence area: Drag and drop the **.licence** file or select the file from your computer.
5. In the Signature area: Drag and drop the **.signature** file or select the file from your computer.
6. Select **Update**.
7. A confirmation is shown if the update was successful.

15.8 Preview features

15.8.1 About Preview feature

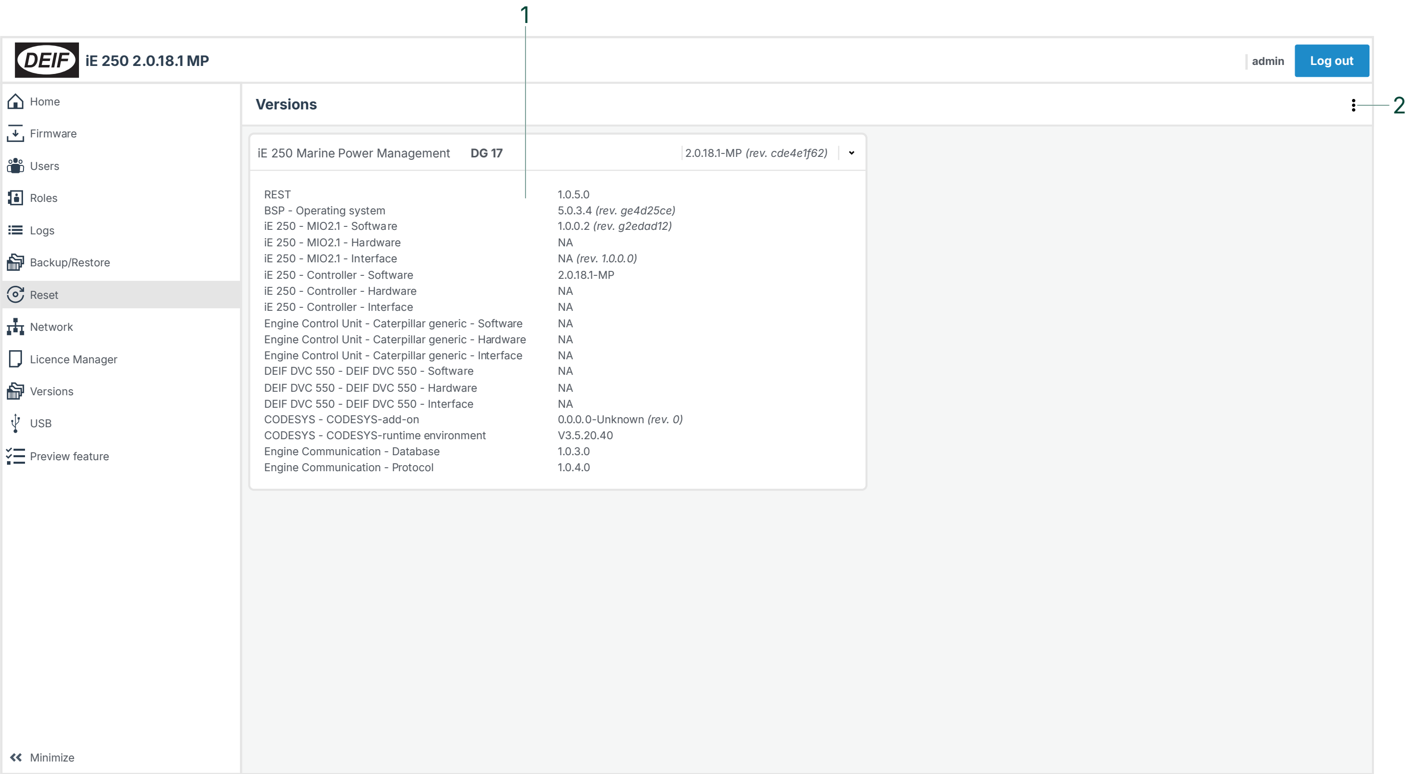
Use the **Preview feature** to try out new features before they are officially released.



No.	Item	Notes
1	Control options	Enable or Not enable the Preview features selected. You can optionally include a startup message.
2	Write	Update the controller with the Enabled or Not enabled features. You must restart the controller for this to take effect.
3	Feature controls	Enable or Not enable the features in the controller application.

15.9 Versions

The versions page can be useful if you need to contact DEIF support for assistance.



No.	Item	Notes
1	Version information	Shows the version information.
2	⋮ More options	Include or exclude extra information: • Revisions • Modules

16. Hardware characteristics

16.1 General characteristics

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

The hardware includes digital bi-directional channels. These can be used as either digital outputs or digital inputs. In PICUS, under `Configure > Input/Output`, these terminals are named **DIO**. After selecting a DIO, you can select the IO type (*Digital input*, or *Digital output*) in PICUS.

The hardware includes analogue bi-directional channels. These can be used as either analogue outputs or analogue inputs. In PICUS, under `Configure > Input/Output`, these terminals are named **AIO**. After selecting an AIO, you can select the IO type (*Analogue input*, or *Analogue output*) in PICUS.

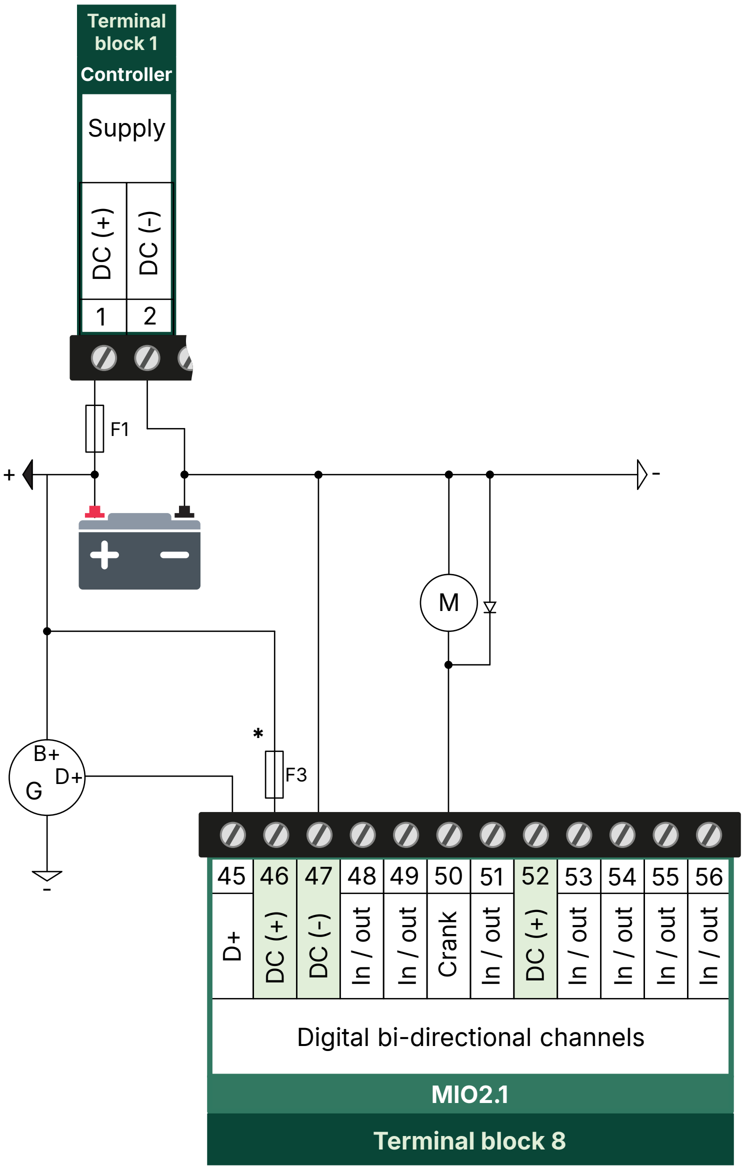
Technical specifications

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

16.2 Controller

16.2.1 Power supply

The power supply is connected to terminals 1 and 2 on the controller.



Backup power

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

Start current

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

Battery-powered systems normally do not have a problem with start current.

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

Reverse polarity

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

* MIO2.1 E-stop power cut-off

You can connect an external emergency stop button to terminal 46. When the external emergency stop button is pressed, the power to the D+ (terminal 45) and DIO channels 9 to 12 (terminals 48 to 51) is broken.

Alternatively, you can connect an external emergency stop button to terminal 52. When the external emergency stop button is pressed, the power to DIO channels 13 to 16 (terminals 53 to 56) is broken.

NOTE The hardware emergency stop (terminal 46) is NOT related to the `Alarm system > Additional functions > Emergency stop` input, or the controller emergency stop alarm parameters (configured under `Engine > Emergency stop`).

NOTE The DC (+) supply (terminals 46 and/or 52) must be powered for the digital inputs 1 to 8 (terminals 57 to 64) to work.

More information
See **E-stop power cut-off** in the **Installation instructions**.

Diode compensation

`Hardware > PCM2.1 > Diode compensation`

Parameter	Range	Notes
`Diode offset`	0.0 to 1.0 V DC	This corrects the power supply measurement values used for the supply voltage alarms. Use this to compensate for a small decrease in voltage over the diode.

Heat emission

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

Power supply voltage analogue output

`Hardware > Power supply > PCM2.1`

Function	I/O	Details
`PCM2.1 supply voltage [V]`	Analogue output	The supply voltage for the PCM2.1 which can also be configured to an output curve.

16.2.2 Digital inputs

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

Polarity

The digital inputs use negative switching.

The controller activates the *Emergency stop* safety function for a LOW digital input. For all other digital input functions, the controller activates the function for a HIGH digital input.

Configuration

The digital inputs are configurable. That is, for each digital input, you can assign digital input function(s) and/or configure alarm(s).

You can also create responses to digital inputs using CustomLogic. You can also activate some digital input functions using a Modbus command.

Controller types and application drawing

The controller type determines which digital input functions are available.

To see certain digital input functions, you must include the corresponding equipment in the application drawing.

Controller operation

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

16.2.3 Digital outputs

Configuration

All digital outputs are configurable.

You can assign a digital output function or an alarm to a digital output. Alternatively, you can create customised a digital output function using CustomLogic, and assign it to a digital output.

Controller types and application drawing

The controller type determines which digital output functions are available.

To see certain digital output functions, you must include the corresponding asset in the application drawing.

Configure output state

On the display or with PICUS, you can select a digital output channel and configure the output state. Under *Output state*, select **Close when active** (the output is closed while the function is active), or **Open when active** (the output is open while the function is active).

16.2.4 Analogue inputs

The controller can use an analogue input to receive operating data. The controller can also activate alarms based on the analogue input.

Alternatively, an analogue input can be configured to operate as a supervised binary input (dry contact), and assigned a digital input function. This is described at the end of this topic.

Analogue input function

Assigning a function to the analogue input is optional.

You can assign one (or more) of the controller's analogue input functions to the input. You can only select functions that use the same units.

Alternatively, if you want to use the analogue input as a supervised binary input, you can assign one (or more) of the controller's digital input functions to the input.

Analogue input type

Under *Sensor value (x-axis)*, select the input type. You can also adjust the input range.

You can select from these input types:
- 0 to 20 mA
- 0 to 10 V
- 0 to 10000 ohm

Analogue input sensor setup

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

Pre-configured curves may be available for the function. Alternatively, you can select a previously customised curve, or customise a curve.

Sensor failure

You can configure customised alarms for sensor failure. The *Below range alarm* is activated when the analogue input is below the specified value. Similarly, the *Above range alarm* is activated when the analogue input is above the specified value.

NOTICE

Use of sensor failure alarms

Do not use the sensor failure alarms to respond to ordinary operating data. Configure customised analogue input alarms instead.

Analogue input alarms

You must complete the sensor setup before configuring any analogue input alarms.

You can configure any number of alarms for an analogue input. However, you cannot exceed 25 customised alarms for the controller.

Supervised binary input

Analogue inputs used for supervised binary inputs should be configured using the function type **Supervised binary**.

Use an analogue input curve to define the supervised binary input. The supervised binary input curve is a step function. That is, the curve consists of a horizontal line (with the value 0 or 1), a vertical line (the point where the curve changes), and another horizontal line (with the value 1 or 0).

To avoid instability, configure the curve so that the change point is far away from the input closed and open values.

If the analogue input measurement corresponds to a function input that is **not zero**, then the controller uses **one** as the function input.

16.2.5 Analogue outputs

An analogue output can be used to output operating data or values.

Analogue output function

Assign one function to the analogue output. You can adjust the *Function input (x)* range.

Analogue output type

After assigning a function, under *Output (y)*, select the output type. You can also adjust the output range.

The output types that can be selected depend on the hardware.

Module	Terminals	Output types
Controller	13, 14, 15 and 16	0 to 20 mA 0 to 10 V

Analogue output curve

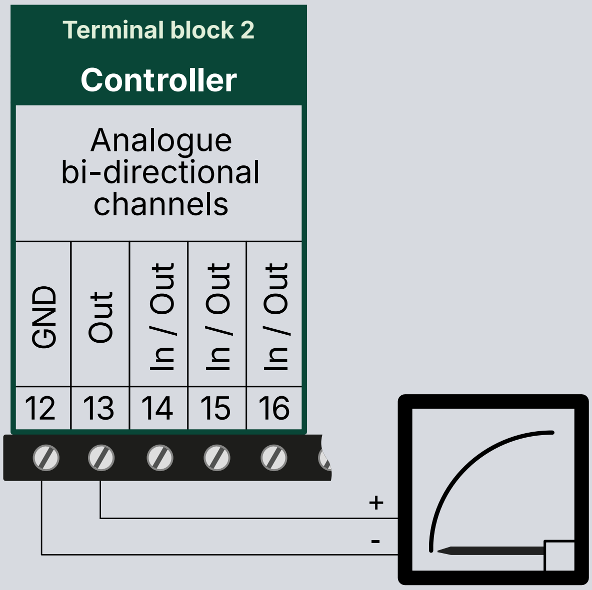
The output requires a curve. The curve allows the controller to convert the selected function's value to the analogue output.

Pre-configured curves may be available for the function. Alternatively, you can select a previously customised curve, or customise a curve.

Output for a switchboard instrument

Output *Generator power* example

The customer has a 1 MW genset, and wants to display the power from the genset on the switchboard. He uses a DEIF DQ-96x with a scale from -100 to 1500 kW.
The designer creates the following wiring for a `Generator > Power (P) > Generator | Total [kW]` analogue output:



The designer selects 0 to 20 mA and configures a customised function curve with an output of 4 mA for -100 kW, and 20 mA for 1500 kW.

16.2.6 CAN bus communication

16.2.6.1 About CAN bus communication

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

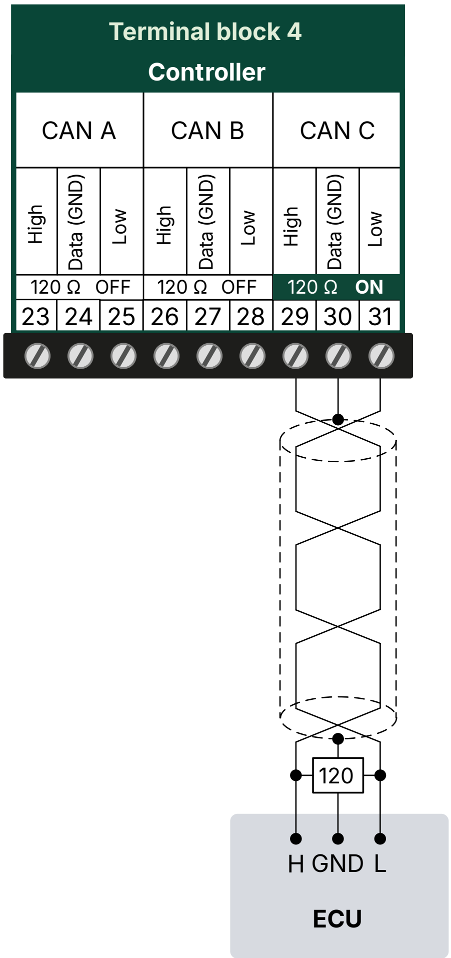
16.2.6.2 CAN bus cable

Recommended CAN bus cable

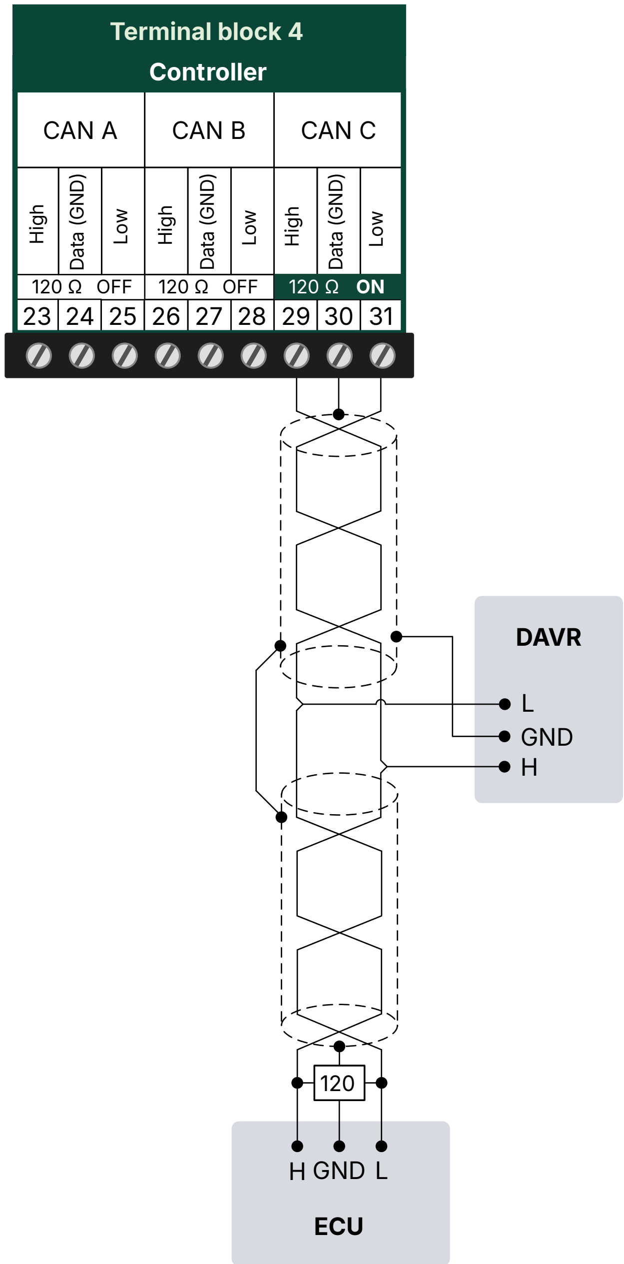
CAN communication (Engine, DAVR) RS-485 communication (Modbus)
Belden 3105A or equivalent, 22 AWG (0.33 mm²) twisted pair, shielded, impedance 120 Ω (Ohm), < 40 mΩ/m, min. 95 % shield coverage.

16.2.6.3 CAN bus ECU or DAVR communication

ECU only



DAVR and ECU on same CAN bus



16.2.7 Ethernet communication

16.2.7.1 About communication

The controllers communicate with each other to manage the system over the DEIF network Ethernet. Controllers are connected together in a network with Ethernet cables.

Controllers can be connected with **Network chain** or **Network ring** configuration. Do not include display units or other equipment in the chain or ring. Alternatively, controllers can be connected using a star configuration.

Connect the controller in a **Network ring** configuration for communication redundancy. If there is a disruption or failure to one of the connections, the DEIF proprietary ring protocol changes the communication path within 100 milliseconds.

You can use either the **Display** or **PICUS** to configure the controller rack communication. You must use the **Display** to configure the display specific IP address settings. Changes to communication settings require a power cycle.

DANGER!

Power cycle

The controller or display must be powered off and powered on for communication changes to apply.

This must be done by authorised personnel who understand the risks involved in accessing the power supply or installation design. Take extreme care in the enclosure next to the ACM terminals. The controllers must not be in operation and the controlled breakers must be open.

A new controller has a default **Controller ID** of **0** (zero). You must configure the ID to the required ID number, otherwise an alarm occurs. The controller ID must be the same as on the single-line application drawing.

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

16.2.7.2 Constraints

- Up to 64 controllers can be connected to each other in each network.
- Display units can be connected to the controllers, but must not be used as part of a network chain or ring.
- Configurable switches and fiber extenders can be included in the network.
  - It is the customer's responsibility to configure and test these.
  - DEIF is not responsible for the performance or functionality of any non-DEIF equipment in the network.
- The Ethernet cables must not be longer than 100 metres, point-to-point.
- The Ethernet cables must meet or exceed the SF/UTP CAT5e specification.
- The Interconnection (major ring) can only be used for infrastructure network.

16.2.7.3 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 3.
Functions	• Load sharing communication • Authentication (non-DEIF equipment cannot disrupt communication) • Connects the other controllers. • Password protection 　◦ Customisable permission levels

16.2.7.4 Communication settings

Setting	Range	Default	Notes
`Controller ID`	1 to 64	0	If you change the controller ID using the display, you must update the controller ID in the PICUS single-line application drawing. (This is not required for single controller applications, since they are not affected by controller ID changes.)

Setting	Range	Default	Notes
			The system can have up to 32 controllers, with controller IDs in the given range.
`IPv6 address`		No default	This cannot be changed.
`Static IPv4`	Enabled, Not enabled	Not enabled	**Enabled** uses IPv4 address. **Not enabled** uses IPv6 address.
`IPv4 address`	0.0.0.0, 255.255.255.255 *	No default	Static IPv4 address for the controller.
`Subnet mask`	0.0.0.0, 255.255.255.255 *	No default	Depends on the IPv4 address.
`Default gateway`	0.0.0.0, 255.255.255.255 *	No default	
`Preferred DNS`	0.0.0.0, 255.255.255.255 *	No default	
`Alternate DNS`	0.0.0.0, 255.255.255.255 *	No default	

NOTE * The range of addresses that you can actually use depends on your network design. If you select **Static**, then you must give the controller a unique IPv4 address. In addition, some addresses in this range are reserved.

NOTICE

Controller restart required

The controller must be powered off and powered on again for changes to these settings to take effect.

16.2.7.5 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.

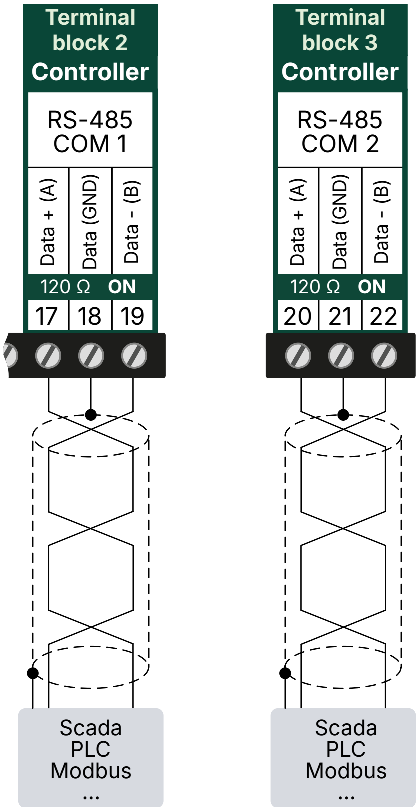
NOTE * You cannot configure all Ethernet ports as **Disabled**. At least one Ethernet port must remain configured.

16.2.8 Serial communication COM 1 / COM 2

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

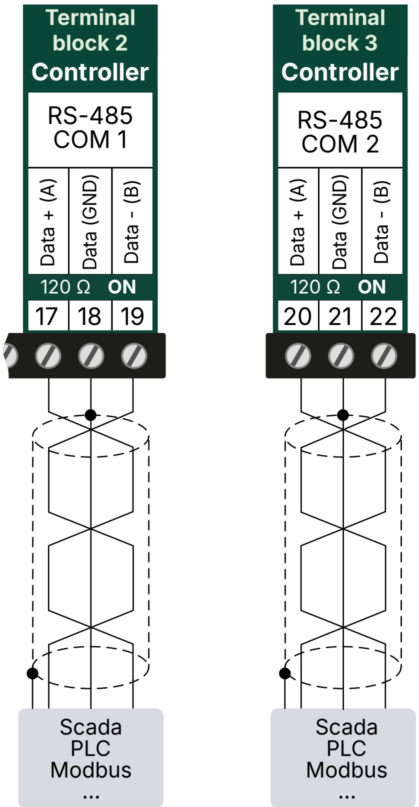
2-wire connection

With 2-wires, connect the GND terminal to the cable shield. Only connect the shield to earth at one end.



3-wire connection

Only connect the shield to earth at one end.



16.2.9 Factory reset

To use the controller in a new application, it can be useful to do a factory reset.

NOTICE

A factory reset deletes all controller information

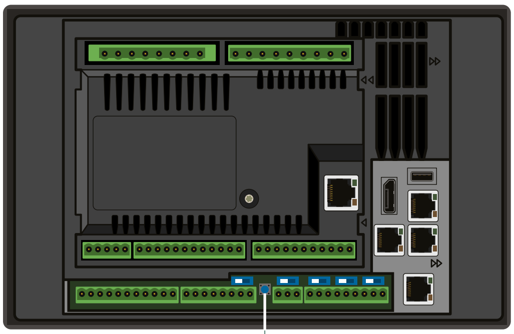
You cannot recover any controller information after a factory reset. All settings, including Ethernet configuration and passwords, are reset to their defaults.

Make sure that you want to do a factory reset. Create a full controller backup, and store it safely on your computer. Make sure that you have the information that you will need after the factory reset. This should include the default passwords, along with the new user and password configuration, and the Ethernet communication settings.

More information
See the PICUS manual for how to create backups from your controller.

How to do a factory reset

1. Remove the controller power supply.
2. Press and hold the factory reset button located at the bottom:



Factory reset

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.

16.2.10 CPU load as an analogue output

You can configure an analogue output with a function for the CPU load. The controller uses the configured curve to convert this value to an analogue output. You can configure functions for the CPU load overall, or for any of the CPU cores.

Analogue output

`Hardware > CPU > Load`

Function	I/O	Units	Details
`Currently [%]`	Analogue output	0 to 100 %	The controller measures the overall CPU load as a percentage.
`Average over 10 seconds [%]`	Analogue output	0 to 100 %	The controller measures the average CPU load over 10 seconds as a percentage.
`Average over 1 minute [%]`	Analogue output	0 to 100 %	The controller measures the average CPU load over 1 minute as a percentage.
`Average over 10 minutes [%]`	Analogue output	0 to 100 %	The controller measures the average CPU load over 10 minutes as a percentage.

`Hardware > CPU > Core #*`

Function	I/O	Units	Details
`Currently [%]`	Analogue output	0 to 100 %	The controller measures the CPU core # load as a percentage.
`Average over 10 seconds [%]`	Analogue output	0 to 100 %	The controller measures the average CPU core # over 10 seconds as a percentage.
`Average over 1 minute [%]`	Analogue output	0 to 100 %	The controller measures the average CPU core # over 1 minute as a percentage.
`Average over 10 minutes [%]`	Analogue output	0 to 100 %	The controller measures the average CPU core # over 10 minutes as a percentage.

NOTE # is 1 to 4.

16.3 Add-on modules

16.3.1 Measurement Input Output module MIO2.1

16.3.1.1 Voltage measurements

The MIO2.1 has two sets of terminals for voltage measurement. Terminals 78 to 81 measure the voltage on the A-side. Terminals 83 to 86 measure the voltage on the B-side.

The MIO uses the voltage measurements for synchronisation and protective functions. The measurements are shared with the controller for regulation, supervision, and logging. For power functions, the A-side voltage measurements are used combination with the relevant current measurements (terminals 72 to 77, or 70 to 71).

For 3-phase systems, to supervise phase-neutral or phase-earth voltages, you must also connect the neutral voltage measurements (terminal 78 on the A-side, and terminal 83 on the B-side).

16.3.1.2 Current measurements

The MIO2.1 measures the current, then uses these measurements for protective functions. The current measurements are shared with the controller for supervision and logging. For power functions, the A-side voltage measurements are used combination with the relevant current measurements (terminals 72 to 77, or 70 to 71).

You do not have to connect 4th current (terminals 70 and 71). You can use the 4th current input to measure the neutral current, the earth current, or a custom current (for example, the mains current).

16.3.1.3 Digital inputs

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

Polarity

The digital inputs use negative switching.

The controller activates the *Emergency stop* safety function for a LOW digital input. For all other digital input functions, the controller activates the function for a HIGH digital input.

Configuration

The digital inputs are configurable. That is, for each digital input, you can assign digital input function(s) and/or configure alarm(s).

You can also create responses to digital inputs using CustomLogic. You can also activate some digital input functions using a Modbus command.

Controller types and application drawing

The controller type determines which digital input functions are available.

To see certain digital input functions, you must include the corresponding equipment in the application drawing.

Controller operation

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

16.3.1.4 Digital outputs

Configuration

All digital outputs are configurable.

You can assign a digital output function or an alarm to a digital output. Alternatively, you can create customised a digital output function using CustomLogic, and assign it to a digital output.

Controller types and application drawing

The controller type determines which digital output functions are available.

To see certain digital output functions, you must include the corresponding asset in the application drawing.

Configure output state

On the display or with PICUS, you can select a digital output channel and configure the output state. Under *Output state*, select **Close when active** (the output is closed while the function is active), or **Open when active** (the output is open while the function is active).

16.3.1.5 Analogue outputs

An analogue output can be used to output operating data or values.

Analogue output function

Assign one function to the analogue output. You can adjust the *Function input (x)* range.

Analogue output type

After assigning a function, under *Output (y)*, select the output type. You can also adjust the output range.

The output types that can be selected depend on the hardware.

Module	Terminals	Output types
MIO2.1	40-41 and 43-44	-10 to 10 V PWM

Analogue output curve

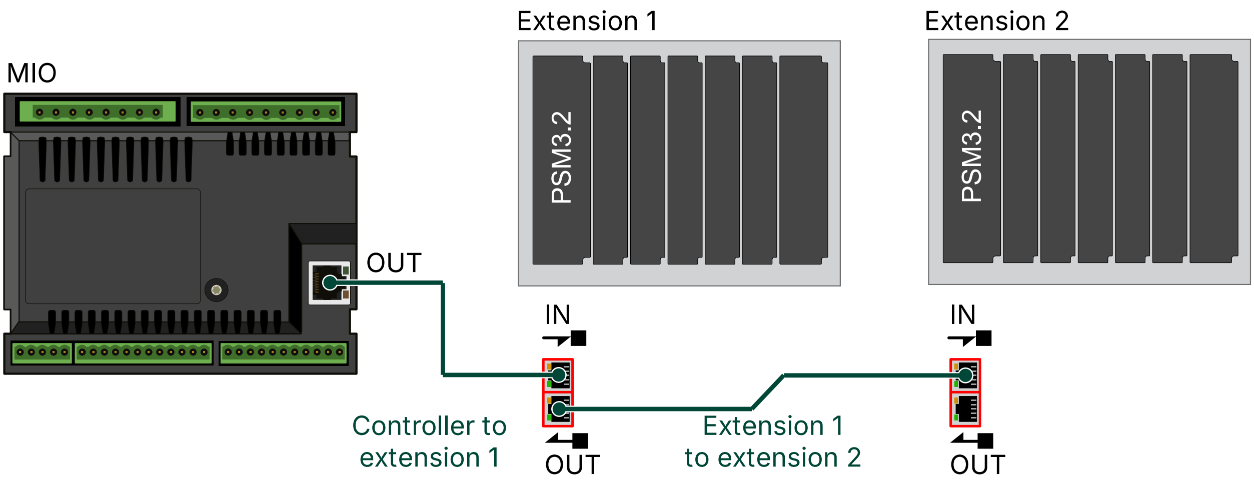
The output requires a curve. The curve allows the controller to convert the selected function's value to the analogue output.

Pre-configured curves may be available for the function. Alternatively, you can select a previously customised curve, or customise a curve.

16.3.1.6 EtherCAT communication

16.3.1.6.1 Extension rack communication

Extension racks are connected to a controller using the EtherCAT port on the MIO2.1. Do not use this port for any other communication.



NOTE EtherCAT ring connections for redundancy are not possible.

Internal communication requirements

The OUT port must always be connected to the IN port on the next extension rack.

Power off the extension rack(s) before you exchange or re-connect them to another controller.

- Up to 5 extension racks can be connected to the same controller.
- The controller and extension rack must be connected directly (without a switch between them).

EtherCAT cable requirements

- The cables must not be longer than 100 metres from point-to-point.
- The cables must meet or exceed the SF/UTP CAT5e specification.
- The cable bend radius must not be tighter than the minimum bend radius specified by the cable manufacturers.
  - We recommend that you always follow the cable manufacturer's bend radius requirements.
  - It is recommended to use velcro-strips (and not cable-ties) for the Ethernet cables.

More information
See **Fieldbus configuration** in the PICUS manual for how to configure communication with extension rack(s).

16.4 Plug-in modules

16.4.1 8 Digital bi-directional channels

16.4.1.1 Digital inputs

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

Polarity

The digital inputs use negative switching.

The controller activates the *Emergency stop* safety function for a LOW digital input. For all other digital input functions, the controller activates the function for a HIGH digital input.

Configuration

The digital inputs are configurable. That is, for each digital input, you can assign digital input function(s) and/or configure alarm(s).

You can also create responses to digital inputs using CustomLogic. You can also activate some digital input functions using a Modbus command.

Controller types and application drawing

The controller type determines which digital input functions are available.

To see certain digital input functions, you must include the corresponding equipment in the application drawing.

Controller operation

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

16.4.1.2 Digital outputs

Configuration

All digital outputs are configurable.

You can assign a digital output function or an alarm to a digital output. Alternatively, you can create customised a digital output function using CustomLogic, and assign it to a digital output.

Controller types and application drawing

The controller type determines which digital output functions are available.

To see certain digital output functions, you must include the corresponding asset in the application drawing.

Configure output state

On the display or with PICUS, you can select a digital output channel and configure the output state. Under *Output state*, select **Close when active** (the output is closed while the function is active), or **Open when active** (the output is open while the function is active).

16.4.2 4 Analogue bi-directional channels

16.4.2.1 Analogue inputs

The controller can use an analogue input to receive operating data. The controller can also activate alarms based on the analogue input.

Analogue input function

Assigning a function to the analogue input is optional.

You can assign one (or more) of the controller's analogue input functions to the input. You can only select functions that use the same units.

Analogue input type

Under *Sensor value (x-axis)*, select the input type. You can also adjust the input range.

You can select from these input types:

- 0 to 20 mA
- 0 to 10 V
- 0 to 10000 ohm

Analogue input sensor setup

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

Pre-configured curves may be available for the function. Alternatively, you can select a previously customised curve, or customise a curve.

Sensor failure

You can configure customised alarms for sensor failure. The *Below range alarm* is activated when the analogue input is below the specified value. Similarly, the *Above range alarm* is activated when the analogue input is above the specified value.

NOTICE
Use of sensor failure alarms Do not use the sensor failure alarms to respond to ordinary operating data. Configure customised analogue input alarms instead.

Analogue input alarms

You must complete the sensor setup before configuring any analogue input alarms.

You can configure any number of alarms for an analogue input. However, you cannot exceed 25 customised alarms for the controller.

Supervised binary input

Analogue inputs used for supervised binary inputs should be configured using the function type **Supervised binary**.

Use an analogue input curve to define the supervised binary input. The supervised binary input curve is a step function. That is, the curve consists of a horizontal line (with the value 0 or 1), a vertical line (the point where the curve changes), and another horizontal line (with the value 1 or 0).

To avoid instability, configure the curve so that the change point is far away from the input closed and open values.

If the analogue input measurement corresponds to a function input that is **not zero**, then the controller uses **one** as the function input.

16.4.2.2 Analogue outputs

An analogue output can be used to output operating data or values.

Analogue output function

Assign one function to the analogue output. You can adjust the *Function input (x)* range.

Analogue output type

After assigning a function, under *Output (y)*, select the output type. You can also adjust the output range.

The output types that can be selected depend on the hardware.

Analogue output curve

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

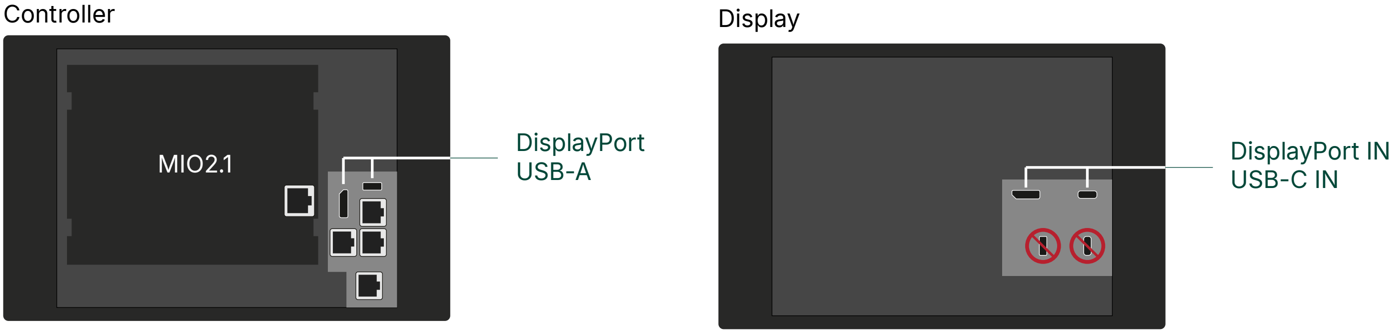
Pre-configured curves may be available for the function. Alternatively, you can select a previously customised curve, or customise a curve.

16.5 iE 7 Local display

16.5.1 iE 7 display connections

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

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

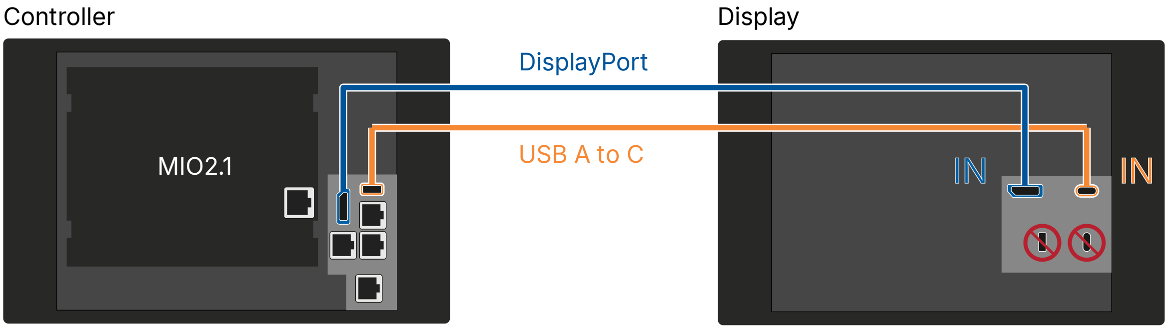


The additional USB ports on the display are for future use.

Connection constraints

- The display is only for use with a base-mounted controller.
- The **DisplayPort IN** and **USB type C IN** cables must be connected to operate the base-mounted controller.
- Controllers must be connected directly without a USB hub or similar.
- All USBs support 2.0.
- Both the DisplayPort and USB A to C cables are supplied.
- Connection to the display must use the ports marked **IN**.

Base-mounted controller to display connection



USB Connection to display must use USB IN.

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	
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 mains failure		A plant mode where the gensets automatically take over the load from the mains connection if the mains fails.
Available power		In power management, available power is the capacity of the system to supply more power.
Base load		The generator supplies a constant load. For **GENSET** controllers, configure the asymmetric load sharing parameters to have a base load from a specific genset.
Blackout		The busbar voltage is less than 10 % of the nominal voltage, and all generator breakers are open.
Breaker		A mechanical switching device that closes to connect power sources to the busbar, or to connect busbar sections. The breaker opens to disconnect the power sources or to split the busbar.
[B-side]		The B-side side of the breaker. For a **GENSET** controller, this is the busbar. For a **BUS TIE breaker** controller, this is Busbar B.
Busbar		The copper conductors which connect the power sources to the power consumers. Represented on the single-line application drawing as the line that connects all the power sources and power consumers. If the bus tie breaker is open, there are two separate and independent busbar sections. Similarly, if the bus tie breaker is closed, there is only one busbar.

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.
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	
EMERGENCY genset controller		Controls and protects an emergency genset.
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.
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.
Fixed power		A plant mode where the plant produces a fixed amount of power.
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. The Power Management System can automatically start and stop gensets to ensure that the required power is available.
Governor	GOV	Regulates the engine speed.
Ground		A connection between the equipment and earth. For marine applications, a ground is a connection to the ship's frame.
	GOST	Regional standards maintained by the Euro-Asian Council for Standardization, Metrology and Certification.
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.
Hybrid controller		Controls an inverter with a power source. This includes control of the breaker.
Hysteresis		An offset added to prevent rapid switching when a value is near the control point.
Ingress Protection Rating, or International Protection Rating	IP	The degree of protection against solids and water provided by mechanical casings and electrical enclosures.
Inhibit		A pre-defined condition that inhibits the alarm action. For example, for the inhibit ACM wire break, if the controller detects a wire break on the voltage measurements, the voltage unbalance alarm is prevented from occurring. Inhibited alarms are not shown in the alarm display.
Institute of Electrical and Electronics Engineers	IEEE	
International Association of Classification Societies	IACS	
International Electrotechnical Commission	IEC	

Term	Abbreviation	Explanation
International Organization for Standardization	ISO	
Internet Protocol version 4	IPv4	A protocol for communication across networks. IPv4 currently routes the most traffic on the Internet, but will gradually be replaced by IPv6.
Internet Protocol version 6	IPv6	A protocol for communication across networks. Among other things, IPv6 has a much larger address space than IPv4.
	JEM-TR177	Japan Electrical Manufacturers Association's noise standard.
Latch		An extra layer of protection that keeps the alarm action activated. When the alarm is not active and acknowledged, it can be unlatched.
Light emitting diode	LED	Used to show the controller and equipment status and alarms.
Liquid crystal display	LCD	The screen of the display unit. The information displayed varies, depending on the controller mode, the equipment operation and the operator input.
Load sharing		The controllers adjust the gensets so that each genset supplies the right amount of the total power. For equal load sharing, each genset supplies the same proportion of its nominal power.
Magnetic pickup	MPU	Measures the genset speed (that is, RPM). This sensor is normally located at the genset flywheel.
Manual mode	Manual	A controller operating mode. Operator commands (for example, close breaker) start pre-programmed sequences in the controller. Apart from trips, the controller does not automatically open or close breakers or start or stop the asset.
Mean Time Between Failures	MTBF	
Mean Time To Failure	MTTF	
Multi-line 300	ML 300	A DEIF product platform.
Multi-master system		All controllers perform all the power management calculations, based on shared information.
Name	[ ]	Square brackets show that the name inside the square bracket must be adapted according to the controller type. For example, for a **GENSET** controller, [A-side] is "Generator".
National Electrical Code	NEC	A standard for the safe installation of electrical wiring and equipment in the United States.
Network time protocol	NTP	Used to synchronise the time of a computer client or server to another server or reference time source.
Neutral	N	The neutral line in a three-phase electrical system.
Network ring		An Ethernet connection topology where the controllers are connected in a line, and the last controller is connected back to the first.
Network chain		An Ethernet connection topology where the controllers are connected in a line.
Nominal setting	nom or NOM	The expected voltage and frequency for the system, and each power source's maximum load and current. Many of the controller's alarms are based on percentages of the nominal settings.
	NPN	A type of transistor.
Number	#	Hash represents a number. The description is the same for each item in the range. For example, "Controller ID #" represents any of the possible controller IDs.
Oil pressure	OP	

Term	Abbreviation	Explanation
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.
Power management system	PMS	The power management controllers work together as a power management system.
Printed circuit board	PCB	Supports and electrically connects components.
Programmable logic controller	PLC	A digital computer used for the automation of electromechanical processes.
Proportional integral derivative	PID	A feedback controller.
Pt100, Pt1000		Platinum temperature sensors
Pulse width modulation	PWM	Terminals with an output that uses variable pulse widths, and behaves as an analogue output.
	PNP	A type of transistor.
Rapid spanning tree protocol	RSTP	A protocol used to compute the topology of a local area network.
Reactive power	Q	The 3-phase reactive power, measured in kvar.
Reference		The signal sent to a control system that represents the desired value of the output.
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.

Term	Abbreviation	Explanation
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.
SHAFT generator controller		Controls and protects the system when a shaft generator is connected.
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.
SHORE connection controller		Controls and protects the system and a shore connection breaker, when a shore connection is connected.
Shutdown		An emergency or fast stop of the genset engine. No cooldown time is allowed.
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 the emergency generator breaker and the busbar.
Time	t	
Transmission control protocol/internet protocol	TCP/IP	The Internet protocol suite. It provides end-to-end connectivity by specifying data handling.
Trip		An emergency or fast opening of a breaker. No attempt is made to de-load the breaker before it opens.
United Kingdom	UK	
United States of America	US, USA	The USA sometimes requires different technical standards. They also use their own system of units.
Universal serial bus	USB	Communication protocol.
	UL 94	A plastics flammability standard released by Underwriters Laboratories of the USA.
Voltage	V	Electrical potential difference. U is used as an abbreviation for voltage in most of Europe, Russia and China.

Term	Abbreviation	Explanation
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				
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)				

Unit	Name	Measures	US unit	US name	Conversion	Alternative units
W	watt	Power				
Ω	ohm	Resistance				

17.3 Symbols

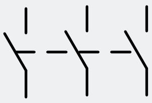
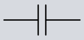
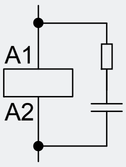
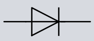
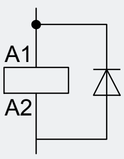
17.3.1 Mathematical symbols

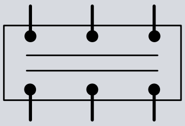
Abbreviation	Symbolises	Example
+	Addition	2 + 3 = 5
-	Subtraction	5 - 2 = 3
x	Multiplication (numbers)	2 × 3 = 6
/	Division	15 / 3 = 5
·	Multiplication (units)	5 N·m = 5 Newton metres
Σ	Summation	Σ Nominal power for connected gensets = 1000 kW + 1500 kW + 500 kW = 3000 kW

17.3.2 Drawing symbols

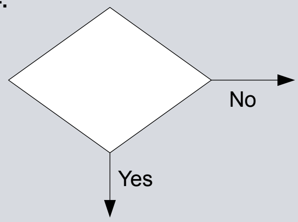
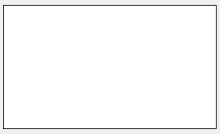
The drawings use EU symbols.

Electrical symbols

Symbol	Symbol name
	3-phase breaker
	Capacitor
Contactor 	Contactor with RC snubber
•	Connector dot
	Current transformer (S1 and · show "current in"; S2 shows "current out")
	Diode
	Fuse
Ω	Ohmmeter
Relay 	Relay with freewheeling diode

Symbol	Symbol name
	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
	Information message
	Start or end