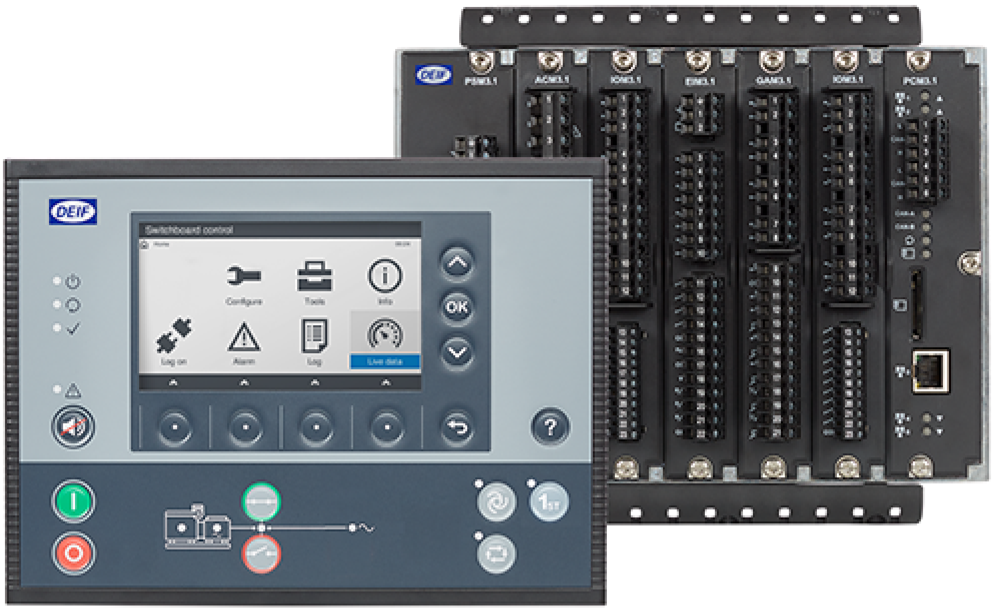
DESIGNER'S HANDBOOK

PPM 300

Protection and Power Management



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3. AC configuration and nominal settings

5. Breakers, synchronisation and de-loading

8. Engine interface communication

9. GENSET controller

15. Modbus

16. Hardware characteristics

1. About the Designer's handbook

1.1 Intended users of the Designer's handbook

The Designer's handbook is primarily for the person who designs the control system, electrical system, and communication system where the controllers are installed. This includes drawing the system drawings, setting the controller parameters, and selecting and setting up the protections and functions. The Designer's handbook can also be used during commissioning to check the design drawings and the controller parameters. Operators may find the Designer's handbook useful for understanding the system and for troubleshooting.

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

1.2 Symbols and conventions in the Designer's handbook

Inputs and outputs

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

Parameters

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

Functions

As far as possible, the Designer's handbook descriptions are based on functions. Each function description includes the relevant input and output functions, and parameters.

Multi-function parameters and I/Os

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

Parameter used by more than one function example

For a GENSET controller, **Configure > Parameters > Generator > Nominal settings > Nominal settings 1 > Voltage (V)** is the genset *Nominal voltage* for the first set of nominal settings. The *Nominal voltage* is the basis for all the voltage alarms.

General names

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

Use of square brackets examples

[Source] represents the *Generator* for a GENSET controller.

[Hardware module] represents the relevant controller hardware module.

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

More information
See **System principles, Overall principles, General names for controller types** for more information.

Numbered possibilities

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

Use of hash # example

Controller ID #: # represents 1 to 64. That is, the system can have up to 32 controllers, each with their own unique Controller ID between 1 and 64.

Number format

The number format uses the following symbols.

Description	Symbol	Symbol name	Example
Decimal separator	.	dot	10.1 s = 10 seconds 100 milliseconds
Thousands separator	,	comma	20,000 kW = 20 MW

1.3 Symbols for notes

Safety notes

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

CAUTION
This highlights potentially dangerous situations. If the guidelines are not followed, these situations could result in personal injury or damaged equipment.

General notes

INFO
This highlights general information.

More information
This highlights where to find more information.

Example heading

This highlights examples.

1.4 Software versions

The information in this document corresponds to the following software versions.

PPM 300 Software versions

Software	Details	Version
PCM APPL	Controller application	1.0.15.x
DU APPL	Display unit application	1.0.15.x
PICUS	PC software	1.0.15.x

1.5 Technical support

If you need technical support:

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

You can read more about service and support options on www.deif.com.

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 and the relay terminals, as this could lead to injury or death.

Controller power supply

The controller must have 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.

If the controller has no power supply, it is OFF and does **not** provide any protection. The controller cannot enforce any trips, shutdowns or latches when it is off. The controller does **not** provide any control or power management. All the controller relays de-energise.

Connect the controller 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

Under *Switchboard control*, the operator controls and 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 any power management.
- The controller **does not** accept operator commands.
- The controller cannot and **does not** prevent any manual operator actions.

The switchboard design must therefore ensure that the system is sufficiently protected when the controller is under *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 present. If the alarm action is manually overridden, a latched alarm does NOT provide any 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

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

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.

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

Do not manually override active alarm actions

DANGER!

Manual override of alarm action

Do not override the alarm action of an active alarm.

An alarm may be active because it is latched, or because the alarm condition is still present. If the alarm action is manually overridden, a latched alarm does NOT provide any protection.

Latched *Over-current* alarm example

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

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

Do not use unsupported hardware modules

Only use the hardware modules that are listed in the Technical specifications. Unsupported hardware modules can make the controller malfunction.

Data security

To minimise the risk of data security breaches we recommend:

- If possible, avoid to expose controllers and networks to public networks and the Internet.
- Use additional security layers like a VPN for remote access.
- Install a firewall.
- Restrict access to authorised persons.

1.7 Legal information

Third party equipment

DEIF takes no responsibility for the installation or operation of any third party equipment, including the **genset**.

Warranty

The rack may only be opened to remove, replace, and/or add a hardware module or the internal battery on PCM3.1. The procedure in the **Installation instructions** must be followed. If the rack is opened for any other reason, and/or the procedure is not followed, then the warranty is void.

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

Open source software

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

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2. System principles

2.1 About the controllers

2.1.1 About the PPM 300

The PPM 300 Protection and Power Management controller is a highly configurable and designed for marine use. It includes a wide range of control, protection and supervision functions. Applications range from simple genset control and protection, to fully integrated and engineered power management solutions, developed for fuel-efficient operation. Each controller contains all the functions that are needed to protect and control a diesel generator, an inverter with battery storage (HYBRID), an emergency diesel generator, a shaft generator, a shore connection, or a bus tie breaker. You can connect up to 32 controllers to create one integrated system solution for standard applications.

The controllers' power management system controls the system and ensures that it operates optimally. It ensures that the power required is always available and takes preventative actions to ensure a reliable power supply. Up to 64 heavy consumers can be configured in the system.

The PPM 300 controllers work together as a true multi-master system. This means that each controller functions as a master controller. If a controller fails, the remaining controllers continue to function. Redundant communication between the controllers is possible. If a communication link fails, the system continues to function.

AC measurements can be configured with average filters for use on noisy or oscillating systems.

The controller display unit can have push-buttons for the operator to change the controller mode, close and open the breaker, and start and stop a generator or inverter. The colour graphic screen shows status and info messages. Visual synchronisation screen shows the synchronisation state and values. The screen also allows access to live data, and alarm management. With the right authorisation, the operator can also check and/or change the input/output and parameter configuration. The light indicators of the display unit show the system status.

Each controller includes processors and high-speed internal communication. This provides fast protection functions and includes built-in redundancy.

The controller design is modular, and hardware modules may be replaced or added in the field.

PICUS is a proprietary, free PC software interface to the controller. The designer can use PICUS to create a single-line diagram for the system, and configure the inputs, outputs and parameters for all the controllers in the system. PICUS also offers system emulation, supervision, and management of permissions, backups and firmware updates.

Flexible application creation in PICUS with the added option for quick connection of equipment.

The network communication can be configured for IP address settings and for type of Ethernet port and connection node.

2.1.2 Controller types

The GENSET controller type controls both a breaker and the genset engine. The EMERGENCY genset controller type controls both breakers and the genset engine. The HYBRID controller type controls both the inverter breaker and the inverter. The SHAFT generator, SHORE connection, and BUS TIE breaker controller types each control one breaker.

The hardware listed is for the recommended configuration. Additional modules may be ordered and mounted as required. A customised PPM 300 controller may also be ordered. For example, you may need additional inputs and outputs.

Type	Application	Slot 1	Slot 2	Slot 3	Slot 4	Slot 5	Slot 6	Slot 7
GENSET	Control and protection of a diesel generator	PSM3.1	ACM3.1	IOM3.1	EIM3.1	GAM3.1	IOM3.1	PCM3.1
EMERGENCY genset	Control and protection of an emergency diesel generator (including as a harbour generator)	PSM3.1	ACM3.1	IOM3.1	EIM3.1	GAM3.1	Blind module	PCM3.1
HYBRID	Control and protection of an inverter and power source.	PSM3.1	ACM3.1	IOM3.1	EIM3.1	GAM3.1	IOM3.1	PCM3.1
SHAFT generator	Control and protection for a shaft generator	PSM3.1	ACM3.1	IOM3.1	Blind module	Blind module	Blind module	PCM3.1
SHORE connection	Control and protection for a shore connection	PSM3.1	ACM3.1	IOM3.1	Blind module	Blind module	Blind module	PCM3.1
BUS TIE breaker	Control and protection for a bus tie breaker	PSM3.1	ACM3.1	IOM3.1	Blind module	Blind module	Blind module	PCM3.1

2.1.3 Change controller type

You can change the type of the controller with the display unit (**Tools > Advanced > Change type**). This feature requires the necessary permission in order to access it.

Restrictions on changing type

Changing the controller type is restricted by the initial type of the controller.

- GENSET, EMERGENCY genset or HYBRID controllers can be changed to any other PPM 300 controller type.
- SHAFT generator, SHORE connection, or BUS TIE breaker controllers can only be changed to one of these three controller types.

You can only change the controller type if it is safe for commissioning:

1. The engine must be stopped (not applicable to BUS TIE breaker controller).
2. The breaker must be open (for EMERGENCY genset controller, BOTH breakers must be open).
3. The controller must be under 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.

More information
See the controller types in the **Data sheet** for more information on each different controller configuration.

2.2 Application as a system

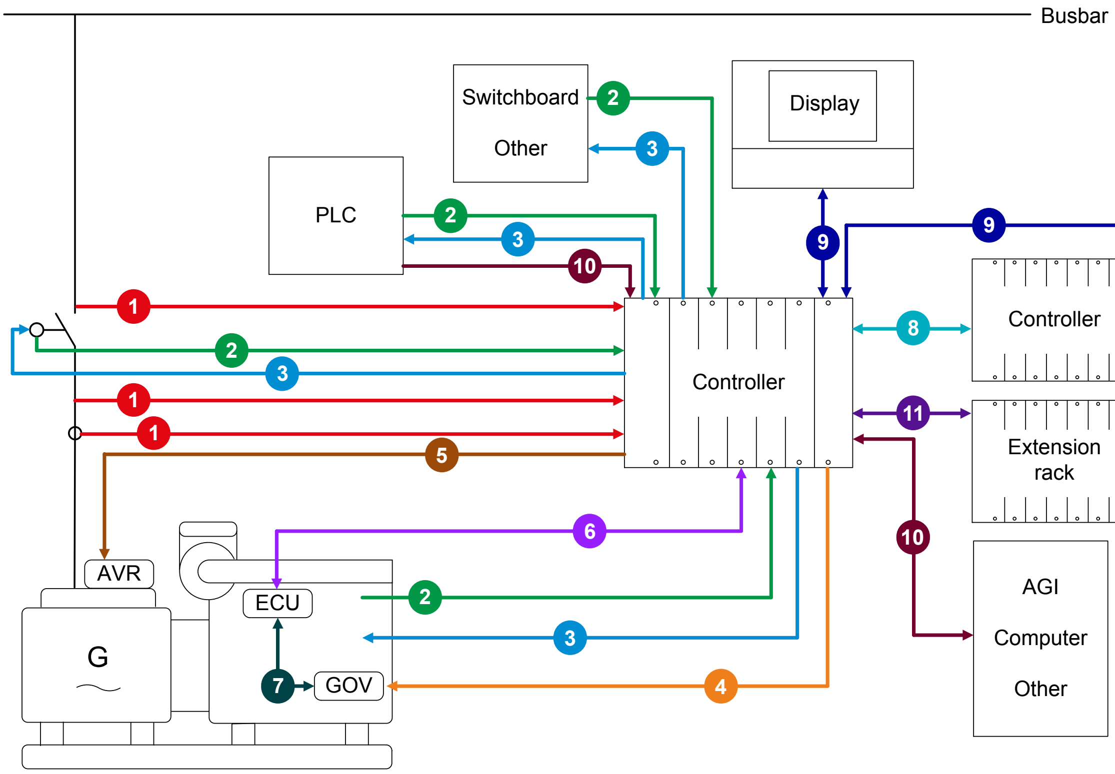
2.2.1 How it works

The PPM 300 controllers work together as a standard power management system for use in marine applications. The system provides power management, protection and supervision functions.

The power management system calculates the control set points, although some of these can also come from third party equipment (external set points). The power management system automatically starts and stops engines, and closes and opens breakers. The operator, or another external source, can also initiate these actions.

A number of controllers are used together to create a controller system. Each controller has configurable hardware, which in turn has configurable inputs and outputs. The controller gets information from the measurements, the inputs, and the DEIF network. The controller sends out information using the outputs, and the DEIF network.

Information can flow between a GENSET controller and the genset it controls in many ways. It can also flow to the display, another controller, a PLC, and the switchboard.



Point	Type	Description	Uses
1	AC measurements	The controller measures the AC voltage and current from the genset and the voltage on the busbar.	Protection, running detection, control, synchronisation, power management, and logging.
2	Analogue and digital inputs	Analogue and digital measurement devices on the genset can be connected to the controller. The controller can also receive analogue and digital inputs from breakers, a PLC, the switchboard, and other sources (for example, heavy consumers).	A wide variety of purposes, including protection, user inputs, various levels of alarms, power management, running detection, and logging.
3	Analogue and digital outputs	The controller can send analogue and digital outputs to the genset, breakers, a PLC, the switchboard (for example, for lights and meters), and other equipment (for example, heavy consumers).	A wide variety of purposes, including control, status and alarm indicators, and as input to a PLC.
4	Analogue or digital outputs for governor control	The controller can control the genset governor (GOV) using digital outputs (relay control), or analogue outputs.	Regulate the genset frequency, and/or active power (depending on the system configuration).
5	Analogue or digital outputs for AVR control	The controller can control the genset automatic voltage regulator (AVR) using digital outputs (relay control), or analogue outputs.	Regulate the genset voltage and/or reactive power (depending on the system configuration).
6	CAN bus communication	The controller receives information from the ECU using CAN bus communication.	Read the engine data, various levels of alarms, running detection, and logging.
7	ECU controls GOV (future use)		

Point	Type	Description	Uses
8	Analogue load sharing	The controllers produce a voltage proportional to the percentage of their nominal power for the load sharing line, and then use the voltage on the load sharing line to adjust their genset set points.	Equal load sharing (active and/or reactive) between 2 or more gensets.
9	DEIF network	The DEIF equipment communicates with other DEIF equipment using this network.	Send inputs from the display to the controller, and information from the controller to the display. Send information from one controller to another, including power management, load sharing, and heavy consumers.
10	Modbus TCP/IP	Allows external devices to communicate with the controller using the Modbus TCP/IP communication protocol.	A wide variety of purposes, including monitoring, off site control, and alarm handling.
11	Internal communication	Allows DEIF controllers to communicate with DEIF extension units. The communication ports are located on the power supply modules (PSM).	Extend controller functionality by adding additional inputs and outputs to one or more extension units.

Configurable hardware

After you assign a function to an input or output, you can assign parameters to that function. Each controller type has a default configuration.

Most of the controller inputs and outputs can be assigned any function. Functions are **not** restricted to specific hardware modules. For example, governor and AVR control functions can use any inputs and outputs, and do **not** have to use the inputs and outputs on the Governor and AVR modules (GAM3.1 and/or GAM3.2).

Variety of input and output types

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

For example, a generator breaker close can be initiated by the power management system for a GENSET controller in AUTO mode. Alternatively, if the GENSET controller is in SEMI mode, an operator using the display unit, PICUS, a digital input, CustomLogic, or an external system using a Modbus command can initiate the generator breaker close.

Similarly, the generator excitation (AVR) can be controlled using an analogue output, or digital outputs.

The DEIF network allows information from all the controllers to be used by any of the controllers. For example, for 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.

Each controller's display only displays the operating information for the paired controller.

2.2.2 Maximum number of controllers

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

These restrictions also apply:

Types	Possible	Notes
GENSET controller	1 to 32	There must be at least one GENSET controller.
EMERGENCY genset controller	0 to 1	
HYBRID controller	0 to 32	

Types	Possible	Notes
SHAFT generator controller	0 to 31	See **Restrictions**.
SHORE connection controller	0 to 31	See **Restrictions**.
BUS TIE breaker controller	0 to 31	

2.2.3 Restrictions

PPM 300 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

PPM 300 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

PPM 300 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.

2.2.4 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*. 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 SEMI 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.

Table 2.1 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.	SEMI	External	The operator presses the **Start** button on the display unit. The controller gets the command over the DEIF network, and starts the sequence to start the genset.

Command	Mode	Type	Example
A digital input, which is assigned an external command function, is activated.	SEMI	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. Under **Configure > Input/output**, 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.	SEMI	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.	SEMI	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).	SEMI	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 info message if the controller cannot execute the command. For example, if a GENSET controller is under *Switchboard control*, it ignores a *Start engine* command. The controller displays the info message *Engine start not possible in SWBD*.

2.2.5 Priority of input sources

Each controller can receive inputs from a number of sources. The rules for when a source can be used, as well as how the controller handles conflicting inputs, are described below.

Digital input functions

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

Rules 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. 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.
4. 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 unit push-buttons have the same priority as wiring connected to hardware.

Analogue input functions

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

Rules for analogue input functions:

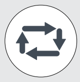
1. If the analogue input function is assigned to hardware, Modbus can only read the input value. Modbus and CustomLogic cannot modify the input value.
2. If the analogue input function is not assigned to hardware, Modbus and CustomLogic can modify the input value.
3. If Modbus and CustomLogic send conflicting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

2.3 Control and modes

2.3.1 About the control modes

The controllers use control types and modes to distinguish between fully automatic operation and various degrees of operator (or external) control.

Table 2.2 Controller types and modes

Type	PMS control	AUTO mode	SEMI mode	SWBD control
Push-button				
GENSET controller	●	●	●	●
EMERGENCY genset controller	●	●	●	●
HYBRID controller	●	●	●	●
SHAFT generator controller	●	-	-	●
SHORE connection controller	●	-	-	●
BUS TIE breaker controller	●	-	-	●

- The **GENSET**, **HYBRID**, and **EMERGENCY genset** controllers normally run in AUTO mode. Alternatively, they can run in SEMI mode, so that an operator or external command can initiate a controller sequence.
  - Both AUTO and SEMI mode are under power management system (PMS) control.
  - These controllers can be changed between SEMI and AUTO mode using the display unit push-buttons, a digital input, or an external signal.
  - In AUTO mode, as needed, the power management system automatically starts (or stops) the genset engines, and connects (or disconnects) the generators breakers.
- The **SHAFT generator**, **SHORE connection** and **BUS TIE breaker** controllers are normally under PMS control.
  - These controllers do not normally automatically close their breakers.
  - An external command is required to start breaker sequences.
  - These controllers can be configured to automatically close their breakers as part of a blackout recovery sequence.
- If required, any or all of the controllers can be put under **switchboard control** (SWBD), so that the equipment can be operated and controlled manually.
  - Each controller can be put under switchboard control using a digital input, for example, from a switch on the switchboard, from a PLC, or from CustomLogic. The controller remains under switchboard control until the digital input is turned off.
- A controller is **unpowered** if it loses its power supply.

2.3.2 Power management system control

All of the controllers normally run under PMS control. The power management system is enabled and monitors the available power. Load sharing is active. AUTO mode and SEMI mode both fall under PMS control.

Input

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

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

Under *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.

Under *Switchboard control*, the controller does not accept any commands from the display unit 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.

Inputs and outputs

If needed, configure the input(s) and output for each controller under **Configure > Input/output**. Select the hardware module, then select the input/output to configure.

Table 2.3 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*.

INFO
If you want to automatically activate *Switchboard control* when the digital input is deactivated, use the *PMS control* digital input.

Table 2.4 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 under switchboard control. When this input is activated, the controller increases the output to the governor. This affects the *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 under **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 under switchboard control. When this input is activated, the controller decreases the output to the governor. This affects the *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 under **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.

Table 2.5 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 under switchboard control. When this input is activated, the controller increases the output to the AVR. This affects the *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 under **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 under switchboard control. When this input is activated, the controller decreases the output to the AVR. This affects the *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 under **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** for more information.

Manual slope

These parameters are active when the controller is under switchboard control, and the operator manually controls the regulator using the *Manual GOV increase*, *Manual GOV decrease*, *Manual AVR increase*, and *Manual AVR decrease* digital inputs.

Configure these parameters under **Configure > Parameters > Regulators > [Regulator] analogue configuration > Manual slope** (where [Regulator] is either Governor, or AVR).

These parameters are only visible if a governor or AVR output is configured.

Parameter	Range	Default	Notes
Manual GOV slope	0 to 200 %/s	1 %/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 to 200 %/s	10 %/s of genset nominal reactive 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.

Parameters

Controller types: These parameters only apply to the GENSET, HYBRID, and EMERGENCY genset controllers.

These parameters define the controller mode after certain other modes and events. You can configure these parameters under **Configure > Parameters > Local power management > Return modes > After SWBD control**.

If the controller was put under *Switchboard control*, but is now no longer under *Switchboard control*, this parameter determines the controller mode.

Table 2.6 Mode parameter

Options	Notes
No mode change	The default. After *Switchboard control*, the controller returns to the mode it was in before it was under *Switchboard control*.
SEMI mode	After *Switchboard control*, the controller mode is semi-automatic (SEMI).
AUTO mode	After *Switchboard control*, the controller mode is automatic (AUTO).

Events that force controllers under switchboard control

The following events force all the controllers in the section to operate under *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 **Power management**, **Power management protections** for the *Forced to switchboard control* 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 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 SEMI 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.

Alarms under switchboard control

Under *Switchboard control*, if the switchboard design provides for this, the operator can perform a manual synchronisation (for example, by using switchboard buttons for relay speed control of the genset) and then close the breaker. This command does not go through the controller, and the switchboard design must therefore ensure that the breaker synchronisation is always checked before closing.

If an action is performed from the switchboard that activates a controller alarm while the controller is under *Switchboard control*, the controller will execute the associated alarm action. For example, if an alarm with an alarm action *Trip generator breaker and shutdown engine* is activated while the controller is under *Switchboard control*, then the controller trips the breaker and shuts down the engine.

Alarm actions under switchboard control example

For a GENSET controller, you can create a low lube oil pressure alarm (based on an analogue input from a sensor) that has the action *Trip generator breaker and shutdown engine*. If there is a low lube oil pressure, then this alarm shuts down the engine in AUTO or SEMI mode. This alarm also shuts down the engine when the controller is under *Switchboard control*.

You can create a low oil pressure alarm with the *Warning* alarm action. If there is a low oil pressure, then this alarm activates and the warning appears even if the controller is under *Switchboard control*.

The non-essential load (NEL) trips are active under *Switchboard control*. If a condition is present that activates a non-essential load trip alarm, the non-essential loads are disconnected.

Remote breaker signals under 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.

Under *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, under *Switchboard control*, the controller will not respond to the under-voltage coil input. However, under *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 under *Switchboard control*. The controllers do not respond to blackouts or requests from heavy consumers.

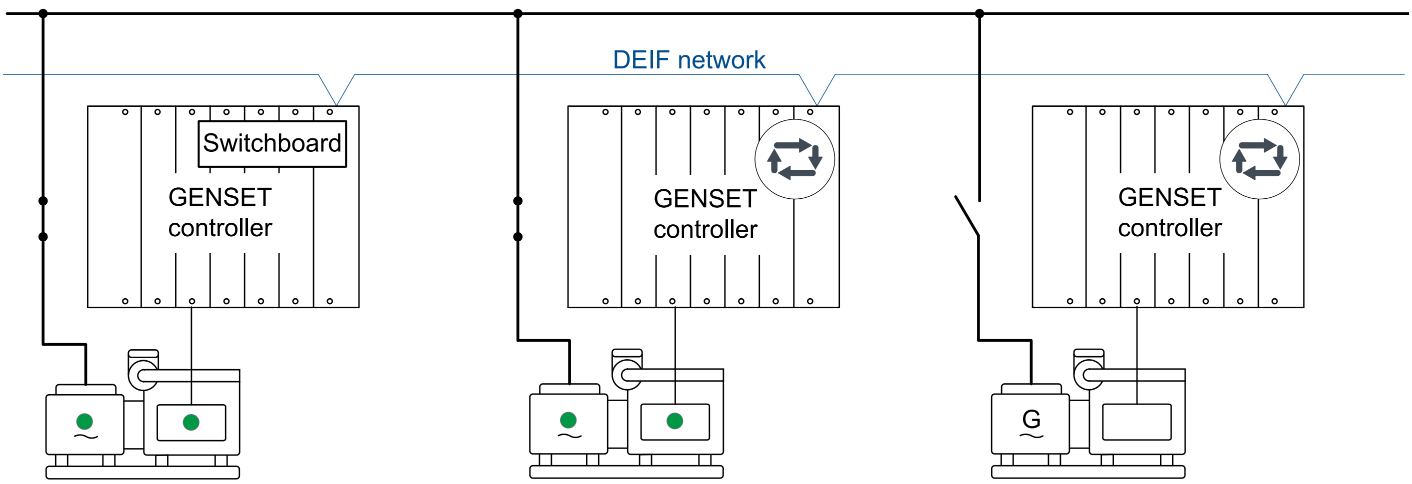
Effect of switchboard control in ONE controller

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

If the controller under *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 under *Switchboard control*, all the other GENSET controllers go into SEMI mode. Power management is disabled.



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

If any **unconnected** controller is put under *Switchboard control*, then this has no effect on the other controllers.

There can be a blackout while a connected controller is under *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

Controller types: Only 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.

Input

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

Function	I/O	Type	Details
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 unit.
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 unit of each GENSET controller.
Mode > In AUTO mode	Digital output	Continuous	Activated if the controller is in AUTO mode.

2.3.5 Semi-automatic (SEMI) mode

Controller types: Only GENSET, HYBRID, and EMERGENCY genset controllers

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

Load sharing is active in SEMI mode.

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

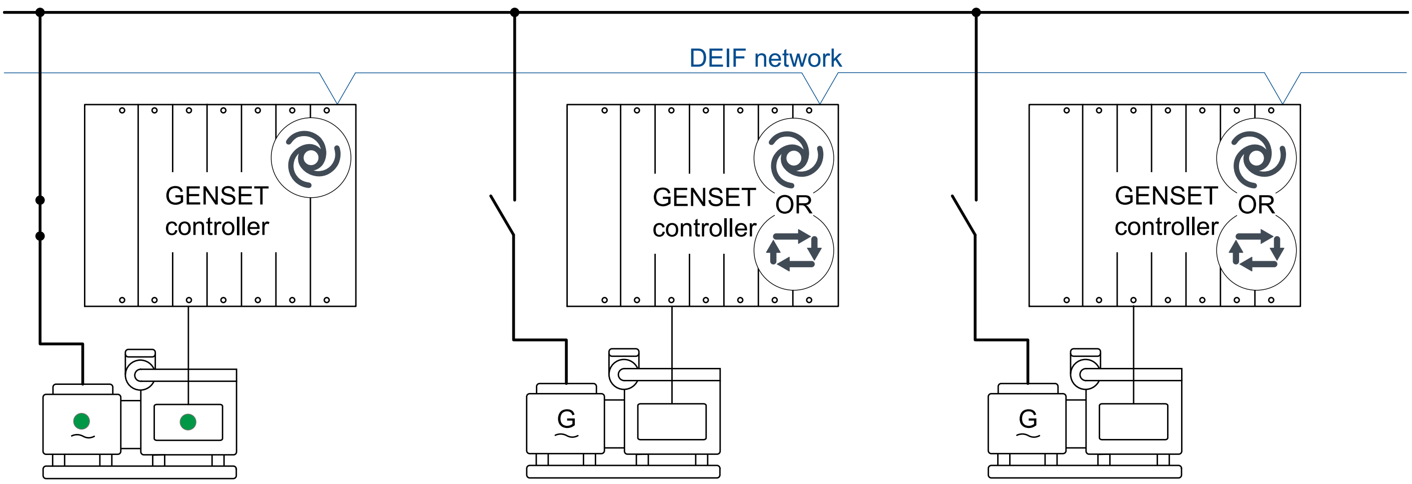
Input

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

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

Effect of SEMI mode on genset priority order

As the following drawing shows, 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 SEMI mode, and even if the genset has the lowest priority.



Event that forces controllers to SEMI mode

If one or more controller in the section with **connected** equipment is under Switchboard control, then all the controllers in the section that are in AUTO mode are forced to SEMI 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 (*Configure* > *Parameters* > *Local power management* > *Return modes* > *After SWBD control*).

More information
See **Power management**, **Power management protections** for the *Forced to SEMI mode* alarm.

2.3.6 Controller unpowered

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

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

The following alarms are activated when a controller detects that one of the system's controllers is unpowered:

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

Effect of the unpowered controller hardware

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

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

The analogue output terminals on GAM3.1 (terminals 12 and 13, and terminals 16 and 17) and GAM3.2 (terminals 3 and 4, and terminals 5 and 6) will have a resistance of over 10 MΩ.

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

Maritime classification approval societies require an independent backup power supply for the controller, to avoid having an unpowered controller.

2.4 Controller 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. For example, governor and AVR control functions can use any inputs and outputs, and do **not** have to use the inputs and outputs on the Governor and AVR module (GAM3.1).

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 equipment and systems.

For example, a generator breaker close can be initiated by the power management system for a GENSET controller in AUTO mode. Alternatively, if the GENSET controller is in SEMI mode, an operator using the display, PICUS, a digital input, CustomLogic, or an external system using a Modbus command can initiate the generator breaker close. Similarly, the generator excitation can be controlled using an analogue output, or digital outputs.

The DEIF network allows information from all the controllers to be used by any of the controllers. For example, for 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.

Each controller's display only displays the operating information for that controller. However, the controller processor also has access to operating information from the rest of the system.

2.5 Alarms and protections

2.5.1 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.

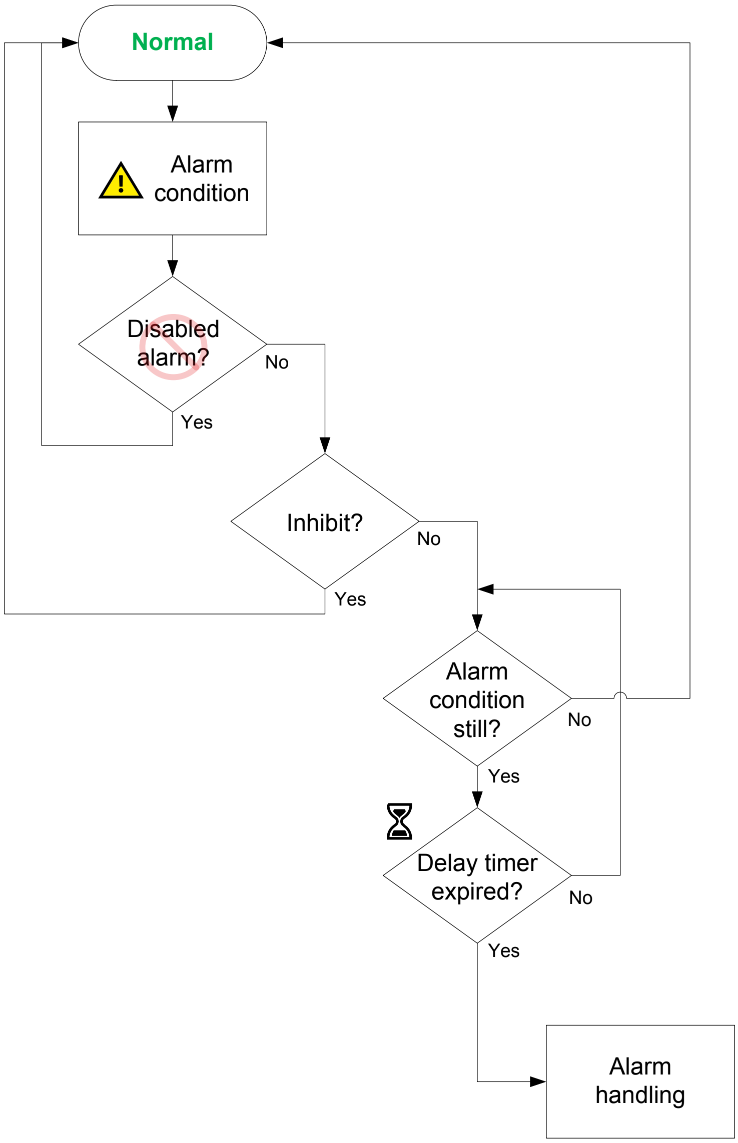
Some of the alarms are **Enabled** by default in the controller. You can enable or disable certain alarms and configure their alarm settings (typically the *Set point* and *Delay*) as required.

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

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

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

Alarm process



The controller detects an *Alarm condition*.

Check whether the alarm is disabled.

Check whether the alarm has an active inhibit.

Check whether the *Alarm condition* is still present.

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

Check whether the *Alarm condition* is still present.

The alarm is activated and included in the alarm list.

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

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

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

INFO
Auto acknowledge can be useful during commissioning and troubleshooting. However, DEIF does not recommend *Auto acknowledge* during normal operation.

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

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

Alarm latch

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

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

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

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

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

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

Operator actions

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

INFO
Operator actions can be done by using the display unit, a digital input, PICUS, Modbus and/or CustomLogic.

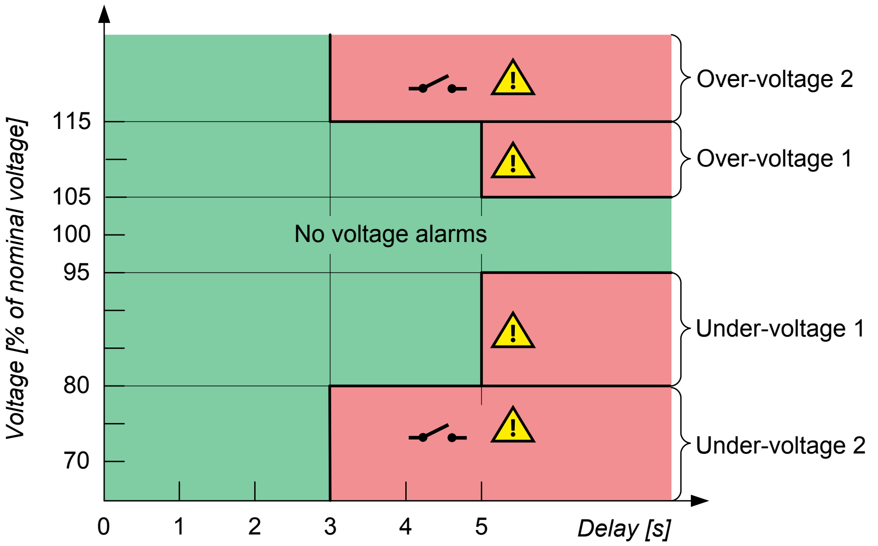
2.5.2 Alarm levels

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

Example of alarm levels

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

Figure 2.1 Example of alarm levels for busbar voltage



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

In the example, an over-voltage *Warning* alarm is activated if the busbar voltage has been over 105 % of the busbar's nominal voltage for 5 seconds. If the busbar voltage is over 115 % of 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.

2.5.3 Operate time

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

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

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

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

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

2.5.4 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.

More information
See **Alarms**, **Alarm parameters** for more information about parameter settings.

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

Limitations

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

Table 2.7 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, for a GENSET controller, 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 CustomLogic

2.6.1 Using CustomLogic

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

More information
See **CustomLogic** in the **PICUS manual** for more information about using CustomLogic.

2.6.2 Enable CustomLogic

Configure *Enable CustomLogic* parameter under **Configure > Parameters > Local > CustomLogic > Configuration**.

Table 2.8 Enable CustomLogic

Parameter	Range	Default	Comment
Enable	Not enabled, Enabled	Not 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.

2.6.3 CustomLogic inputs and outputs (optional)

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

Table 2.9 CustomLogic inputs and outputs (optional)

Function	I/O	Type	Details
Local > CustomLogic > CustomLogic digital input (× 20)	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 > CustomLogic digital output (× 20)	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 *Configure* > *Parameters* > *Local* > *CustomLogic* > *Configuration* > *Enable* is *Enabled*, then the controller activates this output.

2.6.4 Custom parameters

Custom parameters can be used with CustomLogic for reading, comparing, or writing values. Up to 50 customer parameters can be configured.

Configure custom parameters under **Configure > Parameters > Custom parameters**.

Where # is the parameter number from 0 to 49.

Table 2.10 Custom parameter #

Parameter	Range	Default	Comment
Enable #	Not enabled, Enabled	Not enabled	**Not enabled**: The parameter is not used. **Enabled**: The parameter can be used in a CustomLogic project.
Integer #	- 2147483647 to 2147483647	0	The range for the integer value to be stored.
Float #	- 2147480000 to 2147480000	0.0000	The range for the float value to be stored.

2.6.5 Activating controller outputs

CustomLogic cannot directly activate controller outputs that are configured for controller functions. For example, CustomLogic cannot activate the *[Breaker]* > *Control* > *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 *[Breaker]* > *Command* > *Open* digital input. The controller only follows the external command if the controller is in SEMI mode.

2.6.6 CustomLogic and Modbus

Each controller has 20 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.

2.6.7 Restrictions

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 under switchboard control.

However, the controller does not accept external commands under 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 under 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**.

2.7 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 more information about using and configuring the emulation feature.

2.8 Custom parameters

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

Configure custom parameters under **Parameters > Custom parameters**.

Where # is the parameter number from 0 to 49.

Table 2.11 Custom parameter #

Parameter	Range	Default	Comment
Enable #	Not enabled, Enabled	Not enabled	**Not enabled**: The parameter is not used. **Enabled**: The parameter can be used in a CustomLogic project.
Integer #	- 2147483647 to 2147483647	0	The range for the integer value to be stored.
Float #	- 2147480000 to 2147480000	0.0000	The range for the float value to be stored.

2.9 Date and time

2.9.1 About date and time settings

The date and time can be set manually from PICUS or the display, or automatically obtained from an external time server.

The time is stored locally on each controller, and automatically synchronised between all of the DEIF controllers connected in the same Ethernet 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.

Table 2.12 Date and time settings

Setting	Range	Default	Notes
Time	• 00:00:00 to 23:59:59 • 12:00:00 AM to 11:59:59 PM		If an NTP server is configured, then you are not able to change the time manually.
Time format	• 12 hour clock • 24 hour clock	24 hour clock	The *AM/PM* selector for *Time* is only visible when 12 hour clock is selected.
Date	2018-01-01 to 2037-12-31		If an NTP server is configured, then you are not able to change the date manually.
Date format	• YYYY-MM-DD • YY-MM-DD • DD-MM-YYYY • DD-MM-YY • MM-DD-YYYY • MM-DD-YY	YYYY-MM-DD	
Time zone	Selectable list	Etc/UTC	The adjustment for daylight saving is based on the time zone, and are automatically applied by the controller. Daylight savings is not applied to the controller when you select the *Etc/UTC* time zone.

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

Table 2.13 Network time protocol settings

Setting	Range	Default	Notes
Host		-	Type the IP address or server address of the NTP server in this field. When either of the *Host* fields have data inside them, it is no longer possible to configure the date or time manually.
Mode	• Unicast • Multicast	Unicast	**Unicast**: The controller sends requests to the specified host and to request the date and time. The controller updates the date and time when the host responds to the request. **Multicast**: The controller waits for a date and time to be broadcast from a server on the host location. The controller updates the date and time when a broadcast is received.

2.9.2 Setting the time manually

Use the **Configure > Time settings** interface in PICUS or the display unit 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.

2.9.3 Using an external NTP server

Use the **Configure > Time settings** interface in PICUS to configure the NTP server.

INFO
For this option, the network design **must** allow the controllers to access the NTP server(s).

If two NTP servers are configured, then the NTP server with the lowest **Stratum** is the server used. If the NTP servers have the same **Stratum**, then the NTP server configured in **Server 1** is the server used.

2.10 About permissions

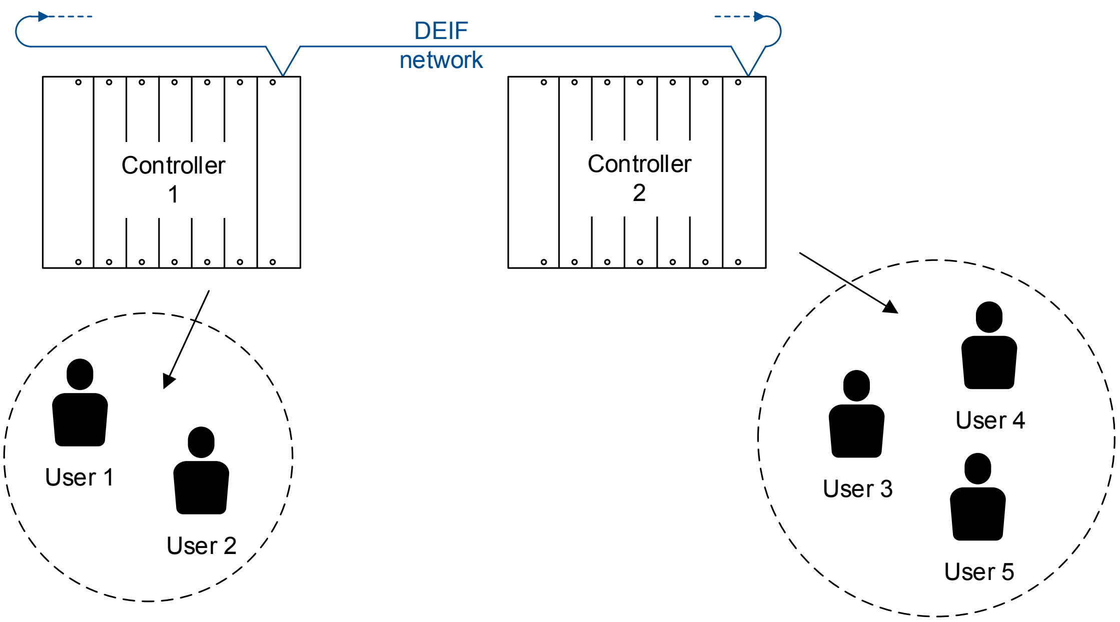
Access to the controllers' configuration and functionality is protected with user permission access. The controller is supplied with a number of default *Groups*, *Users* and *Passwords*.

INFO
Only users with the correct permission may access, configure, or update the configuration.

Permission structure

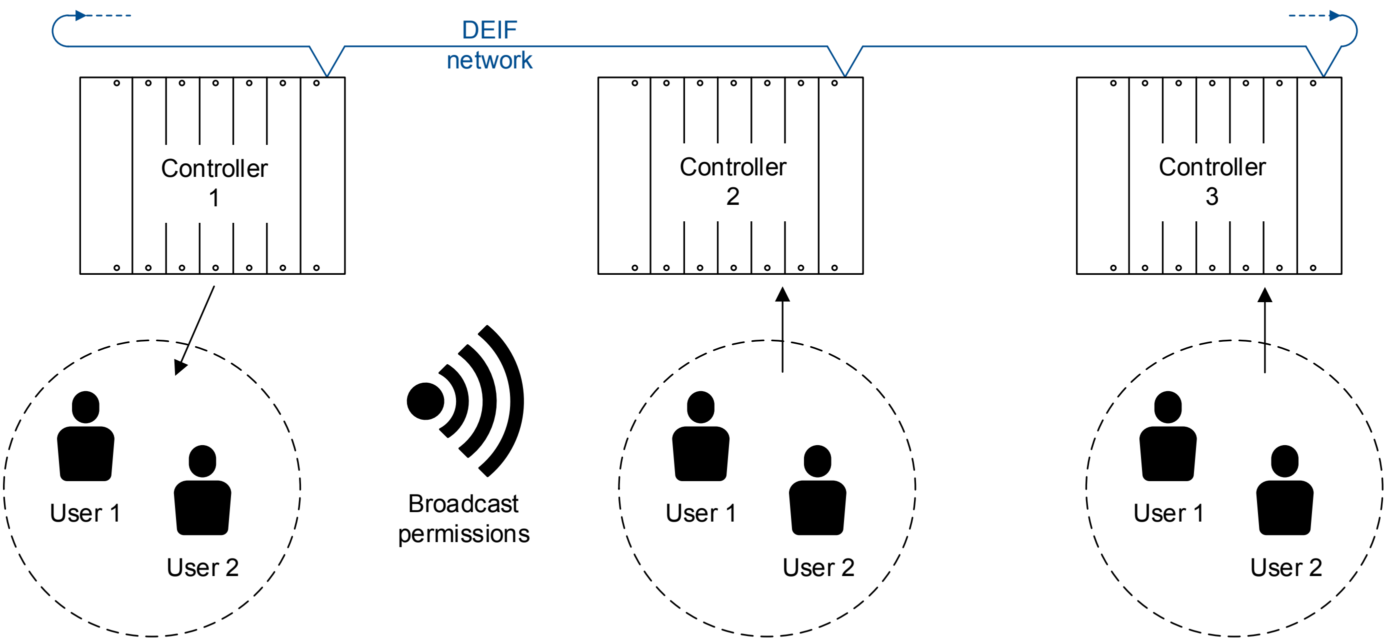
The permissions structure allows the creation and maintenance of **users** and **groups** within each controller configuration. These are stored locally on each controller, and therefore each controller can store its own set of user permissions and groups.

Figure 2.2 User profiles on controllers



However, you can also **Broadcast** these settings to any or all of the other connected controller(s), which creates the same permissions on them.

Figure 2.3 Broadcast user profiles to all controllers



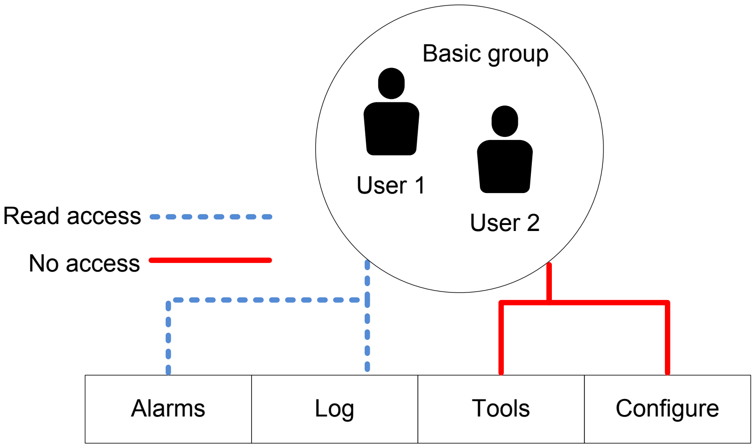
INFO
Create the same permissions on all the connected controllers. If a controller must have different permission settings, do not broadcast these settings.

Each **user** is a member of a **group**. The **group** gives the **user** permissions to associated features or functions of the controller.

When a **user** is assigned to a **group**, they inherit the permissions for that **group**.

In the following diagram, you can see the permissions that **User 1** and **User 2** have to the controller. Both **User 1** and **User 2** are members of a basic permission group, and they inherit the permissions from that specific group.

Figure 2.4 Simple permission example



In the diagram, **User 1** and **User 2** are members of the **Basic group**. They have read access to the **Alarms**, and **Log**, but they have no access to the **Tools** or **Configure** functions.

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

INFO
In order to benefit fully from the permissions structure, you need to set up your **users** and **groups** with careful consideration.

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

2.10.1 User settings

The following information is stored for each of the *Users* on the controller.

Table 2.14 User settings

Setting	Type	Notes
User name	Required	Minimum 2 characters.
Organisation	Optional	
Group	Required	Selectable from list.
Mobile number	Optional	
Direct number	Optional	
Email (primary)	Optional	
Email (secondary)	Optional	
Notes	Optional	
Password	Required	Minimum 8 characters.

2.10.2 Group settings

Permissions are divided into group settings and the permission levels under that group.

Group settings

The *Group settings* contain the general information about the permission group.

Setting	Type	Notes
Name	Required	
Owner	Optional	
Date of creation	Automatic	System created
Users in group	Automatic	List of users assigned to this group
Notes	Optional	

Group permissions

The group permissions grant or remove access to each of the different areas in the software.

Table 2.15 Access levels

Setting	Notes
Read access	Allows settings to be read from the controller.
Read/write access	Allows settings to be read or written back to the controller.
No access	Allows no access for the function or setting.
Mixed access	Where permissions are different at different levels within the permission area. Assigned automatically by system.

Table 2.16 Permission areas and features

Software area	Tasks
Live Data	Live Data
Application	• Single-line creator • Emulation • Single-line supervision
Alarms	• Alarm acknowledge • Alarm reset latch • Alarm out of service • Alarm shelved
I/O status	I/O status
Log	• Log • Engine interface J1939 DM2
Tools	• Translations • Report • Backup • Restore • Restore configuration • Trending • Communication • Regulator status • Alarm test • Advanced

Software area	Tasks
	◦ Firmware ◦ Change controller ◦ Permissions
Configure	• Date and time • View design • Input/output configuration • Parameters • Counters • CustomLogic • Flexible Modbus • Fieldbus configuration • Fieldbus supervision

2.10.3 Default users

NOTICE

Secure your system

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

Default users

The controller is supplied with a number of default *users*, *groups*, and *passwords*. These provide initial access to the controller and should be changed during commissioning.

Table 2.17 Default users

User	Password (before PCM APPL 1.0.13.x)	Password (from PCM APPL 1.0.13.x or later)	Group
Operator	00000000	0	Operators
Service	00000002	0	Service engineers
Designer	00000003	0	Designers
Admin	00000004	0	Administrators

2.10.4 Default group permissions

Table 2.18 Operators group

Permission		Read	Read write	No access	Mixed access
Live data		●			
	Live data	●			
Application					●
	Single-line creator			●	
	Single-line supervision	●			
	Single-line emulation			●	
Alarms					●

Permission		Read	Read write	No access	Mixed access
	Alarm acknowledge		●		
	Alarm reset latch		●		
	Alarm out of service	●			
	Alarm shelved	●			
Log		●			
	Log	●			
	Engine interface	●			
Tools					●
	Translations	●			
	Report		●		
	Backup	●			
	Restore	●			
	Restore configuration	●			
	Communication	●			
	Regulator status	●			
	Alarm test	●			
Tools > Advanced				●	
	Firmware			●	
	Change controller			●	
	Permissions			●	
Configure					●
	Date and time	●			
	View design	●			
	Input/output configuration	●			
	Parameters	●			
	Counters	●			
	CustomLogic			●	
	Flexible Modbus	●			
	Fieldbus configuration			●	
	Fieldbus supervision		●		

Table 2.19 Service engineers group

Permission		Read	Read write	No access	Mixed access
Live data		●			
	Live data	●			
Application			●		
	Single-line creator		●		
	Single-line supervision		●		
	Single-line emulation		●		

Permission		Read	Read write	No access	Mixed access
Alarms			•		
	Alarm acknowledge		•		
	Alarm reset latch		•		
	Alarm out of service		•		
	Alarm shelved		•		
Logs		•			
	Log	•			
	Engine interface	•			
Tools					•
	Translations		•		
	Report		•		
	Backup		•		
	Restore		•		
	Restore configuration		•		
	Communication		•		
	Regulator status	•			
	Alarm test		•		
Tools > Advanced					•
	Firmware		•		
	Change controller		•		
	Permissions	•			
Configure					•
	Date and time		•		
	view design		•		
	Input/output configuration		•		
	Parameters		•		
	Counters		•		
	CustomLogic		•		
	Flexible Modbus		•		
	Fieldbus configuration			•	
	Fieldbus supervision		•		

Table 2.20 Designers group

Permission		Read	Read write	No access	Mixed access
Live data		•			
	Live data	•			
Application			•		
	Single-line creator		•		
	Single-line supervision		•		

Permission		Read	Read write	No access	Mixed access
	Single-line emulation		•		
Alarms			•		
	Alarm acknowledge		•		
	Alarm reset latch		•		
	Alarm out of service		•		
	Alarm shelved		•		
Logs					•
	Log	•			
	Engine interface		•		
Tools					•
	Translations		•		
	Report		•		
	Backup		•		
	Restore		•		
	Restore configuration		•		
	Communication		•		
	Regulator status	•			
	Alarm test		•		
Tools > Advanced					•
	Firmware		•		
	Change controller		•		
	Permissions	•			
Configure			•		
	Date and time		•		
	View design		•		
	Input/output configuration		•		
	Parameters		•		
	Counters		•		
	CustomLogic		•		
	Flexible Modbus		•		
	Fieldbus configuration		•		
	Fieldbus supervision		•		

NOTE You cannot delete the Administrators group.

Table 2.21 Administrators group

Permission		Read	Read write	No access	Mixed access
Live data		•			
	Live data	•			

Permission		Read	Read write	No access	Mixed access
Application			•		
	Single-line creator		•		
	Single-line supervision		•		
	Single-line emulation		•		
Alarms			•		
	Alarm acknowledge		•		
	Alarm reset latch		•		
	Alarm out of service		•		
	Alarm shelved		•		
Logs					•
	Log	•			
	Engine interface		•		
Tools			•		
	Translations		•		
	Report		•		
	Backup		•		
	Restore		•		
	Restore configuration		•		
	Communication		•		
	Regulator status	•			
	Alarm test		•		
Tools > Advanced			•		
	Firmware		•		
	Change controller		•		
	Permissions		•		
Configure			•		
	Date and time		•		
	View design		•		
	Input/output configuration		•		
	Parameters		•		
	Counters		•		
	CustomLogic		•		
	Flexible Modbus		•		
	Fieldbus configuration		•		
	Fieldbus supervision		•		

NOTE You cannot delete the Display group.

Table 2.22 Display group

Permission		Read	Read write	No access	Mixed access
Live data		●			
	Live data	●			
Application				●	
	Single-line creator			●	
	Single-line supervision			●	
	Single-line emulation			●	
Alarms					●
	Alarm acknowledge		●		
	Alarm reset latch		●		
	Alarm out of service	●			
	Alarm shelved	●			
Logs		●			
	Log	●			
	Engine interface	●			
Tools					●
	Translations	●			
	Report			●	
	Backup			●	
	Restore			●	
	Restore configuration			●	
	Communication	●			
	Regulator status	●			
	Alarm test			●	
Tools > Advanced				●	
	Firmware			●	
	Change controller			●	
	Permissions			●	
Configure					●
	Date and time	●			
	View design	●		●	
	Input/output configuration	●			
	Parameters	●			
	Counters	●			
	CustomLogic			●	
	Flexible Modbus			●	
	Fieldbus configuration			●	
	Fieldbus supervision			●	

2.11 Event log

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

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

2.12 Non-Essential Loads (NEL)

You can assign a non-essential load to a GENSET, HYBRID, EMERGENCY genset, SHAFT generator and/or SHORE connection controller.

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

Table 2.23 NEL configuration options

Name	Details
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.
Label	Customisable label for the non-essential load.

The NEL must be assigned to the controller on the single-line diagram in order for the NEL functions to be visible under the controller inputs and outputs.

2.12.1 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 or use inhibits.

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

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

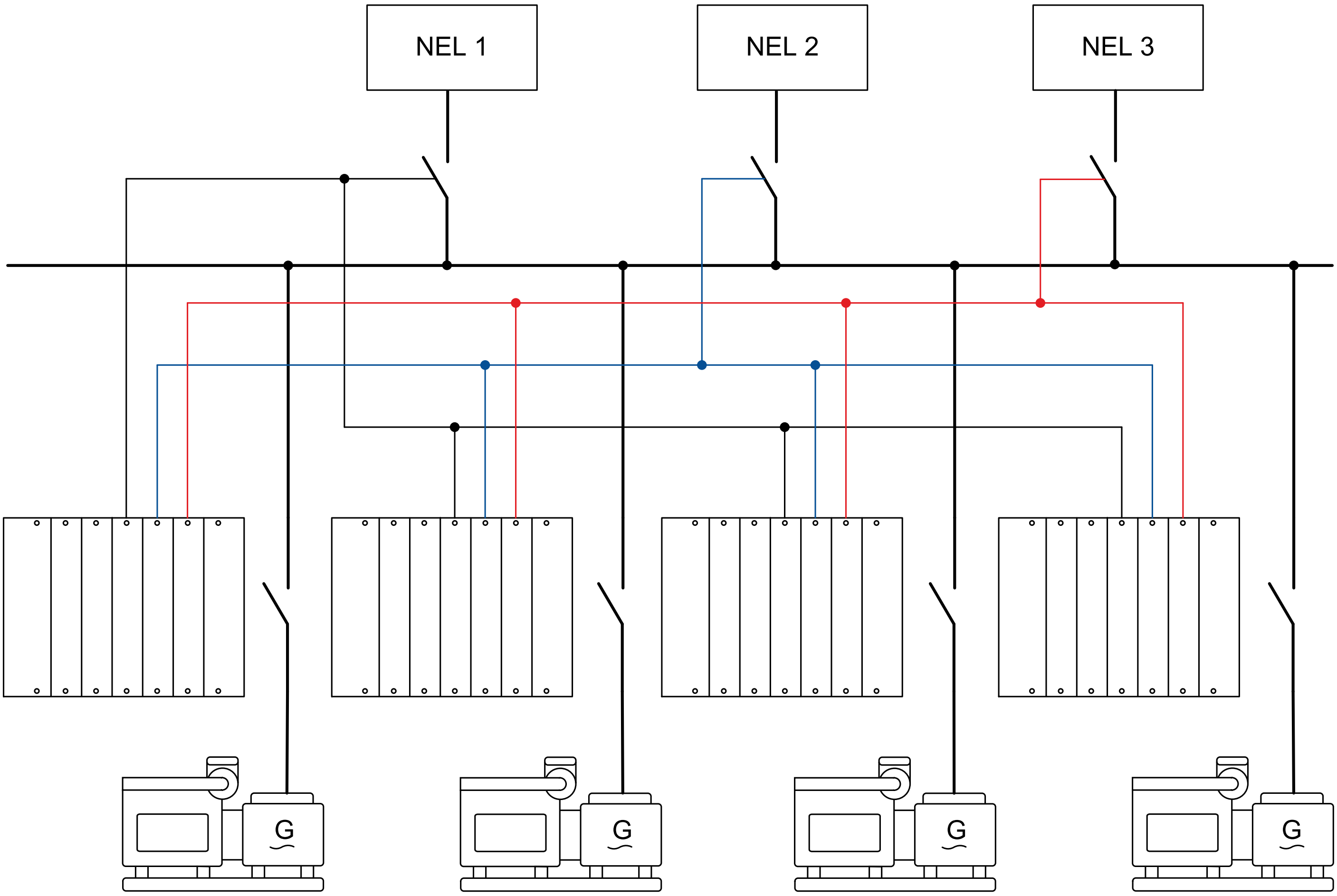
The NEL trip relay is activated when one or more of the NEL alarms is activated. It remains active whenever there is at least one NEL alarm, even if the original NEL alarm is deactivated.

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

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

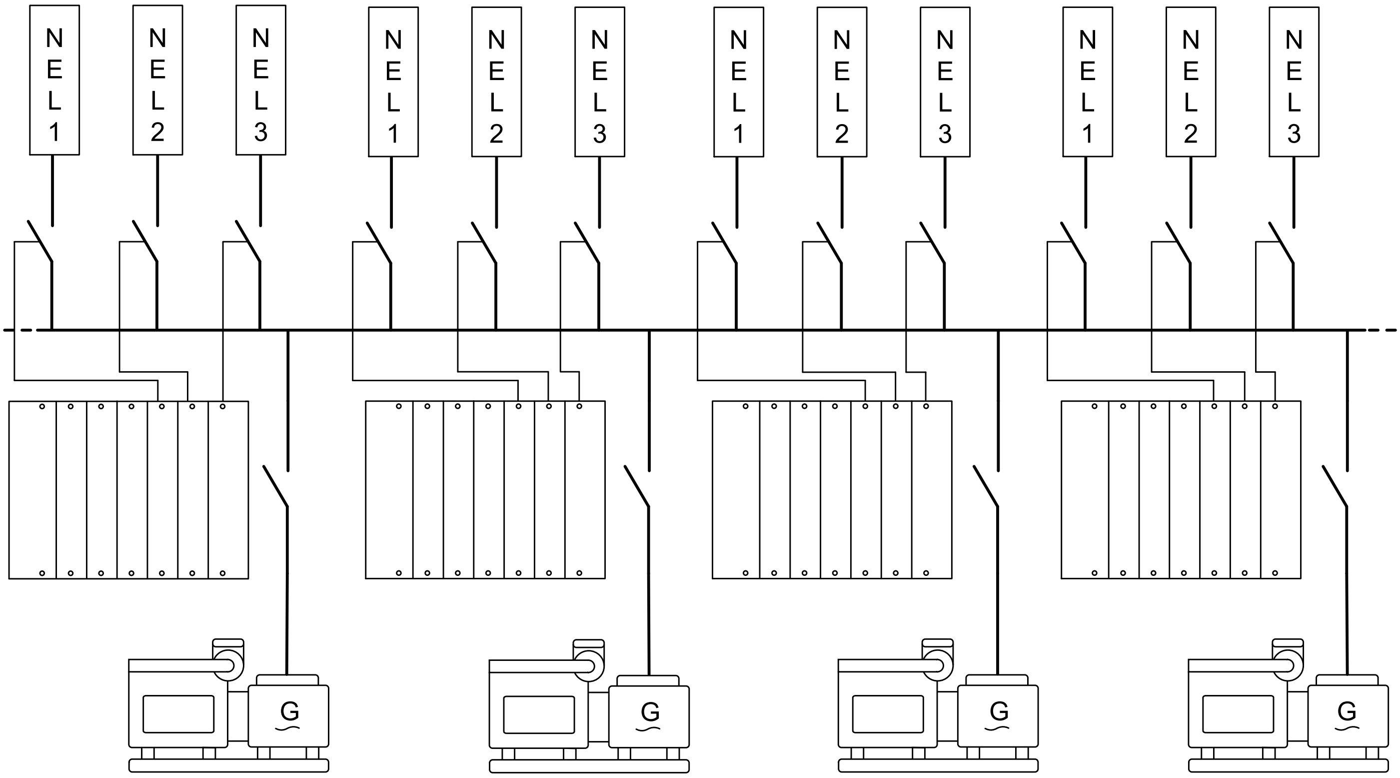
Wiring examples

Figure 2.5 Example of three non-essential loads that are connected for full redundancy



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

Figure 2.6 Example of 12 non-essential loads that are connected with no redundancy



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

Inputs and outputs

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

Table 2.24 Hardware required in addition to the minimum standard controller wiring

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.

Parameters

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

Configure this parameter under **Configure > Parameters > Non-essential load trip > Trip # > Settings**, where # is 1, 2 or 3.

Table 2.25 Non-essential load parameter

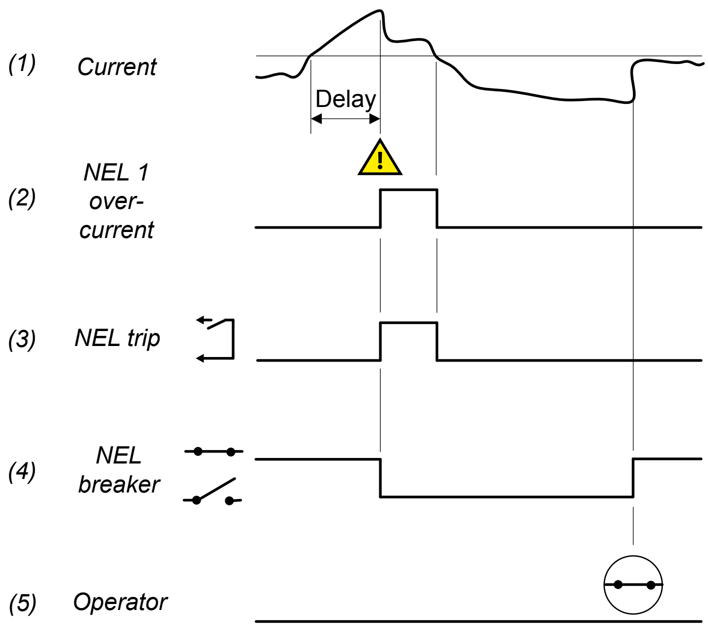
Parameter	Range	Default	Notes
Trip when breaker trips	Not enabled, Enabled	Not enabled	**Not enabled**: Controller breaker trips have no direct effect on the non-essential load trips.

Parameter	Range	Default	Notes
			Enabled: Whenever the controller breaker trips, then the controller also activates the *Non-essential load trip #* output. The NEL trip remains active as long as the breaker trip is active.

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

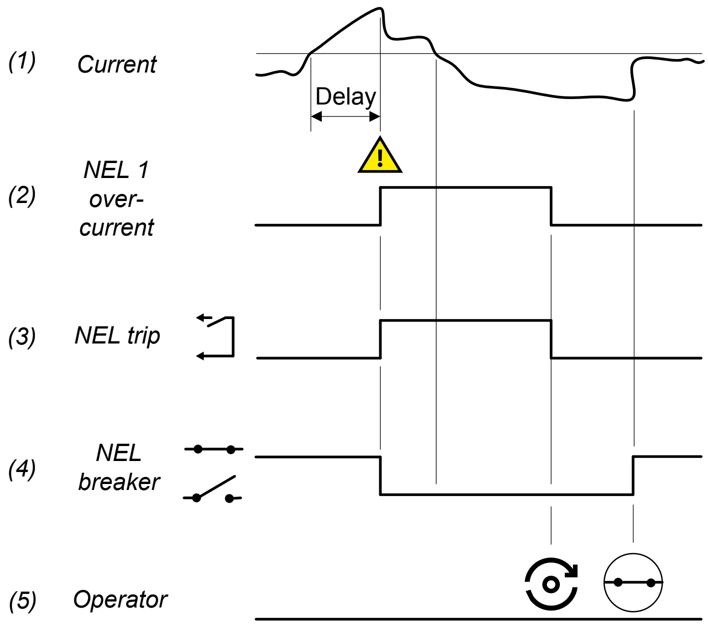
How the NEL function works

Table 2.26 Sequence diagram example with 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.

Table 2.27 Sequence diagram example with NEL 1 over-current with a latch

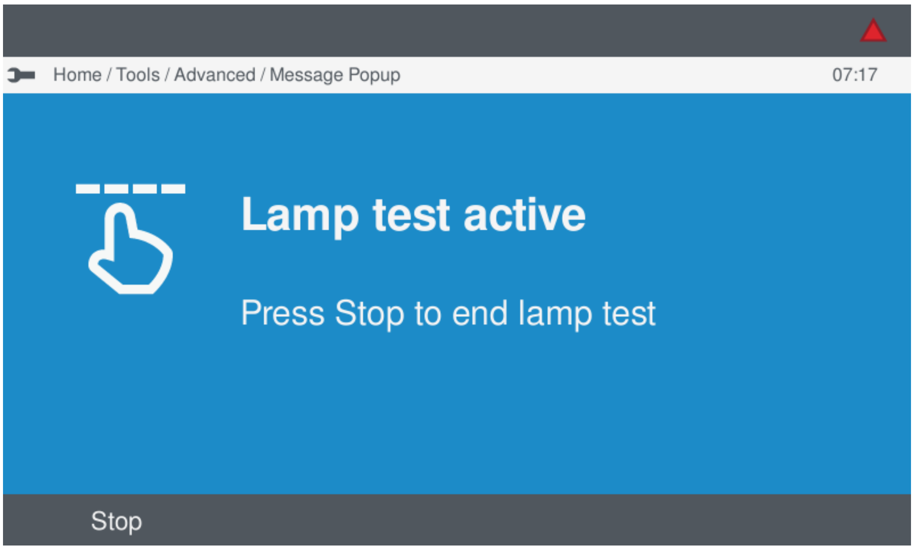


1. **Current**: See the previous example.
2. **NEL 1 over-current**: The controller activates the NEL alarm when the operating value is above the set point for the delay time.
   - The alarm is reset when the latch is reset.
3. **NEL trip**: *Non-essential load trip > Non-essential load trip #* (digital 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.

2.13 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.



Inputs

The table below describes optional inputs for the lamp test.

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

Table 2.28 Optional inputs for the lamp test

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.

Configure the parameters under **Configure > Parameters > Test functions > Lamp test**.

Table 2.29 Lamp test parameters

Parameter	Range	Default	Comment
Activate	Not enabled, Enabled	Not 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	18 s	The time for the lamp test.
Color cycle time	1 s to 1 h	3 s	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.

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

INFO
To identify a controller, use the **Identify** function.

2.14 Alive

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.

Outputs

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

Table 2.30 Optional inputs for the lamp test

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.

Configure the parameters under **Configure > Parameters > Local > Alive > Alive configuration**.

Table 2.31 Alive parameters

Parameter	Range	Default	Comment
Duty cycle	0 to 100 %	50 %	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	0.1 s to 60 s	2 s	The time between the start of a high signal to the start of the next high signal.

3. AC configuration and nominal settings

3.1 AC configuration

Phase configuration: AC configuration

Configure Phase configuration: AC configuration under:

```
Configure > Parameters > [Source] > AC setup > Phase configuration
```

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

Parameter	Range	Default	Notes
AC configuration	• Three-phase • Three-phase (2 CT, L1-L3) • Split-phase L1-L3 • Split-phase L1-L2 • Split-phase L2-L3 • Single-phase L1 • Single-phase L2 • Single-phase L3	Three-phase	**Three-phase**: The generator and busbar 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 generator and busbar 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. **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 generator and busbar 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 generator and busbar 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 generator and busbar 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** under **Wiring the equipment** in the **Installation instructions** for examples of three-phase, single-phase wiring, and split-phase wiring.

Phase configuration: AC setup

Configure Phase configuration: AC setup under:

```
Configure > Parameters > [Source] > Voltage protections
```

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

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

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

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

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

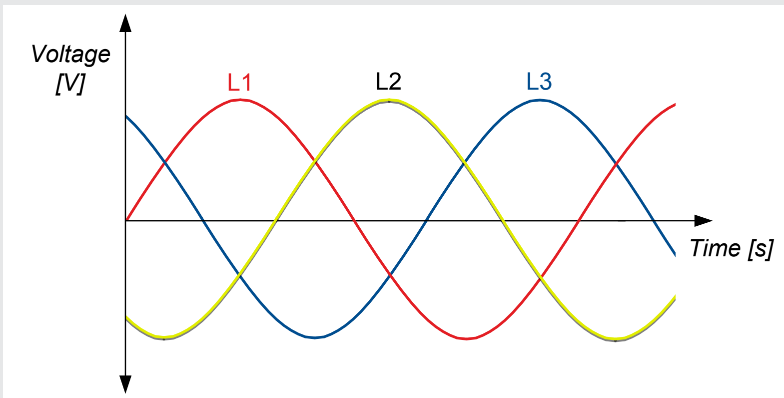
Phase direction: AC phase rotation

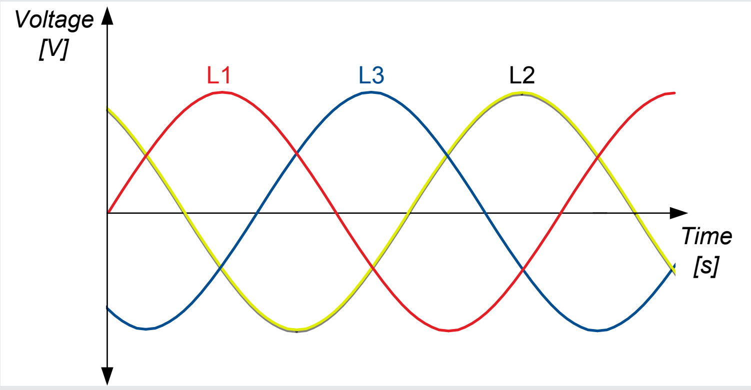
Configure *Phase direction: AC phase rotation* under:

```
Configure > Parameters > [Source] > AC setup > Phase direction
```

You must 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.

Parameter	Range	Default	Notes
AC phase rotation	• L1-L2-L3 • L1-L3-L2	L1-L2-L3	**L1-L2-L3**: The global standard phase rotation is L1-L2-L3. Using an alternative wiring can lead to confusion, fatal accidents and serious damage to equipment. 

Parameter	Range	Default	Notes
			L1-L3-L2: DEIF does not recommend that you wire the system L1-L3-L2, due to the potential for confusion. However, this parameter allows the controller to function correctly even though the generator is wired L1-L3-L2. 

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

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

3.1.1 [Source] and [Busbar] for each controller type

The names used for [Source] and [Busbar] for the AC configuration of each controller type:

Controller type	[Source] (ACM3.1 terminals 5 to 8)	[Busbar] (ACM3.1 terminals 1 to 4)
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

3.1.2 [Source] AC configuration

Configure the source's AC configuration under:

```
Configure > Parameters > [Source] > AC setup
```

Voltage transformer

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

Configure the Voltage transformer under:

```
Configure > Parameters > [Source] > AC setup > Voltage transformer
```

You must set these parameters if there is a voltage transformer on the source'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).

Parameter	Range	Default	Notes
Primary	10 V to 160 kV	400 V	The voltage transformer primary side (source side) value.
Secondary	17 to 690 V	400 V	The voltage transformer secondary side (controller side) value. Note: No phase shift is allowed in the voltage transformer. That is, the phase angle 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. However, this range starts at 17 V to allow switchboard tests.

More information
See `[Source]` **AC configuration** under **Wiring the equipment** in the **Installation instructions** for an example of generator voltage transformer wiring.

Current transformer

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

Configure the Current transformer under:

```
Configure > Parameters > [Source] > AC setup > Current transformer
```

CAUTION
Changing the current transformer settings, changes the protection range for the over-current and fast over-current 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 source's current measurement. These parameters only apply to the current measurements on L1, L2 and L3.

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

Parameter	Range	Default	Notes
Primary	5 to 9000 A	1000 A	The current transformer primary side (source side) nominal current.
Secondary	1 or 5 A	1 A	The current transformer secondary side (controller side) nominal current. You can select either 1 A or 5 A.

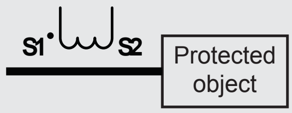
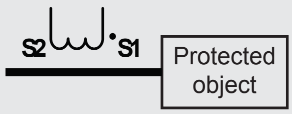
CT - ACM3.2 - Consumer side

Configure these parameters under:

```
Configure > Parameters > [Source] > AC setup > CT - ACM3.2 - Consumer side
```

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

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

Parameter	Range	Default	Notes
Primary	5 to 9000 A	1000 A	The current transformer primary side nominal current for terminals 1 to 6.
Secondary	1 or 5 A	1 A	The current transformer secondary side nominal current for terminals 1 to 6. You can select either 1 A or 5 A.
Current reference dir.	• Towards prot. obj. • Away from prot. obj.	Towards prot. obj.	Defines if the current transformer direction is installed towards or away from the protected object for terminals 1 to 6.  **Towards**:  **Away**:

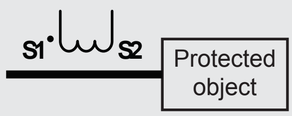
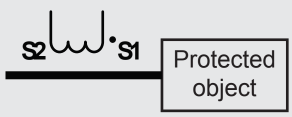
CT - ACM3.2 - Neutral side

Configure these parameters under:

```
Configure > Parameters > [Source] > AC setup > CT - ACM3.2 - Neutral side
```

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

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

Parameter	Range	Default	Notes
Primary	5 to 9000 A	1000 A	The current transformer primary side nominal current for terminals 7 to 12.
Secondary	1 or 5 A	1 A	The current transformer secondary side nominal current for terminals 7 to 12. You can select either 1 A or 5 A.
Current reference dir.	• Towards prot. obj. • Away from prot. obj.	Towards prot. obj.	Defines if the current transformer direction is installed towards or away from the protected object for terminals 7 to 12.  **Towards**:  **Away**:

Voltage and frequency OK

Configure these parameters under:

```
Configure > Parameters > [Source] > AC setup > Voltage and frequency OK
```

The controller uses these parameters to calculate whether the voltage and frequency from the source measurements are OK, so that the breaker can close.

Parameter	Range	Default	Notes
Voltage and frequency OK	0 s to 1 h	2 s	If the voltage and frequency are OK for this time in seconds, then the equipment's LED becomes steady green. The breaker is not allowed to close before the LED is steady green (that is, not flashing).
Minimum OK voltage	70 to 100 %	95 %	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 %	105 %	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 to 100 %	99 %	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 to 110 %	101 %	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 start)

For the GENSET, EMERGENCY genset, SHAFT generator and/or SHORE connection controller, configure these parameters under:

```
Configure > Parameters > [Source] > AC setup > Voltage and frequency OK (blackout start)
```

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.

Parameter	Range	Default	Notes
Voltage and frequency OK	0 s to 1 h	2 s	If the voltage and frequency from the source are OK for this time in seconds, then the equipment 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 %	95 %	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 %	105 %	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 to 100 %	94 %	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 to 110 %	106 %	The frequency must below this frequency (as a percent of nominal frequency) for the breaker to start to synchronise and close.

3.1.3 [Busbar] AC configuration

Configure the busbar's AC configuration under:

```
Configure > Parameters > [Busbar] > AC setup
```

Voltage transformer

Configure the Voltage transformer under:

```
Configure > Parameters > [Busbar] > AC setup > Voltage transformer
```

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

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

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

Parameter	Range	Default	Notes
Primary	10 to 160 kV	400 V	The voltage transformer primary side (busbar side) value.
Secondary	17 to 690 V	400 V	The voltage transformer secondary side (controller side) value. Note: No phase shift is allowed in the voltage transformer. That is, the phase angle must be the same on the high and low voltage sides of the busbar voltage measurement transformer. Note: The minimum normal operating voltage for the controller is 100 V. However, this range starts at 17 V to allow switchboard tests.

More information
See **[Busbar] AC configuration** under **Example wiring for controller functions** in the **Installation instructions** for an example of busbar voltage transformer wiring.

Voltage and frequency OK

Configure the Voltage and frequency OK under:

```
Configure > Parameters > [Busbar] > AC setup > Voltage and frequency OK
```

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

Parameter	Range	Default	Notes
Voltage and frequency OK	0 s to 3600 s	0 s	If the busbar voltage and frequency are OK for this time in seconds, then the busbar LED becomes steady green. The breaker is not allowed to close before the busbar LED is steady green (that is, not flashing).
Minimum OK voltage	70 to 100 %	95 %	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 %	105 %	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 to 100 %	98 %	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 to 110 %	102 %	The frequency must below this frequency (as a percent of nominal frequency) for the breaker to start to synchronise and close.

Blackout detection

Configure the Blackout detection under:

```
Configure > Parameters > [Busbar] > AC setup > Blackout detection
```

Parameter	Range	Default	Notes
Blackout delay	0 s to 3600 s	0 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.

3.1.4 Voltage and frequency as digital outputs

For the [Source] and the [Busbar], 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.

Outputs

Assign the function to a digital output under:

```
Configure > Input/output
```

Select the hardware module and select the digitial output to configure.

Function	I/O	Type	Details
[Source] > State > Voltage and frequency OK	Digital output	Continuous	Activated if the voltage and frequency from the source are within the range specified in under `Configure > Parameters > [Source] > AC setup > Voltage and frequency OK`.
[Source] > State > No voltage and frequency	Digital output	Continuous	Activated if the phase-to-phase voltage from the source is less than 10 % of the nominal voltage.
[Busbar] > State > Voltage and frequency OK	Digital output	Continuous	Activated if the voltage and frequency at the [Busbar] are within the range specified in under `Configure > Parameters > [Busbar] > AC setup > Voltage and frequency OK`.
[Source] > State > No voltage and frequency	Digital output	Continuous	Activated if the phase-to-phase voltage at the [Busbar] is less than 10 % of the nominal voltage.

3.1.5 4th current input configuration

Nominal current

Configure the Nominal current under:

```
Configure > Parameters > Local > 4th current input > Nominal settings > Nominal settings # >
Current (I4)
```

Where # is 1 to 4.

Parameter	Range	Nominal setting 1	Nominal setting 2	Nominal setting 3	Nominal setting 4	Notes
Nominal (4th)	1 A to 9 kA	867 A	345 A	345 A	345 A	The maximum 4th current flow during normal operation.

Current transformer

You can configure the 4th current input current transformer under:

```
Configure > Parameters > Local > 4th current input > Current transformer (I4)
```

You must set these parameters if there is a current transformer on the 4th current input measurement.

Parameter	Range	Default	Notes
Primary (I4)	5 A to 9 kA	1 kA	The current transformer primary side (measurement side) nominal current.
Secondary (I4)	1 or 5 A	1 A	The current transformer secondary side (controller side) nominal current. You can select either 1 A or 5 A.

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

3.2 Nominal settings

3.2.1 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.

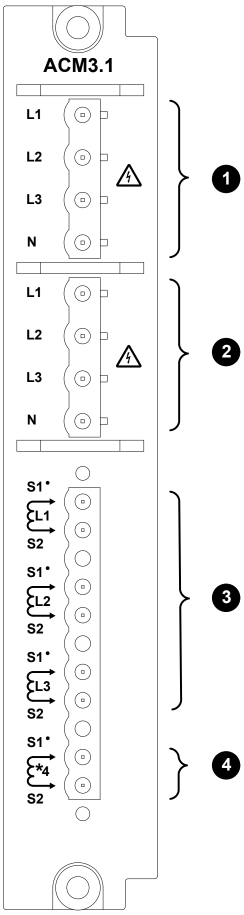
Each controller can store four sets of nominal settings. You can easily change the active set of nominal settings by changing the parameter, using a digital input, analogue input, or an external source (for example, Modbus).

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 more information about the nominal settings and regulation for more information about the analogue regulator offsets.

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



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

Inputs and outputs

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

Table 3.1 Nominal settings inputs and outputs

Function	I/O	Type	Details
Local > Nominal settings > Controller nominal setting > Nominal setting #	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 setting # 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 setting #	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.

Parameters

More information
See **each controller type** for the nominal setting parameters for voltage, current and generator speed (if applicable).

```
Configure > Parameters > Local > Nominal settings > Controller nominal setting
```

.

Table 3.2 Local nominal setting parameters

Parameter	Range	Default	Notes
Selection	• Nominal setting 1 • Nominal setting 2 • Nominal setting 3 • Nominal setting 4	Nominal setting 1	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	**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.

Configure this parameter under

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

where # is 1 to 8.

Table 3.3 Power management nominal setting parameter

Parameter	Range	Default	Notes
Selection	• Nominal setting 1 • Nominal setting 2 • Nominal setting 3 • Nominal setting 4	Nominal setting 1	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.

3.2.2 Nominal power calculations

Configure the controller nominal power calculations under

```
Configure > Parameters > [Source] > Nominal settings > Nominal settings # > Calculation method
```

where # is 1 to 4.

Reactive power (Q) nominal

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

Table 3.4 Calculation method

Parameter	Range	Default	Notes
Reactive power (Q) nominal	See notes	Q nominal calculated	**Q nominal calculated**: The controller calculates Q nominal based on S nominal and the power factor. **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.

It is normally not necessary to change these defaults. The DEIF ML-2 products use Q nominal = P nominal.

P or S nominal

Table 3.5 Calculation method

Parameter	Range	Default	Notes
P or S nominal	See notes	No calculation	**No calculation**: *P nominal* has the value entered in the Power (P) nominal parameter. *S nominal* has the value entered in the Apparent power (S) nominal parameter. **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.

3.3 AC measurement filters

3.3.1 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, 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 an averaged value based on a 200 ms sample.
- Averaged : 800 ms - Show an averaged value based on an 800 ms sample.

3.3.2 AC measurement filters

Configure these parameters under **Configure > Parameters > Local > AC measurement filters > Primary AC measurements**.

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

3.4 AC measurements as analogue outputs

3.4.1 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.

3.4.2 [Source] AC measurements

Assign the AC measurement function to an analogue output under `Configure > Input/output`. Select a hardware module with an analogue output, then select the output to configure.

Function names

The [Source] AC measurement function names follow these formats:

[Source] > [Physical quantity] > [Equipment] | [Measurement] [[unit]].

For example, *Shore busbar* > *Phase angle* > *Shore* | *Phase angle L3-L1 [degrees]*.

Table 3.6 [Source] AC measurement function names for each controller type

Controller type	[Source]	[Equipment]
GENSET	Generator	Generator
HYBRID	Inverter	Inverter
EMERGENCY genset	Generator	Generator
SHAFT generator	Generator	Generator
SHORE connection	Shore busbar	Shore
BUS TIE breaker	Busbar B	Busbar A

Table 3.7 [Source] voltage analogue output functions

Function	Details
[Source] > Voltage (V) > [Equipment] | L1-N [V AC]	The controller outputs the L1-N voltage from the source.
[Source] > Voltage (V) > [Equipment] | L2-N [V AC]	The controller outputs the L2-N voltage from the source.
[Source] > Voltage (V) > [Equipment] | L3-N [V AC]	The controller outputs the L3-N voltage from the source.
[Source] > Voltage (V) > [Equipment] | N [V AC]	The controller outputs the N voltage from the source, relative to the star point.
[Source] > Voltage (V) > [Equipment] | L1-L2 [V AC]	The controller outputs the L1-L2 voltage from the source.
[Source] > Voltage (V) > [Equipment] | L2-L3 [V AC]	The controller outputs the L2-L3 voltage from the source.
[Source] > Voltage (V) > [Equipment] | L3-L1 [V AC]	The controller outputs the L3-L1 voltage from the source.
[Source] > Voltage (V) > [Equipment] | Positive sequence [V AC]	The controller outputs the magnitude of the positive sequence voltage.
[Source] > Voltage (V) > [Equipment] | Negative sequence [V AC]	The controller outputs the magnitude of the negative sequence voltage.
[Source] > Voltage (V) > [Equipment] | Zero sequence [V AC]	The controller outputs the magnitude of the zero sequence voltage from the source.
[Source] > Voltage (V) > [Equipment] | L-N min. [V AC]	The controller outputs the lowest L-N voltage (that is, for the phase with the lowest L-N voltage).
[Source] > Voltage (V) > [Equipment] | L-N max. [V AC]	The controller outputs the highest L-N voltage (that is, for the phase with the highest L-N voltage).
[Source] > Voltage (V) > [Equipment] | L-N unbalanced [V AC]	The controller outputs the L-N unbalanced voltage from the source, relative to the zero of the star point.
[Source] > Voltage (V) > [Equipment] | L-L min. [V AC]	The controller outputs the lowest L-L voltage (that is, for the phases with the lowest L-L voltage).
[Source] > Voltage (V) > [Equipment] | 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 source.
[Source] > Voltage (V) > [Equipment] | L-L unbalanced [V AC]	The controller outputs the L-L unbalanced voltage between the phases of the source.

Table 3.8 [Source] frequency analogue output functions

Function	Details
[Source] > Frequency (f) (from voltage) > [Equipment] | L1 [Hz]	The controller outputs the L1 frequency (based on the voltage measurement).
[Source] > Frequency (f) (from voltage) > [Equipment] | L2 [Hz]	The controller outputs the L2 frequency (based on the voltage measurement).
[Source] > Frequency (f) (from voltage) > [Equipment] | L3 [Hz]	The controller outputs the L3 frequency (based on the voltage measurement).
[Source] > Frequency (f) (from voltage) > [Equipment] | Min. [Hz]	The controller outputs the frequency of the phase with the lowest frequency (based on the voltage measurement).
[Source] > Frequency (f) (from voltage) > [Equipment] | Max. [Hz]	The controller outputs the frequency of the phase with the highest frequency (based on the voltage measurement).
[Source] > Frequency (f) (from current) > [Equipment] | L1 [Hz]	The controller outputs the L1 frequency (based on the current measurement).
[Source] > Frequency (f) (from current) > [Equipment] | L2 [Hz]	The controller outputs the L2 frequency (based on the current measurement).

Function	Details
[Source] > Frequency (f) (from current) > [Equipment] | L3 [Hz]	The controller outputs the L3 frequency (based on the current measurement).
[Source] > Frequency (f) (from current) > [Equipment] | Min. [Hz]	The controller outputs the frequency of the phase with the lowest frequency (based on the current measurement).
[Source] > Frequency (f) (from current) > [Equipment] | Max. [Hz]	The controller outputs the frequency of the phase with the highest frequency (based on the current measurement).

Table 3.9 [Source] current analogue output functions

Function	Details
[Source] > Current (I) > [Equipment] | L1 [A]	The controller outputs the L1 current from the source.
[Source] > Current (I) > [Equipment] | L2 [A]	The controller outputs the L2 current from the source.
[Source] > Current (I) > [Equipment] | L3 [A]	The controller outputs the L3 current from the source.
[Source] > Current (I) > [Equipment] | N [A]	The controller outputs the N current from the source, relative to the star point.
[Source] > Current (I) > [Equipment] | Positive sequence [A]	The controller outputs the magnitude of the positive sequence current.
[Source] > Current (I) > [Equipment] | Negative sequence [A]	The controller outputs the magnitude of the negative sequence current.
[Source] > Current (I) > [Equipment] | Zero sequence [A]	The controller outputs the magnitude of the zero sequence current from the source.
[Source] > Current (I) > [Equipment] | Min. [A]	The controller outputs the lowest phase current.
[Source] > Current (I) > [Equipment] | Max. [A]	The controller outputs the highest phase current.
[Source] > Current (I) > [Equipment] | Unbalanced nominal [A]	The controller outputs the unbalanced current from the source, calculated using the nominal method.
[Source] > Current (I) > [Equipment] | Unbalanced average [A]	The controller outputs the unbalanced current from the source, calculated using the average method.

Table 3.10 [Source] current - ACM3.2 analogue output functions

Function	Details
[Source] > Current (I) - ACM3.2 > [Equipment] | L1 (Consumer side) [A]	The controller outputs the L1 current from the consumer side.
[Source] > Current (I) - ACM3.2 > [Equipment] | L2 (Consumer side) [A]	The controller outputs the L2 current from the consumer side.
[Source] > Current (I) - ACM3.2 > [Equipment] | L3 (Consumer side) [A]	The controller outputs the L3 current from the consumer side.
[Source] > Current (I) - ACM3.2 > [Equipment] | Min (Consumer side) [A]	The controller outputs the lowest phase current from the consumer side.
[Source] > Current (I) - ACM3.2 > [Equipment] | Max (Consumer side) [A]	The controller outputs the highest phase current from the consumer side.
[Source] > Current (I) - ACM3.2 > [Equipment] | L1 (Neutral side) [A]	The controller outputs the L1 current from the neutral side.
[Source] > Current (I) - ACM3.2 > [Equipment] | L2 (Neutral side) [A]	The controller outputs the L2 current from the neutral side.
[Source] > Current (I) - ACM3.2 > [Equipment] | L3 (Neutral side) [A]	The controller outputs the L3 current from the neutral side.

Function	Details
[Source] > Current (I) - ACM3.2 > [Equipment] | Min (Neutral side) [A]	The controller outputs the lowest phase current from the neutral side.
[Source] > Current (I) - ACM3.2 > [Equipment] | Max (Neutral side) [A]	The controller outputs the highest phase current from the neutral side.
[Source] > Current (I) - ACM3.2 > [Equipment] | L1 differential [A]	The controller outputs the difference between the consumer and the neutral side of the L1 current.
[Source] > Current (I) - ACM3.2 > [Equipment] | L2 differential [A]	The controller outputs the difference between the consumer and the neutral side of the L2 current.
[Source] > Current (I) - ACM3.2 > [Equipment] | L3 differential [A]	The controller outputs the difference between the consumer and the neutral side of the L3 current.
[Source] > Current (I) - ACM3.2 > [Equipment] | Min differential [A]	The controller outputs the lowest difference between the consumer and the neutral side phase currents.
[Source] > Current (I) - ACM3.2 > [Equipment] | Max differential [A]	The controller outputs the highest difference between the consumer and the neutral side phase currents.
[Source] > Current (I) - ACM3.2 > [Equipment] | L1 restraint [A]	The controller outputs the L1 restraint current.
[Source] > Current (I) - ACM3.2 > [Equipment] | L2 restraint [A]	The controller outputs the L2 restraint current.
[Source] > Current (I) - ACM3.2 > [Equipment] | L3 restraint [A]	The controller outputs the L3 restraint current.
[Source] > Current (I) - ACM3.2 > [Equipment] | Min. restraint [A]	The controller outputs the lowest phase restraint current.
[Source] > Current (I) - ACM3.2 > [Equipment] | Max. restraint [A]	The controller outputs the highest phase restraint current.
[Source] > Current (I) - ACM3.2 > [Equipment] | Frequency [Hz]	The controller outputs the frequency of the phase with the highest frequency (based on the ACM3.2 current measurements).

Table 3.11 [Source] power analogue output functions

Function	Details
[Source] > Power (P) > [Equipment] | L1 [kW]	The controller outputs the L1 power.
[Source] > Power (P) > [Equipment] | L2 [kW]	The controller outputs the L2 power.
[Source] > Power (P) > [Equipment] | L3 [kW]	The controller outputs the L3 power.
[Source] > Power (P) > [Equipment] | Total [kW]	The controller outputs the total power.
[Source] > Power (P) > [Equipment] | Min. [kW]	The controller outputs the power of the phase with the lowest power.
[Source] > Power (P) > [Equipment] | Max. [kW]	The controller outputs the power of the phase with the highest power.
[Source] > Power (P) > [Equipment] | Total [%]	The controller outputs the total power, as a percentage of the source's nominal power.
[Source] > Power (P) > [Equipment] | Available [kW]	The controller outputs the available power for the source in kW. Available power = Nominal power - Total power
[Source] > Power (P) > [Equipment] | Available [%]	The controller outputs the available power for the source, as a percentage of the source's nominal power. Available power = Nominal power - Total power

Table 3.12 [Source] reactive power analogue output functions

Function	Details
[Source] > Reactive power (Q) > [Equipment] | L1 [kvar]	The controller outputs the L1 reactive power.
[Source] > Reactive power (Q) > [Equipment] | L2 [kvar]	The controller outputs the L2 reactive power.

Function	Details
[Source] > Reactive power (Q) > [Equipment] | L3 [kvar]	The controller outputs the L3 reactive power.
[Source] > Reactive power (Q) > [Equipment] | Total [kvar]	The controller outputs the total reactive power.
[Source] > Reactive power (Q) > [Equipment] | Min. [kvar]	The controller outputs the reactive power of the phase with the lowest reactive power.
[Source] > Reactive power (Q) > [Equipment] | Max. [kvar]	The controller outputs the reactive power of the phase with the highest reactive power.
[Source] > Reactive power (Q) > [Equipment] | Total [%]	The controller outputs the total reactive power, as a percentage of the source's nominal reactive power.
[Source] > Reactive power (Q) > [Equipment] | Available [kvar]	The controller outputs the available reactive power for the source in kvar. Available reactive power = Nominal reactive power - Total reactive power
[Source] > Reactive power (Q) > [Equipment] | Available [%]	The controller outputs the available reactive power for the source, as a percentage of the source's nominal reactive power. Available reactive power = Nominal reactive power - Total reactive power

Table 3.13 [Source] apparent power analogue output functions

Function	Details
[Source] > Apparent power (S) > [Equipment] | L1 [kVA]	The controller outputs the L1 apparent power.
[Source] > Apparent power (S) > [Equipment] | L2 [kVA]	The controller outputs the L2 apparent power.
[Source] > Apparent power (S) > [Equipment] | L3 [kVA]	The controller outputs the L3 apparent power.
[Source] > Apparent power (S) > [Equipment] | Total [kVA]	The controller outputs the total apparent power.
[Source] > Apparent power (S) > [Equipment] | Min. [kVA]	The controller outputs the apparent power of the phase with the lowest apparent power.
[Source] > Apparent power (S) > [Equipment] | Max. [kVA]	The controller outputs the apparent power of the phase with the highest apparent power.
[Source] > Apparent power (S) > [Equipment] | Total [%]	The controller outputs the total apparent power, as a percentage of the source's nominal apparent power.
[Source] > Apparent power (S) > [Equipment] | Available [kVA]	The controller outputs the available apparent power for the source in kVA. Available apparent power = Nominal apparent power - Total apparent power
[Source] > Apparent power (S) > [Equipment] | Available [%]	The controller outputs the available apparent power for the source, as a percentage of the source's nominal apparent power. Available apparent power = Nominal apparent power - Total apparent power

Table 3.14 [Source] power factor analogue output functions

Function	Details
[Source] > Power factor (PF) > [Equipment] | cos phi	The controller outputs the power factor, calculated as cos phi.
[Source] > Power factor (PF) > [Equipment] | Power factor	The controller outputs the power factor.

Table 3.15 [Source] phase angle analogue output functions

Function	Details
[Source] > Phase angle > [Equipment] | Phase angle L1-L2 [degrees]	The controller outputs the phase angle between L1 and L2.
[Source] > Phase angle > [Equipment] | Phase angle L2-L3 [degrees]	The controller outputs the phase angle between L2 and L3.
[Source] > Phase angle > [Equipment] | Phase angle L3-L1 [degrees]	The controller outputs the phase angle between L3 and L1.
[Source] > Phase angle > [Equipment] | A-B phase angle L1 [degrees]	The controller outputs the phase angle between L1 of the source and L1 of the busbar.
[Source] > Phase angle > [Equipment] | A-B phase angle L2 [degrees]	The controller outputs the phase angle between L2 of the source and L2 of the busbar.
[Source] > Phase angle > [Equipment] | A-B phase angle L3 [degrees]	The controller outputs the phase angle between L3 of the source and L3 of the busbar.

3.4.3 [Busbar] AC measurements

Assign the AC measurement function to an analogue output under `Configure > Input/output`. Select a hardware module with an analogue output, then select the output to configure.

Function names

The busbar AC measurement function names follow these formats:

[Busbar] > [Physical quantity] > [Equipment] | [Measurement] [[unit]].

For example, *Busbar A > Apparent power (S) > Busbar A | Total [kVA]*.

Table 3.16 [Busbar] AC measurement function names for each controller type

Controller type	[Busbar]	[Equipment]
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

Table 3.17 [Busbar] voltage analogue output functions

Function	Details
[Busbar] > Voltage (V) > [Equipment] | L1-N [V AC]	The controller outputs the L1-N voltage from the busbar.
[Busbar] > Voltage (V) > [Equipment] | L2-N [V AC]	The controller outputs the L2-N voltage from the busbar.
[Busbar] > Voltage (V) > [Equipment] | L3-N [V AC]	The controller outputs the L3-N voltage from the busbar.
[Busbar] > Voltage (V) > [Equipment] | N [V AC]	The controller outputs the N voltage from the busbar.
[Busbar] > Voltage (V) > [Equipment] | L1-L2 [V AC]	The controller outputs the L1-L2 voltage from the busbar.
[Busbar] > Voltage (V) > [Equipment] | L2-L3 [V AC]	The controller outputs the L2-L3 voltage from the busbar.
[Busbar] > Voltage (V) > [Equipment] | L3-L1 [V AC]	The controller outputs the L3-L1 voltage from the busbar

Function	Details
[Busbar] > Voltage (V) > [Equipment] | Positive sequence [V AC]	The controller outputs the magnitude of the positive sequence voltage.
[Busbar] > Voltage (V) > [Equipment] | Negative sequence [V AC]	The controller outputs the magnitude of the negative sequence voltage.
[Busbar] > Voltage (V) > [Equipment] | Zero sequence [V AC]	The controller outputs the magnitude of the zero sequence voltage.
[Busbar] > Voltage (V) > [Equipment] | L-N min. [V AC]	The controller outputs the lowest L-N voltage (that is, for the phase with the lowest L-N voltage).
[Busbar] > Voltage (V) > [Equipment] | L-N max. [V AC]	The controller outputs the highest L-N voltage (that is, for the phase with the highest L-N voltage).
[Busbar] > Voltage (V) > [Equipment] | L-N unbalanced [V AC]	The controller outputs the L-N unbalanced voltage.
[Busbar] > Voltage (V) > [Equipment] | L-L min. [V AC]	The controller outputs the lowest L-L voltage (that is, for the phases with the lowest L-L voltage).
[Busbar] > Voltage (V) > [Equipment] | L-L max. [V AC]	The controller outputs the highest L-L voltage (that is, for the phases with the highest L-L voltage).
[Busbar] > Voltage (V) > [Equipment] | L-L unbalanced [V AC]	The controller outputs the L-L unbalanced voltage.

Table 3.18 [Busbar] frequency analogue output functions

Function	Details
[Busbar] > Frequency (f) > [Equipment] | L1 [Hz]	The controller outputs the L1 frequency (based on the voltage measurement).
[Busbar] > Frequency (f) > [Equipment] | L2 [Hz]	The controller outputs the L2 frequency (based on the voltage measurement).
[Busbar] > Frequency (f) > [Equipment] | L3 [Hz]	The controller outputs the L3 frequency (based on the voltage measurement).
[Busbar] > Frequency (f) > [Equipment] | Min. [Hz]	The controller outputs the frequency of the phase with the lowest frequency (based on the voltage measurement).
[Busbar] > Frequency (f) > [Equipment] | Max. [Hz]	The controller outputs the frequency of the phase with the highest frequency (based on the voltage measurement).

Table 3.19 [Busbar] phase angle analogue output functions

Function	Details
[Busbar] > Phase angle > [Equipment] | Phase angle L1-L2 [degrees]	The controller outputs the phase angle between L1 and L2.
[Busbar] > Phase angle > [Equipment] | Phase angle L2-L3 [degrees]	The controller outputs the phase angle between L2 and L3.
[Busbar] > Phase angle > [Equipment] | Phase angle L3-L1 [degrees]	The controller outputs the phase angle between L3 and L1.

3.4.4 4th current input

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

Table 3.20 4th current input current analogue output function

Function	Details
Local > 4th current input > Current (I) > L4 [A]	The controller outputs the 4th current (based on the 4th current measurement).

Table 3.21 4th current input frequency analogue output function

Function	Details
Local > 4th current input > Frequency (f) > L4 [Hz]	The controller outputs the 4th frequency (based on the 4th current measurement).

Table 3.22 4th current input power analogue output function

Function	Details
Local > 4th current input > Power (P) > L4 [kW]	The controller outputs the 4th power (based on the 4th current measurement and the [Busbar] L1 voltage).

Table 3.23 4th current input reactive power analogue output function

Function	Details
Local > 4th current input > Reactive power (Q) > L4 [kvar]	The controller outputs the 4th reactive power (based on the 4th current measurement and the [Busbar] voltage).

Table 3.24 4th current input apparent power analogue output function

Function	Details
Local > 4th current input > Apparent power (S) > L4 [kVA]	The controller outputs the 4th apparent power (based on the 4th current measurement and the [Busbar] voltage).

Table 3.25 4th current input power factor analogue output functions

Function	Details
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 [Busbar] 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 [Busbar] voltage).

Table 3.26 4th current input phase angle analogue output function

Function	Details
Local > 4th current input > Phase angle > L4 [degrees]	The controller outputs the phase angle between the 4th current measurement and the [Busbar] L1 voltage measurement.

3.5 Source AC protections

3.5.1 About AC protections

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

Controller type	[Source]	[Breaker]
GENSET	Diesel genset	GB
HYBRID	Inverter	Breaker
EMERGENCY genset *	Emergency diesel genset	EGB and TB *
SHAFT generator	Shaft generator	SGB

Controller type	[Source]	[Breaker]
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. C37.2-1996 (R2008).

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

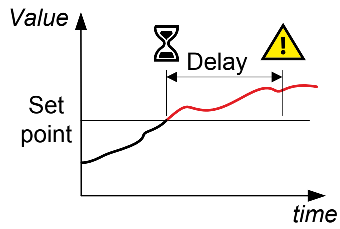
3.5.2 [Source] over-voltage (ANSI 59)

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

Table 3.27 Alarm present in controller types

GENSET	EMERGENCY genset	HYBRID	SHAFT	SHORE connection	BUS TIE breaker
●	●	●	●	●	●

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



Configure the parameters under:

```
Configure > Parameters > [Source] > Voltage protections > Over-voltage #
```

where # is 1 or 2.

Table 3.28 Default parameters

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

Table 3.29 Default inhibits

Controller type	Inhibit(s)
GENSET	Generator breaker closed
HYBRID	Inverter breaker closed
EMERGENCY genset	EDG in parallel, EDG handling blackout
SHAFT generator	Shaft breaker closed
SHORE connection	Shore breaker closed

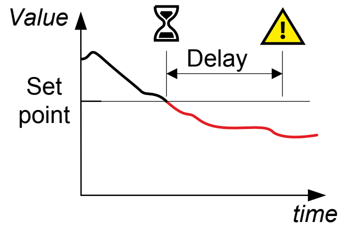
3.5.3 [Source] under-voltage (ANSI 27)

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

Table 3.30 Alarm present in controller types

GENSET	EMERGENCY genset	HYBRID	SHAFT	SHORE connection	BUS TIE breaker
●	●	●	●	●	●

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



Configure the parameters under:

```
Configure > Parameters > [Source] > Voltage protections > Under-voltage #
```

where # is 1 or 2.

Table 3.31 Default parameters

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

Table 3.32 Default inhibits

Controller type	Inhibit(s)
GENSET	• Generator breaker closed

Controller type	Inhibit(s)
	• Engine not running • Idle run active
HYBRID	• Inverter breaker closed • Inverter not running
EMERGENCY genset	• Engine not running • Idle run active • EDG in parallel • EDG handling blackout
SHAFT generator	• Shaft breaker closed • Shaft generator not running
SHORE connection	• Shore breaker closed

3.5.4 [Source] voltage unbalance (ANSI 47)

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

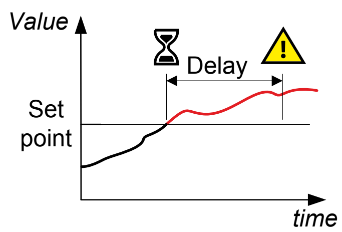
NOTE * This operate time includes the minimum user-defined delay of 100 ms.

Table 3.33 Alarm present in controller types

GENSET	EMERGENCY genset	HYBRID	SHAFT	SHORE connection	BUS TIE breaker
●	●	●	-	-	●

The alarm response is based on the highest difference between any of the three phase-to-phase voltage or phase-to-neutral true RMS values and the average voltage, as measured by the controller. The phase-to-phase voltage is the default.

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



Configure the parameters under:

```
Configure > Parameters > [Source] > Voltage protections > Voltage unbalance
```

Table 3.34 Default parameters

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

Table 3.35 Default inhibits

Controller type	Inhibit(s)
GENSET	ACM wire break
HYBRID	ACM wire break
EMERGENCY genset	EDG handling blackout
SHAFT generator	ACM wire break
SHORE connection	ACM wire break
BUS TIE breaker	ACM wire break

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 %.

3.5.5 Negative sequence voltage (ANSI 47)

Protection	IEC symbol (IEC60617)	ANSI (IEEE C37.2)	IEC 61850	Operate time
Negative sequence voltage		47	PNSC	< 200 ms *

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

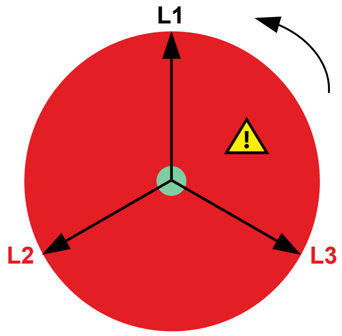
Table 3.36 Alarm present in controller types

GENSET	EMERGENCY genset	HYBRID	SHAFT	SHORE connection	BUS TIE breaker
●	-	●	-	-	●

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

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

The alarm response is based on the estimated phase-to-neutral voltage phasors, as measured from the source.



Configure the parameters under

```
Configure > Parameters > [Source] > Voltage protections > Negative sequence voltage
```

Table 3.37 Default parameters

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

3.5.6 Zero sequence voltage (ANSI 59Uo)

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

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

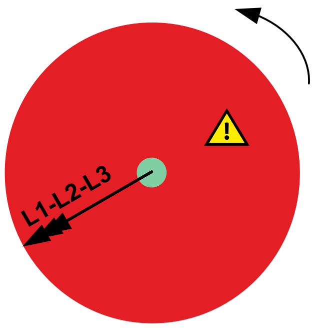
Table 3.38 Alarm present in controller types

GENSET	EMERGENCY genset	HYBRID	SHAFT	SHORE connection	BUS TIE breaker
●	-	●	-	-	●

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

This protection is used for detecting earth faults.

The alarm response is based on the estimated phase-to-neutral voltage phasors, as measured from the source.



Configure the parameters under:

```
Configure > Parameters > [Source] > Voltage protections > Zero sequence voltage
```

Table 3.39 Default parameters

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

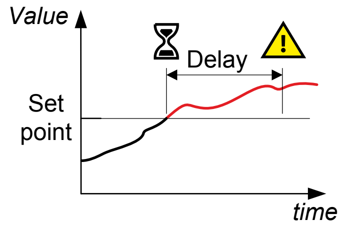
3.5.7 Over-current (ANSI 50TD)

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

Table 3.40 Alarm present in controller types

GENSET	EMERGENCY genset	HYBRID	SHAFT	SHORE connection	BUS TIE breaker
●	●	●	●	●	●

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



Configure the parameters under **Configure > Parameters > [Source] > Current protections > Over-current #**, where # is 1 or 2.

Table 3.41 Default parameters

Parameter	Range	Over-current 1	Over-current 2
Set point	Variable. Depends on current transformer settings.	100 %	110 %
Delay	0.00 s to 1 h	20 s	60 s
Enable	Not enabled, Enabled	Enabled	Enabled
Latch	Not enabled, Enabled	Not enabled	Enabled
Alarm action		Warning	Trip [Breaker]

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

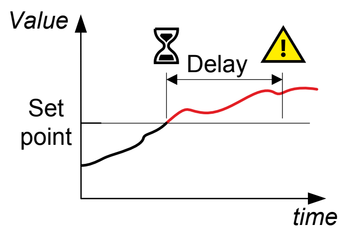
Protection	IEC symbol (IEC60617)	ANSI (IEEE C37.2)	IEC 61850	Operate time
Fast over-current	3I>>>	50/50TD *	PIOC *	< 50 ms

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

Table 3.42 Alarm present in controller types

GENSET	EMERGENCY genset	HYBRID	SHAFT	SHORE connection	BUS TIE breaker
●	●	●	●	●	●

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



Configure the parameters under:

```
Configure > Parameters > [Source] > Current protections > Fast over-current #
```

where # is 1 or 2.

Table 3.43 Default parameters

Parameter	Range	Fast over-current 1	Fast over-current 2
Set point	Variable. Depends on current transformer settings.	200 %	300 %
Delay	0.00 s to 1 h	0.00 s	0.00 s
Enable	Not enabled, Enabled	Not enabled	Not enabled
Latch	Not enabled, Enabled	Enabled	Enabled
Action		Trip [Breaker]	Trip [Breaker]

3.5.9 Current unbalance (ANSI 46)

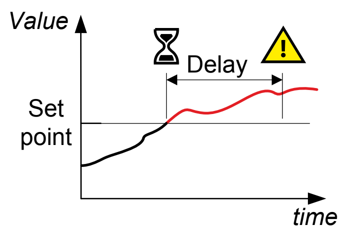
Protection	IEC symbol (IEC60617)	ANSI (IEEE C37.2)	IEC 61850	Operate time
Current unbalance	IUB>	46	-	< 200 ms *

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

Table 3.44 Alarm present in controller types

GENSET	EMERGENCY genset	HYBRID	SHAFT	SHORE connection	BUS TIE breaker
●	●	●	-	-	●

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



Configure the parameters under:

```
Configure > Parameters > [Source] > Current protections > Current unbalance (average calc.)
```

or

```
Configure > Parameters > [Source] > Current protections > Current unbalance (nominal calc.)
```

Table 3.45 Default parameters

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

Average method

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

Average method example

A GENSET 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. See the example below.

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 %.

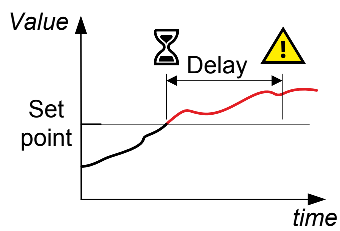
3.5.10 Directional over-current (ANSI 67)

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

Table 3.46 Alarm present in controller types

GENSET	EMERGENCY genset	HYBRID	SHAFT	SHORE connection	BUS TIE breaker
●	-	●	-	-	-

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



Configure the parameters under:

```
Configure > Parameters > [Source] > Current protections > Directional over-current #
```

where # is 1 or 2*.

Table 3.47 Default parameters

Parameter	Range	Directional over-current 1	Directional over-current 2
Set point	-300 to 300 % of nominal current	110 %	130 %
Delay	0.00 s to 1 h	0.10 s	0.10 s
Enable	Not enabled, Enabled	Not enabled	Not enabled
Action		Warning	Warning

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*.

3.5.11 Inverse time over-current (ANSI 51)

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

Table 3.48 Alarm present in controller types

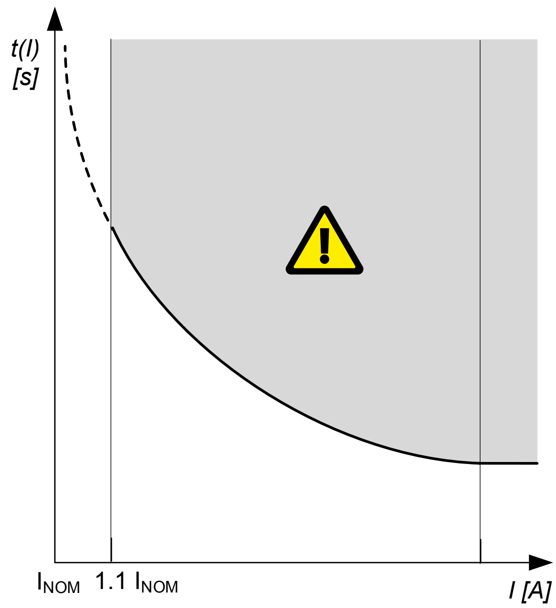
GENSET	EMERGENCY genset	HYBRID	SHAFT	SHORE connection	BUS TIE breaker
●	●	●	●	●	●

This is an inverse time over-current alarm.

The alarm response is based on the highest phase current true RMS values, based on IEC 60255 part 151, as measured by the controller.

The alarm response time depends on an approximated integral of the current measurement over time. The integral is only updated when the measurement is above the activation threshold (indicated in the diagram to the right by the value 1.1 I_{NOM}). 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.
1.1 = Threshold default setting.



Inverse time over-current calculation method

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

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

where:

t(G)	Theoretical operating time constant value of G, in seconds
k, c and α	Constants for the selected curve (*k* and *c* in seconds, *α* (alpha) has no unit)
G	Measured value, that is, I_{phase}
G_S	Alarm set point ($G_S = I_{nom}$ * LIM / 100 %)
TMS	Time multiplier setting

Parameters

Configure the parameters under:

```
Configure > Parameters > [Source] > Current protections > Inverse time over-current
```

Table 3.49 Three-phase inverse time over-current alarm default parameters

Parameter	Range	Inverse time over-current
Curve	See the table below	IEC inverse
Limit (the set point, also known as LIM)	2 to 200 % of nominal current	110 %
Time multiplier setting (TMS)	0.01 to 100.0	1.0
Threshold (G_T)	1.0 to 1.3	1.1
k (only used if custom curve is selected)	0.001 s to 2 min	0.14 s
c (only used if custom curve is selected)	0.000 s to 1 min	0 s
alpha (α, or a) (only used if custom curve is selected)	0.001 to 1 min	0.02
Enable	Not enabled, Enabled	Not enabled
Latch	Not enabled, Enabled	Enabled
Alarm action		Trip [Breaker]

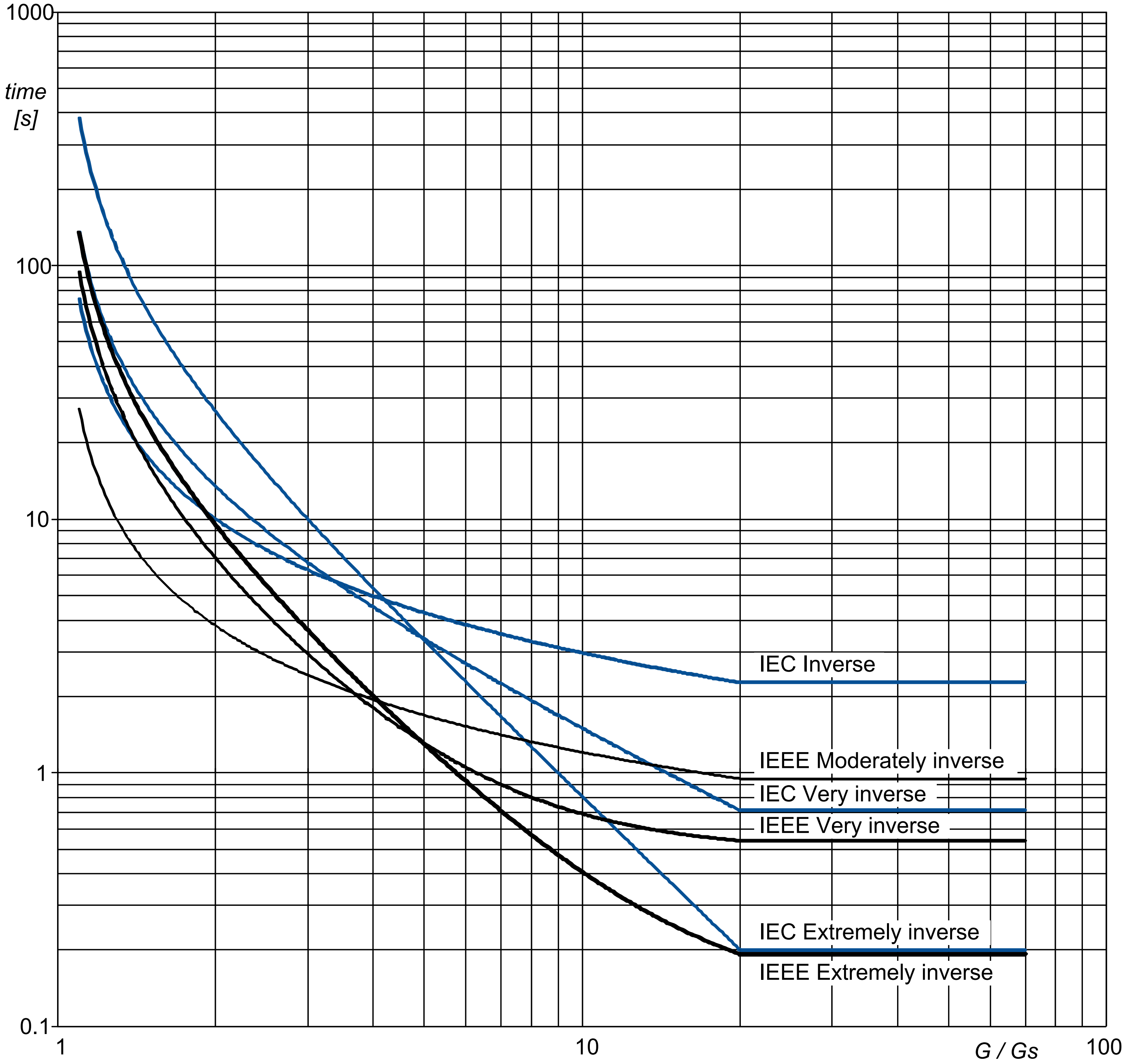
Standard inverse time over-current curves

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

Table 3.50 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

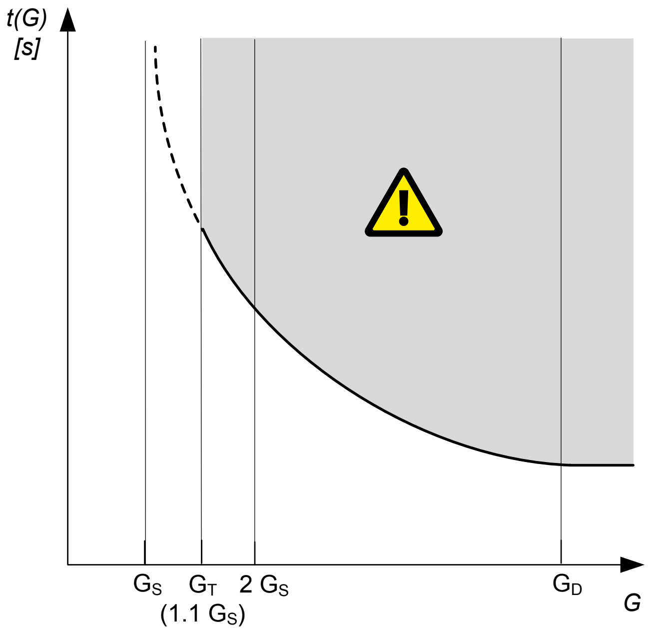
Figure 3.1 Standard curve shapes for inverse time over-current, with time multiplier setting (TMS) = 1



Definite time characteristic

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

Figure 3.2 Inverse time over-current time characteristic graph



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

Influence of the CT primary current rating on G_D example

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

G_D of the inverse time over-current characteristic graph according to IEC60255 is 7000 A.

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

However, the highest G_D value where measurements can be made is 1750 A.

- Because the secondary current rating is 5 A, the formula to calculate the measurable G_D is $G_D = 3.5 \times I_{CT\ primary}$.
- $G_D = 3.5 \times I_{CT\ primary} = 3.5 \times 500 = 1750$ A

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

3.5.12 Negative sequence current (ANSI 46)

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

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

Table 3.51 Alarm present in controller types

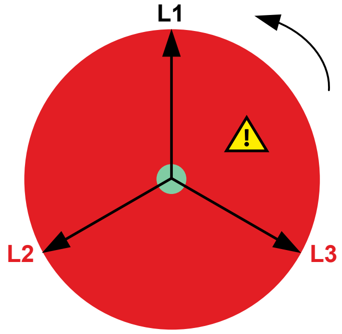
GENSET	EMERGENCY genset	HYBRID	SHAFT	SHORE connection	BUS TIE breaker
●	-	●	-	-	●

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

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

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

The alarm response is based on the estimated phase-to-neutral current phasors, from the source, as measured by the controller.



Configure the parameters under:

```
Configure > Parameters > [Source] > Current protections > Negative sequence current
```

Table 3.52 Default parameters

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

3.5.13 Zero sequence current (ANSI 51Io)

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

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

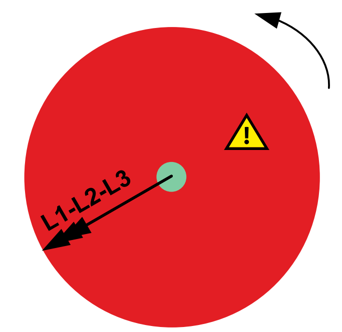
Table 3.53 Alarm present in controller types

GENSET	EMERGENCY genset	HYBRID	SHAFT	SHORE connection	BUS TIE breaker
●	-	●	-	-	●

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

This protection is used for detecting earth faults.

The alarm response is based on the estimated phase-to-neutral current phasors from the source, as measured by the controller.



Configure the parameters under

```
Configure > Parameters > [Source] > Current protections > Zero sequence current
```

Table 3.54 Default parameters

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

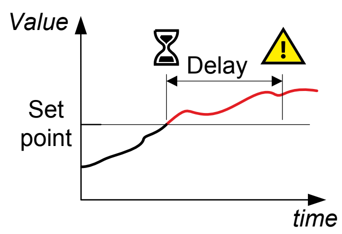
3.5.14 [Source] over-frequency (ANSI 81O)

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

Table 3.55 Alarm present in controller types

GENSET	EMERGENCY genset	HYBRID	SHAFT	SHORE connection	BUS TIE breaker
●	●	●	●	●	●

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



Configure the parameters under:

```
Configure > Parameters > [Source] > Frequency protections > Over-frequency #
```

where # is 1 or 2.

Table 3.56 Default parameters

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

Table 3.57 Default inhibits

Controller type	Inhibit(s)
GENSET	Generator breaker closed
HYBRID	Inverter breaker closed
EMERGENCY genset	Generator breaker closed, Tie breaker closed
SHAFT generator	Shaft breaker closed
SHORE connection	Shore breaker closed

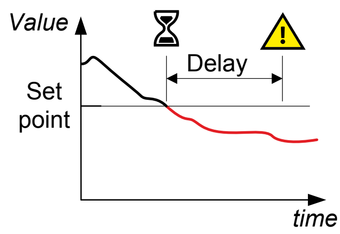
3.5.15 [Source] under-frequency (ANSI 81U)

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

Table 3.58 Alarm present in controller types

GENSET	EMERGENCY genset	HYBRID	SHAFT	SHORE connection	BUS TIE breaker
●	●	●	●	●	●

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



Configure the parameters under

```
Configure > Parameters > [Source] > Frequency protections > Under-frequency #
```

where # is 1 or 2.

Table 3.59 Default parameters

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

Table 3.60 Default inhibits

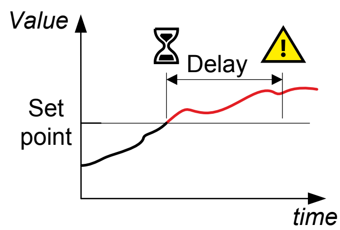
Controller type	Inhibit(s)
GENSET	• Generator breaker closed

Controller type	Inhibit(s)
	• Engine not running • Idle run active
HYBRID	• Inverter breaker closed • Inverter not running
EMERGENCY genset	• Generator breaker closed • Tie breaker closed • Engine not running • Idle run active
SHAFT generator	• Shaft breaker closed • Shaft generator not running
SHORE connection	• Shore breaker closed

3.5.16 Overload (ANSI 32)

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

The alarm response is based on the active power (all phases), from the source, as measured by the controller.



Configure the parameters under:

```
Configure > Parameters > [Source] > Power protections > Overload #
```

where # is 1 or 2.

Table 3.61 Default parameters

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

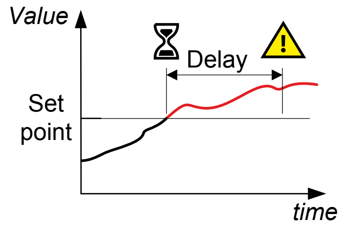
3.5.17 Reverse power (ANSI 32R)

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

Table 3.62 Alarm present in controller types

GENSET	EMERGENCY genset	HYBRID	SHAFT	SHORE connection	BUS TIE breaker
●	●	●	●	●	-

The alarm response is based on the active power (all phases), to the source, as measured by the controller.



Configure the parameters under:

```
Configure > Parameters > [Source] > Power protections > Reverse power #
```

where # is 1 or 2.

Table 3.63 Default parameters

Parameter	Range	Reverse power 1	Reverse power 2
Set point	0 to 200 % of nominal power	8.0 %	15.0 %
Delay	0.00 s to 1 h	5.00 s	2.00 s
Enable	Not enabled, Enabled	Enabled	Enabled
Latch	Not enabled, Enabled	Enabled	Enabled
Action		Trip [Breaker]	Trip [Breaker]

Table 3.64 Default inhibits

Controller type	Inhibit(s)
SHAFT generator	Power take home active

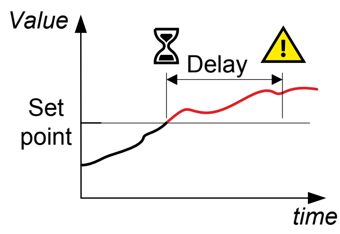
3.5.18 Overload reverse power (ANSI 32R)

Protection	IEC symbol (IEC60617)	ANSI (IEEE C37.2)	IEC 61850	Operate time
Overload reverse power		32R		< 100 ms

Table 3.65 Alarm present in controller types

GENSET	EMERGENCY genset	HYBRID	SHAFT	SHORE connection	BUS TIE breaker
-	-	●	-	-	-

The alarm response is based on the active power (all phases), to the source, as measured by the controller.



Configure the parameters under:

```
Configure > Parameters > Inverter > Power protections > Overload reverse power #
```

where # is 1 or 2.

Table 3.66 Default parameters

Parameter	Range	Overload reverse power 1	Overload reverse power 2
Set point	0 to 200 % of nominal power	95.0 %	110.0 %
Delay	0.00 s to 1 h	30 s	30 s
Enable	Not enabled, Enabled	Enabled	Enabled
Latch	Not enabled, Enabled	Not enabled	Enabled
Action		Warning	Trip breaker

Table 3.67 Default inhibits

Controller type	Inhibit(s)
HYBRID controller	Operating mode PTI (Power take in)
	Operating mode standby

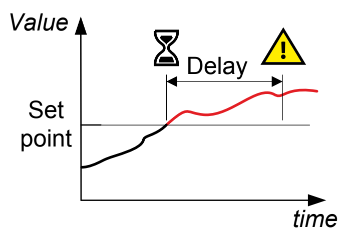
3.5.19 Reactive power export (ANSI 40O)

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

Table 3.68 Alarm present in controller types

GENSET	EMERGENCY genset	HYBRID	SHAFT	SHORE connection	BUS TIE breaker
●	●	●	●	●	●

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



Configure the parameters under:

```
Configure > Parameters > [Source] > Reactive power protections > Reactive power export #
```

where # is 1 or 2.

Table 3.69 Default parameters

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

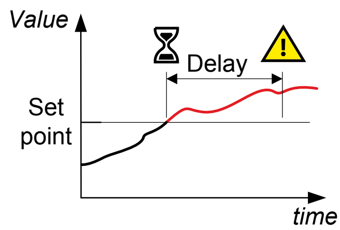
3.5.20 Reactive power import (ANSI 40U)

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

Table 3.70 Alarm present in controller types

GENSET	EMERGENCY genset	HYBRID	SHAFT	SHORE connection	BUS TIE breaker
●	●	●	●	●	●

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



Configure the parameters under:

```
Configure > Parameters > [Source] > Reactive power protections > Reactive power import #
```

where # is 1 or 2.

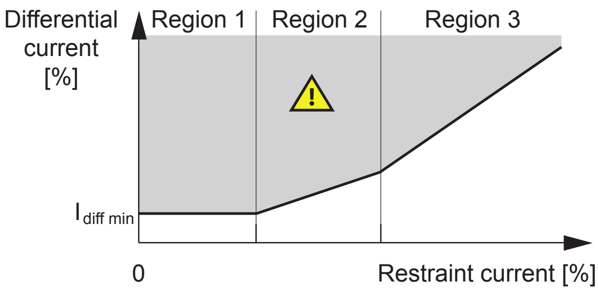
Table 3.71 Default parameters

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

3.5.21 Generator differential current protection (ANSI 87G)

Protection	IEC symbol (IEC60617)	ANSI (IEEE C37.2)	IEC 61850	Operate time
Generator stabilised differential current	Id>	87G	PDIF	< 55 ms
Generator high set differential current	Id>>	87G	PDIF	< 55 ms

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



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

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

More information
See **AC configuration and nominal settings > AC configuration > [Source] AC configuration** for more information about changing the reference direction of the current transformer.

Configure the parameters for the *Stabilised differential current* protection under:

```
Configure > Parameters > Generator > Current protections > Stabilised differential current
```

Table 3.72 Stabilised differential current default parameters

Parameter	Range	Default
I diff. min.	5 to 100 % of I_{nom}	15 %
Region 1: End	10 to 150 % of I_{nom}	75 %
Region 2: Slope	10 to 50 % of I_{nom}	20 %
Region 2: End	100 to 1000 % of I_{nom}	200 %
Region 3: Slope	30 to 100 % of I_{nom}	75 %
Delay	0 to 60 s	0.00 s
Enable	Not enabled, Enabled	Enabled
Latch	Not enabled, Enabled	Enabled
Alarm action		Trip generator breaker + AVR + stop engine*

Configure the parameters for the *High set differential current* protection under

```
Configure > Parameters > Generator > Current protections > High set differential current
```

Table 3.73 High set differential current default parameters

Parameter	Range	Default
Set point	50 to 1200 % of I_{nom}	800 %
Delay	0 to 60 s	0.00 s
Enable	Not enabled, Enabled	Enabled
Latch	Not enabled, Enabled	Enabled
Alarm action		Trip generator breaker + AVR + stop engine*

3.5.22 Synchronisation check, including blackout close (ANSI 25)

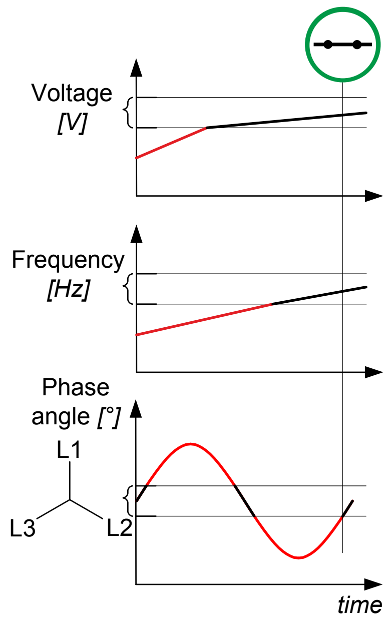
Protection	IEC symbol (IEC60617)	ANSI (IEEE C37.2)	IEC 61850	Operate time
Synchronisation check (including blackout close)	-	25	RSYN	-

For all breakers under power management system (PMS) control, the sync check ensures that the voltages, frequencies, and phase angles are within the allowed limits before the controller closes the breaker.

The synchronisation check includes blackout close. That is, if equipment is trying to close a breaker to a busbar that does not have voltage, the breaker is allowed to close without synchronisation.

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

The synchronisation check 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 synchronisation check is based on the parameters under

```
Configure > Parameters > Breakers > [Breaker] configuration > Synchronisation setting
```

More information
See **Power management**, **Blackout** for more information about blackout closing.

3.6 Busbar AC protections

3.6.1 [Busbar] over-voltage (ANSI 59)

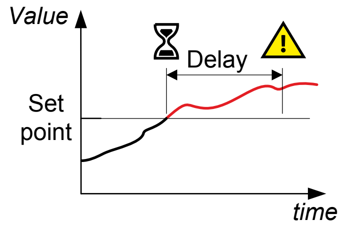
Protection	IEC symbol (IEC60617)	ANSI (IEEE C37.2)	IEC 61850	Operate time
Over-voltage	U>, U>>	59	PTOV	< 50 ms

Table 3.74 Alarm present in controller types

GENSET	EMERGENCY genset	HYBRID	SHAFT	SHORE connection	BUS TIE breaker
●	●	●	●	●	●

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

For the BUS TIE breaker controller, these voltages are measured on busbar B.



Configure the parameters under:

```
Configure > Parameters > [Busbar] > Voltage protections > Over-voltage #
```

where # is 1 or 2.

Table 3.75 Default parameters

Parameter	Range	Busbar over-voltage 1	Busbar over-voltage 2
Set point	90 to 120 % of nominal voltage	105 %	115 %
Delay	0.00 s to 1 h	5.00 s	3.00 s
Enable	Not enabled, Enabled	Enabled	Enabled
Latch	Not enabled, Enabled	Not enabled	Enabled
Action		Warning	Trip [Breaker] *

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.

Table 3.76 Default inhibits

Controller type	Inhibit(s)
GENSET	• Generator breaker open
HYBRID	• Inverter breaker open
EMERGENCY genset	• Generator breaker open • Tie breaker open • EDG handling blackout
SHAFT generator	• Shaft breaker open
SHORE connection	• Shore breaker open

3.6.2 [Busbar] under-voltage (ANSI 27)

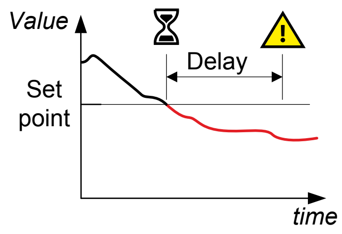
Protection	IEC symbol (IEC60617)	ANSI (IEEE C37.2)	IEC 61850	Operate time
Under-voltage	U<, U<<	27	PTUV	< 50 ms

Table 3.77 Alarm present in controller types

GENSET	EMERGENCY genset	HYBRID	SHAFT	SHORE connection	BUS TIE breaker
●	●	●	●	●	●

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

For the BUS TIE breaker controller, these voltages are measured on busbar B.



Configure the parameters under:

```
Configure > Parameters > [Busbar] > Voltage protections > Under-voltage #
```

where # is 1 or 2.

Table 3.78 Default parameters

Parameter	Range	Busbar under-voltage 1	Busbar under-voltage 2
Set point	50 to 100 % of nominal voltage	95 %	80 %
Delay	0.00 s to 1 h	5.00 s	3.00 s
Enable	Not enabled, Enabled	Enabled	Enabled
Latch	Not enabled, Enabled	Not enabled	Enabled
Action		Warning	Trip [Breaker] *

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.

Table 3.79 Default inhibits

Controller type	Inhibit(s)
GENSET	• Generator breaker open • ACM wire break
HYBRID	• Inverter breaker open • ACM wire break
EMERGENCY genset	• Generator breaker open • Tie breaker open • EDG handling blackout
SHAFT generator	• Shaft breaker open • ACM wire break
SHORE connection	• Shore breaker open • ACM wire break
BUS TIE breaker	• ACM wire break

3.6.3 [Busbar] voltage unbalance (ANSI 47)

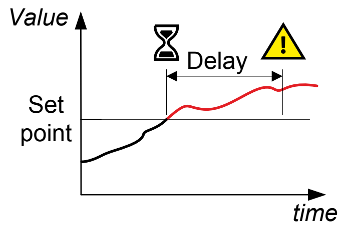
Protection	IEC symbol (IEC60617)	ANSI (IEEE C37.2)	IEC 61850	Operate time
Voltage unbalance (voltage asymmetry)	UUB>	47	-	< 200 ms *

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

Table 3.80 Alarm present in controller types

GENSET	EMERGENCY genset	HYBRID	SHAFT	SHORE connection	BUS TIE breaker
•	•	•	•	•	•

The alarm response is based on the highest difference between any of the three busbar phase-to-phase voltage or phase-to-neutral true RMS values and the average voltage, as measured by the controller. The phase-to-phase voltage is the default.



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.

For the BUS TIE breaker controller, these are the voltages measured on busbar B.

Configure the parameters under:

```
Configure > Parameters > [Busbar] > Voltage protections > Voltage unbalance
```

Table 3.81 Default parameters

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

Table 3.82 Default inhibits

Controller type	Inhibit(s)
GENSET	ACM wire break
HYBRID	ACM wire break
EMERGENCY genset	EDG handling blackout
SHAFT generator	ACM wire break
SHORE connection	ACM wire break
BUS TIE breaker	ACM wire break

Busbar voltage unbalance example

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

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

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

3.6.4 [Busbar] over-frequency (ANSI 81O)

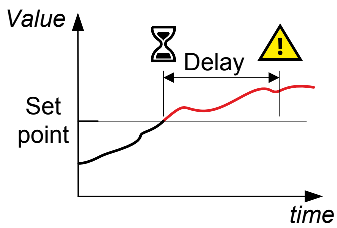
Protection	IEC symbol (IEC60617)	ANSI (IEEE C37.2)	IEC 61850	Operate time
Over-frequency	f>, f>>	81O	PTOF	< 50 ms

Table 3.83 Alarm present in controller types

GENSET	EMERGENCY genset	HYBRID	SHAFT	SHORE connection	BUS TIE breaker
●	●	●	●	●	●

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

For the BUS TIE breaker controller, this is the frequency measured on busbar B.



Configure the parameters under:

```
Configure > Parameters > [Busbar] > Frequency protections > Over-frequency #
```

where # is 1 or 2.

Table 3.84 Default parameters

Parameter	Range	Busbar over-frequency 1	Busbar over-frequency 2
Set point	100 to 130 % of nominal frequency	105 %	110 %
Delay	0.00 s to 1 h	5.00 s	8.00 s
Enable	Not enabled, Enabled	Enabled	Enabled
Latch	Not enabled, Enabled	Not enabled	Enabled
Alarm action		Warning	Trip [Breaker] *

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.

Table 3.85 Default inhibits

Controller type	Inhibit(s)
GENSET	• Generator breaker open
HYBRID	• Inverter breaker open
EMERGENCY genset	• Generator breaker open • Tie breaker open • EDG handling blackout
SHAFT generator	• Shaft breaker open
SHORE connection	• Shore breaker open

3.6.5 [Busbar] under-frequency (ANSI 81U)

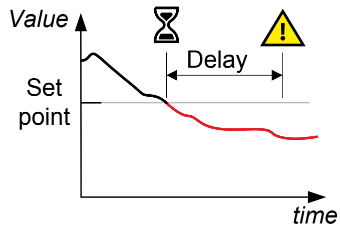
Protection	IEC symbol (IEC60617)	ANSI (IEEE C37.2)	IEC 61850	Operate time
Under-frequency	f<, f<<	81U	PTUF	< 50 ms

Table 3.86 Alarm present in controller types

GENSET	EMERGENCY genset	HYBRID	SHAFT	SHORE connection	BUS TIE breaker
●	●	●	●	●	●

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

For the BUS TIE breaker controller, this is the frequency measured on busbar B.



Configure the parameters under:

```
Configure > Parameters > [Busbar] > Frequency protections > Under-frequency #
```

where # is 1 or 2.

Table 3.87 Default parameters

Parameter	Range	Busbar under-frequency 1	Busbar under-frequency 2
Set point	80 to 100 % of nominal frequency	96 %	93 %
Delay	0.00 s to 1 h	10.00 s	5.00 s
Enable	Not enabled, Enabled	Enabled	Enabled
Latch	Not enabled, Enabled	Not enabled	Enabled
Action		Warning	Trip [Breaker] *

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 that it controls.

Table 3.88 Default inhibits

Controller type	Inhibit(s)
GENSET	• Generator breaker open • ACM wire break
HYBRID	• Inverter breaker open • ACM wire break
EMERGENCY genset	• Generator breaker open • Tie breaker open • EDG handling blackout
SHAFT generator	• Shaft breaker open • ACM wire break
SHORE connection	• Shore breaker open • ACM wire break
BUS TIE breaker	• ACM wire break

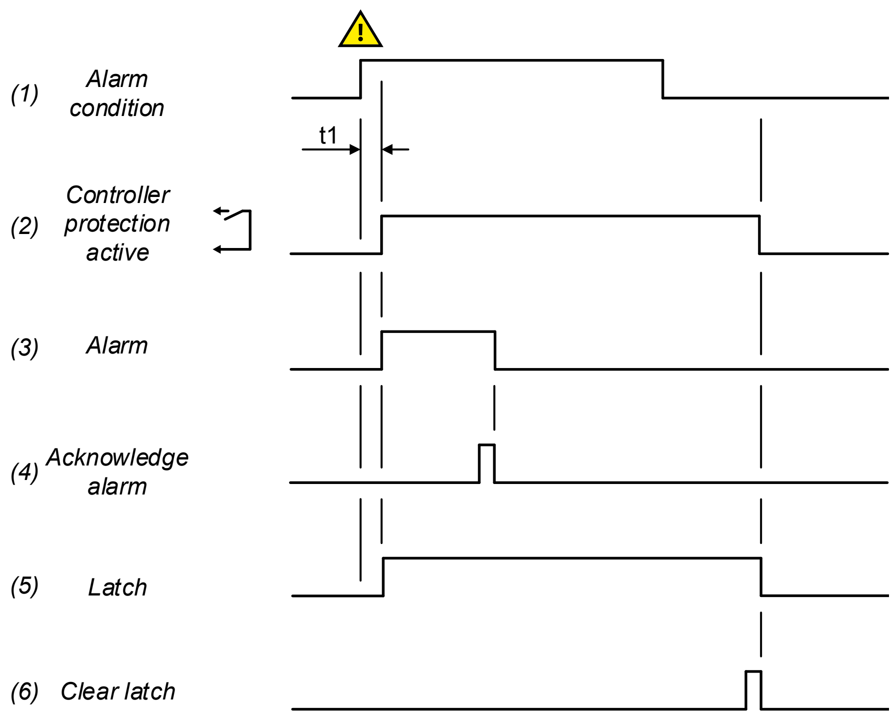
3.7 Other AC protections

3.7.1 Lockout relay (ANSI 86)

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

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

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



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

For most alarms, a latch can be *Enabled* as a parameter under

```
Configure > Parameters > [Alarm location] > [Alarm] > Latch
```

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

[Alarm] is the alarm name.

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

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

Optional: Configuring an external lockout relay

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

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.

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

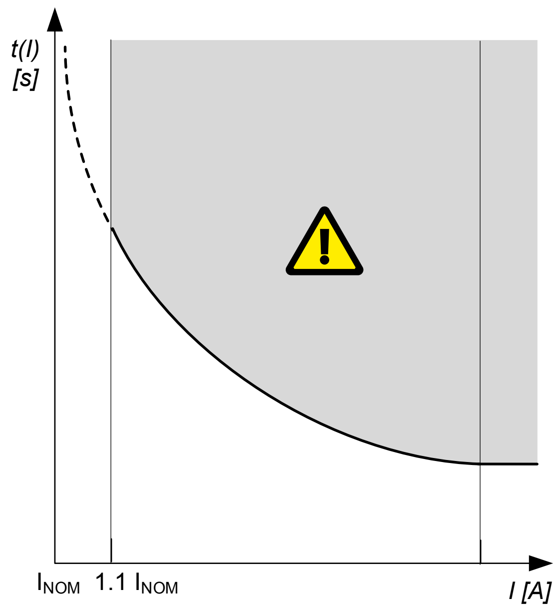
Protection	IEC symbol (IEC60617)	ANSI (IEEE C37.2)	IEC 61850	Operate time
Earth inverse time over-current		51G		-

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

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

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

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



Wiring

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

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

Parameters

Configure the parameters under:

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

Table 3.89 Default parameters

Parameter	Range	Earth inverse time over-current
Curve	See the reference	IEC Inverse
Limit (the set point, also known as LIM)	2 to 200 % of nominal current (4th current input)	10 %
Time multiplier setting (TMS)	0.01 to 100.0	1.0
Threshold	1.0 to 1.3	1.1
k (only used if custom curve is selected)	0.001 s to 2 min	0.14 s
c (only used if custom curve is selected)	0 s to 1 min	0 s
alpha (α, or a) (only used if custom curve is selected)	0.001 to 1	0.02
Enable	Not enabled, Enabled	Enabled
Latch	Not enabled, Enabled	Enabled
Alarm action		Trip breaker

More information
See **Source AC protections**, **Inverse time over-current (ANSI 51N)** in this chapter for the calculation method, the standard curves, and information about the definite time characteristic.

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

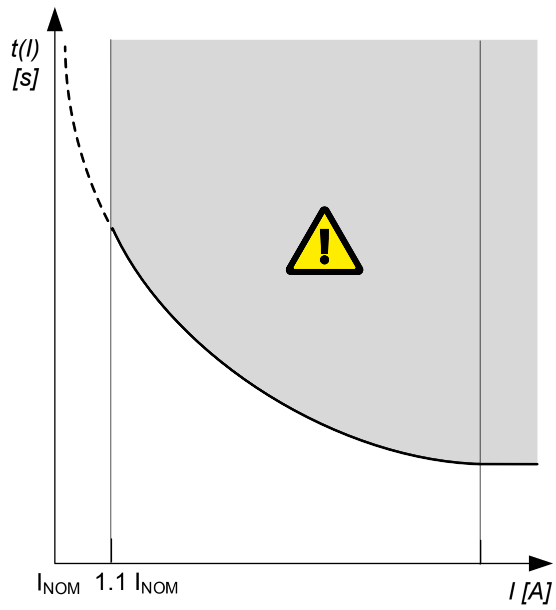
Protection	IEC symbol (IEC60617)	ANSI (IEEE C37.2)	IEC 61850	Operate time
Neutral inverse time over-current		51N		-

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

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

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

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



Wiring

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

More information
See **Wiring examples for controller functions** 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 have both of these protections at the same time.

Parameters

Configure the parameters under

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

Table 3.90 Default parameters

Parameter	Range	Neutral inverse time over-current
Curve	See the reference	IEC Inverse
Limit (the set point, also known as LIM)	2 to 200 % of nominal current (4th current input)	30 %
Time multiplier setting (TMS)	0.01 to 100.0	1.0
Threshold	1.0 to 1.3	1.1
k (only used if custom curve is selected)	0.001 s to 2 min	0.14 s
c (only used if custom curve is selected)	0 s to 1 min	0 s
alpha (α, or a) (only used if custom curve is selected)	0.001 to 1	0.02

Parameter	Range	Neutral inverse time over-current
Enable	Not enabled, Enabled	Enabled
Latch	Not enabled, Enabled	Enabled
Alarm action		Trip [Breaker]

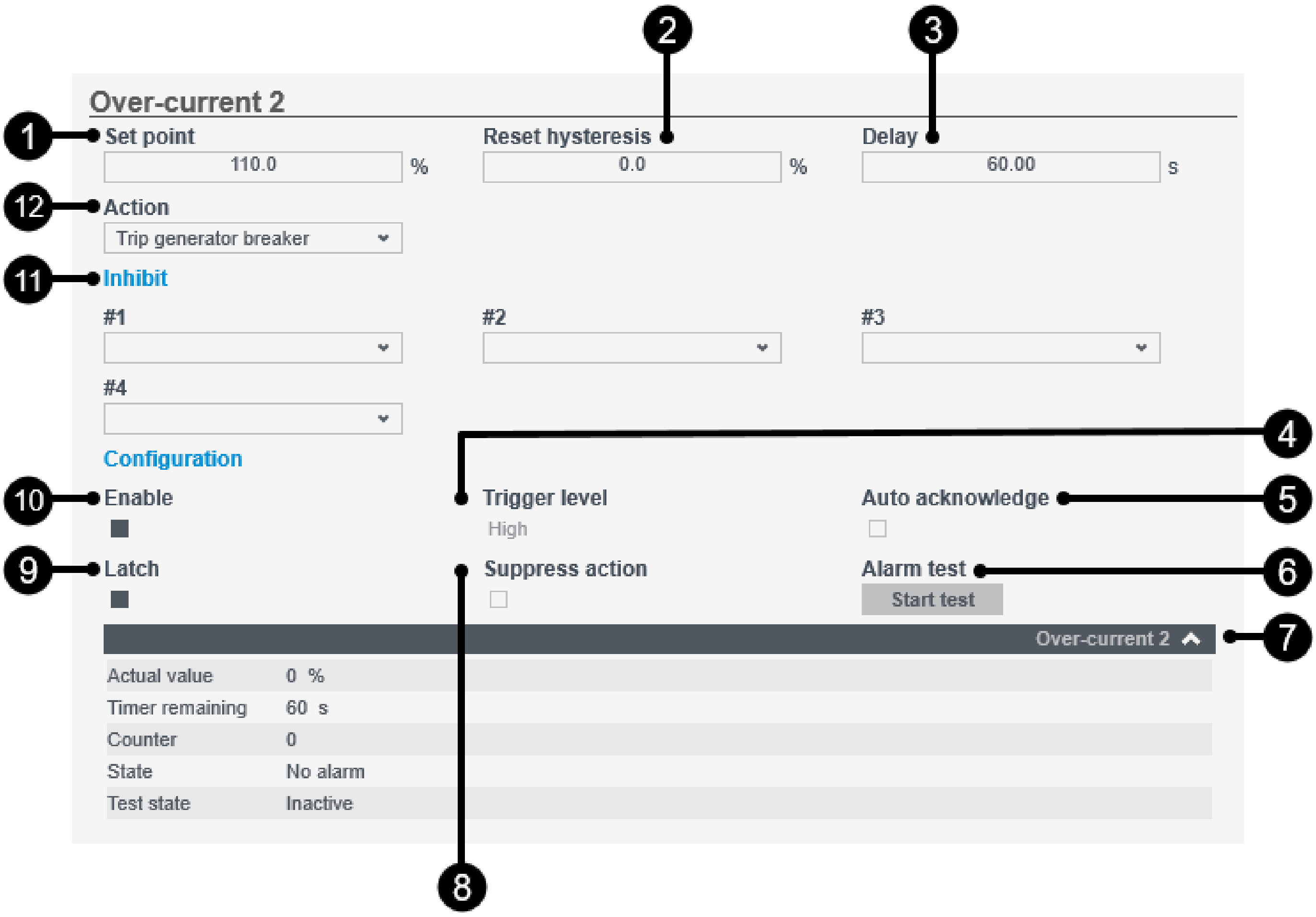
More information
See **Source AC protections**, **Inverse time over-current (ANSI 51)** in this chapter for the calculation method, the standard curves, and information about the definite time characteristic.

4. Alarms and protections

4.1 Alarm parameters

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

Figure 4.1 Typical alarm parameters in PICUS



#	Parameter	Range	Notes
1	Set point	Varies	The setting at which the alarm is triggered. Must be considered with *Trigger level* setting.
2	Reset hysteresis	Varies	See **Reset hysteresis** for more information.
3	Delay	Varies	Delay before the alarm becomes active.
4	Trigger level (fixed) *	High, Low	Whether the alarm is triggered at a **High** or **Low** setting.
5	Auto acknowledge	Not enabled, Enabled	If **Enabled** the alarm is automatically acknowledged when it occurs.
6	Alarm test	Start test, Stop test	Selecting **Start test** starts an alarm test for the selected protection. Starting an alarm test also activates the alarm action. Selecting **Stop test** stops the alarm test for the selected protection.
7	Additional alarm information	Varies	Shows additional information about the state of the alarm.

#	Parameter	Range	Notes
8	Suppress action	Not enabled, Enabled	If **Enabled** the alarm action is suppressed. The alarm message will appear in the alarm list.
9	Latch	Not enabled, Enabled	If **Enabled** the alarm is latched when it occurs and requires both acknowledgement and reset (unlatch) to clear.
10	Enable	Not enabled, Enabled	If the alarm is enabled or not enabled in the controller.
11	Inhibit(s) #1 to #32	Varies	Inhibit(s), that if active, can inhibit the alarm from becoming active. Note that there are only four fields for inhibits in PICUS.
12	Action	Varies	Action to be taken.

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

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

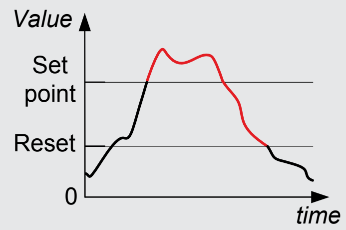
Reset hysteresis

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.

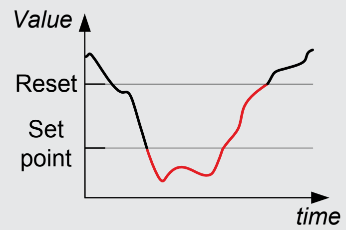
Overspeed example

Consider an *Overspeed* alarm with a *Set point* of 110 % of nominal speed and a *Reset hysteresis* of 10 %. The overspeed alarm cannot be reset until the operating value falls below 100 % of nominal speed. The red line in the following figure shows that the alarm is activated when the value exceeds the *Set point*. The alarm is only deactivated when the value drops below the reset value.



Under-speed example

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

The following graphs show how the *Delay* works.

Figure 4.2 Delay for a high alarm based on an analogue operating value

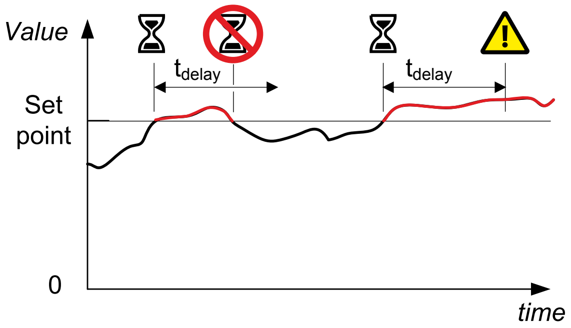
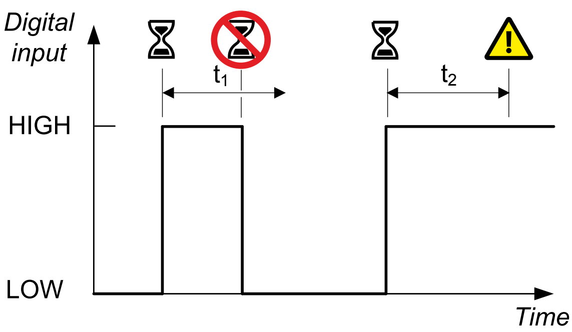


Figure 4.3 Delay for a high alarm based on a digital input



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 conditions are met. Alarm actions also act as a type of alarm categorisation. Minor alarm situations may be assigned warnings, while a critical situation may trip the breaker 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.

The description of the common alarm actions follows.

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

Block	
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.) **Genset start is blocked**: If the genset is stopped, the controller will not start it. (If the genset is running, this alarm action does not stop the genset.)

PMS-controlled stop	
Controller types	GENSET, HYBRID, and EMERGENCY genset controllers
Priority	Medium
Effect	The breaker is de-loaded and then opened. After the cooldown period, the genset stops. 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.

Priority of alarm action

It is possible for two or more alarm actions to be active for the same equipment at the same time. In these cases, the controller performs the alarm *Action* with the highest priority. A later alarm *Action* with a lower priority does not change the controller's execution of the earlier alarm *Action* with the higher priority. Similarly, if a 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 the inhibit conditions are active. When an inhibit is active, the controller does not activate the alarm *Action*, even if all the other alarm conditions are met. Inhibits are automatic and are not controlled by the operator.

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 needs to be acknowledged (and unlatched if required) before the alarm 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 the appropriate default inhibits for each alarm. You can remove these inhibits, and/or add more inhibits. In addition to the default inhibits, you can also configure three customisable I/O inhibits for selection.

More information
See **Alarms**, **Customised inhibits** for more information.

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, then 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 **Power management, Blackout** for more information about blackout recovery.

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.

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.

Table 4.1 Additional alarm information

Information	Notes
Actual value	Shows the operating value of the alarm.
Timer remaining	Shows the remaining delay time before the alarm activates.
Counter	Counts how many times the alarm was activated. The amount shown also includes activation during an alarm test.
State	Shows the state of the alarm. **More information** See **Alarms > Alarm handling** for a detailed description of each alarm state.
Test state	Shows if an alarm test is in progress (**Active**) or not in progress (**Inactive**) for the alarm.
Reset counter value	Changes the *Counter* parameter value to the selected value.

4.2 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, and/or CustomLogic.

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

Inputs

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

Table 4.2 Hardware required in addition to the minimum standard controller wiring

Function	I/O	Type	Details
Alarm system > Inhibits > Activate inhibit #, where # is 1 to 3	Digital input	Continuous	When the digital input is activated, then the controller applies *Inhibit #*, where # is 1 to 3.

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

Parameters

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

Table 4.3 Inhibit parameters

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

4.2.1 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, and/or CustomLogic.

Input

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

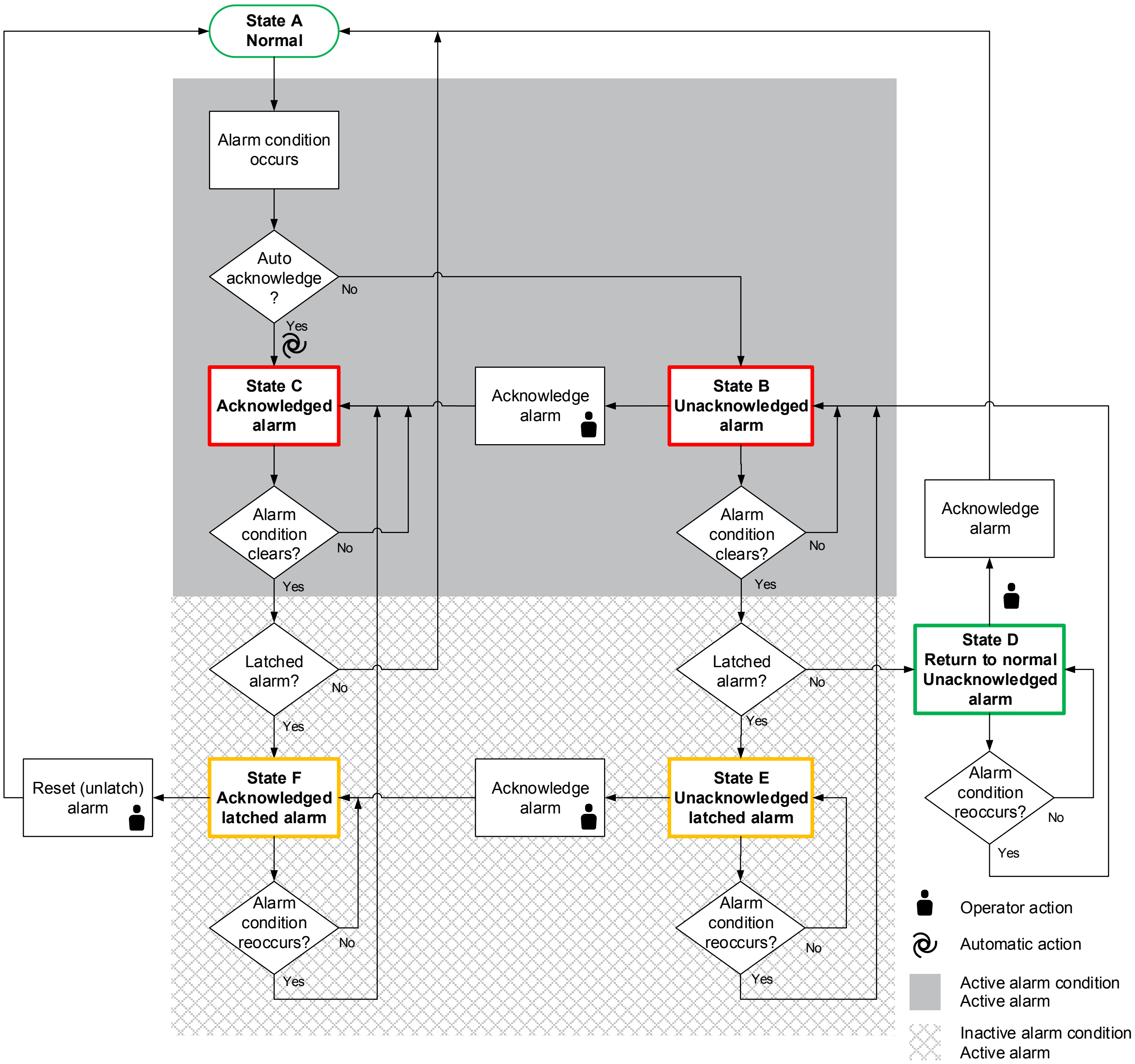
Function	I/O	Type	Details
Alarm system > Additional functions > Suppress alarm action	Digital input	Continuous	When the digital input is activated, then the controller suppresses all the alarms with *Suppress action* enabled.

4.3 Alarm handling

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

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

Figure 4.4 Alarm processing states (excluding state G, H and I)



INFO

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

Table 4.4 Alarm states

Alarm state	Description	Alarm condition*	Alarm**
A	Normal operating condition	No	Inactive
B	Unacknowledged alarm	Yes	Active
C	Acknowledged alarm	Yes	Active
D	Unacknowledged alarm	No	Inactive

Alarm state	Description	Alarm condition*	Alarm**
E	Unacknowledged latched alarm	No	Active
F	Acknowledged latched alarm	No	Active

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

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

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

Automatic actions

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

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

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

Operator alarm actions

An operator can perform the following alarm actions:

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

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

4.3.1 Acknowledge

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

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

Table 4.5 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*.

Inputs

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

Table 4.6 Optional hardware

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.

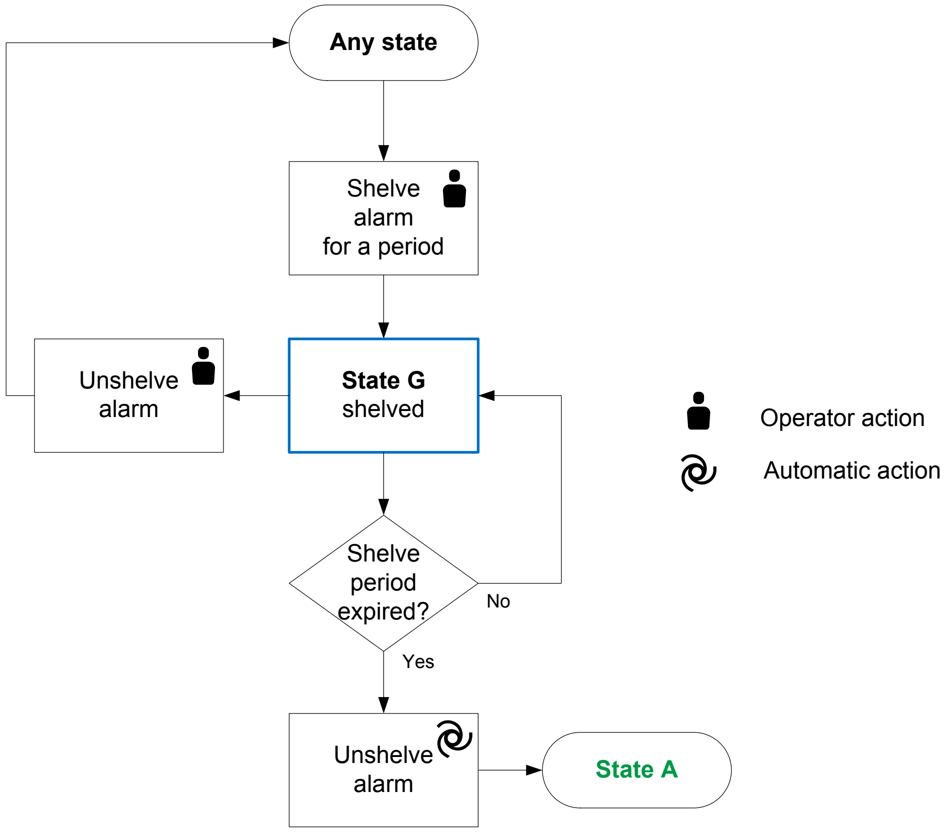
4.3.2 Shelve

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

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

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

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



Operator shelves the alarm.

Operator unshelves the alarm.

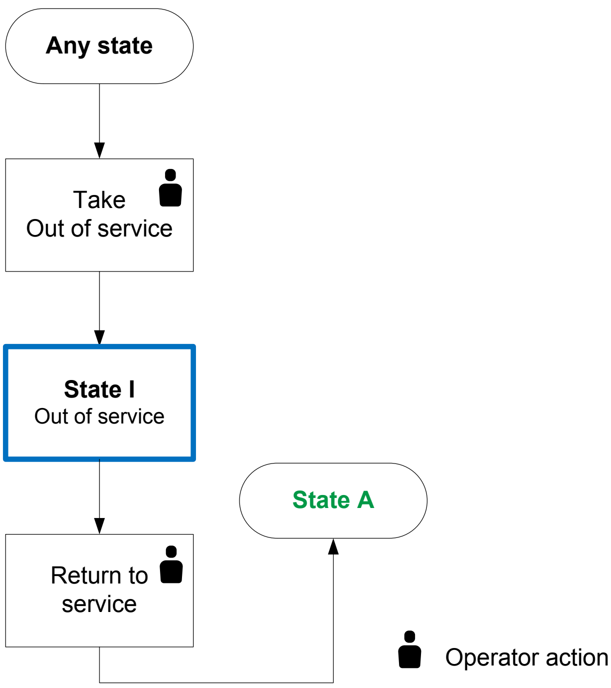
Check whether the shelve period has expired.

The controller automatically unshelves the alarm after the period expires.

4.3.3 Out of service

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

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



Operator removes the alarm from service.

Alarm is out of service and not active.

Operator returns the alarm to service.

4.3.4 Latch reset

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

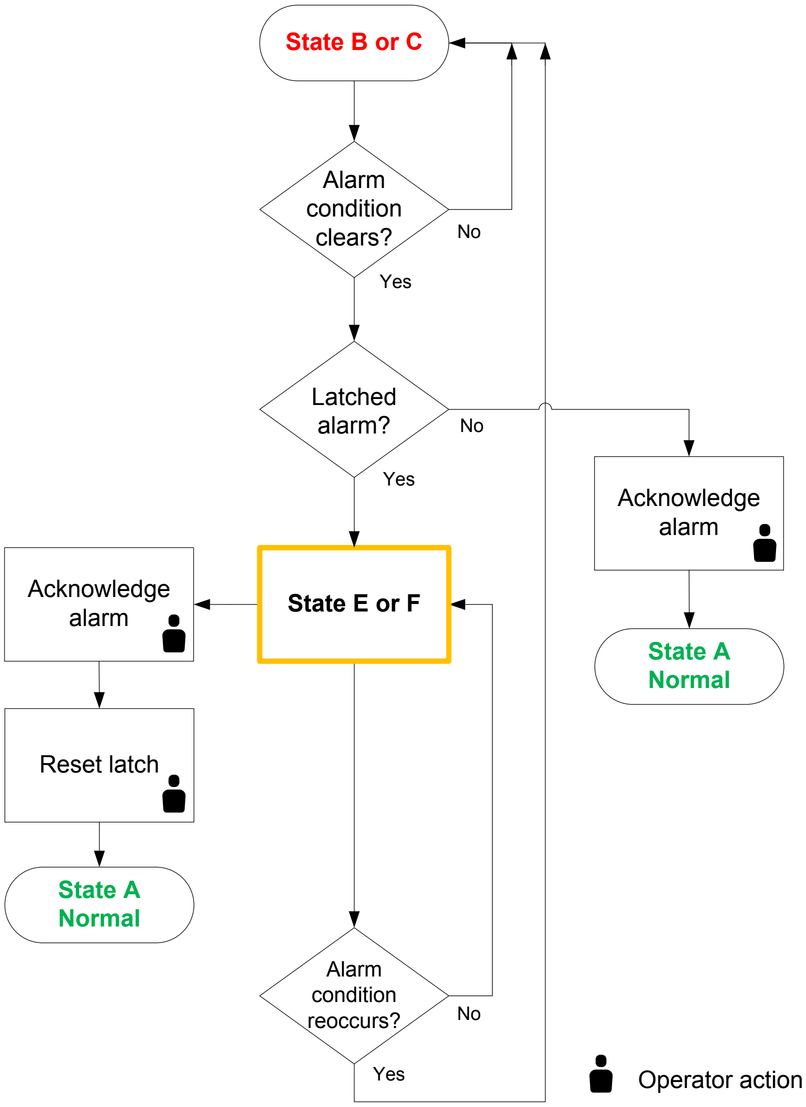
INFO
Alarm latching can provide an extra layer of safety for the system.

The controller checks the *Alarm condition*.

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

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

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



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 then resets the latch.

Input

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

Table 4.7 Optional hardware

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

4.4 Alarm test

The alarm tests activate controller alarms AND all their alarm actions. You can activate alarm tests from the **Alarms** page in PICUS, or by enabling the **Enable alarm test** parameter, or by starting an alarm test for an individual alarm using the alarm's **Alarm test** parameter. When you use the **Enable alarm test** parameter to perform the alarm test, all the enabled alarms and their alarm actions are activated, and shut down the engine.

DANGER!
DO NOT use the alarm test during normal operation. The alarm actions will force the system under switchboard control, trip all the breakers, create a blackout.

More information
See **Alarms > Alarm parameters > Alarm test** for more information about testing individual alarms.

More information
See **Alarms > Tasks > Perform an alarm test** in the **PICUS manual** for more information about the alarm test buttons available on the **Alarms** page in PICUS.

Before the test

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

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

During the test

When the test is *Enabled*, the alarms appear on the display and in the alarm list, and are recorded in the log. Test alarms appear in green text on the display, and are marked with a grey dot in the **T** column in the alarm list in PICUS.

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 alarm list, and the alarm action continues until the alarm test stops.

Latches: 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, but the alarm condition remains active after the test are still acknowledged when the alarm test stops.

4.4.1 Alarm status digital outputs

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

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

Table 4.8 Alarm status digital output functions

Function	Type	Details	GENSET	EMERGENCY	HYBRID	SHAFT	SHORE	BTB
Local > System OK > Status OK	Continuous	Activated if the power supply to PSM3.1 is OK, and all of the controller hardware module self-checks were OK. *Status OK* is always configured on terminals 3 and 4 of PCM3.1. *Status OK* can also be configured on any other digital output terminals. This digital output has a safety function. The controller deactivates this output if there is a problem with the controller.	●	●	●	●	●	●
Alarm system > State > Any warning alarm	Continuous	Activated if there are any warning alarm active in the controller.	●	●	●	●	●	●
Alarm system > State > Any block alarm	Continuous	Activated if there is any active alarm in the controller with the alarm action *Block*.	●	●	●	●	●	●
Alarm system > State > Any PMS-controlled stop alarm	Continuous	Activated if there is any active alarm in the controller with the alarm action *PMS-controlled stop*.	●	●	●			
Alarm system > State > Any PMS-controlled open breaker alarm	Continuous	Activated if there is any active alarm in the controller with the alarm action *PMS-controlled open breaker*.				●	●	●
Alarm system > State > Any GB trip alarm	Continuous	Activated if there is any active alarm in the controller with the alarm action *Trip generator breaker*.	●	●				
Alarm system > State > Any breaker trip alarm	Continuous	Activated if there is any active alarm in the controller with the alarm actions *Trip breaker*.			●			
Alarm system > State > Any GB trip and stop alarm	Continuous	Activated if there is any active alarm in the controller with the alarm action *Trip generator breaker and stop engine*and/or *Trip generator breaker and AVR and stop engine*.	●	●				

Function	Type	Details	GENSET	EMERGENCY	HYBRID	SHAFT	SHORE	BTB
Alarm system > State > Any breaker trip and stop inverter alarm	Continuous	Activated if there is any active alarm in the controller with the alarm action *Trip breaker and stop inverter*and/or *Trip breaker and AVR and stop inverter*.			•			
Alarm system > State > Any GB trip and shutdown alarm	Continuous	Activated if there is any active alarm in the controller with the alarm action *Trip generator breaker and shutdown engine* and/or *Trip generator breaker and AVR and shutdown engine*.	•	•				
Alarm system > State > Any alarm	Continuous	Activated if there are any acknowledged, unacknowledged or alarms with active latches in the controller.	•	•	•	•	•	•
Alarm system > State > Any unacknowledged alarm	Continuous	Activated if there are any unacknowledged alarms in the controller.	•	•	•	•	•	•
Alarm system > State > Any latched alarm	Continuous	Activated if there are any active alarms with active latches in the controller.	•	•	•	•	•	•
Alarm system > State > Any shelved alarm	Continuous	Activated if there are any shelved alarms in the controller.	•	•	•	•	•	•
Alarm system > State > Any out of service alarm	Continuous	Activated if any alarms in the controller are out of service.	•	•	•	•	•	•
Alarm system > State > Any SGB trip alarm	Continuous	Activated if there is any active alarm in the controller with the alarm action *Trip shaft generator breaker*.				•		
Alarm system > State > Any SCB trip alarm	Continuous	Activated if there is any active alarm in the controller with the alarm action *Trip shore connection breaker*.					•	
Alarm system > State > Any BTB trip alarm	Continuous	Activated if there is any active alarm in the controller with the alarm action *Trip bus tie breaker*.						•
Alarm system > State > Any AVR trip alarm	Continuous	Activated if there is any active alarm with the alarm action *Trip AVR*.	•	•	•	•		
Alarm system > State > Any GB + AVR alarm	Continuous	Activated if there is any active alarm with the alarm action *Trip generator breaker + AVR*.	•	•				
Alarm system > State > Any breaker + AVR alarm	Continuous	Activated if there is any active alarm with the alarm action *Trip breaker + AVR*.			•			

Function	Type	Details	GENSET	EMERGENCY	HYBRID	SHAFT	SHORE	BTB
Alarm system > State > Any SGB + AVR alarm	Continuous	Activated if there is any active alarm with the alarm action *Trip generator breaker + AVR*.				•		
Alarm system > State > Any GB + AVR + stop engine alarm	Continuous	Activated if there is any active alarm with the alarm action *Trip generator breaker + AVR + stop engine*.	•	•				
Alarm system > State > Any breaker + AVR + stop inverter alarm	Continuous	Activated if there is any active alarm with the alarm action *Trip breaker + AVR + stop inverter*.			•			

Applications

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

4.5 Horn output function

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

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

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

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

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

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

More information
See **Alarms**, **Horn outputs**, **Silencing alarms** for more information.

Output

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

Table 4.9 Hardware required in addition to the minimum standard controller wiring

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

Parameters

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

Table 4.10 Default horn output parameters

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

Simple horn

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

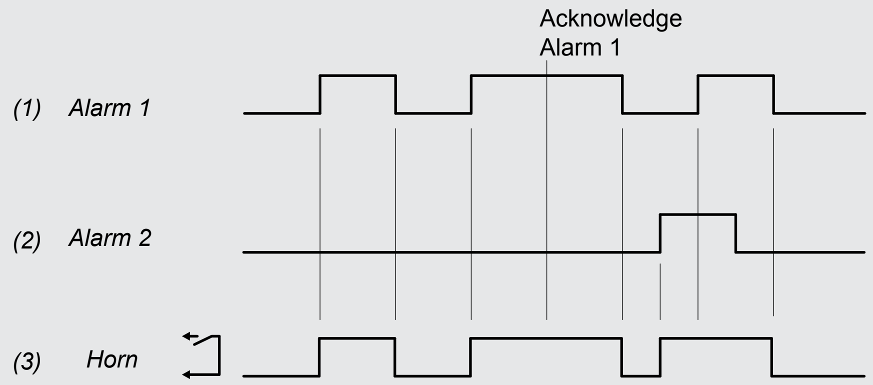
The horn output is deactivated when there are no active alarms.

Table 4.11 Simple horn parameters

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

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

Simple horn example



Simple horn with acknowledge

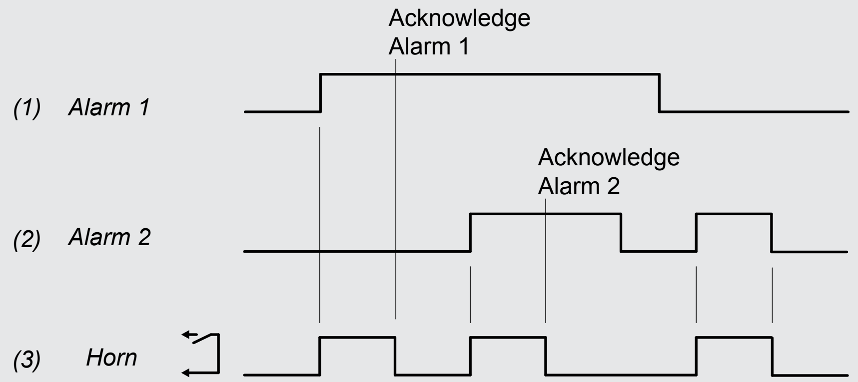
The horn output is activated when one or more alarms are active.

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

Table 4.12 Simple horn with acknowledge parameters

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

Simple horn with acknowledge example



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

Siren

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

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

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

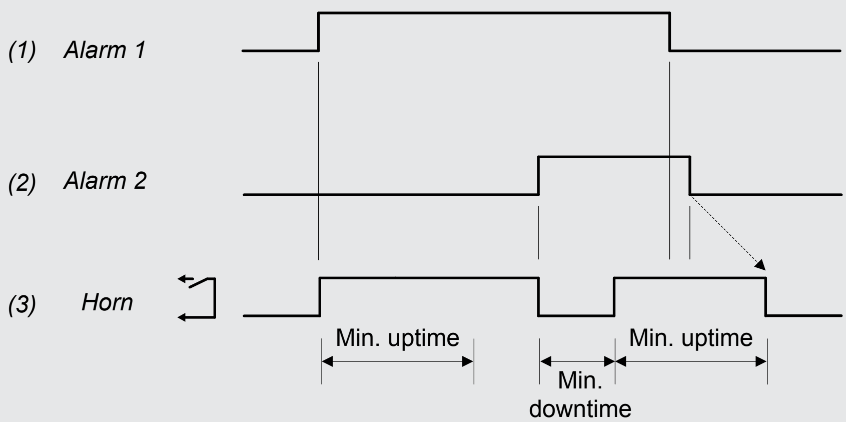
Each time the horn output is activated, the horn output must remain activated for the time in the *Minimum up time* parameter. This stops multiple new alarms from deactivating the horn output.

Table 4.13 Siren parameters

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

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

Siren example



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

Siren with acknowledge

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

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

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

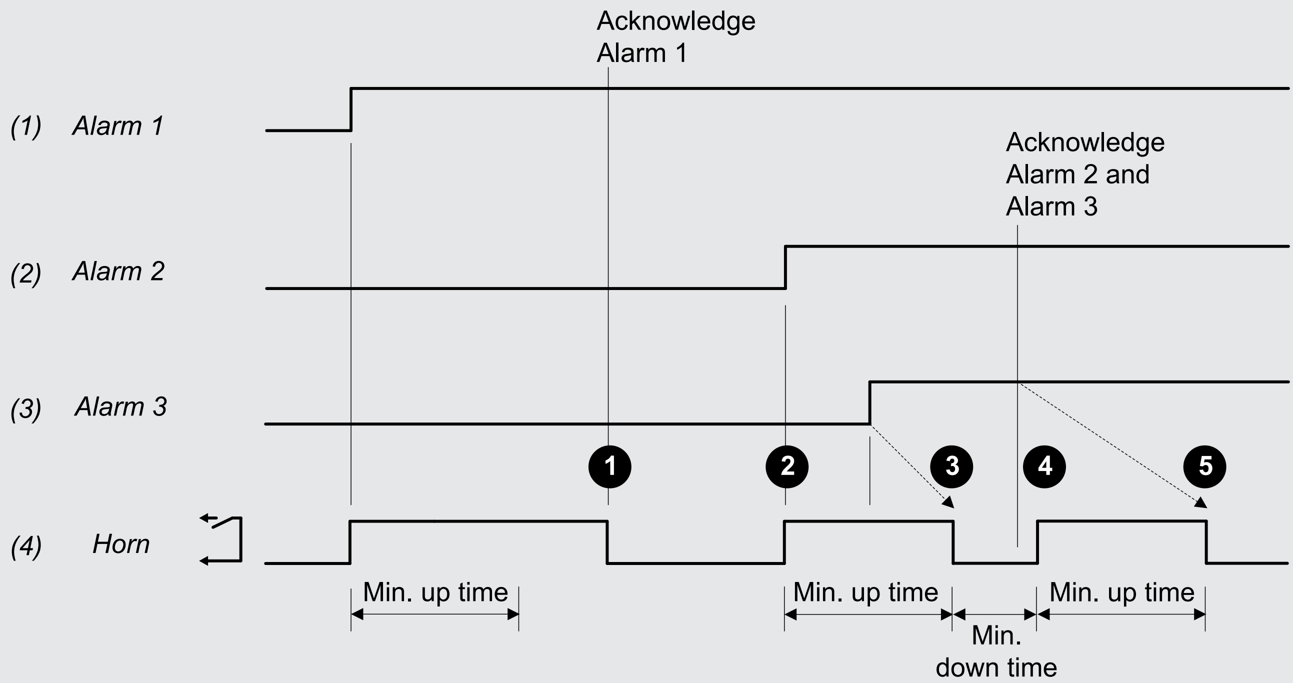
There is no new *Minimum down time* when all the alarms are acknowledged.

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

Table 4.14 Siren with acknowledge parameters

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

Siren with acknowledge example

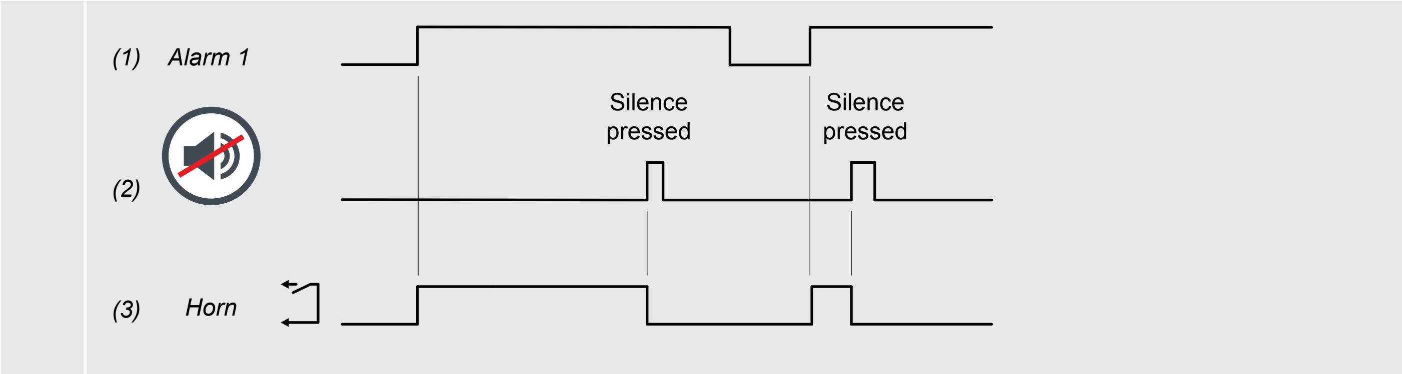


1. The horn output is deactivated when alarm 1 is acknowledged. There is no *Minimum down time* when the alarms are acknowledged.
2. Alarm 2 becomes active, and shortly after that, alarm 3 become active. For alarm 2, the horn output remains activated for the *Minimum up time*.
3. The horn output is then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

Horn silence

When the operator presses **Horn silence**  on the display unit, the controller immediately deactivates all horn outputs. **Horn silence**  does NOT have any other effect on the alarm system. If a new alarm is activated after the push-button is pressed, then the horn output restarts.

Effect of the horn silence push-button example



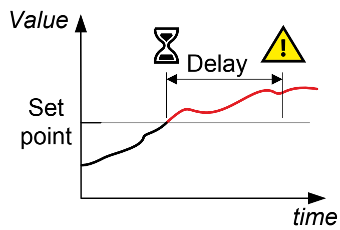
INFO

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

4.6 Non-essential loads

4.6.1 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 source, as measured by the controller.

By default, up to three NEL trips are available.

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

Configure the parameters under **Configure > Parameters > Non-essential load trip > Trip #** > **Over-current**, where # is 1, 2 or 3.

Table 4.15 Default parameters

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

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

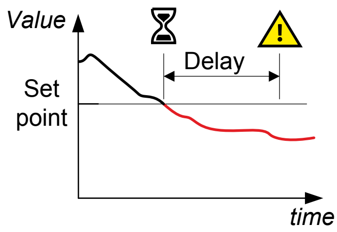
Inhibits: The trips are inhibited if the breaker to the busbar is open.

4.6.2 NEL # under-frequency

These NEL trips are for busbar under-frequency protection.

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

By default, up to three NEL trips are available.



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

Configure the parameters under **Configure > Parameters > Non-essential load trip > Trip # > Under-frequency**, where # is 1, 2 or 3.

Table 4.16 Default parameters

Parameter	Range	Trip 1 > Under-frequency	Trip 2 > Under-frequency	Trip 3 > Under-frequency
Set point	70 to 100 % of nominal frequency	95 %	95 %	95 %
Delay	0.1 s to 1 h	5.0 s	8.0 s	10.0 s
Enable	Not enabled, Enabled	Not enabled	Not enabled	Not enabled
Action*		Warning	Warning	Warning

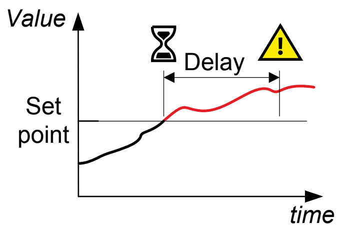
*Note: The NEL function also trips NEL #. You cannot reconnect the NEL until the alarm is deactivated. The alarm action cannot be changed.

4.6.3 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 source, as measured by the controller.

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



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

Configure the parameters under **Configure > Parameters > Non-essential load trip > Trip #** > **Overload 1**, where # is 1, 2 or 3.

Table 4.17 Default overload NEL trip parameters

Parameter	Range	Trip 1 > Overload 1	Trip 2 > Overload 1	Trip 3 > Overload 1
Set point	10 to 200 % of nominal power	100 %	100 %	100 %
Time delay	0.1 s to 1 h	5.0 s	8.0 s	10.0 s
Enable	Not enabled, Enabled	Not enabled	Not enabled	Not enabled
Action*		Warning	Warning	Warning

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

Configure the parameters under **Configure > Parameters > Non-essential load trip > Trip #** > **Overload 2**, where # is 1, 2 or 3.

Table 4.18 Default fast overload NEL trip parameters

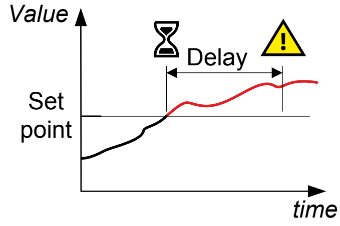
Parameter	Range	Trip 1 > Overload 2	Trip 2 > Overload 2	Trip 3 > Overload 2
Set point	10 to 200 % of nominal power	110 %	110 %	110 %
Time delay	0.1 s to 100 s	1.0 s	1.0 s	1.0 s
Enable	Not enabled, Enabled	Not enabled	Not enabled	Not enabled
Action*		Warning	Warning	Warning

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

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

4.6.4 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 source, as measured by the controller.

By default, up to three NEL trips are available.

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

Configure the parameters under **Configure > Parameters > Non-essential load trip > Trip #** > **Reactive overload**, where # is 1, 2 or 3.

Table 4.19 Default reactive overload NEL trip parameters

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

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

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

4.7 Custom input alarms

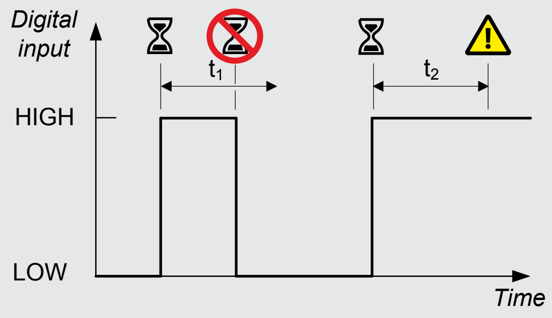
4.7.1 Digital input (DI) alarms

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.

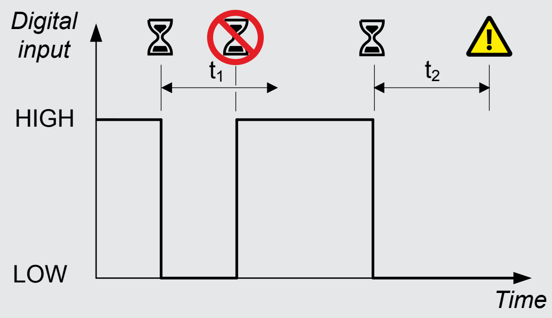
By default, a digital input (DI) is normally open, and the alarm is activated if the digital input is closed for longer than the *Time delay*.



LOW input trigger example

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

Select *Low* for the alarm trigger level.



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

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

Table 4.20 Custom alarm (DI) parameters

Parameter	Range	Default	Notes
Name	Text	-	Name for the alarm
Trigger level	Low, High	-	Whether the alarm is triggered at **High** or **Low**.
Auto acknowledge	Not enabled, Enabled	Not enabled	
Latch	Not enabled, Enabled	Not enabled	
Delay	0 s to 1 h	10 s	
Action	Selectable list	-	
Inhibit(s)	Selectable list	-	

4.7.2 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.

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.

INFO
Configure the analogue input (AI) sensor setup (including the scale) before creating an alarm for the input.

More information
See **Hardware characteristics and configuration, General characteristics, Analogue input characteristics and configuration** for information about configuring sensor failure alarms.

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

Table 4.21 Custom alarm (AI) parameters

Parameter	Range	Default	Notes
Name	Text		Name for the alarm
Trigger level	Low, High	High	Whether the alarm is triggered at **High** or **Low**.
Auto acknowledge	Not enabled, Enabled	Not enabled	
Delay	0 s to 1 h	10 s	
Set point	Varies	-	Depends upon selected input scale unit
Reset hysteresis	Varies	-	Depends upon selected input scale unit
Action	Selectable list	-	
Inhibit(s)	Selectable list	-	

Low oil pressure analogue input alarm example

Configure the analogue input for the oil pressure sensor under **Configure > Input/output > [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.

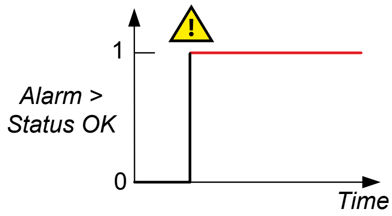
Configure the sensor as follows:
Sensor = *0 to 25 mA*
Units = *bar*
Select an unused *Custom input scale #*.
Input (mA), Minimum = *4*, Maximum = *20*
Output (bar), Minimum = *0*, Maximum = *10*
Create two points for the curve: *4 mA and 0 bar*, and *20 mA and 10 bar*.

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.

4.8 General system alarms

4.8.1 System not OK



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

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

- All the modules in the rack are sending an OK signal.
- All the modules in the rack have a software version that is compatible with the controller application software.
- All the modules required for 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.
- The controller software has started and is running OK.

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

Configure the parameters under **Configure > Parameters > Local > Monitoring > System not OK**. The alarm is always enabled.

Table 4.22 Default parameters

Parameter	Range	Default	Notes
Action		Warning	
Latch	Not enabled, Enabled	Enabled	

More information
See **Alarms**, **Alarm test and status**, **Alarm status digital outputs** for more information about the configuration of the *Status OK* alarm output.

4.8.2 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.

4.8.3 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.

4.8.4 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.

4.8.5 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.

4.8.6 Fieldbus connection missing

This alarm is for the internal communication between the controller and its extension units. If there is a redundancy connection, this alarm communicates that an Ethernet connection is missing or broken.

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

4.8.7 Fieldbus conflict

This alarm is for the internal communication between the controller and its extension units. If there is a hardware change or hardware failure, this alarm communicates that the hardware configuration does not match the previous hardware configuration. Use *Configure* > *Fieldbus configuration* in PICUS to correct the hardware configuration.

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

4.8.8 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 diagrams 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.

4.8.9 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.

4.8.10 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.

4.8.11 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 **Configure > Parameters > Communication > NTP**. The alarm action is always *Warning* and cannot be changed.

4.8.12 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 **Configure > Parameters > Communication > NTP**. The alarm action is *Warning* and cannot be changed.

4.8.13 Live power detected (emulation)

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

The controller activates this alarm if **Configure > Parameters > Test functions > Emulation > Emulation active** is *Enabled* and live power is detected on ACM3.1.

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

4.8.14 Emulation disabled (live power)

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

The controller activates this alarm if **Configure > Parameters > Test functions > Emulation > Emulation active** is *Enabled* and live power is detected on ACM3.1. The alarm changes the emulation parameter to *Not enabled* on all controllers in the system.

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

4.9 General hardware module alarms

4.9.1 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*. This alarm activates the *System not OK* alarm. The alarm parameters are not visible.

INFO
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.

4.9.2 Required I/O 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*.

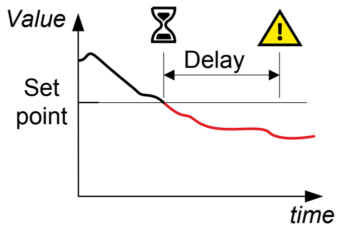
If one or more default controller hardware modules are missing, then this alarm is activated on start-up. The controller also activates the *System not OK* alarm. The alarm parameters are not visible.

4.10 Power supply module PSM3.1

4.10.1 PSM3.1 1 supply voltage low alarm

This default alarm is for power supply voltage protection.

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



Configure the parameters under **Configure > Parameters > Hardware > PSM3.1 1 > Low voltage alarm** .

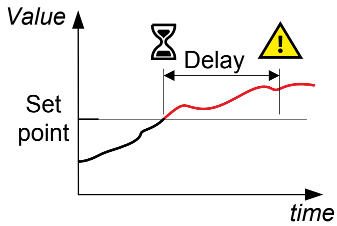
Table 4.23 Default parameters

Parameter	Range	PSM3.1 1 supply voltage low
Set point	8.0 to 32.0 V DC	18.0 V DC
Delay	0 s to 1 h	1.0 s
Enable	Not enabled, Enabled	Enabled
Alarm action		Warning

4.10.2 PSM3.1 1 supply voltage high alarm

This default alarm is for power supply voltage protection.

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



Configure the parameters under **Configure > Parameters > Hardware > PSM3.1 1 > High voltage alarm** .

Table 4.24 Default parameters

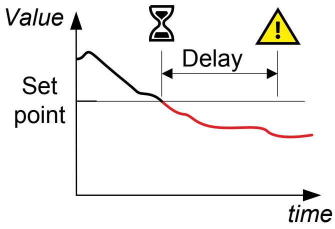
Parameter	Range	PSM3.1 1 supply voltage high
Set point	12.0 to 36.0 V DC	30.0 V DC
Delay	0 s to 1 h	1.0 s
Enable	Not enabled, Enabled	Enabled
Alarm action		Warning

4.11 Power supply module PSM3.2

4.11.1 PSM3.2 1 supply voltage low alarm

This default alarm is for power supply voltage protection.

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



Configure the parameters under **Configure > Parameters > Hardware > PSM3.2 1 > Low voltage alarm** .

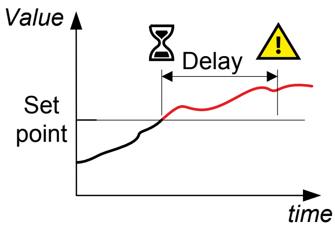
Table 4.25 Default parameters

Parameter	Range	PSM3.2 1 supply voltage low
Set point	8.0 to 32.0 V DC	18.0 V DC
Delay	0 s to 1 h	1.0 s
Enable	Not enabled, Enabled	Enabled
Alarm action		Warning

4.11.2 PSM3.2 1 supply voltage high alarm

This default alarm is for power supply voltage protection.

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



Configure the parameters under **Configure > Parameters > Hardware > PSM3.2 1 > High voltage alarm** .

Table 4.26 Default parameters

Parameter	Range	PSM3.2 1 supply voltage high
Set point	12.0 to 36.0 V DC	30.0 V DC
Delay	0 s to 1 h	1.0 s

Parameter	Range	PSM3.2 1 supply voltage high
Enable	Not enabled, Enabled	Enabled
Alarm action		Warning

4.12 Alternating current module ACM3.1

4.12.1 [Source]/[Busbar] L1-L2-L3 wire break

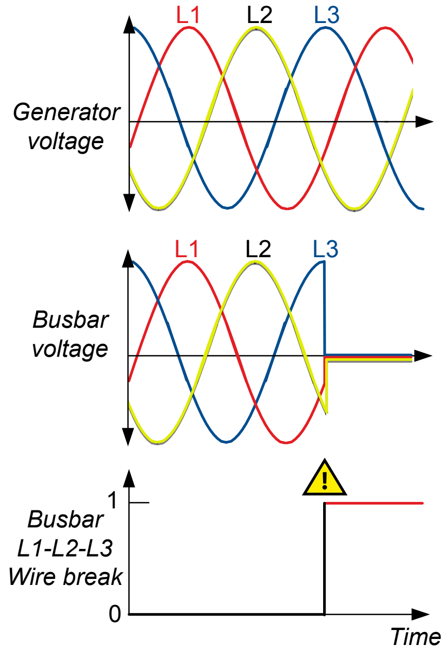
Controller types: GENSET, HYBRID, SHAFT generator, SHORE connection and BUS TIE breaker controllers

These alarms alert the operator to a voltage measurement failure:

- *[Source] L1-L2-L3 wire break*
- *[Busbar] L1-L2-L3 wire break*

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

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



Parameters

Configure > Parameters > [Source] > AC setup > Multiple phase wire break

Configure > Parameters > [Busbar] > AC setup > Multiple phase wire break

Table 4.27 Default parameters

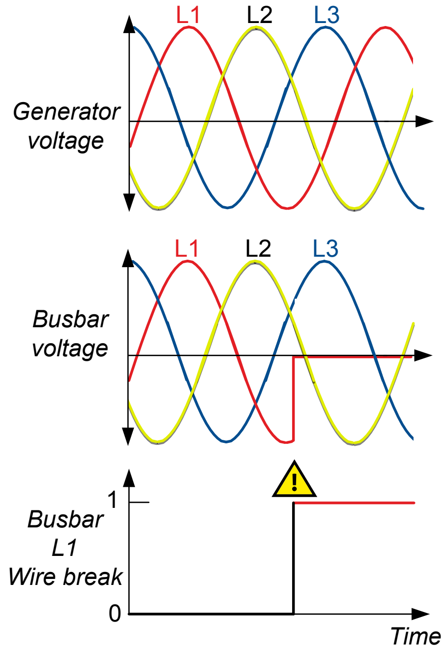
Parameter	Range	Default
Enable	Not enabled, Enabled	Enabled
Latch	Not enabled, Enabled	Enabled
Alarm action		Warning

4.12.2 [Source]/[Busbar] L# wire break

Controller types: GENSET, HYBRID, SHAFT generator, SHORE connection and BUS TIE breaker controllers

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

- *[Source] L1 wire break*
- *[Source] L2 wire break*
- *[Source] L3 wire break*
- *[Busbar] L1 wire break*
- *[Busbar] L2 wire break*
- *[Busbar] L3 wire break*



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

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

Parameters

Configure the [Source] parameters under **Configure > Parameters > [Source] > AC setup > L# wire break**, where # is 1, 2 or 3.

Configure the [Busbar] parameters under **Configure > Parameters > [Busbar] > AC setup > L# wire break**, where # is 1, 2 or 3.

Table 4.28 Default parameters

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

4.12.3 ACM 1 data is missing

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

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

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

4.12.4 ACM 1 protections not running

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

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

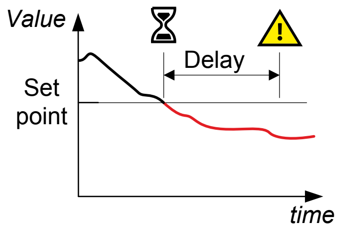
The alarm action is *Warning*, and the alarm is always enabled. The alarm parameters are not visible.

4.13 Engine interface module EIM3.1

4.13.1 EIM3.1 # supply voltage low or missing alarm

This default alarm is for auxiliary power supply voltage protection.

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



Configure the parameters under **Configure > Parameters > Hardware > EIM3.1 # > Low voltage alarm**.

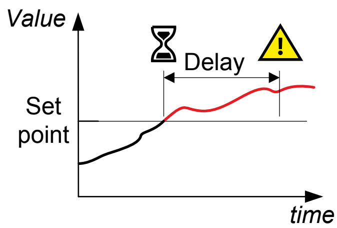
Table 4.29 Default parameters

Parameter	Range	EIM3.1 # supply voltage low or missing
Set point	8.0 to 32.0 V DC	18.0 V DC
Delay	0 s to 1 h	1.0 s
Enable	Not enabled, Enabled	Enabled
Alarm action		Warning

4.13.2 EIM3.1 # supply voltage high alarm

This default alarm is for auxiliary power supply voltage protection.

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



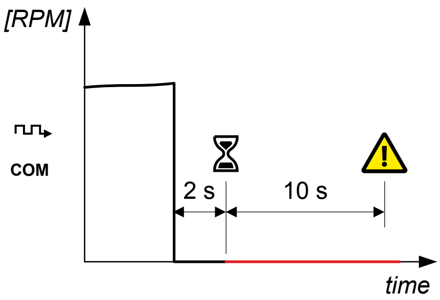
Configure the parameters under **Configure > Parameters > Hardware > EIM3.1 # > High voltage alarm**.

Table 4.30 Default parameters

Parameter	Range	EIM3.1 # supply voltage high
Set point	12.0 to 36.0 V DC	30.0 V DC
Delay	0 s to 1 h	1.0 s
Enable	Not enabled, Enabled	Enabled
Alarm action		Warning

4.13.3 Magnetic pickup wire break alarm

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



Configure the parameters under **Configure** > **Parameters** > **Engine** > **Running detection** > **Magnetic pickup wire break**.

Table 4.31 Default parameters

Parameter	Range	Magnetic pickup wire break
Delay	1 s to 1 h	10 s
Enable	Not enabled, Enabled	Not enabled
Action		Warning
Inhibit		Engine not running

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

4.13.4 EIM3.1 # relay 4 wire break alarm

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

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

Hardware:
EIM 3.1

Configure the parameters under **Configure** > **Parameters** > **Hardware** > **EIM3.1 #** > **Relay 4 supervision**.

Table 4.32 Default parameters

Parameter	Range	EIM3.1 # relay 4 wire break
Delay	0 s to 1 h	1 s
Enable	Not enabled, Enabled	Not enabled
Action		Warning

4.14 Governor and AVR module GAM3.2

4.14.1 GAM3.2 1 status not OK

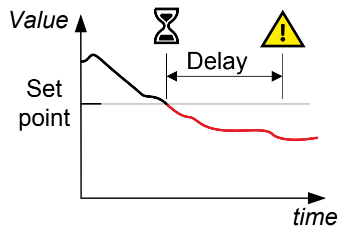
This alarm communicates that the GAM3.2 cannot perform stand-alone regulation. This may be due to incomplete or incorrect configuration.

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

4.14.2 GAM3.2 1 supply voltage low or missing

This default alarm is for auxiliary power supply voltage protection.

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



Configure the parameters under **Configure > Parameters > Hardware > GAM3.2 1 > Low voltage alarm**.

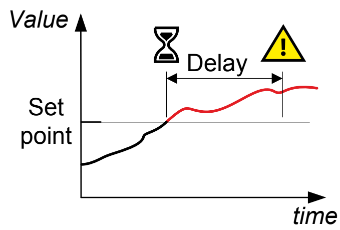
Table 4.33 Default parameters

Parameter	Range	GAM3.2 1 supply voltage low or missing
Set point	8.0 to 32.0 V DC	18.0 V DC
Delay	0 s to 1 h	1.0 s
Enable	Not enabled, Enabled	Enabled
Alarm action		Warning

4.14.3 GAM3.2 1 supply voltage high alarm

This default alarm is for auxiliary power supply voltage protection.

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



Configure the parameters under **Configure > Parameters > Hardware > GAM3.2 1 > High voltage alarm**.

Table 4.34 Default parameters

Parameter	Range	GAM3.2 1 supply voltage high
Set point	12.0 to 36.0 V DC	30.0 V DC
Delay	0 s to 1 h	1.0 s
Enable	Not enabled, Enabled	Enabled
Alarm action		Warning

4.15 Processor and communication module PCM3.1

4.15.1 Controller temperature too high

This is a built-in alarm for the controller internal temperature, as measured on PCM3.1. The alarm is triggered when the controller internal temperature is higher than 80 °C (176 °F). The alarm action is *Warning*. The alarm parameters are not visible.

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

Impact of temperature on lifetime

The expected minimum lifetime for the controller is 10 years, for constant operation at ambient temperatures up to 40 °C. This lifetime is halved for each additional 10 °C rise in ambient temperature.

4.15.2 PCM clock battery failure alarm

The *PCM clock battery failure* alarm is activated when the battery in PCM3.1 needs to be replaced. The alarm action is *Warning*. The alarm parameters are not visible.

More information
See **Maintenance**, **PCM3.1 internal battery**, **Changing the battery** in the **Operator's manual**.

4.15.3 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, PPU 300 controllers and PPM 300 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.

4.16 Advanced blackout prevention

4.16.1 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 optional, and is not enabled by default.

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 power management system 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.

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.

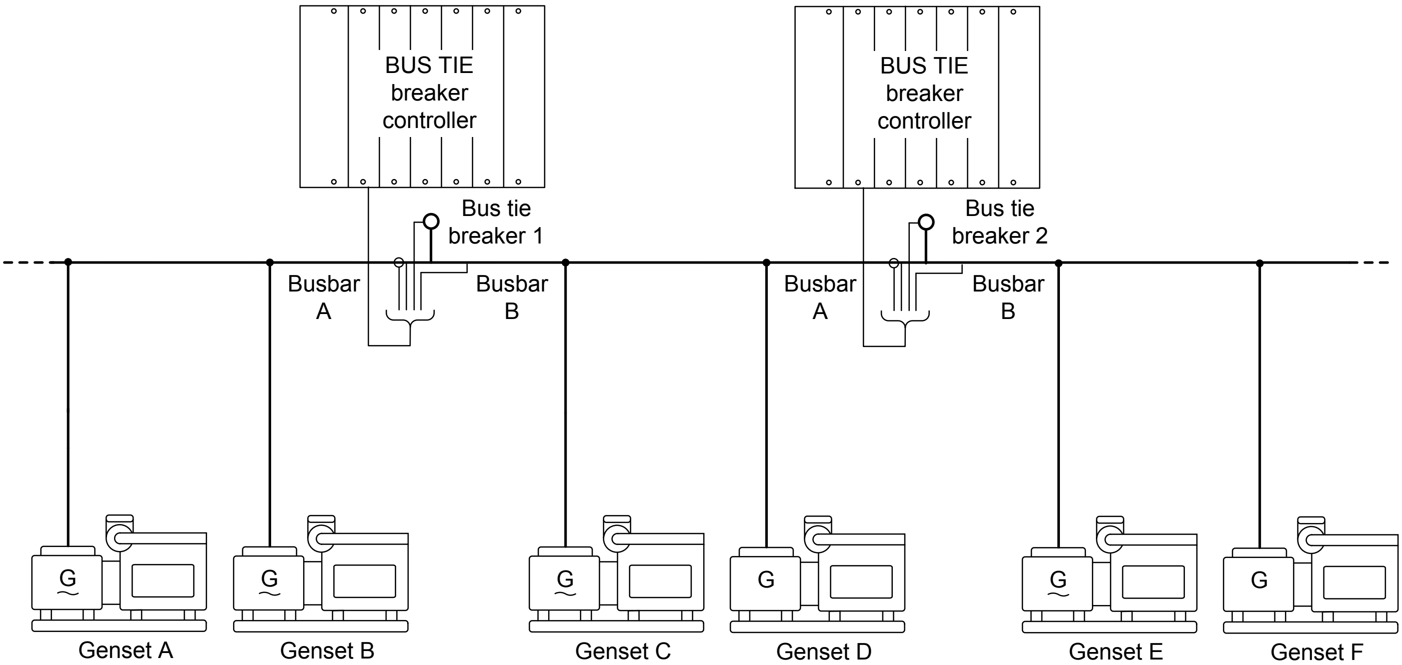
When a BTB is opened or closed, the busbar sections change.

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 **Power management**, **Power management principles**, **Busbar sections** for more information.

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

Figure 4.5 Example of ABP with two bus tie breakers



If all the ABP protections are enabled in both BUS TIE breaker controller 1 and BUS TIE breaker controller 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.

Parameters in the GENSET controllers

Configure this parameter under **Configure > Parameters > Local power management > Advanced blackout prevention**.

Parameter	Range	Default	Comment
Delay after load share changes	0 s to 1 h	12 s	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. • 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

Parameters in the BUS TIE breaker controller

Configure this parameter under **Configure > Parameters > Local power management > Advanced blackout prevention**.

Parameter	Range	Default	Comment
Delay after load share changes	0 s to 1 h	12 s	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:

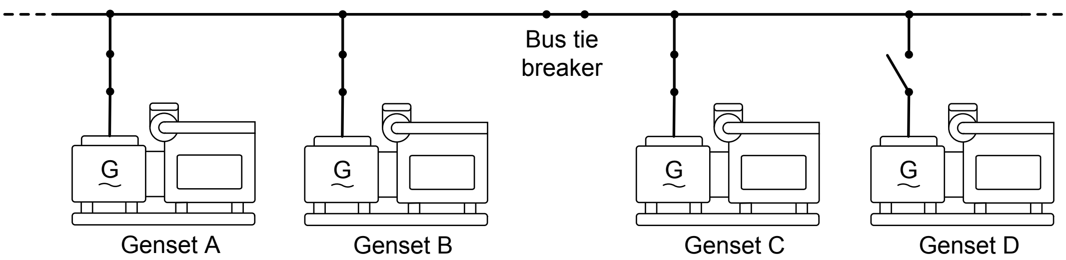
- P load sharing failure (low frequency) on a DG
- P load sharing failure (high frequency) on a DG
- Q load sharing failure (low voltage) on a DG
- Q load sharing failure (high voltage) on a DG
- Overload on a DG
- Reverse power on a DG
- Reactive power export on a DG
- Reactive power import on a DG

- 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.

Figure 4.6 Example of an ABP single-line drawing



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.

4.16.2 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.

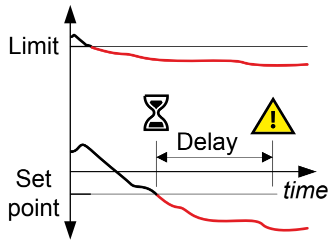
For Genset A, the load sharing error is (500 kW - 600 kW) / (1 000 kW) = -0.1 = -10 %

For Genset B, the load sharing error is (400 kW - 300 kW) / (500 kW) = 0.2 = 20 %

4.16.3 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

Configure the parameters under **Configure > Parameters > Local power management > Advanced blackout prevention > P load sharing failure (low frequency)**.

Table 4.35 Default parameters

Parameter	Range	Default
Low frequency limit	90 to 110 %	99 %
Set point	-100 to -0.1 %	-20 %
Delay	0 s to 1 h	3 s
Enable	Not enabled, Enabled	Not enabled
Latch	Not enabled, Enabled	Enabled
Action		Trip generator breaker

BUS TIE breaker controller

Configure the parameters under **Configure > Parameters > Local power management > Advanced blackout prevention > P load sharing failure (low frequency)**.

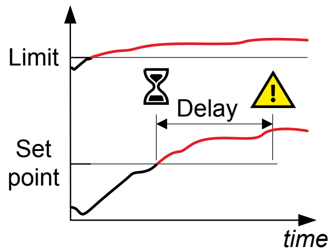
Table 4.36 Default parameters

Parameter	Range	Default
Low frequency limit	90 to 110 %	99.5 %
Set point	-100 to -0.1 %	-20 %
Delay	0 s to 1 h	2 s
Enable	Not enabled, Enabled	Not enabled
Latch	Not enabled, Enabled	Enabled
Action		Trip bus tie breaker
Inhibit		Bus tie breaker open

4.16.4 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

Configure the parameters under **Configure > Parameters > Local power management > Advanced blackout prevention > P load sharing failure (high frequency)**.

Table 4.37 Default parameters

Parameter	Range	Default
High frequency limit	90 to 110 %	101 %
Set point	0.1 to 100 %	20 %
Delay	0 s to 1 h	3 s
Enable	Not enabled, Enabled	Not enabled
Latch	Not enabled, Enabled	Enabled
Action		Trip generator breaker

BUS TIE breaker controller

Configure the parameters under **Configure > Parameters > Local power management > Advanced blackout prevention > P load sharing failure (high frequency)**.

Table 4.38 Default parameters

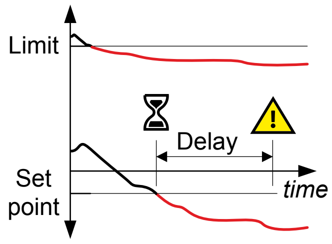
Parameter	Range	Default
High frequency limit	90 to 110 %	100.5 %
Set point	0.1 to 100 %	20 %
Delay	0 s to 1 h	2 s
Enable	Not enabled, Enabled	Not enabled

Parameter	Range	Default
Latch	Not enabled, Enabled	Enabled
Action		Trip bus tie breaker
Inhibit		Bus tie breaker open

4.16.5 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

Configure the parameters under **Configure > Parameters > Local power management > Advanced blackout prevention > Q load sharing failure (low voltage)**.

Table 4.39 Default parameters

Parameter	Range	Default
Low voltage limit	90 to 110 %	99 %
Set point	-100 to -0.1 %	-20 %
Delay	0 s to 1 h	3 s
Enable	Not enabled, Enabled	Not enabled
Latch	Not enabled, Enabled	Enabled
Action		Trip generator breaker

BUS TIE breaker controller

Configure the parameters under **Configure > Parameters > Local power management > Advanced blackout prevention > Q load sharing failure (low voltage)**.

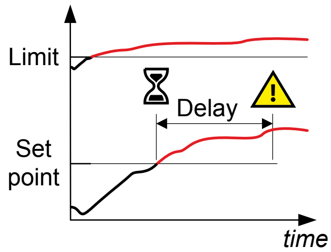
Table 4.40 Default parameters

Parameter	Range	Default
Low voltage limit	90 to 110 %	99.5 %
Set point	-100 to -0.1 %	-20 %
Delay	0 s to 1 h	2 s
Enable	Not enabled, Enabled	Not enabled
Latch	Not enabled, Enabled	Enabled
Action		Trip bus tie breaker
Inhibit		Bus tie breaker open

4.16.6 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

Configure the parameters under **Configure > Parameters > Local power management > Advanced blackout prevention > Q load sharing failure (high voltage)**.

Table 4.41 Default parameters

Parameter	Range	Default
High voltage limit	90 to 110 %	101 %
Set point	0.1 to 100 %	20 %
Delay	0 s to 1 h	3 s
Enable	Not enabled, Enabled	Not enabled
Latch	Not enabled, Enabled	Enabled
Action		Trip generator breaker

BUS TIE breaker controller

Configure the parameters under **Configure > Parameters > Local power management > Advanced blackout prevention > Q load sharing failure (high voltage)**.

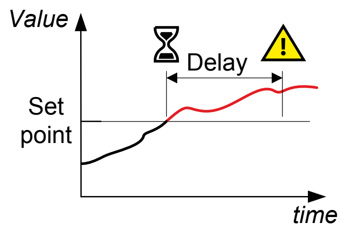
Table 4.42 Default parameters

Parameter	Range	Default
High voltage limit	90 to 110 %	100.5 %
Set point	0.1 to 100 %	20 %
Delay	0 s to 1 h	2 s
Enable	Not enabled, Enabled	Not enabled
Latch	Not enabled, Enabled	Enabled
Action		Trip bus tie breaker
Inhibit		Bus tie breaker open

4.16.7 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.



Configure the parameters under **Configure > Parameters > Local power management > Advanced blackout prevention > Overload on a DG**.

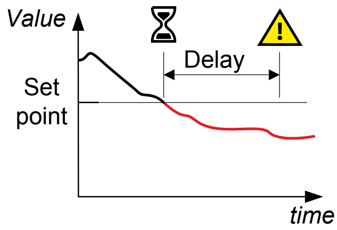
Table 4.43 Default parameters

Parameter	Range	Default
Set point	70 to 250 %	120 %
Delay	0 s to 1 h	3 s
Enable	Not enabled, Enabled	Not enabled
Latch	Not enabled, Enabled	Enabled
Action		Trip bus tie breaker
Inhibit		Bus tie breaker open

4.16.8 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.



Configure the parameters under **Configure > Parameters > Local power management > Advanced blackout prevention > Reverse power on a DG**.

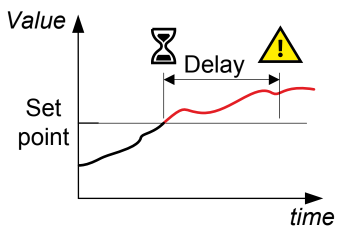
Table 4.44 Default parameters

Parameter	Range	Default
Set point	-25 to -0.1 %	-5 %
Delay	0 s to 1 h	3 s
Enable	Not enabled, Enabled	Not enabled
Latch	Not enabled, Enabled	Enabled
Action		Trip bus tie breaker
Inhibit		Bus tie breaker open

4.16.9 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.



Configure the parameters under **Configure > Parameters > Local power management > Advanced blackout prevention > Reactive power export on a DG**.

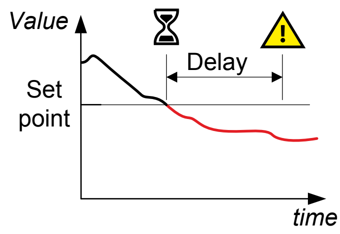
Table 4.45 Default parameters

Parameter	Range	Default
Set point	0.1 to 250 %	120 %
Delay	0 s to 1 h	10 s
Enable	Not enabled, Enabled	Not enabled
Latch	Not enabled, Enabled	Enabled
Action		Trip bus tie breaker
Inhibit		Bus tie breaker open

4.16.10 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.



Configure the parameters under **Configure > Parameters > Local power management > Advanced blackout prevention > Reactive power import on a DG**.

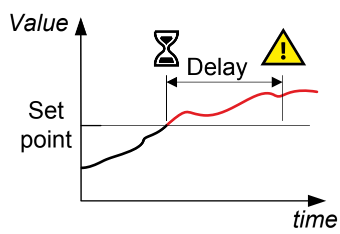
Table 4.46 Default parameters

Parameter	Range	Default
Set point	-120 to -0.1 %	-100 %
Delay	0 s to 1 h	10 s
Enable	Not enabled, Enabled	Not enabled
Latch	Not enabled, Enabled	Enabled
Action		Trip bus tie breaker
Inhibit		Bus tie breaker open

4.16.11 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.



Configure the parameters under **Configure > Parameters > Local power management > Advanced blackout prevention > Over-current on a DG**.

Table 4.47 Default parameters

Parameter	Range	Default
Set point	70 to 250 %	200 %
Delay	0 s to 1 h	0.3 s
Enable	Not enabled, Enabled	Not enabled
Latch	Not enabled, Enabled	Enabled
Action		Trip bus tie breaker
Inhibit		Bus tie breaker open

5. Breakers, synchronisation and de-loading

5.1 Introduction

5.1.1 Introduction to synchronisation and de-loading

A number of power sources can supply power to the same busbar. These power sources must be synchronised in order to safely connect them. Synchronisation consists of matching the voltage, frequency and phases on both sides of the breaker that must be closed.

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

This chapter describes:

- Regulation required to synchronise and de-load
- Synchronisation and de-loading under power management or switchboard control
- Synchronisation and de-loading in AUTO or SEMI mode (GENSET and EMERGENCY genset controllers)
- Configuring the breakers
- Dynamic synchronisation
- Static synchronisation

More information
See **Regulation** for more information on the regulation of the gensets.

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

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

5.1.2 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 system (PMS) adjusts the genset speed(s) so that the frequencies and phases of the power sources on either side of the breaker match.

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

It does not matter whether the gensets are already connected to the busbar, or whether the unregulated equipment is already connected to the busbar. In both cases, the PMS only regulates the gensets to synchronise.

The power management system regulates the gensets to synchronise the power sources. The controller measures the synchronisation across its breaker(s). When the synchronisation is within the configured limits, the controller activates the *Breakers > [Breaker] > Control > 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.

5.1.3 Regulation required for de-loading

Whenever possible, the breakers are de-loaded before they are opened, to reduce the wear on them. A breaker is de-loaded by reducing the flow of power through the breaker to the required level. In AUTO and SEMI mode, the power management system de-loads a breaker by regulating and/or starting the appropriate gensets to take the load off that breaker.

INFO
The power management system 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 system adjusts the genset speed(s) so that the frequencies and phases of the power sources on either side of the breaker match. For de-loading, the power management system adjusts the genset speed(s) to minimise the flow of power through the breaker.

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

Genset breaker de-loading in SEMI mode

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

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

PMS-controlled stop

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

INFO
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.

5.2 Synchronisation in each control mode

5.2.1 Synchronisation in AUTO mode

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

5.2.2 Synchronisation in SEMI mode

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

Synchronisation in SEMI mode example

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

5.2.3 Synchronisation under switchboard control

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

To get under 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 5.1 Example of typical third party equipment used during switchboard control

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.

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

INFO
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 **System principles, Control and modes, Switchboard control** 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

CAUTION

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.

5.3 Configuring breakers

5.3.1 Breaker commands

Inputs

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

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

Table 5.2 Breaker commands (optional)

Function	I/O	Type	Details
Breakers > [Breaker] > Command > [*B] open	Digital input	Pulse	This input has the same effect as pressing the *Breaker open* button on the display unit.
Breakers > [Breaker] > Command > [*B] close	Digital input	Pulse	This input has the same effect as pressing the *Breaker close* button on the display unit.
Breakers > [Breaker] > Command > Block [*B] close	Digital input	Continuous	The controller does not allow the breaker to close while this input is active.

5.3.2 Pulse breaker

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

Wiring examples

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

Inputs and outputs

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

Table 5.3 Breaker configuration

Function	I/O	Type	Details
Breakers > [Breaker] > Control > [*B] close	Digital output	Pulse	The controller activates the *Close* output to close the breaker.
Breakers > [Breaker] > Control > [*B] open	Digital output	Pulse	The controller activates the *Open* output to open the breaker.
Breakers > [Breaker] > Control > [*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

Configure the parameters under **Configure > Parameters > Breakers > [Breaker] configuration > Configuration**.

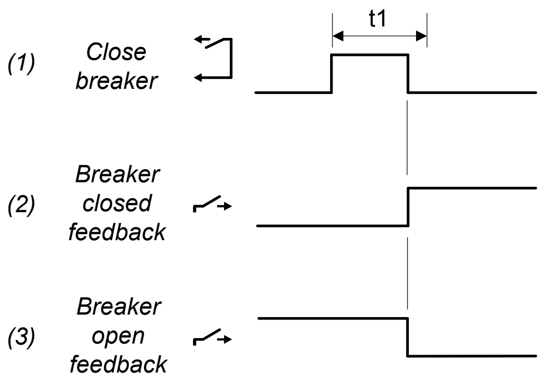
Table 5.4 Parameters for a pulse breaker

Parameter	Range	Default	Notes
Breaker type	• Pulse breaker • Compact breaker • Continuous breaker	Pulse breaker	This breaker requires a pulse signal to close, and a different pulse signal to open.
Pulse time ON	0.0 to 10.0 s	1.0 s	The length of the synchronisation pulse (that is, the 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	5 %	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 source.

Sequence diagram

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

Table 5.5 Closing a pulse breaker

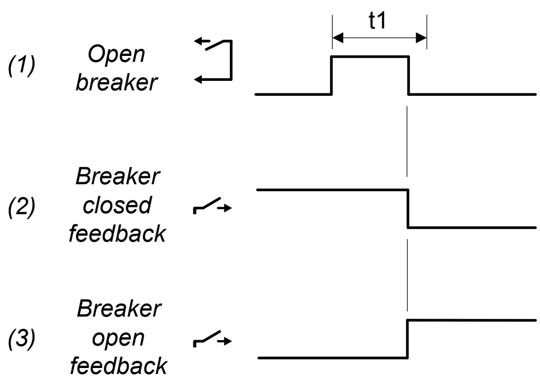


t1 Pulse on (*Parameters > Breakers > [Breaker] > Pulse time ON*)

To close a pulse breaker:

1. **Close breaker**: *Breakers > [Breaker] > Control > [*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 5.6 Opening a pulse breaker

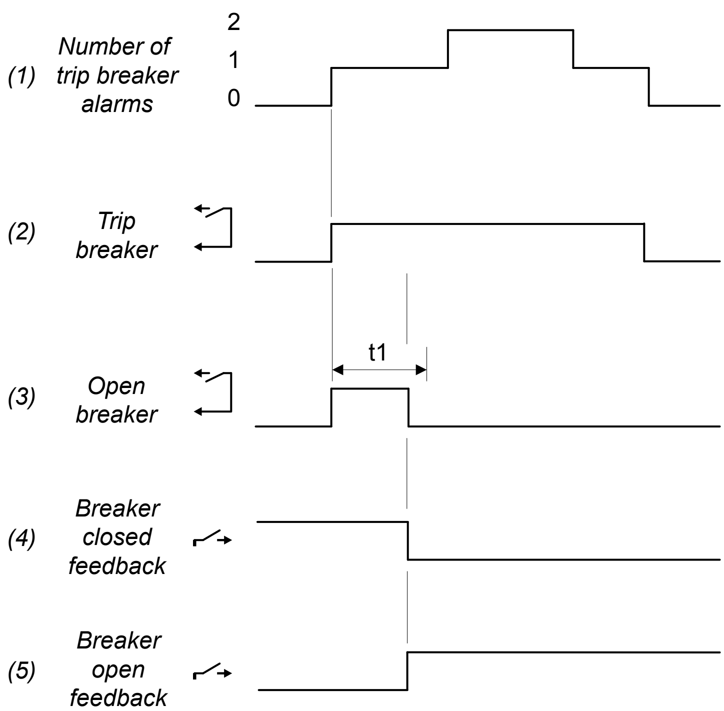


t1 Pulse on (*Parameters > Breakers > [Breaker] > Pulse time ON*)

To open a pulse breaker:

1. **Open breaker**: *Breakers > [Breaker] > Control > [*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 5.7 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] > Control > [*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] > Control > [*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.

5.3.3 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

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

Table 5.8 Breaker configuration

Function	IO	Type	Details
Breakers > [Breaker] > Control > [*B] close	Digital output	Pulse	When the power sources are synchronised, the controller activates the *[*B] close* output to close the breaker.
Breakers > [Breaker] > Control > [*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] > Control > [*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.

Table 5.9 Breaker commands for a compact breaker

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

Configure the parameters under **Configure > Parameters > Breakers > [Breaker] configuration** > **Configuration**.

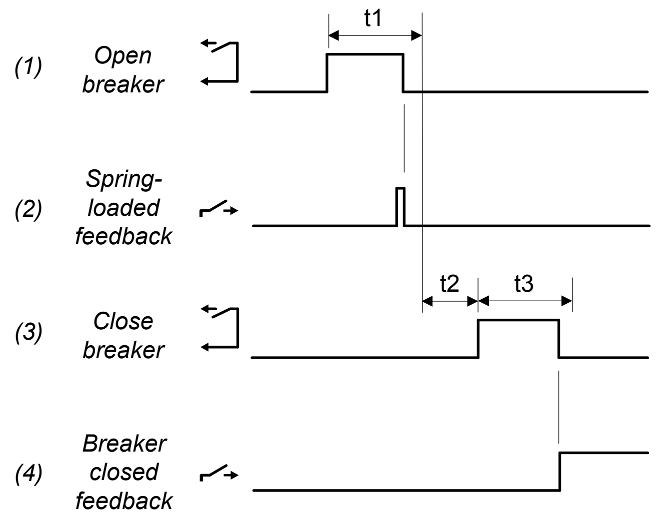
Table 5.10 Parameters for a compact breaker

Parameter	Range	Default	Notes
Breaker type	• Pulse breaker • Compact breaker • Continuous breaker	Pulse 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 10.0 s	1.0 s	The length of the synchronisation 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.
Pulse time OFF	0.0 to 10.0 s	0.5 s	During the close sequence, after spring-loading, the controller will not send the *[*B] close* pulse until after this time has elapsed.
Spring load time	0.0 to 30.0 s	1.0 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	5 %	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 source.

Sequence diagrams

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

Table 5.11 Closing a compact breaker



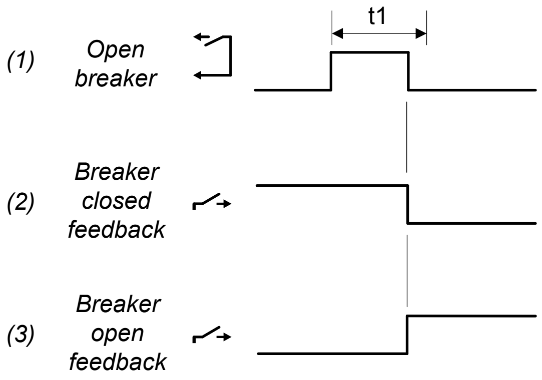
t1	Spring load time (*Parameters* > *Breakers* > *[Breaker] configuration* > *Spring load time*)
t2	Wait after spring-loading (*Parameters* > *Breakers* > *[Breaker]* > *Pulse time OFF*)
t3	Pulse on (*Parameters* > *Breakers* > *[Breaker]* > *Pulse time ON*)

To close a compact breaker:

1. **Open breaker**: *Breakers* > *[Breaker]* > *Control* > *[*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]* > *Control* > *[*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 5.12 Opening a compact breaker

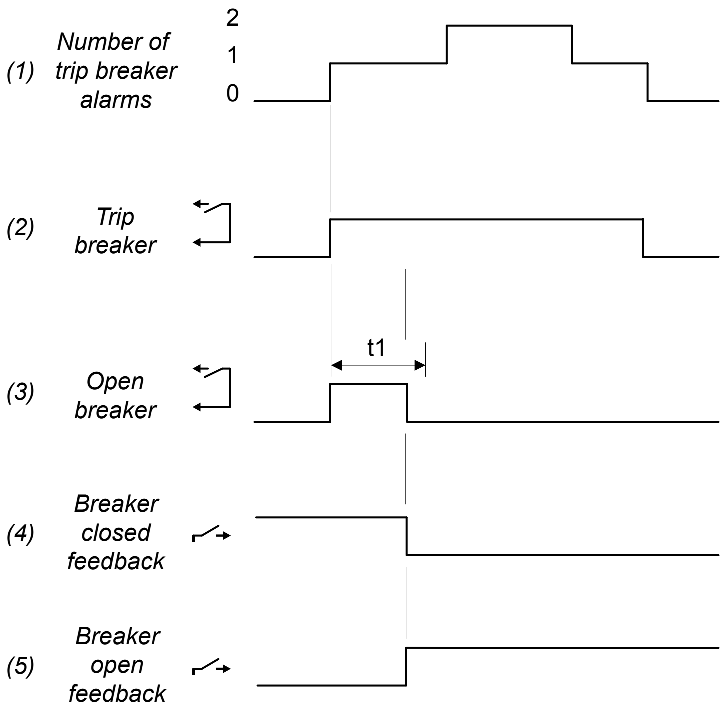


t1 Pulse on (*Parameters* > *Breakers* > *[Breaker]* > *Pulse time ON*)

To open a compact breaker:

1. **Open breaker**: *Breakers* > *[Breaker]* > *Control* > *[*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 5.13 Trip a compact 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]* > *Control* > *[*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]* > *Control* > *[*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.

5.3.4 Continuous breaker

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

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

Inputs and outputs

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

INFO
For a continuous breaker, DEIF recommends installing both of the breaker control relays to ensure precise synchronisation and AC protection operate times.

Table 5.14 Breaker configuration

Function	I/O	Type	Details
Breakers > [Breaker] > Control > [*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] > Control > [*B] open	Digital output	Continuous	The controller activates the *Open* output when the breaker must open. The controller deactivates the *Open* output when the breaker must close. The *Open* relay ensures the AC protection operate times.
Breakers > [Breaker] > Control > [*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

Configure the parameters under **Configure > Parameters > Breakers > [Breaker] configuration > Configuration.**

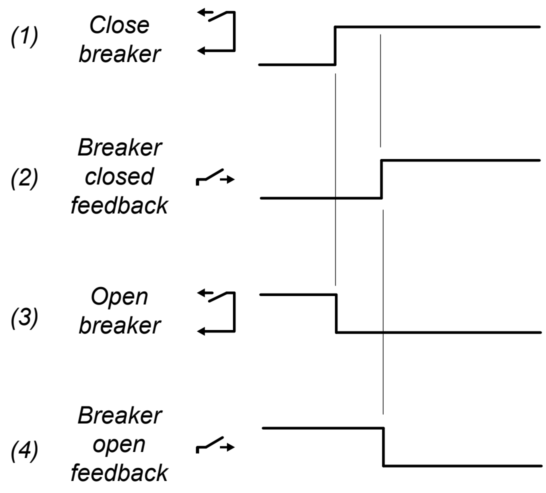
Table 5.15 Parameters for a continuous breaker

Parameter	Range	Default	Notes
Breaker type	• Pulse breaker • Compact breaker • Continuous breaker	Pulse 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	5 %	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 source.

Sequence diagrams

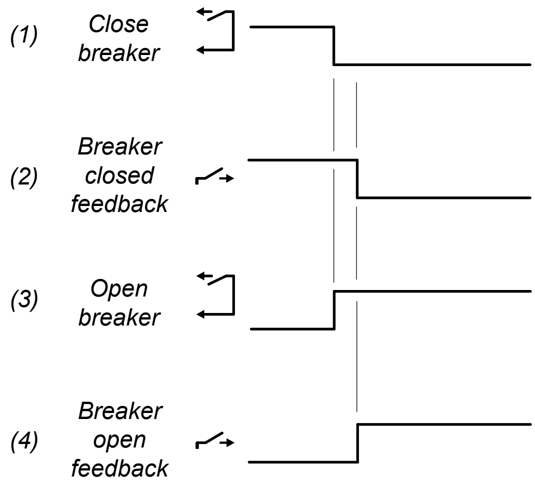
The sequence diagrams below show the sequences for closing and opening for a continuous breaker.

Table 5.16 Closing a continuous breaker



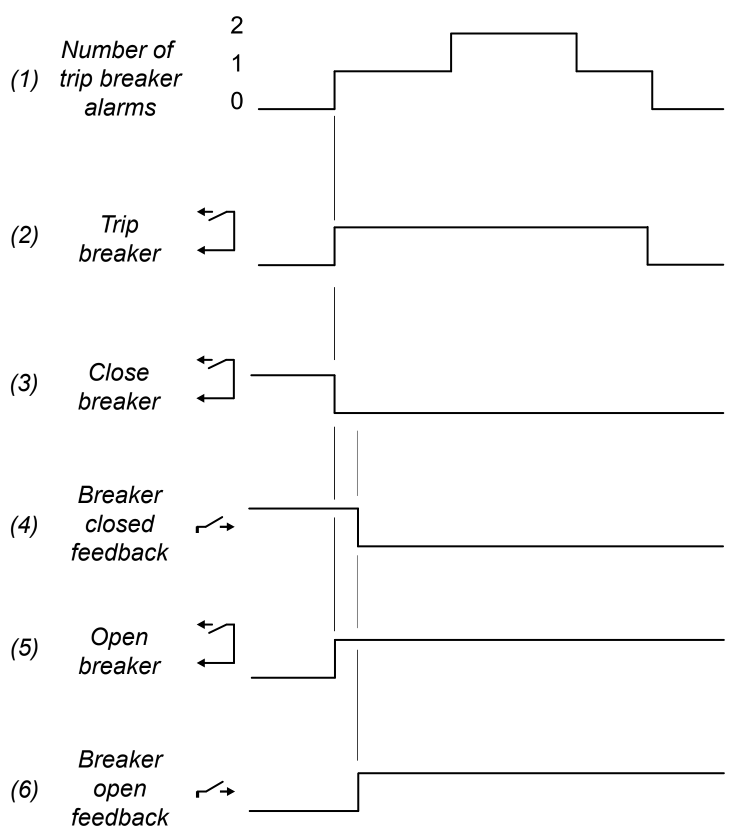
1. **Close breaker**: *Breakers* > *[Breaker]* > *Control* > *[*B] close* (digital output). The controller activates this output to close the breaker.
2. **Breaker closed feedback**: *Breakers* > *[Breaker]* > *Feedback* > *[*B] closed* (digital input). This input is activated when the breaker is closed.
3. **Open breaker**: *Breakers* > *[Breaker]* > *Control* > *[*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 5.17 Opening a continuous breaker



1. **Close breaker**: *Breakers* > *[Breaker]* > *Control* > *[*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]* > *Control* > *[*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 5.18 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] > Control > [*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] > Control > [*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] > Control > [*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.

5.3.5 Redundant breaker feedback

Redundant breaker feedback can be configured on bus tie breaker controllers and externally controlled breakers.

Wiring examples

More information
See **Wiring examples for controller functions, Breaker wiring** in the **Installation instructions** for an example of redundant breaker feedback wiring.

Inputs

Assign the redundant breaker feedback inputs **Configure > Input/output**. Select the hardware module, then select the input to configure. The redundant breaker feedback inputs are only visible if a redundant breaker feedback was configured to the controller.

Table 5.19 Hardware required in addition to the minimum standard controller wiring

Function	I/O	Type	Details
Breakers > Breaker feedback # > Feedback > Breaker # feedback open*	Digital input	Continuous	Wire this feedback from the breaker, to inform the controller when the breaker is open.
Breakers > Breaker feedback # > Feedback > Breaker # feedback 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 that has it's redundant breaker feedback assigned to the controller.

5.3.6 External breaker

More information
See **Power management**, **Externally controlled breakers** for information on how the external breaker works.

5.3.7 Short circuit, and short circuit close attempts

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

Hardware

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

Table 5.20 Breaker configuration

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!
Closing a breaker after a short circuit is extremely risky.

Configure the parameter under **Configure > Parameters > Power management rules > Configuration # > Blackout > Short circuit close attempts**, where # is 1 to 8.

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

Parameter	Range	Default	Notes
Set point	0 to 1	0	*0 close attempts*: The power management system 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.

5.3.8 Breaker state outputs

You can configure outputs for the breaker state.

Inputs and outputs

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

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

Table 5.21 Breaker states

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.

5.4 Synchronisation functions

5.4.1 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 avoid a reverse power trip after synchronisation.

This type of synchronisation is relatively fast because of the minimum and maximum frequency differences. Synchronisation is possible while the controller is still busy 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 phase angles are matched, the controller can send the close breaker signal.

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

Inputs and outputs

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

Parameters

Configure the synchronisation parameters under **Configure > Parameters > Breakers > [Breaker] configuration > Synchronisation setting**.

Table 5.22 Dynamic synchronisation parameters

Name	Range	Default	Notes
Sync. type	Dynamic, Static	Dynamic	*Dynamic* must be selected.
Delta frequency min.	-0.5 to 0.3 Hz	-0.1 Hz	For synchronisation: Add *Delta frequency min.* to the busbar frequency, for the **minimum** frequency of the synchronising generator.

Name	Range	Default	Notes
			If this value is too low, there can be reverse power when the breaker closes.
Delta frequency max.	0.0 to 2.0 Hz	0.3 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 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.

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 **SHAFT generator controller**, **Other SHAFT generator controller functions**, **Power take home (PTH)** for more information.

Slip frequency

The slip frequency is calculated as follows:

Slip frequency = (*Delta frequency min.* + *Delta frequency max.*)/2

Slip frequency example

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

The slip frequency is **0.1 Hz**.

When the dynamic synchronisation starts, the frequency control function regulates the synchronising genset frequency towards the following set point:

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

Slip frequency bad example

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

	The slip frequency is **0.0 Hz**. There is a risk that there will be no movement, and thus no synchronisation.

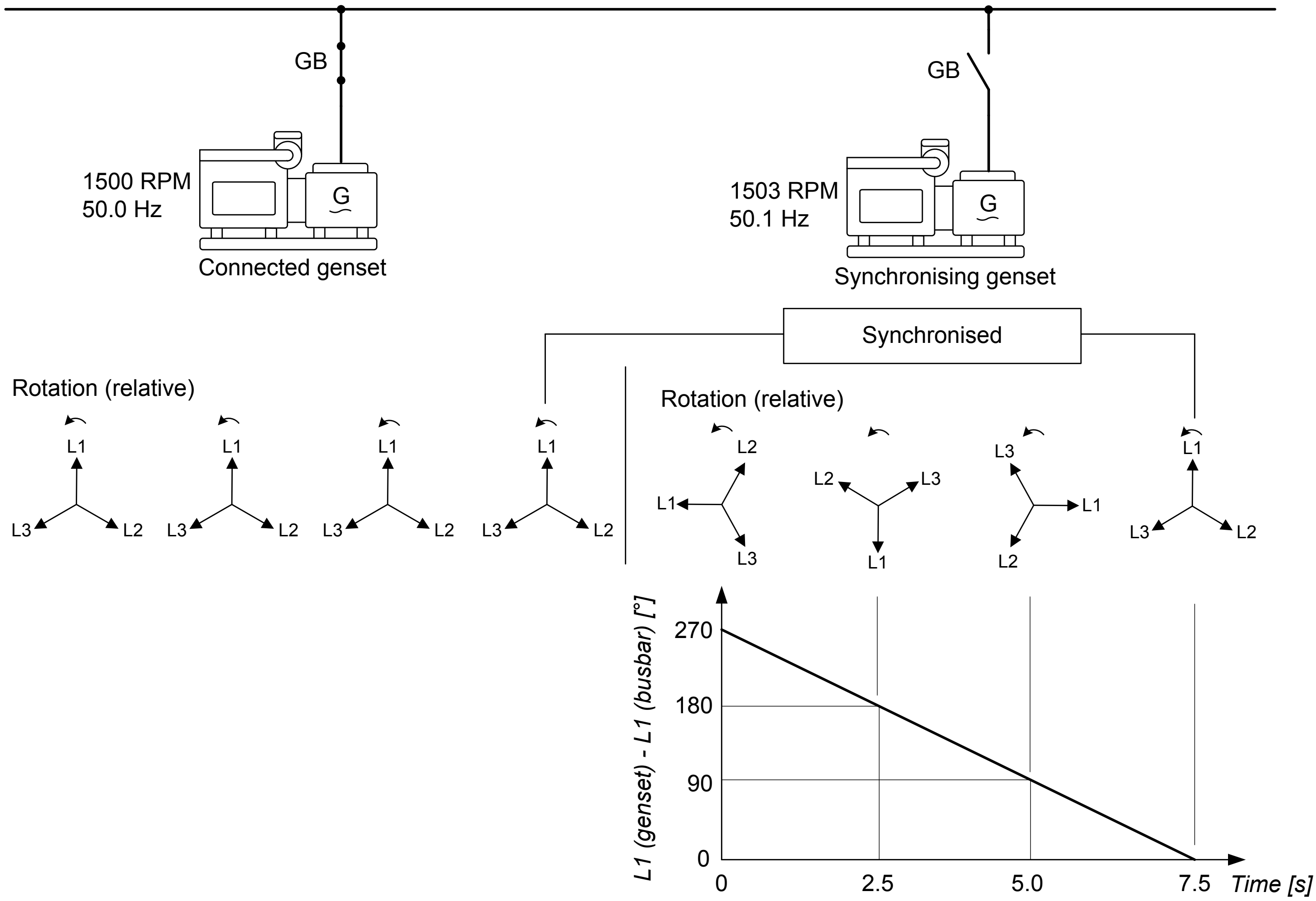
Speed up for slip frequency under 0.3 Hz

If the slip frequency is under 0.3 Hz, the controller automatically speeds up the synchronisation rotation until the phase angle difference is 30 degrees. This cannot be configured or disabled.

Dynamic synchronisation principle

The dynamic synchronisation principle is shown in the following example.

Figure 5.1 Dynamic synchronisation principle, with vector diagrams



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

In this example, the synchronising genset is running at 1503 RPM (about 50.1 Hz). The online genset is running at 1500 RPM (about 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.

In the example above, the difference in the phase angle between the synchronising genset and the busbar gets smaller and smaller. When difference in the phase angle is near zero, the controller will send the breaker close signal based on the *Breaker closing time* (this is not shown in the example). In this way, the breaker physically closes when the genset is exactly synchronised with the busbar.

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

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

INFO
The phases for both three-phase systems rotate. However, in this example, the vectors for the busbar are shown as stationary to simplify the explanation. This is because we are only interested in the phase angle difference to calculate when to send the *Breakers* > *[Breaker]* > *Control* > *[*B] Close* signal.

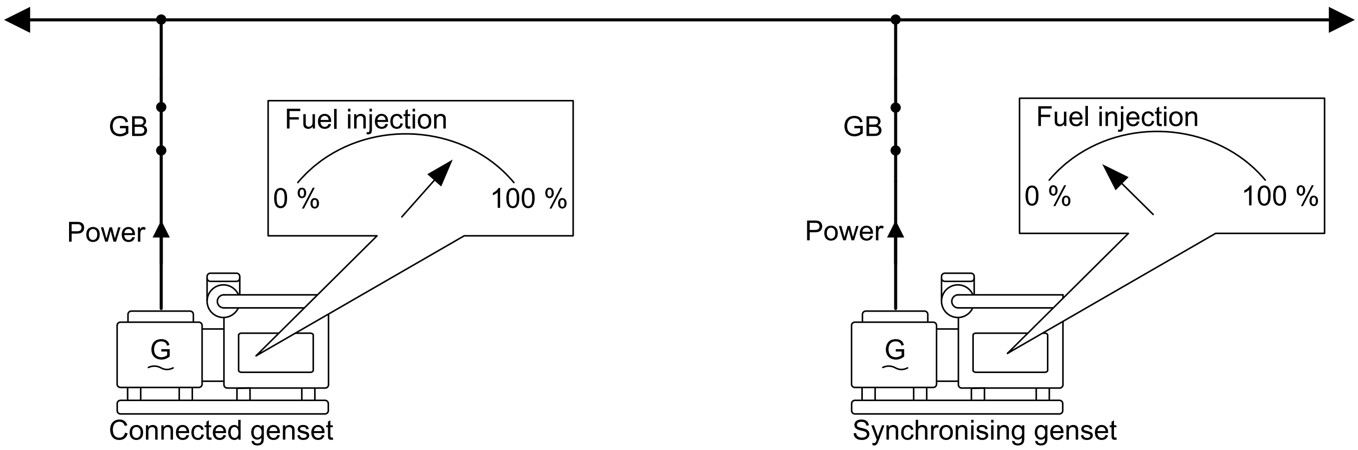
Load distribution after synchronisation

When the breaker closes, the synchronising genset will take some of the load if it has a positive slip frequency. A negative slip frequency may lead to reverse power in the synchronising genset.

INFO
The proportion of the load that the synchronising genset takes depends on the frequency difference, and the prime mover characteristics.

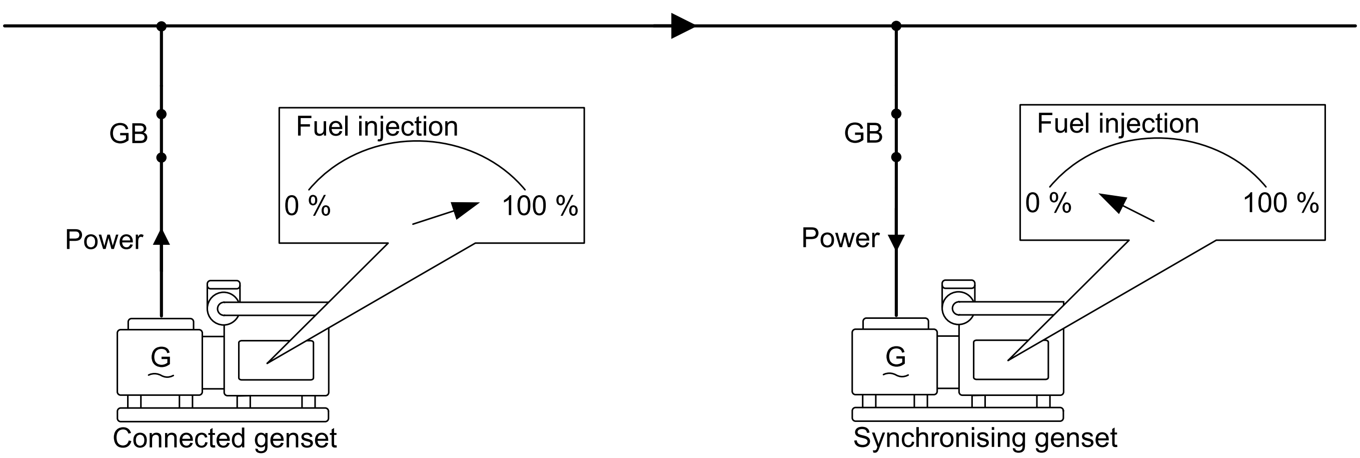
The following example shows that at a given *positive* slip frequency, the synchronising genset will *export* power to the load after the breaker closes.

Figure 5.2 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.

Figure 5.3 Example of load distribution after synchronisation with a negative slip frequency



INFO
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 phase angle of the L1 vectors 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 will start the close breaker signal when the difference between the phase angles of the sources is 9 degrees.

5.4.2 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 phase angles of the source and the busbar matching exactly. Static synchronisation is most suited to systems with a very stable busbar 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 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

Configure the synchronisation parameters under **Configure > Parameters > Breakers > [Breaker] configuration > Synchronisation setting**.

Table 5.23 Static synchronisation parameters

Name	Range	Default	Notes
Sync. type	• Dynamic • Static	Dynamic	*Static* must be selected. To see the static synchronisation parameters, write the change to the controller, and refresh.
Delta frequency min.	-0.5 to 0.3 Hz	-0.1 Hz	For synchronisation: Add *Delta frequency min.* to the busbar frequency, for the **minimum** frequency of the synchronising generator. This value must be negative for static synchronisation.
Delta frequency max.	0.0 to 2.0 Hz	0.3 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.*

Name	Range	Default	Notes
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. This is not used for static synchronisation.
Phase window*	0.0 to 45.0 deg	5.0 deg	The maximum phase angle difference allowed for synchronisation.
Minimum time in phase window	0.1 s to 15 min	1.0 s	To close the breaker, the measurements must show that the controller will be able to keep the phase angle difference within the phase window for this minimum time.

*Note: These parameters are only used for static synchronisation.

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.

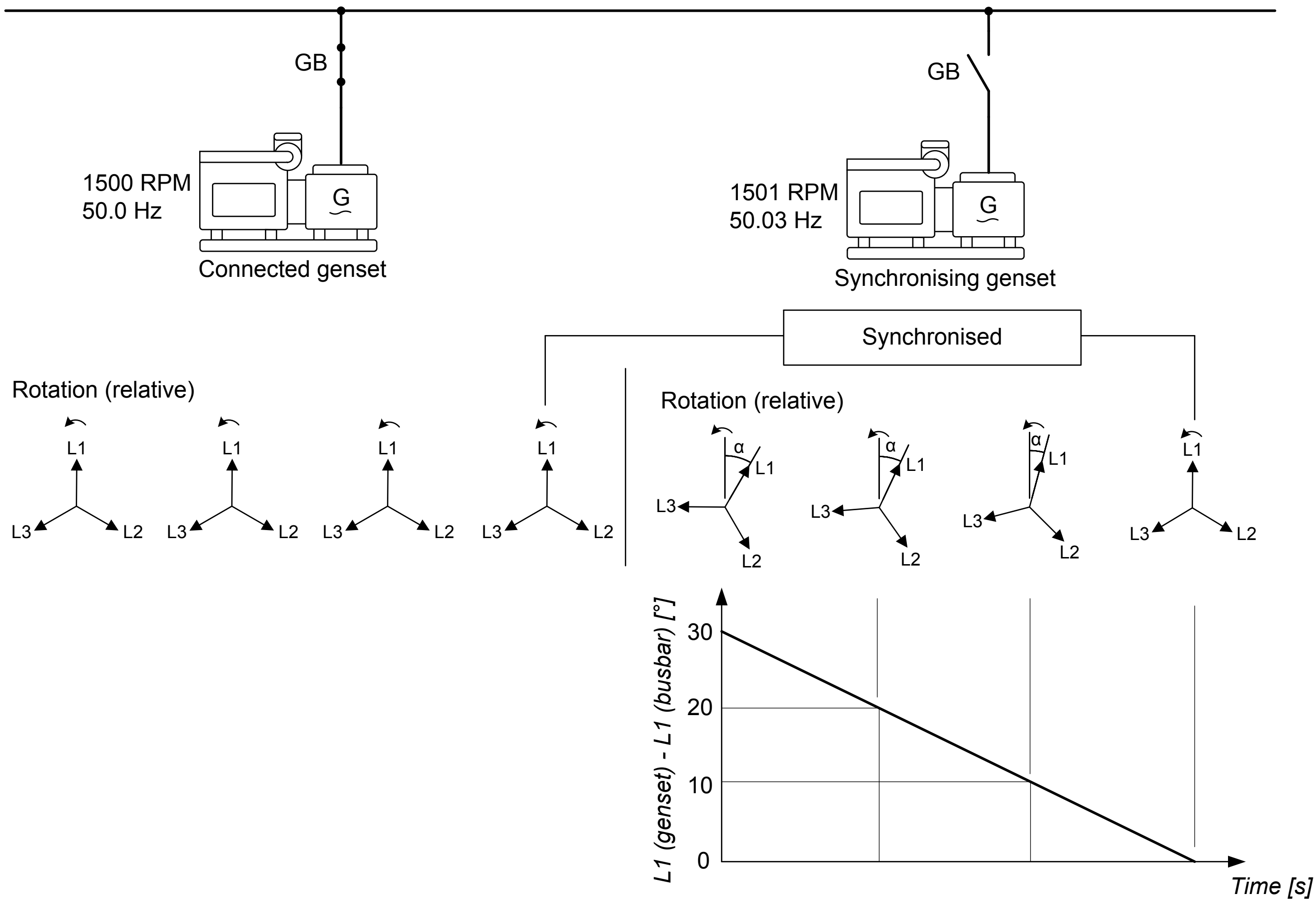
For a SHAFT generator controller, the synchronisation settings for power take home (PTH) can be configured separately. These are under *Synchronisation setting (PTH)*.

More information
See **SHAFT generator controller**, **Other SHAFT generator controller functions**, **Power take home (PTH)** for more information.

Static synchronisation principle

The static synchronisation principle is shown below. In the example, the frequency difference is 0.03 Hz. Phase synchronisation regulation reduces the phase angle difference from 30 degrees to 0 degrees.

Figure 5.4 Static synchronisation principle



Phase synchronisation regulation

When static synchronisation starts, the frequency regulation regulates the synchronising genset frequency towards the busbar frequency.

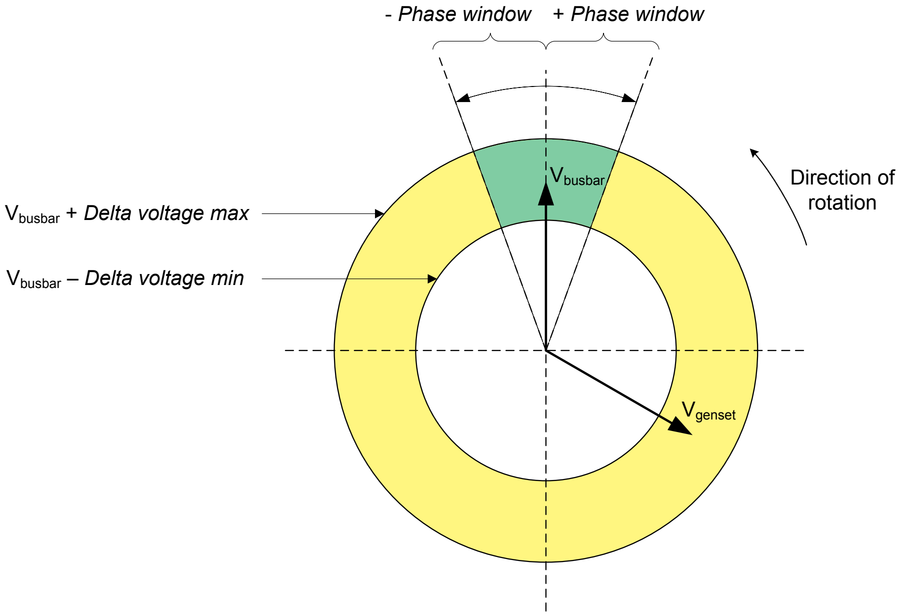
When the genset-busbar difference is 50 mHz, the phase synchronisation function takes over. The controller now ignores $f_{set\ point}$. The controlling parameter for the phase synchronisation regulation is the phase angle difference between the synchronising genset and the busbar.

Close breaker signal

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

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

Figure 5.5 Voltage and phase angle difference for static synchronisation



Load distribution after synchronisation

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

5.4.3 Regulator synchronisation parameters

During synchronisation the controller regulates the governor to change the frequency and phase angle. These settings are only used during synchronisation, and can be configured to optimise the synchronisation speed for the system.

Analogue regulator output parameters

Configure these parameters under **Configure > Parameters > Regulators > GOV analogue configuration > Frequency synchronisation**.

Table 5.24 Analogue frequency synchronisation parameters

Parameter	Range	Default	Notes
Kp	0 to 60	2.5	The PID gain for the regulator.
Ti	0 s to 1 min	2.5 s	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	0 s	The PID control derivative.

Configure these parameters under **Configure > Parameters > Regulators > GOV analogue configuration > Phase synchronisation**.

Table 5.25 Analogue phase synchronisation parameters

Parameter	Range	Default	Notes
Kp	0 to 60	2.5	The PID gain for the regulator.
Ti	0 s to 1 min	2.5 s	The PID control integral time.

Parameter	Range	Default	Notes
			To turn off the integral component, set Ti to 0. This might cause unexpected regulator behaviour.
Td	0 to 2 s	0 s	The PID control derivative.

INFO
The phase synchronisation parameters are only used when static synchronisation is selected.

Relay regulator output parameters

Configure these parameters under **Configure > Parameters > Regulators > GOV relay configuration > Frequency synchronisation**.

Table 5.26 Relay frequency synchronisation parameters

Parameter	Range	Default	Notes
Kp	0 to 100	10	The gain for the regulator.

Configure these parameters under **Configure > Parameters > Regulators > GOV relay configuration > Phase synchronisation**.

Table 5.27 Relay phase synchronisation parameters

Parameter	Range	Default	Notes
Kp	0 to 100	10	The gain for the regulator.

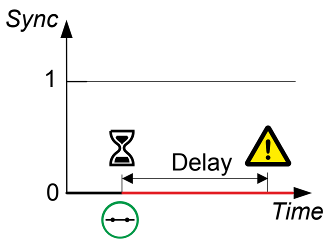
INFO
The phase synchronisation parameters are only used when static synchronisation is selected.

5.5 Synchronisation and breaker alarms

5.5.1 Breaker synchronisation failure

This alarm alerts the operator about a breaker synchronisation failure.

The alarm is based on the synchronisation of the source to the busbar, as measured by the controller. The alarm is activated if the controller has not been able to synchronise within the delay time.



Configure the parameters under **Configure > Parameters > Breakers > [Breaker] monitoring > Synchronisation failure**. The alarm action is always *Trip [Breaker]* and *Latched*.

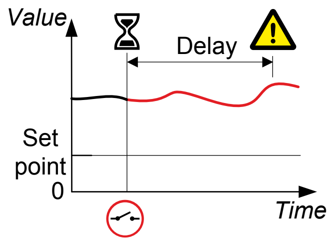
Table 5.28 Default parameters

Parameter	Range	Default
Delay	30 s to 5 min	• GENSET, EMERGENCY genset, SHAFT generator, SHORE connection controllers: 1 min • BUS TIE breaker controller: 2 min
Enable	Not enabled, Enabled	Enabled

5.5.2 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.



Configure the parameters under **Configure > Parameters > Breakers > [Breaker] monitoring > De-load failure**.

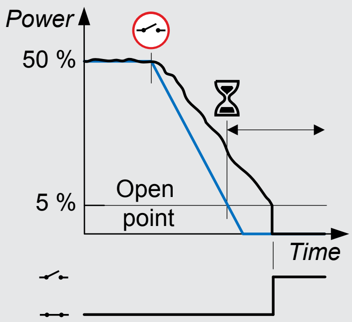
The *Open point (de-loading)* is configured under **Configure > Parameters > Breakers > [Breaker] configuration > Configuration**.

Table 5.29 Default parameters

Parameter	Range	Default
Delay	0.0 s to 1 h	10.0 s
Enable	Not enabled, Enabled	Enabled
Alarm action		Warning

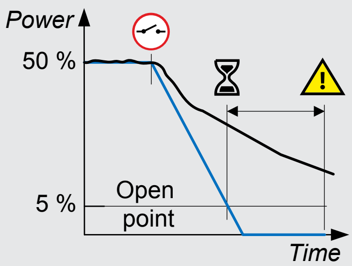
Effect of de-load ramp example

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.



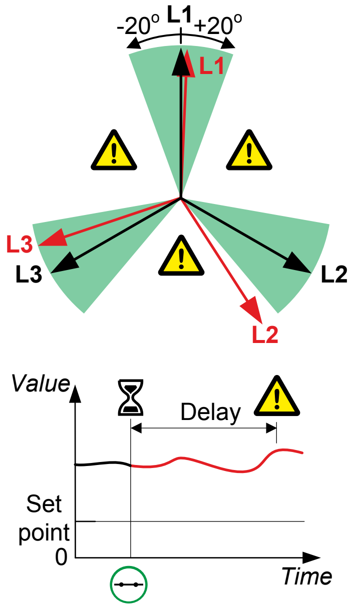
More information
See **Regulation** for more de-loading information.

5.5.3 Vector mismatch

This alarm alerts the operator to a vector mismatch during synchronisation.

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

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



Configure the parameters under **Configure > Parameters > Breakers > [Breaker] monitoring > Vector mismatch**.

Table 5.30 Default parameters

Parameter	Range	Default
Set point	1 to 20 degrees	20 degrees
Delay	5 s to 1 min	10 s DEIF recommends that this delay is lower than the genset *Breaker synchronisation failure* delay.
Enable	Not enabled, Enabled	Enabled
Alarm action		Warning

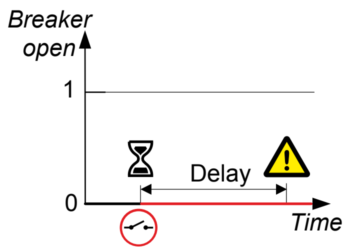
Frequency-based inhibit

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

5.5.4 Breaker opening failure

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

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



Configure the parameters under **Configure > Parameters > Breakers > [Breaker] monitoring > Opening failure**. The alarm is always enabled when at least one breaker feedback is configured. The alarm action is always *Latch enabled*.

Table 5.31 Default parameters

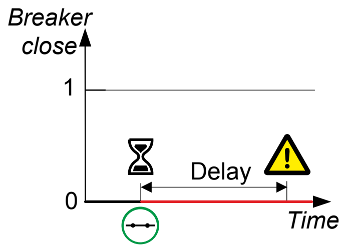
Parameter	Range	Default
Delay	0.1 to 10.0 s	2.0 s
Alarm action		Block

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

5.5.5 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.



Configure the parameters under **Configure > Parameters > Breakers > [Breaker] monitoring > Closing failure**. This alarm is always enabled when at least one breaker feedback is configured for the breaker. The alarm action is *Trip [Breaker]* and *Latched*.

Table 5.32 Default parameters

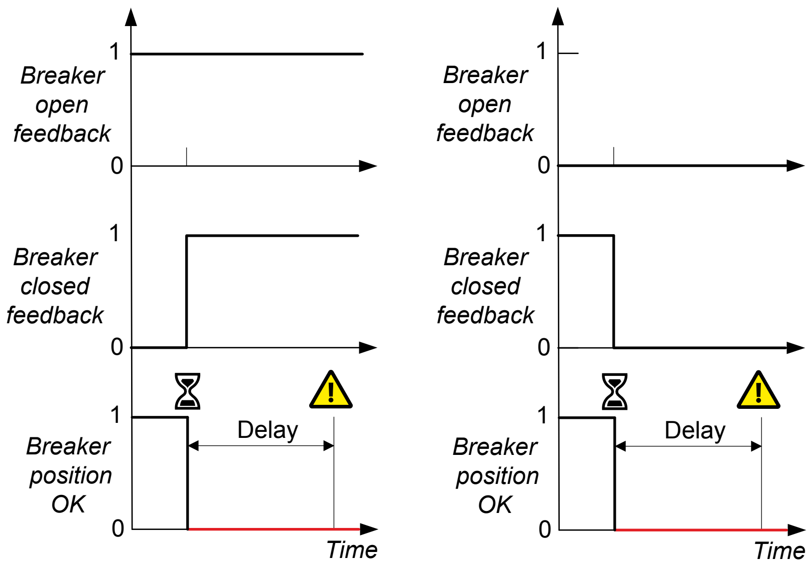
Parameter	Range	Default
Delay	0.1 to 10.0 s	2.0 s

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

5.5.6 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.



Configure the parameters under **Configure > Parameters > Breakers > [Breaker] monitoring > Position failure**.

The alarm is always *Enabled* and *Latched* when both breaker feedback functions are configured for the breaker. The alarm action is *Warning* for external breakers and *Block* for all other breakers.

Table 5.33 Default parameters

Parameter	Range	Default
Delay	0.1 to 5.0 s	1.0 s

INFO
If only one or no breaker feedbacks are configured in the **Input/output** for the breaker, then the parameters are not visible.

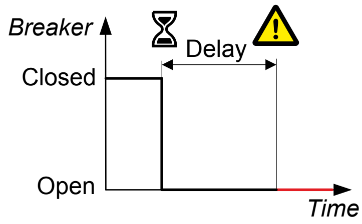
All controllers in section under switchboard control

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

5.5.7 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.



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

For the tie breaker, the alarm action is always *Trip tie breaker* and *Latched*. For all other breakers, the alarm action is always *Block* and *Latched*.

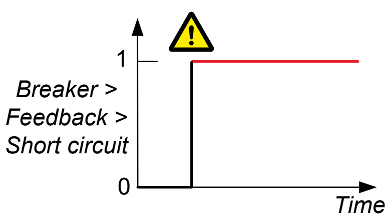
The delay is always 0.1 s.

Table 5.34 Default parameters

Parameter	Range	Default
Enable	Not enabled, Enabled	Enabled
Inhibit		Controller under SWBD control

5.5.8 Breaker short circuit

The alarm response is based on the digital input with the *Breaker* > *Feedback* > *[*B] short circuit* function (see below). This digital input is typically wired to the breaker's short circuit feedback.



Configure the parameters under **Configure > Parameters > Breakers > [Breaker] monitoring > Short circuit**. The alarm action is *Trip [Breaker]*.

Table 5.35 Default parameters

Parameter	Range	Default
Enable	Enabled, Not enabled	Enabled
Latch	Enabled, Not enabled	Enabled

Hardware

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

Table 5.36 Breaker configuration

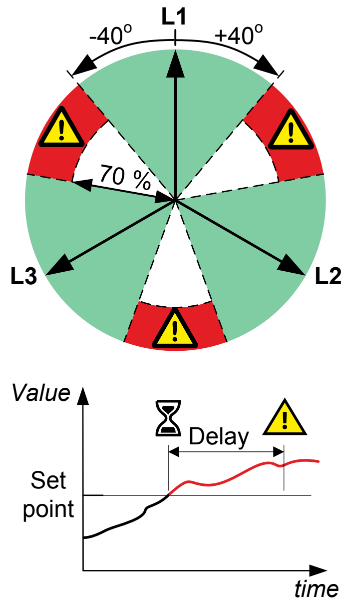
Function	I/O	Type	Details
Breakers > [Breaker] > Feedback > [*B] short circuit	Digital input	Continuous	• Required for short circuit detection, when the breaker is tripped independently due to a short circuit. One input is required for each breaker. • The breaker activates this input when it detects a short circuit. The controller then activates the *[Breaker] short circuit* alarm.

5.5.9 Phase sequence error

This alarm is for phase sequence error protection.

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

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



Configure the parameters under **Configure > Parameters > [Source] / [Busbar] > AC setup > Phase sequence error**. The alarm action is *Trip [Breaker]* and cannot be changed.

Table 5.37 Default parameters

Parameter	Range	Default
Detection voltage*	30 to 90 % of nominal source/busbar voltage	70 %*
Delay	1 to 10 s	1 s
Enable	Not enabled, Enabled	Enabled
Latch	Not enabled, Enabled	Enabled

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

5.5.10 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** diagram, but the **Input/output** functions that are required for the breaker type are not fully configured.

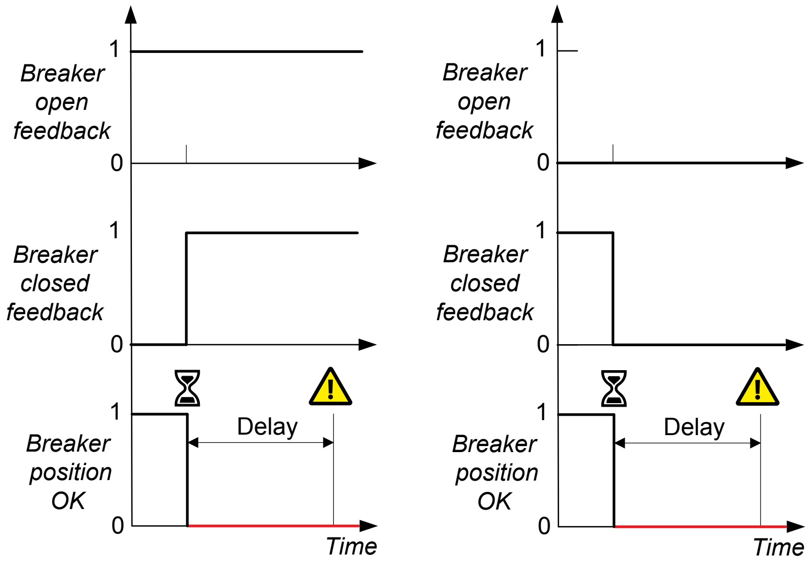
This alarm is always enabled, and has the alarm action *Block, Latch enabled*. You cannot see or change the parameters for this alarm.

5.5.11 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 system 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.

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

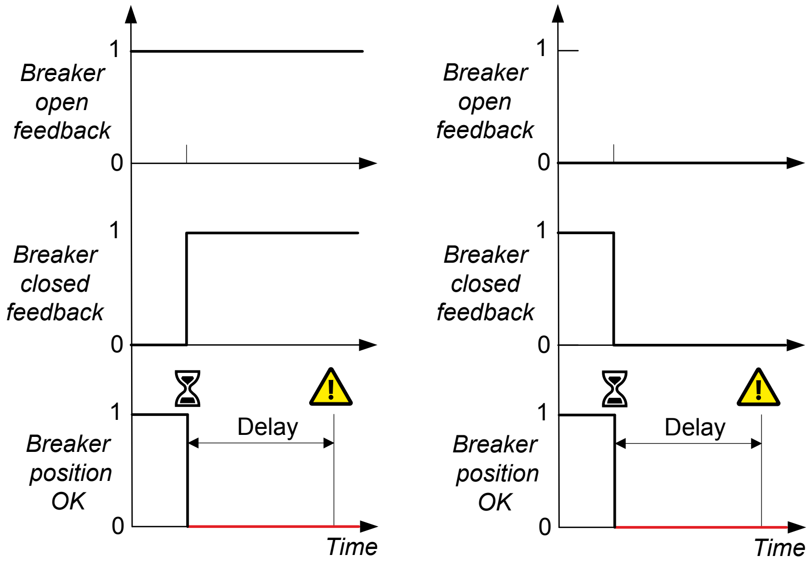
5.5.12 Any bus tie breaker position failure

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.



Parameters

Configure the parameters under **Configure > Parameters > System > Monitoring > Any bus tie breaker position failure**.

Table 5.38 Default parameters

Parameter	Range	Default
Alarm action		Warning

All affected controllers under 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 under switchboard control. The controllers remain under switchboard control until the position failure is fixed.

INFO
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.

6. Regulation

6.1 Introduction

6.1.1 Overview

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

While the controller is under PMS control, the controller sets the regulation mode according to the system conditions.

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

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

More information
See **System principles**, **Control and modes**, **Switchboard control** for more information about how to control the regulators manually through the controller.

INFO
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 and relay 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 opposed 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.

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 set point where the controller does not send regulation signals to the governor or automatic voltage regulator when using relay control. 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.

6.1.2 Analogue regulation

For regulation, an analogue output is a continuous signal.

Configuring analogue outputs

Assign the analogue output regulation function(s) under **Configure > Input/output**.

Set **Configure > Parameters > Regulators > [Regulator] general configuration > Regulator output > Output type** to *Analogue* (where *[Regulator]* is *Governor* or *AVR*).

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 under **Configure > Input/output**.

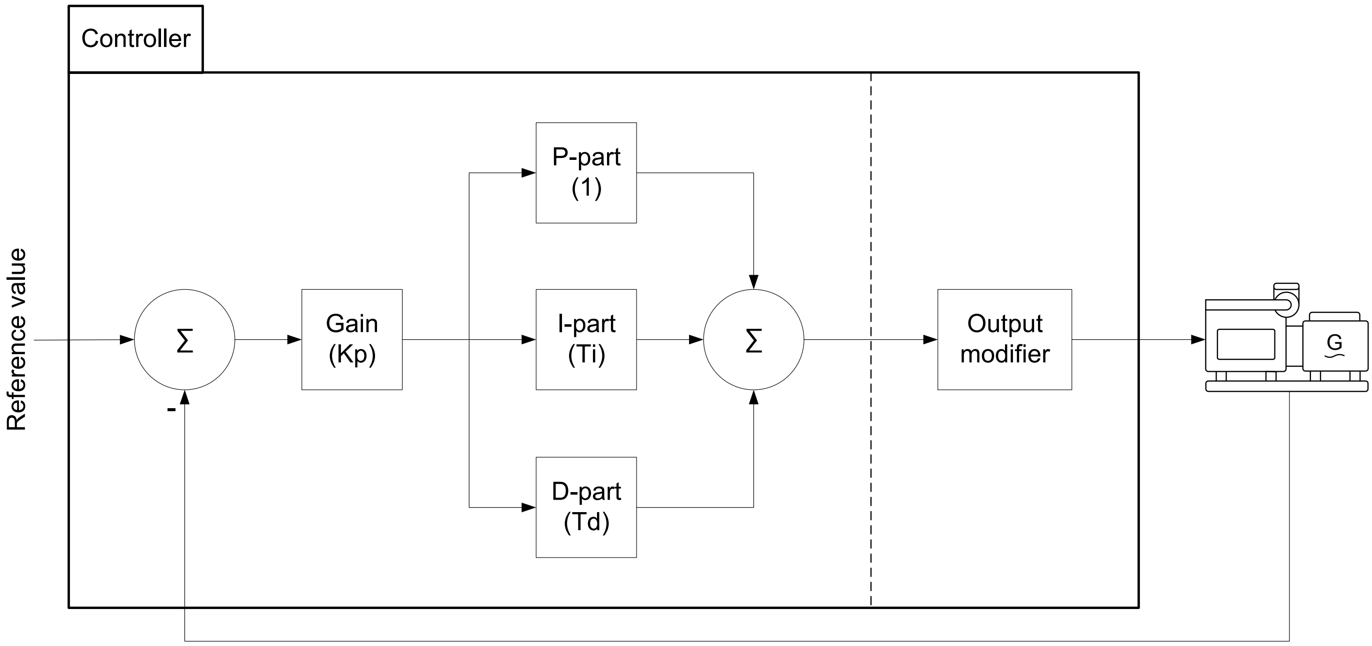
More information
See **Hardware characteristics and configuration, Governor and AVR module GAM 3.1, Pulse width modulation (PWM) output characteristics** for more information about the relationship between duty cycles and the PWM output.

Analogue PID controller

A schematic of the analogue PID controller is given below. Analogue control is continuous, and consists of these steps:

1. The controller measures the operating value(s).
2. The controller deducts the measured value from the reference value (that is, the set point) to determine the error (also known as the deviation).
3. The controller modifies the error using a PID controller, and sends the result to the output modifier.
4. The output modifier converts the modified error to a suitable signal for the governor or AVR.
5. The governor or AVR then adjusts the genset.

Figure 6.1 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 amplitude of a signal. The amplitude increases for a gain higher than 1, and decreases for a gain between 0 and 1.

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 amplified 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* reduces 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:

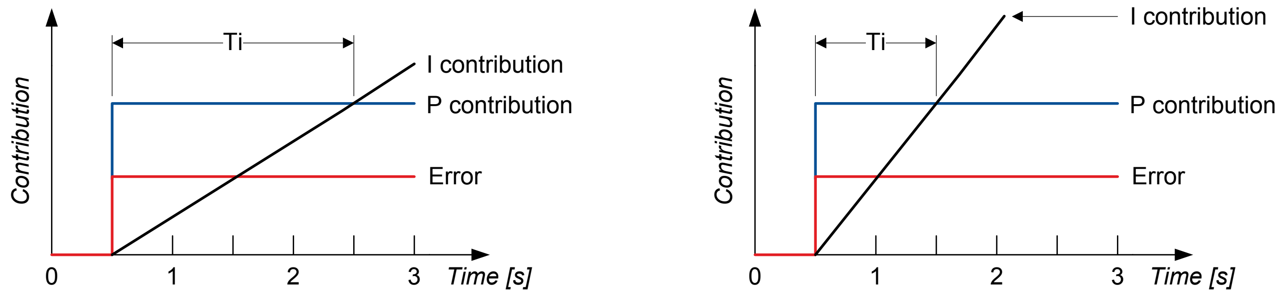
- The amplified error
- The integral action time (*Ti*)
- The error history

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 shorter, the contribution of the integral part is higher.

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 will have a small contribution to the correction.



The error history is calculated using integration.

INFO
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 action time (*Td*)
- The current rate of change of the error

The derivative part uses a linear extrapolation of the current rate of change over *Td* to predict the future error. This works well for slower systems, since they are easier to predict than faster systems. 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.

INFO
Set *Td* to zero to turn off the derivative part.

INFO
Use the derivative part if the situation requires very precise regulation (for example, static synchronisation). If the derivative part is used, it MUST be properly tuned.

Tuning the controller PID

You can tune each of the PID parts to optimise the controller regulation for your system.

6.1.3 Relay regulation

Relay control activates or deactivates 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 communicate with the governor or AVR, assign the digital output regulation functions under **Configure > Input/output**.

Set the parameter **Configure > Parameters > Regulators > [Regulator] general configuration > Output type** to *Relay* (where *[Regulator]* is *Governor* or *AVR*).

Relay regulation ranges

The controller determines whether the output should be increased or decreased by comparing the measured value to the set point. The controller determines how far the deviation (also known as the error) is from the set point, and selects an output range. The output can be in one of three ranges, which are summarised in the table below:

Table 6.1 Relay regulation ranges

Range	Relay position	Notes
Constant range	Closed or intermittent open/close	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. 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 set point for high *Kp* values and low *Kp* values. The *Maximum ON time* parameter is set to 100 %.

Figure 6.2 Up and down relay on time for different deviations from the set point

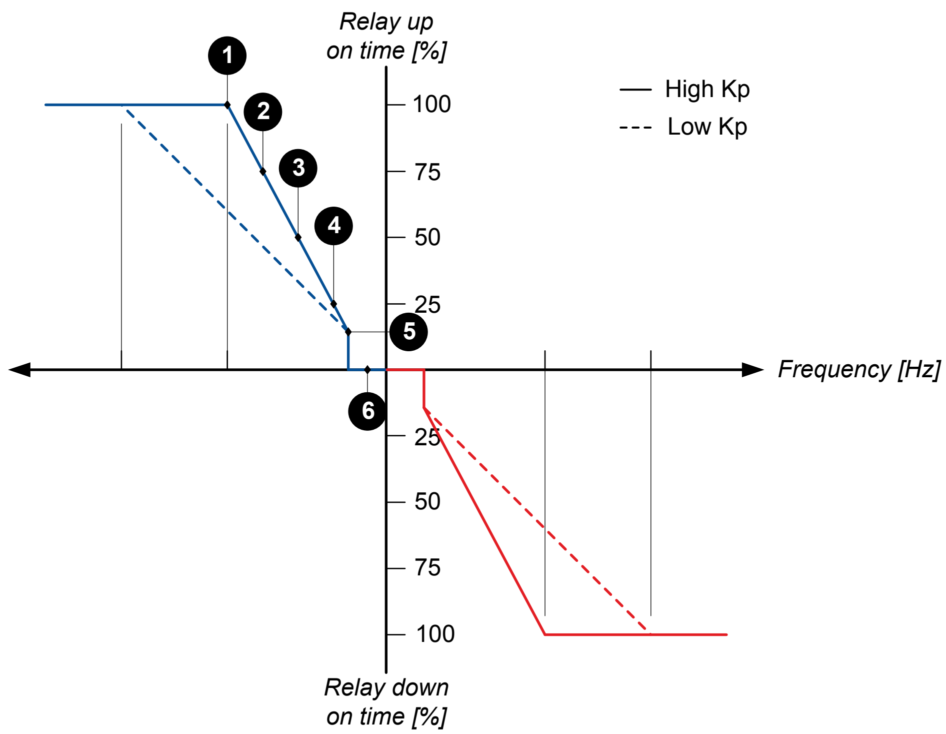
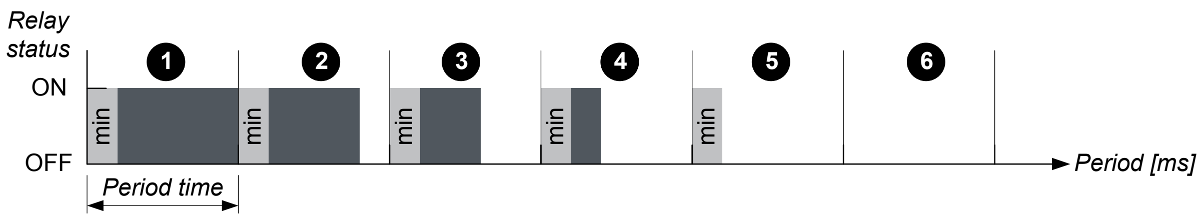


Figure 6.3 Relay action based on measurements at the end of the period time



Pulse properties

A relay control pulse has three main properties:

- Period time
- Minimum ON time
- Maximum ON time

The *Period time* is measured 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.

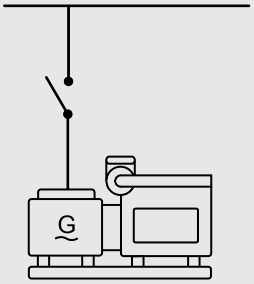
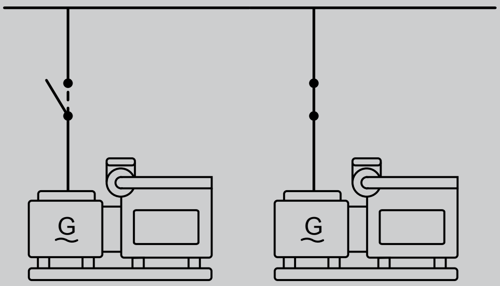
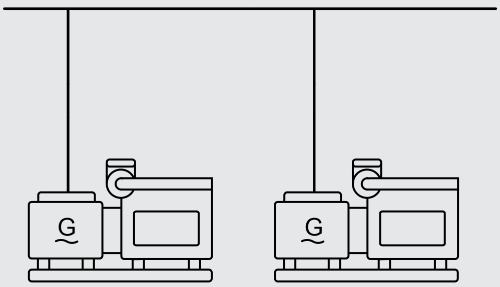
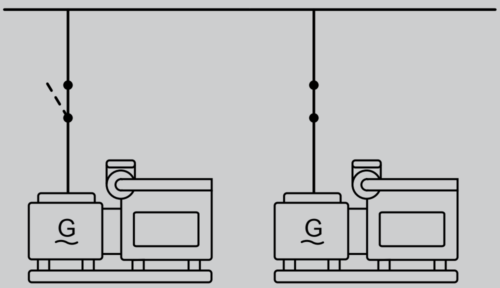
The pulse length is never shorter than the *Minimum ON time*. Once the pulse length is equal to or greater than the period time, the controller shifts from the variable range to the constant range, if the *Maximum ON time* is set to 100 %. The deviation where this shift occurs depends on *Kp* and the period time. As *Kp* increases, the variable range decreases. As *Kp* decreases, the variable range increases.

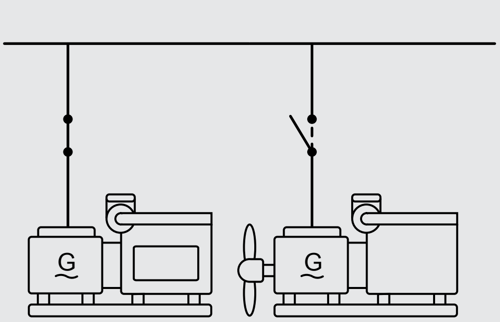
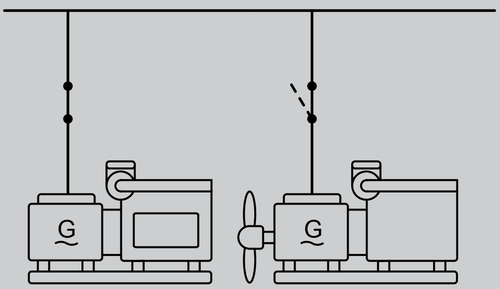
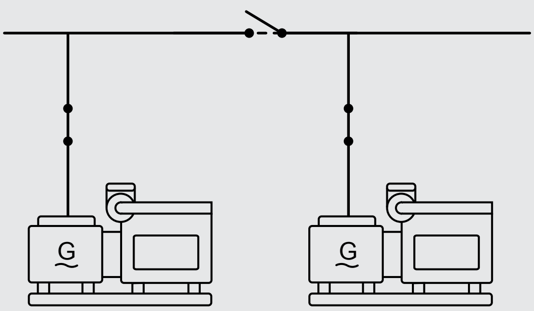
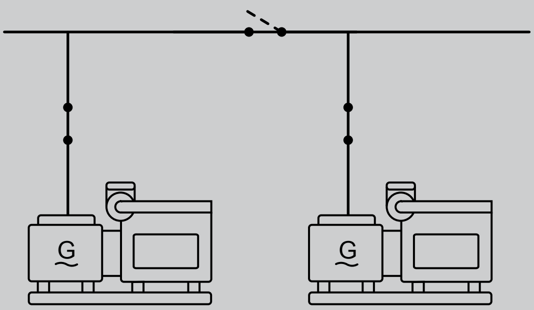
6.1.4 Regulation mode overview

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.

The table below shows under which conditions the modes are active.

Table 6.2 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
	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

Condition		Governor mode	AVR mode
	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 the power management system (PMS).	• 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 PMS.	• 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 PMS.	• 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 PMS.	• Power regulation	• Reactive power regulation

6.2 Governor regulation modes

6.2.1 Overview

The genset regulation system consists of a number of basic control modes for the governor. 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 interface, and sent to the governor.

INFO
To see the parameters mentioned in this section, you must have a governor configured in the controller *Input/output* (relay output or analogue output).

This section will give an overview of each governor regulation mode, and the associated configuration.

6.2.2 Frequency regulation

If 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 **Regulation**, **External communication using Modbus** for more information about how the frequency set point is configured using Modbus.

Analogue governor output frequency parameters

The following tables contain the parameters for an analogue governor output that are used during frequency regulation.

The frequency regulation parameters define analogue regulation when the controller regulates the frequency.

Configure these parameters under **Configure > Parameters > Regulators > GOV analogue configuration > Frequency regulation**.

Parameter	Range	Default	Notes
Kp	0 to 60	2.5	The PID gain for the regulator.
Ti	0 s to 1 min	2.5 s	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	0 s	The PID control derivative.

Relay governor output frequency parameters

The following tables contain the parameters for a relay governor output that are used during frequency regulation.

The frequency regulation parameters define relay regulation when the controller regulates the frequency.

Configure these parameters under **Configure > Parameters > Regulators > GOV relay configuration > Frequency regulation**.

Parameter	Range	Default	Notes
Kp	0 to 100	10	This is the gain for the regulator.
Deadband	0.2 to 10 %	0.5 %	The deadband for the regulator, as a percentage of the nominal frequency.

6.2.3 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 **Breakers, synchronisation and de-loading**, **Introduction**, **Regulation required for synchronisation** for more information.

6.2.4 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 **Breakers, synchronisation and de-loading**, **Introduction**, **Regulation required for synchronisation** for more information.

6.2.5 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 **Breakers, synchronisation and de-loading**, **Introduction**, **Regulation required for de-loading** for more information.

INFO
If a single genset is connected to the busbar, changing the governor input only changes the frequency of the genset and not the power.

Alternatively the power set point can be configured using Modbus.

More information
See **Regulation**, **External communication using Modbus** for more information about how the power set point is configured using Modbus.

Analogue governor output power parameters

The following table contains the parameters for an analogue governor output that are used during power regulation.

The power regulation parameters define analogue regulation when the controller regulates the governor to change the genset active power output.

Configure these parameters under **Configure > Parameters > Regulators > GOV analogue configuration > Power regulation**.

Parameter	Range	Default	Notes
Kp	0 to 60	0.5	The PID gain for the regulator.
Ti	0 s to 1 min	5 s	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	0 s	The PID control derivative time.

Relay governor output power parameters

The following tables contain the parameters for a relay governor output that are used during power regulation.

The power regulation parameters define relay regulation when the controller regulates the governor to change the genset active power output.

Configure these parameters under **Configure > Parameters > Regulators > GOV relay configuration > Power regulation**.

Parameter	Range	Default	Notes
Kp	0 to 100	10	This is the gain for the regulator.
Deadband	0.2 to 10 %	2 %	The deadband for the regulator, as a percentage of the nominal power.

6.2.6 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 System 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 **Power management**, **Load sharing** for more information about asymmetric load sharing.

Analogue governor output power load sharing parameters

The following table contains the parameters for an analogue governor output that are used during power load sharing.

The power load sharing parameters define analogue regulation when the controller regulates the governor to control the genset active power output for load sharing.

Configure these parameters under **Configure > Parameters > Regulators > GOV analogue configuration > Power load sharing regulation**.

Parameter	Range	Default	Notes
Kp	0 to 60	2.5	The PID gain for the regulator.
Ti	0 s to 1 min	2.5 s	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	0 s	The PID control derivative.
P weight	0 to 100 %	15 %	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 following table contains the parameters for a relay governor output that are used during power load sharing.

The power load sharing parameters define relay regulation when the controller regulates the governor to control the genset active power output for load sharing.

Parameter	Range	Default	Notes
Kp	0 to 100	10	This is the gain for the regulator.
f deadband	0.2 to 10 %	1 %	The frequency deadband for the regulator, as a percentage of nominal frequency.

Parameter	Range	Default	Notes
			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 to 100 %	10 %	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 %	2 %	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.

6.2.7 Governor stand-alone mode

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

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

INFO
Stand-alone mode is **not** related to a stand-alone genset.

DANGER!
The manual regulation inputs in stand-alone mode override any other regulation. The GAM3.2 does not stop the user from sending regulation signals that might damage the genset.
The operator can create a dangerous situation during stand-alone mode. The rest of the controller could be disabled during stand-alone mode, and therefore be unable to provide protection. The system design and operator training must take these dangers into account.

Inputs and outputs

Configure the inputs and outputs under **Configure > Input/output**. Select the **GAM3.2**, then select the input or output to configure.

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

Function	I/O	Type	Details
Regulators > GOV > Modes > Stand-alone mode	Digital input	Continuous	The operator activates this input to activate stand-alone mode. If you want one digital input to activate both GOV and AVR stand-alone mode, also configure *Regulators* > *AVR* > *Modes* > *Stand-alone mode* on the same input.
Regulators > GOV > Manual > Manual GOV increase	Digital input	Continuous	When this input is activated during stand-alone mode, the GAM3.2 increases the output to the governor. That is, the *Regulator* > *GOV* > *Control* > *GOV output [%]* analogue output, or the *Regulators* > *GOV* > *Control* > *GOV increase* digital output.

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

More information
See **Regulation, Governor** for general information on regulation.

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

More information
See **Breakers, synchronisation and de-loading, Synchronisation in each control mode, Synchronisation under switchboard control** for more information on manual regulation.

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

How it works during normal controller operation

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

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

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

How it works if the rest of the controller is disabled

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

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

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

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

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

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

How it works when stand-alone mode is deactivated

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

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

6.3 AVR regulation modes

6.3.1 Overview

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.

INFO
To see the parameters mentioned in this section, you must have an AVR configured in the controller *Input/output* (relay output or analogue output).

This section will give an overview of each AVR regulation mode, and the associated configuration.

6.3.2 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 **Regulation**, **External communication over Modbus** for more information about how the voltage set point is configured using Modbus.

Analogue AVR output voltage parameters

The following table contains the parameters for an analogue AVR output that are used during voltage regulation.

The voltage regulation parameters define analogue regulation when the controller regulates AVR to change the voltage.

Configure these parameters under **Configure > Parameters > Regulators > AVR analogue configuration > Voltage regulation**.

Parameter	Range	Default	Notes
Kp	0 to 60	2.5	The PID gain for the regulator.
Ti	0 s to 1 min	2.5 s	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	0 s	The PID control derivative.

Relay AVR output voltage parameters

The following tables contain the parameters for a relay AVR output that are used during voltage regulation.

The voltage regulation parameters define relay regulation when the controller regulates the voltage.

Configure these parameters under **Configure > Parameters > Regulators > AVR relay configuration > Voltage regulation**.

Parameter	Range	Default	Notes
Kp	0 to 100	10	This is the gain for the regulator.
Deadband	0 to 10 %	2 %	The deadband for the regulator, as a percentage of the nominal voltage.

6.3.3 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.

More information
See **AC configuration and nominal settings**, **General equipment AC protections** for more information.

If a genset is connected to the busbar along with other power generating equipment, 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 equipment. Increasing the excitation in the generator automatically increases the reactive power that the genset provides, and decreases the load on the other power generating equipment.

Alternatively the reactive power set point can be configured using Modbus.

More information
See **Regulation**, **External communication over Modbus** for more information about how the reactive power set point is configured using Modbus.

Analogue AVR output reactive power parameters

The following table contains the parameters for an analogue AVR output that are used during reactive power regulation.

The reactive power regulation parameters define analogue regulation when the controller regulates the genset reactive power output.

Configure these parameters under **Configure > Parameters > Regulators > AVR analogue configuration > Reactive power regulation**

Parameter	Range	Default	Notes
Kp	0 to 60	2.5	The PID gain for the regulator.
Ti	0 s to 1 min	2.5 s	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	0 s	The PID control derivative.

Relay AVR output reactive power parameters

The following table contains the parameters for a relay AVR output that are used during reactive power regulation.

The reactive power regulation parameters define relay regulation when the controller regulates the genset reactive power output.

Configure these parameters under **Configure > Parameters > Regulators > AVR relay configuration > Reactive power regulation**.

Parameter	Range	Default	Notes
Kp	0 to 100	10	This is the gain for the regulator.
Deadband	0 to 10 %	2 %	The deadband for the regulator, as a percentage of the nominal reactive power.

6.3.4 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 **Power management**, **Load sharing** for more information.

Analogue AVR output reactive power load sharing parameters

The following table contains the parameters for an analogue AVR output that are used during reactive power load sharing.

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.

Configure these parameters under **Configure > Parameters > Regulators > AVR analogue configuration > Reactive power load sharing regulation**.

Parameter	Range	Default	Notes
Kp	0 to 60	2.5	The PID gain for the regulator.
Ti	0 s to 1 min	2.5 s	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	0 s	The PID control derivative.
Q weight	0 to 100 %	15 %	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 following table contains the parameters for a relay AVR output that are used during reactive power load sharing.

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.

Configure these parameters under **Configure > Parameters > Regulators > AVR relay configuration > Reactive power load sharing regulation**.

Parameter	Range	Default	Notes
Kp	0 to 100	10	This is the gain for the regulator.
V deadband	0 to 10 %	1 %	The voltage deadband for the regulator, as a percentage of the nominal voltage.
Q deadband	0 to 10 %	2 %	The reactive power deadband for the regulator, as a percentage of the nominal reactive power.
Q weight	0 to 100 %	15 %	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.

6.3.5 AVR stand-alone mode

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

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

INFO
Stand-alone mode is **not** related to a stand-alone genset.

DANGER!
The manual regulation inputs in stand-alone mode override any other regulation. The GAM3.2 does not stop the user from sending regulation signals that might damage the genset.
The operator can create a dangerous situation during stand-alone mode. The rest of the controller could be disabled during stand-alone mode, and therefore be unable to provide protection. The system design and operator training must take these dangers into account.

Inputs and outputs

Configure the inputs and outputs under **Configure > Input/output**. Select the **GAM3.2**, then select the input or output to configure.

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

Function	I/O	Type	Details
Regulators > AVR > Modes > Stand-alone mode	Digital input	Continuous	The operator activates this input to activate stand-alone mode. If you want one digital input to activate both GOV and AVR stand-alone mode, also configure *Regulators > GOV > Modes > Stand-alone mode* on the same input.
Regulators > AVR > Manual > Manual AVR increase	Digital input	Continuous	When this input is activated during stand-alone mode, the GAM3.2 increases the output to the AVR. That is, the *Regulator > AVR > Control > AVR output [%]* analogue output, or the *Regulators > AVR > Control > AVR increase* digital output.

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

More information
See **Regulation, Automatic voltage regulator** for general information on regulation.

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

More information
See **Breakers, synchronisation and de-loading, Synchronisation in each control mode, Synchronisation under switchboard control** for more information on manual regulation.

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

How it works during normal controller operation

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

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

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

How it works if the rest of the controller is disabled

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

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

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

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

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

How it works when stand-alone mode is deactivated

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

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

6.4 External communication

6.4.1 Overview

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, or Modbus.

This section gives an overview of how and when external communication is used in the controller, the inputs associated with it, and the associated parameters.

INFO
To see the inputs and parameters mentioned in this section, you must have a governor and/or AVR configured in the controller *Input/output* (relay output or analogue output).

6.4.2 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 **Configure > 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 **Configure > Parameters**, or by activating a digital input that is configured to activate the function, or using Modbus.

Inputs

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

Table 6.3 Hardware required in addition to the minimum standard controller wiring

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 **Configure > Parameters > 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 **Configure > Parameters > 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 **Configure > Parameters > 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 **Configure > Parameters > 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 **Configure > Parameters > 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 **Configure > Parameters > 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 **Configure > Parameters > 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 **Configure > Parameters > 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 **Configure > Parameters > 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 **Configure > Parameters > Regulators > AVR general configuration > External offset > Cos phi set point enable** to *Not enabled*.

Governor parameters

You can configure the governor common settings under **Configure > Parameters > Regulators > GOV general configuration**.

INFO
To see these parameters, you must assign a governor output function.

External offset

These parameters allow analogue inputs to determine the genset's frequency or power set point.

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. • **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.

Parameter	Range	Default	Notes
			• **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.

INFO
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.

AVR parameters

You can configure the governor common settings under **Configure > Parameters > Regulators > AVR general configuration**.

INFO
To see these parameters, you must assign an AVR output function.

External offset

These parameters allow analogue inputs to determine the genset's voltage, reactive power or cos phi set point.

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. • **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.

INFO
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.

6.4.3 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.

Inputs

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

INFO
These inputs are only visible if a regulation output (either relay or analogue) is configured.

Table 6.4 Hardware required in addition to the minimum standard controller wiring

Function	I/O	Type	Details
Regulators > GOV > External set points > Activate external f offset	Digital input	Pulse	When activated, the controller changes **Configure > Parameters > 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 **Configure > Parameters > 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 **Configure > Parameters > 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 **Configure > Parameters > 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 **Configure > Parameters > 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 **Configure > Parameters > 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 **Configure > Parameters > 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 **Configure > Parameters > 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 **Configure > Parameters > 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 **Configure > Parameters > 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.

Table 6.5 Modbus function parameters

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.

6.5 Governor

6.5.1 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.

The sections below describe the input and output setup and common input parameters for the governor regulation function.

Inputs and outputs

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

The governor general configuration settings apply to all the controller's governor regulation outputs (for example, relay, analogue, pulse width modulation, and so on). You can configure the governor general configuration settings under **Configure > Parameters > Regulators > GOV general configuration**.

INFO
To see these parameters, you must assign a governor output function.

Regulator output

If a governor analogue regulation output and both governor relay regulation outputs are configured, then one output must be selected as the output that sends feedback to the governor.

Parameter	Range	Default	Notes
Regulator output	• Off • Relay • Analogue	Relay	**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**: The controller uses an analogue output to regulate the governor (only visible if a governor analogue regulator output 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.

Parameter	Range	Default	Notes
Regulator delay	0 s to 1 h	0 s	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

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). You can configure the governor regulation set points under **Configure > Parameters > Regulators > GOV regulation set points**.

INFO
To see these parameters, you must assign a governor output function.

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.

Parameter	Range	Default ramp 1	Default ramp 2	Notes
[s]	0 to 3600 s	0 s; 50 s	0 s; 1000 s	The time coordinate for the active power ramp up curve.
[%]	0 to 100 %	0 %; 100 %	0 %; 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.

Parameter	Range	Default ramp 1	Default ramp 2	Notes
[s]	0 to 3600 s	0 s; 20 s	0 s; 1000 s	The time coordinate for the power ramp down curve.
[%]	0 to 100 %	100 %; 0 %	100 %; 0 %	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.

6.5.2 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.

Wiring example

Figure 6.4 Example of analogue output wiring for governor regulation

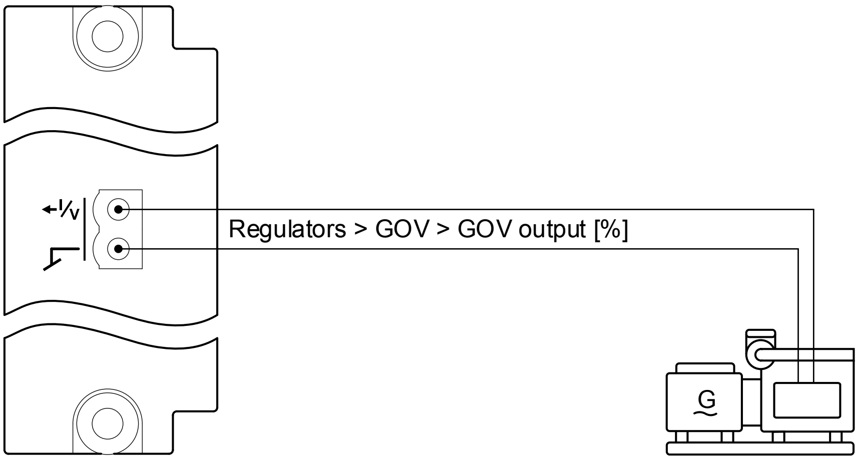
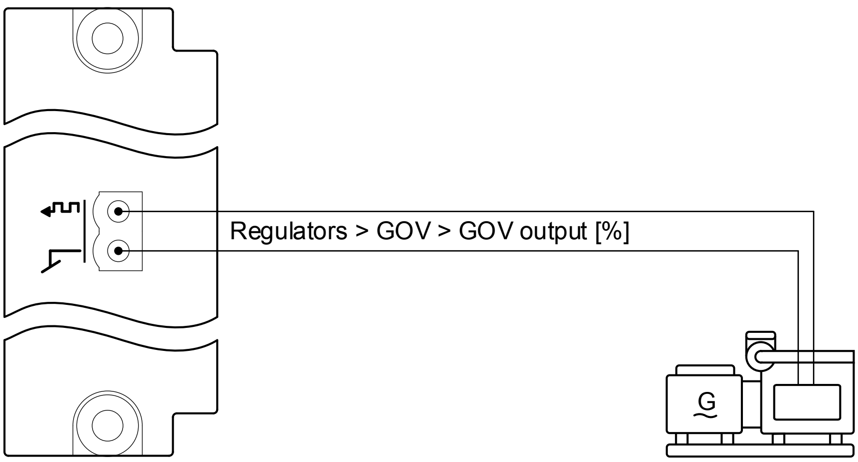


Figure 6.5 Example of pulse width modulation analogue output wiring for governor regulation



Inputs and Outputs

You must assign the governor regulation analogue output under **Configure > Input/output**. Select the hardware module, then select an analogue output to configure.

Table 6.6 Governor regulation analogue output

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.

INFO
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**, **Tasks**, **Configure the output setup** in the **PICUS manual** for more information about how to configure an analogue output.

Parameters

You can configure the governor analogue control parameters under **Configure > Parameters > Regulators > GOV analogue configuration**.

INFO
To see the governor analogue control parameters, you must assign the **Regulators > GOV > GOV output [%]** function to an analogue output.

Offset

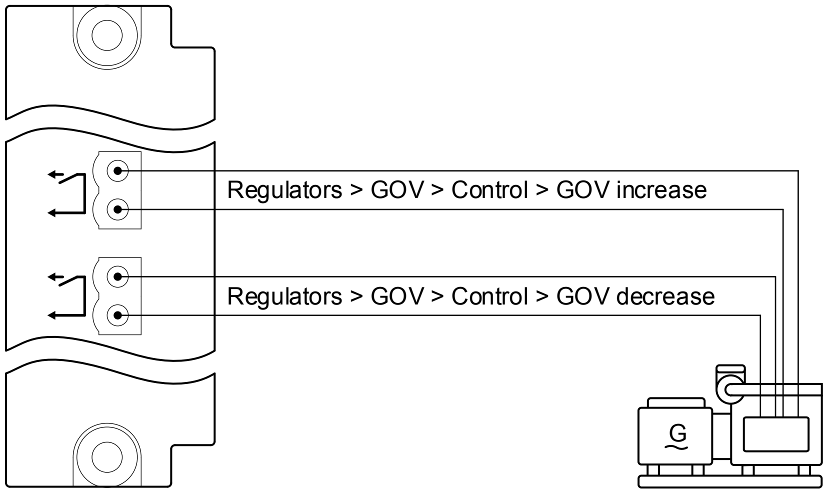
When you start and/or run a genset, you might want to adjust the starting point for analogue regulation. This is done by changing the output offset.

Parameter	Range	Default	Notes
GOV output offset 1 GOV output offset 2 GOV output offset 3 GOV output offset 4	-100 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.

6.5.3 Governor relay regulation function

You can configure relay outputs on the controller to regulate the governor. You can also set a number of parameters for the governor relay regulation function.

Wiring example



Outputs

You must assign these outputs under **Configure > Input/output**. Select the hardware module, then select a digital output to configure.

Table 6.7 Governor: Relay output hardware

Function	I/O	Type	Details
Regulators > GOV > Control > 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 > Control > GOV decrease	Digital output	Variable-length pulse	The controller activates this output to regulate the governor to decrease the engine speed or power.

Parameters

INFO
To see these parameters, you must assign the functions to digital outputs.

Configure the governor regulation parameters for automatic configuration under **Configure > Parameters > Regulators > GOV relay configuration > Automatic configuration**.

These parameters adjust the controller's relay control output.

Parameter	Range	Default	Notes
Period time	250 ms to 32.5 s	1500 ms	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*.

Parameter	Range	Default	Notes
			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	200 ms	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 to 100 %	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 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.

6.6 Automatic voltage regulator

6.6.1 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 settings apply to all the controller's AVR regulation outputs (for example, relay or analogue). You can configure the AVR common settings under **Configure > Parameters > Regulators > AVR general configuration**.

INFO
To see these parameters, you must configure an AVR output function.

Regulator output

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.

Parameter	Range	Default	Notes
Regulator output	• Off • Relay • Analogue	Analogue	**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**: The controller uses an analogue output to regulate the AVR (only visible if an analogue AVR regulator output 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 at this point, still low compared to nominal value. The regulation delay is intended to delay regulation until the governor and AVR have settled frequency and voltage on their preset values. This prevents regulation overshoot at start-up.

Parameter	Range	Default	Notes
Regulator delay	0 s to 1 h	2 s	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

The AVR regulation set point settings apply to all the controller's AVR regulation outputs (for example, relay or analogue). You can configure the AVR common settings under **Configure > Parameters > Regulators > AVR regulation set points**.

INFO
To see these parameters, you must configure an AVR output function.

Reactive power ramp up

This parameter 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 parameter consists of one curve. The curve can consist of 2 to 10 coordinates for the time and the percentage of the genset nominal reactive power.

Parameter	Range	Default ramp 1	Notes
[s]	0 to 3600 s	0 s; 50 s	The time coordinate for the reactive power ramp up curve.
[%]	0 to 100 %	0 %; 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.

Reactive 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 one curve. The curve can consist of 2 to 10 coordinates for the time and the percentage of the genset nominal reactive power.

Parameter	Range	Default ramp 1	Notes
[s]	0 to 3600 s	0 s; 20 s	The time coordinate for the reactive power ramp down curve.
[%]	0 to 100 %	100 s; 0 %	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.

6.6.2 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.

Wiring example

Figure 6.6 Example of analogue output wiring for AVR regulation

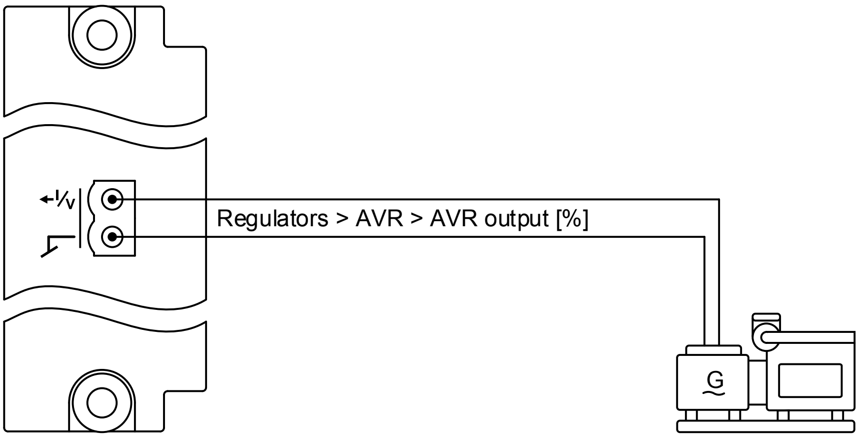
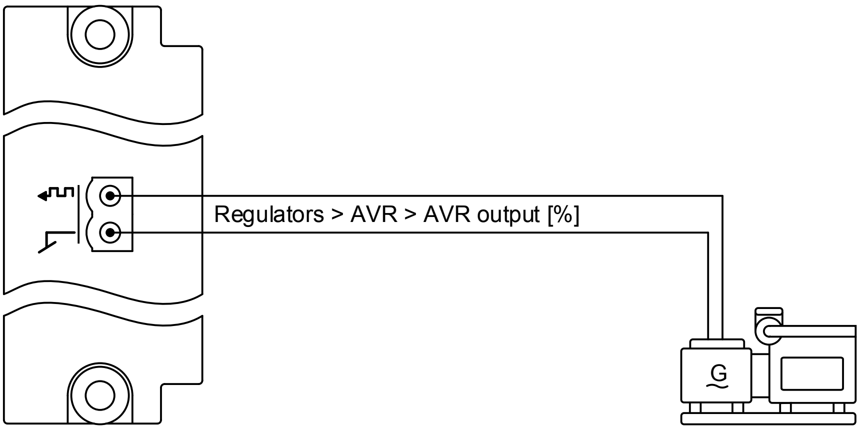


Figure 6.7 Example of pulse width modulation analogue output wiring for AVR regulation



Inputs and outputs

You must assign the AVR regulation analogue output under **Configure > Input/output**. Select the hardware module, then select an analogue output to configure.

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.

INFO
The setup and parameters for AVR regulation using pulse width modulation (PWM) is exactly the same as for an analogue output.

More information
See **Input/Output**, **Tasks**, **Configure the output setup** in the **PICUS manual** for more information about how to configure an analogue output.

Parameters

You can configure the AVR analogue control parameters under **Configure > Parameters > Regulators > AVR analogue configuration**.

INFO
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).

Offset

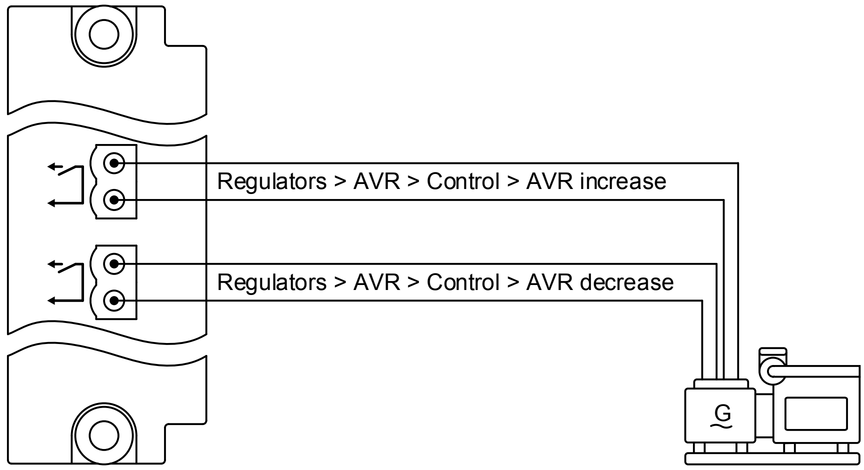
When you start and/or run a genset, you might want to adjust the starting point for analogue regulation. This is done by changing the output offset.

Parameter	Range	Default	Notes
AVR output offset 1 AVR output offset 2 AVR output offset 3 AVR output offset 4	-100 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.

6.6.3 AVR relay regulation parameters

You can configure relay outputs on the controller to regulate the AVR. You can also set a number of parameters for the AVR relay regulation function.

Wiring example



Outputs

You must assign these outputs under **Configure > Input/output**. Select the hardware module, then select a digital output to configure.

Table 6.8 AVR: Relay output hardware

Function	I/O	Type	Details
Regulators > AVR > Control > 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 > Control > 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

INFO
To see these parameters, you must assign the functions to digital outputs.

Configure the AVR regulation parameters for automatic regulation under **Configure > Parameters > Regulators > AVR relay configuration > Automatic configuration**.

These parameters adjust the controller's relay control output.

Parameter	Range	Default	Notes
Period time	50 ms to 15 s	500 ms	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	100 ms	The *Minimum ON time* must be long enough to ensure that the AVR can detect the shortest pulse that the controller sends to it. You can increase the *Minimum ON time* to force a slow system to respond to the controller's regulation. If the controller needs to increase the AVR output, the AVR increase digital output is activated for at least the Minimum ON time. While the controller is increasing the AVR output, the AVR decrease digital output is not activated. If the controller needs to decrease the AVR output, the AVR decrease digital output is activated for at least the Minimum ON time. While the controller is decreasing the AVR output, the AVR increase digital output is not activated.
Maximum ON time	0 to 100 %	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.

6.7 Configuration alarms

6.7.1 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.

6.7.2 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.

6.7.3 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 **Configure** > **Parameters** > **Regulators** > **GOV general configuration** > **Regulator output > Output type**

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

6.7.4 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 **Configure** > **Parameters** > **Regulators** > **AVR: common settings** > **Regulator output > Output type**

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

6.7.5 GOV stand-alone configuration error

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

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

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

    - If using the AVR stand-alone on the same input, this GOV setting must be set the same as the AVR stand-alone activation, otherwise a configuration conflict alarm activates. Both must be configured High or Low. If one is High and the other Low, the alarm activates.

Configure the parameters under **Configure > Parameters > Regulators > GOV general configuration > Stand-alone configuration error**.

Table 6.9 Default parameters

Parameter	Range	Default
Delay	0 s to 1 h	1 min
Enable	Not enabled, Enabled	Not enabled
Alarm action		Warning

6.7.6 AVR stand-alone configuration error

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

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

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

Configure the parameters under **Configure > Parameters > Regulators > AVR general configuration > Stand-alone configuration error**.

Table 6.10 Default parameters

Parameter	Range	Default
Delay	0 s to 1 h	1 min
Enable	Not enabled, Enabled	Not enabled
Alarm action		Warning

6.8 Regulation alarms

6.8.1 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.

INFO
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.

Configure the parameters under **Configure > Parameters > Regulators > GOV monitoring > Regulation error**.

INFO
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.

Table 6.11 Default parameters

Parameter	Range	Default
Set point (absolute value)	1 to 100 % regulation deviation	30 %
Delay	10 s to 1 h	60 s
Enable	Not enabled, Enabled	Enabled
Alarm action		Warning

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.

6.8.2 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.

INFO
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.

Configure the parameters under **Configure > Parameters > Regulators > AVR monitoring > Regulation error**.

INFO
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.

Table 6.12 Default parameters

Parameter	Range	Default
Set point (absolute value)	1 to 100 % regulation deviation	30 %
Delay	10 s to 1 h	60 s
Enable	Not enabled, Enabled	Enabled
Alarm action		Warning

Alarm deviation examples

1. The controller is running fixed voltage regulation with a set point of 400 V, and the measured voltage is 250 V.
   - The deviation from the set point is |(250 V - 400 V)| / 400 V × 100 = 38 %.
   - The deviation is more than the alarm set point. If the measured power is stays below 280 V for longer than the delay, then the alarm activates.
2. The controller is running fixed reactive power regulation with a set point of 0 % of nominal reactive power, and the measured value is 2 % of nominal reactive power.
   - The deviation from the set point is 2 %.
   - The deviation is less than the alarm set point, and the alarm is not activated.
3. The controller is running fixed cos phi regulation with a set point of 0.9 I, and the measured value is 0.95 C.
   - The deviation from the set point is |(0.95 C - 0.9 I)| / 0.9 I × 100 = 17 %.
   - The deviation is less than the alarm set point, and the alarm is not activated.

6.8.3 P load sharing failure

This alarm is for genset active power load sharing failure.

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

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

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

Configure the parameters under **Configure > Parameters > Regulators > GOV monitoring > P load sharing failure**.

Table 6.13 Default parameters

Parameter	Range	Default
Set point	0 to 50 % regulation deviation	15 %
Delay	0 s to 1 h	30 s
Enable	Not enabled, Enabled	Not enabled
Alarm action		Warning

6.8.4 Q load sharing failure

This alarm is for genset reactive power load sharing failure.

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

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

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

Configure the parameters under **Configure > Parameters > Regulators > AVR monitoring > Q load sharing failure**.

Table 6.14 Default parameters

Parameter	Range	Default
Set point	0 to 50 % regulation deviation	15 %
Delay	0 s to 1 h	30 s
Enable	Not enabled, Enabled	Not enabled
Alarm action		Warning

7. Power management

7.1 Power management principles

7.1.1 Introduction

Power management ensures that the required power is available, the system runs as efficiently as possible, and the system responds appropriately to changes. This requires the controllers to share information and work together.

Power management scope

The power management system performs the following functions:

- 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

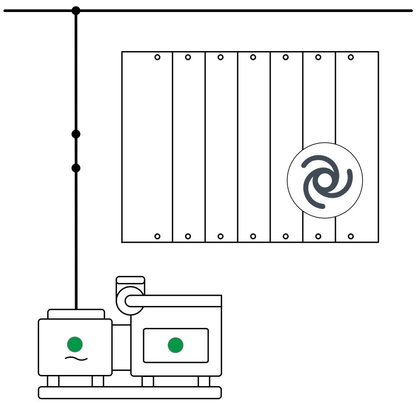
The controllers should normally be under power management control. The GENSET, HYBRID, and EMERGENCY genset controllers can then be in either AUTO or SEMI mode. The power management system functions best when all the controllers are in AUTO mode. SEMI mode is a type of service mode, and controllers should not normally be in this mode.

A controller is under 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 system can also force controllers under switchboard control.

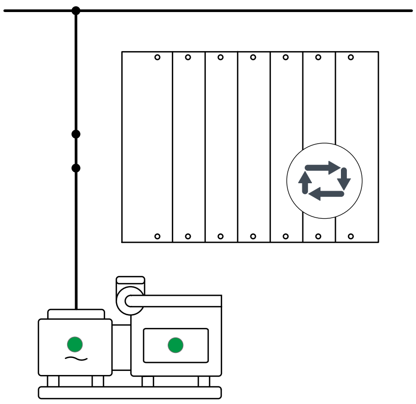
More information
See **System principles**, **Control and modes** for more information.

Power management status

Enabled The power management system is **enabled** 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 system is limited if there are not enough GENSET controllers in AUTO mode to supply the load.

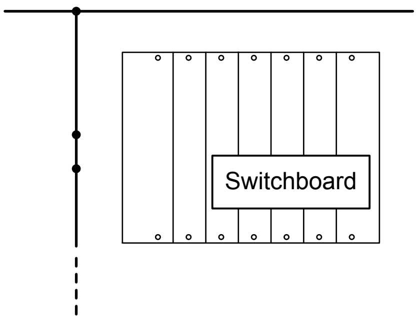


Partially enabled The power management system is **partially enabled** if all the GENSET controllers are in SEMI mode. The controllers can share the load and restore power after a blackout. However, there is no automatic genset start or stop. The power management system does not include the available power from connected GENSET controllers in SEMI mode in the available power calculations.



Disabled The power management system 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 system controls.

If there is a blackout, then the equipment under switchboard control is no longer connected automatically. The power management system 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.

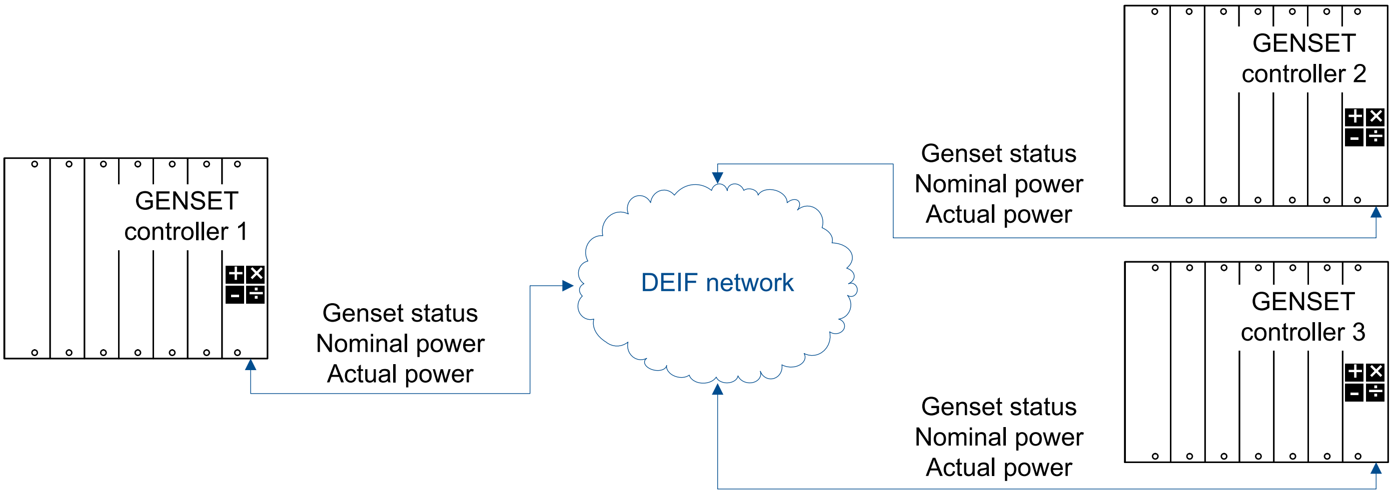
The power management with hybrid inverters, that is inverter start, stop, and load sharing, can be configured to maximise the system's use of the power source.

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).

The following sketch shows an example of the information flow for the load-dependent start function.

Figure 7.1 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 genset status, genset nominal power, and the genset power that the controller measures, using the DEIF network.
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.

Protections

Most power management failures activate the standard controller alarms.

Only the alarms that are specific to power management are described in this chapter.

Finding alarms example

The power management system may fail to de-load a GENSET controller's generator breaker. The GENSET controller then activates the *GB de-load failure* alarm.

This alarm is described in the **Breakers** chapter, under **Synchronisation and breaker protections**.

7.1.2 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 • 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 display unit 1st priority push-button, the display unit interface, or Modbus ◦ Delayed priority shift • Dynamic (first genset to connect has the highest priority) • Running hours
Heavy consumer management	• Up to 4 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

	Functions
	◦ 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

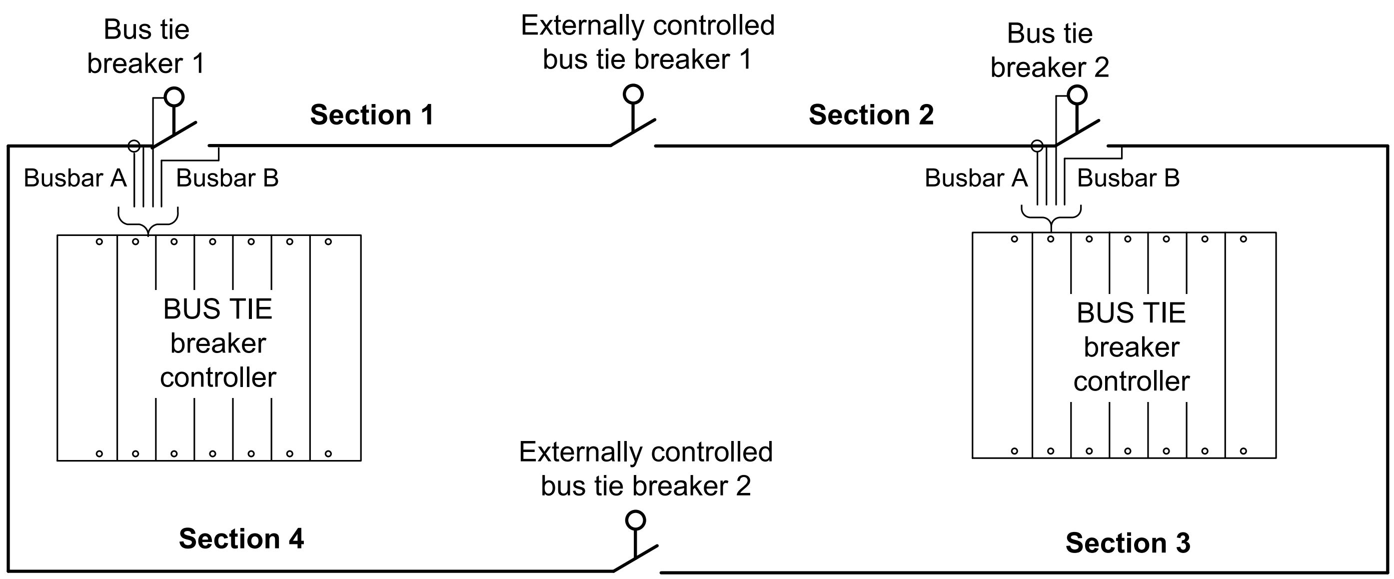
NOTE * For some controllers, the default hardware does not include analogue inputs. Extra hardware must be installed if analogue feedback from the heavy consumer is required.
** Up to 3 externally-controlled breakers per EMERGENCY genset controller.

7.1.3 Busbar sections

The power management system manages the power for the busbar sections, according to a set of power management rules. If bus tie breakers are present, then the busbar sections are dynamic. That is, the sections change whenever bus tie breakers are opened or closed.

Each BUS TIE breaker controller and each externally controlled bus tie breaker can create a new busbar section, as shown in the example below.

Figure 7.2 Example of busbar sections created by bus tie breakers and externally controlled bus tie breakers

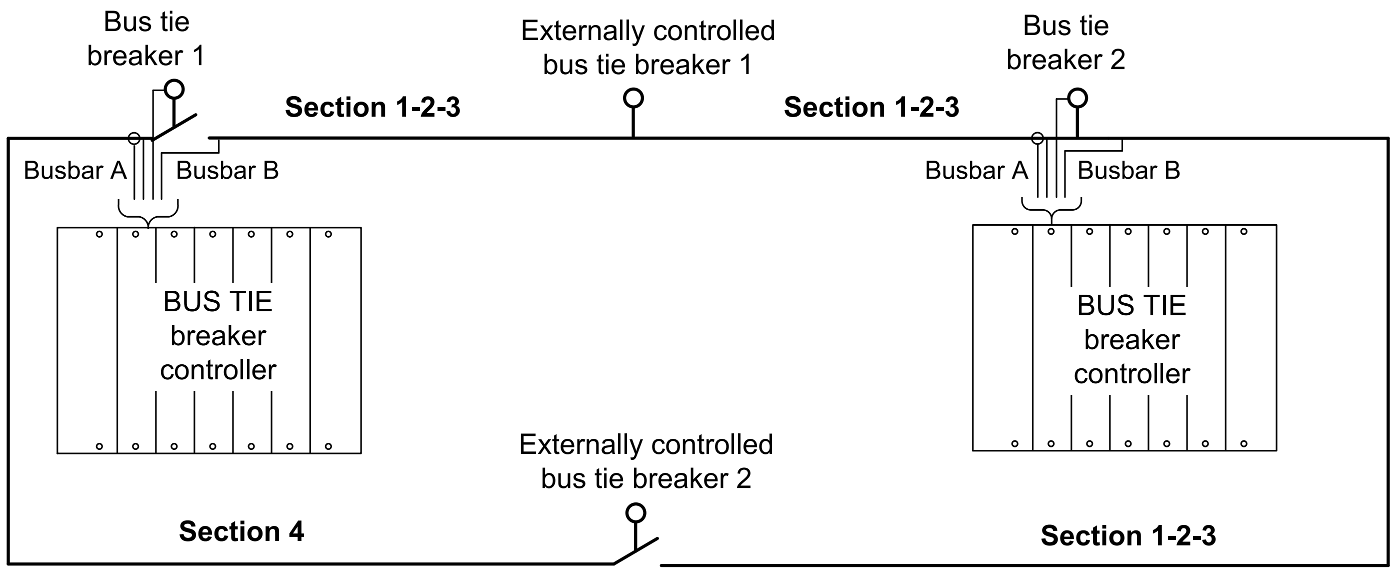


More information
See **Power management**, **Externally controlled breakers**, **Externally controlled bus tie breaker** in this document for information about setting up and controlling an externally controlled bus tie breaker.

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.

Figure 7.3 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.

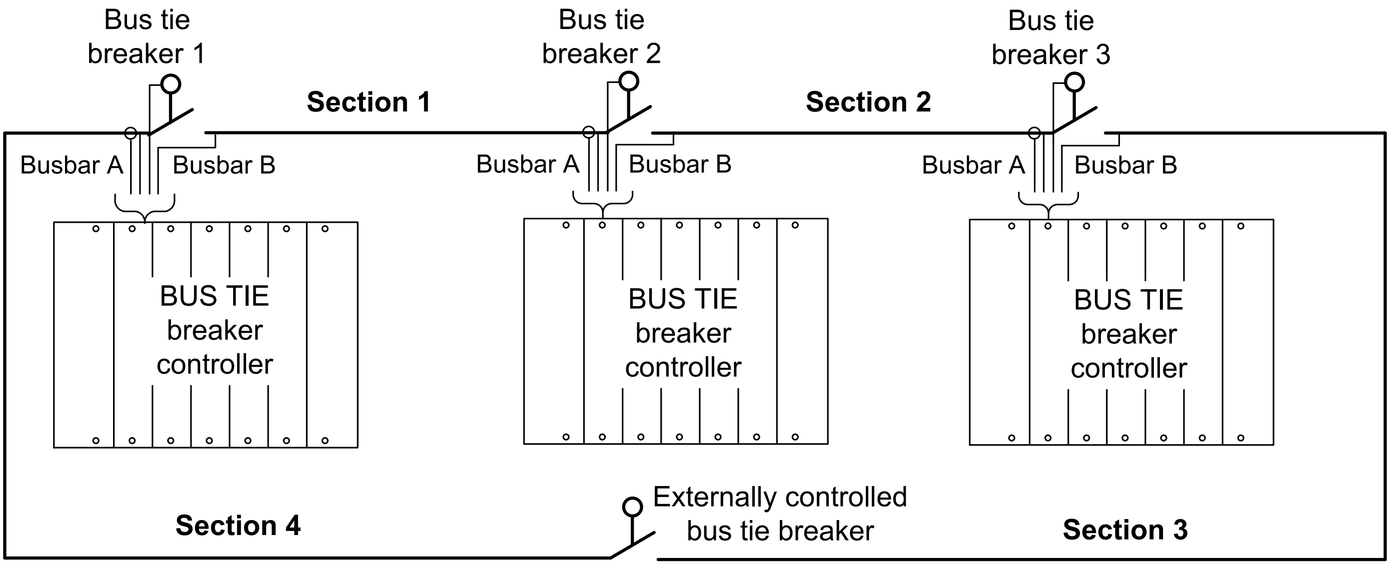
INFO
The busbar sections are numbered here to make it easier to understand sections. However, busbar section numbers are not used in PICUS. When CustomLogic is used to set the power management rules for one controller in the section, then all the controllers in that section start to use the same power management rules.

More information
See **Power management**, **Power management principles**, **Section power management** for more information about the power management rules for each busbar section.

7.1.4 Ring busbar connection

BUS TIE breaker controllers and/or externally controlled bus tie breakers can be installed in system with a ring busbar, as shown in the following example.

Figure 7.4 Example of a ring busbar



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

Parameters

Configure this parameter under **Configure > Parameters > System power management > Bus tie breaker > Closed ring**.

Parameter	Range	Default	Comment
Close last BTB in a ring allowed	Not enabled, Enabled	Not enabled	**Not enabled**: The power management system (PMS) 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 PMS allows the last open bus tie breaker to close to create a ring busbar.

CAUTION
If externally controlled bus tie breaker(s) are present in the system and these are open, then the PMS 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.

7.1.5 Local power management

Local power management parameters only apply to one controller. They are configured under **Configure > Parameters > Local power management**. These parameters do not affect any other controllers in the system.

7.1.6 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

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

Table 7.1 Optional hardware

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 #, where # is 1 to 8	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, where # is 1 to 8	Digital output	Continuous	The controller activates this relay when the controller is using the specified set of power management rules.

Parameters

The parameters are configured under **Configure > Parameters > Power management rules > Configuration #**, where # 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

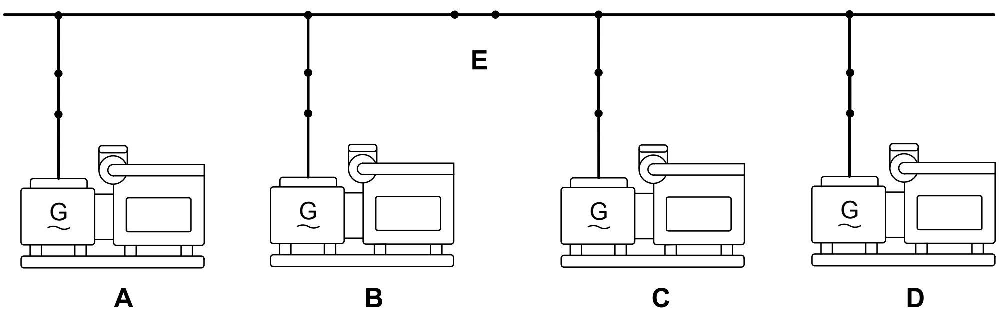
The PMS uses the least restrictive section's power management rules when joining two sections. The PMS does not try to anticipate what the power management rules will be after sections are joined.

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 7.5 Single-line diagram for the example



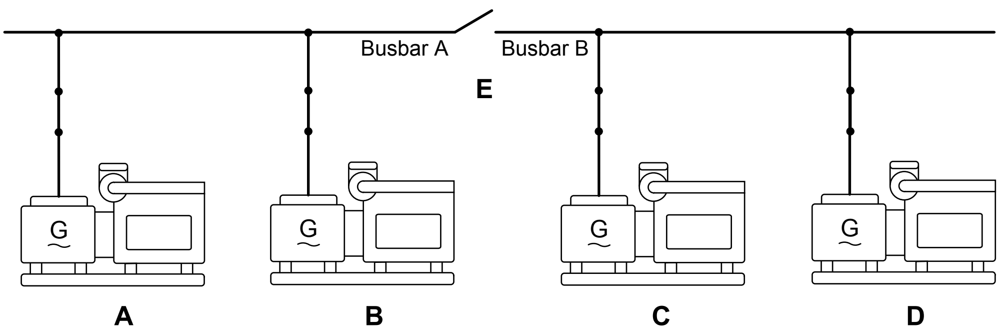
CustomLogic is configured as follows:

- 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 7.6 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.

7.1.7 System power management

System power management parameters apply to the whole system. They are configured in the connected controller under **Configure > Parameters > System power management**. When you write changes to the connected controller, then the controller automatically updates the system power management parameters in **all** the controllers in the system.

7.1.8 Parallel operation

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. The power sources may be the gensets, hybrid inverter, the shaft generator, the shore connection and/or the emergency genset.

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.

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 **EMERGENCY genset controller**, **Other EMERGENCY genset controller functions** for more information about the test function and harbour operation.

7.1.9 Managing 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 system (PMS) 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 also set the minimum number of missing controllers before the mode is changed under **Configure > Parameters > System > Monitoring > Missing controllers**.

CAUTION
If controllers are missing, then the PMS cannot know their operating information, including the breaker positions. Evaluate the risks before configuring these parameters

Parameters

Configure the parameters under **Configure > Parameters > System > Monitoring**.

Parameter	Range	Default	Notes
Mode while controller missing	• Switchboard control • No mode change	Switchboard control	If the minimum number of controllers are missing: • **Switchboard control**: The PMS changes the mode of the remaining controllers to switchboard control. • **No mode change**: The PMS 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 • SEMI mode • AUTO mode	No mode change	If the minimum number of controllers are missing, and *Switchboard control* is not specified in *Mode while controller missing*: • **No mode change**: The PMS does not change the mode of the remaining controllers. • **SEMI mode** : The PMS changes the remaining controllers to SEMI mode. • **AUTO mode** : The PMS changes the remaining controllers to AUTO mode.

7.2 Connected, consumed and available power

7.2.1 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 PMS 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 PMS state of the power sources. It includes all the sources that are connected to the section (that is, breaker closed and supplying power).

INFO
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:

Nominal power = Σ 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.

INFO
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 generators 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 SEMI 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.

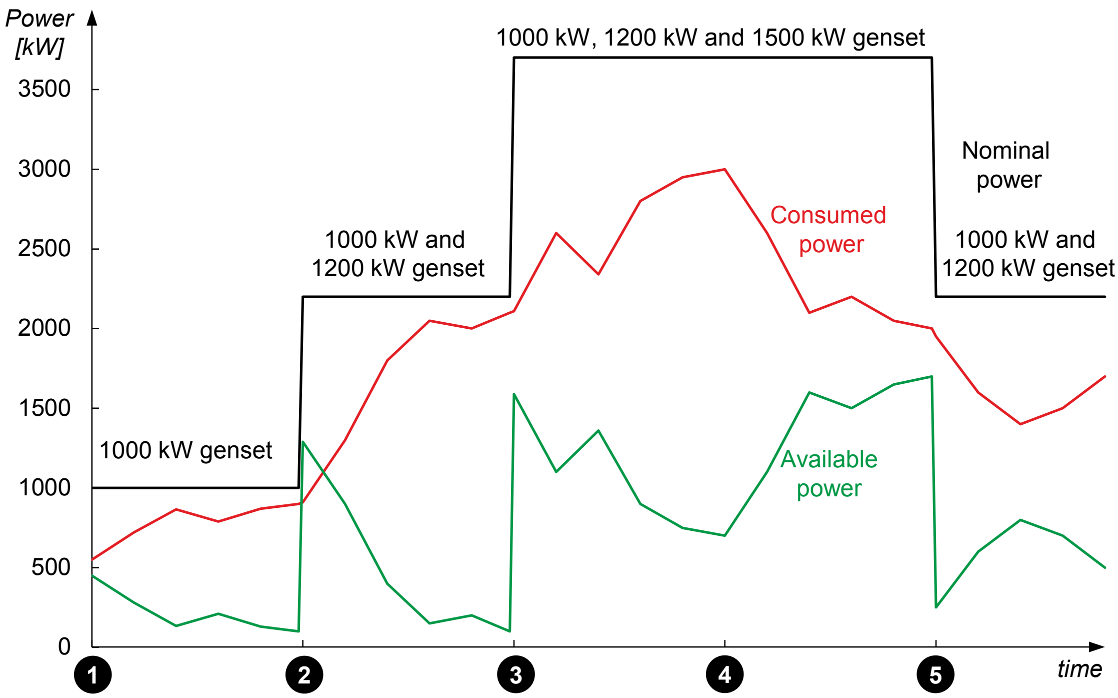
Available power = Nominal power - Total consumed power

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.

INFO
This 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.

Configure the parameter under **Configure > Parameters > Local power management > Delays > P delay after genset connects**.

Parameter	Range	Default	Notes
Delay	0 to 30 s	0 s	The delay is not active for the first genset that connects to a busbar.

7.2.2 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.

INFO
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

You can configure digital inputs so that the operator can easily change secured mode. Configure these inputs under **Configure > Input/output**.

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.

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

Table 7.2 Secured mode digital output functions

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 PMS reduces the PMS power available by the reserved power *Set point*:

Available power = Nominal power - Consumed power - Reserved power

You can configure these parameters under **Configure > Parameters > Power management rules > Configuration # > Power reservation > Reserved power**, where # is 1 to 8.

Parameter	Range	Default	Notes
Enable	Not enabled, Enabled	Not 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	480 kW	The reserved power that the controller must subtract from the available power.

INFO
If this parameter is set too high, then heavy consumers might not be able to connect.

7.2.3 Power analogue outputs

You can configure an analogue output with a function for a power value in a section. The controller calculates this value from the information from all the controllers in the section.

Assign the AC measurement function to an analogue output under **Configure > Input/output > Power management**. Select a hardware module with an analogue output, then select the output to configure.

Table 7.3 Power value outputs

Function	I/O	Units	Details
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.
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*.
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.
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.
Section | PMS P used [%]	Analogue output	-100 to 100 %	The PMS power used as a percentage of the PMS nominal power in the section.
Section | Conn. P avail. [kW]	Analogue output	0 kW to 10 MW	The total available power from all the connected generators in the section.
Section | Conn. P used [kW]	Analogue output	0 kW to 10 MW	The total load in the section.
Section | Conn. P nom. [kW]	Analogue output	0 kW to 10 MW	The total nominal power for the connected gensets in the section.

Function	I/O	Units	Details
Section | Conn. P avail. [%]	Analogue output	-100 to 100 %	The total available power as a percentage of the connected nominal power in the section.
Section | Conn. P used [%]	Analogue output	-100 to 100 %	The load as a percentage of the connected nominal power in the section.

Applications

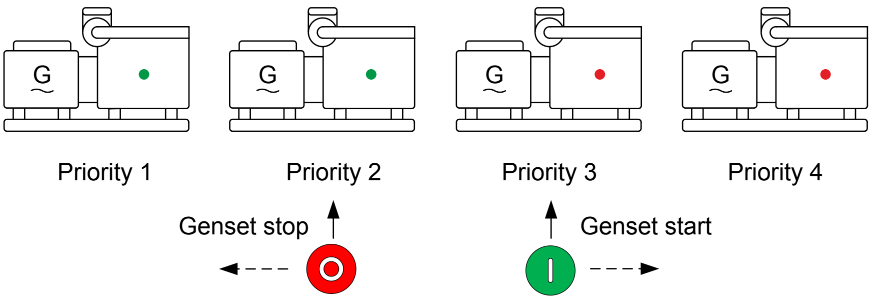
An analogue output with a power value may be wired to a switchboard instrument, to help with troubleshooting. For example, use *Section | PMS P avail. [kW]* to troubleshoot load-dependent start and stop.

7.3 Genset priority

7.3.1 Genset start and stop priority order

Each genset has a priority that the power management system (PMS) 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 PMS 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 PMS 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.

INFO
Poorly selected genset priorities can lead to inefficient operation in a system that consists of gensets of different sizes. This is because the PMS 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 PMS ensures that the gensets run according to their priority order to provide the power required by the load.

Priority in the system

The PMS has one genset priority order, which includes all the GENSET controllers in the system. The genset priority order does not change when tie breakers open to create new sections. The order does not change when tie breakers close to join sections.

Priority in sections

Within a section, the PMS uses the genset priority order for the GENSET controllers that are in the section.

If a 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 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 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.

7.3.2 Priority selection method

Configure this parameter under **Configure > Parameters > System power management > Priority > Selection**. The default parameter is shown in bold.

Method	Notes
Manual	The genset priority is defined by pushing the push-button **1st priority** (1ST) on the display unit, or using the Modbus interface. See **Manual genset priority** later in this chapter for details.
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 the power management system. See **Manual genset priority** later in this chapter for details.
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** later in this chapter for details.
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 1st priority push-button. See **Running hours for genset priority** later in this chapter for details.

7.3.3 Manual genset 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. Alternatively, if all the GENSET controllers are in SEMI mode while you set the genset priority, then this prevents unwanted automatic genset starts and/or stops.

Input

If needed, assign the input under **Configure > Input/output**. Select the hardware module, then select the input to configure.

Table 7.4 Optional input

Function	I/O	Type	Details
Power management > 1st priority	Digital input	Pulse	This input functions exactly like the **1st priority** (1ST) push-button.

Setting the genset priority using the 1st priority push-button

You can set the genset priority manually by using the 1st priority push-button on the display unit of the gensets in the reverse of the priority order you want.

1st priority push-button 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. Press the push-button **1st priority** (1ST) on the genset's display unit (then wait for the LED next to the push-button to come on) in the following order: D, C, B, A.
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 pressing the 1st priority push-button on the display unit.

Setting the genset priority using the display unit

The display unit includes an interface to let the operator easily rearrange the genset priorities in the system.

More information
See **Configure**, **Priority**, **View or configure priority** for more information about how to change the priority for multiple controllers.

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 system 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.

7.3.4 Dynamic genset priority

For *Dynamic* priority, the power management system 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 SEMI 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 SEMI 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 1st priority button on the GENSET controller display units, as well as inputs from *Power management > 1st priority* digital inputs, and the **Configure > Priority** interface on the display unit.

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 system 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.

7.3.5 Running hours for genset priority

You can use *Running hours* for genset priority to ensure that all the gensets have about the same running hours (total or offset). 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.

INFO
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

Configure these parameters under **Configure > Parameters > System power management > Priority > Running hours**.

Parameter	Range	Default	Notes
Method	Total, Trip	Total	*Total*: The priority is based on the total running hours for each genset.

Parameter	Range	Default	Notes
			Trip: 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	175 h	The regular interval for re-evaluating the genset priority, based on running hours.

Total

By default, the priority order calculation is based on each genset's absolute running hours.

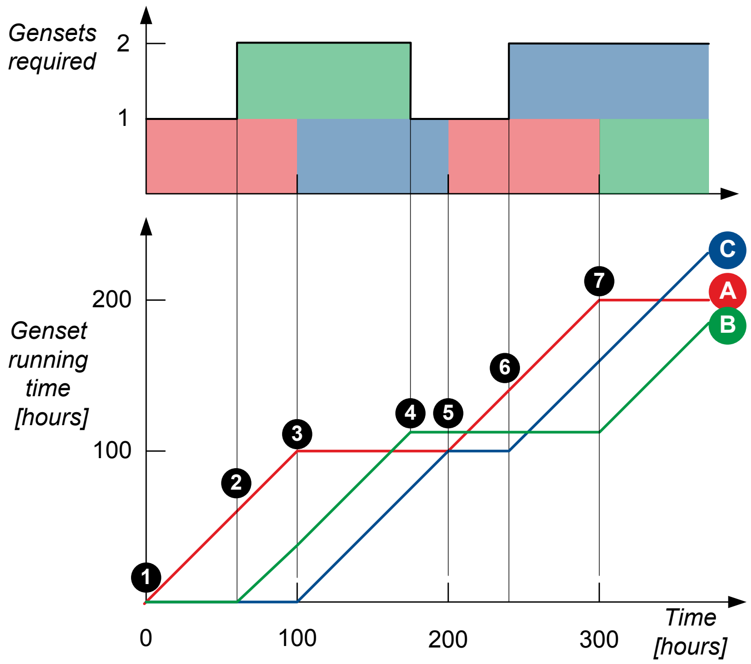
Trip

You can use *Trip* to avoid a situation where gensets with significantly different running times are over- or under-used. For example, if *Total* 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.



	0	100	200	300
Priority	ABC	CBA	ACB	BCA
A hours	**0**	100	**100**	200
B hours	0	40	115	**115**
C hours	0	**0**	100	160

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.

7.3.6 Genset priority digital outputs

Controller type: GENSET controllers only.

You can configure a digital output with a function for the genset priority.

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

Table 7.5 Genset priority functions

Function	I/O	Type	Details
Power management > Is first priority	Digital output	Continuous	Activated when the GENSET controller has the first priority in the section.
Power management > Is first standby	Digital output	Continuous	Activated when the GENSET controller controls the first genset in the section that the power management system would attempt to connect when another genset is required.

7.4 Genset start and stop

7.4.1 Introduction

The power management system 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 system will not stop the last connected genset.

INFO
For load-dependent start and stop, only GENSET controllers in AUTO mode are included in the available power calculations. Power from GENSET controllers that are in SEMI 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, while a precautionary genset start responds to busbar instability.

More information
See **Precautionary genset start** and **Blackout recovery** in this chapter for more information.

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 system response.

More information
See **EMERGENCY genset controller** for more information on the EMERGENCY genset controller blackout response.

7.4.2 Load-dependent start configuration

This configuration defines when the power management system (PMS) automatically starts gensets. The PMS starts gensets when the section load increases, for example, if the operator starts some equipment.

These parameters only apply to GENSET controllers in AUTO mode.

INFO
If the PMS available power is negative, the PMS starts another genset immediately, and does not wait for the load-dependent start timer.

Parameters

Configure the parameters under **Configure > Parameters > Power management rules > Configuration # > Load-dependent start/stop > Configuration** (where # is 1 to 8) to define the overall load-dependent start and stop configuration.

Parameter	Range	Default	Notes
Power selection	• Calculation in P • Calculation in S	Calculation in P	• **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	• **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.

Configure the parameters under **Configure > Parameters > Power management rules > Configuration # > Load-dependent start/stop > Start 1** (where # is 1 to 8) to define the first set of start parameters. By default, the PMS uses these parameters.

Parameter	Range	Default	Notes
Enable	Not enabled, Enabled	Enabled	**Not enabled**: The PMS ignores this set of parameters. **Enabled**: The PMS uses this set of parameters.
P available limit	1 kW to 9 GW	100 kW	*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 PMS starts the next genset in the priority order.
S available limit	1 kVA to 9 GVA	100 kVA	*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 PMS starts the next genset in the priority order.
Load limit	1 to 100 %	90 %	*Method* = *Percent* must be selected, otherwise this parameter is ignored.

Parameter	Range	Default	Notes
			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 PMS 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	30 s	If the load exceeds the limit for the whole of the delay period, then the PMS starts the next genset in the priority order.

Configure the parameters under **Configure > Parameters > Power management rules > Configuration # > Load-dependent start/stop > Start 2** (where # is 1 to 8) to define the second set of start parameters. By default, the PMS ignores these parameters.

Parameter	Range	Default	Notes
Enable	Not enabled, Enabled	Not enabled	**Not enabled**: The PMS ignores this set of parameters. **Enabled**: The PMS 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 MW to 9 GW	100 kW	*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 PMS starts another genset, according to the priority order.
S available limit	1 kVA to 9 GVA	100 kVA	*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 PMS starts another genset, according to the priority order.
Load limit	1 to 100 %	90 %	*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 PMS 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	30 s	If the load exceeds the limit for the whole of the delay period, the PMS 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 PMS 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 PMS starts another genset.

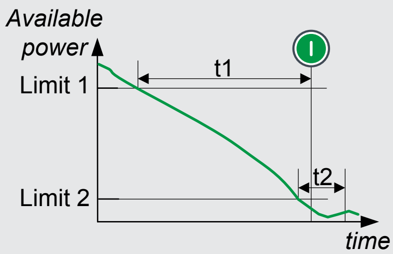
Two sets of load-dependent start parameters

You can use both sets of load-dependent start parameters:

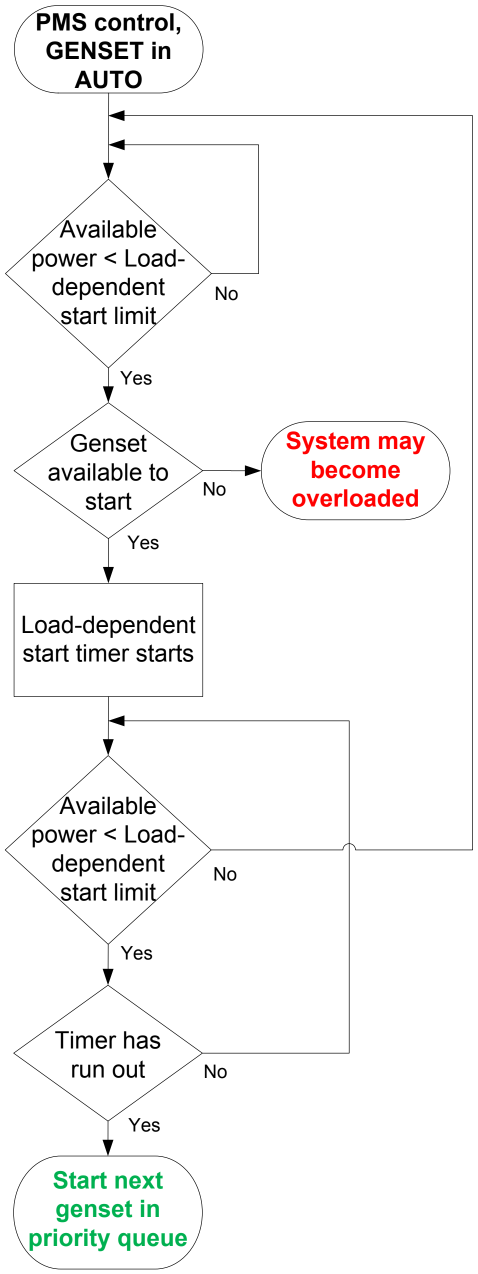
- Configure one parameter set for low available power, with a long timer setting.
  - The timer period helps to ensure that the genset start really is needed.
- Configure the other parameter set with a low timer setting for very low available power.
  - This ensures that the PMS responds quickly to a 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 PMS starts a genset.



7.4.3 Load-dependent start flowchart



1. The sequence starts if the PMS available power falls below the start limit.
2. A genset must be able to start for the sequence to continue. Otherwise, the system may become overloaded.
3. The load-dependent start timer starts.
4. If the PMS available power is below the load-dependent start limit until the timer runs out, the power management system starts the next available genset in the priority order.

7.4.4 Load-dependent stop configuration

This configuration defines when the power management system (PMS) automatically stops gensets. The PMS stops gensets when the section load decreases.

These parameters only apply to GENSET controllers in AUTO mode.

Hardware

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

Name	I/O	Type	Details
Power management > Block load-dependent stop	Digital input	Continuous	Optional. The PMS prevents load-dependent stops in the section while this input is activated.

Parameters

Configure the parameters under **Configure > Parameters > Power management rules > Configuration # > Load-dependent start/stop > Configuration** (where # is 1 to 8) to define the overall load-dependent start and stop configuration.

Parameter	Range	Default	Notes
Power selection	• Calculation in P • Calculation in S	Calculation in P	• **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	• **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.

Configure the parameters under **Configure > Parameters > Power management rules > Configuration # > Load-dependent start/stop > Stop 1** (where # is 1 to 8) to define the first set of stop parameters. By default, the PMS uses these parameters.

Parameter	Range	Default	Notes
Enable	Not enabled, Enabled	Enabled	**Not enabled**: The PMS ignores this set of parameters. **Enabled**: The PMS uses this set of parameters.
P available limit	1 kW to 9 GW	200 kW	*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 PMS stops a genset, according to the priority order.
S available limit	1 kVA to 9 GVA	200 kVA	*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 PMS stops a genset, according to the priority order.
Load limit	1 to 100 %	70 %	*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 PMS 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	30 s	If the load is less than the limit for the whole of the *Delay* period, then the PMS stops a genset, according to the priority order.

Configure the parameters under **Configure > Parameters > Power management rules > Configuration # > Load-dependent start/stop > Stop 2** (where # is 1 to 8) to define the second set of stop parameters. By default, the PMS ignores these parameters.

Parameter	Range	Default	Notes
Enable	Not enabled, Enabled	Not enabled	**Not enabled**: The PMS ignores this set of parameters. **Enabled**: The PMS 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	200 kW	*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 PMS stops a genset, according to the priority order.
S available limit	1 kVA to 9 GVA	200 kVA	*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 PMS stops a genset, according to the priority order.
Load limit	1 to 100 %	70 %	*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 PMS 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	30 s	If the load would be less than the limit for the whole of the *Delay* period if a genset was stopped, the PMS 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 PMS 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 PMS does not stop genset B.

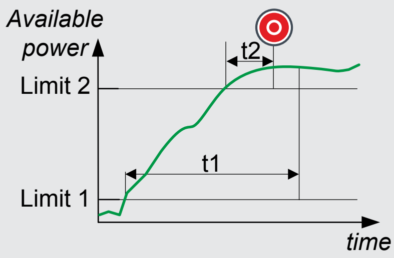
Two sets of load-dependent stop parameters

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 PMS 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 PMS stops a genset.

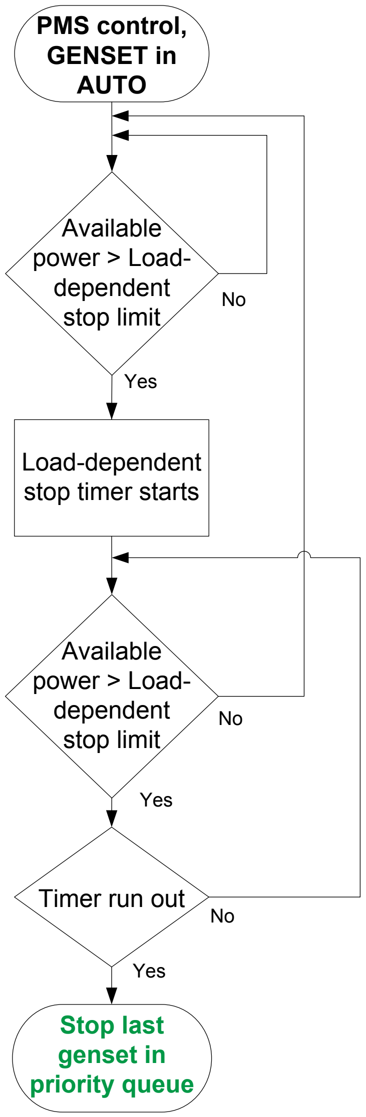


Conditions that block load-dependent stops

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 **Configure > Parameters > Power management rules > Configuration # > Number of gensets connected > Minimum**
- A heavy consumer is active, and *Block stop when active* is enabled.
  - See **Configure > Parameters > 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 **Configure > Input/output > Power management > Block load-dependent stop**

7.4.5 Load-dependent stop flowchart



1. The load-dependent stop timer starts when the PMS available power is more than (the load-dependent stop limit + the nominal power of the lowest priority running genset).
2. If the PMS available power is more than (the load-dependent stop limit + the nominal genset power) until the timer runs out, the power management system sends a stop command to the last running genset in the priority order.

7.4.6 Power method for load-dependent start and stop

For the *Power* method, the power management system (PMS) 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.

INFO
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 PMS 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.

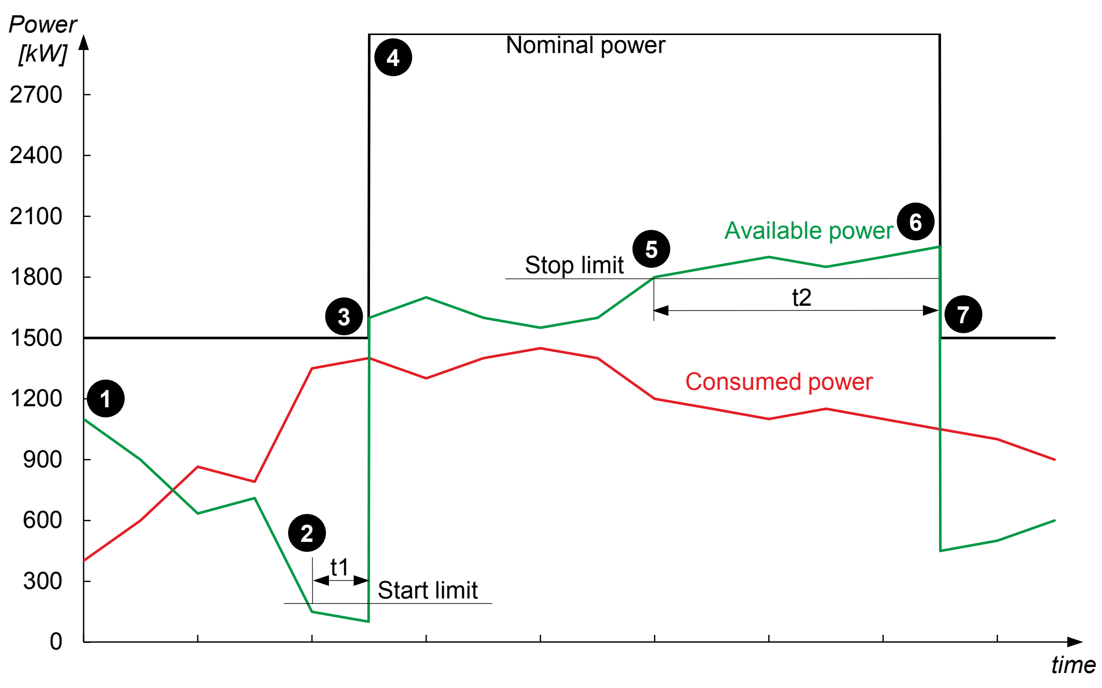
Example

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.

INFO
The load-dependent delay default is 30 seconds. The values in the example are for clarity.



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 PMS 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 PMS send a command to the second genset to stop.
7. The second genset stops, and the first genset supplies the load.

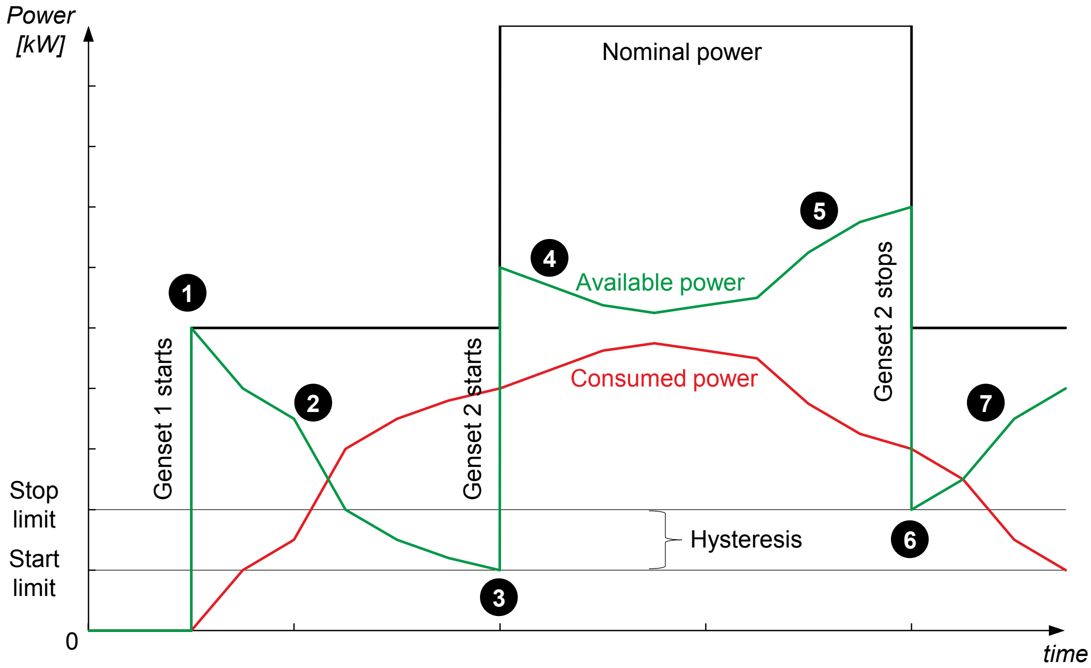
7.4.7 Power method and hysteresis

For the power method:

Hysteresis = Load-dependent stop limit - Load-dependent start limit

INFO
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 unpowered.



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.

INFO
The hysteresis for the percent method works differently. See **Percent method and hysteresis**.

7.4.8 Percent method for load-dependent start and stop

For the *Percent* method, the power management system (PMS) 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

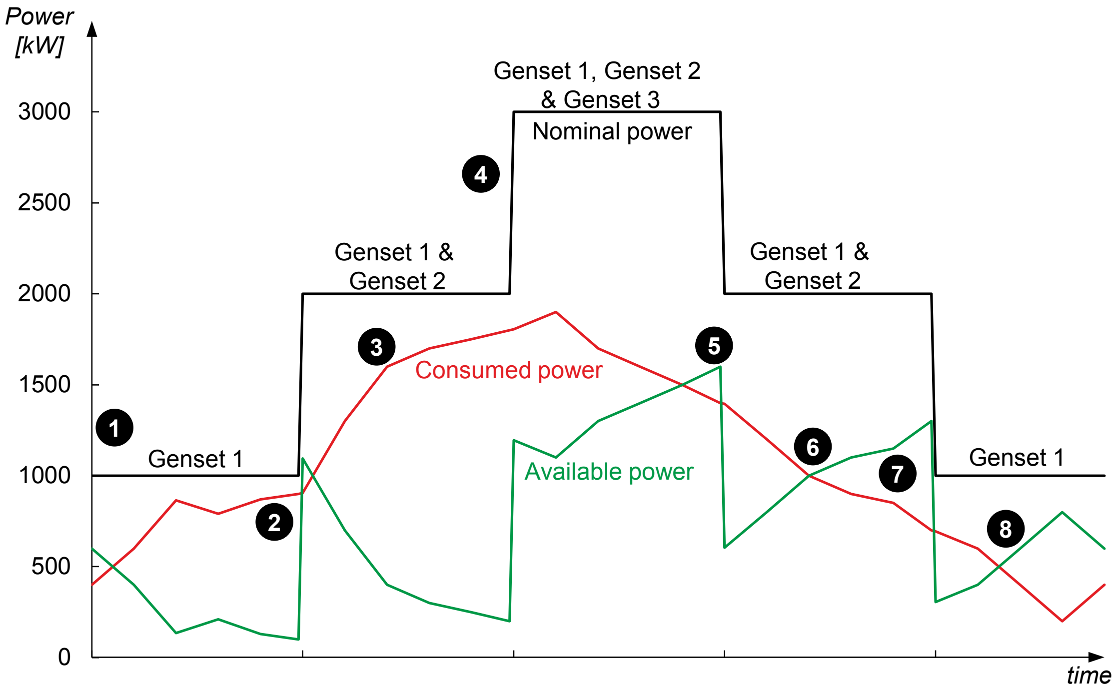
The PMS calculates what the genset load percentage would be if the connected genset that is last in the priority order is stopped. If this is lower than the *Load-dependent stop* limit, that genset will be stopped.

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 PMS 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 PMS 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 PMS 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 PMS 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.

7.4.9 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

INFO
For the percent method, 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.

INFO
The hysteresis for the power method works differently. See **Power method and hysteresis**.

7.4.10 Non-connected genset

Controller type: Only GENSET controllers

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 SEMI 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.

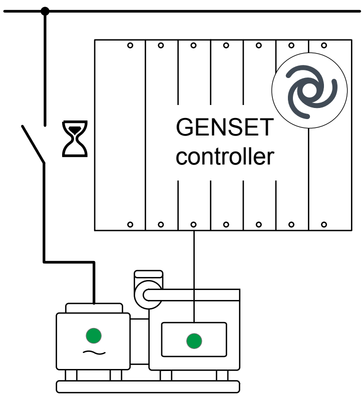
Configure the parameter under **Configure > Parameters > Local power management > Non-connected genset > Stop timer**.

Parameter	Range	Default	Notes
Delay	0 s to 1 h	1 min	The timer starts when both of these conditions are met: • The genset start sequence is finished. • 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

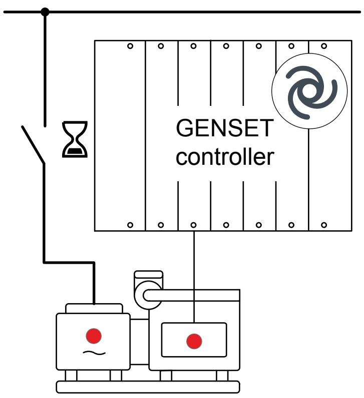
Non-connected genset running in AUTO

The timer starts ....



... the timer expires.

The power management system stops the genset.



7.4.11 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. See **Precautionary genset start based on an input** below.

In addition, for busbar frequency and voltage alarms, the power management system automatically starts a genset as a precaution. See **Precautionary genset start based on an alarm** below.

INFO
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 SEMI mode and stop the genset.

INFO
Precautionary genset start does not start the emergency genset.

Precautionary genset start based on an input

If needed, assign the input under **Configure > Input/output**. Select the hardware module, then select the input to configure.

Table 7.6 Optional input

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.

INFO
You can wire this input to any GENSET controller(s) in the section.

Precautionary genset start in section digital output

If needed, assign the output under **Configure > Input/output**. Select the hardware module, then select the output to configure.

Table 7.7 Optional output

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.

Table 7.8 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

Table 7.9 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

INFO
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.

7.4.12 Number of gensets connected

These parameters determine the minimum and maximum number of connected gensets required for the section.

Configure the parameters under **Configure > Parameters > Power management rules > Configuration # > Number of gensets connected**.

Maximum

These parameters set the maximum number of gensets connected for GENSET controllers in AUTO mode.

Parameter	Range	Default	Notes
Enable	Not enabled, Enabled	Not enabled	**Not enabled**: The power management system ignores this limit. **Enabled**: The power management system uses this limit.
Set point	1 to 64	5	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.

INFO
This parameter is an absolute limit on the number of connected GENSET controllers in AUTO mode. For example, if the maximum number of gensets are already running, the power management system will not connect an additional genset temporarily to take over the load from a running genset. This means that if the maximum number of gensets is already running, then changing the priorities will not connect a new genset.

CAUTION
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.

Minimum

These parameters set the minimum number of gensets connected with their GENSET controllers in AUTO mode. Note that any gensets with GENSET controllers in SEMI mode or under switchboard control are not included. You can use these parameters to guarantee a minimum level of power available.

Parameter	Range	Default	Notes
Enable	Not enabled, Enabled	Not enabled	**Not enabled**: The power management system ignores this limit. **Enabled**: The power management system uses this limit.
Set point	1 to 64	1	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. The system is limited to a maximum of 12 controllers. If you have 12 GENSET controllers, and you set this parameter to 12 or higher, all the gensets in AUTO mode are always connected.

7.5 Blackout

7.5.1 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.

INFO
When there is at least one controller under PMS 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 (**Configure > Parameters > Busbar > AC setup > Blackout detection > Blackout delay**).

*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 system 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**, where # is 1 to 8, can allow 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.

More information
See **System principles**, **Control and modes**, **Switchboard control** for information on events that force controllers under switchboard control.

7.5.2 Blackout recovery configuration

When a blackout is detected, all the GENSET controllers or HYBRID in PTO mode that are in SEMI mode are changed to AUTO mode.

Input

Assign the input under **Configure > Input/output**.

Table 7.10 Optional input

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 a GENSET or HYBRID controller, configure this parameter under **Configure > Parameters > Local power management > Blackout**.

Parameter	Range	Default	Notes
Allow blackout recovery	Not enabled, Enabled	Enabled	**Not enabled**: The power management system does not attempt to close the inverter breaker if a blackout is detected. **Enabled**: 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.

For a SHAFT generator controller, configure this parameter under **Configure > Parameters > Local power management > Blackout > Blackout close**.

Parameter	Range	Default	Notes
Enable SG blackout close	Not enabled, Enabled	Not 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.

For a SHORE connection controller, configure this parameter under **Configure > Parameters > Local power management > Blackout > Blackout close**.

Parameter	Range	Default	Notes
Enable SC blackout close	Not enabled, Enabled	Not 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.

For a BUS TIE breaker controller, configure this parameter under **Configure > Parameters > Local power management > Blackout close**.

Parameter	Range	Default	Notes
Enable BTB blackout close	Not enabled, Enabled	Not 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.

Configure this parameter under **Configure > 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	Default	Notes
Mode	• No mode change • SEMI mode • AUTO mode	No mode change	This parameter selects the controller mode after the blackout. • **No mode change**: The GENSET controller mode is the same as before the blackout. • **SEMI mode**: The GENSET controller is changed to SEMI mode after the blackout. • **AUTO mode**: The GENSET controller remains in AUTO mode after the blackout.

Configure this parameter under **Configure > Parameters > Power management rules > Configuration # > Blackout > Blackout recovery**, where # is 1 to 8.

Parameter	Range	Default	Notes
Number of gensets to start	1 to 64	1	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. The system is limited to a maximum of 12 controllers.

Configure this parameter under **Configure > Parameters > Power management rules > Configuration # > Blackout > Short circuit close attempts**, where # is 1 to 8.

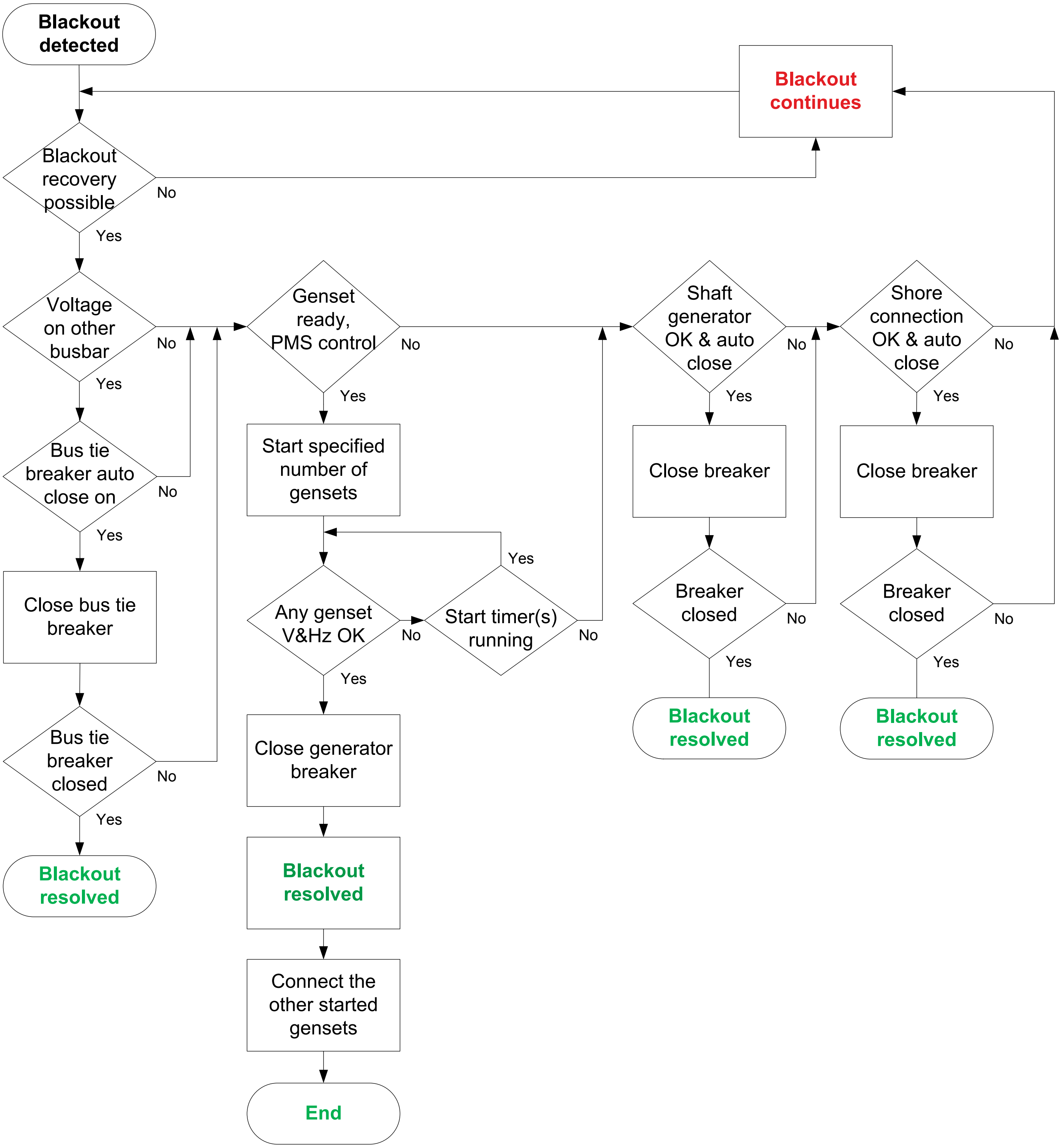
Parameter	Range	Default	Notes
Set point	0 to 1	0	**0** close attempts: The power management system will not close any breakers to connect to a system where a short circuit was detected. The tripped breaker must first be reset. The *GB short circuit* alarm must be acknowledged and the latch reset. **1** 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.

Alarms

More information
See **Power management**, **Power management protections**, **Blackout detection mismatch** for more information about the alarm.

More information
See **Alarms**, **Alarm parameters**, **Action suppressed** for information about suppressing alarm actions during blackout recovery.

7.5.3 Blackout recovery flowchart



1. After a blackout is detected, the power management system 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 system 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 system checks whether there are any GENSET controllers under PMS control, with gensets ready to start.

a. The power management system changes all GENSET controllers in SEMI mode to AUTO mode.
b. The power management system 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 system 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 system checks whether a shaft generator with auto close ON is present and OK to supply power.
   - Yes: The power management system sends a breaker close signal to the controller. If the breaker closes, the blackout is resolved.
5. The power management system checks whether a shore connection with auto close ON is present and OK to supply power.
   - Yes: The power management system sends a breaker close signal to the controller. If the breaker closes, the blackout is resolved.

More information
See **SHAFT generator controller**, **Shaft generator breaker**, **Shaft generator breaker blackout close flowchart** for more information.

More information
See **SHORE connection controller**, **Shore connection breaker**, **Shore connection breaker blackout close flowchart** for more information.

7.6 Load sharing

7.6.1 Introduction

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 system must perform **load sharing** for the gensets.

The **load sharing** is achieved by using the **DEIF network load sharing** (for DEIF controllers connected together via Ethernet cabling).

Table 7.11 Load sharing possibilities

Load sharing connection	Asymmetric	Equal
DEIF network	•	•

INFO
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.

7.6.2 DEIF network load sharing

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

However, the SHAFT generator and SHORE connection controllers can only supply a base load (by adjusting the power from the gensets).

INFO
For load sharing over the DEIF network, the load sharing can be either equal or asymmetrical.

Load sharing over the DEIF network occurs automatically when the controllers are under PMS control, provided all the necessary I/O settings and parameters are configured.

INFO
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.

7.6.3 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 under switchboard control, then that controller does not control the governor or AVR. Therefore, it cannot participate in load sharing.

For controllers under power management system control (in AUTO and SEMI mode), the power management system 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.

7.6.4 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 the power management system 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 under PMS control (power management system), if enabled, the power management system uses asymmetric P load sharing to share the load between the connected equipment. The shared load may be the total system load. However, if a connected controller is under 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 under switchboard control, then that controller does not control its load, and therefore it cannot participate in load sharing.

Input

If required, assign input functions under **Configure > Input/output**. Select the hardware module, then select the input to configure.

Table 7.12 Optional hardware

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 **Configure > Parameters > 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 **Configure > Parameters > 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 **Configure > Parameters > Local power management > Asymmetric load sharing > P configuration > Enable** to *Not enabled*.

Parameters

Configure the following parameters under **Configure > Parameters > Local power management > Asymmetric load sharing > P configuration**.

These parameters only apply to the selected GENSET or HYBRID controller. Other GENSET or HYBRID controllers can have different parameters.

Parameter	Range	Default	Notes
Enable	• Enabled • Not enabled	Not enabled	• **Enabled**: Asymmetric P load sharing is active for the GENSET or HYBRID controller. The power management system 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. • **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.
Source	• Parameter	Parameter	The controller only uses these parameters when asymmetric P load sharing is enabled.

Parameter	Range	Default	Notes
	• External • External -> Off • External -> Parameter		• **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**: 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	80 %	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.

Configure the following parameters under **Configure > Parameters > Power management rules > Configuration # > Asymmetric load sharing > P configuration**.

These parameters apply to all the GENSET or HYBRID controllers in the section.

Parameter	Range	Default	Notes
Minimum	1 to 100 % of nominal active power	5 %	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	0.5 s	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	95 %	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	0.5 s	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	Switch to equal	This parameter controls how the load sharing is handled if either minimum or maximum are exceeded.

Configure the following parameters under **Configure > Parameters > Power management rules > Configuration # > Asymmetric load sharing > Start when an asymmetric set point is exceeded**. *

Parameter	Range	Default	Notes
Enable	• Enabled • Not 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	30 s	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.

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.

INFO
If you enabled asymmetric P load sharing, you can ensure 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** in this chapter for more information.

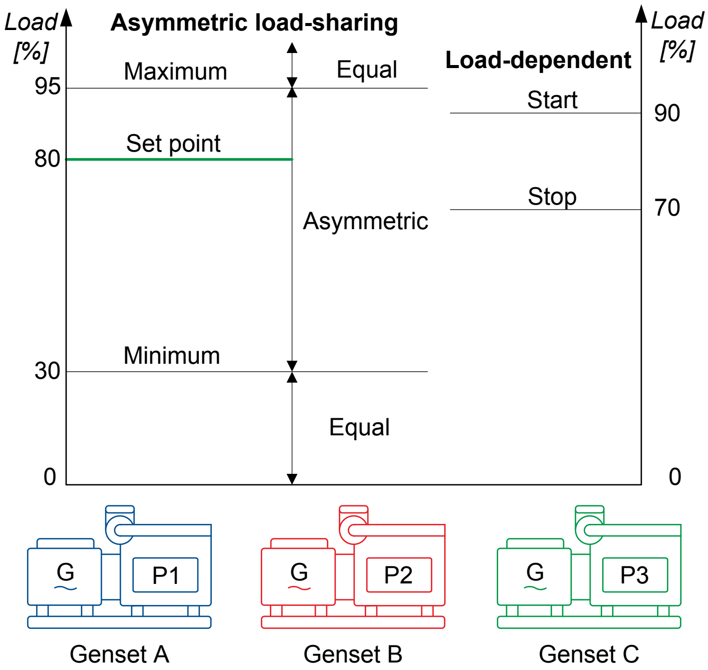
7.6.5 Asymmetric P load sharing - Example 1

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.

Table 7.13 Example 1 configuration

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.

Table 7.14 Example 1 - 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).

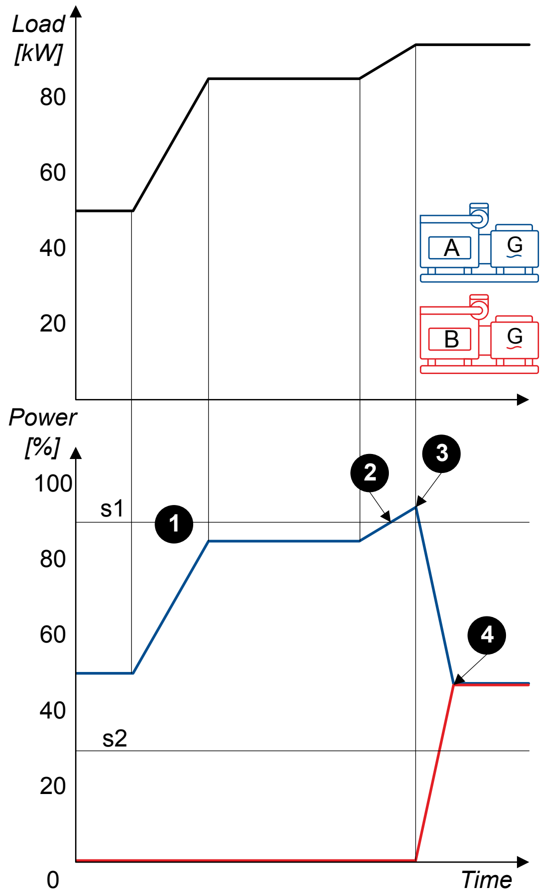


Table 7.15 Example 1 - Sequence 2 of 4 : Load increase 2

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.

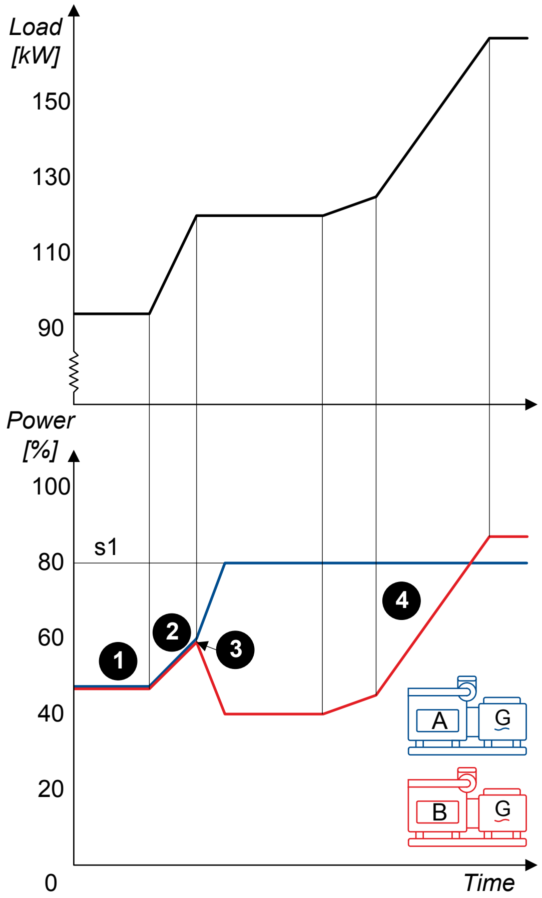


Table 7.16 Example 1 - Sequence 3 of 4 : Load increase 3

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.

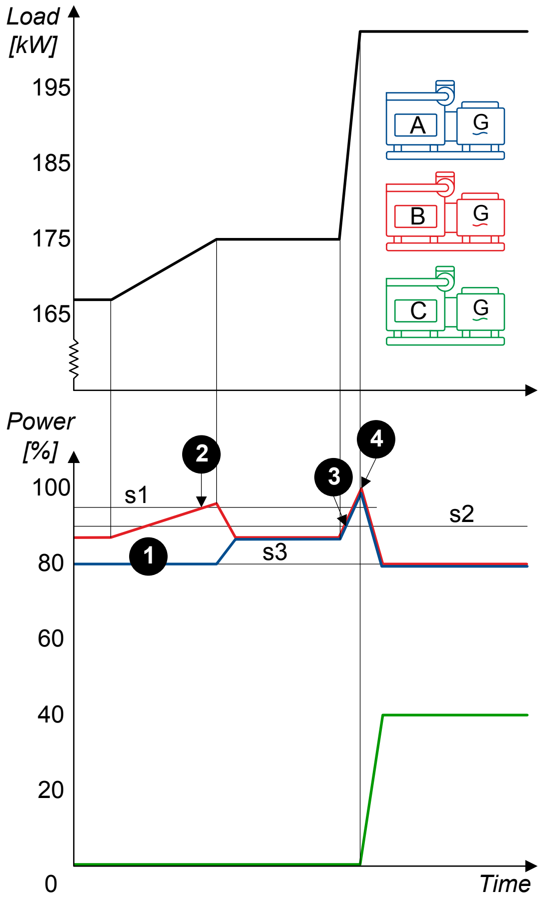
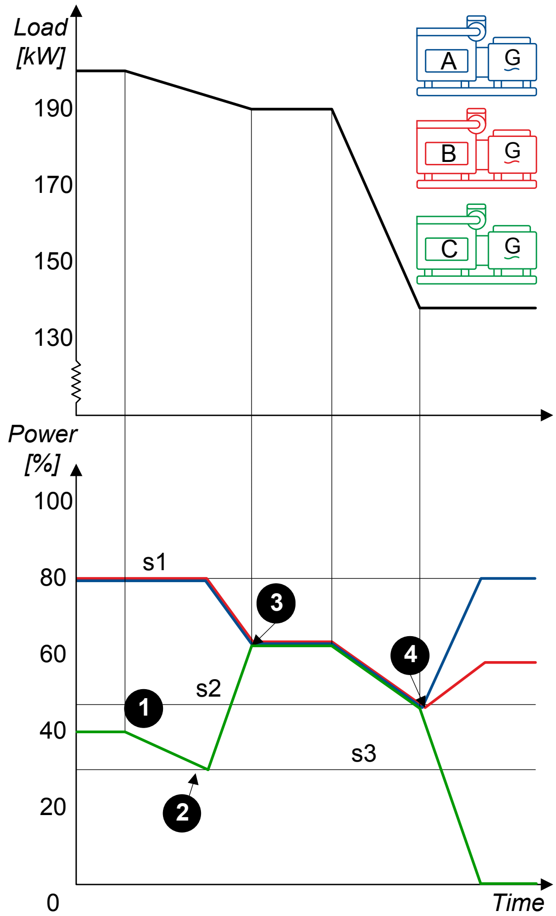


Table 7.17 Example 1 - Sequence 4 of 4 : Load decrease

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.



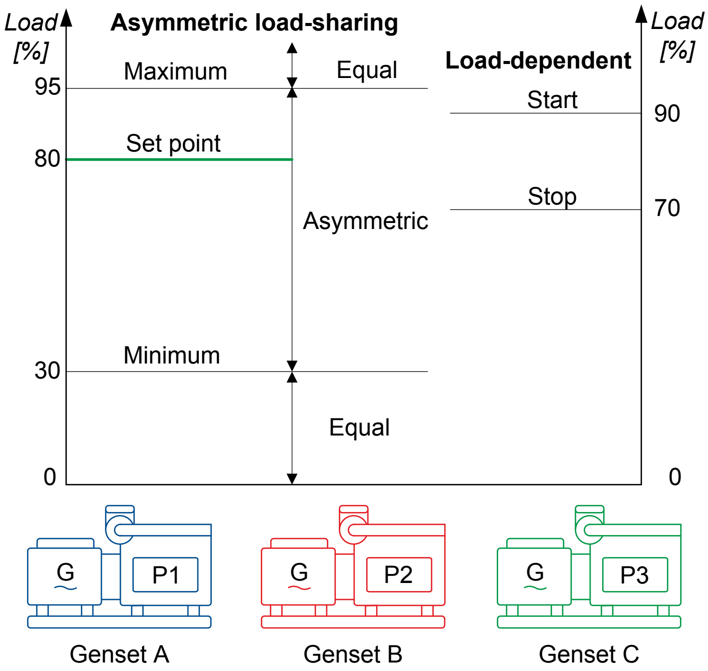
7.6.6 Asymmetric P load sharing - Example 2

In this example, three GENSET controllers are configured so that when the asymmetric limits are exceeded, the load sharing set point is adjusted.

Table 7.18 Example 2 configuration

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.

Table 7.19 Example 2 - 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).

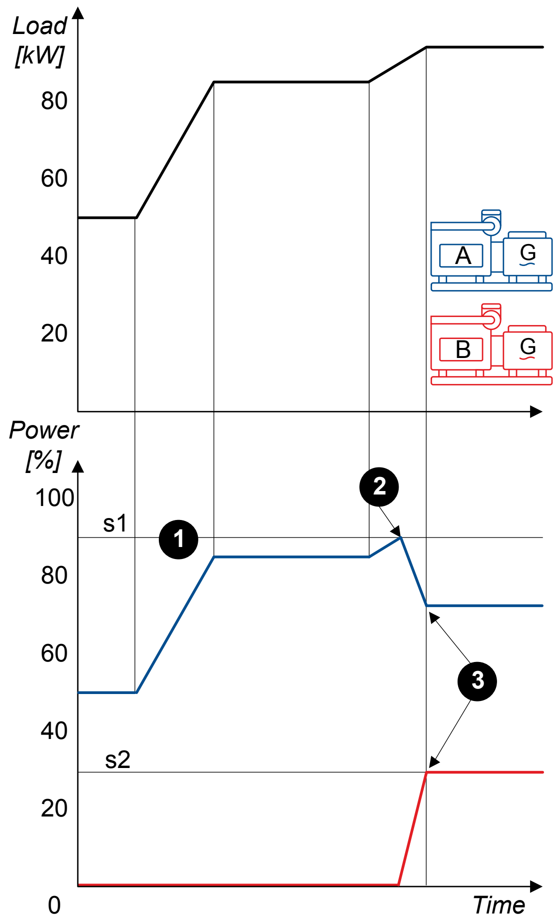


Table 7.20 Example 2 - Sequence 2 of 4 : Load increase 2

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.

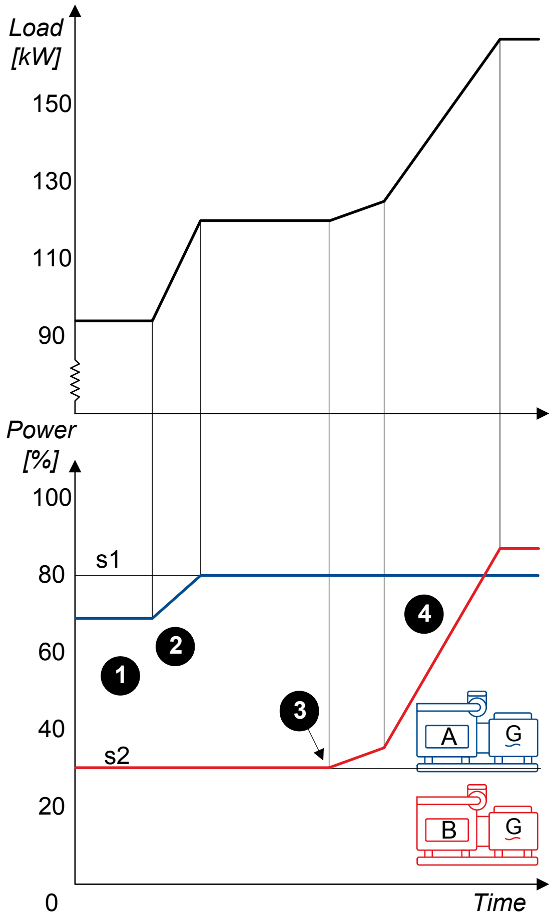


Table 7.21 Example 2 - Sequence 3 of 4 : Load increase 3

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.

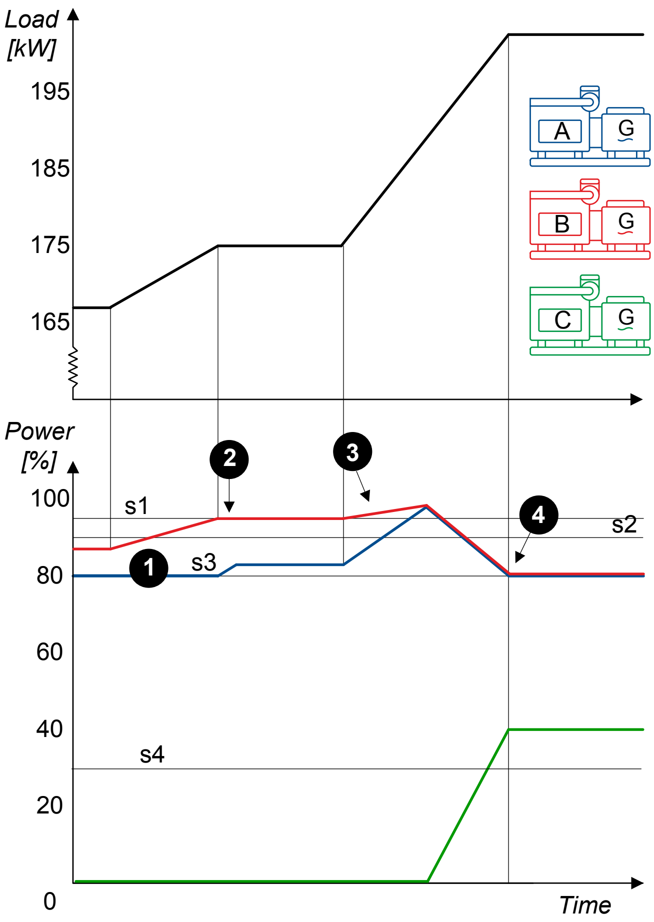
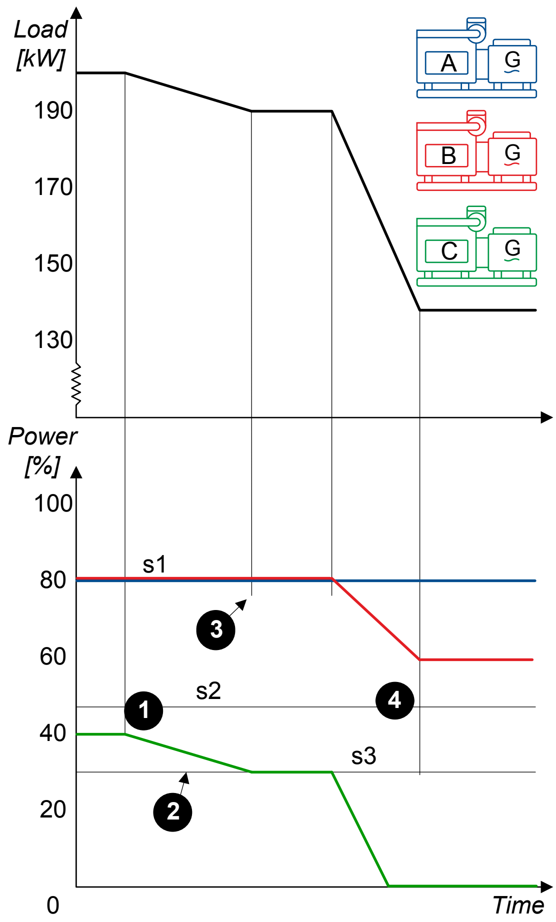


Table 7.22 Example 2 - Sequence 4 of 4 : Load decrease

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.



7.6.7 Asymmetric P load sharing - Example 3

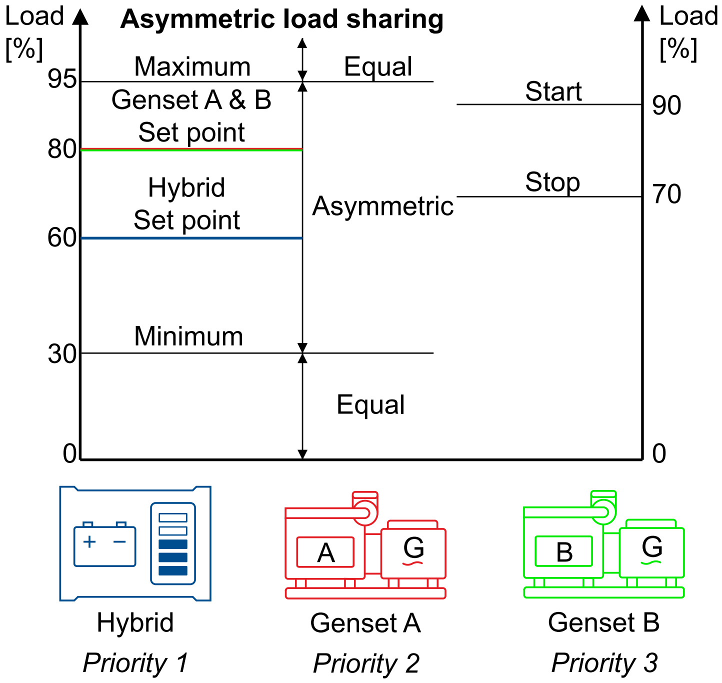
In this example, three GENSET controllers are configured so that when the asymmetric limits are exceeded, the load sharing set point is adjusted.

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.

Table 7.23 Example 3 configuration

The following example is based on this configuration:

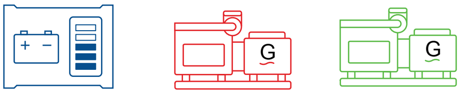
- Hybrid, Gensets A, B : Nominal load = 100 kW
- Hybrid is configured to give a constant discharge at 60 %
- All are in the same section
- Asymmetric P load sharing
  - *Enabled* for all
  - *Set point* = 60 % for hybrid with constant discharge
  - *Set point* = 80 % for gensets A and B
  - *Minimum* = 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 %



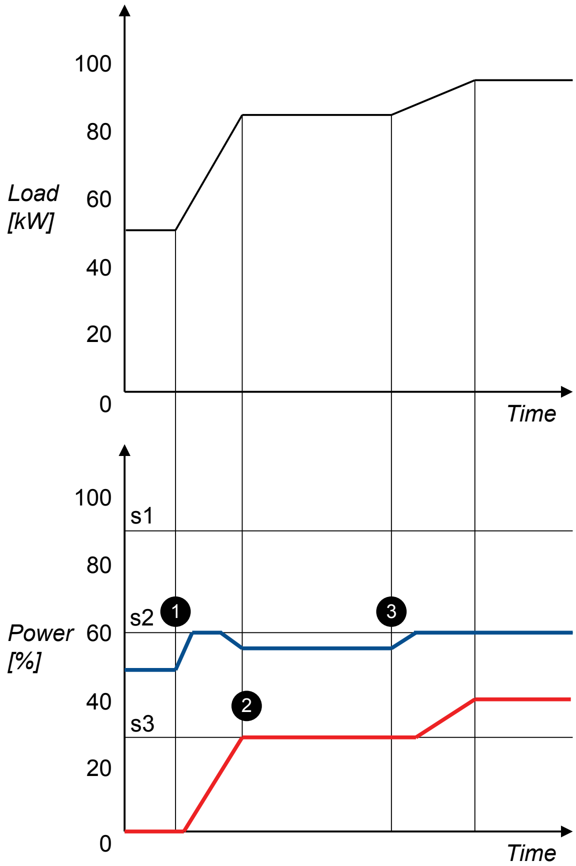
NOTE * To make the effect of asymmetric P load sharing clearer in this example, the asymmetric P load sharing *Minimum* is higher than the default (5 %).

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.

Table 7.24 Example 3 - Sequence 1 of 4 : Load increase 1



Hybrid	Genset A	Genset B
Priority 1	*Priority 2*	*Priority 3*



Parameters

s1 = Load-dependent start

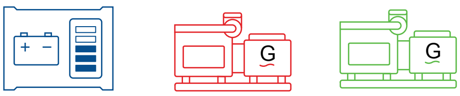
s2 = Hybrid load sharing set point (60 %)

s3 = Asymmetric P load sharing *Minimum* (30 %)

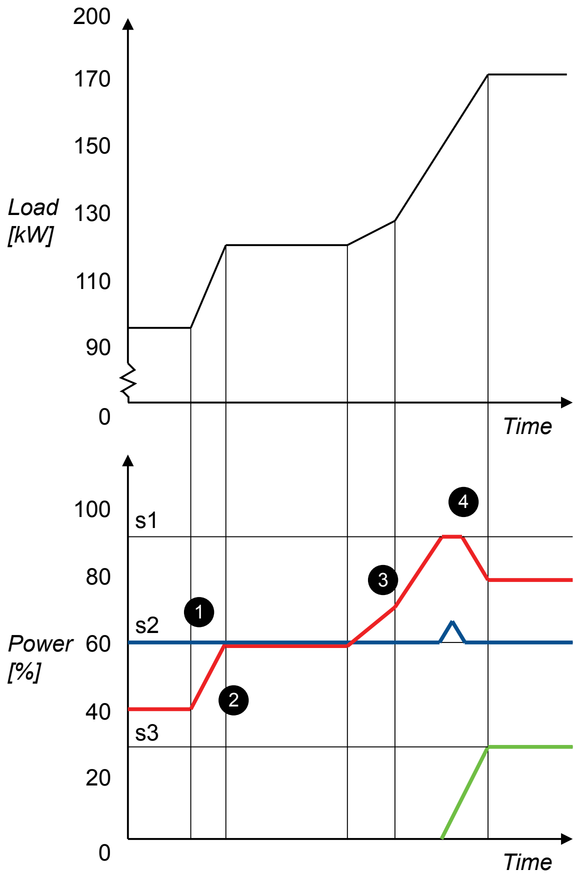
Points on graph

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.

Table 7.25 Example 3 - Sequence 2 of 4 : Load increase 2



Hybrid	Genset A	Genset B
Priority 1	*Priority 2*	*Priority 3*



Parameters

s1 = Load-dependent start

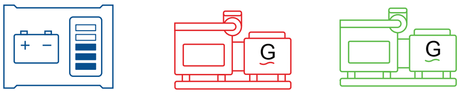
s2 = Hybrid load sharing set point (60 %)

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.

Table 7.26 Example 3 - Sequence 3 of 4 : Load increase 3



Hybrid	Genset A	Genset B
Priority 1	*Priority 2*	*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.

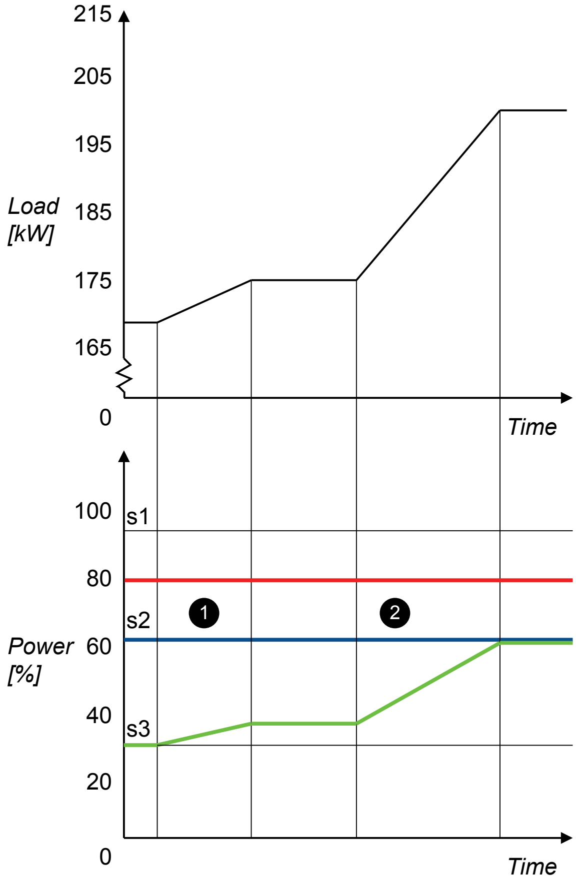
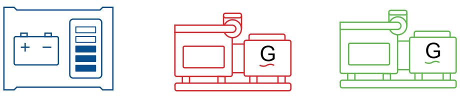


Table 7.27 Example 3 - Sequence 4 of 4 : Load decrease



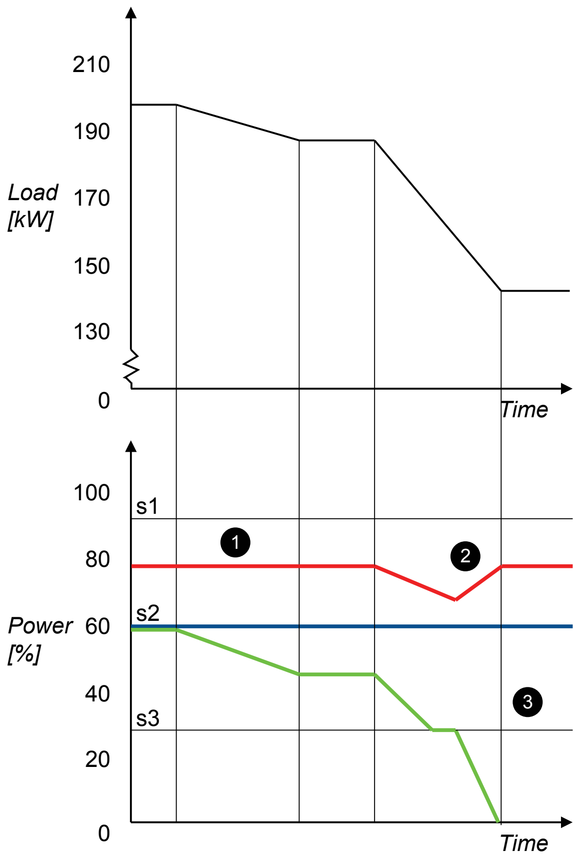
Hybrid	Genset A	Genset B
Priority 1	*Priority 2*	*Priority 3*

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.



7.6.8 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.

Asymmetric Q load sharing can also be configured so that, as far as possible, a particular genset supplies a base reactive power load.

Asymmetric Q 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 Q load sharing is done by the power management system over the DEIF network.

Hardware

The following hardware is required for asymmetric Q load sharing.

Name	Details
DEIF network	The DEIF 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 under PMS control (power management system), if enabled, the power management system 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 under switchboard control, then the shared reactive power load is the remaining reactive power load.

If a controller is under switchboard control, then that controller does not control its reactive load, and therefore it cannot participate in reactive power load sharing.

Input

If required, assign input functions under **Configure > Input/output**. Select the hardware module, then select the input to configure.

Table 7.28 Optional hardware

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 **Configure > Parameters > 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 **Configure > Parameters > 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 **Configure > Parameters > Local power management > Asymmetric load sharing > Q configuration > Enable** to *Not enabled*.

Parameters

Configure the following parameters under **Configure > 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	Default	Notes
Enable	• Enabled • Not enabled	Not enabled	• **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. • **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 controller without asymmetric Q load sharing shares the load equally with the other gensets without asymmetric Q load sharing.
Source	• Parameter • External • External -> Off • External -> Parameter	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	80 %	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.

Configure the following parameters under **Configure > Parameters > Power management rules > Configuration # > Asymmetric load sharing > Q configuration**.

These parameters apply to all the GENSET controllers in the section.

Parameter	Range	Default	Notes
Minimum	1 to 100 % of nominal reactive power	5 %	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	0.5 s	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	95 %	This maximum reduces the risk of genset overloading.

Parameter	Range	Default	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	0.5 s	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	Switch to equal	This parameter controls how the load sharing is handled if either minimum or maximum are exceeded.

Configure the following parameters under **Configure > Parameters > Power management rules > Configuration # > Asymmetric load sharing > Start when an asymmetric set point is exceeded**.

Parameter	Range	Default	Notes
Enable	• Enabled • Not 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	30 s	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 **AC configuration and nominal settings**, **Nominal settings**, **Nominal power calculations** for more information.

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.

INFO
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** in this chapter for more information.

INFO
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.

7.6.9 SHAFT generator base load

INFO
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.

Parameters

These parameters are only visible in a SHAFT generator controller.

Configure the following parameter under **Configure > Parameters > Local power management > Shaft generator base load > Enable**.

Parameter	Range	Default	Notes
Enable SG base load	Not enabled, Enabled	Not enabled	**Not enabled**: The shaft generator cannot run in long-term parallel with the gensets. **Enabled**: Base load is active for the SHAFT generator controller. The GENSET-SHAFT parallel timer protection is disabled.

Configure the following parameter under **Configure > Parameters > 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, 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. 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*.

Parameter	Range	Default	Notes
			If the gensets are running at the *Maximum limit*, the power management system increases the load on the shaft generator.

Configure the following parameter under **Configure > Parameters > 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.

Configure the following parameter under **Configure > Parameters > 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.

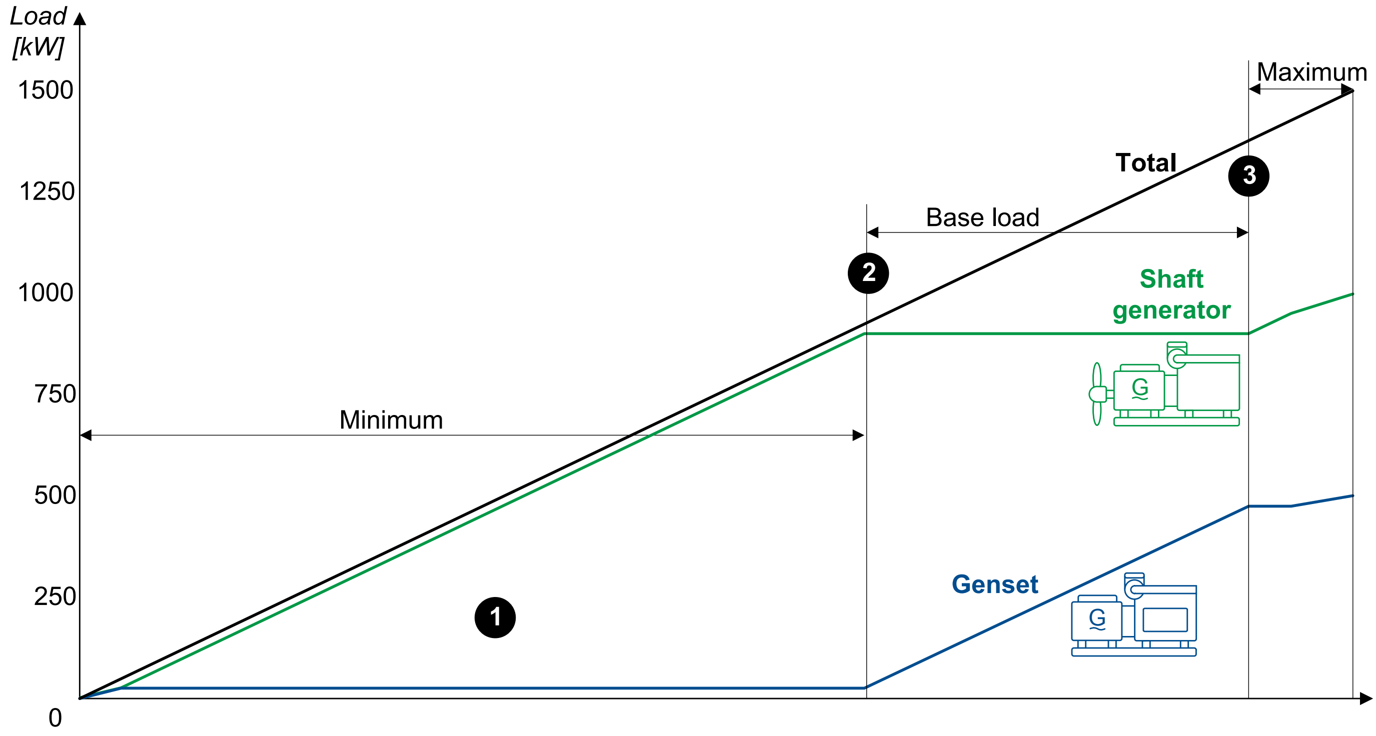
INFO
The only way to run the shaft generator in long-term parallel with gensets is by enabling and configuring a base load for the shaft generator.

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.



7.6.10 SHORE connection base load

INFO
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.

Configure the following parameter under **Configure > Parameters > 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.

Configure the following parameter under **Configure > Parameters > 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.

Parameter	Range	Default	Notes
			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*. If the gensets are running at the *Maximum limit*, the power management system increases the load on the shore connection.

Configure the following parameter under **Configure > Parameters > 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.

Configure the following parameter under **Configure > Parameters > 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.

INFO
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.

7.6.11 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**, **Regulation alarms** for more information about load sharing failure alarms.

7.7 Heavy consumer management

7.7.1 Introduction

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 four heavy consumers. The controller manages the heavy consumer function across the DEIF network.

A heavy consumer can be assigned to any controller.

For the heavy consumer function, the power from connected gensets in SEMI 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.

INFO
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.

INFO
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.

7.7.2 Configuring heavy consumers

Single line diagram

Table 7.29 Heavy consumer configuration options

Name	Details
System ID	The unique heavy consumer number in the system. Range = 1 to 48.
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**, **Power management wiring**, **Heavy consumer** in the **Installation instructions** for examples of heavy consumer wiring.

Inputs and outputs

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

Table 7.30 Hardware required in addition to the minimum standard controller wiring

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.

Table 7.31 Optional outputs

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.

Configure these parameters under **Configure > Parameters > Heavy consumers > [Heavy consumer #] > Nominal settings**, where # is 1 to 4.

Table 7.32 Heavy consumer nominal settings

Parameter	Range	Default	Comment
Initial load	100 to 500 %	125 %	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. Use this parameter to allow a high connection current.
Nominal load	0 kVA to 1 GVA	100 kVA	The heavy consumer nominal load.
Power factor	0.6 to 1.0	0.9	The heavy consumer power factor.

Configure this parameter under **Configure > Parameters > Heavy consumers > [Heavy consumer #] > Acknowledge**, where # is 1 to 4.

Table 7.33 Heavy consumer acknowledge

Parameter	Range	Default	Comment
Pulse width	1 to 10 s	1 s	The heavy consumer acknowledge digital output is activated for this period.
Delay	0 to 30 s	0 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.

Configure this parameter under **Configure > Parameters > Heavy consumers > [Heavy consumer #] > Request signal**, where # is 1 to 4.

Table 7.34 Heavy consumer request signal type

Parameter	Range	Default	Comment
Type	Pulse, Continuous	Pulse	**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.

Configure this parameter under **Configure > Parameters > Power management rules > Configuration # > Load-dependent start/stop > Heavy consumer**, where # is 1 to 8.

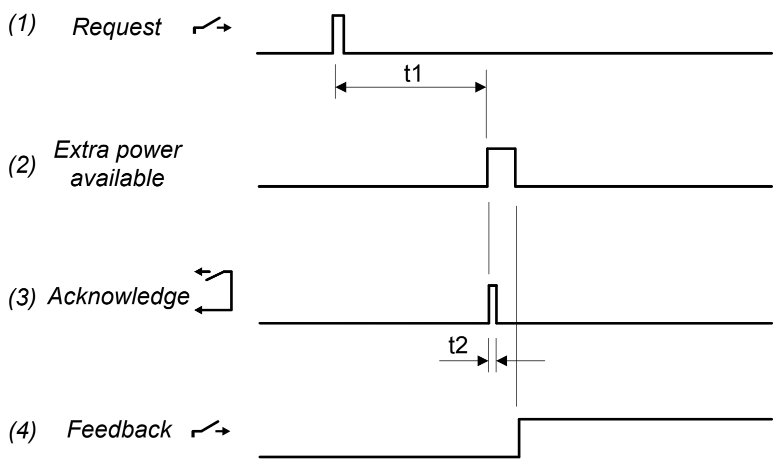
Table 7.35 Optional: Heavy consumer load-dependent stop

Parameter	Range	Default	Notes
Block stop when active	Not enabled, Enabled	Not 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.

7.7.3 Heavy consumer sequence

Fixed heavy consumer sequence

Figure 7.7 Sequence diagram for the fixed heavy consumer function with a pulse request signal



t1 = Time required to start extra genset(s) for the heavy consumer

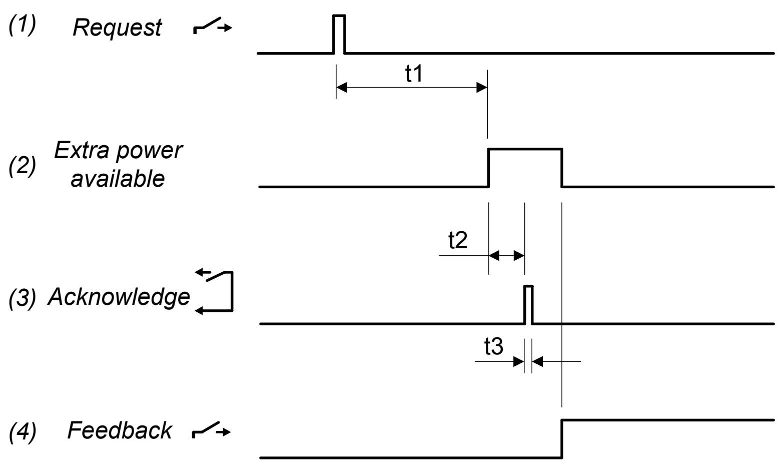
t2 = Pulse width (**Configure > Parameters > Heavy consumers > [Heavy consumer #] > Acknowledge**, where # is 1 to 4 and [Heavy consumer #] can be replaced by the heavy consumer *Controller label*)

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

Figure 7.8 Sequence diagram for the fixed heavy consumer function with a pulse request signal and an acknowledge delay



t1 = Time required to start extra genset(s) for the heavy consumer

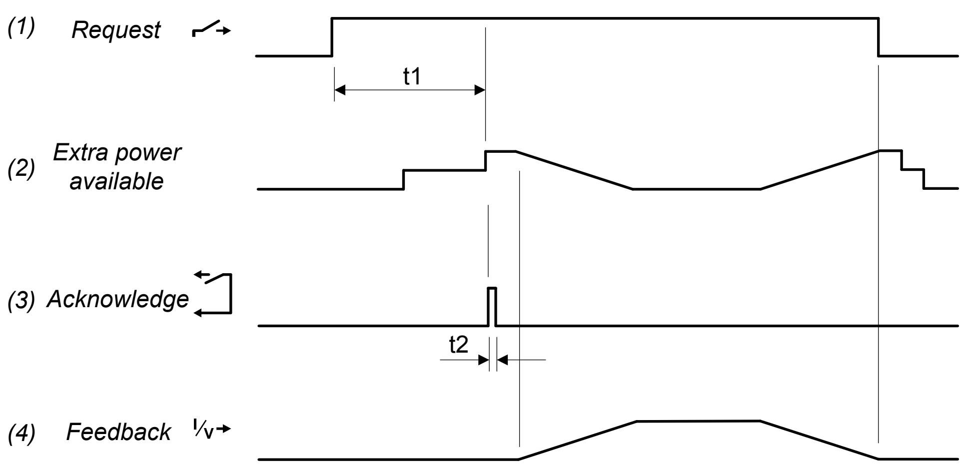
t2 = Acknowledge delay

t3 = Pulse width (**Configure > Parameters > Heavy consumers > [Heavy consumer #] > Acknowledge**, where # is 1 to 4 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

Figure 7.9 Sequence diagram for the variable heavy consumer function with a continuous request signal



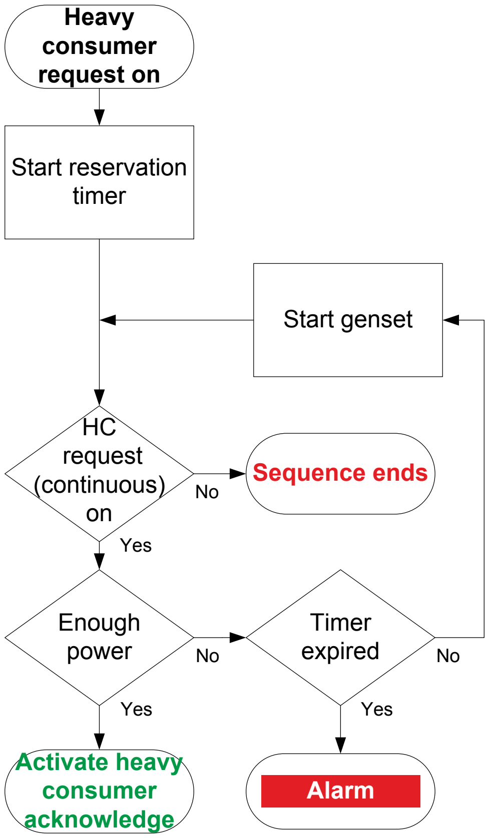
t1 = Time required to start extra genset(s) for the heavy consumer

t2 = Pulse width (**Configure > Parameters > Heavy consumers > [Heavy consumer #] > Acknowledge**, where # is 1 to 4 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.

7.7.4 Heavy consumer flowcharts and example

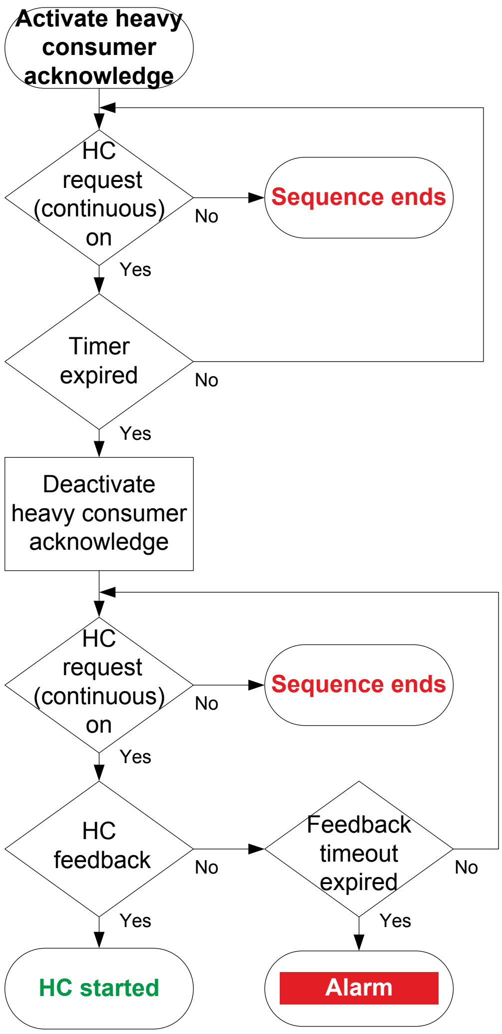
Heavy consumer request flowchart



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.

INFO
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.

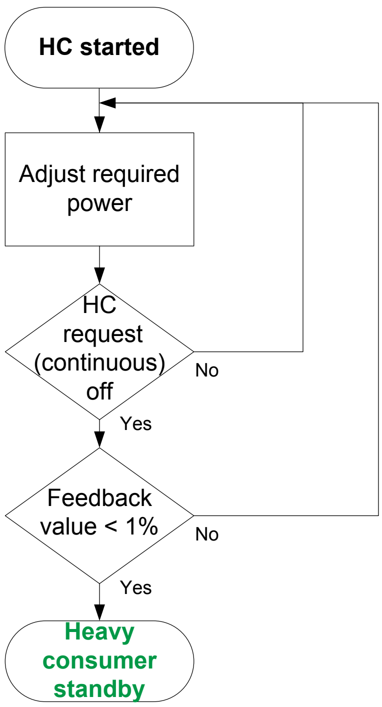
Heavy consumer acknowledge and feedback flowchart



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.

INFO
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

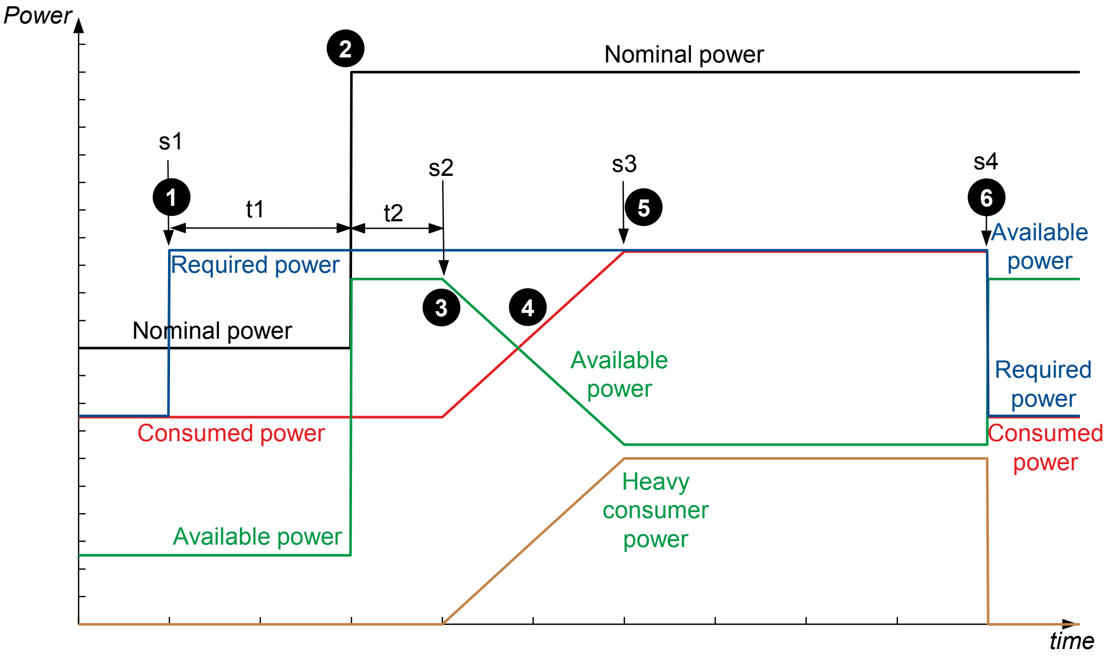


1. When the heavy consumer is connected, the controller adjust the power requirements for the system.
2. When the heavy consumer is no longer required, the operator (or an external signal) must:
   - **Pulse request signal**: Reduce the heavy consumer power consumption.
   - **Continuous request signal**: 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 7.10 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

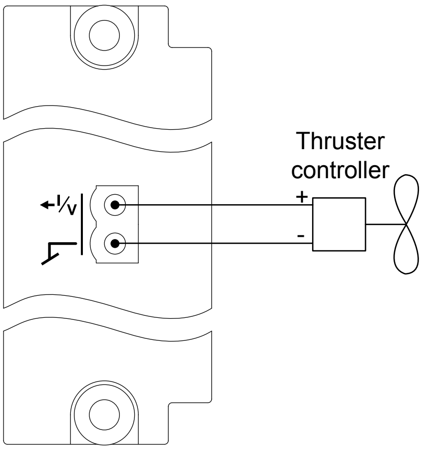
1. An operator or an external signal activates the *Heavy consumers* > *[Heavy consumer #]* > *Request*. The required power is more than the nominal power, so the PMS sends a start command to a genset.
2. The genset starts and connects, so that the nominal power is more than the required power. The controller 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.

7.7.5 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.

Wiring example

Figure 7.11 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

Assign one of the following output functions under **Configure > Input/output**. Select the hardware module, then select an output to configure.

Table 7.36 Hardware required in addition to the minimum standard controller wiring

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 %	

INFO
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 SEMI mode and any controllers under switchboard control in the available power.

7.7.6 Protections

More information
See **Power management**, **Power management alarms**, **Heavy consumer reservation not possible** and **Heavy consumer feedback timeout** for more information about the power management protections for heavy consumers.

7.8 Externally controlled breakers

7.8.1 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**, **Breaker wiring** in the **Installation instructions** for an example of external breaker wiring.

Inputs and outputs

Assign the externally controlled bus tie breaker inputs in the chosen controller under **Configure > Input/output**. Select the hardware module, then select the digital input or digital output to configure.

Table 7.37 Hardware required in addition to the minimum standard controller wiring

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.

Table 7.38 Optional hardware

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.

INFO
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 **Breakers, synchronisation and de-loading**, **Introduction**, **Regulation required for synchronisation** for more information about synchronising busbars.

Alarm

More information
See **Power management**, **Power management alarms**, **Breaker # feedback position failure** for more information about the alarm.

7.8.2 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.

Inputs and outputs

Assign the externally controlled shore connection inputs in the chosen controller under **Configure > Input/output**. Select the hardware module, then select the digital input to configure.

Table 7.39 Hardware required in addition to the minimum standard controller wiring

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.

Table 7.40 Optional hardware

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 open* 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 under switchboard control. The operator must then manually synchronise and afterwards manually close the external breaker.

INFO
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 **Breakers, synchronisation and de-loading**, **Introduction**, **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 under 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

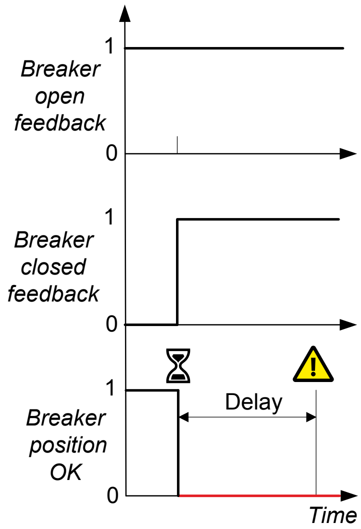
More information
See **Power management**, **Power management alarms**, **Breaker # feedback position failure** for more information about the alarm.

7.9 Power management alarms

7.9.1 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.



Configure the parameter under **Configure > Parameters > Breakers > Breaker # feedback monitoring > Position failure**. The parameter is only visible if there is an external breaker is on the single-line diagram. This alarm is always enabled. The alarm action is *Warning, Latch enabled*.

Table 7.41 Default parameter

Parameter	Range	Default
Delay	1 s to 1 h	1 s

All controllers in the busbar sections under switchboard control

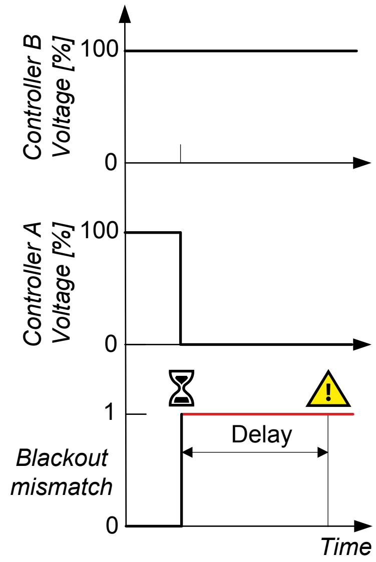
If the *Breaker # feedback position failure* alarm is activated for an externally controlled bus tie breaker without redundant breaker feedback, the controller cannot be sure whether the breaker is open or closed. The power management system therefore puts all the controllers in the sections on either side of the externally controlled bus tie breaker under switchboard control. The controllers remain under switchboard control until the position failure is fixed, the alarm is acknowledged, and the latch is reset.

7.9.2 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.



Configure the parameters under **Configure > Parameters > System > Monitoring > Blackout detection mismatch**.

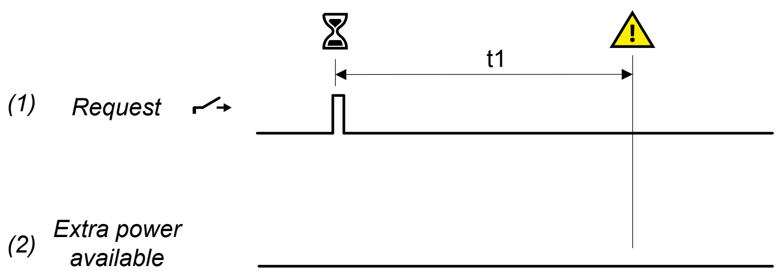
Table 7.42 Default parameters

Parameter	Range	Default
Delay	0 s to 1 h	1 s
Enable	Not enabled, Enabled	Not enabled
Action		Warning

7.9.3 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.

Configure the parameters under **Configure > Parameters > Heavy consumers > [Heavy consumer #] > Reservation not possible**, where # is 1 to 4 and [Heavy consumer #] can be replaced with the *Controller label* of the heavy consumer. This alarm is always enabled.

Table 7.43 Default parameters

Parameter	Range	Default
Delay	1 s to 1 h	2 min
Action		Warning, Latch enabled

7.9.4 Heavy consumer feedback timeout

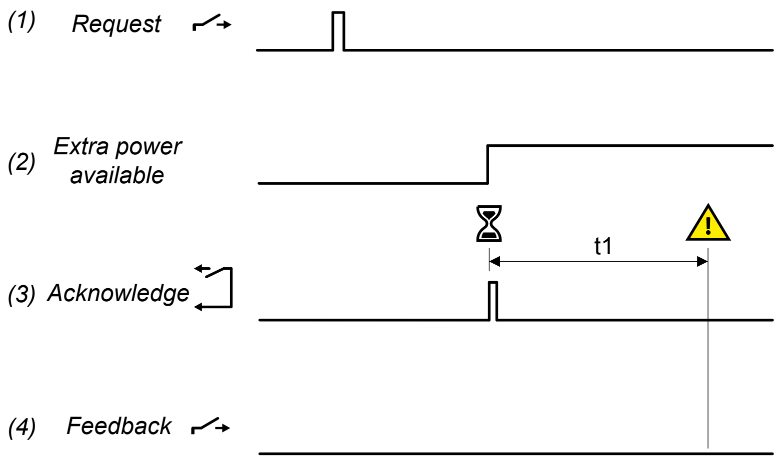
This alarm communicates that the requested heavy consumer did not give feedback within the configured time after the request was acknowledged.

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.



Configure the parameters under **Configure > Parameters > Heavy consumers > [Heavy consumer #] > Feedback timeout**, where # is 1 to 4 and [Heavy consumer #] can be replaced by the heavy consumer *Controller label*. This alarm is always enabled.

Table 7.44 Default parameters

Parameter	Range	Default
Delay	1 s to 1 h	30 s
Action		Warning, Latch enabled

7.9.5 Missing all controllers

This alarm communicates a network failure.

The alarm is based on the network between the controllers included in the single-line diagram. 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 under switchboard control.

Configure the parameters under **Configure > Parameters > System alarms > Communication > Missing all controllers**. This alarm is always enabled.

Table 7.45 Default parameters

Parameter	Range	Default
Action		Warning

7.9.6 Missing controller ID

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

The alarm is activated when a controller is present on the single-line diagram, 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.

7.9.7 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 diagram. The alarm is activated when the controller detects another controller with the same *Controller ID* as itself. The affected controllers are also forced under switchboard control.

Configure the parameters under **Configure > Parameters > System > Monitoring > Duplicate controller ID**. This alarm is always enabled.

Table 7.46 Default parameters

Parameter	Range	Default
Action		Warning

7.9.8 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 diagram. The controller activates the alarm if there is at least one controller in the single-line diagram that it cannot communicate with. This alarm is not suppressed by *Missing all controllers*.

Configure the parameters under **Configure > Parameters > System > Monitoring > Missing any controller**. This alarm is always enabled.

Table 7.47 Default parameters

Parameter	Range	Default
Action		Warning

7.9.9 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 diagram. 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 **Configure > Parameters > System > Monitoring > Mode while controller missing** and **PMS mode while controller missing**.

CAUTION
If controller(s) are missing, then the PMS cannot know their operating information, including the breaker positions. Evaluate the risks before configuring this set point.

Configure the parameters under **Configure > Parameters > System > Monitoring > Missing controllers**.

Table 7.48 Default parameters

Parameter	Range	Default
Set point	1 to 5	2
Action		Warning

7.9.10 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.

Configure the parameters under **Configure > Parameters > Local power management > Alarms > Forced to switchboard control**.

Table 7.49 Default parameters

Parameter	Range	Default
Enable	Not enabled, Enabled	Not enabled

More information
See **System principles**, **Control and modes**, **Switchboard control** for more information on the conditions that can force the controller under switchboard control.

7.9.11 Forced to SEMI mode

This alarm communicates that an alarm has forced the controller into SEMI mode.

The alarm is based on the conditions that can force the controller to SEMI mode. When the condition(s) that activated the alarm are resolved, the controller remains in SEMI mode. An external signal (for example, an operator presses the AUTO button on the display unit) is required to change the controller to AUTO mode.

Controller types: This alarm is present in the GENSET and EMERGENCY genset controllers.

Configure the parameters under **Configure > Parameters > Local power management > Alarms > Forced to SEMI mode**.

Table 7.50 Default parameters

Parameter	Range	Default
Action		Warning
Enable	Not enabled, Enabled	Enabled

7.9.12 DEIF network redundancy broken

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

Configure the alarm parameters under **Configure > Parameters > Communication > DEIF network > DEIF network redundancy broken**. This alarm action is always *Warning*.

Table 7.51 Ethernet redundancy broken default parameters

Parameter	Range	Default
Enable	Not enabled, Enabled	Enabled

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

7.9.13 Single-line missing/none active

This alarm communicates that the single-line diagram cannot be read from the controller, or that no single-line diagram 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 under switchboard control.

7.9.14 Different single-line configurations

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

This alarm is activated when a single-line diagram 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 under switchboard control. The alarm parameters are not visible in PICUS.

7.9.15 Controller not part of system

This alarm communicates that the controller has a *Controller ID* that is not included in the single-line diagram. Check or configure the system under **Configure > Single-line**.

The alarm is always *Enabled*, and the action is *Warning*. The controller will also be forced under switchboard control. The alarm parameters are not visible in PICUS.

7.9.16 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 diagram.

This alarm is activated when the *Controller ID* is assigned to an incorrect controller type in the single-line diagram, and the single-line diagram 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

An EMERGENCY genset controller has *Controller ID* 1, but on the single-line diagram *Controller ID* 1 is assigned to a BUS TIE breaker controller. The alarm is activated when the single-line diagram is written to the controller.

7.9.17 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.

7.9.18 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, PPU 300 controllers and PPM 300 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.

7.9.19 PMS disabled due to an error

This alarm communicates that there is an internal error in the PMS software. PMS 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.

8. Engine interface communication

8.1 About

8.1.1 How it works

The PPM 300 can receive information from an ECU using the CAN bus communication. The information can be used as input for the controller's own control functions. The PPM 300 also uses the information as display values, alarms, shutdown alarms and as values to be transmitted through Modbus.

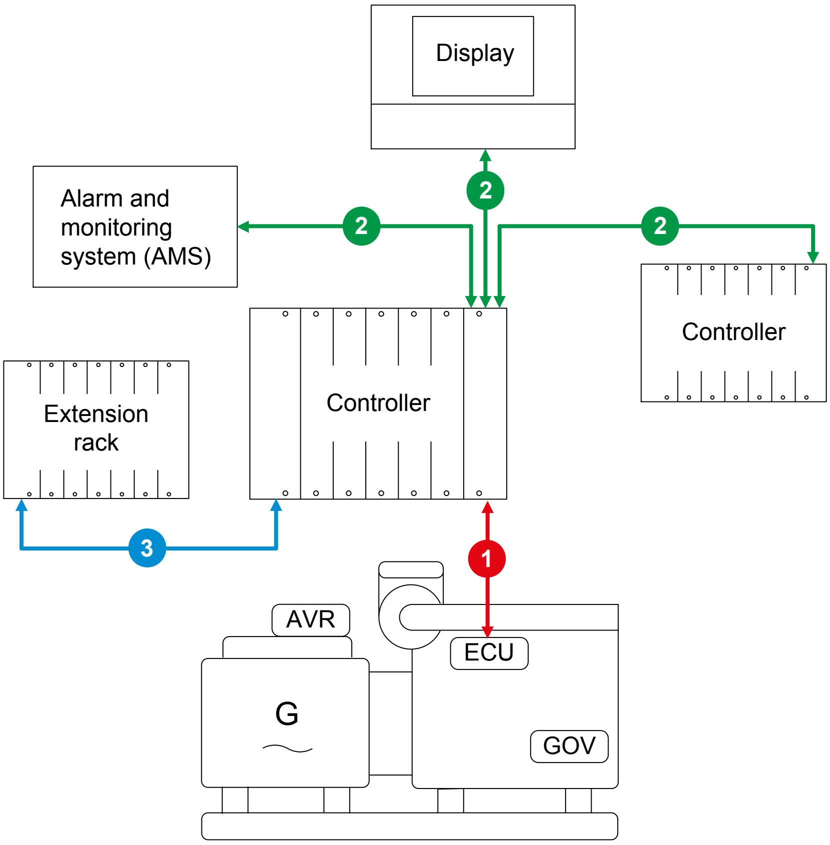


Table 8.1

No.	Notes
1	CAN bus communication to ECU
2	DEIF network communication to controllers, displays, AMS.
3	Internal communication to extension racks.

Most of the engine communication protocols are based on SAE J1939. J1939 is a very large standard, and most of it is irrelevant to engine communication. The PPM 300 supports only relevant parts of J1939. The parts of J1939 that are supported are described in Generic J1939.

The ECU is wired to the CAN bus A communication on the controller's PCM3.1 module. The ECU is added to the controller using the Fieldbus configuration and assigned the source address.

More information
See **CAN bus A communication wiring** in the **Installation instructions** for more information about how to wire an ECU to the controller and an example cable specification.

Once added to your controller, the ECU can be accessed on many different pages in PICUS or the display as an additional hardware selection. For example, configuring 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.

Priority of engine information with an ECU and analogue input values

A controller could be configured with both an ECU and with an EIM3.1 using analogue inputs, for values such as Engine oil pressure, Coolant level, and so on. In this situation, the controller uses the analogue input values as first priority, before using the ECU values. If the analogue input values are not able to be read, the controller uses the ECU values in their place.

8.1.2 Example configuration for an ECU

This example shows how to configure an ECU to read and use the value of the engine oil level.

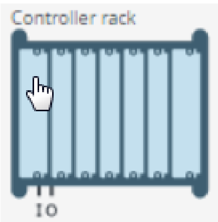
PGN:	Parameter group number
SPN:	Suspect parameter number
P:	J1939 priority
S:	Object's start bit in the CAN telegram
L:	Object's length. By default, the value is in bits.
Unit:	Unit in display (bar/°C can be changed to psi/°F)

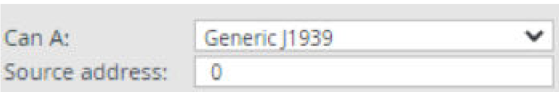
`Engine > ECU > Lube oil`

Text	PGN	S	L	P	SPN	Unit	J1939-71 scaling	Offset
Engine oil level	65263	16	8	6	98	%	0.4 %/bit	0.0 %

Add the ECU with Fieldbus

The ECU is added to the controller by using the Fieldbus configuration.

1. Launch **PICUS** and connect to your controller.
2. Open the **Fieldbus configuration** page:
   - `Configure > Fieldbus configuration`
3. Select the controller rack:
   - 

4. Under CAN A, select the protocol **Generic J1939**.
5. Enter the source address, if different from the default address **0**.
   - 

6. Select **Write** to update the controller.

Configure the ECU power setting (optional)

The default ECU Power setting is **Auto**, which uses either the engine run coil setting, ECU Power digital output, or otherwise assumes the power is always on.

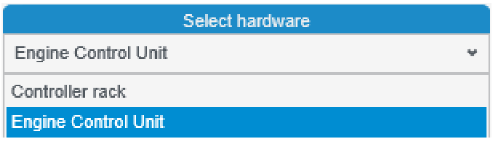
1. If required, use PICUS to configure the ECU Power configuration:
   - `Configure > Parameters > Communication> Fieldbus > CAN bus > ECU > ECU Power configuration`
2. Configure the setting as required.
3. Select **Write** to update the controller.

The ECU can now be accessed on many different pages in PICUS or the display as an additional hardware selection.

- Live data
  - Additional panel for engine speed, coolant temperature, and oil pressure.
- Input/output
  - Digital inputs or Supervised binary inputs
  - Analogue outputs
- Alarms (DM1)
- Logs (DM2)

View or configure the ECU functions and custom alarms on input/output

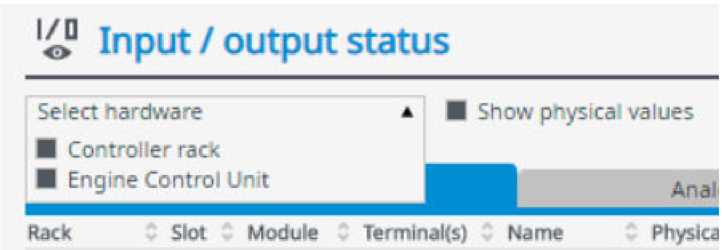
You can directly view the ECU values, assigned functions, custom sensor curves, and custom alarms on the input/output page.

1. Use **PICUS** to view the Input/output page:
   - `Configure > Input/output`
2. Select the ECU under the hardware selection:
   - 

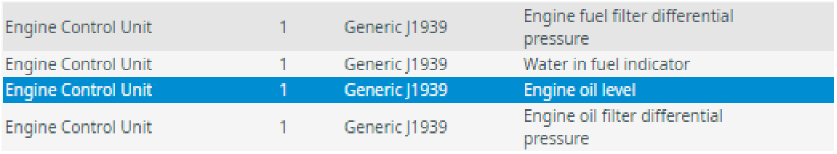
3. The ECU information is now shown.
4. You can now:
   - View or assign functions
   - View or configure the sensor setup for the curve/function
   - Create and configure custom alarms
5. Select **Save** to save the changes in PICUS.
6. Select **Write** to update the controller.

View the ECU values on I/O status

You can also view the ECU values in PICUS on the I/O status page.

1. Use **PICUS** to view the **I/O status page**.
2. Select the ECU under **Select hardware**, and also select **Show physical values**:
   - 

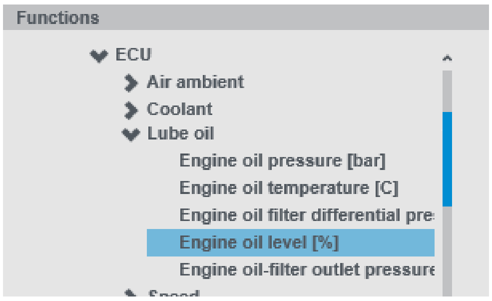
3. The ECU Engine oil level can be found in the list:

- 

Engine Control Unit	1	Generic J1939	Engine fuel filter differential pressure
Engine Control Unit	1	Generic J1939	Water in fuel indicator
Engine Control Unit	1	Generic J1939	Engine oil level
Engine Control Unit	1	Generic J1939	Engine oil filter differential pressure

Use the ECU values in CustomLogic

You can also use the ECU Engine oil level in CustomLogic as a function, for example with a Compare block:

- 

More information
See **Fieldbus configuration** in the **PICUS manual** for more information about Fieldbus configuration and supervision.

8.2 Generic J1939

8.2.1 J1939 measurements

These are the J1939 measurements that the PPM 300 supports. Not all measurements are supported by all engines (see the specific engine description).

By default, the engine is expected to use source address **0** (the most commonly used setting on ECUs). If a different source address is required, you can configure it on the Fieldbus configuration page and assign a different source address. The range is 0 to 255.

PGN:	Parameter group number
SPN:	Suspect parameter number
P:	J1939 priority
S:	Object's start bit in the CAN telegram
L:	Object's length. By default, the value is in bits.
Unit:	Unit in display (bar/°C can be changed to psi/°F)

Engine > ECU > Air ambient

Text	PGN	S	L	P	SPN	Unit	J1939-71 scaling	Offset
Atmospheric pressure	65269	0	8	6	108	kPa	0.5 kPa/bit	0.0 kPa
Ambient air temperature	65269	24	16	6	171	°C	0.03125 °C/bit	-273.0 °C

Engine > ECU > Coolant

Text	PGN	S	L	P	SPN	Unit	J1939-71 scaling	Offset
Engine coolant temperature	65262	0	8	6	110	°C	1.0 °C/bit	-40.0 °C
Coolant level	65263	56	8	6	111	%	0.4 %/bit	0.0 %
Coolant pressure	65263	48	8	6	109	kPa	2.0 kPa/bit	0.0 kPa

Text	PGN	S	L	P	SPN	Unit	J1939-71 scaling	Offset
Coolant filter differential pressure	65270	56	8	6	112	kPa	0.5 kPa/bit	0.0 kPa
Engine coolant temperature 2	64870	0	8	6	4076	°C	1.0 °C/bit	-40.0 °C
Engine coolant temperature 3	64870	56	8	6	6209	°C	1.0 °C/bit	-40.0 °C
Engine coolant pump outlet temperature	64870	8	8	6	4193	°C	1.0 °C/bit	-40.0 °C
Engine auxiliary coolant temperature	65172	8	8	6	1212	°C	1.0 °C/bit	-40.0 °C
Engine auxiliary coolant pressure	65172	0	8	6	1203	kPa	4.0 kPa/bit	0.0 kPa

Engine > ECU > DPF

Text	PGN	S	L	P	SPN	Unit	J1939-71 scaling	Offset
Diesel particulate filter lamp command	64892	0	3	6	3697		1.0 /bit	0.0
Diesel particulate filter active regeneration status	64892	10	2	6	3700		1.0 /bit	0.0
Diesel particulate filter regeneration status	64892	12	3	6	3701		1.0 /bit	0.0
Diesel particulate filter active regeneration inhibited	64892	18	2	6	3703		1.0 /bit	0.0
Aftertreatment 1 diesel exhaust fluid tank level	65110	0	8	6	1761	%	0.4 %/bit	0.0 %
Aftertreatment 1 diesel exhaust fluid tank temperature	65110	8	8	6	3031	°C	1.0 °C/bit	-40.0 °C
Aftertreatment 1 intake NOx	61454	0	16	6	3216	ppm	0.05 ppm/bit	-200.0 ppm
Aftertreatment 1 outlet NOx	61455	0	16	6	3226	ppm	0.05 ppm/bit	-200.0 ppm
Aftertreatment 1 DEF actual dosing quantity	61475	0	16	3	4331	g/h	0.3 g/h/bit	0.0 g/h
Aftertreatment 1 DEF doser absolute pressure	61475	40	8	3	4334	kPa	8.0 kPa/bit	0.0 kPa
Aftertreatment 1 SCR dosing air assist valve	64833	8	8	6	4336	%	0.4 %/bit	0.0 %
Aftertreatment 1 DEF dosing requested quantity	61476	0	16	3	4348	g/h	0.3 g/h/bit	0.0 g/h
Aftertreatment 1 SCR catalyst intake gas temperature	64830	0	16	5	4360	°C	0.03125 °C/bit	-273.0 °C
Aftertreatment 1 SCR catalyst outlet gas temperature	64830	24	16	5	4363	°C	0.03125 °C/bit	-273.0 °C

Text	PGN	S	L	P	SPN	Unit	J1939-71 scaling	Offset
Aftertreatment 2 intake NOx	61456	0	16	6	3255	ppm	0.05 ppm/bit	-200.0 ppm
Aftertreatment 2 outlet NOx	61457	0	16	6	3265	ppm	0.05 ppm/bit	-200.0 ppm
Aftertreatment 2 DEF actual dosing quantity	61478	0	16	3	4384	g/h	0.3 g/h/bit	0.0 g/h
Aftertreatment 2 DEF dosing absolute pressure	61478	40	8	3	4387	kPa	8.0 kPa/bit	0.0 kPa
Aftertreatment 2 SCR dosing air assist valve	64827	8	8	6	4389	%	0.4 %/bit	0.0 %
Aftertreatment 2 DEF dosing requested quantity	61479	0	16	3	4401	g/h	0.3 g/h/bit	0.0 g/h
Aftertreatment 2 SCR catalyst intake gas temperature	64824	0	16	6	4413	°C	0.03125 °C/bit	-273.0 °C
Aftertreatment 2 SCR catalyst outlet gas temperature	64824	24	16	6	4415	°C	0.03125 °C/bit	-273.0 °C
Aftertreatment SCR operator inducement active	65110	37	3	6	5245		1.0 /bit	0.0
Aftertreatment SCR operator inducement severity	65110	45	3	6	5246		1.0 /bit	0.0
Aftertreatment 1 DPF outlet gas temperature	64947	16	16	6	3246	°C	0.03125 °C/bit	-273.0 °C
Aftertreatment 1 DPF time to next active regeneration	64697	0	32	6	5978	h	0.000277777777777778 h/bit	0.0 h
Diesel particulate filter 1 soot load percent	64891	0	8	6	3719	%	1.0 %/bit	0.0 %
Aftertreatment 1 DEF average consumption	64878	0	16	6	3826	L/h	0.05 L/h/bit	0.0 L/h
Aftertreatment 1 intake percent oxygen 1	61454	16	16	6	3217	%	0.000514 %/bit	-12.0 %
Aftertreatment 1 outlet percent oxygen 1	61455	16	16	6	3227	%	0.000514 %/bit	-12.0 %

Engine > ECU > Engine counters

Text	PGN	S	L	P	SPN	Unit	J1939-71 scaling	Offset
Engine Hours	65253	0	32	6	247	h	0.05 h/bit	0.0 h
Trip engine running time	65200	64	32	7	1036	h	0.05 h/bit	0.0 h
Trip idle time	65200	16	32	7	1037	h	0.05 h/bit	0.0 h

Engine > ECU > Engine load

Text	PGN	S	L	P	SPN	Unit	J1939-71 scaling	Offset
Drivers demand engine percent torque	61444	8	8	3	512	%	1.0 %/bit	-125.0 %
Actual engine - percent torque	61444	16	8	3	513	%	1.0 %/bit	-125.0 %
Percent load at current speed	61443	16	8	3	92	%	1.0 %/bit	0.0 %
Nominal power	65214	0	16	7	166	kW	0.5 kW/bit	0.0 kW
Nominal friction - percent torque	65247	0	8	6	514	%	1.0 %/bit	-125.0 %
Engine demand - percent torque	61444	56	8	3	2432	%	1.0 %/bit	-125.0 %

Engine > ECU > Exhaust gas

Text	PGN	S	L	P	SPN	Unit	J1939-71 scaling	Offset
Exhaust gas temperature	65270	40	16	6	173	°C	0.03125 °C/bit	-273.0 °C
Particulate trap inlet pressure	65270	0	8	6	81	kPa	0.5 kPa/bit	0.0 kPa
Exhaust temperature right	65031	0	16	6	2433	°C	0.03125 °C/bit	-273.0 °C
Exhaust temperature left	65031	16	16	6	2434	°C	0.03125 °C/bit	-273.0 °C
Exhaust port temperature 01	65187	0	16	7	1137	°C	0.03125 °C/bit	-273.0 °C
Exhaust port temperature 02	65187	16	16	7	1138	°C	0.03125 °C/bit	-273.0 °C
Exhaust port temperature 03	65187	32	16	7	1139	°C	0.03125 °C/bit	-273.0 °C
Exhaust port temperature 04	65187	48	16	7	1140	°C	0.03125 °C/bit	-273.0 °C
Exhaust port temperature 05	65186	0	16	7	1141	°C	0.03125 °C/bit	-273.0 °C
Exhaust port temperature 06	65186	16	16	7	1142	°C	0.03125 °C/bit	-273.0 °C
Exhaust port temperature 07	65186	32	16	7	1143	°C	0.03125 °C/bit	-273.0 °C
Exhaust port temperature 08	65186	48	16	7	1144	°C	0.03125 °C/bit	-273.0 °C
Exhaust port temperature 09	65185	0	16	7	1145	°C	0.03125 °C/bit	-273.0 °C
Exhaust port temperature 10	65185	16	16	7	1146	°C	0.03125 °C/bit	-273.0 °C
Exhaust port temperature 11	65185	32	16	7	1147	°C	0.03125 °C/bit	-273.0 °C
Exhaust port temperature 12	65185	48	16	7	1148	°C	0.03125 °C/bit	-273.0 °C
Exhaust port temperature 13	65184	0	16	6	1149	°C	0.03125 °C/bit	-273.0 °C

Text	PGN	S	L	P	SPN	Unit	J1939-71 scaling	Offset
Exhaust port temperature 14	65184	16	16	6	1150	°C	0.03125 °C/bit	-273.0 °C
Exhaust port temperature 15	65184	32	16	6	1151	°C	0.03125 °C/bit	-273.0 °C
Exhaust port temperature 16	65184	48	16	6	1152	°C	0.03125 °C/bit	-273.0 °C
Exhaust port temperature 17	65183	0	16	7	1153	°C	0.03125 °C/bit	-273.0 °C
Exhaust port temperature 18	65183	16	16	7	1154	°C	0.03125 °C/bit	-273.0 °C
Exhaust port temperature 19	65183	32	16	7	1155	°C	0.03125 °C/bit	-273.0 °C
Exhaust port temperature 20	65183	48	16	7	1156	°C	0.03125 °C/bit	-273.0 °C
Engine exhaust gas oxygen sensor closed loop operation	64841	32	4	6	4240		1.0 /bit	0.0

Engine > ECU > Fuel

Text	PGN	S	L	P	SPN	Unit	J1939-71 scaling	Offset
Fuel temperature	65262	8	8	6	174	°C	1.0 °C/bit	-40.0 °C
Fuel rate	65266	0	16	6	183	L/h	0.05 L/h/bit	0.0 L/h
Fuel delivery pressure	65263	0	8	6	94	kPa	4.0 kPa/bit	0.0 kPa
Water in fuel indicator	65279	0	2	6	97		1.0 /bit	0.0
Engine trip fuel	65257	0	32	6	182	L	0.5 L/bit	0.0 L
Engine total fuel used	65257	32	32	6	250	L	0.5 L/bit	0.0 L
Trip fuel gaseous	65199	0	32	7	1039	kg	0.5 kg/bit	0.0 kg
Total fuel used gaseous	65199	32	32	7	1040	kg	0.5 kg/bit	0.0 kg
Mean trip fuel consumption	65203	32	16	7	1029	L/h	0.05 L/h/bit	0.0 L/h
Fuel supply pump inlet pressure	65130	8	8	6	1381	kPa	2.0 kPa/bit	0.0 kPa
Fuel filter (suction side) differential pressure	65130	16	8	6	1382	kPa	2.0 kPa/bit	0.0 kPa
Engine fuel filter differential pressure	65276	16	8	6	95	kPa	2.0 kPa/bit	0.0 kPa
Engine filtered fuel delivery pressure	64735	8	8	6	5579	kPa	4.0 kPa/bit	0.0 kPa

Engine > ECU > Information

Text	PGN	S	L	P	SPN	Unit	J1939-71 scaling	Offset
Number of actual faults	65230	0	8	6	1218		1.0 /bit	0.0
Battery potential voltage switched	65271	48	16	6	158	V DC	0.05 V DC/bit	0.0 V DC
Crankcase pressure	65263	32	16	6	101	kPa	0.0078125 kPa/bit	-250.0 kPa

Text	PGN	S	L	P	SPN	Unit	J1939-71 scaling	Offset
Exhaust system high temperature lamp command	64892	50	3	6	3698		1.0 /bit	0.0
Engine ECU temperature	65188	16	16	6	1136	°C	0.03125 °C/bit	-273.0 °C
Ambient conditions 2 specific humidity	64992	16	16	6	4490	g/kg	0.01 g/kg/bit	0.0 g/kg
Engines desired operating speed	65247	8	16	6	515	RPM	0.125 RPM/bit	0.0 RPM
Engine operating state	64914	0	4	3	3543		1.0 /bit	0.0
Source address of controlling device	61444	40	8	3	1483		1.0 /bit	0.0
ECU identification information	64965	-8	1600	6	2902		1.0 /bit	0.0
Engine operating derate request	64914	56	8	3	3644	%	0.4 %/bit	0.0 %
SW identification	65242	8	1600	6	234		1.0 /bit	0.0
Engine throttle actuator 1 control command	61466	0	16	4	3464	%	0.0025 %/bit	0.0 %
Long-term fuel trim	64841	0	16	6	4237	%	0.1 %/bit	-100.0 %
Short-term fuel trim	64841	16	16	6	4236	%	0.1 %/bit	-100.0 %
Engine desired ignition timing no 1	65159	0	16	7	1433	°	0.0078125 °/bit	-200.0 °
Engine actual ignition timing	65159	48	16	7	1436	°	0.0078125 °/bit	-200.0 °
Engine amber warning lamp command	64775	2	2	6	5078		1.0 /bit	0.0
Engine red stop lamp command	64775	4	2	6	5079		1.0 /bit	0.0

Engine > ECU > Intake

Text	PGN	S	L	P	SPN	Unit	J1939-71 scaling	Offset
Boost pressure	65270	8	8	6	102	kPa	2.0 kPa/bit	0.0 kPa
Air inlet temperature	65269	40	8	6	172	°C	1.0 °C/bit	-40.0 °C
Engine intake manifold 1 temperature	65270	16	8	6	105	°C	1.0 °C/bit	-40.0 °C
Air inlet pressure	65270	24	8	6	106	kPa	2.0 kPa/bit	0.0 kPa
Air filter differential pressure	65270	32	8	6	107	kPa	0.05 kPa/bit	0.0 kPa
Engine intercooler temperature	65262	48	8	6	52	°C	1.0 °C/bit	-40.0 °C
Engine intake manifold 1 absolute pressure	64976	32	8	6	3563	kPa	2.0 kPa/bit	0.0 kPa
Air filter differential pressure 2	64976	0	8	6	2809	kPa	0.05 kPa/bit	0.0 kPa

Text	PGN	S	L	P	SPN	Unit	J1939-71 scaling	Offset
Engine intake manifold 2 temperature	65189	0	8	7	1131	°C	1.0 °C/bit	-40.0 °C
Engine charge air cooler 1 outlet temperature	65129	48	16	6	2630	°C	0.03125 °C/bit	-273.0 °C

Engine > ECU > Lube oil

Text	PGN	S	L	P	SPN	Unit	J1939-71 scaling	Offset
Engine oil pressure	65263	24	8	6	100	kPa	4.0 kPa/bit	0.0 kPa
Engine oil temperature	65262	16	16	6	175	°C	0.03125 °C/bit	-273.0 °C
Engine oil filter differential pressure	65276	24	8	6	99	kPa	0.5 kPa/bit	0.0 kPa
Engine oil level	65263	16	8	6	98	%	0.4 %/bit	0.0 %
Engine oil-filter outlet pressure	65130	32	8	6	3549	kPa	4.0 kPa/bit	0.0 kPa

Engine > ECU > Speed

Text	PGN	S	L	P	SPN	Unit	J1939-71 scaling	Offset
Engine speed	61444	24	16	3	190	RPM	0.125 RPM/bit	0.0 RPM
Accelerator pedal position	61443	8	8	3	91	%	0.4 %/bit	0.0 %
Engine rated speed	65214	16	16	7	189	RPM	0.125 RPM/bit	0.0 RPM
Engine speed at idle point 1	65251	0	16	6	188	RPM	0.125 RPM/bit	0.0 RPM

Engine > ECU > Turbo charger

Text	PGN	S	L	P	SPN	Unit	J1939-71 scaling	Offset
Turbo oil temperature	65262	32	16	6	176	°C	0.03125 °C/bit	-273.0 °C
Engine turbocharger 1 turbine intake temperature	65176	0	16	6	1180	°C	0.03125 °C/bit	-273.0 °C
Engine turbocharger 2 turbine intake temperature	65176	16	16	6	1181	°C	0.03125 °C/bit	-273.0 °C
Engine turbocharger 1 speed	65245	8	16	6	103	RPM	4.0 RPM/bit	0.0 RPM
Engine turbocharger 2 speed	65179	8	16	7	1169	RPM	4.0 RPM/bit	0.0 RPM
Engine turbocharger 3 speed	65179	24	16	7	1170	RPM	4.0 RPM/bit	0.0 RPM

8.3 ECU functions

8.3.1 ECU Power configuration

This function 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 (see below)
- Externally powered

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

Table 8.2 Digital output

Function	I/O	Type	Details
Engine > Control > ECU Power	Digital output	Continuous	Connect this to the ECU power control.

Parameters

Configure these parameters under:

```
Configure > Parameters > Communication> Fieldbus > CAN bus > ECU
```

Parameter	Range	Default	Comment
ECU Power configuration	Auto, Always ON	Auto	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.
ECU Powerup time	0 s to 5 min	2 s	If an ECU Communication failure is detected, after the delay period has expired, this alarm becomes active. After the delay the alarm is triggered.

8.4 ECU protections

8.4.1 ECU Communication failure alarm

Configure the parameters under:

```
Configure > Parameters > Communication > Fieldbus > CAN bus > ECU > ECU Communication failure
```

Table 8.3 Default parameters

Parameter	Range	Default
Enable	Not enabled, Enabled	Enabled
Delay	0 s to 120 s	1 s
Latch	Not enabled, Enabled	Not enabled
Alarm action		Warning

8.4.2 ECU CAN bus off

Configure these parameters under:

```
Configure > Parameters > Communication > Fieldbus > CAN bus > Bus off
```

Table 8.4 CAN-A bus off parameters

Parameter	Range	ECU Amber warning lamp
Enable	-	Enabled
Latch	Not enabled, Enabled	Not enabled
Alarm action		Warning

Table 8.5 CAN-B bus off parameters

Parameter	Range	ECU Amber warning lamp
Enable	-	Enabled
Latch	Not enabled, Enabled	Not enabled
Alarm action		Warning

8.4.3 ECU Red stop lamp alarm

Configure the parameters under:

```
Configure > Parameters > Engine > ECU > ECU Red stop lamp
```

Table 8.6 Default parameters

Parameter	Range	ECU Red stop lamp
Enable	-	Enabled *
Latch	-	Enabled *
Alarm action		Trip generator breaker and shutdown engine

NOTE * Always enabled and cannot be changed.

8.4.4 ECU Amber warning lamp alarm

Configure the parameters under:

```
Configure > Parameters > Engine > ECU > ECU Amber warning lamp
```

Table 8.7 Default parameters

Parameter	Range	ECU Amber warning lamp
Enable	-	Enabled *
Latch	Not enabled, Enabled	Not enabled
Alarm action		Warning

NOTE * Always enabled and cannot be changed.

8.4.5 ECU Protect lamp alarm

Configure the parameters under:

```
Configure > Parameters > Engine > ECU > ECU Protect lamp
```

Table 8.8 Default parameters

Parameter	Range	ECU Protect lamp
Enable	-	Enabled *
Latch	-	Enabled *
Alarm action		Warning

NOTE * Always enabled and cannot be changed.

8.4.6 ECU Malfunction indicator lamp alarm

Configure the parameters under:

```
Configure > Parameters > Engine > ECU > ECU Malfunction indicator lamp
```

Table 8.9 Default parameters

Parameter	Range	ECU Malfunction indicator lamp
Enable	-	Enabled *
Latch	Not enabled, Enabled	Not enabled
Alarm action		Warning

NOTE * Always enabled and cannot be changed.

9. GENSET controller

9.1 GENSET controller overview

9.1.1 Description

A GENSET controller controls and protects a diesel engine and generator (that is, a genset), 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.

9.1.2 Application

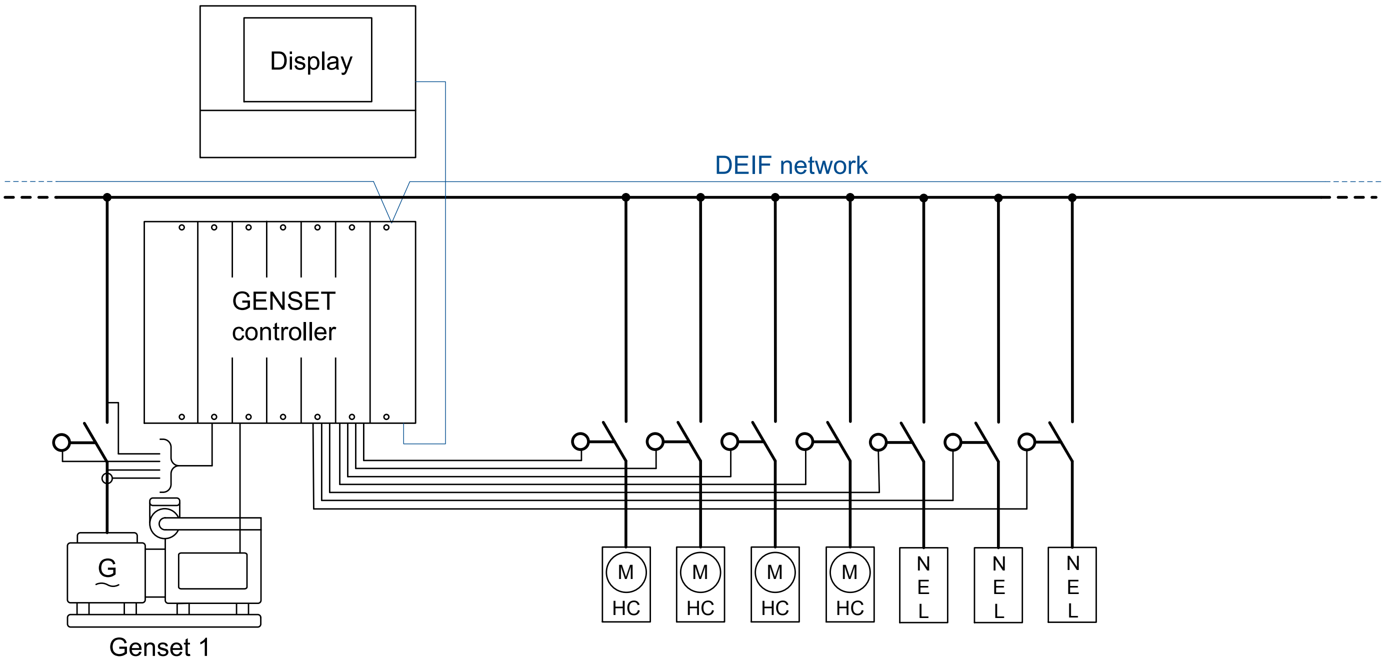
A GENSET controller controls and protects a diesel engine and generator (that is, a genset), as well as the generator breaker. A system can include a number of GENSET controllers.

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 four heavy consumers (HC) and connect up to three non-essential load groups (NEL).

Figure 9.1 Example GENSET controller with optional heavy consumers and non-essential loads



9.1.3 GENSET controller functions

	Functions
Pre-programmed sequences	• Genset start sequence and genset stop sequence ◦ Running detection (Multiple feedback options: Frequency, MPU/W/NPN/PNP (RPM), Digital input, Oil pressure) ◦ Run coil and/or stop coil for engine control

	Functions
	◦ Temperature-dependent cooldown • Breaker sequences ◦ Generator breaker close sequence (with synchronisation) ◦ Generator breaker open sequence (with de-loading) • Generator breaker blackout close
Genset regulation	• PID regulators for analogue outputs • P regulators for relay outputs ◦ *Relay period time* and *Minimum ON time* configurable • Set point selection ◦ Select mode or external set point, using digital input, Modbus, and/or CustomLogic • 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) ◦ Generator 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 • Temperature-controlled start & stop
Control types	• Power management system (PMS) control ◦ AUTO mode ◦ SEMI mode • Switchboard control ◦ Operator controls the system from the switchboard ◦ Only the controller protections are active
Control modes	• AUTO mode ◦ Automatic power management ◦ Automatic load-dependent genset start & stop ◦ Automatic synchronisation & de-loading, and breaker control

	Functions
	• SEMI mode ◦ Operations only on operator command ◦ Operator-initiated synchronisation and de-loading ◦ Display unit push-buttons for genset start & stop, breaker open & close, and 1st priority • Display unit push-buttons ◦ Change control mode (AUTO & SEMI) ◦ 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 SEMI mode

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.

Generator nominal settings

Configure these nominal settings under **Configure > Parameters > [Source] > Nominal settings > Nominal settings #**, where # is 1 to 4.

Table 9.1 Controller nominal settings

Nominal setting	Range	Default	Notes
Voltage (V)	10 V to 160 kV	400 V	The phase-to-phase* nominal AC voltage for the genset.
Current (I)	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)	20 to 100 Hz	50 Hz	The system nominal frequency, typically either 50 Hz or 60 Hz. All the controllers in the system should have the same nominal frequency.
Power (P)	1 kW to 0.9 GW	480 kW	The nominal active power may be on the genset nameplate.
Apparent power (S)	1 kVA to 1 GVA	530 kVA	The nominal apparent power should be on the genset or generator nameplate.
Power factor (PF)	0.6 to 1	0.9	The power factor should be on the genset or generator nameplate.

*Note: In a single-phase set up the nominal AC voltage is phase-to-neutral.

Configure this under **Configure > Parameters > Generator > Nominal settings > Nominal settings # > Calculation method**, where # is 1 to 4:

Table 9.2 Nominal setting 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

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

Busbar nominal settings

Configure these nominal settings under **Configure > Parameters > Busbar > Nominal settings > Nominal settings #**, where # is 1 to 4.

Table 9.3 Controller nominal settings

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

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.

Outputs

The table below describes the stop coil and run coil outputs for the engine.

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

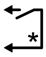
For a *Stop coil*, if wire break detection is required, use EIM relay 4 () (terminals 9,10).

Table 9.4 Run coil and stop coil outputs

Function	I/O	Type	Details
Engine > Control > 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 > Control > 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

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

Function	I/O	Type	Details
Engine > Feedback > Digital running detection	Digital input	Continuous	Optional. External equipment activates the digital input when the engine is running.

The controller can also use the following inputs for running feedback.

Function	I/O	Type	Details
Frequency	Generator voltage measurements	Continuous	Always present. The controller uses the generator voltage measurements to calculate the frequency. The controller then compares the frequency with the detection set point. Note: The controller cannot measure the frequency at very low voltages. See the **Data sheet** for the measurement range. The voltage must also be at least 10 % of nominal for the controller to use the frequency for running detection. For safety, DEIF recommends that you install at least one other running detection input.
MPU	HSDI	Continuous	Optional. The MPU input (on the first EIM3.1 in the controller rack) is connected to an MPU mounted on the engine.
W	HSDI	Continuous	Optional. The W input (on the first EIM3.1 in the controller rack) is connected to the battery recharging generator and measures the engine speed. Alternatively, the W input can be connected to an NPN/PNP sensor.
Engine > Running detection > Oil [bar]	Analogue input	Pressure in bar	Optional. This set of analogue input terminals are connected to a transducer for the engine oil pressure.

Parameters

Configure these parameters under **Configure > Parameters > Engine > Nominal settings > Nominal settings #**, where # is 1 to 4.

Parameter	Range	Nominal setting 1	Nominal setting 2	Nominal setting 3	Nominal setting 4	Comment
Nominal RPM	100 to 50000 RPM	1500 RPM	1500 RPM	1800 RPM	1800 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.

Configure these parameters under **Configure > Parameters > Engine > Nominal settings > Nominal settings # > Number of teeth**, where # is 1 to 4.

Parameter	Range	Default	Comment
Number of magnetic pickup teeth	1 to 10000	1	The controller uses the number of teeth to calculate the engine speed from the MPU/W/NPN/PNP measurement signal.

Configure these parameters under **Configure > Parameters > Engine > Running detection > Feedback type**.

Parameter	Range	Default	Comment
Primary running feedback	The available running feedbacks (depends on hardware)	Frequency	Select one of the inputs as the primary running feedback.

Parameter	Range	Default	Comment
			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.

Configure these parameters under **Configure > Parameters > Engine > Running detection > Detection set point**.

Parameter	Range	Default	Comment
MPU	0 to 50000 RPM	1000 RPM	Running detection is ON when the engine speed measured by the MPU/W/NPN/PNP input is above this set point.
Frequency	10 to 100 Hz	32 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.
Use magnetic pickup	Not enabled, Enabled	Enabled	**Not enabled:** The MPU/W/NPN/PNP measurement (connected to the first EIM3.1 in the controller rack) is ignored and not used for running detection. **Enabled:** The MPU/W/NPN/PNP measurement (connected to the first EIM3.1 in the controller rack) is used as a running detection input.
Oil pressure*	0 to 10 bar	3 bar	Running detection is ON when the engine oil pressure measured by the analogue input is above this set point.
Use oil pressure*	Not enabled, Enabled	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.

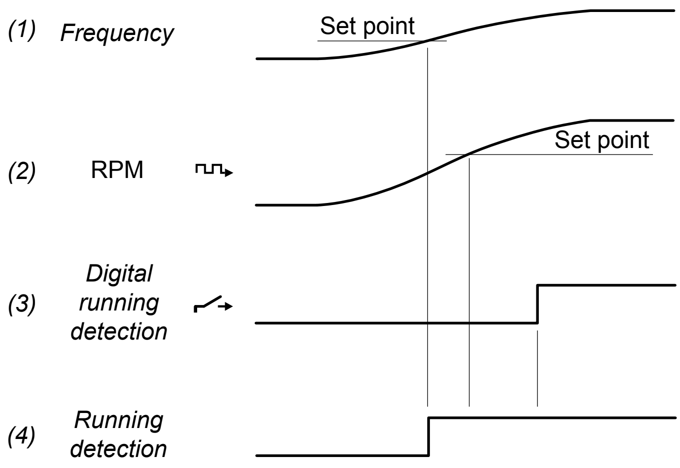
Oil pressure running detection hysteresis

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.

Figure 9.2 Running detection ON sequence diagram

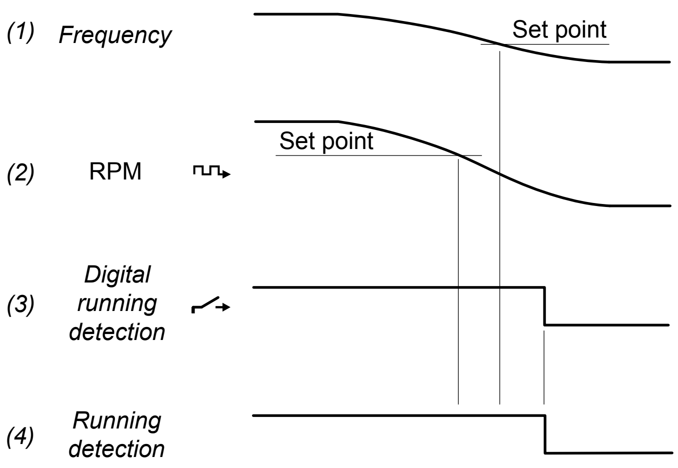


1. **Frequency**: The engine starts and the frequency rises above the set point.
2. **RPM**: (MPU/W/NPN/PNP input). The engine starts and the RPM rises above the set point.
3. **Digital running detection**: *Engine* > *Feedback* > *Digital running detection* (digital input). In the example, the response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

Figure 9.3 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

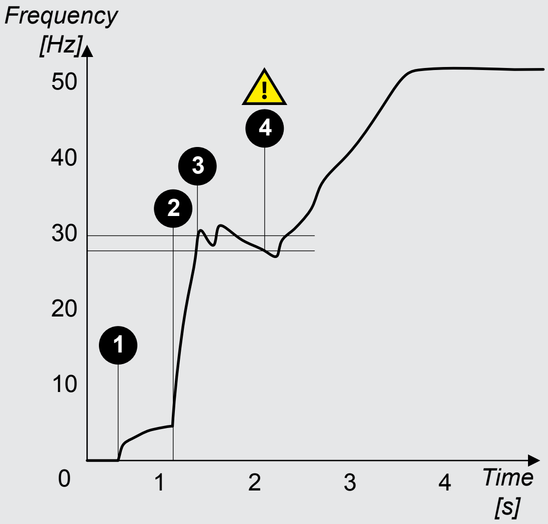
It is possible to only use frequency for running detection. However, using only frequency for running detection increases the risk of not detecting that the genset is running.

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 more information.

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 more information.

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**, **Load sharing** for more information.

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 under PMS control.

9.2.8 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 GENSET controller.

Table 9.5 AC configuration for the GENSET controller

GENSET	General name
Generator	[Source]
Busbar	[Busbar]

9.2.9 Breaker configuration

More information
The **Breakers, synchronisation and de-loading** chapter describes breaker configuration in general. For the GENSET controller, replace "[Breaker]" with "Generator breaker" in these descriptions.

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 **GENSET controller protections** in this chapter for information on how the engine start protections work, and how to configure them.

Controller modes

In AUTO and SEMI 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

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

Table 9.6 Required engine start output

Function	I/O	Type	Details
Engine > Control > Crank	Digital output	Continuous	Connect this output to the engine crank.

Table 9.7 Optional engine start inputs and output

Function	I/O	Type	Details
Engine > Function > Start enable	Digital input	Continuous	Optional. If this input is configured, it must be activated for the engine start sequence to start.
Engine > Control > 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 > Control > 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.

Table 9.8 Optional engine start commands

Function	I/O	Type	Details
Engine > Command > Start engine	Digital input	Pulse	Optional. When the controller is in SEMI mode, 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 SEMI 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. When the controller is in SEMI mode, the operator or another system can activate this input to request the controller to start the engine and then synchronise and close the breaker.

Parameters (required)

Configure these parameters under **Configure > Parameters > Engine > Start sequence > Crank**.

Table 9.9 Crank parameters

Parameter	Range	Default	Comment
Crank on	1 s to 3 min	5 s	For the *Crank on* part of the start sequence, the controller activates the *Crank* output for this period.
Crank off	1 s to 3 min	5 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	400 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.

Configure these parameters under **Configure > Parameters > Engine > Start sequence > Start attempts**.

Parameter	Range	Default	Comment
Normal	1 to 10	3	This parameter limits the wear on the genset from too many start attempts. This is the maximum number of start attempts. If the genset does not start after these attempts, the *Start failure* alarm is activated.

Configure this parameter under **Configure > Parameters > Engine > Running detection > Engine ready**.

Parameter	Range	Default	Comment
Delay	1 s to 5 min	2 s	After *Running detection* is ON, the engine must run for this period before the breaker close sequence can start.

Parameters (optional)

Optional. You must configure the *Engine* > *Start prepare* digital output to see these parameters. Configure these parameters under **Configure > Parameters > Engine > Start sequence > Start prepare**.

Table 9.10 Start prepare parameters

Parameter	Range	Default	Comment
Start prepare	0 s to 5 min	5 s	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 to 20 s	0 s	Optional. The controller keeps the *Start prepare output* activated for this time during cranking.

Optional. You must configure the *Engine* > *Run coil* digital output to see these parameters. Configure these parameters under **Configure > Parameters > Engine > Start sequence > Run coil**.

Table 9.11 Run coil parameters

Parameter	Range	Default	Comment
Run coil before crank	0 s to 3 min	1 s	Optional. The controller activates the *Run coil* output for this time before the *Crank* output is activated.
During start attempts	Follow crank, Always on	Follow crank	**Follow crank**: If the start attempt fails, the controller deactivates the *Crank* output and the *Run coil*. **Always on**: 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.

Optional. You must configure the *Engine* > *Stop coil* digital output to see these parameters. Configure these parameters under **Configure > Parameters > Engine > Start sequence > Stop coil**.

Table 9.12 Stop coil parameters

Parameter	Range	Default	Comment
During crank off	Activated, Not activated	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 (optional)

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 > Control > Idle run** before starting the engine. The controller then waits for one of the engine conditions (coolant temperature, oil temperature, external input condition, or the maximum timer) to be fulfilled before increasing to nominal speed.

During the idle run start period, the operator can override the period and press **Start** on the display, the controller then cancels the idle run start period and increases to nominal speed.

Additionally, during the idle run start period, the operator can press **Stop** to abort the engine start sequence and run the engine stop sequence..

Optional. You must configure the *Engine* > *Control* > *Idle run* digital output to see these parameters.

NOTICE

Inhibited alarms before PCM APPL 1.0.14.x

The Idle run function requires a number of alarms to be inhibited, for example an inhibit on the under-frequency # alarm, in order for the engine to run at idle speed. For existing applications, which have been upgraded to PCM APPL 1.0.14.x or later, you must configure these inhibits manually on those protections. For each protection, for example Under-frequency 1, configure the inhibit Idle run active. For all new controllers supplied from DEIF from PCM APPL 1.0.14.x pre-installed, all the inhibits are configured by default.

Idle start (optional)

Configure these parameters under **Configure > Parameters > Engine > Idle run start > Idle run**.

Table 9.13 Idle run start parameters

Parameter	Range	Default	Comment
Enable	Not enabled, Enabled	Not enabled	Enables the engine to idle run until a condition is true before changing to nominal speed.
Extended inhibit	0 s to 60 min	2 s	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.

Configure these parameters under **Configure > Parameters > Engine > Idle run start > Minimum**.

Table 9.14 Minimum parameters

Parameter	Range	Default	Comment
Use	Not enabled, Enabled	Enabled	Uses minimum set point to determine if the engine is ready to increase to nominal speed.
Delay	0 s to 120 min	5 s	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.

Configure these parameters under **Configure > Parameters > Engine > Idle run start > Coolant temperature**.

Table 9.15 Coolant temperature parameters

Parameter	Range	Default	Comment
Use	Not enabled, 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	50 °C	The temperature the engine coolant must reach before ending the idle run start.

Configure these parameters under **Configure > Parameters > Engine > Idle run start > Oil temperature**.

Table 9.16 Oil temperature parameters

Parameter	Range	Default	Comment
Use	Not enabled, 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	40 °C	The temperature the engine oil must reach before ending the idle run start.

Configure these parameters under **Configure > Parameters > Engine > Idle run start > External condition**.

Table 9.17 External condition parameters

Parameter	Range	Default	Comment
Use	Not enabled, 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.

Configure these parameters under **Configure > Parameters > Engine > Idle run start > Maximum**.

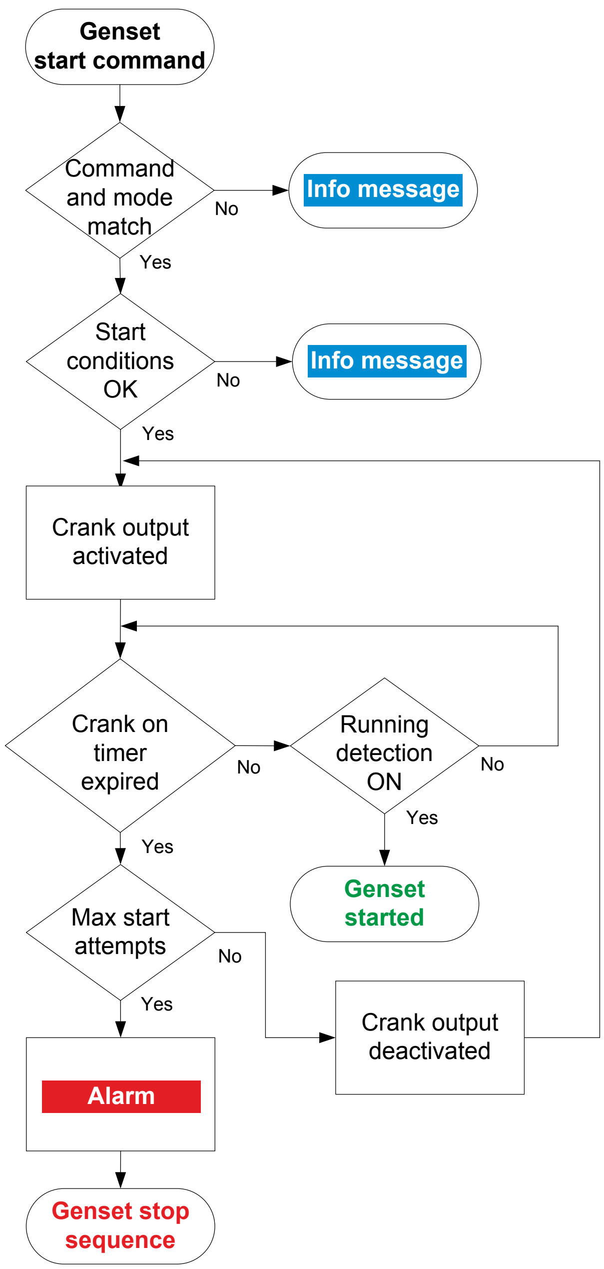
Table 9.18 Maximum parameters

Parameter	Range	Default	Comment
Use	Not enabled, Enabled	Enabled	Uses maximum set point to determine if the engine is ready to increase to nominal speed.
Delay	1 s to 120 min	60 s	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.

Table 9.19 Engine start flowchart *



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 SEMI mode, the command to start the genset can come from the following:
     - The operator can press the push-button **Start** on the display unit.
     - 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. **Crank output activated:** If all the start conditions are OK, the controller activates the *Crank* output and a timer.
4. **Running detection ON:** While the start timer runs, the controller checks whether *Running detection* is ON.
   - When the controller detects that the genset is running, the genset start is complete.
5. **Crank on timer expired:** If *Running detection* is OFF after the *Crank on* timer runs out, the controller checks the number of start attempts:
   - If the maximum number of start attempts has not been reached, the controller attempts to start the genset again.
   - If the maximum number of start attempts has been reached, the controller activates the *Start failure* alarm and stops the engine.

NOTE * Both *Start prepare* and *Idle run start* functions are not shown here.

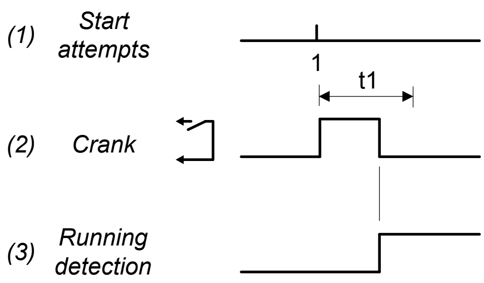
9.3.3 Engine start sequence

These sequence diagrams show the 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*.

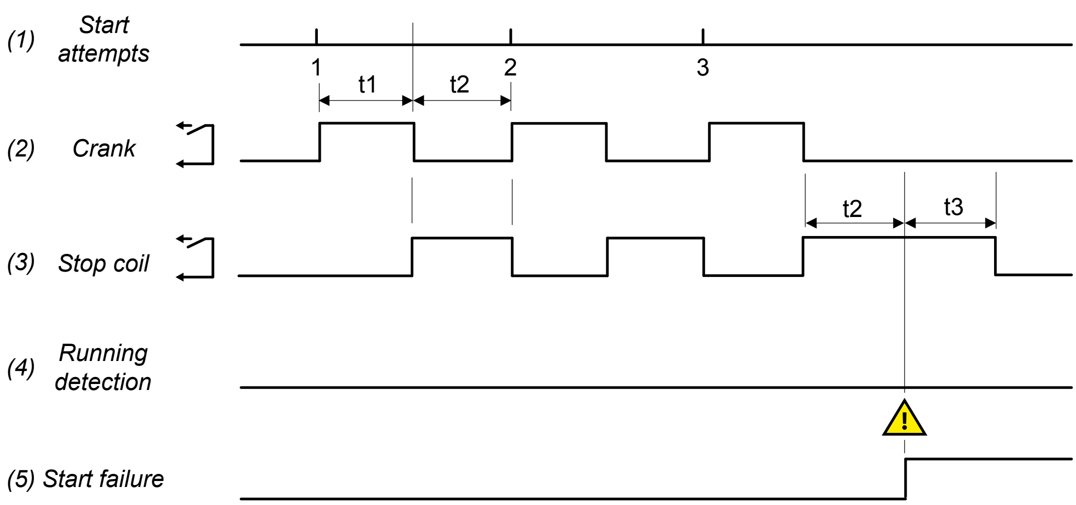
Figure 9.4 Successful engine start sequence for a stop coil system



t1 = Crank on (**Parameters > Engine > Start sequence > Crank > Crank on**)

1. **Start attempts**: The engine starts during the first start attempt.
2. **Crank**: *Engine* > *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.

Figure 9.5 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:

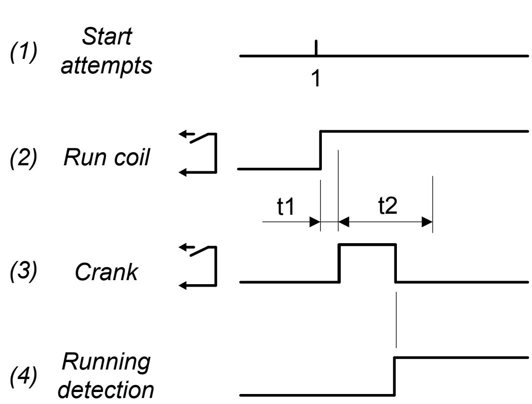
1. **Start attempts**: **Parameters > Engine > Start sequence > Start attempts > Normal** = 3.
2. **Crank**: *Engine* > *Crank* (digital output). The controller activates the *Crank* output for the *Crank on* time, and deactivates it for *Crank off* time.

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*.

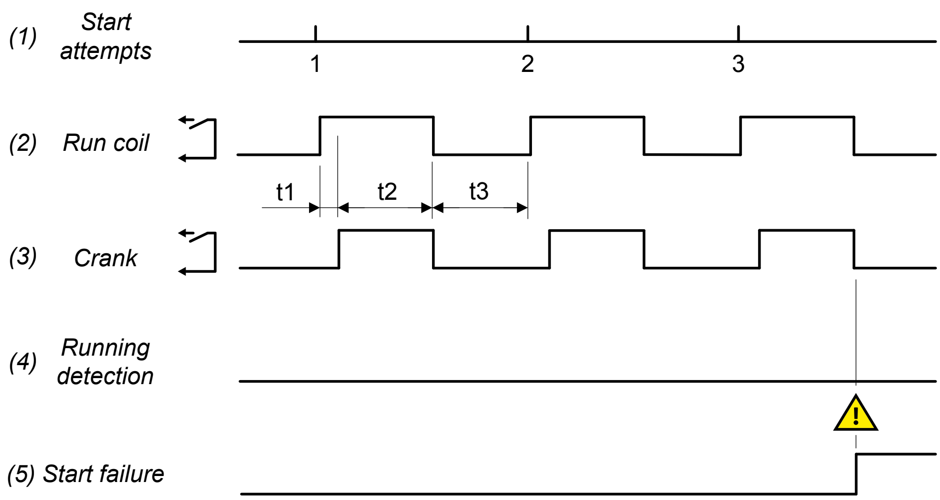
Table 9.20 Successful engine start sequence for a run coil system



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.

Figure 9.6 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**)

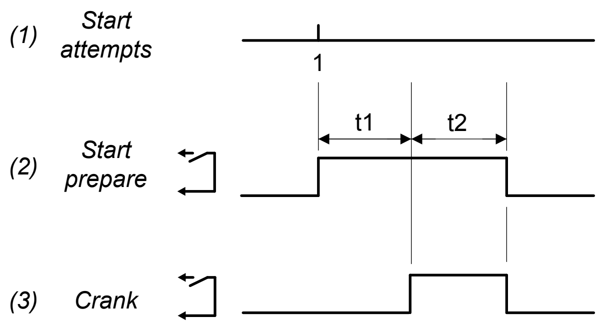
1. **Start attempts**: **Parameters > Engine > Start sequence > Start attempts > Normal** = 3.
2. **Run coil**: *Engine* > *Run coil* (digital output). The controller activates the *Run coil* at the time in the *Run coil before crank* parameter. If *Running detection* is still OFF after cranking, the 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* > *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.

Start prepare (optional)

You can use the optional *Engine* > *Start prepare* digital output with a stop coil or a run coil system.

Table 9.21 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* > *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* > *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 SEMI 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*

INFO
The *Block* alarm action will not interrupt the genset start sequence after it has begun. However, the *Block* alarm action prevents a new genset start sequence from starting.

When the start sequence is interrupted, the controller does the following:

- Deactivates the *Crank* output.
- Activates the *Stop coil* output (if present). Alternatively, deactivates the *Run coil* output (if present).
- Deactivates the *Start prepare* output (if present).

There is no cooldown period when the engine start sequence is interrupted.

INFO
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 SEMI 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.

Inputs and outputs

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

Table 9.22 Optional inputs for the engine stop function

Function	I/O	Type	Details
Engine > Command > Stop engine	Digital input	Pulse	Optional. When the controller is in SEMI mode, the operator or another system can activate this input to request the controller to stop the engine.
Engine > Control > 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 SEMI 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

Configure this parameter under **Configure > Parameters > Engine > Stop sequence > Cooldown**.

Parameter	Range	Default	Comment
Cooldown time	1 s to 3 h	240 s	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	0 °C	Optional. The engine cooldown stops if the engine coolant water temperature reaches this threshold before the cooldown timer expires.

Configure these parameters under **Configure > Parameters > Engine > Stop sequence > Extended stop**.

Parameter	Range	Default	Comment
Stop coil activated	1 s to 3 min	5 s	The *Stop coil* remains activated for this period after *Running detection* is OFF. During this period a new start attempt is not possible.

Idle run (optional)

You can 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 > Control > 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* > *Control* > *Idle run* digital output to see these parameters.

NOTICE

Inhibited alarms before PCM APPL 1.0.14.x

The Idle run function requires a number of alarms to be inhibited, for example an inhibit on the under-frequency # alarm, in order for the engine to run at idle speed. For existing applications, which have been upgraded to PCM APPL 1.0.14.x or later, you must configure these inhibits manually on those protections. For each protection, for example Under-frequency 1, configure the inhibit Idle run active. For all new controllers supplied from DEIF from PCM APPL 1.0.14.x pre-installed, all the inhibits are configured by default.

Idle stop (optional)

Configure these parameters under **Configure > Parameters > Engine > Idle run stop > Idle run**.

Table 9.23 Idle run stop parameters

Parameter	Range	Default	Comment
Enable	Not enabled, Enabled	Not enabled	Enables the engine to idle run until a condition is true before stopping the engine.

Configure these parameters under **Configure > Parameters > Engine > Idle run stop > Minimum**.

Table 9.24 Minimum parameters

Parameter	Range	Default	Comment
Use	Not enabled, Enabled	Enabled	Uses minimum set point to determine if the engine is ready to stop.
Delay	0 s to 120 min	5 s	This is the minimum time the idle run stop is active.

Configure these parameters under **Configure > Parameters > Engine > Idle run stop > Coolant temperature**.

Table 9.25 Coolant temperature parameters

Parameter	Range	Default	Comment
Use	Not enabled, Enabled	Enabled	Uses coolant temperature set point to determine if the engine is ready to stop.
Set point	- 50 to 200 °C	90 °C	The temperature the engine coolant must reach before ending the idle run stop.

Configure these parameters under **Configure > Parameters > Engine > Idle run stop > Oil temperature**.

Table 9.26 Oil temperature parameters

Parameter	Range	Default	Comment
Use	Not enabled, Enabled	Enabled	Uses oil temperature set point to determine if the engine is ready to stop.
Set point	- 50 to 200 °C	60 °C	The temperature the engine oil must reach before ending the idle run stop.

Configure these parameters under **Configure > Parameters > Engine > Idle run stop > External condition**.

Table 9.27 External condition parameters

Parameter	Range	Default	Comment
Use	Not enabled, 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.

Configure these parameters under **Configure > Parameters > Engine > Idle run stop > Maximum**.

Table 9.28 Maximum parameters

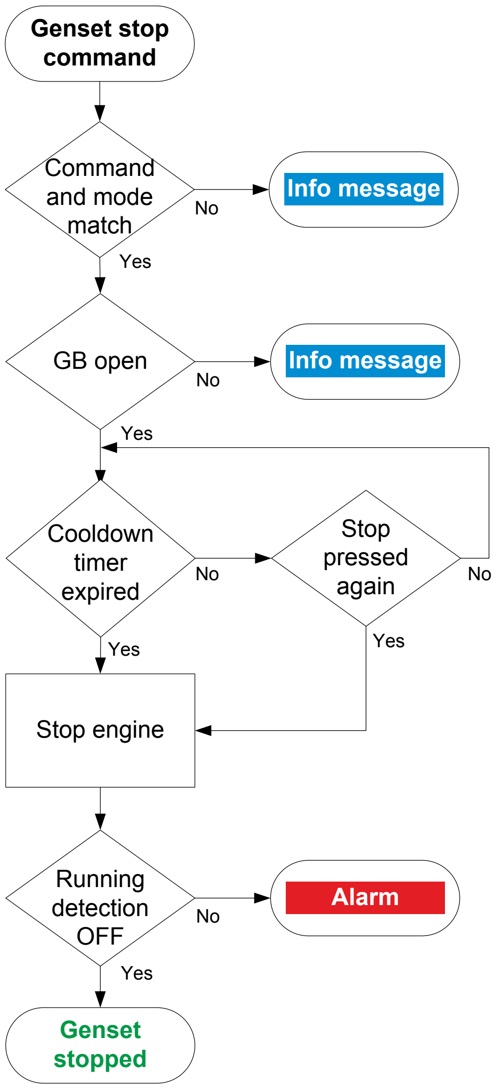
Parameter	Range	Default	Comment
Use	Not enabled, Enabled	Enabled	Uses maximum set point to determine if the engine is ready to stop.
Delay	1 s to 120 min	60 s	This is the maximum time the idle run stop can operate.

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.

Table 9.29 Engine stop flowchart *



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 SEMI mode, the command to stop the genset 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 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.

NOTE * *Idle run stop* function is not shown here.

9.4.3 Engine stop sequence

These sequence diagrams show the engine stop sequence.

Figure 9.7 Engine stop sequence for a stop coil system

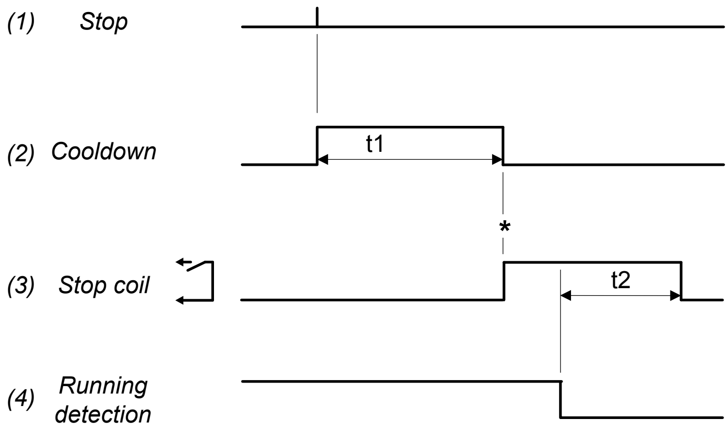
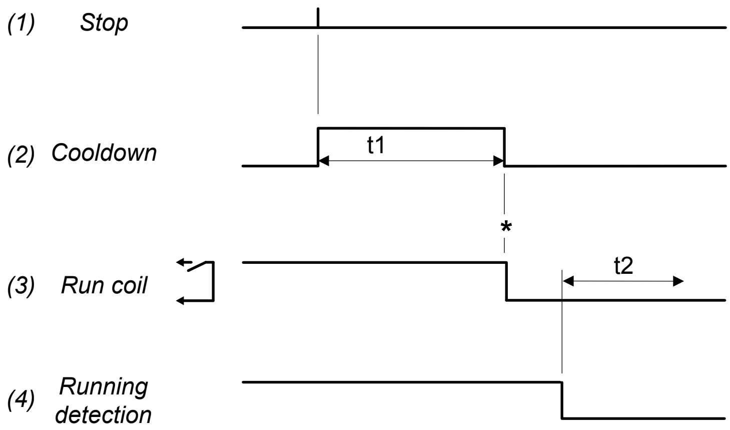


Figure 9.8 Engine stop sequence for a run coil system



t1 Cooldown (**Configure > Parameters > Engine > Stop sequence > Cooldown > Normal**)

t2 Extended stop (**Configure > Parameters > Engine > Stop sequence > Extended stop > Stop coil activated**)

* 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 the **Engine stop flowchart** for more information.
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* > *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* > *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 an analogue input with the *Engine > Cooldown > Coolant water [C]* function and **Configure > Parameters > Engine > Stop sequence > Cooldown > Temperature threshold**.

INFO
You must configure the analogue input function to see the parameters.

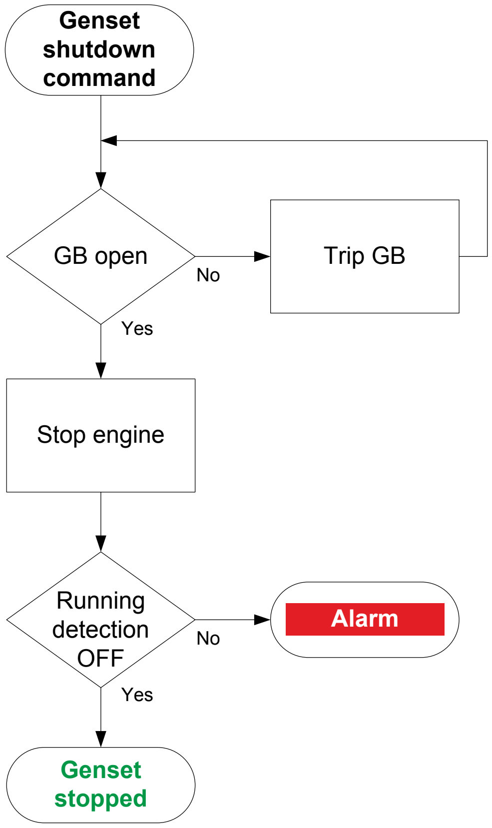
9.4.4 Engine shutdown flowchart

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.

Table 9.30 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.

INFO
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 Introduction

The generator breaker (GB) connects the genset to the busbar. The genset must be running, and synchronised with the busbar, for the generator breaker to close. The generator breaker is an important part of the system safety, and trips to protect the genset from problems on the busbar. The generator breaker also trips to stop genset problems from disturbing the busbar.

General breaker information

More information
See the **Breakers, synchronisation and de-loading** chapter for more information on synchronisation and breakers. This includes the inputs and output functions and the parameters to configure.

[Breaker] refers to *Generator breaker*. The breaker abbreviation (*[*B]*) is *GB*.

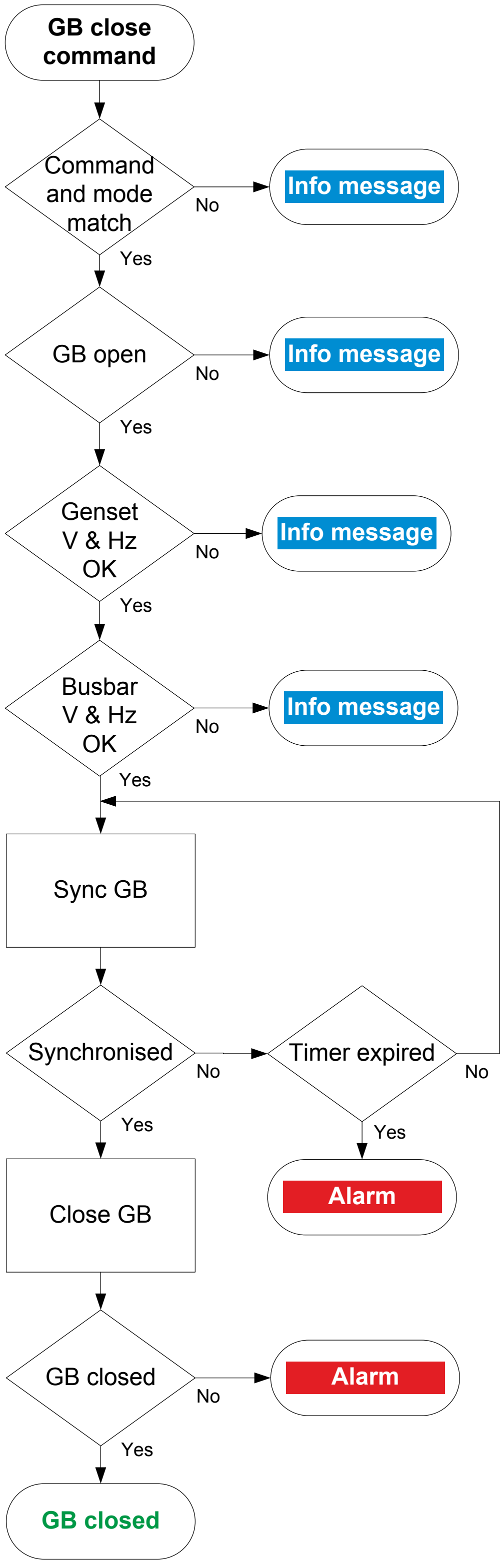
9.5.2 Generator breaker close flowchart

The following flowchart shows the sequence that the controller normally uses to close the generator breaker.

More information
See **Generator breaker blackout close flowchart** for information about how to allow the genset 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 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 close the generator breaker. The controller ignores all other external commands.
   - In SEMI 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* > *Control* > *GB Close* output to close the breaker.
   - If the genset and busbar do not synchronise within the time allowed, the controller activates a *GB synchronisation failure* alarm.
6. **GB closed:** The controller checks whether the generator breaker has closed.
   - If the generator breaker has closed, the generator breaker close sequence has been completed successfully.
   - If the generator breaker has not closed, the controller activates the *GB closing failure* alarm.

*Note: See **Configure > Parameters > [Source] / [Busbar] AC setup > Voltage and frequency OK** for these ranges.

9.5.3 Generator breaker blackout close

The power management system can automatically close the generator breaker as part of the blackout response.

More information
See **Power management**, **Blackout** 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 SEMI mode, the operator cannot close the breaker by pushing the push button **Close breaker** on the display unit.

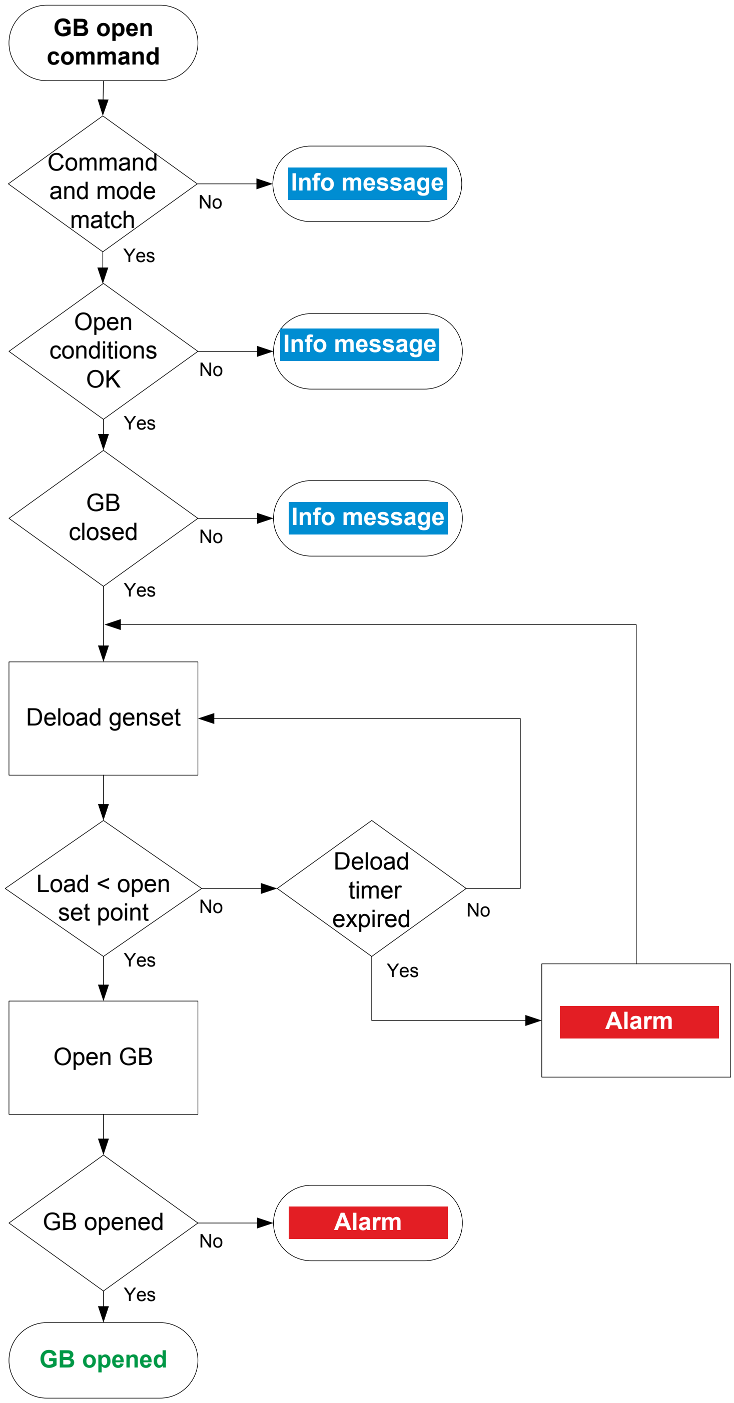
9.5.4 Generator breaker open flowchart

The following 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*.

INFO
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.

INFO
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 the push-button **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 SEMI mode, the command to open the genset 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. **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 *Generator breaker* > *Control* > *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.
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

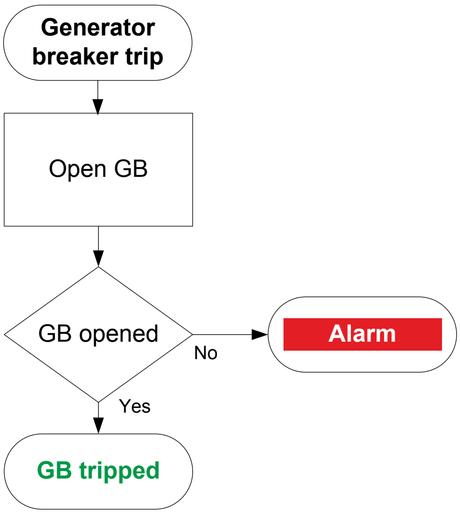
The controller automatically trips the generator breaker (GB) for these alarm actions:

- 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.

Table 9.31 Generator breaker trip flowchart



1. **Open GB**: When a trip is required, the controller activates the *Breakers > Generator breaker > Control > 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 Other GENSET controller functions

9.6.1 Temperature-controlled start & stop

You can use this optional function to prevent the engine from getting so cold that it cannot start. When the temperature falls below a certain value, third party equipment must activate the digital input.

This function works in both AUTO and SEMI mode, but not when the controller is under Switchboard control.

Assign the input under **Configure > Input/output > [Hardware module] > DI**.

Function	I/O	Type	Details
Engine > Function > Temperature-controlled start/stop	Digital input	Continuous	**Activated**: The controller starts the engine. **Deactivated**: The controller stops the engine if no other function requires the engine to run.

9.6.2 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.

Inputs and outputs

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

Function	I/O	Type	Details
Engine > Control > Priming	Digital output	Continuous	Optional. Use this output to prime the engine at regular intervals.

Parameters

To see these parameters, you must assign the *Priming* function to a digital output. Configure these parameters under **Configure > Parameters > Engine > Maintenance > Priming**.

Parameter	Range	Default	Comment
Enable	Not enabled, Enabled	Not enabled	**Not enabled**: The controller does not activate the *Priming* output.

Parameter	Range	Default	Comment
			Enabled: After the engine stops, the controller activates the *Priming* output for the period configured under *ON timer*. The controller then deactivates the output for the period configured under *OFF timer*. The on and off cycle repeats until the engine starts.
ON timer	0 s to 1 h	5 s	The priming period.
OFF timer	0 s to 1 h	30 s	The interval between each priming.

9.6.3 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.

Inputs and outputs

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

Function	I/O	Type	Details
Engine > Power derate > Temperature > Derate # temperature [C] (where # is 1 to 3)	Analogue input	The measurement must be in °C.	This can measure any temperature, for example, the engine cooling water.

Parameters

Configure these parameters under **Configure > Parameters > Engine > Temperature > Power derate #**, where # is 1, 2 or 3.

INFO
The analogue input(s) must be configured to see the power derate parameter and curve.

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 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.

More information
See **Parameters, Tasks, Edit a parameter curve** in the **PICUS manual** for more information.

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.

9.6.4 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.

Inputs and outputs

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

Function	I/O	Type	Details
Engine > Power derate > Percentage > Derate percentage [%]	Analogue input	The measurement must be in %.	

Parameters

Configure these parameters under **Configure > Parameters > Engine > Power derate > Percentage**.

INFO
The analogue input(s) must be configured to see the power derate parameter and curve.

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 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.

9.6.5 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.

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

Table 9.32 Engine operating value outputs

Function	I/O	Units	Details
Engine > Power derate > Derate # temperature [C], where # is 1 to 3	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 engine derate temperature.
Engine > Running detection > Oil [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.

Function	I/O	Units	Details
Engine > Running detection > 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 > Cooldown > 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.

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 (*Engine > Running detection > MPU [RPM]*) can be displayed.

9.6.6 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.

Outputs

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

Table 9.33 Engine state functions

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.

9.6.7 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)

INFO
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.

Configure the digital outputs under **Input/output > Digital output > Generator > Energy counters > [Counter pulse]**.

INFO
You must configure the digital output function to see the parameters.

Configure the energy transfer required for a pulse under **Parameters > Generator > Energy counters > [Counter]**

Table 9.34 Active energy export counter parameters

Parameter	Range	Default	Comment
Pulse every	1 kWh to 10 MWh	10 kWh	The value when a digital output sends a pulse.
Pulse length	0.1 s to 1 h	1 s	The length of the pulse that is sent. This value should be long enough so the pulse can be registered by the external counter.

Table 9.35 Reactive energy export counter parameters

Parameter	Range	Default	Comment
Pulse every	1 kvarh to 10 Mvarh	10 kvarh	The value when a digital output sends a pulse.
Pulse length	0.1 s to 1 h	1 s	The length of the pulse that is sent. This value should be long enough so the pulse can be registered by the external counter.

Table 9.36 Energy counter function and corresponding parameter full names

[Counter pulse]	[Counter]
Active energy export pulse 1	Active energy export
Reactive energy export pulse 1	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 1*.
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.

9.6.8 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.

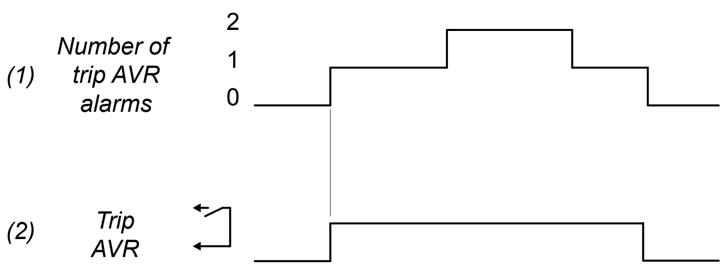
Inputs and outputs

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

Function	I/O	Type	Details
[Source] > 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.

Function	I/O	Type	Details
			When the output is active, the controller pauses AVR regulation.

Table 9.37 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**: *[Source]* > *AVR* > *Trip AVR* (digital output). The controller activates this output until all alarms with a *Trip AVR* (or similar) alarm action are not active.

9.7 GENSET controller alarms

9.7.1 GENSET controller alarms

INFO
These alarms are in addition to the AC protections and general alarms for PPM 300 controllers.

Table 9.38 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
	EIM3.1 # relay 4 wire break (where # is 1 to 3)
	Engine stop (external)
	Engine start (external)
	Start enable removed during start
	Total running hours notification
	Trip running hours notification
	Magnetic pickup wire break
Generator	Voltage or frequency not OK
	AVR regulation error
Load sharing	P load sharing failure
	Q load sharing failure

	Alarms
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
	GOV stand-alone configuration error*
	AVR stand-alone configuration error*
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)
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 SEMI mode
	Trip AVR output not configured

*Note: Only in GAM3.2.

9.7.2 Alarm actions

The GENSET 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.

9.7.3 Inhibits

The controller includes the following inhibits:

Table 9.39 Controller 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.
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 systems > Inhibits > Activate inhibit 2* digital input is activated.
Inhibit 3	The *Alarm systems > Inhibits > Activate inhibit 3* digital input is activated.

9.7.4 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 GENSET controller, as well as which general alarm corresponds to each GENSET controller alarm.

Table 9.40 Breaker alarm names for the GENSET controller

GENSET alarm	Configure > Parameters >	General name
GB synchronisation failure	Breakers > Generator breaker monitoring > Synchronisation failure	Breaker synchronisation failure
GB de-load failure	Breakers > Generator breaker monitoring > De-load failure	Breaker de-load failure
Vector mismatch	Breakers > Generator breaker monitoring > Vector mismatch	Vector mismatch
GB opening failure	Breakers > Generator breaker monitoring > Opening failure	Breaker opening failure
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

GENSET alarm	Configure > Parameters >	General name
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

9.7.5 AC alarms

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

The following tables show where to configure these alarms for the GENSET controller.

Table 9.41 Generator AC alarm names for the GENSET controller

Controller alarm	Configure > Parameters >	General name
Generator over-voltage 1 or 2	Generator > Voltage protections > Over-voltage 1 or 2	Over-voltage
Generator under-voltage 1 or 2	Generator > Voltage protections > Under-voltage 1 or 2	Under-voltage
Generator voltage unbalance	Generator > Voltage protections > Voltage unbalance	Voltage unbalance
Negative sequence voltage	Generator > Voltage protections > Negative sequence voltage	Negative sequence voltage
Zero sequence voltage	Generator > Voltage protections > Zero sequence voltage	Zero sequence voltage
Generator over-current 1 or 2	Generator > Current protections > Over-current 1 or 2	Over-current
Fast over-current 1 or 2	Generator > Current protections > Fast over-current 1 or 2	Fast over-current
Current unbalance (average calc.)	Generator > Current protections > Current unbalance (average calc.)	Current unbalance (average calc.)
Current unbalance (nominal calc.)	Generator > Current protections > Current unbalance (nominal calc.)	Current unbalance (nominal calc.)
Directional over-current 1 or 2	Generator > Current protections > Directional over-current 1 or 2	Directional over-current
Inverse time over-current	Generator > Current protections > Inverse time over-current	Inverse time over-current
Negative sequence current	Generator > Current protections > Negative sequence current	Negative sequence current
Zero sequence current	Generator > Current protections > Zero sequence current	Zero sequence current
Stabilised differential current	Generator > Current protections > Stabilised differential current	Stabilised differential current
High set differential current	Generator > Current protections > High set differential current	High set differential current
Generator over-frequency 1 or 2	Generator > Frequency protections > Over-frequency 1 or 2	Over-frequency
Generator under-frequency 1 or 2	Generator > Frequency protections > Under-frequency 1 or 2	Under-frequency
Overload 1 or 2	Generator > Power protections > Overload 1 or 2	Overload
Reverse power 1 or 2	Generator > Power protections > Reverse power 1 or 2	Reverse power
Reactive power export 1 or 2	Generator > Reactive power protections > Reactive power export 1 or 2	Reactive power export
Reactive power import 1 or 2	Generator > Reactive power protections > Reactive power import 1 or 2	Reactive power import

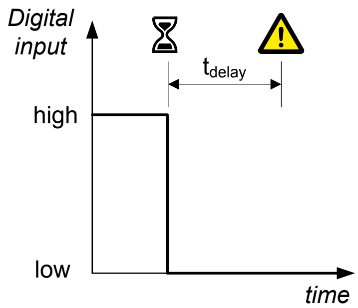
Table 9.42 Busbar AC alarm names for the GENSET controller

Controller alarm	Configure > Parameters >	General name
Busbar over-voltage 1 or 2	Busbar > Voltage protections > Over-voltage 1 or 2	Busbar over-voltage
Busbar under-voltage 1 or 2	Busbar > Voltage protections > Under-voltage 1 or 2	Busbar under-voltage
Busbar voltage unbalance	Busbar > Voltage protections > Voltage unbalance	Busbar voltage unbalance
Busbar over-frequency 1 or 2	Busbar > Frequency protections > Over-frequency 1 or 2	Busbar over-frequency
Busbar under-frequency 1 or 2	Busbar > Frequency protections > Under-frequency 1 or 2	Busbar under-frequency

9.7.6 Emergency stop

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

When this input is present, the alarm is always enabled. The alarm parameters are not visible. The alarm action is *Trip generator breaker and shutdown engine*, latch enabled.



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

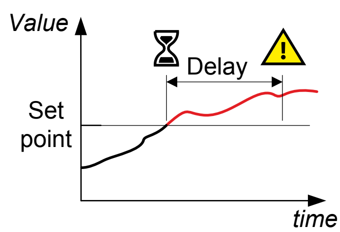
Function	I/O	Type	Details
Alarm system > Additional functions > Emergency stop	Digital input	Continuous	Wire the emergency stop digital input so that it is normally activated. If the emergency stop digital input is not activated, then controller activates the *Emergency stop* alarm.

CAUTION
The *Emergency stop* is part of the safety chain, 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.

9.7.7 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.



Configure these parameters under **Configure > Parameters > Engine > Protections > Overspeed #**, where # is 1 or 2.

Table 9.43 Default parameters

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

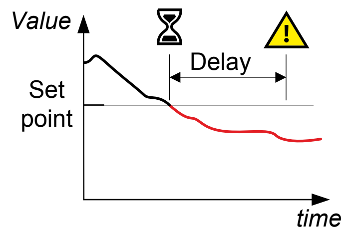
Parameter	Range	Overspeed 1	Overspeed 2
Enable	Not enabled, Enabled	Not enabled	Not enabled
Latch	Not enabled, Enabled	Not enabled	Enabled
Action		Warning	Trip generator breaker and shutdown engine

INFO
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.

9.7.8 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.



Configure these parameters under **Configure > Parameters > Engine > Protections > Underspeed #**, where # is 1 or 2.

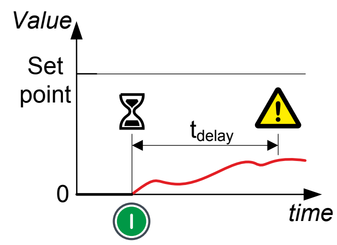
Table 9.44 Default parameters

Parameter	Range	Underspeed 1	Underspeed 2
Set point (lower than)	0 to 100 % of nominal speed	90 %	80 %
Delay	0 s to 3 min	5 s	1 s
Enable	Not enabled, Enabled	Not enabled	Not enabled
Action		Warning	Warning
Inhibit(s)		• Engine not running • Idle run active	• Engine not running • Idle run active

9.7.9 Crank failure

The alarm response is based on the MPU/W/NPN/PNP input. This alarm is only available if the magnetic pickup (MPU) has been chosen as the primary running feedback.

The timer starts when cranking starts (that is, when the *Crank* output is activated). The alarm is activated if the set point has not been reached within the delay time.



Configure the parameters under **Configure > Parameters > Engine > Start sequence > Crank failure**.

Table 9.45 Default parameters

Parameter	Range	Default
Set point (lower than)	1 to 400 RPM	50 RPM
Delay	0 s to 3 min	20 s

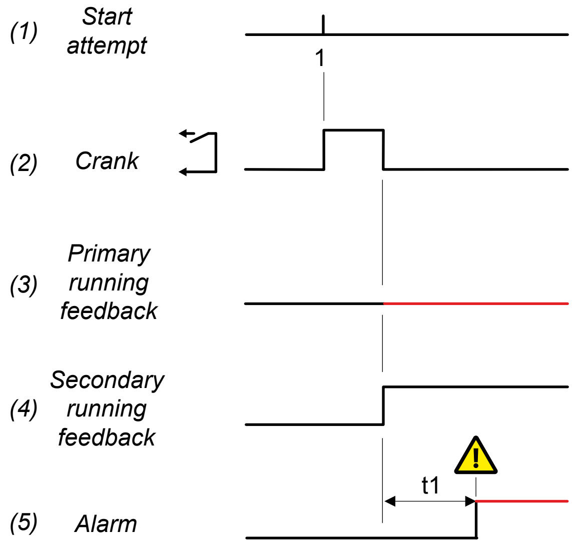
Parameter	Range	Default
Enable	Not enabled, Enabled	Not enabled
Action		Warning

9.7.10 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.



Configure the parameters under **Configure > Parameters > Engine > Running detection > Primary running feedback failure**. The alarm is always *Enabled*.

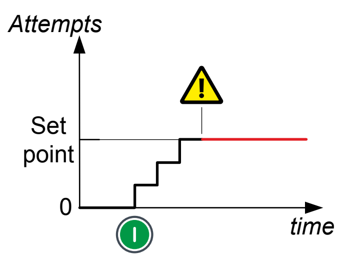
Table 9.46 Default parameters

Parameter	Range	Default
Delay	0 s to 3 min	2 s
Latch	Not enabled, Enabled	Enabled
Action		Warning

9.7.11 Start failure

This alarm is for genset start failure.

If the genset has not started after the maximum number of start attempts are completed (see the parameter *Normal*), the controller activates this alarm.



Configure number of start attempts under **Configure > Parameters > Engine > Start sequence > Start attempts**.

Table 9.47 Default parameter

Parameter	Range	Default
Normal	1 to 10	3

Configure the start failure parameters under **Configure > Parameters > Engine > Start sequence > Start failure**.

Table 9.48 Default parameters

Parameter	Range	Default
Enable	Not enabled, Enabled	Enabled
Latch	Not enabled, Enabled	Enabled
Action		Block

9.7.12 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.

Configure the parameters under **Configure > Parameters > Engine > Start sequence > Start enable remove during start**.

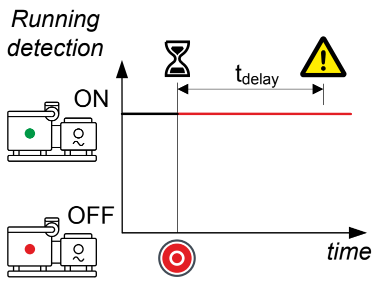
Table 9.49 Default parameters

Parameter	Range	Default
Alarm action		Warning
Enable	Not enabled, Enabled	Not enabled

9.7.13 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.



Configure the parameters under **Configure > Parameters > Engine > Stop sequence > Stop failure**.

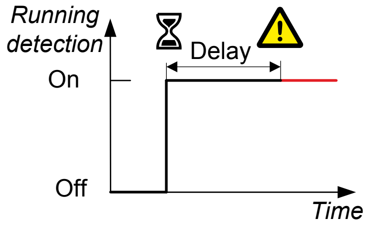
Table 9.50 Default parameters

Parameter	Range	Default
Delay	0 s to 5 m	30 s
Enable	Not enabled, Enabled	Enabled
Action		Warning

9.7.14 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.



Configure the parameters under **Configure > Parameters > Engine > Start sequence > Engine started (external)**.

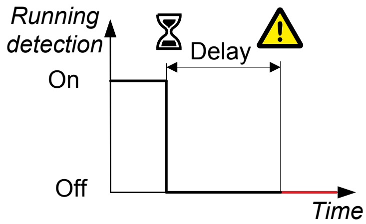
Table 9.51 Default parameters

Parameter	Range	Default
Enable	Not enabled, Enabled	Enabled
Action		Warning

9.7.15 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.



Configure the parameters under **Configure > Parameters > Engine > Stop sequence > Engine stopped (external)**.

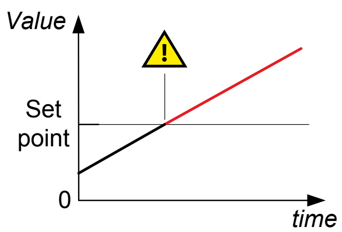
Table 9.52 Default parameters

Parameter	Range	Default
Enable	Not enabled, Enabled	Enabled
Latch	Not enabled, Enabled	Enabled
Action		Block

9.7.16 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.



Configure these parameters under **Configure > Parameters > Engine > Maintenance > Running hours total**.

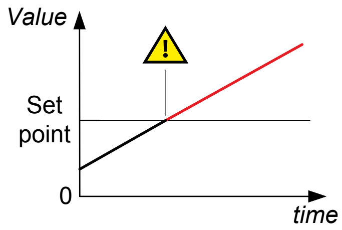
Table 9.53 Default parameters

Parameter	Range	Running hours total
Set point	0 to 1,000,000 hours	500 hours
Enable	Not enabled, Enabled	Not enabled
Action		Warning

9.7.17 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.



Configure these parameters under **Configure > Parameters > Engine > Maintenance > Running hours trip**.

Table 9.54 Default parameters

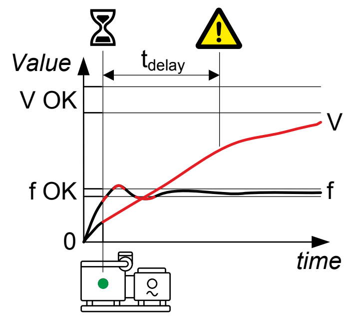
Parameter	Range	Running hours trip
Set point	0 to 1,000,000 hours	500 hours
Enable	Not enabled, Enabled	Not enabled
Action		Warning

9.7.18 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 source.



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

The alarm action is always *Block*.

Table 9.55 Default parameters

Parameter	Range	Voltage or frequency not OK
Delay	1 s to 1 h	30 s
Enable	Not enabled, Enabled	Enabled
Inhibit(s)		• Engine not running • [Breaker] closed

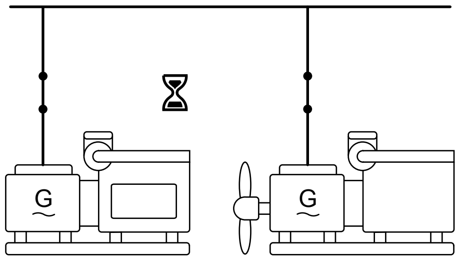
Parameter	Range	Voltage or frequency not OK
		• Idle run active

9.7.19 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 **Configure** > **Parameters** > **Local power management** > **Parallel timers** > **DG-SG max parallel time**. The alarm action is always *Trip generator breaker,* latch enabled.

Table 9.56 Default parameters

Parameter	Range	Default
Delay	0.1 s to 1 h	1 min
Enable	Not enabled, Enabled	Enabled

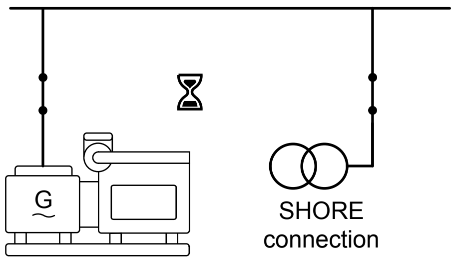
More information
See **SHAFT generator controller**, **SHAFT generator controller protections**, **SG-DG max. parallel time** for the alarm in the SHAFT generator controller that trips the shaft generator breaker.

9.7.20 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 **Configure** > **Parameters** > **Local power management** > **Parallel timers** > **DG-SC max parallel time**. The alarm action is always *Trip generator breaker*, latch enabled.

Table 9.57 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.

9.7.21 Other GENSET controller alarms

The following alarms are also included on the GENSET controller:

- EIM # relay 4 wire break
- Magnetic pickup wire break

More information
See **Hardware characteristics and configuration** for more information.

10. EMERGENCY genset controller

10.1 EMERGENCY genset controller overview

10.1.1 Description

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.

10.1.2 Application

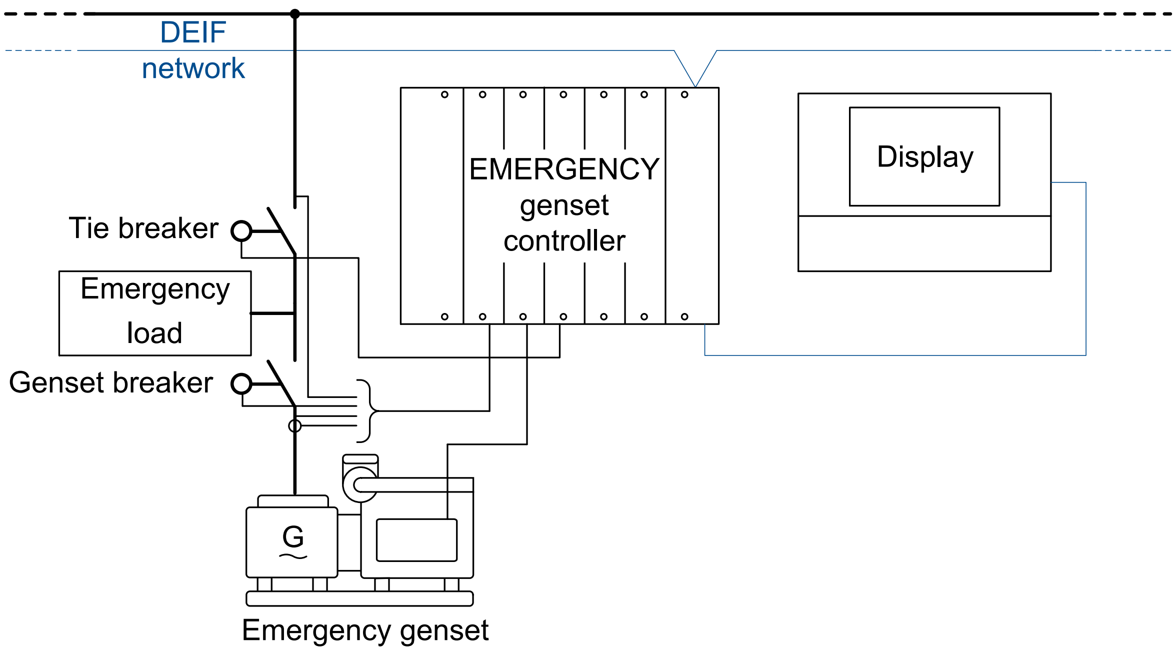
An EMERGENCY genset controller controls and protects an emergency genset (both the engine and the generator), as well as the generator breaker, and the emergency busbar tie breaker. By default, the EMERGENCY genset controller automatically starts the emergency generator when there is no voltage on the 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).

Figure 10.1 Example of an EMERGENCY genset controller application



10.1.3 EMERGENCY genset controller functions

	Functions
Pre-programmed sequences	• Blackout start • Genset start sequence and genset stop sequence ◦ Running detection ◦ 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 SEMI 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 unit
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

	Functions
	• 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)
	  ◦ 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 • Temperature-controlled start/stop

Control types	• Power management system (PMS) control
	  ◦ AUTO mode
	  ◦ SEMI 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
	• SEMI 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/SEMI/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 SEMI 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.

Generator nominal settings

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

Table 10.1 Controller nominal settings

Nominal setting	Range	Default	Notes
Voltage (V)	10 V to 160 kV	400 V	The phase-to-phase* nominal AC voltage for the genset.
Current (I)	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.
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	530 kVA	The nominal apparent power should be on the genset nameplate.
Power factor (PF)	0.6 to 1	0.9	The power factor should be on the genset nameplate.

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

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

Table 10.2 Nominal setting 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

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

Busbar nominal settings

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

Table 10.3 Controller nominal settings

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

10.2.2 Running detection

The controller can be configured to receive engine running feedback from a variety of measurements.

More information
See **GENSET controller**, **GENSET controller principles**, **Running detection** for more information.

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 more information.

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 more information.

10.2.5 Load sharing

During *Harbour mode*, the EMERGENCY genset controller shares the load with other DEIF controllers using the DEIF network.

More information
See **Power management**, **Load sharing** for more information.

10.2.6 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 EMERGENCY genset controller.

Table 10.4 AC configuration for the EMERGENCY genset controller

EMERGENCY genset	General name
Generator	[Source]
Busbar	[Busbar]

10.2.7 Breaker configuration

More information
The **Breakers, synchronisation and de-loading** chapter describes breaker configuration in general. For the EMERGENCY genset controller, replace "[Breaker]" with "Generator breaker" and "Tie breaker" in these descriptions.

10.3 Engine start

10.3.1 Engine start function

The controller software includes pre-programmed genset start sequences.

More information
See **GENSET controller**, **Engine start** for more information.

More information
See **EMERGENCY genset controller**, **EMERGENCY genset controller protections** for more information.

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

Configure this parameter under **Configuration > Parameters > 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

Configure these parameters under **Configuration > Parameters > Breakers > Tie breaker configuration > Configuration**.

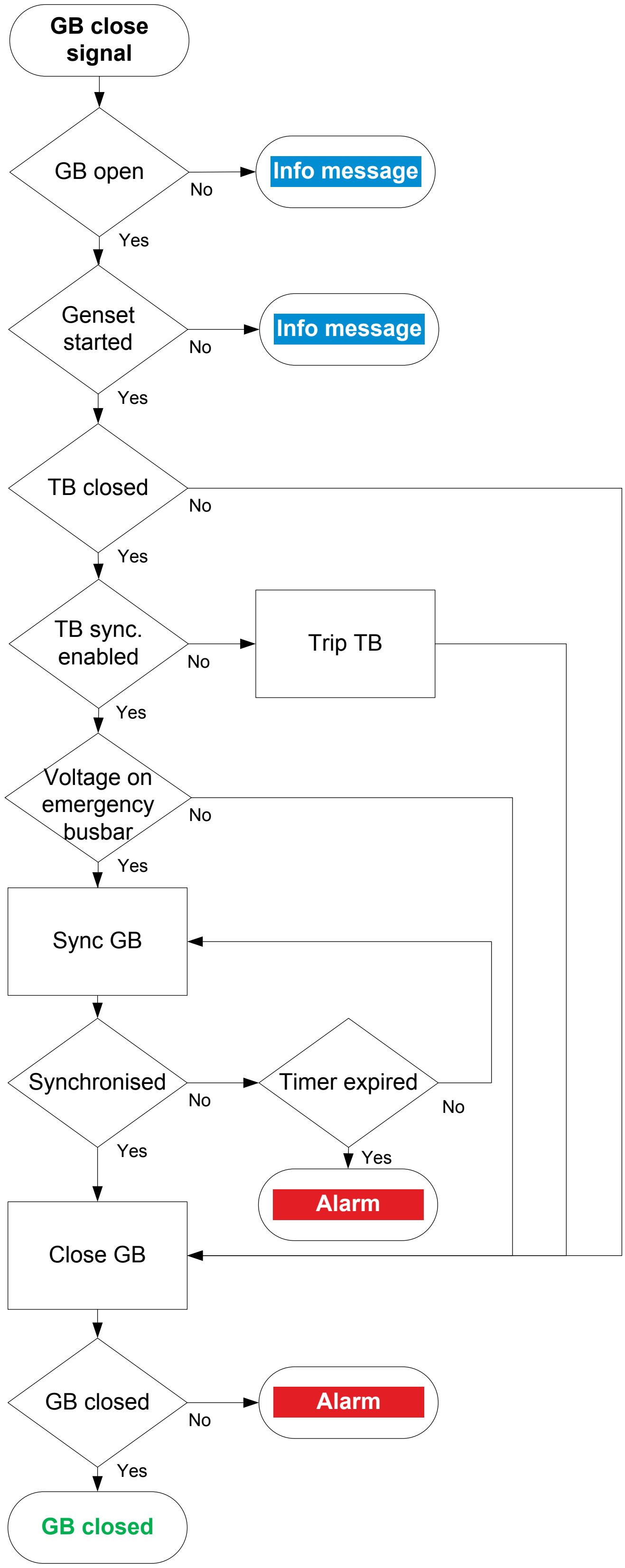
Parameter	Range	Default	Comment
Tie breaker sync. enabled	Not enabled, Enabled	Enabled	**Not enabled**: The tie breaker and the generator breaker can never be closed at the same time. The controller uses a short blackout to do a quick change from one supply to the other. The operator may hear "click-clack" as the one breaker opens and then the other breaker closes. • *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*.

Parameter	Range	Default	Comment
			• *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

The following flowchart below shows the sequence that the controller uses to close the generator breaker for the emergency genset.

This flowchart does not apply to switchboard control. When the controller is under switchboard control, it will not close the breaker. For example, if the operator presses the push-button **Close breaker** on the display unit, 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.

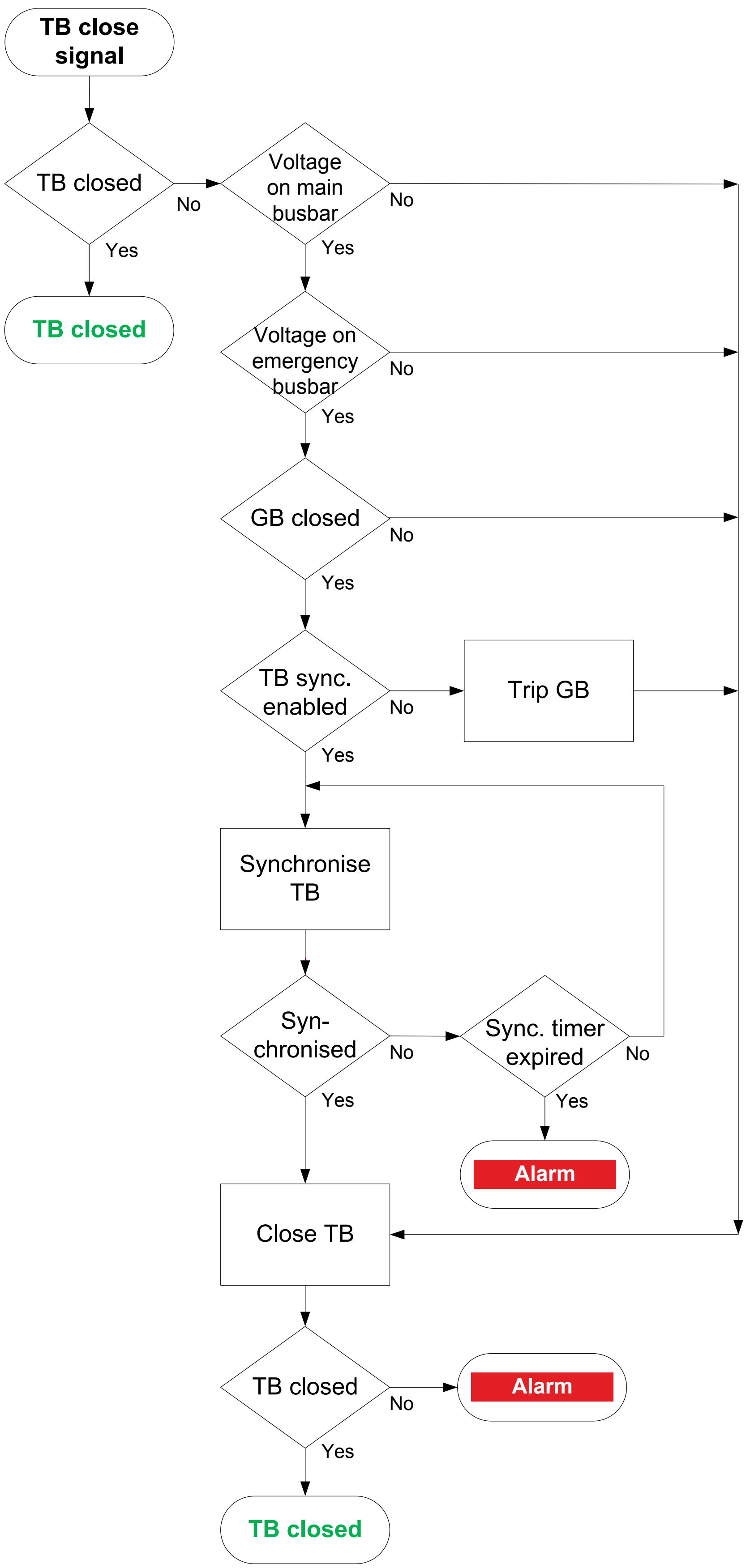
More information
See **Other EMERGENCY genset controller functions**, **Emergency genset configurations** in this chapter for more information about the configuration of the EMERGENCY genset controller.

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.

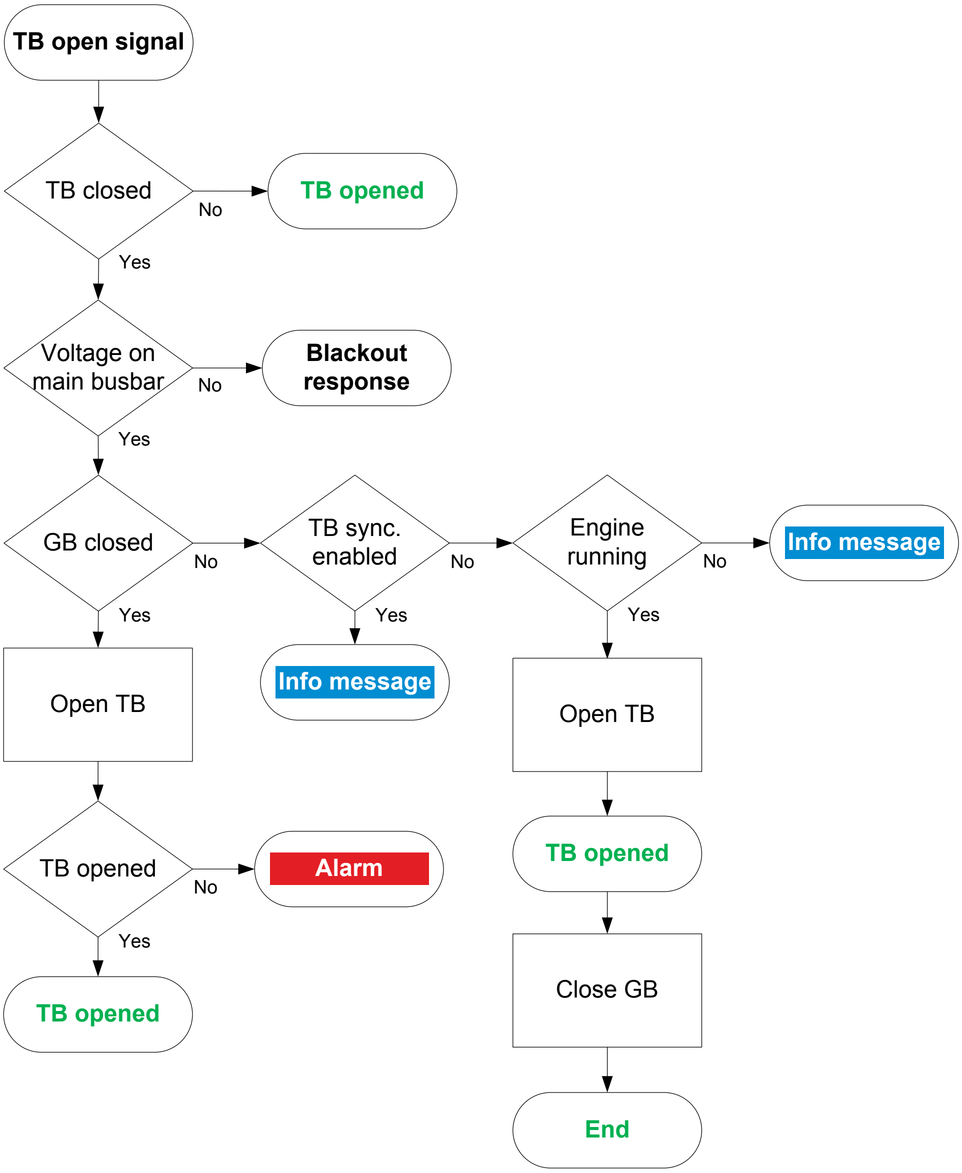
This flowchart does not apply to switchboard control. When the controller is under switchboard control, it will not close the breaker. If, for example, the operator presses the push-button **Close breaker** on the display unit, the controller ignores this command.



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.

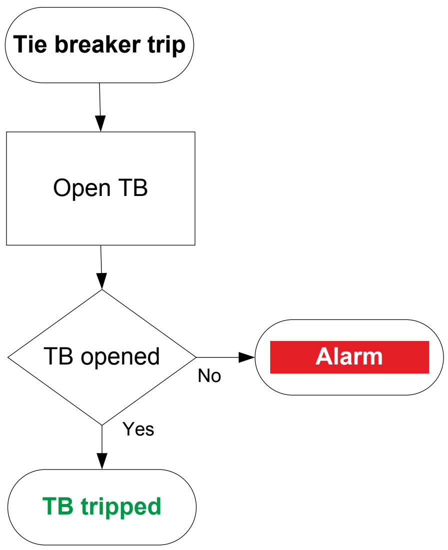
10.5.8 Tie breaker trip flowchart

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 10.5 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 SEMI mode by pressing the push-button **Test** on the display unit, or from a digital input. If **Test** is pressed (or the digital input is activated) when the controller is not in SEMI mode, then the info message *Not in SEMI 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.

Inputs

If needed, assign the digital input under **Configure > Input/output**. Select the hardware module, then select the digital input to configure.

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

Configure these parameters under **Configure > 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.

Configure this parameter under **Configure > Parameters > Local power management > Return modes**.

Parameter	Range	Default	Comment
After EDG test > Mode	• No mode change • SEMI 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 10.6 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.

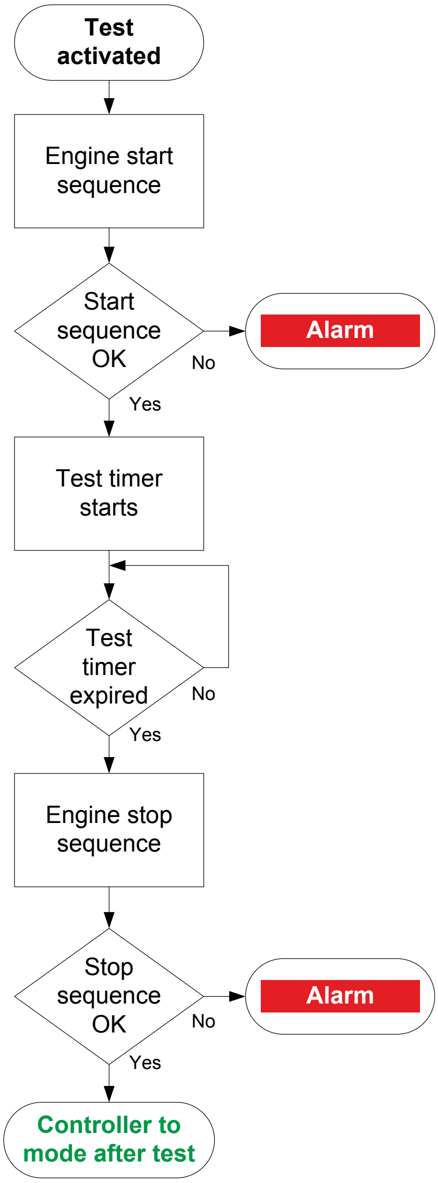
Emergency genset test and blackout

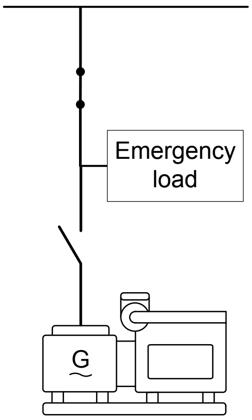
If there is a blackout during the emergency genset test, then the controller stops the test immediately, and starts the blackout response.

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.

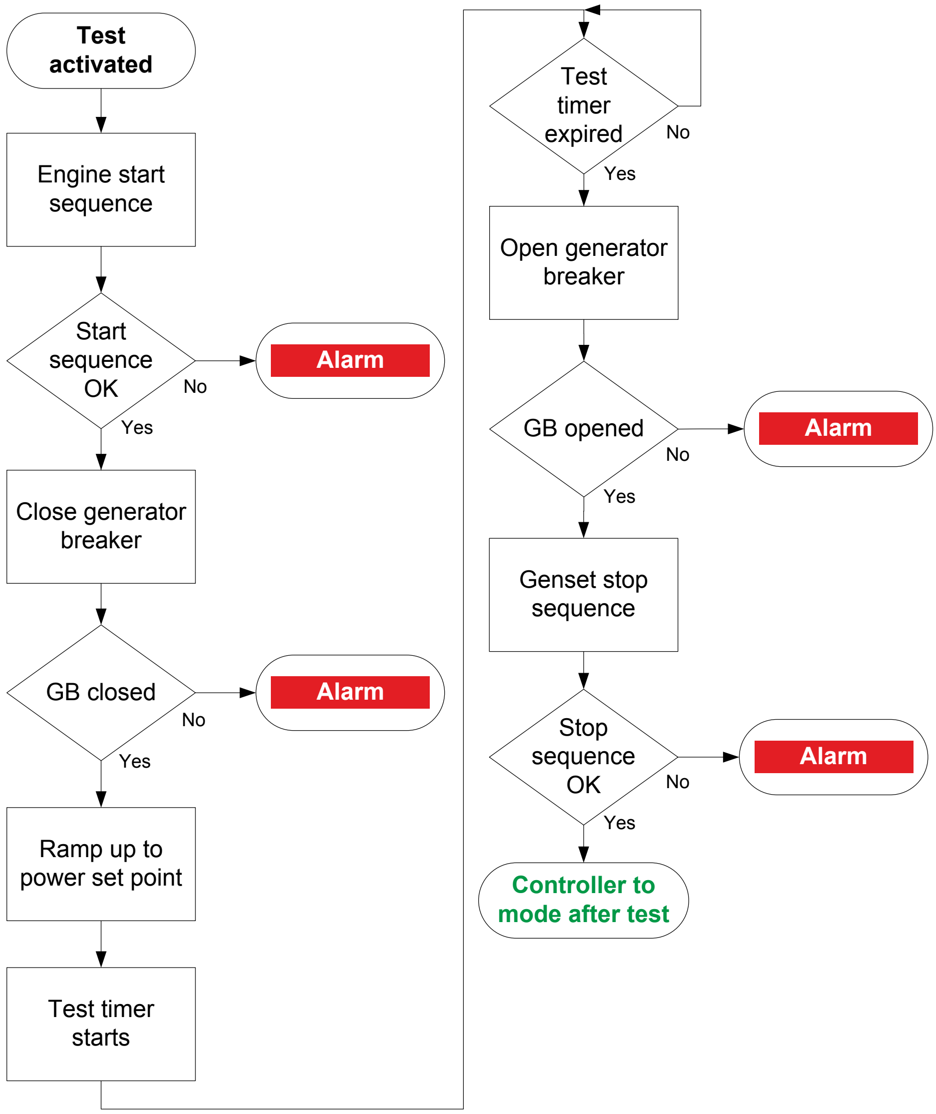


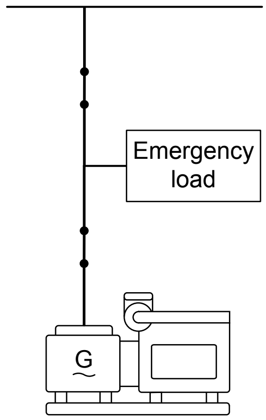


1. The controller starts the emergency genset when the TEST function is activated.
2. The test timer starts when the emergency genset has started.
3. The emergency genset runs at its nominal frequency (without synchronising or closing the genset breaker) until the test timer runs out.
4. After the test 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.

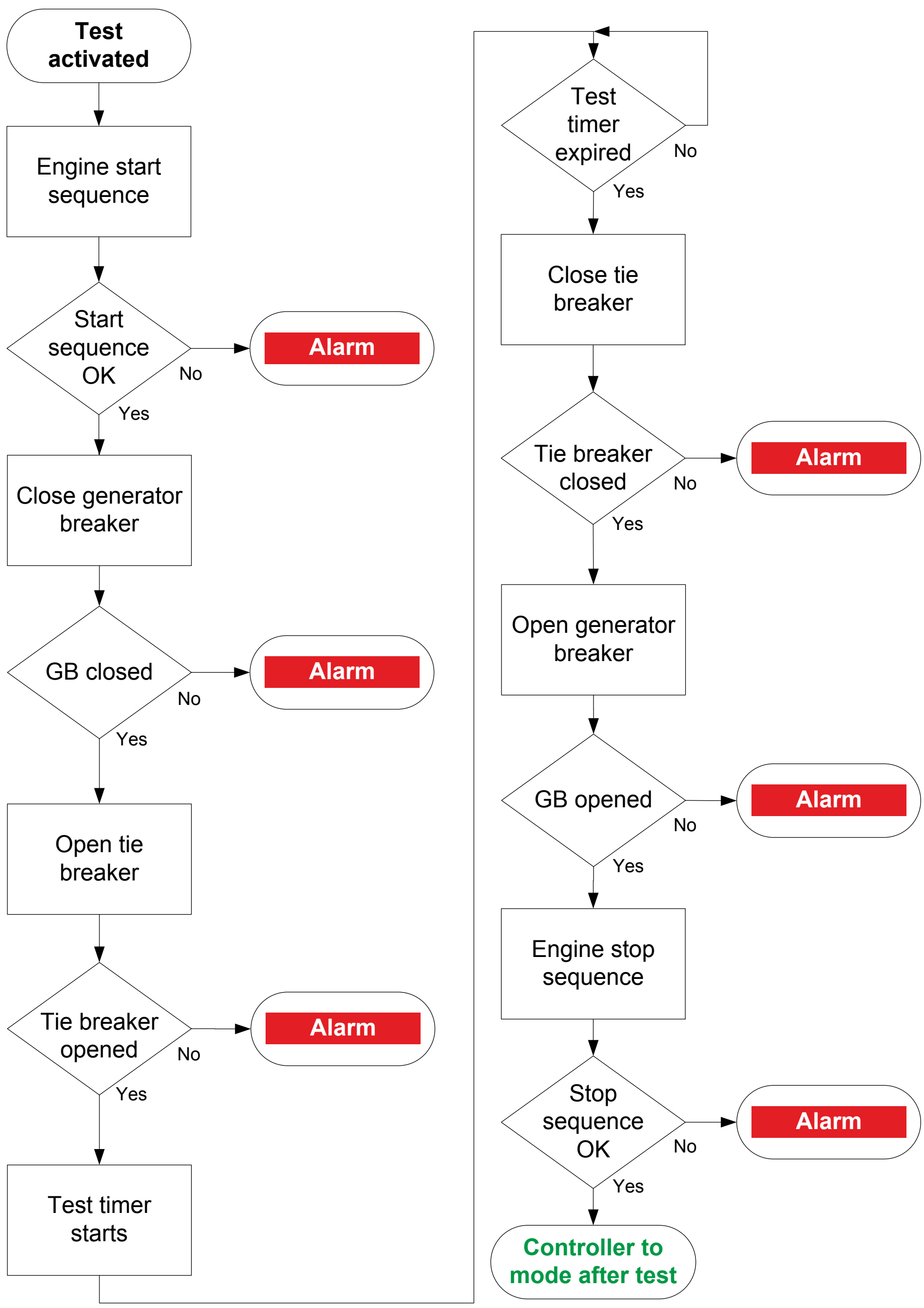


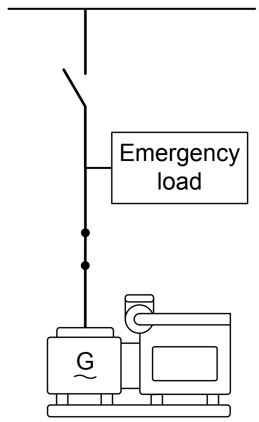


1. The controller starts the emergency genset when the TEST function is activated.
2. The controller synchronises and closes the genset breaker.
3. The controller regulates the emergency genset to supply the load defined in the *Test base load* parameter.
4. The test timer starts.
5. After the test timer 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 Overview

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.

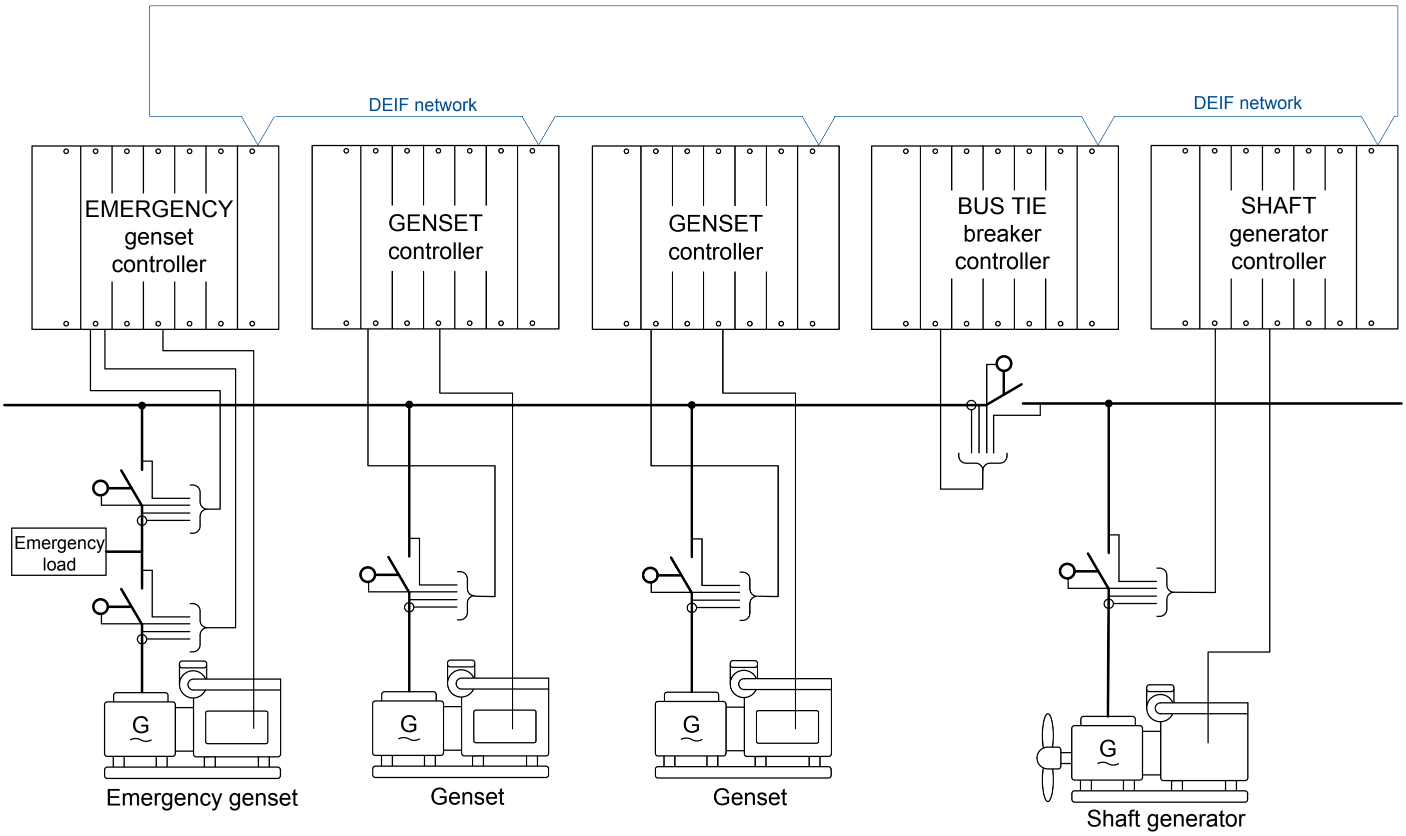
10.7.2 Emergency genset as part of the system

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.

Figure 10.2 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.

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.

INFO
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.

Figure 10.3 Example of a stand-alone emergency genset application

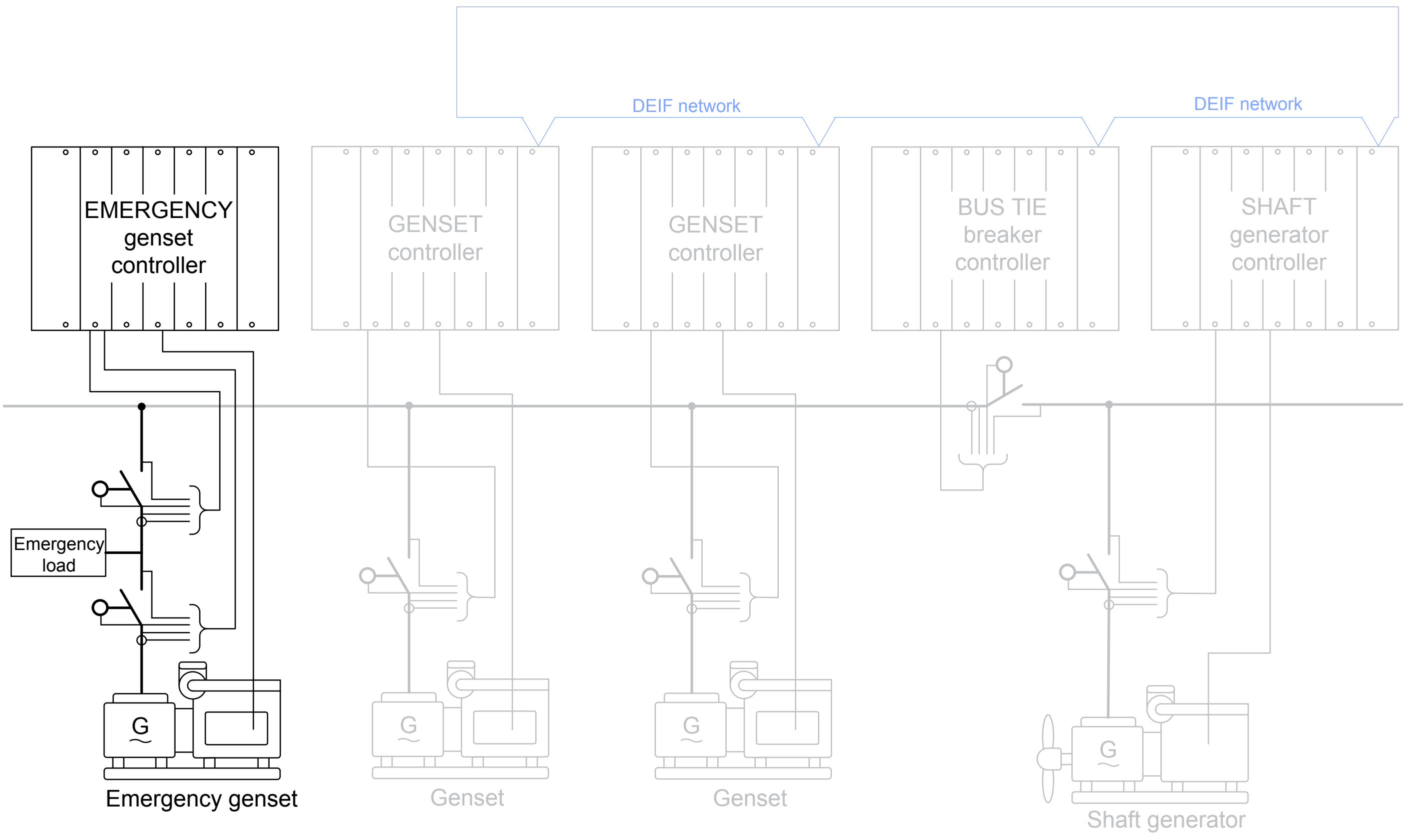
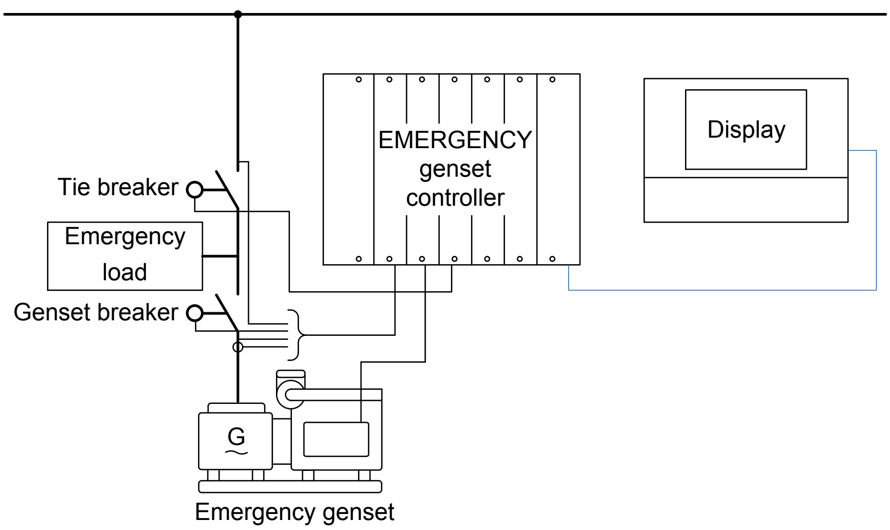


Figure 10.4 Stand-alone emergency genset



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.

INFO
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.

SEMI mode

You can connect stand-alone emergency genset to the main busbar in SEMI 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.

Input

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

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 under 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 controller**, **Emergency genset configurations** for more information.

Parameters

Configure this parameter in **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.

Configure this parameter in **Parameters > 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.

Configure this parameter in **Parameters > 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.

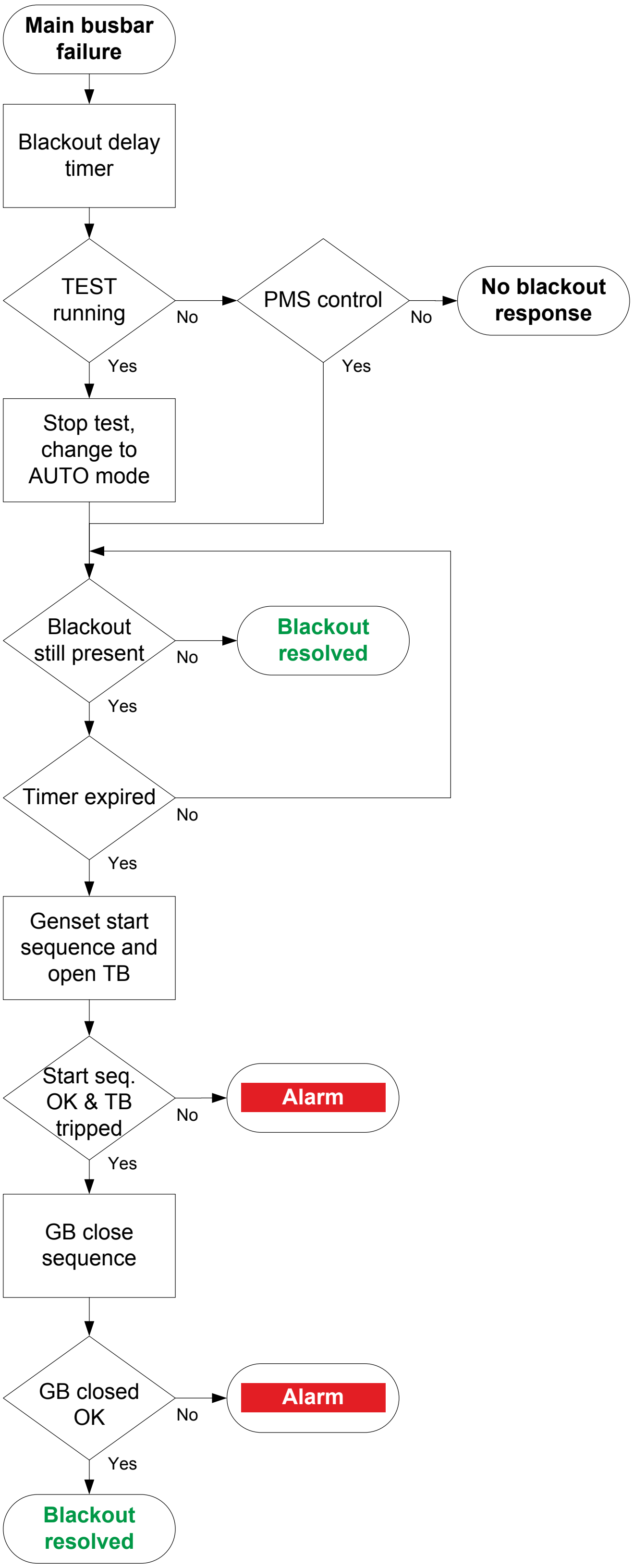
Switchboard control and blackout

An activated *Mode* > *Switchboard control* digital input on the EMERGENCY genset controller forces the controller under 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 under switchboard control. For example: *Controller not part of system* and *Different single-line configurations*.

Apart from these, the EMERGENCY genset controller is not forced under switchboard control by the alarms that force the other controllers under 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

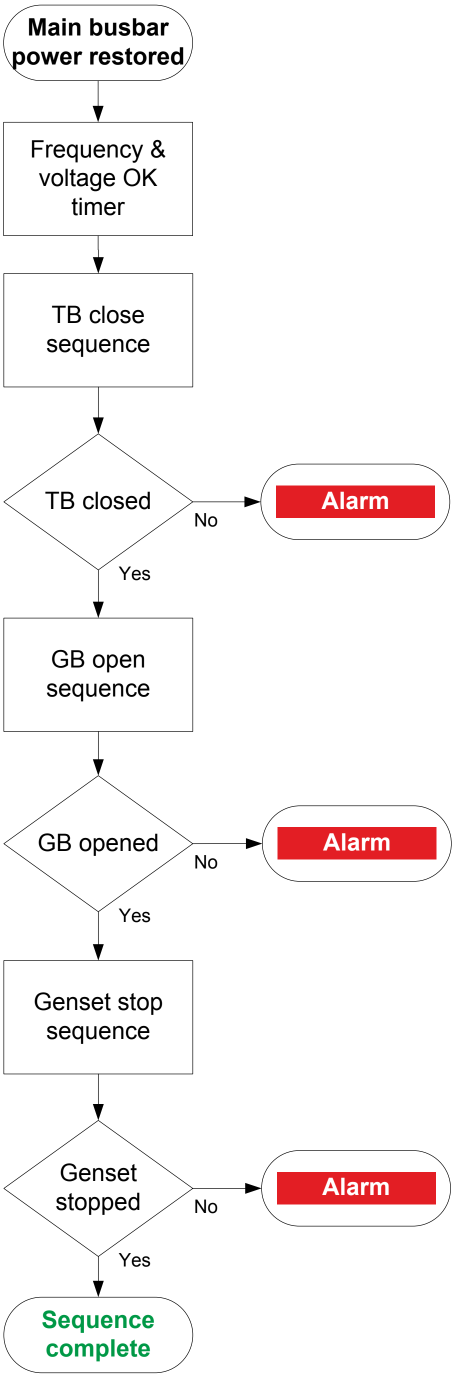


1. **Blackout delay timer:** If the main busbar fails, and the blackout response is possible, then the *Blackout delay* timer starts.
2. **TEST running:** The controller checks whether a *Test* is running. If a test is running the controller stops the test and changes to AUTO mode.
3. **PMS control:** 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 **Configure > Parameters > 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.

INFO
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.

Inputs and outputs

Assign the *Harbour operation* digital input under **Configure > Input/output**. Select the hardware module, then select the digital input to configure.

Table 10.7 Additional wiring required to the minimum standard controller wiring

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.

Optional: Assign the *Harbour operation active* digital output under **Configure > Input/output**. Select the hardware module, then select the digital output to configure.

Table 10.8 Optional wiring

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.

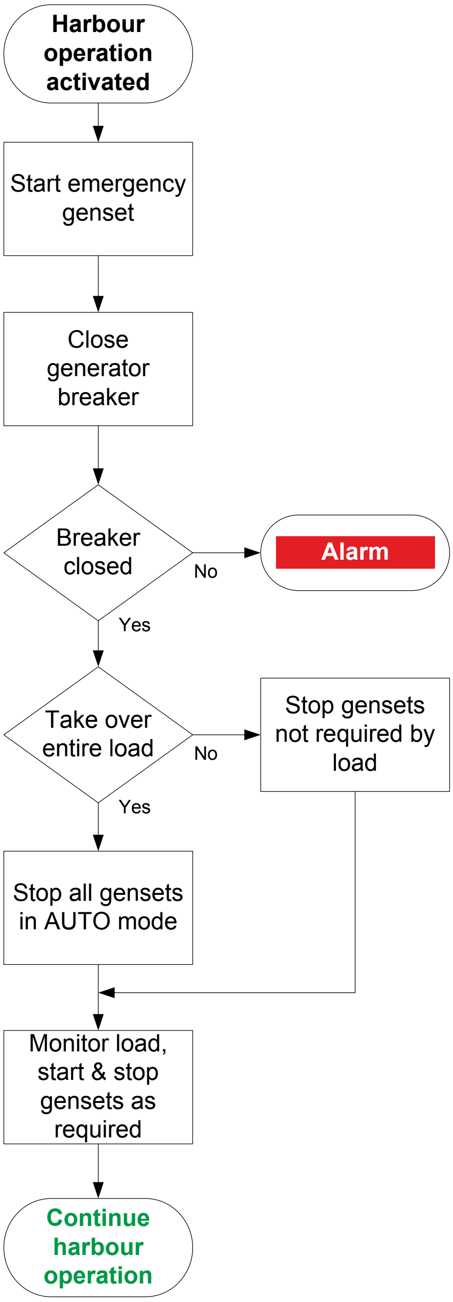
Parameter

Configure this parameter in **Parameters > 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

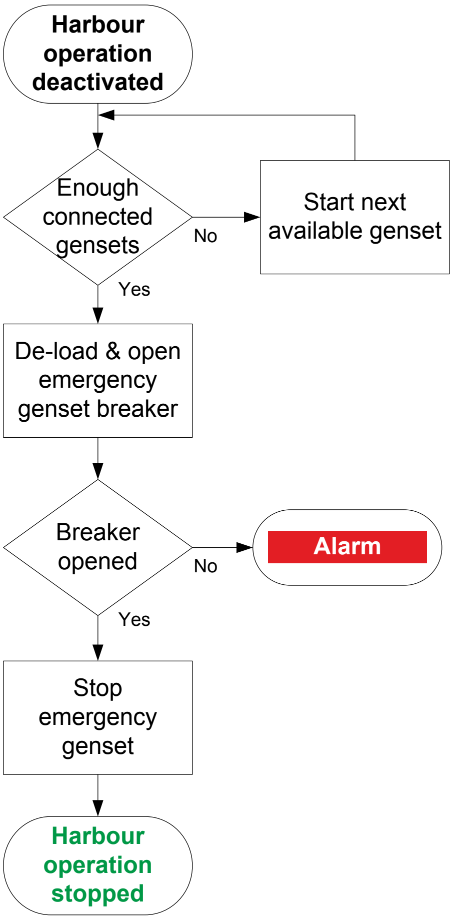
The harbour operation activation sequence is described below.



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.

Parallel timers can be configured under **Parameters > Local power management > Parallel timers**.

INFO
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.

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 **GENSET controller**, **Other GENSET controller functions**, **Counters** 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.

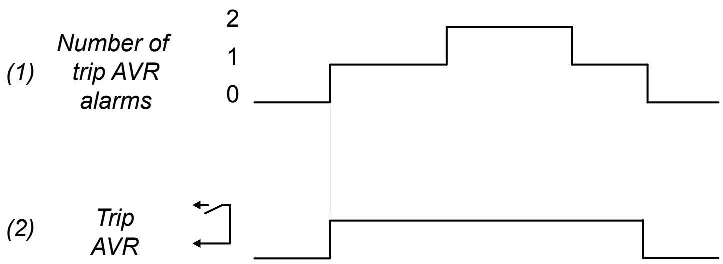
The *Trip AVR* output and alarm action does not initiate a breaker trip. To trip the breaker and the AVR, digital outputs for both actions must be configured and the correct alarm action must selected. For example, the *Trip breaker + AVR* alarm action.

Inputs and outputs

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

Function	I/O	Type	Details
[Source] > 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 10.9 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**: *[Source] > 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 PPM 300 controllers.

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
	EIM3.1 # relay 4 wire break (where # is 1 to 3)
	Engine stop (external)
	Engine start (external)
	Start enable removed during start
	Total running hours notification
	Trip running hours notification
	Magnetic pickup wire break
Generator	Voltage or frequency not OK
	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 SEMI 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

The EMERGENCY genset controller includes the following inhibits:

Table 10.10 EMERGENCY genset controller 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.

Inhibit	Disables the alarm when ...
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.
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

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 EMERGENCY genset controller, as well as which general alarm corresponds to each EMERGENCY genset controller alarm.

Table 10.11 Breaker alarm names for the EMERGENCY genset controller

EMERGENCY genset alarm	Configure > Parameters >	General name
GB synchronisation failure	Breakers > Generator breaker monitoring > Synchronisation failure	Breaker synchronisation failure
GB de-load failure	Breakers > Generator breaker monitoring > De-load failure	Breaker de-load failure
Vector mismatch	Breakers > Generator breaker monitoring > Vector mismatch	Vector mismatch
GB opening failure	Breakers > Generator breaker monitoring > Opening failure	Breaker opening failure
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

EMERGENCY genset alarm	Configure > Parameters >	General name
TB position failure	Breakers > Tie breaker monitoring > Position failure	Breaker position failure
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

10.9.5 AC alarms

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

The following tables show where to configure these alarms for the EMERGENCY genset controller.

Table 10.12 Generator AC alarm names for the EMERGENCY genset controller

EMERGENCY genset alarm	Configure > Parameters >	General name
Generator over-voltage 1 or 2	Generator > Voltage protections > Over-voltage 1 or 2	Over-voltage
Generator under-voltage 1 or 2	Generator > Voltage protections > Under-voltage 1 or 2	Under-voltage
Generator voltage unbalance	Generator > Voltage protections > Voltage unbalance	Voltage unbalance
Generator over-current 1 or 2	Generator > Current protections > Over-current 1 or 2	Over-current
Fast over-current 1 or 2	Generator > Current protections > Fast over-current 1 or 2	Fast over-current
Current unbalance (average calc.)	Generator > Current protections > Current unbalance (average calc.)	Current unbalance (average calc.)
Current unbalance (nominal calc.)	Generator > Current protections > Current unbalance (nominal calc.)	Current unbalance (nominal calc.)
Inverse time over-current	Generator > Current protections > Inverse time over-current	Inverse time over-current
Stabilised differential current	Generator > Current protections > Stabilised differential current	Stabilised differential current
High set differential current	Generator > Current protections > High set differential current	High set differential current
Generator over-frequency 1 or 2	Generator > Frequency protections > Over-frequency 1 or 2	Over-frequency
Generator under-frequency 1 or 2	Generator > Frequency protections > Under-frequency 1 or 2	Under-frequency
Overload 1 or 2	Generator > Power protections > Overload 1 or 2	Overload
Reverse power 1 or 2	Generator > Power protections > Reverse power 1 or 2	Reverse power
Reactive power export 1 or 2	Generator > Reactive power protections > Reactive power export 1 or 2	Reactive power export
Reactive power import 1 or 2	Generator > Reactive power protections > Reactive power import 1 or 2	Reactive power import

Table 10.13 Busbar AC alarm names for the EMERGENCY genset controller

EMERGENCY genset alarm	Configure > Parameters >	General name
Busbar over-voltage 1 or 2	Busbar > Voltage protections > Over-voltage 1 or 2	Busbar over-voltage
Busbar under-voltage 1 or 2	Busbar > Voltage protections > Under-voltage 1 or 2	Busbar under-voltage

EMERGENCY genset alarm	Configure > Parameters >	General name
Busbar voltage unbalance	Busbar > Voltage protections > Voltage unbalance	Busbar voltage unbalance
Busbar over-frequency 1 or 2	Busbar > Frequency protections > Over-frequency 1 or 2	Busbar over-frequency
Busbar under-frequency 1 or 2	Busbar > Frequency protections > Under-frequency 1 or 2	Busbar under-frequency

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 **Configure > Parameters > 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 **Alarms**, **Non-essential loads** for more 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.

Configure the parameters under **Configure > Parameters > Local power management > Emergency generator > EDG not ready for blackout**.

Table 10.14 Default parameters

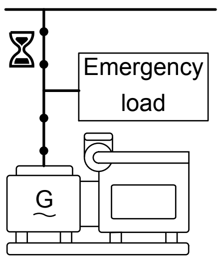
Parameter	Range	Default
Delay	1 s to 3 min	7 s*
Enable	Not enabled, Enabled	Enabled
Action		Warning

*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.



Configure the parameters under **Configure > Parameters > Local power management > Parallel timers > EDG max. parallel time**.

Table 10.15 Default parameters

Parameter	Range	Default
Delay	0.1 s to 1 h	30.0 s
Enable	Not enabled, Enabled	Enabled

INFO
This alarm is ONLY present in the EMERGENCY genset controller.

INFO
This alarm is disabled during the parallel test.

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 start (external)
- Voltage or frequency not OK
- Stop failure
- Engine stop (external)
- Overspeed
- Underspeed
- Start enable removed during start
- Total running hours notification
- Trip running hours notification
- EIM # relay 4 wire break*
- Magnetic pickup wire break*

More information

For the alarms marked with *, see **Hardware characteristics and configuration** for more information.

For the other alarms, see **GENSET controller**, **GENSET controller alarms** for more information.

11. HYBRID controller

11.1 HYBRID controller overview

11.1.1 Description

A HYBRID controller controls an inverter with a power source, and the inverter breaker. A system can include a number of HYBRID controllers.

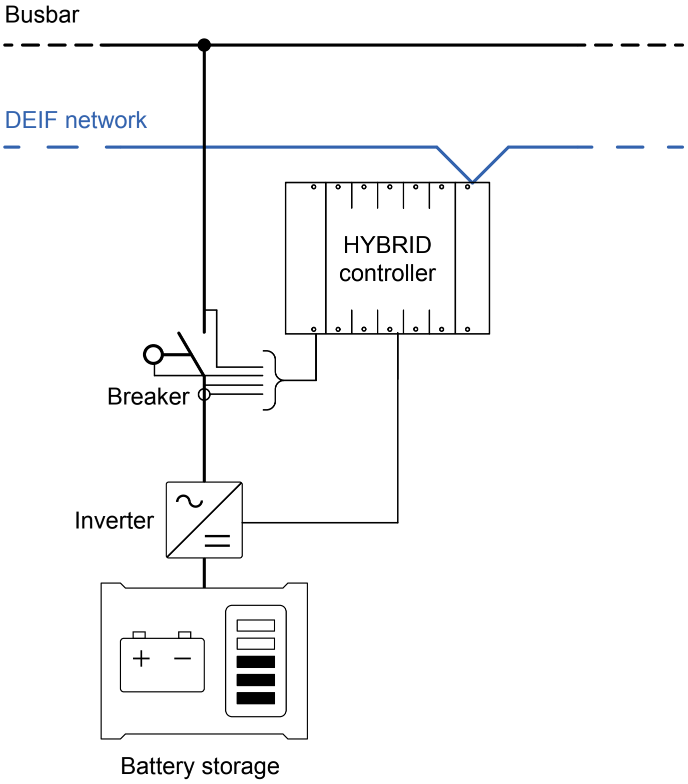
The HYBRID controllers work together to ensure effective power management. This includes Power Take In (PTI) and Power Take Off (PTO) modes, running only on battery power if needed and available, asymmetric load sharing with configurable constant discharge and genset start if required.

11.1.2 Application

A HYBRID controller controls an inverter with battery storage, and the inverter breaker. A system can include a number of HYBRID controllers.

Each HYBRID controller can control up to four heavy consumers (HC) and connect up to three non-essential load groups (NEL).

Figure 11.1 Example HYBRID controller application



11.1.3 HYBRID controller functions

	Functions
Pre-programmed sequences	• Inverter start sequence and inverter stop sequence ◦ Running detection (Digital input) ◦ Start inverter and/or stop inverter for inverter control • Breaker sequences ◦ Inverter breaker close sequence (with synchronisation)

	Functions
	◦ 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 battery storage 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)
Control types	• Power management system (PMS) control ◦ AUTO mode ◦ SEMI 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 • SEMI 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 unit push-buttons for inverter start & stop, breaker open & close, and 1st priority • Display unit push-buttons ◦ Change control mode (AUTO & SEMI) ◦ 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 SEMI 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

Configure these nominal settings under **Configure > Parameters > Inverter > Nominal settings > Nominal settings #**, where # is 1 to 4.

Table 11.1 Controller nominal settings

Nominal setting	Range	Default	Notes
Voltage (V)	10 V to 160 kV	400 V	The phase-to-phase* nominal AC voltage for the inverter.
Current (I)	1 A to 9 kA	867 A	The maximum current flow in one phase (that is, L1, L2 or L3) from the inverter during normal operation.
Frequency (f)	20 to 100 Hz	50 Hz	The system nominal frequency, typically either 50 Hz or 60 Hz. All the controllers in the system should have the same nominal frequency.
Power (P)	1 kW to 0.9 GW	480 kW	The nominal active power may be on the inverter nameplate.
Apparent power (S)	1 kVA to 1 GVA	530 kVA	The nominal apparent power should be on the inverter nameplate.
Power factor (PF)	0.6 to 1	0.9	The power factor should be on the inverter nameplate.

NOTE * In a single-phase set up the nominal AC voltage is phase-to-neutral.

Configure this under **Configure > Parameters > Inverter > Nominal settings > Nominal settings # > Calculation method**, where # is 1 to 4:

Table 11.2 Nominal setting 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

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

Busbar nominal settings

Configure these nominal settings under **Configure > Parameters > Busbar > Nominal settings > Nominal settings #**, where # is 1 to 4.

Table 11.3 Controller nominal settings

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

11.2.2 Start inverter or stop inverter

Outputs

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

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

Table 11.4 Inverter start and stop outputs

Function	I/O	Type	Details
Inverter > Control > Start	Digital output	Continuous	Requests the inverter to start using the configured inverter start sequence.
Inverter > Control > Stop	Digital output	Continuous	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.

Inputs and outputs

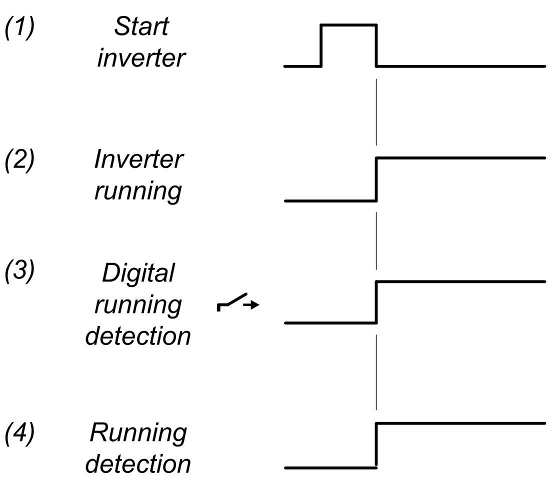
Assign the running feedback input under **Configure > Input/output**. Select the hardware module, then select the input to configure.

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.

Figure 11.2 Running detection ON sequence diagram

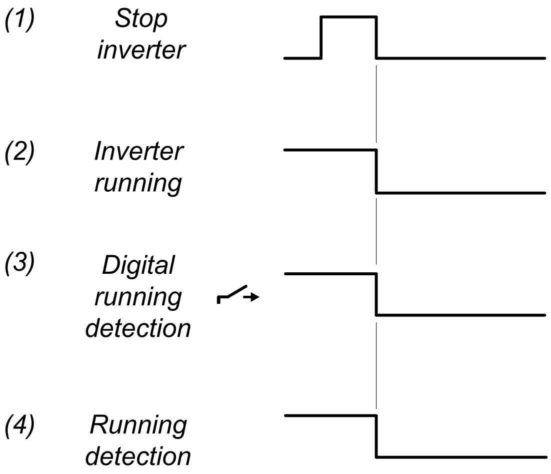


1. **Start inverter**: Request to start the inverter.
2. **Inverter running**: The inverter starts running after the start request.
3. **Digital running detection**: *Inverter > Feedback > Digital running detection* (digital input).
4. **Running detection**: Running detection changes from OFF to ON.

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.

Figure 11.3 Running detection OFF sequence diagram



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 can regulate 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 more information.

11.2.6 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 **Power management**, **Load sharing** for more information.

11.2.7 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 under PMS control.

11.2.8 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.

Table 11.5 AC configuration for the HYBRID controller

HYBRID	General name
Inverter	[Source]
Busbar	[Busbar]

11.2.9 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 **HYBRID controller protections** in this chapter for information on how the inverter start protections work, and how to configure them.

Controller modes

In AUTO and SEMI 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 under switchboard control, the HYBRID controller is not involved. These sequences do not apply to starting an inverter under switchboard control.

Inputs and outputs

The tables below describes the inputs and outputs for the inverter start function.

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

Table 11.6 Required inverter start and run output

Function	I/O	Type	Details
Inverter > Control > Start	Digital output	Pulse	Connect this output to the inverter start.
Inverter > Control > Run	Digital output	Continuous	This output is high when the inverter should run.

Table 11.7 Optional inverter start commands

Function	I/O	Type	Details
Inverter > Command > Start inverter	Digital input	Pulse	Optional. When the controller is in SEMI 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 SEMI 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 SEMI mode, the operator or another system can activate this input to request the controller to connect the inverter, synchronise and close the breaker.

Parameters (required)

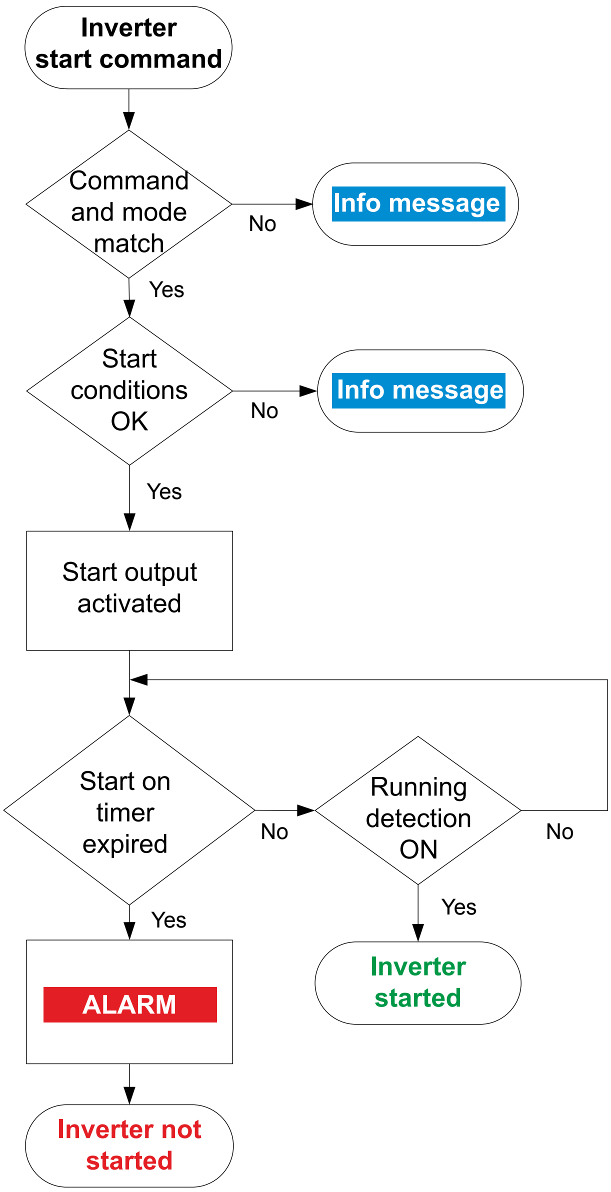
Configure these parameters under **Configure > Parameters > Inverter > Start sequence**.

Parameter	Range	Default	Comment
Restrictions > Allow start when	Breaker is open, Breaker is closed, Breaker in any state	Breaker is open	The controller allows the start of the inverter only if the inverter breaker is in the state required.
Start > Start on	1 s to 3 min	5 s	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. Under switchboard control, if the operator presses the push-button **Start** on the display unit, the controller ignores the command and shows an info message.

Table 11.8 Inverter start flowchart



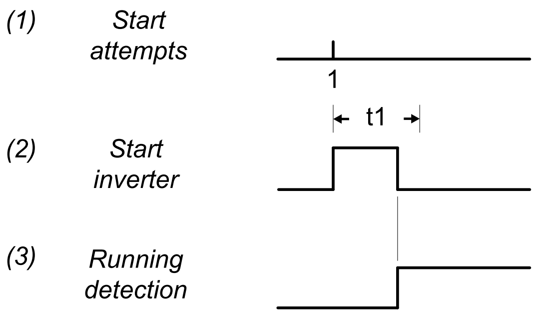
1. **Command and mode match:** The controller checks that the command source and the controller mode match:
   - In AUTO mode, the power management system must send the command to start the inverter. The controller ignores all other external commands.
   - In SEMI mode, the command to start the inverter can come from the following:
     - The operator can press the push-button **Start** (I) 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. **Start conditions OK:** The controller checks whether 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. **Start output activated:** If all the start conditions are OK, the controller activates the *Start* output and a timer.
4. **Running detection ON:** While the start timer runs, the controller checks activates the run output and checks whether *Running detection* is ON.
   - When the controller detects that the inverter is running, the inverter start is complete.
5. **Start on timer expired:** If *Running detection* is OFF after the *Start on* timer runs out, the controller activates the *Start failure* alarm.

11.3.3 Inverter start sequence

These sequence diagrams show the inverter start sequence.

Inverter start sequence

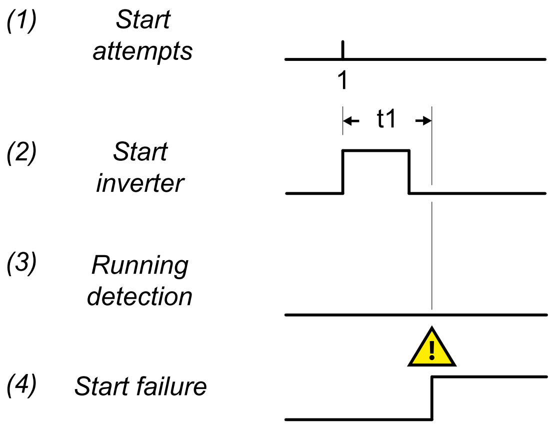
Figure 11.4 Successful inverter start sequence



t1 = Start on (**Parameters > Inverter > Start sequence > Start > Start on**)

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.

Figure 11.5 Failure of inverter start sequence



t1 = Start on (**Parameters > Inverter > Start sequence > Start > Start on**)

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 SEMI 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*

INFO
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 **HYBRID controller alarms** for more information on how the inverter stop alarms work, and how to configure them.

Controller modes

In AUTO and SEMI 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 under switchboard control.

Inputs and outputs

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

Table 11.9 Required inverter stop output

Function	I/O	Type	Details
Inverter > Control > Stop	Digital output	Pulse	Connect this output to the inverter stop.
Inverter > Control > Run	Digital output	Continuous	This output is low when the inverter is stopped.

Table 11.10 Optional inverter stop commands

Function	I/O	Type	Details
Inverter > Command > Stop inverter	Digital input	Pulse	Optional. When the controller is in SEMI 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 SEMI mode, the operator or another system can activate this input to request the controller to disconnect the inverter; deload and open the breaker.

Parameters (required)

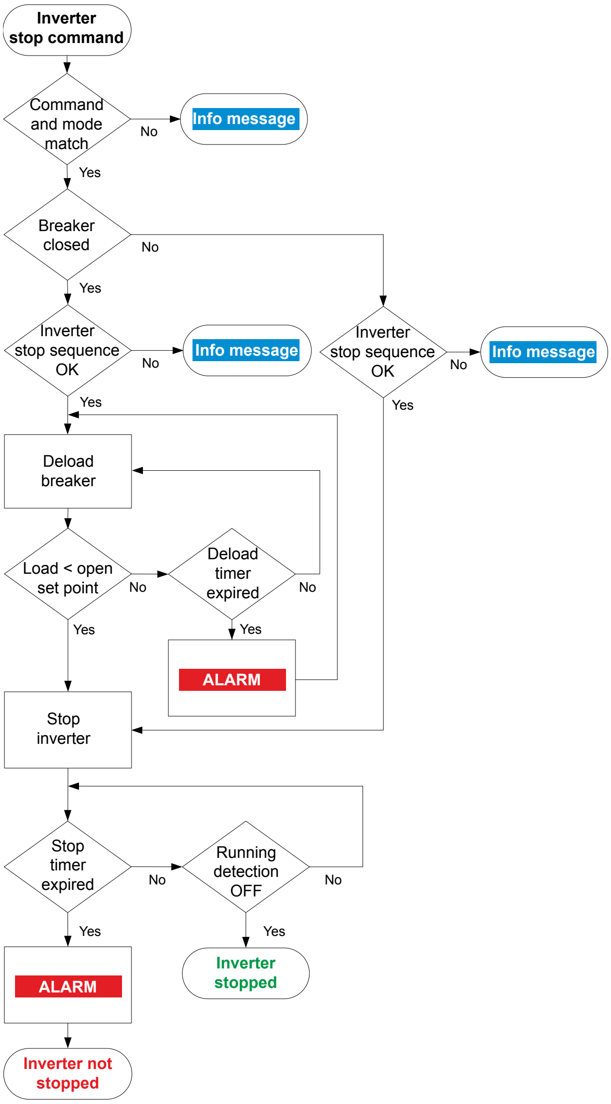
Configure this parameter under **Configure > Parameters > Inverter > Stop sequence**.

Parameter	Range	Default	Comment
Restrictions > Allow stop when	Breaker is open, Breaker is closed, Breaker in any state	Breaker is open	The controller allows the stop of the inverter only if the inverter breaker is in the state required.
Stop failure	1 s to 3 min	5 s	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.

Table 11.11 Inverter stop flowchart

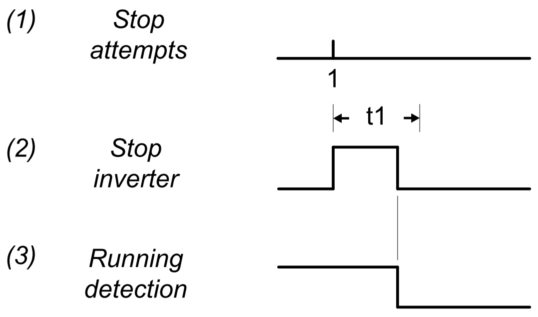


1. **Command and mode match:** The controller checks that the command source and the controller mode match:
   - In AUTO mode, the power management system must send the command to stop the inverter. The controller ignores all other external commands.
   - In SEMI mode, the command to stop the inverter 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. **Breaker closed:** The controller checks the break state.
3. **Inverter stop sequence OK:** 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. **Deload breaker:** 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. **Stop inverter:** 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 an 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

These sequence diagrams show the inverter stop sequence.

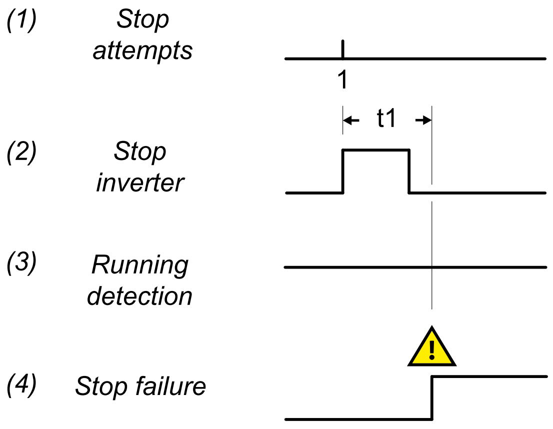
Figure 11.6 Successful inverter stop sequence



t1 = Stop failure (**Parameters > Inverter > Stop sequence > Stop failure**)

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.

Figure 11.7 Failure of inverter stop sequence



t1 = Stop failure (**Parameters > Inverter > Stop sequence > Stop failure**)

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.

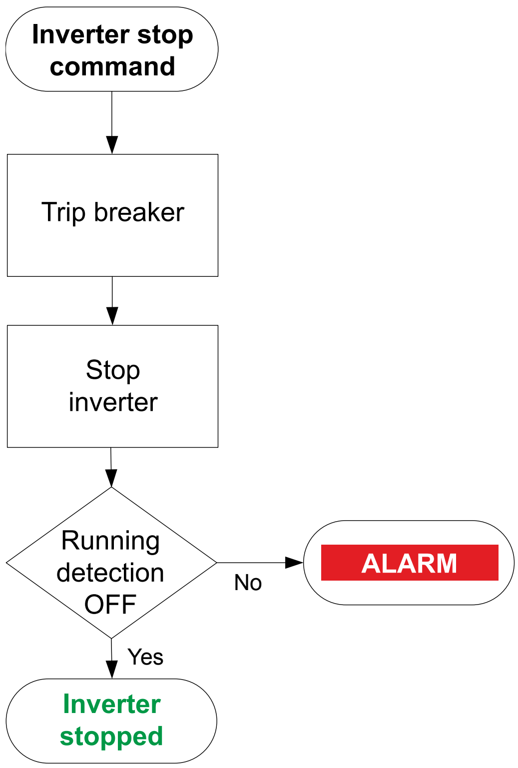
11.4.4 Inverter trip and stop flowchart

The inverter breaker is tripped and the inverter stopped for the following alarm action:

- Trip breaker and stop inverter

The inverter breaker is tripped and the inverter stopped if the controller's *Emergency stop* input is deactivated.

Table 11.12 Inverter trip and stop flowchart



1. **Breaker open**: The controller checks whether the inverter breaker is open. If not, the controller trips the inverter breaker.
2. **Stop inverter**: The controller shuts down the inverter.
3. **Running detection OFF**: If *Running detection* is still ON after the time allowed, the controller activates the *Stop failure* alarm.

11.5 Inverter breaker

11.5.1 Introduction

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 open or close conditions under **Breakers > Inverter breaker configuration**.

Table 11.13 Required inverter start and run output

Function	Range	Default	Details
Allow breaker close when	Inverter is started, Inverter is stopped, Inverter is in any state	Inverter is started	• **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 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.

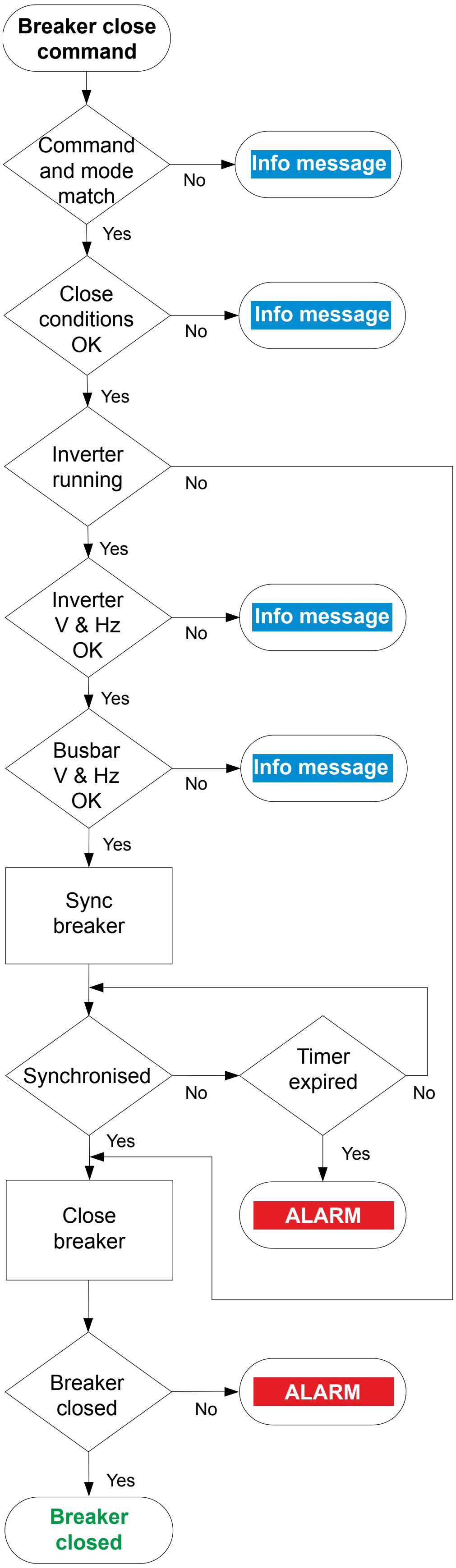
General breaker information

More information
See the **Breakers, synchronisation and de-loading** chapter for more information on synchronisation and breakers. This includes the inputs and output functions and the parameters to configure.

[Breaker] refers to *Inverter breaker*. The breaker abbreviation (*[*B]*) is *Breaker*.

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. **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 breaker. The controller ignores all other external commands.
   - In SEMI 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. **Close conditions OK:** The controller checks whether 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. **Inverter running:** The controller checks whether the inverter is running.
4. **Inverter V & Hz OK:** The controller checks whether the voltage and frequency from the inverter are within the allowed range *. If these are not in the range, then the controller cancels the close command and displays an info message.
5. **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.
6. **Sync breaker:** The controller tries to synchronise the inverter to the busbar.
   - When the inverter and busbar are synchronised, the controller activates the *Breakers* > *Inverter breaker* > *Control* > *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. **Close breaker:** The controller checks whether the inverter breaker has 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 **Configure > Parameters > Inverter > AC setup > Voltage and frequency OK** for these ranges.

NOTE ** See **Configure > Parameters > Busbar > AC setup > Voltage and frequency OK** for these 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 SEMI mode, the operator cannot close the breaker by pushing the push button **Close breaker** on the display.

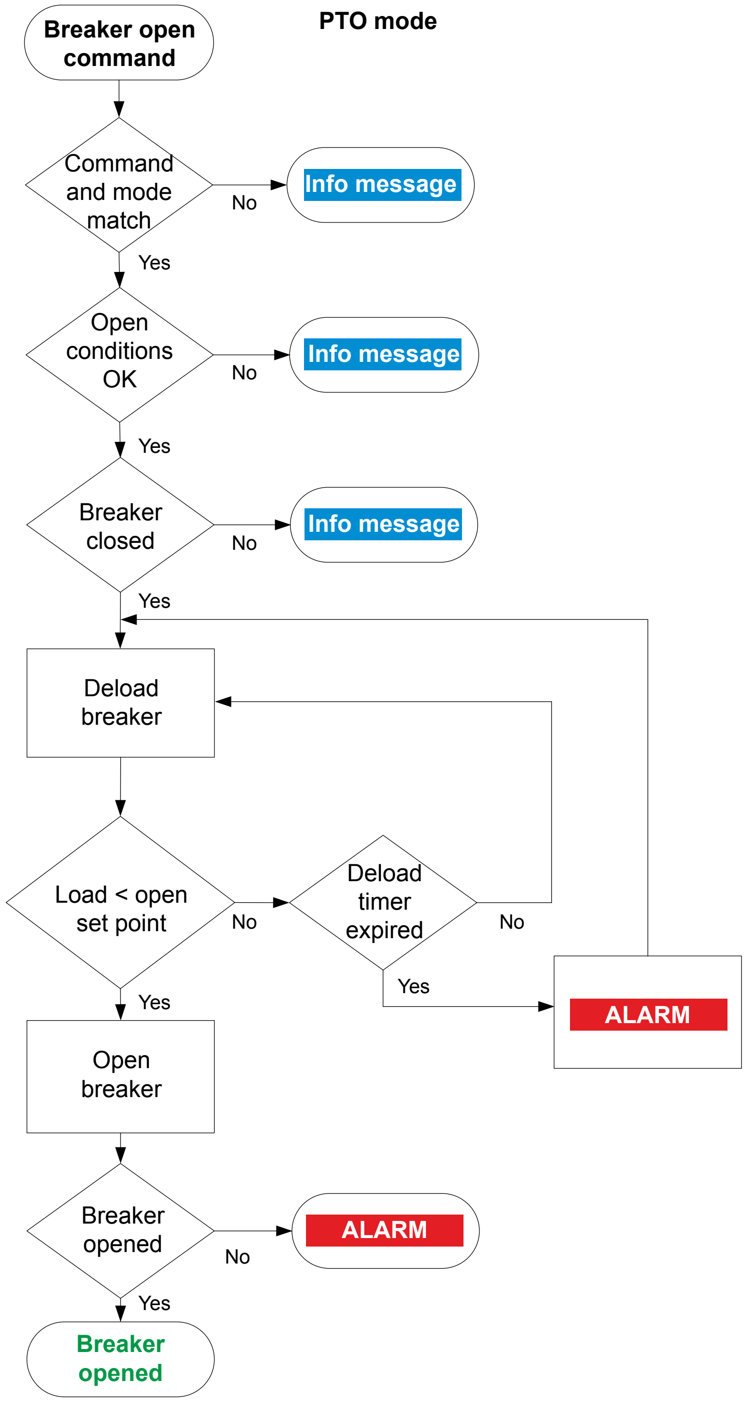
11.5.4 Inverter breaker open flowchart

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.

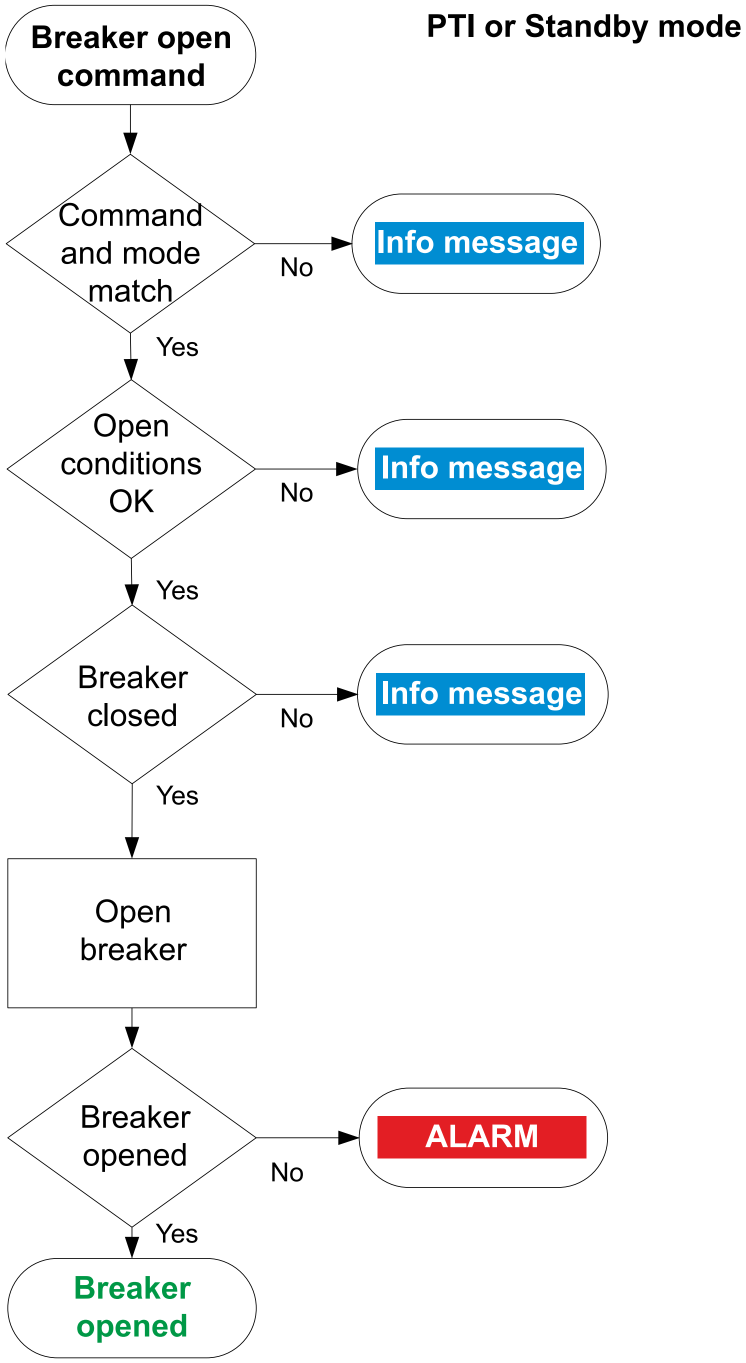
This flowchart does not apply to switchboard control. When the controller is under switchboard control, it will not open the breaker (except for a trip). If, for example, the operator presses the push-button **Open breaker** on the display unit, the controller ignores this command.

PTO mode



1. **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 SEMI 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. **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.
   - 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 power management system de-loads the inverter:
   - When the load is less than the set point for the breaker to open, the controller activates the *Breaker* > *Control* > *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 SEMI 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. **Open conditions OK:** 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. **Breaker closed:** The controller checks whether the breaker is closed. If the breaker is open, the sequence ends.
4. **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.

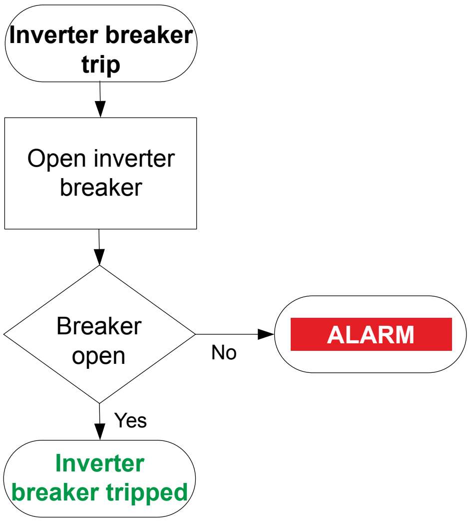
11.5.5 Inverter breaker trip flowchart

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.

Table 11.14 Inverter breaker trip flowchart



1. **Open breaker**: When a trip is required, the controller activates the *Breakers > breaker > Control > 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.

Inputs and outputs

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

Function	I/O	Type	Details
Inverter > Power derate > Derate # temperature [C] (where # is 1 to 3)	Analogue input	The measurement must be in °C.	This can measure any temperature.

Parameters

Configure these parameters under **Configure > Parameters > Inverter > Power derate #**, where # is 1, 2 or 3.

INFO
The analogue input(s) must be configured to see the power derate parameter and curve.

Parameter	Range	Default	Comment
Enable derate	Not enabled, Enabled	Not 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.

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.

Inputs and outputs

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

Function	I/O	Type	Details
Inverter > Power derate > Percentage > Derate percentage [%]	Analogue input	The measurement must be in %.	

Parameters

Configure these parameters under **Configure > Parameters > Inverter > Power derate > Percentage**.

INFO
The analogue input(s) must be configured to see the power derate parameter and curve.

Parameter	Range	Default	Comment
Enable derate	Not enabled, Enabled	Not 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.

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

Table 11.15 Inverter operating value outputs

Function	I/O	Units	Details
Inverter > Power derate > Derate # temperature [C], where # is 1 to 3	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.

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.

Outputs

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

Table 11.16 Inverter state functions

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.
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 on the display unit under **Configure > Counters**. 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)

INFO
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.

Configure the digital outputs under **Input/output > Digital output > Inverter > Energy counters > [Counter pulse]**.

INFO
You must configure the digital output function to see the parameters.

Configure the energy transfer required for a pulse under **Parameters > Inverter > Energy counters > [Counter]**

Table 11.17 Active energy export counter parameters

Parameter	Range	Default	Comment
Pulse every	1 kWh to 10 MWh	10 kWh	The value when a digital output sends a pulse.
Pulse length	0.1 s to 1 h	1 s	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 11.18 Reactive energy export counter parameters

Parameter	Range	Default	Comment
Pulse every	1 kvarh to 10 Mvarh	10 kvarh	The value when a digital output sends a pulse.
Pulse length	0.1 s to 1 h	1 s	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 11.19 Energy counter function and corresponding parameter full names

[Counter pulse]	[Counter]
Active energy export pulse 1	Active energy export
Reactive energy export pulse 1	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 1*.
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.

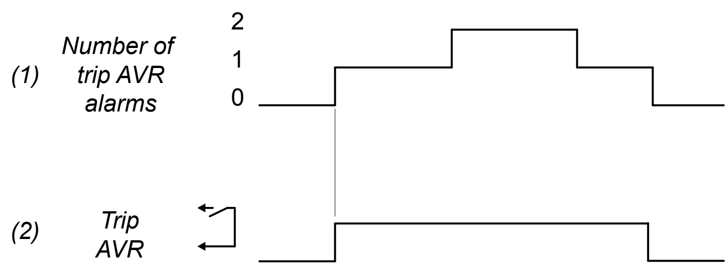
The *Trip AVR* output and alarm action does not initiate a breaker trip. To trip the breaker and the AVR, digital outputs for both actions must be configured and the correct alarm action must selected. For example, the *Trip breaker + AVR* alarm action.

Inputs and outputs

Assign the *Trip AVR* output under **Configure > 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 11.20 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**: *[Source] > 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 PPM 300 controllers.

	Alarms and protections
Inverter	Emergency stop
	Start sequence failure
	Stop sequence 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 stand-alone configuration failure *
	GOV relay setup incomplete
	GOV regulator error
	AVR output selection failure
	AVR output setup failure
	AVR stand-alone configuration failure *
	AVR relay setup incomplete
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)

	Alarms and protections
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 SEMI mode
	Trip AVR output not configured

NOTE * Only in GAM3.2.

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:

Table 11.21 Controller 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.
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.

Inhibit	Disables the alarm when ...
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 11.22 Breaker alarm names for the HYBRID controller

HYBRID alarm	Configure > 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
The **AC configuration and nominal settings** chapter describes AC alarms in general.

The following tables show where to configure these alarms for the HYBRID controller.

Table 11.23 Inverter AC alarm names for the GENSET controller

Controller alarm	Configure > Parameters >	General name
Inverter over-voltage 1 or 2	Inverter > Voltage protections > Over-voltage 1 or 2	Over-voltage
Inverter under-voltage 1 or 2	Inverter > Voltage protections > Under-voltage 1 or 2	Under-voltage
Inverter voltage unbalance	Inverter > Voltage protections > Voltage unbalance	Voltage unbalance
Negative sequence voltage	Inverter > Voltage protections > Negative sequence voltage	Negative sequence voltage
Zero sequence voltage	Inverter > Voltage protections > Zero sequence voltage	Zero sequence voltage

Controller alarm	Configure > Parameters >	General name
Inverter over-current 1 or 2	Inverter > Current protections > Over-current 1 or 2	Over-current
Fast over-current 1 or 2	Inverter > Current protections > Fast over-current 1 or 2	Fast over-current
Current unbalance (average calc.)	Inverter > Current protections > Current unbalance (average calc.)	Current unbalance (average calc.)
Current unbalance (nominal calc.)	Inverter > Current protections > Current unbalance (nominal calc.)	Current unbalance (nominal calc.)
Directional over-current 1 or 2	Inverter > Current protections > Directional over-current 1 or 2	Directional over-current
Inverse time over-current	Inverter > Current protections > Inverse time over-current	Inverse time over-current
Negative sequence current	Inverter > Current protections > Negative sequence current	Negative sequence current
Zero sequence current	Inverter > Current protections > Zero sequence current	Zero sequence current
Stabilised differential current	Inverter > Current protections > Stabilised differential current	Stabilised differential current
High set differential current	Inverter > Current protections > High set differential current	High set differential current
Inverter over-frequency 1 or 2	Inverter > Frequency protections > Over-frequency 1 or 2	Over-frequency
Inverter under-frequency 1 or 2	Inverter > Frequency protections > Under-frequency 1 or 2	Under-frequency
Overload 1 or 2	Inverter > Power protections > Overload 1 or 2	Overload
Reverse power 1 or 2	Inverter > Power protections > Reverse power 1 or 2	Reverse power
Overload reverse power 1 or 2	Inverter > Power protections > Overload reverse power 1 or 2	Overload reverse power
Reactive power export 1 or 2	Inverter > Reactive power protections > Reactive power export 1 or 2	Reactive power export
Reactive power import 1 or 2	Inverter > Reactive power protections > Reactive power import 1 or 2	Reactive power import

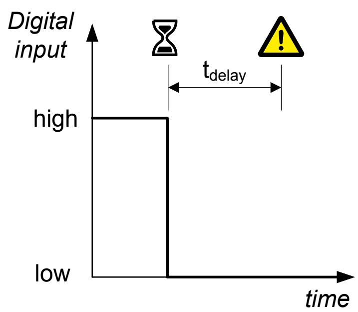
Table 11.24 Busbar AC alarm names for the HYBRID controller

Controller alarm	Configure > Parameters >	General name
Busbar over-voltage 1 or 2	Busbar > Voltage protections > Over-voltage 1 or 2	Busbar over-voltage
Busbar under-voltage 1 or 2	Busbar > Voltage protections > Under-voltage 1 or 2	Busbar under-voltage
Busbar voltage unbalance	Busbar > Voltage protections > Voltage unbalance	Busbar voltage unbalance
Busbar over-frequency 1 or 2	Busbar > Frequency protections > Over-frequency 1 or 2	Busbar over-frequency
Busbar under-frequency 1 or 2	Busbar > Frequency protections > Under-frequency 1 or 2	Busbar under-frequency

11.7.6 Emergency stop

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

When this input is present, the alarm is always enabled. The alarm parameters are not visible. The alarm action is *Trip breaker and stop inverter*.



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

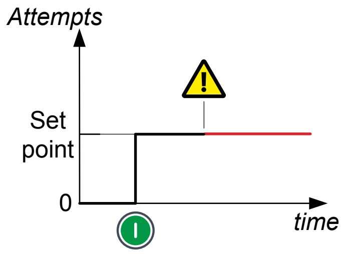
Function	I/O	Type	Details
Alarm system > Additional functions > Emergency stop	Digital input	Continuous	Wire the emergency stop digital input so that it is normally activated. If the emergency stop digital input is not activated, then controller activates the *Emergency stop* alarm.

CAUTION
The *Emergency stop* is part of the safety chain, 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.

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 parameters under **Configure > Parameters > Inverter > Start sequence > Start failure**.

Table 11.25 Default parameters

Parameter	Range	Default
Enable	Not enabled, Enabled	Enabled
Latch	Not enabled, Enabled	Enabled
Action		Block

Configure the start failure parameters under **Configure > Parameters > Inverter > Start sequence**.

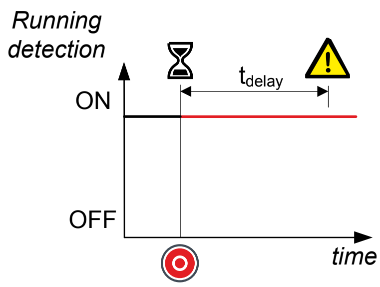
Table 11.26 Other parameters

Parameter	Range	Default
Start > Start on	1 s to 3 min	5 s
Restrictions > Allow start when	Breaker is open, Breaker is closed, Breaker in any state	Breaker is open

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.



Configure the parameters under **Configure > Parameters > Inverter > Stop sequence > Stop failure**.

Table 11.27 Default parameters

Parameter	Range	Default
Delay	0 s to 5 m	5 s
Enable	Not enabled, Enabled	Enabled
Action		Warning

Configure the start failure parameters under **Configure > Parameters > Inverter > Start sequence > Restrictions**.

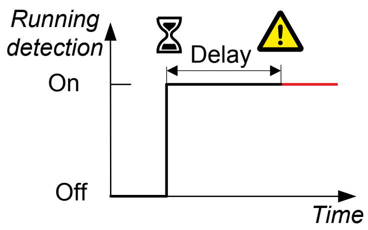
Table 11.28 Other parameters

Parameter	Range	Default
Allow stop when	Breaker is open, Breaker is closed, Breaker in any state	Breaker is open

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 **Configure > Parameters > Inverter > Start sequence > Inverter started (external)**.

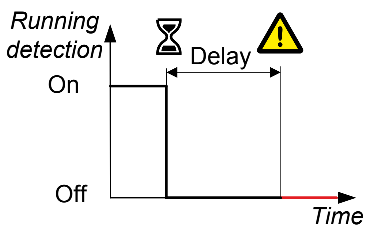
Table 11.29 Default parameters

Parameter	Range	Default
Enable	Not enabled, Enabled	Enabled
Action		Warning

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 **Configure > Parameters > Inverter > Stop sequence > Inverter stopped (external)**.

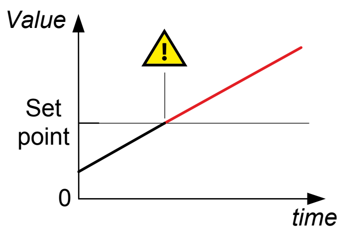
Table 11.30 Default parameters

Parameter	Range	Default
Enable	Not enabled, Enabled	Enabled
Latch	Not enabled, Enabled	Enabled
Action		Block

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.



Configure these parameters under **Configure > Parameters > Inverter > Maintenance > Running hours total**.

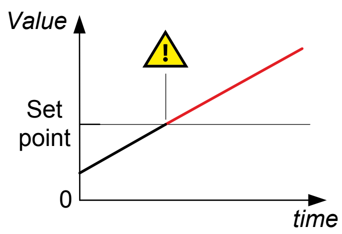
Table 11.31 Default parameters

Parameter	Range	Running hours total
Set point	0 to 1,000,000 hours	500 hours
Enable	Not enabled, Enabled	Not enabled
Action		Warning

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.



Configure these parameters under **Configure > Parameters > Inverter > Maintenance > Running hours trip**.

Table 11.32 Default parameters

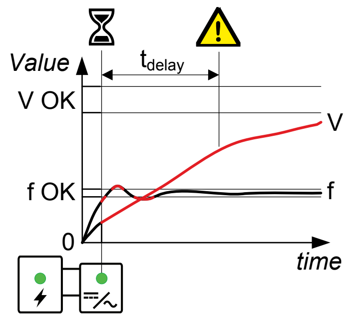
Parameter	Range	Running hours trip
Set point	0 to 1,000,000 hours	500 hours
Enable	Not enabled, Enabled	Not enabled
Action		Warning

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 source.



See **Configure > Parameters > Inverter > AC setup**. The parameters that the alarm is based on are under **Voltage and frequency OK**. The alarm is configured under **Voltage or frequency not OK**.

The alarm action is always *Block*.

Table 11.33 Default parameters

Parameter	Range	Voltage or frequency not OK
Delay	1 s to 1 h	30 s
Enable	Not enabled, Enabled	Enabled
Inhibit(s)		• Inverter not running • Inverter breaker closed

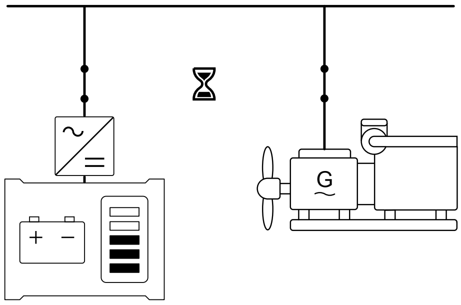
11.7.14 HYBRID-SG max. parallel time

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 11.34 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.

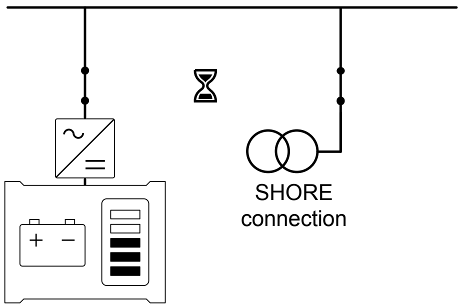
11.7.15 HYBRID-SC max. parallel time

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 11.35 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.

11.7.16 Other HYBRID controller alarms

The following alarms are also included on the HYBRID controller:

- EIM # relay 4 wire break

More information
See **Hardware characteristics and configuration** for more information.

12. SHAFT generator controller

12.1 SHAFT generator controller overview

12.1.1 Description

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.

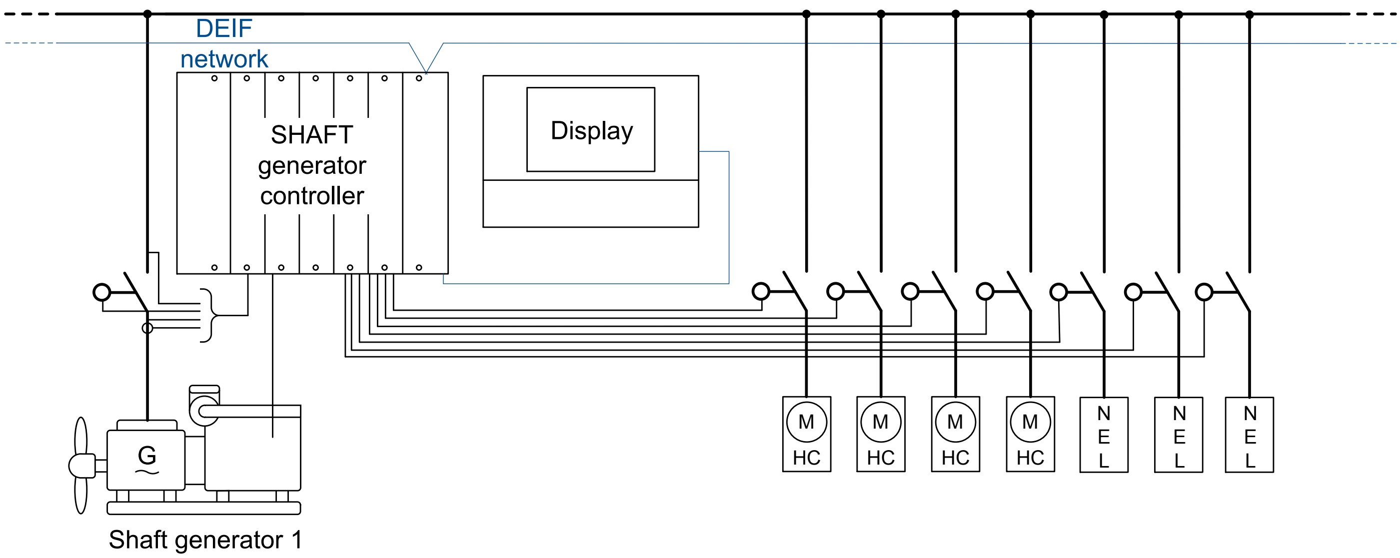
12.1.2 Application

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.

Figure 12.1 Example SHAFT generator controller with optional heavy consumers and non-essential loads



12.1.3 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

Regulation	• Regulators for relay outputs and analogue outputs
	  ◦ Regulation delay
	• Governor regulation
	  ◦ Fixed power
	  ◦ Active power load sharing
	  ◦ Active power ramp down
	  ◦ Frequency-dependent power droop
	• AVR regulation
	  ◦ Fixed cos phi
	  ◦ Fixed reactive power
	  ◦ Reactive power load sharing
	  ◦ Voltage droop
	• Configurable: Power ramp up, power ramp down

12.2 SHAFT generator controller principles

12.2.1 Nominal settings

Generator nominal settings

These nominal settings are under **Configure > Parameters > Generator > Nominal settings > Nominal settings #**, where # is 1 to 4.

Table 12.1 Controller nominal settings

Nominal setting	Range	Default	Notes
Voltage (V)	10 V to 160 kV	400 V	The phase-to-phase nominal voltage for the shaft generator.
Current (I)	1 A to 9 kA	867 A	The maximum current flow in one phase (that is, L1, L2 or L3) from the shaft generator during normal operation.
Frequency (f)	48 to 62 Hz	50 Hz	The system nominal frequency, typically either 50 Hz or 60 Hz. All the controllers in the system should have the same nominal frequency.
Power (P)	1 kW to 900 MW	480 kW	The nominal active power may be on the shaft generator nameplate.
Apparent power (S)	1 kVA to 1 GVA	530 kVA	The nominal apparent power should be on the shaft generator nameplate.
Power factor (PF)	0.6 to 1	0.9	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.

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

Busbar nominal settings

These nominal settings are under **Configure > Parameters > Busbar > Nominal settings > Nominal settings #**, where # is 1 to 4.

Table 12.2 Controller nominal settings

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

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** for more information.

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 **GENSET controller**, **Genset controller principles**, **Running detection** for more information.

12.2.4 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 SHAFT generator controller.

Table 12.3 AC configuration for the SHAFT generator controller

SHAFT generator	General name
Generator	[Source]
Busbar	[Busbar]

12.2.5 Breaker configuration

More information
The **Breakers, synchronisation and de-loading** chapter describes 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 Introduction

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 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 SHAFT generator controller, the breaker abbreviation (*[*B]*) is *SGB*. *[Breaker]* refers to *Shaft generator breaker*.

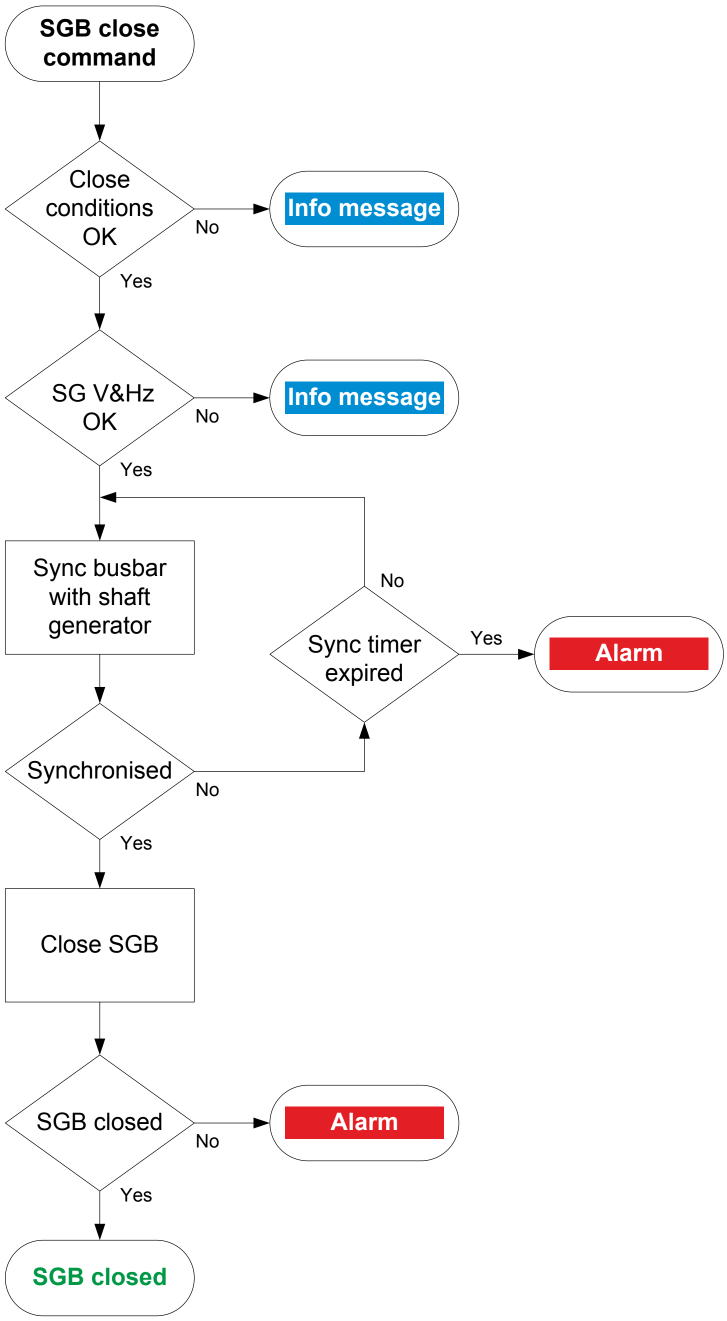
12.3.2 Shaft generator breaker close flowchart

The following flowchart shows the sequence that the controller normally uses to close the shaft generator breaker.

More information
See **Shaft generator breaker blackout close flowchart** for information about 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 unit, the controller ignores this command.

Table 12.4 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 unit.
   - 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 SEMI 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 controller**, **Other SHAFT generator controller functions**, **Shaft generator load transfer without parallel** for more information.

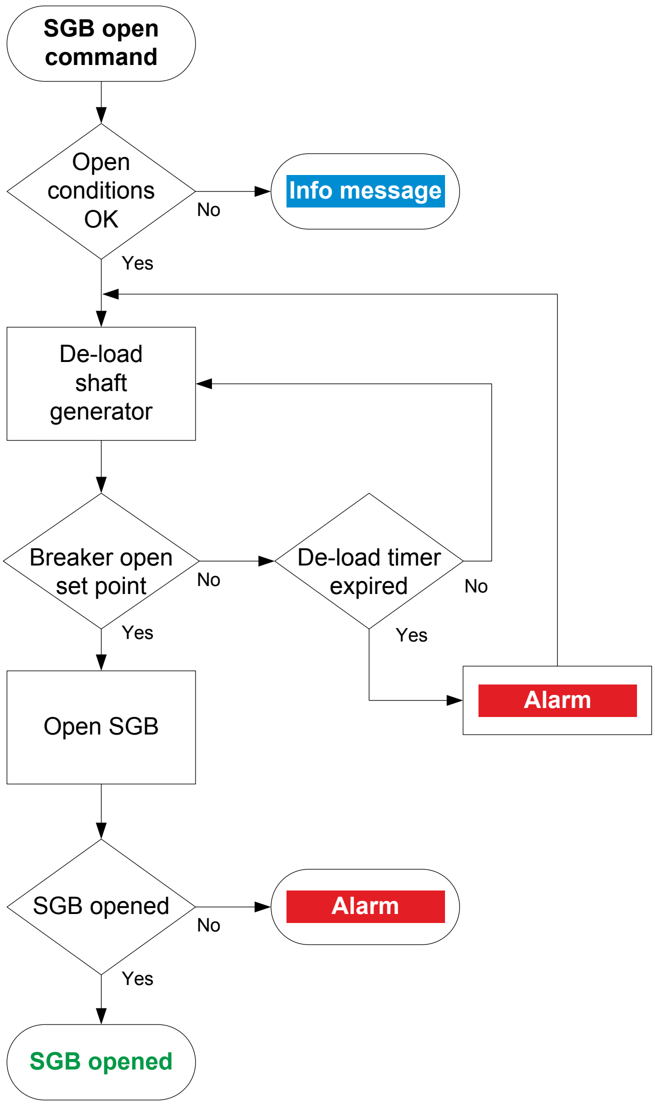
12.3.3 Shaft generator breaker open flowchart

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 unit, the controller ignores this command.

Table 12.5 Shaft generator breaker (SGB) open flowchart



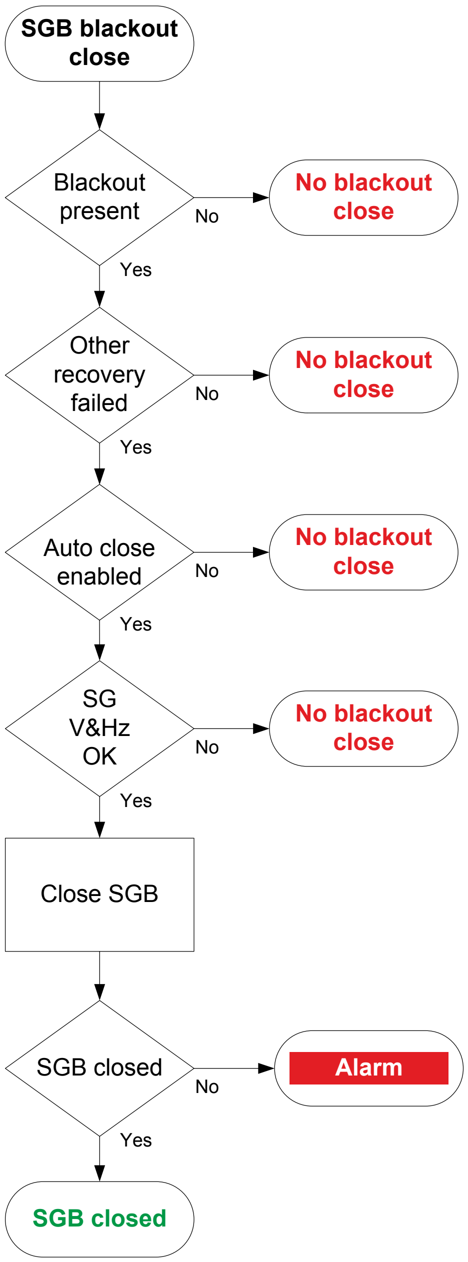
1. **SGB open command:** The shaft generator breaker (SGB) open command can come from the following:
   - The operator can press the push-button **Open breaker** on the display unit.
   - The operator can use PICUS to send an open breaker command.
   - The command can come from an external source.
2. **Open conditions OK:** The controller checks that the open conditions are present:
   - There must be enough gensets in AUTO mode, and/or connected in SEMI 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.

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 **Power management**, **Blackout** for more information.

Table 12.6 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*.

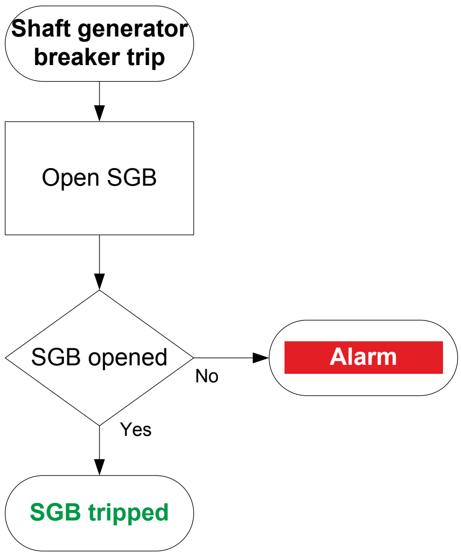
12.3.5 Shaft generator breaker trip flowchart

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.

Table 12.7 Shaft generator breaker trip flowchart



1. **Open SGB:** When a trip is required, the controller activates the *Breakers* > *Shaft generator breaker* > *Control* > *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 before the input is activated. This ensures the minimum load when opening the shaft generator breaker.

Parameters

Configure these parameters under **Configure > 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 %	

Configure these parameters under **Configure > Parameters > 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. Configure these parameters under **Configure > Parameters > Breakers > Shaft generator breaker configuration >Synchronisation setting (PTH)**.

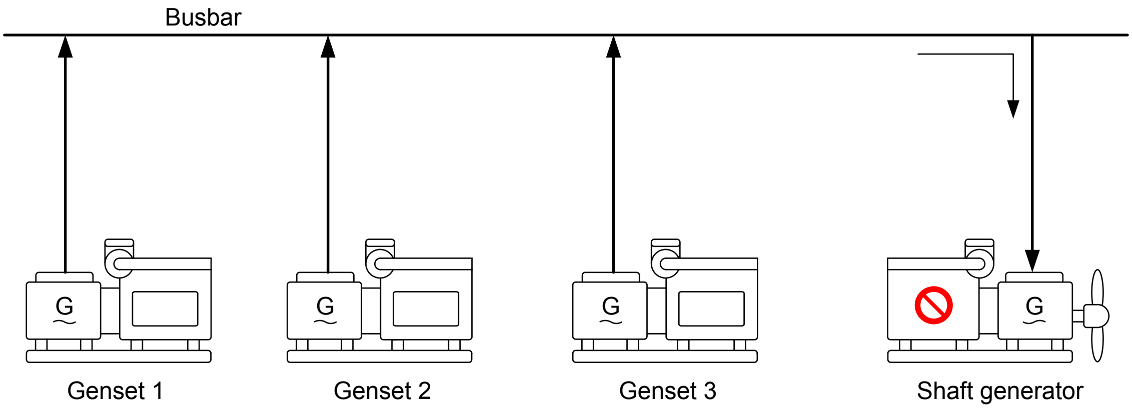
Name	Range	Default	Comment
Sync. type	• Dynamic • Static	Dynamic	The synchronisation type to be performed by controller to close the breaker.
Delta frequency min.	-0.5 to 0.3 Hz	-0.3 Hz	Add *Delta frequency min.* to the busbar frequency, for the **minimum** frequency from the synchronising generator 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.

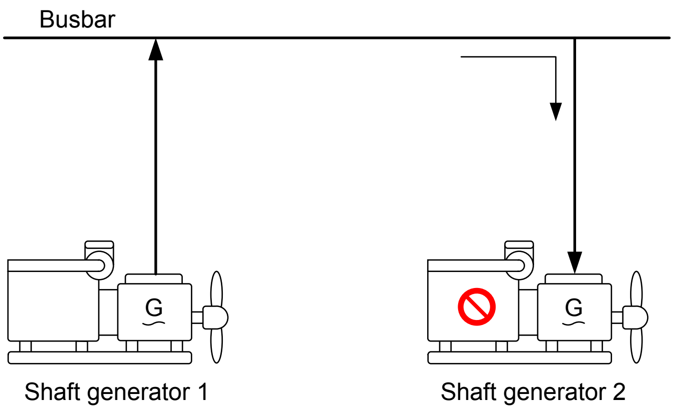
The gensets can also be used to provide power for two shaft generators, both running power take home, if required.

Figure 12.2 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.

Figure 12.3 Power from one shaft generator used for PTH by the other SHAFT generator controller



DANGER!
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

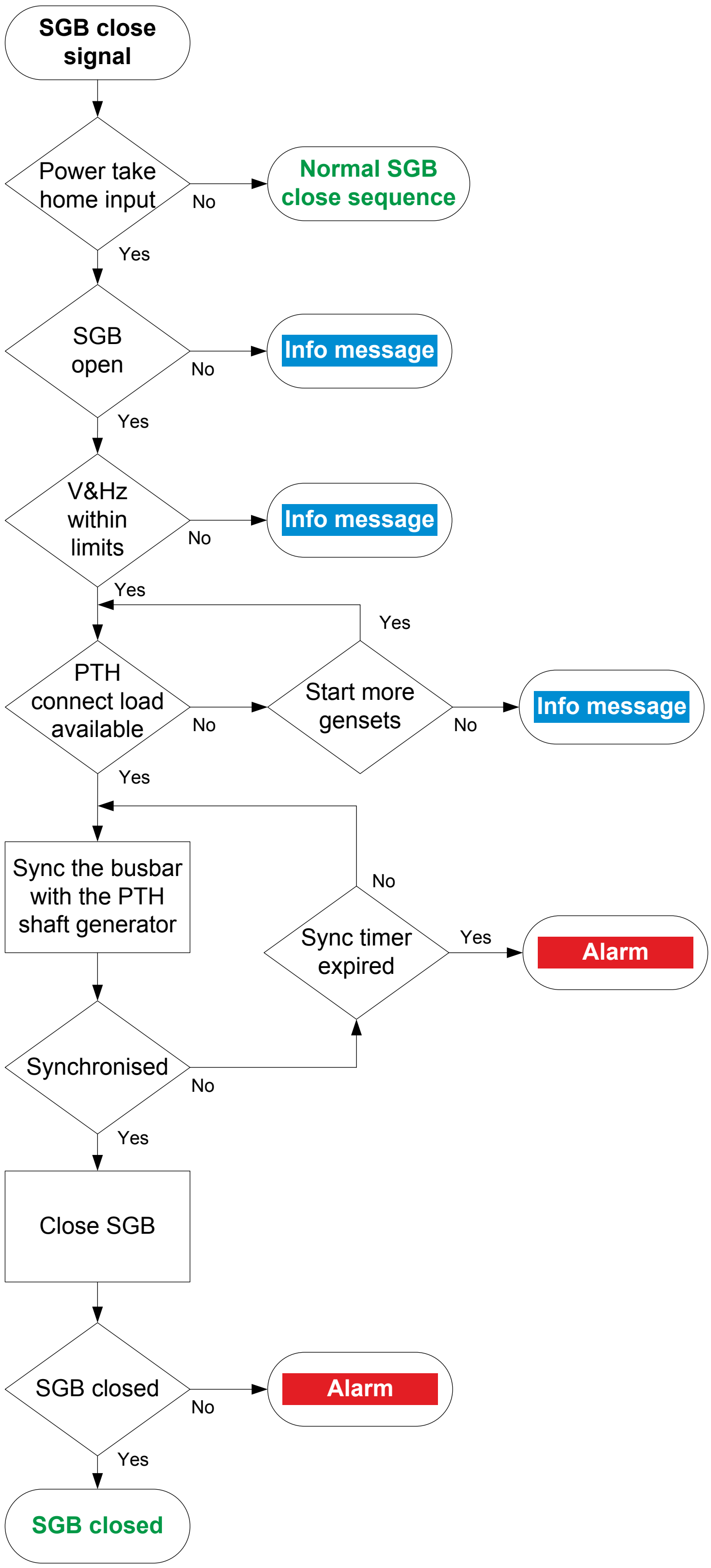
This protection is deactivated by the *Power take home* inhibit in all the connected GENSET controllers:

- 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 unit.

Table 12.8 Shaft generator breaker close sequence for starting PTH



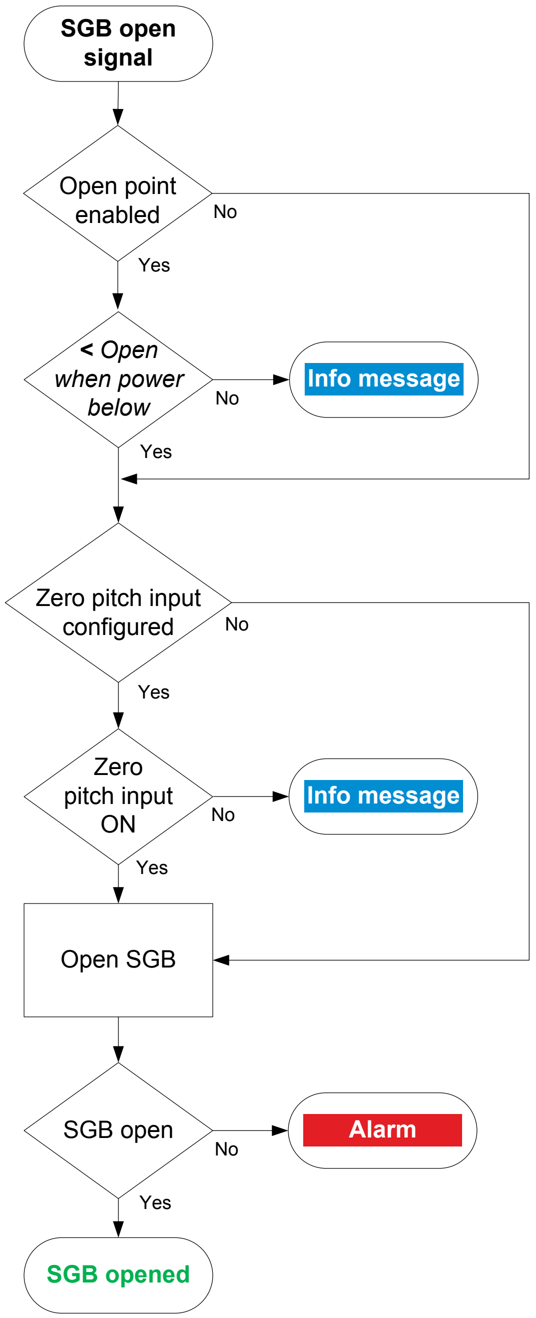
The following conditions must be met to successfully start PTH:

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 unit.

Table 12.9 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.

INFO
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.

INFO
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.

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. This function is enabled under **Parameters > 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 **Power management**, **Load sharing**, **SHAFT generator base load** for more information.

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 unit.

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 unit.
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

Configure these parameters under **Configure > 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.

Configure these parameters under **Configure > Parameters > 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.

Configure these parameters under **Configure > Parameters > 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 under 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 **GENSET controller**, **Other GENSET controller functions**, **Temperature-dependent power derating** 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.

Input

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

Table 12.10 Hardware required in addition to the minimum standard controller wiring

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.

Outputs

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

Table 12.11 Engine state functions

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.

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

Table 12.12 Engine operating value 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 Shaft generator regulation

You can use the SHAFT generator controller regulate a shaft generator, in just the same way as you would use a GENSET controller to regulate a genset. You can use shaft generator regulation to transfer load directly from one shaft generator to another.

INFO
To use this function, the shaft generator must support regulation.

DANGER!
During shaft generator regulation, the ship crew cannot use the shaft to regulate the ship speed.

More information
See the **Regulation** chapter for detailed information about regulation.

Inputs and outputs

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

Table 12.13 Required shaft generator regulation input and outputs

Function	I/O	Type	Details
Regulators > Common > Regulation ON	Digital input	Continuous	The controller only activates shaft generator regulation if this input is configured and activated. Note: This input is only visible after configuring a regulator.
Governor regulation	Analogue output, or digital outputs	Depends on the output type	See the **Regulation** chapter.
AVR regulation	Analogue output, or digital outputs	Depends on the output type	See the **Regulation** chapter.

When the regulation outputs are configured, all of the other regulation inputs and outputs become available. See the **Regulation** chapter for more information.

Parameters

When the regulation outputs are configured, all of the regulation parameters become available. See the **Regulation** chapter for more information.

For regulation, you must configure the SHAFT generator running feedback measurement. See **GENSET controller, GENSET controller principles, Running detection** for more information.

How it works

When *Regulation ON* is activated, the SHAFT generator controller can receive regulation set points from other controllers on the DEIF network. The SHAFT generator controller can send regulation signals to adjust the frequency and/or voltage of the shaft generator.

You can use any of the following for shaft generator regulation:

- The regulation inputs and outputs
- The regulation parameters
- The regulation alarms
- The regulation modes
- External regulation set points
- Stand-alone GAM3.2

Shaft generator regulation does not include the following:

- Shaft prime mover start and stop
- Overspeed and underspeed protections

Shaft generator load transfer without connecting gensets example

The system has two shaft generators (SG1 and SG2). SG1 has shaft generator regulation.

SG1 is running and is connected to the busbar. To transfer the load from SG1 to SG2:

1. If it is not already running, start SG2.
2. Activate *Regulation ON* on SG1.
3. Select the *External set point (Network) regulation* mode on SG1.
4. Activate *Close SGB* on SG2.
   - SG1 regulates its frequency and voltage to match the set point from SG2.
   - When the shaft generators are synchronised, the breaker for SG2 closes.
5. After SG1 and SG2 are connected, activate *Open SGB* on SG1.
   - SG1 de-loads and opens its breaker.

The load has successfully been transferred from SG1 to SG2.

12.4.10 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:

- Running hours and minutes (total and trip)
- Breaker operations and trips
- Active and reactive power export (to the busbar)
- Active and reactive power import (to the shaft generator)
- External breaker operations

INFO
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.

Configure the digital outputs under **Input/output > Digital output > Functions > Generator > Energy counters > [Counter pulse]**.

INFO
You must configure the digital output function to see the parameters.

Configure the energy transfer required for a pulse under **Parameters > Generator > Energy counters > [Counter] > Pulse every**. Configure the pulse length under **Parameters > Generator > Energy counters > [Counter] > Pulse length**.

Table 12.14 Energy counter function and corresponding parameter full names

[Counter pulse]	[Counter]
Active energy export pulse 1	Active energy export
Reactive energy export pulse 1	Reactive energy export
Active energy import pulse 1	Active energy import
Reactive energy import pulse 1	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 1*.

	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.

12.4.11 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.

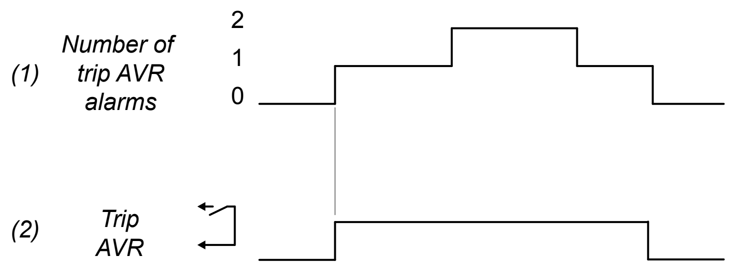
The *Trip AVR* output and alarm action does not initiate a breaker trip. To trip the breaker and the AVR, digital outputs for both actions must be configured and the correct alarm action must selected. For example, the *Trip breaker + AVR* alarm action.

Inputs and outputs

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

Function	I/O	Type	Details
[Source] > 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 12.15 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**: *[Source] > 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 PPM 300 controllers.

	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
	Magnetic pickup wire break alarm *
	Total running hours notification
	Trip running hours notification

	Alarms and protections
Maximum parallel time	SG-DG maximum parallel time
	SG-SG maximum parallel time
	SG-Hybrid maximum 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)
Regulation	• GOV regulation error • GOV regulation mode not selected • GOV stand-alone configuration error ** • P load sharing failure • AVR regulation error • AVR regulation mode not selected • AVR stand-alone configuration error ** • Q load sharing failure
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)
Other	Trip AVR output not configured

NOTE * The default SHAFT generator controller does not include EIM3.1 (required for this alarm).
** Only in GAM3.2.

12.5.2 Alarm actions

The controller has the following alarm actions:

- Warning
- Block
- PMS-controlled open breaker
- Trip shaft 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

The SHAFT generator controller includes the following inhibits:

Table 12.16 SHAFT generator controller inhibits

Inhibit	Disables the alarm when ...
Engine running	*Running detection* is ON.
Engine not running	*Running detection* is OFF.

Inhibit	Disables the alarm when ...
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 • 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
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 SHAFT generator controller, as well as which general alarm corresponds to each SHAFT generator controller alarm.

Table 12.17 Breaker alarm names for the SHAFT generator controller

SHAFT generator alarm	Configure > 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
The **AC configuration and nominal settings** chapter describes AC alarms in general.

The following tables show where to configure these alarms for the SHAFT generator controller.

Table 12.18 Generator AC alarm names for the SHAFT generator controller

SHAFT generator alarm	Configure > Parameters >	General name
Generator over-voltage 1 or 2	Generator > Voltage protections > Over-voltage 1 or 2	Over-voltage
Generator under-voltage 1 or 2	Generator > Voltage protections > Under-voltage 1 or 2	Under-voltage
Generator voltage unbalance	Generator > Voltage protections > Voltage unbalance	Voltage unbalance
Generator over-current 1 or 2	Generator > Current protections > Over-current 1 or 2	Over-current
Fast over-current 1 or 2	Generator > Current protections > Fast over-current 1 or 2	Fast over-current
Current unbalance (average calc.)	Generator > Current protections > Current unbalance (average calc.)	Current unbalance (average calc.)
Current unbalance (nominal calc.)	Generator > Current protections > Current unbalance (nominal calc.)	Current unbalance (nominal calc.)
Inverse time over-current	Generator > Current protections > Inverse time over-current	Inverse time over-current
Stabilised differential current	Generator > Current protections > Stabilised differential current	Stabilised differential current
High set differential current	Generator > Current protections > High set differential current	High set differential current
Generator over-frequency 1 or 2	Generator > Frequency protections > Over-frequency 1 or 2	Over-frequency
Generator under-frequency 1 or 2	Generator > Frequency protections > Under-frequency 1 or 2	Under-frequency
Overload 1 or 2	Generator > Power protections > Overload 1 or 2	Overload
Reverse power 1 or 2	Generator > Power protections > Reverse power 1 or 2	Reverse power
Reactive power export 1 or 2	Generator > Reactive power protections > Reactive power export 1 or 2	Reactive power export
Reactive power import 1 or 2	Generator > Reactive power protections > Reactive power import 1 or 2	Reactive power import

Table 12.19 Busbar AC alarm names for the SHAFT generator controller

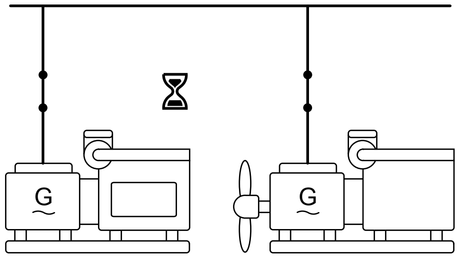
SHAFT generator alarm	Configure > Parameters >	General name
Busbar over-voltage 1 or 2	Busbar > Voltage protections > Over-voltage 1 or 2	Busbar over-voltage
Busbar under-voltage 1 or 2	Busbar > Voltage protections > Under-voltage 1 or 2	Busbar under-voltage
Busbar voltage unbalance	Busbar > Voltage protections > Voltage unbalance	Busbar voltage unbalance
Busbar over-frequency 1 or 2	Busbar > Frequency protections > Over-frequency 1 or 2	Busbar over-frequency
Busbar under-frequency 1 or 2	Busbar > Frequency protections > Under-frequency 1 or 2	Busbar under-frequency

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.



The alarm can be configured under **Configuration > Parameters > Local power management > Parallel timers**. This alarm is inhibited by *Power take home active*. The action is *Trip shaft generator breaker*, *Latch enabled*.

Table 12.20 SG-DG max. parallel time parameters

Parameter	Range	Default
Delay	0.1 s to 1 h	3 min
Enable	Not enabled, Enabled	Enabled

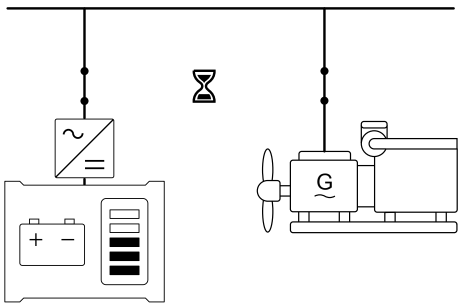
More information
See **GENSET controller**, **GENSET controller protections**, **DG-SG max. parallel time** for the alarm in the GENSET controller that trips the generator breaker.

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.



The alarm can be configured under **Configuration > Parameters > Local power management > Parallel timers**. This alarm is inhibited by *Power take home active*. The action is *Trip shaft generator breaker*, *Latch enabled*.

Table 12.21 SG-HYBRID max. parallel time parameters

Parameter	Range	Default
Delay	0.1 s to 1 h	3 min
Enable	Not enabled, Enabled	Enabled

More information
See **HYBRID controller**, **HYBRID controller protections**, **HYBRID-SG max. parallel time** for the alarm in the HYBRID controller that trips the inverter breaker.

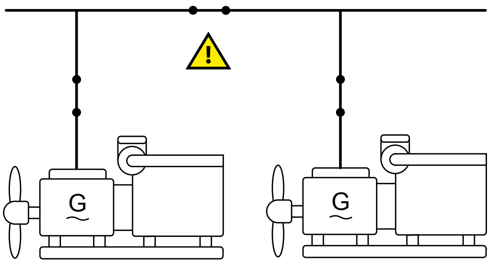
12.5.8 SG-SG max. parallel time

DANGER!
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.

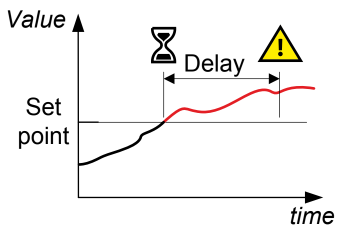
The alarm is inhibited in the SHAFT generator controller if *Power take home active* is activated.

INFO
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.



Configure these parameters under **Configure > Parameters > Engine > Protections > Overspeed #**, where # is 1 or 2.

Table 12.22 Default parameters

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

INFO
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

More information

For the alarm marked with *, see **Hardware characteristics and configuration** for more information.

For the other alarms, see **GENSET controller**, **GENSET controller alarms** for more information.

13. SHORE connection controller

13.1 SHORE connection controller overview

13.1.1 Description

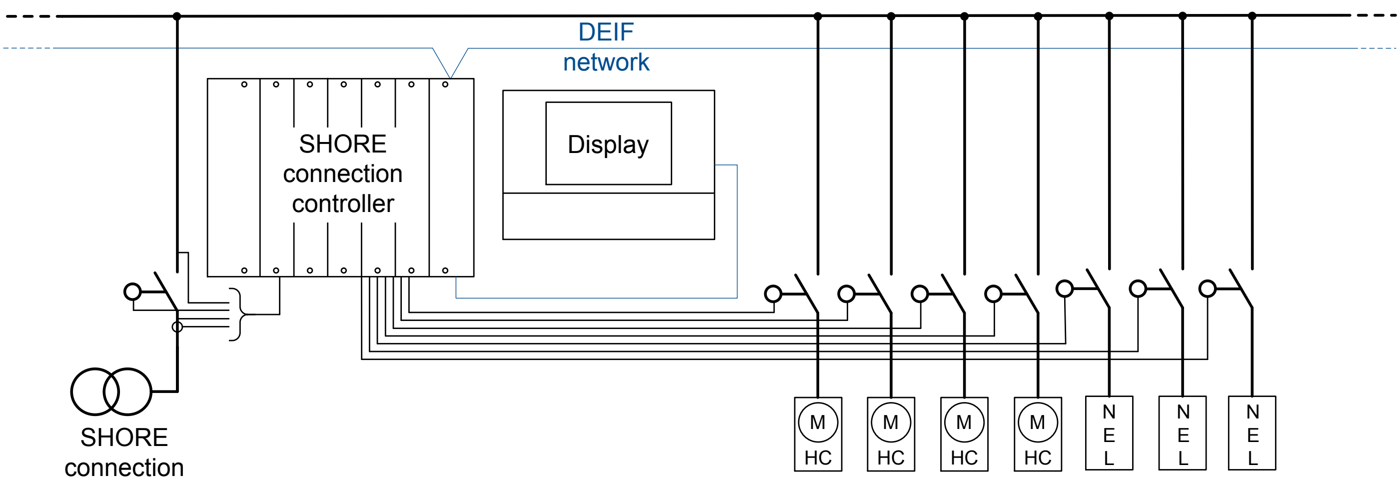
A SHORE connection controller controls and protects the system and the shore connection breaker when a shore connection is connected. When the shore connection is in use, it is normally the ship's only power source. However, the gensets may run in parallel with the shore connection for a limited time.

13.1.2 Application

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.

Figure 13.1 Example SHORE connection controller with optional heavy consumers and non-essential loads



13.1.3 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 • 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

	Functions
	◦ 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 busbar nominal settings

These nominal settings are found under **Configure > Parameters > Shore connection > Nominal settings > Nominal settings #**, where # is 1 to 4.

Table 13.1 Controller nominal settings

Nominal setting	Range	Default	Notes
Voltage (V)	10 V to 160 kV	400 V	The phase-to-phase nominal voltage for the shore connection.
Current (I)	1 A to 9 kA	867 A	The maximum current from the shore connection during normal operation.
Frequency (f)	48 to 62 Hz	50 Hz	The system nominal frequency. All the controllers in the system should have the same nominal frequency.
Power (P)	1 kW to 900 MW	480 kW	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 kVA to 1 GVA	530 kVA	Shore connection apparent power.
Power factor (PF)	0.6 to 1	0.9	Shore connection power factor.

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

Ship busbar nominal settings

These settings are under **Configure > Parameters > Busbar > Nominal settings > Nominal settings #**, where # is 1 to 4.

Table 13.2 Controller nominal settings

Nominal setting	Range	Default	Notes
Voltage (V)	10 V to 160 kV	400V	The phase-to-phase nominal voltage for the busbar. If there is no transformer between the shore connection and the ship busbar, the nominal voltage for the busbar will be the same as the nominal voltage for the shore connection.
Frequency (f)	48 to 62 Hz	50 Hz	The system nominal frequency. All the controllers in the system should have the same nominal frequency.

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.

13.2.3 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 SHORE connection controller.

Table 13.3 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 more information about 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.

Inputs

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

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

Table 13.4 Breaker commands (optional)

Function	I/O	Type	Details
Breakers > Shore connection breaker > Command > SCB action open	Digital input	Pulse	This input starts the breaker de-load and opening procedure. This input can also be used to confirm the selection, when *Operator select* is selected under **Breaker action**.

Function	I/O	Type	Details
			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.

Parameters

Configure the parameters under **Configure > Parameters > Shore breaker configuration > Configuration**.

Table 13.5 Additional shore connection parameters

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 Introduction

The shore connection breaker (SCB) connects the shore connection to the 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 busbar. If it is configured correctly, the shore connection breaker also trips to stop shore connection problems from disturbing the busbar.

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 SHORE connection controller, the breaker abbreviation (*[*B]*) is *SCB*. *[Breaker]* refers to *Shore connection breaker*.

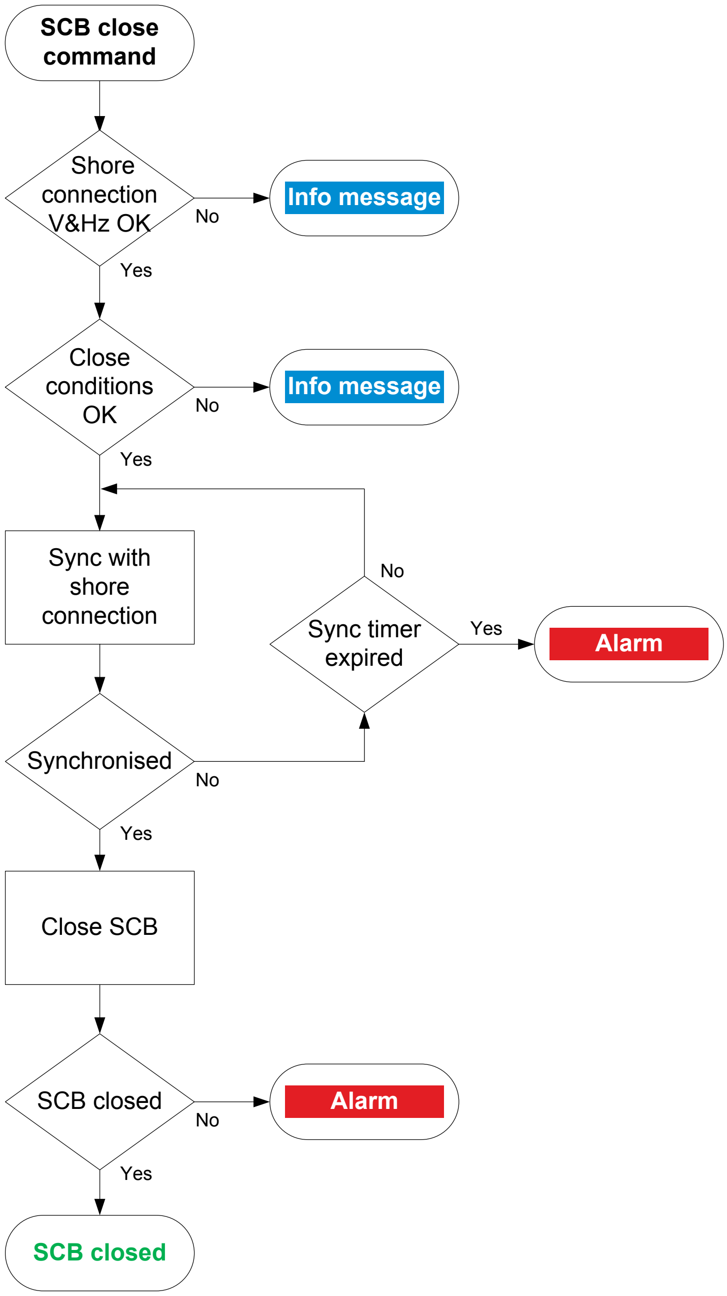
13.3.2 Shore connection breaker close flowchart

The following flowchart shows the sequence that the controller normally uses to close the shore connection breaker.

More information
See **SHORE connection controller**, **Shore connection breaker**, **Shore connection breaker blackout close flowchart** for information about how to allow the shore connection 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 unit, the controller ignores this command.

Table 13.6 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 unit.
   - 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 under 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 SEMI 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 under 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 under 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

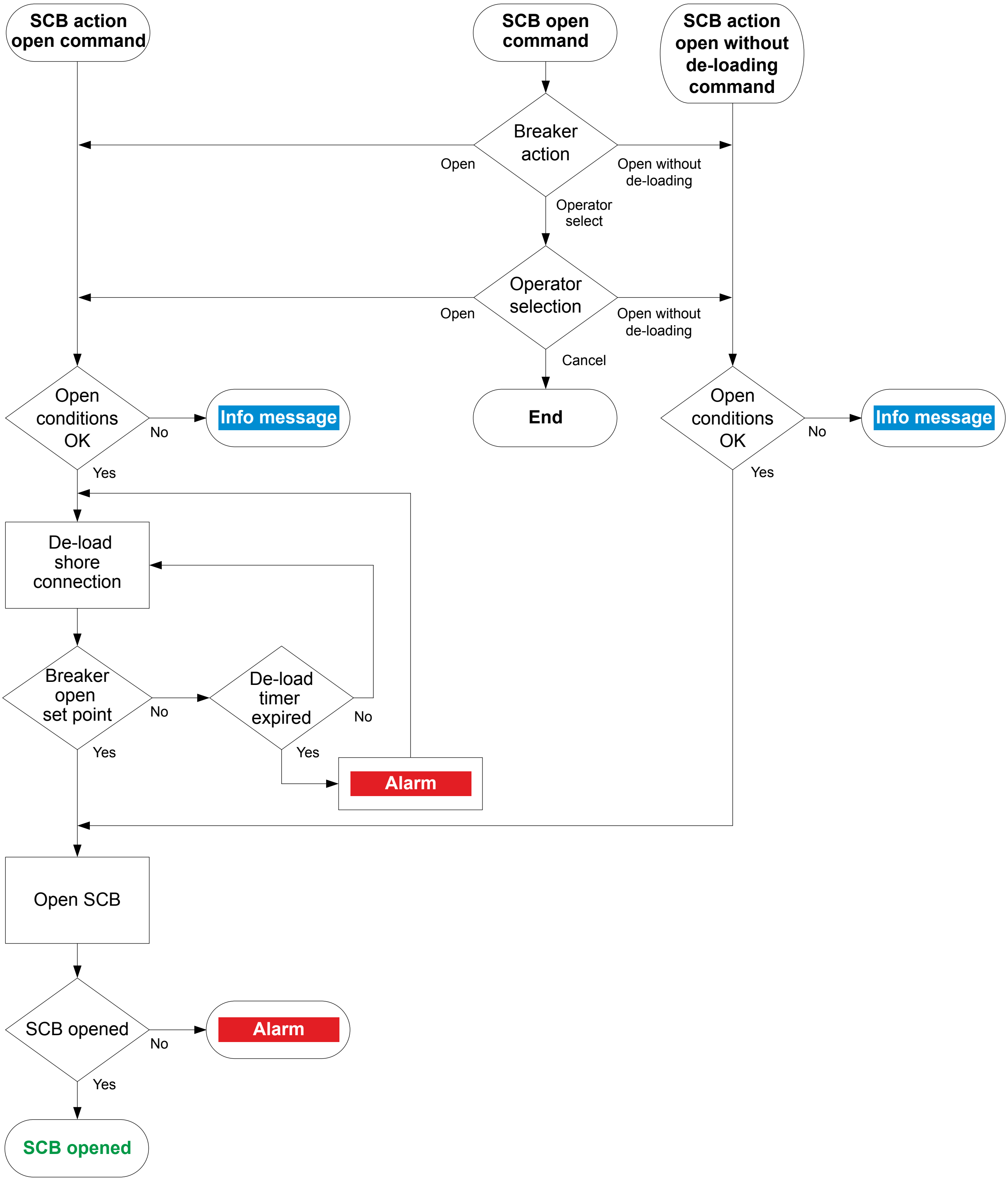
The following flowchart shows the sequence that the controller normally uses to open the shore connection breaker (SCB). This sequence is also used for the alarm action *PMS-controlled open breaker*.

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 under 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 unit, the controller ignores this command.

CAUTION
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.

Table 13.7 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 unit. 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 SEMI 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.

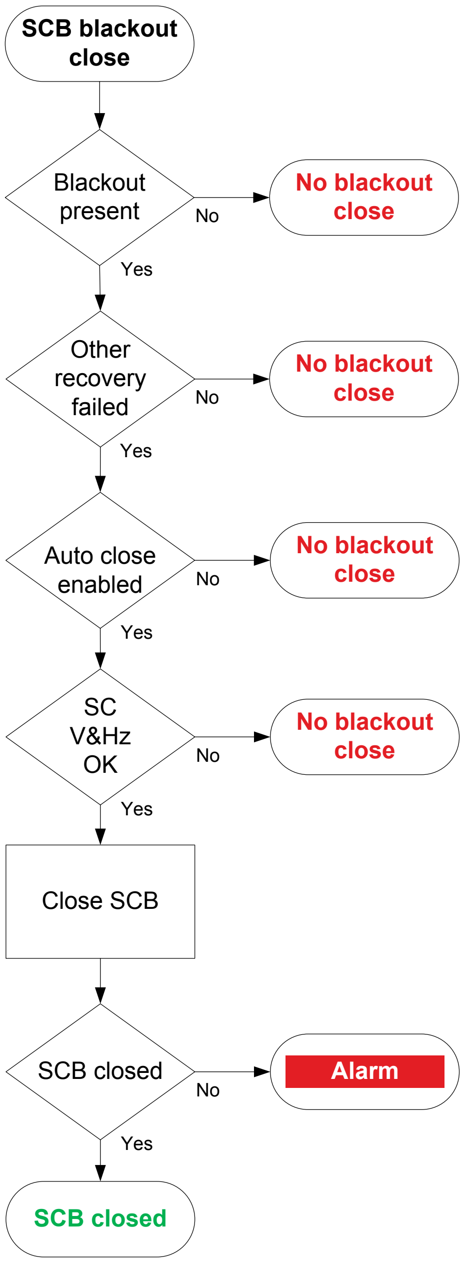
   Open without de-loading selected
   - The controller opens the breaker without de-loading.
4. **SCB opened:** The controller checks whether the SCB has opened.
   - If the SCB has opened, the SCB open sequence has been completed successfully.
   - If the SCB has not opened, an *SCB open failure* alarm is activated.

13.3.4 Shore connection breaker blackout close flowchart

The following flowchart shows the sequence that the controller uses to connect the shore connection to a black busbar.

More information
See **Power management**, **Blackout** for more information.

Table 13.8 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.

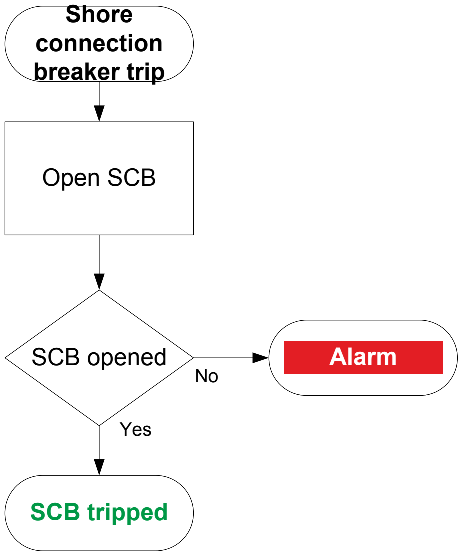
13.3.5 Shore connection breaker trip flowchart

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.

Table 13.9 Shore connection breaker trip flowchart



1. **Open SCB:** When a trip is required, the controller activates the *Breakers > Shore connection breaker > Control > 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.

Input

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

Table 13.10 Hardware required in addition to the minimum standard controller wiring

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

Configure these parameters under **Configure > Parameters > Local power management > Shore connection ship-to-ship > Open point**.

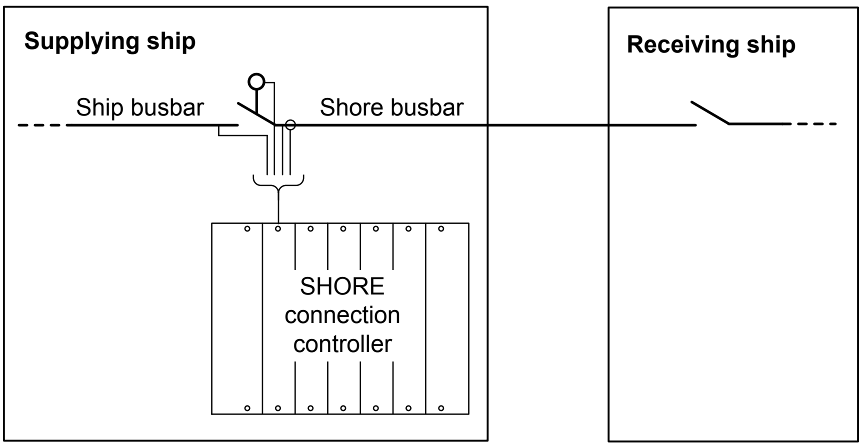
Parameter	Range	Default	Comment
Open point enabled	Not enabled, Enabled	Not enabled	**Not enabled**: The power management system can open the shore connection breaker (SCB) at any load. **Enabled**: For the power management system to open the SCB, the load on the SCB must be less than the value in *Open 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.

Configure this parameter under **Configure > Parameters > 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

Figure 13.2 Example of a ship-to-ship application



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 PPM 300, or controlled by any other controller.

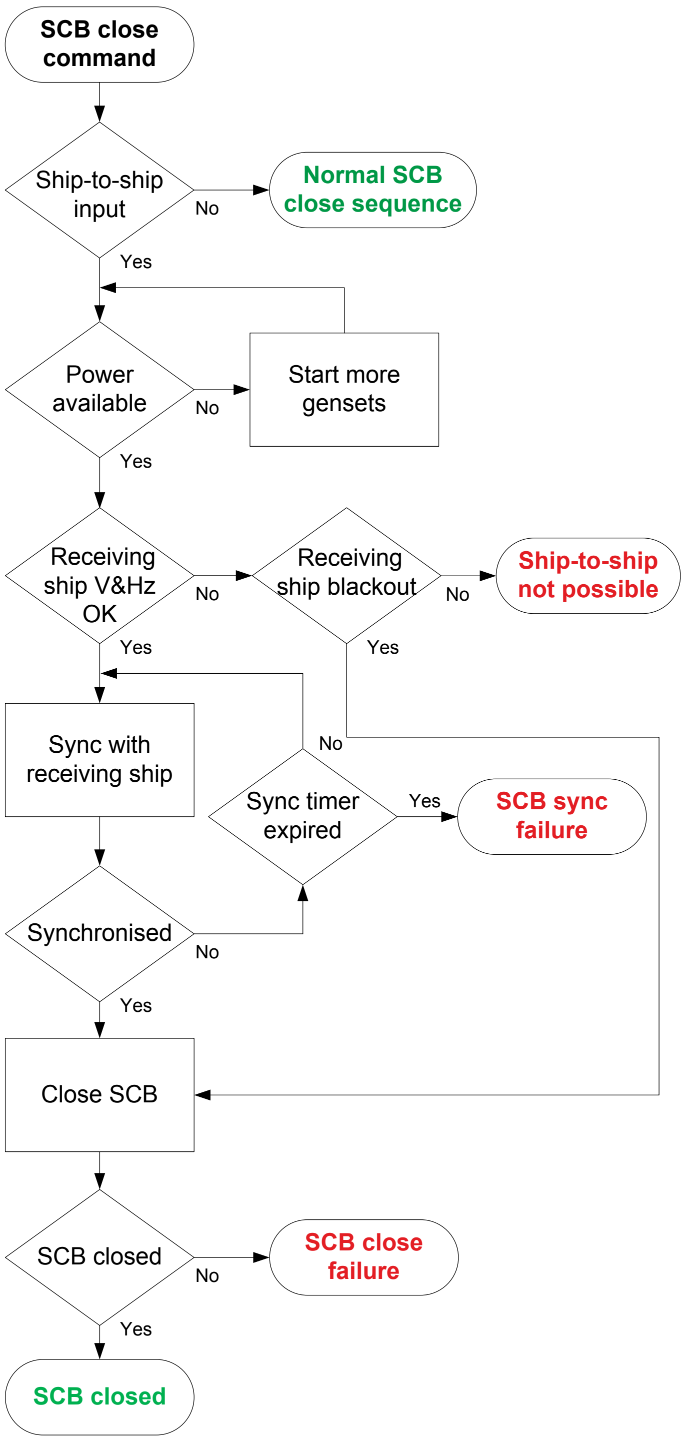
The SHORE connection controller on the supplying ship uses the AC measurements to detect the conditions on the receiving ship. There is no other communication between the SHORE connection controller on the supplying ship and the receiving ship.

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 unit.
   - 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 under **Parameters > 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 **Power management**, **Load sharing**, **SHORE connection base load** for more information.

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.

Configure this parameter under **Parameters > 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.

Parameter

Configure the parameter under **Configure > Parameters > Power management rules > Configuration # > Shore connection > Parallel**, where # is the power management rule number.

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

Parameter	Range	Default	Notes
			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, 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.

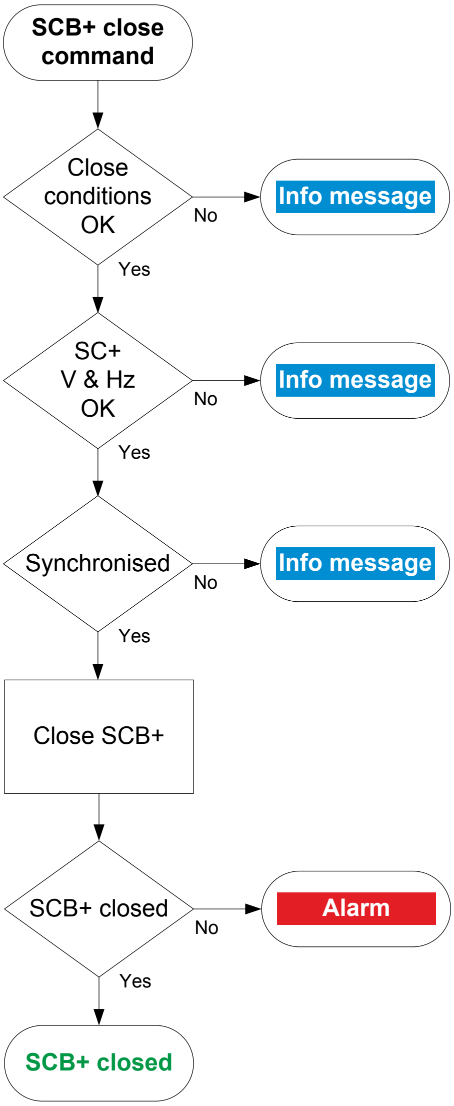
Connecting additional shore connections

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 unit.
   - 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 (*Configure* > *Parameters* > *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 13.11 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 13.12 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.

CAUTION
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 senstive shore connection.

Parameters

Configure the parameters under **Configure > 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

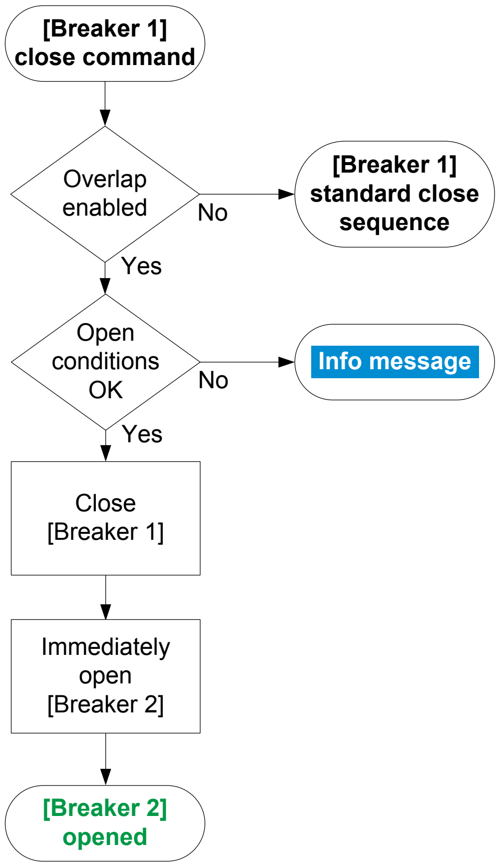
In the description below, the connecting equipment can either be a genset that connects to a busbar powered by one or more shore connections, or a shore connection that connects to a busbar powered by one or more gensets. The connecting equipment controller controls *Breaker 1*, while the connected equipment 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 unit.

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 unit.
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 unit under **Configure > Counters**. 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.

Configure the digital outputs under **Input/output > Digital output > Functions > Shore connection > Energy counters > [Counter pulse]**.

INFO
You must configure the digital output function to see the parameters.

Configure the energy transfer required for a pulse under **Parameters > Shore connection > Energy counters > [Counter]**

Table 13.13 Active energy export counter parameters

Parameter	Range	Default	Comment
Pulse every	1 kWh to 10 MWh	10 kWh	The value when a digital output sends a pulse.
Pulse length	0.1 s to 1 h	1 s	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 13.14 Reactive energy export counter parameters

Parameter	Range	Default	Comment
Pulse every	1 kvarh to 10 Mvarh	10 kvarh	The value when a digital output sends a pulse.
Pulse length	0.1 s to 1 h	1 s	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 13.15 Active energy import counter parameters

Parameter	Range	Default	Comment
Pulse every	1 kWh to 10 MWh	10 kWh	The value when a digital output sends a pulse.
Pulse length	0.1 s to 1 h	1 s	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 13.16 Reactive energy import counter parameters

Parameter	Range	Default	Comment
Pulse every	1 kvarh to 10 Mvarh	10 kvarh	The value when a digital output sends a pulse.
Pulse length	0.1 s to 1 h	1 s	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 13.17 Energy counter function and corresponding parameter full names

[Counter pulse]	[Counter]
Active energy export pulse 1	Active energy export
Reactive energy export pulse 1	Reactive energy export
Active energy import pulse 1	Active energy import
Reactive energy import pulse 1	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 1*.
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 PPM 300 controllers.

	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
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
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:

Table 13.18 SHORE connection controller 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 busbar voltage is above 10% of the nominal voltage.
No shore voltage	The shore busbar voltage is below 10% of the nominal voltage.
Shore frequency present	The shore busbar frequency is above 10% of the nominal frequency.
No shore frequency	The shore busbar 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
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 SHORE connection controller, as well as which general alarm corresponds to each SHORE connection controller alarm.

Table 13.19 Breaker alarm names for the SHORE connection controller

SHORE connection alarm	Configure > 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
The **AC configuration and nominal settings** chapter describes AC alarms in general.

The following tables show where to configure these alarms for the SHORE connection controller, as well as which general alarm corresponds to each SHORE connection controller alarm.

Table 13.20 AC alarm names for the SHORE connection controller

SHORE connection alarm	Configure > Parameters >	General name
Shore connection over-voltage 1 or 2	Shore connection > Voltage protections > Over-voltage 1 or 2	Over-voltage
Shore connection under-voltage 1 or 2	Shore connection > Voltage protections > Under-voltage 1 or 2	Under-voltage
Shore connection voltage unbalance	Shore connection > Voltage protections > Voltage unbalance	Voltage unbalance
Shore connection over-current 1 or 2	Shore connection > Current protections > Over-current 1 or 2	Over-current
Fast over-current 1 or 2	Shore connection > Current protections > Fast over-current 1 or 2	Fast over-current
Current unbalance (average calc.)	Shore connection > Current protections > Current unbalance (average calc.)	Current unbalance (average calc.)
Current unbalance (nominal calc.)	Shore connection > Current protections > Current unbalance (nominal calc.)	Current unbalance (nominal calc.)
Inverse time over-current	Shore connection > Current protections > Inverse time over-current	Inverse time over-current
Shore connection over-frequency 1 or 2	Shore connection > Frequency protections > Over-frequency 1 or 2	Over-frequency
Shore connection under-frequency 1 or 2	Shore connection > Frequency protections > Under-frequency 1 or 2	Under-frequency
Overload 1 or 2	Shore connection > Power protections > Overload 1 or 2	Overload

SHORE connection alarm	Configure > Parameters >	General name
Reverse power 1 or 2	Shore connection > Power protections > Reverse power 1 or 2	Reverse power
Reactive power export 1 or 2	Shore connection > Reactive power protections > Reactive power export 1 or 2	Reactive power export
Reactive power import 1 or 2	Shore connection > Reactive power protections > Reactive power import 1 or 2	Reactive power import

Table 13.21 Busbar AC alarm names for the SHORE connection controller

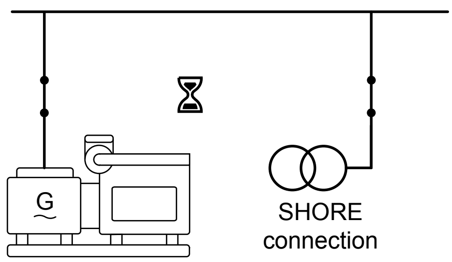
SHORE connection alarm	Configure > Parameters >	General name
Busbar over-voltage 1 or 2	Busbar > Voltage protections > Over-voltage 1 or 2	Busbar over-voltage
Busbar under-voltage 1 or 2	Busbar > Voltage protections > Under-voltage 1 or 2	Busbar under-voltage
Busbar voltage unbalance	Busbar > Voltage protections > Voltage unbalance	Busbar voltage unbalance
Busbar over-frequency 1 or 2	Busbar > Frequency protections > Over-frequency 1 or 2	Busbar over-frequency
Busbar under-frequency 1 or 2	Busbar > Frequency protections > Under-frequency 1 or 2	Busbar under-frequency

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.



The alarm can be configured under **Configuration > Parameters > Local power management > Parallel timers**. The action is *Trip shore connection breaker*, *Latch enabled*.

Table 13.22 SC-DG max. parallel time parameters

Parameter	Range	Default
Delay	0.1 s to 1 h	3 min
Enable	Not enabled, Enabled	Enabled

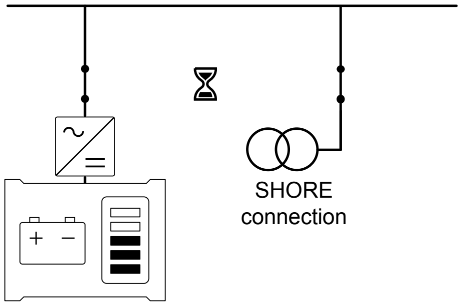
More information
See **GENSET controller**, **GENSET controller protections**, **DG-SC max. parallel time** for the alarm in the GENSET controller that trips the generator breaker.

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.



The alarm can be configured under **Configuration > Parameters > Local power management > Parallel timers**. The action is *Trip shore connection breaker*, *Latch enabled*.

Table 13.23 SC-HYBRID max. parallel time parameters

Parameter	Range	Default
Delay	0.1 s to 1 h	3 min
Enable	Not enabled, Enabled	Enabled

More information
See **HYBRID controller**, **HYBRID controller protections**, **HYBRID-SC max. parallel time** for the alarm in the HYBRID controller that trips the inverter breaker.

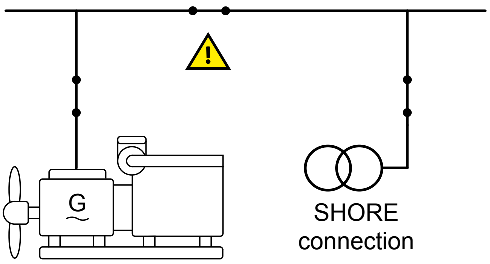
13.5.8 SC-SG max. parallel time

DANGER!
Connecting a shaft generator to a shore connection 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.



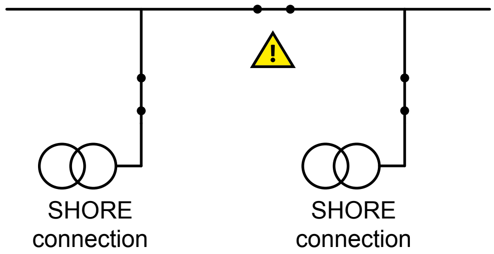
The alarm has a delay of 0.1 s. The alarm is always enabled. The alarm action is *Trip shore connection breaker*, *Latch enabled*. The alarm parameters are not visible in PICUS.

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 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.

INFO
To prevent a blackout, only the SHORE connection controller with the highest *Controller ID* trips its breaker.

14. BUS TIE breaker controller

14.1 BUS TIE breaker controller overview

14.1.1 Description

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.

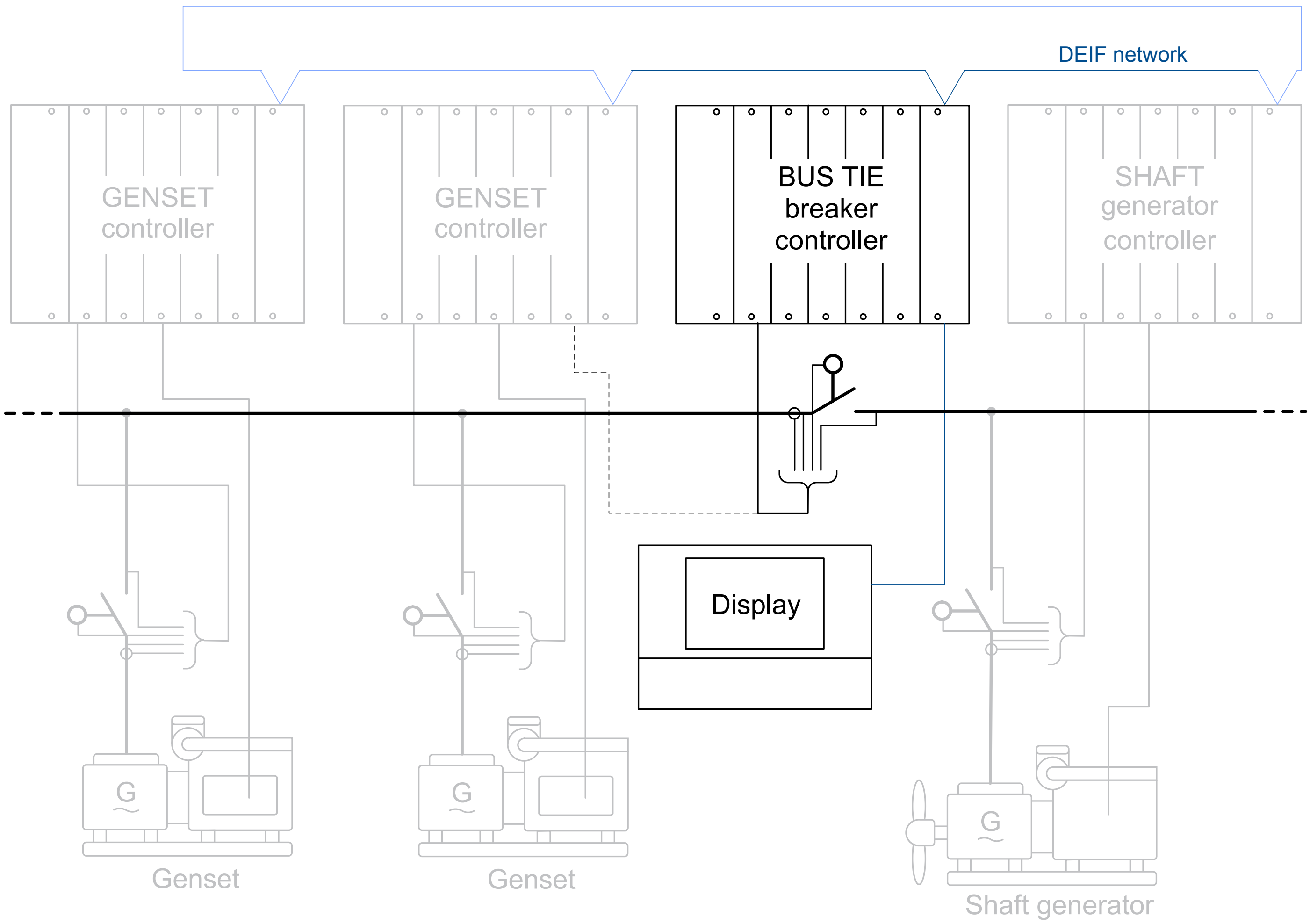
14.1.2 Application

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 is no restriction on the number of BUS TIE breaker controllers. There can be a ring busbar connection.

Figure 14.1 Example BUS TIE breaker controller



14.1.3 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) ◦ Energy differential (active and reactive) ◦ External breaker operations • Energy counters with configurable digital outputs (for external counters) ◦ Energy export (active and reactive) (to busbar B) ◦ Energy import (active and reactive) (to busbar A) ◦ Energy differential (active and reactive)
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 bus tie breakers and externally controlled bus tie breakers

14.2 BUS TIE breaker controller principles

14.2.1 Configuring a BUS TIE breaker controller

Configure each BUS TIE breaker controller in the single-line diagram, using 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 **Power management**, **Power management principles**, **Busbar sections** for more information about busbar sections.

14.2.2 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

Configure these nominal settings under **Configure > Parameters > Busbar A > Nominal settings > Nominal settings #**, where # is 1 to 4.

Table 14.1 Controller nominal settings

Nominal setting	Range	Default	Notes
Voltage (V)	10 V to 160 kV	400 V	The phase-to-phase* nominal AC voltage for busbar A.
Current (I)	1 A to 9 kA	867 A	The maximum current flow in one phase (that is, L1, L2 or L3) in busbar A during normal operation.
Frequency (f)	48 to 62 Hz	50 Hz	The system nominal frequency, typically either 50 Hz or 60 Hz. All the controllers in the system should have the same nominal frequency.
Power (P)	1 kW to 900 MW	480 kW	The nominal active power for the bus tie breaker. Ignored if *P nominal calculated* is selected.
Apparent power (S)	1 kVA to 1 GVA	530 kVA	The nominal apparent power for the bus tie breaker. Ignored if *S nominal calculated* is selected.
Power factor (PF)	0.6 to 1	0.9	The nominal power factor at the bus tie breaker.

*Note: In a single-phase set up the nominal AC voltage is phase-to-neutral.

Configure the nominal settings calculation method under **Configure > Parameters > Busbar A > Nominal settings > Nominal settings # > Calculation method**, where # is 1 to 4.

Table 14.2 Nominal setting 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

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

Busbar B nominal settings

Configure these nominal settings under **Configure > Parameters > Busbar B > Nominal settings > Nominal settings #**, where # is 1 to 4.

Table 14.3 Controller nominal settings

Nominal setting	Range	Default	Notes
Voltage (V)	10 V to 160 kV	400 V	The phase-to-phase nominal voltage for 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.
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.

14.2.3 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 BUS TIE breaker controller.

Table 14.4 AC configuration for the BUS TIE breaker controller

BUS TIE breaker	General name
Busbar A	[Source]
Busbar B	[Busbar]

14.2.4 Breaker configuration

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 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 unit.
- 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)

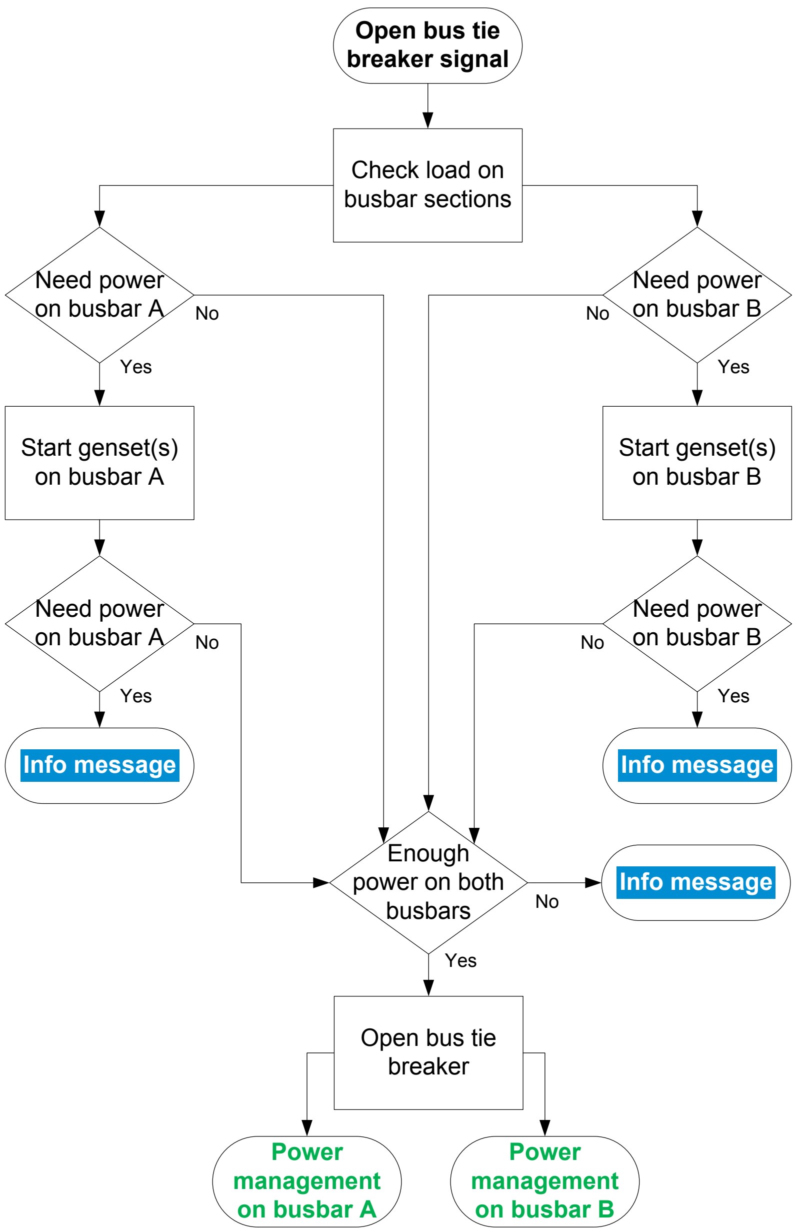
- There are enough gensets available under PMS control to supply the required power to each busbar section.
  - If the required GENSET controllers are in SEMI mode, then their gensets must be **connected**.
  - GENSET controllers in AUTO mode need not be connected. The power management system can start 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 and description show how the busbar is split.

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*.

Table 14.5 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 unit.
- 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 under PMS control (that is, they are not under 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

INFO
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 SEMI 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.

Inputs and outputs

Optional: Assign the supply mode input(s) under **Configure > Input/output**. Select the hardware module, then select the input to configure.

Table 14.6 Breaker configuration

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 *Configure* > *Parameters* > *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 *Configure* > *Parameters* > *Local power management* > *Bus tie breaker* > *Supply mode after BTB close* > *Supply mode after connecting* to *Stay on SG/SC supply* (see below).

Parameters

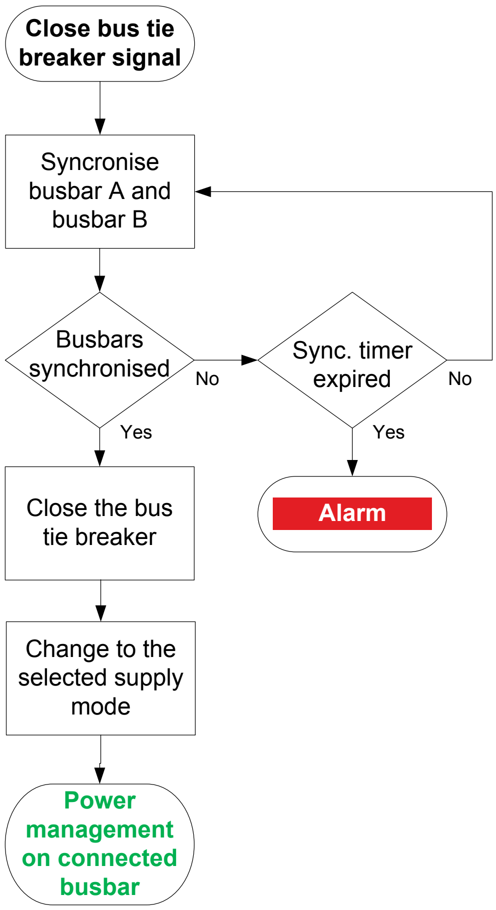
Configure this parameter under **Configure > Parameters > Local power management > Bus tie breaker > Supply mode after BTB close**.

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

The following flowchart and description show how the busbar sections are connected.

Table 14.7 Connecting the busbar sections flowchart



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

More information

See **Power management**, **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.

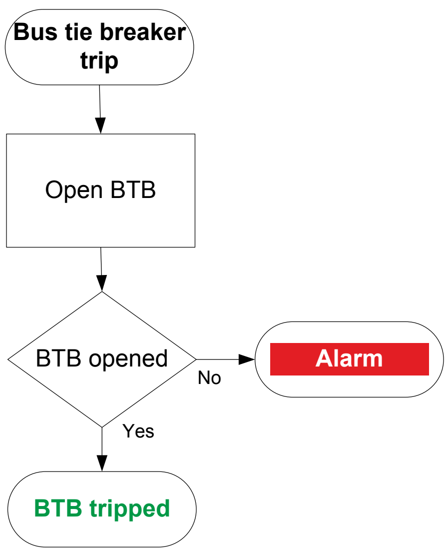
14.3.4 Bus tie breaker trip flowchart

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.

Table 14.8 Bus tie breaker trip flowchart



1. **Open BTB:** When a trip is required, the controller activates the *Breakers* > *Bus tie breaker* > *Control* > *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)
- Active and reactive energy differential (the difference between the energy export and import)
- 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.

Configure the digital outputs under **Input/output > Digital output > Functions > Busbar A > Energy counters > [Counter pulse]**.

INFO
You must configure the digital output function to see the parameters.

Configure the energy transfer required for a pulse under **Parameters > Busbar A > Energy counters > [Counter]**.

Table 14.9 Active energy export counter parameters

Parameter	Range	Default	Comment
Pulse every	1 kWh to 10 MWh	10 kWh	The value when a digital output sends a pulse.
Pulse length	0.1 s to 1 h	1 s	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 14.10 Reactive energy export counter parameters

Parameter	Range	Default	Comment
Pulse every	1 kvarh to 10 Mvarh	10 kvarh	The value when a digital output sends a pulse.
Pulse length	0.1 s to 1 h	1 s	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 14.11 Active energy import counter parameters

Parameter	Range	Default	Comment
Pulse every	1 kWh to 10 MWh	10 kWh	The value when a digital output sends a pulse.
Pulse length	0.1 s to 1 h	1 s	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 14.12 Reactive energy import counter parameters

Parameter	Range	Default	Comment
Pulse every	1 kvarh to 10 Mvarh	10 kvarh	The value when a digital output sends a pulse.
Pulse length	0.1 s to 1 h	1 s	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 14.13 Active energy differential counter parameters

Parameter	Range	Default	Comment
Pulse every	1 kWh to 10 MWh	10 kWh	The value when a digital output sends a pulse.
Pulse length	0.1 s to 1 h	1 s	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 14.14 Reactive energy differential counter parameters

Parameter	Range	Default	Comment
Pulse every	1 kvarh to 10 Mvarh	10 kvarh	The value when a digital output sends a pulse.
Pulse length	0.1 s to 1 h	1 s	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 14.15 Energy counter function and corresponding parameter full names

[Counter pulse]	[Counter]
Active energy export pulse 1	Active energy export
Reactive energy export pulse 1	Reactive energy export
Active energy import pulse 1	Active energy import

[Counter pulse]	[Counter]
Reactive energy import pulse 1	Reactive energy import
Active energy differential pulse 1	Active energy differential
Reactive energy differential pulse 1	Reactive energy differential

Application example for an energy counter output

1. Connect the digital output to an external counter.
2. Configure the digital output using the display unit or PICUS to *Active energy export pulse 1*.
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.

14.5 BUS TIE breaker controller protections

14.5.1 BUS TIE breaker controller protections

These alarms are in addition to the AC protections and general alarms for PPM 300 controllers.

	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)
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

The BUS TIE breaker controller includes the following inhibits:

Table 14.16 BUS TIE breaker controller 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

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 BUS TIE breaker, as well as which general alarm corresponds to each BUS TIE breaker alarm.

Table 14.17 Breaker alarm names for the BUS TIE breaker controller

BUS TIE breaker alarm	Configure > Parameters >	General name
BTB synchronisation failure	Breakers > Bus tie breaker monitoring > Synchronisation failure	Breaker synchronisation failure
BTB de-load failure	Breakers > Bus tie breaker monitoring > De-load failure	Breaker de-load failure
Vector mismatch	Breakers > Bus tie breaker monitoring > Vector mismatch	Vector mismatch
BTB opening failure	Breakers > Bus tie breaker monitoring > Opening failure	Breaker opening failure
BTB closing failure	Breakers > Bus tie breaker monitoring > Closing failure	Breaker closing failure
BTB position failure	Breakers > Bus tie breaker monitoring > Position failure	Breaker position failure
BTB trip (external)	Breakers > Bus tie breaker monitoring > Tripped (external)	Breaker trip (external)
BTB short circuit	Breakers > Bus tie breaker monitoring > Short circuit	Breaker short circuit
BTB configuration failure	-	Breaker configuration failure
Busbar A phase sequence error	Busbar A > AC setup > Phase sequence error	Phase sequence error
Busbar B phase sequence error	Busbar B > AC setup > Phase sequence error	Phase sequence error

14.5.5 AC alarms

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

The following tables show where to configure these alarms for the BUS TIE breaker controller, as well as which general alarm corresponds to each BUS TIE breaker controller alarm.

Table 14.18 Busbar A AC alarm names for the BUS TIE breaker controller

BUS TIE breaker alarm	Configure > Parameters >	General name
Busbar A over-voltage 1 or 2	Busbar A > Voltage protections > Over-voltage 1 or 2	Over-voltage
Busbar A under-voltage 1 or 2	Busbar A > Voltage protections > Under-voltage 1 or 2	Under-voltage
Busbar A voltage unbalance	Busbar A > Voltage protections > Voltage unbalance	Voltage unbalance
Negative sequence voltage	Busbar A > Voltage protections > Negative sequence voltage	Negative sequence voltage
Zero sequence voltage	Busbar A > Voltage protections > Zero sequence voltage	Zero sequence voltage
Busbar A over-current 1 or 2	Busbar A > Current protections > Over-current 1 or 2	Over-current
Fast over-current 1 or 2	Busbar A > Current protections > Fast over-current 1 or 2	Fast over-current
Current unbalance (average calc.)	Busbar A > Current protections > Current unbalance (average calc.)	Current unbalance (average calc.)
Current unbalance (nominal calc.)	Busbar A > Current protections > Current unbalance (nominal calc.)	Current unbalance (nominal calc.)
Inverse time over-current	Busbar A > Current protections > Inverse time over-current	Inverse time over-current
Negative sequence current	Busbar A > Voltage protections > Negative sequence current	Negative sequence current
Zero sequence current	Busbar A > Voltage protections > Zero sequence current	Zero sequence current
Busbar A over-frequency 1 or 2	Busbar A > Frequency protections > Over-frequency 1 or 2	Over-frequency
Busbar A under-frequency 1 or 2	Busbar A > Frequency protections > Under-frequency 1 or 2	Under-frequency
Overload 1 or 2	Busbar A > Power protections > Overload 1 or 2	Overload
Reactive power export 1 or 2	Busbar A > Reactive power protections > Reactive power export 1 or 2	Reactive power export
Reactive power import 1 or 2	Busbar A > Reactive power protections > Reactive power import 1 or 2	Reactive power import

Table 14.19 Busbar B AC alarm names for the BUS TIE breaker controller

BUS TIE breaker alarm	Configure > Parameters >	General name
Busbar B over-voltage 1 or 2	Busbar B > Voltage protections > Over-voltage 1 or 2	Busbar over-voltage
Busbar B under-voltage 1 or 2	Busbar B > Voltage protections > Under-voltage 1 or 2	Busbar under-voltage
Busbar B voltage unbalance	Busbar B > Voltage protections > Voltage unbalance	Busbar voltage unbalance
Busbar B over-frequency 1 or 2	Busbar B > Frequency protections > Over-frequency 1 or 2	Busbar over-frequency
Busbar B under-frequency 1 or 2	Busbar B > Frequency protections > Under-frequency 1 or 2	Busbar under-frequency

15. Modbus

15.1 Modbus in the controller

15.1.1 Overview

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

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

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

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

Refer to the Modbus tables, available for download at www.deif.com, to see how the controller data is mapped to the Modbus addresses.

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

15.1.2 Warnings

DANGER!
The DEIF controllers do not include a firewall or other Internet security measures. It is the customer's own responsibility to protect the network. The controller provides no access restrictions (for example group and user permissions) when accessed through Modbus TCP. If the controllers are connected to a network connection outside of the controller network, the controller can be accessed and configured through Modbus TCP by anyone connected to the network.

DANGER!
All controller settings can be accessed and modified through Modbus TCP. This includes disabling critical controller protections by changing settings and alarms. Use the Modbus tables provided by DEIF to ensure that you do not disable critical protections.

15.2 Modbus implementation in the controller

15.2.1 Modbus TCP protocol

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

More information
See **Tools, Communication, Configure communication** in the **Operator's manual** for more information about how to configure the controller communication information.

15.2.2 Modbus communication port

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

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

15.2.3 Controller identifier

The Modbus TCP protocol will always use the controller IPv4 address to identify the controller that the master wants to communicate with. However, some Modbus communication tools will still require/automatically add a Modbus Slave ID, also known as a unit identifier, for the unit that the server is communicating with. For these cases the controller accepts Modbus Slave IDs from 1 to 247. This is the case for all ML 300 controllers in the network that communicate using the Modbus TCP protocol.

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

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

15.2.4 Data handling

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

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

Data format (endian)

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

Sign

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

Conversion

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

Conversions can also be used to force unit conversions on specific addresses.

INFO
Reverse formulas are NOT automatically determined.

Modbus data conversion example

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

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

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

Refresh rate

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

Table 15.1 Modbus data refresh rates

Data	Maximum refresh rate	Function group example
AC measurements	20 ms	[Source] ACM measurements
Values	40 ms	Alarm parameter: Enable

15.3 Modbus tables

15.3.1 Download Modbus tables

To download the Modbus tables, follow these steps:

1. Visit the DEIF website at: www.deif.com.
2. Use the search option to open the search box:
   - 

3. Enter the product name.
4. Select the product from the search results.
5. On the product page, select **Documentation**:
   - 

6. Under the section **Documents**, select **+ Modbus tables**:
7. Select the Modbus tables for your product to start the download.

15.3.2 Modbus table overview

The Modbus tables are stored in a Microsoft® Excel file that contains five spreadsheets with Modbus data. The table below gives a short description of each of the spreadsheets in the file.

Table 15.2 Modbus table spreadsheet overview

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

15.4 Specific Modbus function groups

15.4.1 CustomLogic: Modbus signal

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

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

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

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

15.4.2 Breaker priority: Buffered value

Overview

You can find the function group *Breaker priority: Buffered value* in the Holding register of the Modbus table. The function group acts as a temporary storage area for the breaker priority values that will be written to the controller using the function group *Breaker priority: Write values*.

When you read a value from these addresses, the breaker priority that you want to assign to the breaker that is stored in the address is returned to you. When you write a value to these addresses, the value is stored and ready to be written to the controller when you activate *Breaker priority: Write values*.

CAUTION
The breaker priorities and the Modbus address associated to a specific breaker is dependent on the **Single line** configuration. If you change the **Single line** configuration, you will change the associated Modbus addresses. If you add or remove GENSET controllers from the **Single line** configuration, the breaker priorities can change.

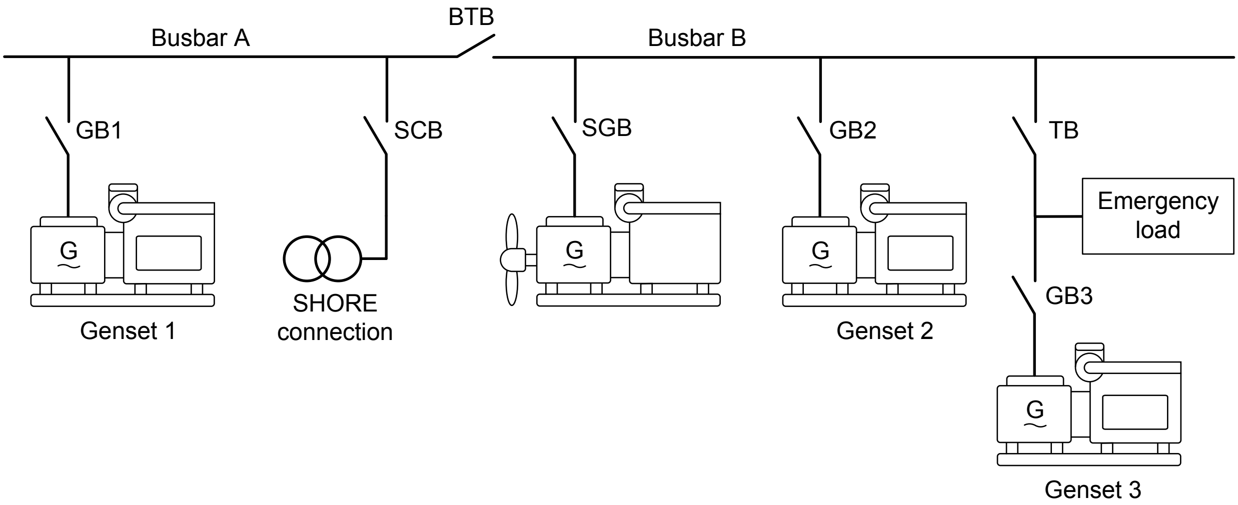
Breaker priority allocation

The following rules are applied when breaker priorities are assigned:

- Only GENSET controllers receive a breaker priority value that is greater than zero (0).
- All other controller types receive a breaker value of zero (0).
- An EMERGENCY genset controller uses two Modbus addresses, the first for the tie breaker and the second for the generator breaker. Both breakers have a breaker priority of zero (0).
- Breaker priorities are assigned to the first available breaker priority, according to the order in which controllers are added to the single line diagram.
- Breaker priority Modbus addresses are assigned to the first available breaker priority Modbus address, according to the order in which controllers are added to the single line diagram.

Example of how breaker priority works

Figure 15.1 Breaker priority example system



In the example diagram, it is assumed that the single line diagram in the controller was built by placing the components in the diagram in the following order:

1. Genset 1
2. Shore connection
3. Bus tie breaker
4. Shaft generator
5. Genset 2
6. Emergency genset

This means that the breakers were assigned the values and priorities in the table below.

Table 15.3 Example breaker priority values assigned to each Modbus address

Component	Modbus address (Holding register and input register)	Breaker priority: Buffered value	Breaker priority: Value
Genset 1	14001	0	1
Shore connection	14002	0	0
Bus tie breaker	14003	0	0
Shaft generator	14004	0	0
Genset 2	14005	0	2
Emergency genset	14006	0	0
	14007	0	0

The Modbus addresses are assigned to the breaker for the controller. This means an emergency genset always uses two Modbus addresses for breaker priority, one for each breaker. The Modbus addresses are assigned to the components in the order that they were inserted into the single line diagram. The Modbus address(es) assigned to a component will not change when the controller ID changes.

Only genset breakers will be assigned a breaker priority value that is between 1 and 128. All other components and addresses which are unassigned (for example 14008 in the example above) have a breaker priority value of 0. Both the breakers for an emergency genset always have a breaker priority of 0. Breakers with a breaker priority of 0 assigned to them, cannot be changed.

If a component is removed from the single line diagram, the Modbus address becomes free and can be reassigned. The breaker priorities are automatically reassigned for all the remaining components in the single line diagram. For example if we remove Genset 1 and the emergency genset from the example above the table will look as follows:

Table 15.4 Updated breaker priority values and Modbus addresses after removing components

Component	Modbus address (Holding register and input register)	Breaker priority: Buffered value	Breaker priority: Value
-	14001	0	0
Shore connection	14002	0	0
Bus tie breaker	14003	0	0
Shaft generator	14004	0	0
Genset 2	14005	0	1
-	14006	0	0
-	14007	0	0

If we add the emergency genset back into the single line diagram, and then add Genset 1 back into the single line diagram the table will look as follows:

Table 15.5 Updated breaker priority values and Modbus addresses after adding components

Component	Modbus address (Holding register and input register)	Breaker priority: Buffered value	Breaker priority: Value
Emergency genset (TB)	14001	0	0
Shore connection	14002	0	0
Bus tie breaker	14003	0	0
Shaft generator	14004	0	0
Genset 2	14005	0	1
Emergency genset (GB3)	14006	0	0
Genset 1	14007	0	2

The table above shows that the breakers are assigned the first open Modbus address in the Modbus table. This means that it is possible for an emergency genset to have its breakers assigned to Modbus addresses that do not follow directly on one another. Because Genset 1 has a higher Modbus address (14007) than Genset 2 (14005), by default it is assigned a lower priority than Genset 2 after the change was made in the single line diagram.

When you want to change the breaker priorities by using Modbus, write the desired priority value to the Modbus address in the function group *Breaker priority: Buffered value*. When you are satisfied with the breaker priorities, activate *Breaker priorities: Write values* to write the values to the controller. Only values between 1 and 128 are accepted inputs for breaker priorities. Breakers that already have a priority of 0 assigned to them, cannot be changed. You cannot write the breaker priorities to the controller if there are duplicate non-zero entries in *Breaker priority: Buffered value*. The tables below show the results after new breaker priorities were written to the buffered values, and after the buffered values were written to the controller.

Table 15.6 Breaker priority values after writing new values to the buffer addresses

Component	Modbus address (Holding register and input register)	Breaker priority: Buffered value	Breaker priority: Value
Emergency genset (TB)	14001	0	0
Shore connection	14002	0	0
Bus tie breaker	14003	0	0

Component	Modbus address (Holding register and input register)	Breaker priority: Buffered value	Breaker priority: Value
Shaft generator	14004	0	0
Genset 2	14005	2	1
Emergency genset (GB3)	14006	0	0
Genset 1	14007	1	2

Table 15.7 Breaker priority values after writing the buffered values to the controller

Component	Modbus address (Holding register and input register)	Breaker priority: Buffered value	Breaker priority: Value
Emergency genset (TB)	14001	0	0
Shore connection	14002	0	0
Bus tie breaker	14003	0	0
Shaft generator	14004	0	0
Genset 2	14005	2	2
Emergency genset (GB3)	14006	0	0
Genset 1	14007	1	1

15.5 Setting up Modbus

15.5.1 Setting up Modbus TCP/IP communication

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

- The device interfacing with the controller must be connected to one of the following:
  - An Ethernet connection on the controller communication module (that is, PCM3.1).
  - Another controller in the DEIF network.
- The controller must have a unique IPv4 address which is active.
- Modbus TCP communication software must be installed on the device communicating with the controller.

More information
See **Wiring the communication** in the **Installation instructions** for more information about how to wire the Ethernet connection to the controller.

15.6 Modbus alarm

15.6.1 Modbus communication timeout

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

Configure the parameters under **Configure > Parameters > Communication > Modbus > Modbus communication timeout**.

Table 15.8 Default parameters

Parameter	Range	Default
Delay	0.1 s to 1 h	10 s
Enable	Not enabled, Enabled	Not enabled
Action		Warning

16. Hardware characteristics

16.1 General characteristics

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

The descriptions may include references to hardware modules that are not supported by the controller type. The supported hardware modules are listed in the **Data sheet**.

Technical specifications

More information
See the **Data sheet** for technical specifications for the hardware modules and terminals.

16.1.1 Frame ground characteristics

Symbol	Hardware modules
⏚	PSM3.1 PSM3.2 EIM3.1 GAM3.2 DU 300

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

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

16.1.2 Power supply characteristics

Symbol	Hardware modules
+ -	PSM3.1 PSM3.2 EIM3.1 GAM3.2
+ -	DU 300

The power supply is connected to these terminals.

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

Backup power

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

Start current

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

Battery-powered systems normally do not have a problem with start current.

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

Reverse polarity

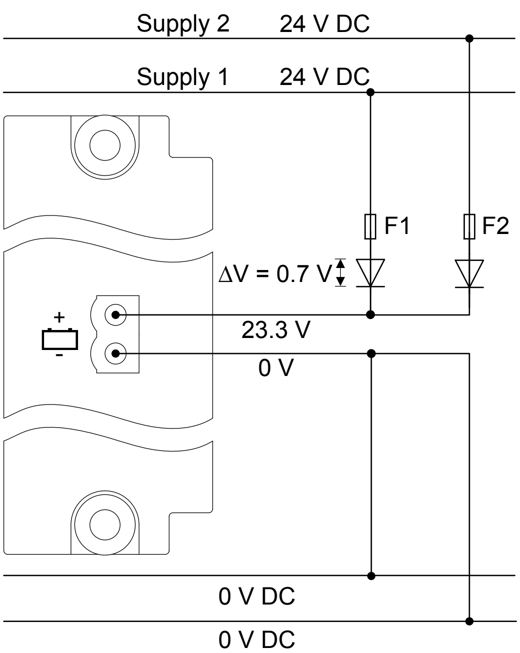
The power supply is protected against reverse polarity. That is, if the power supply terminals are switched, the DEIF equipment will not be damaged. However, the DEIF equipment will not be able to operate until the power supply has been connected correctly.

Diode compensation

Diode compensation is available in PSM3.1, PSM3.2, EIM3.1 and GAM3.2. Set the parameter under **Configure > Parameters > Hardware > [PSM3.1 1, PSM3.2 1, EIM3.1 1 or GAM3.2 1] > Diode compensation** .

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

Figure 16.1 Example of a voltage decrease over a diode

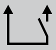
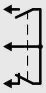
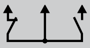


Heat emission

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

16.1.3 Relay output characteristics and configuration

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

Symbol	Hardware modules
	IOM3.2
	DU 300 (terminals 6,7)
	IOM3.1
	DU 300 (terminals 3,4,5)

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

Configuration

All relay outputs are configurable, except for PSM3.1 terminals 3,4 (*Status OK*), GAM3.2 terminals 14,15 (*GAM3.2 1 Status OK*), and the DU 300 relays. A controller can have a number of relay outputs.

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

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

Controller types and single-line diagram

The controller type determines which digital output functions are available.

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

Relay state

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

Table 16.1 Relay state

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

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

Relay hardware

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

Normally open relay hardware:

- All PSM3.1 relays
- IOM3.1 terminals 1,2

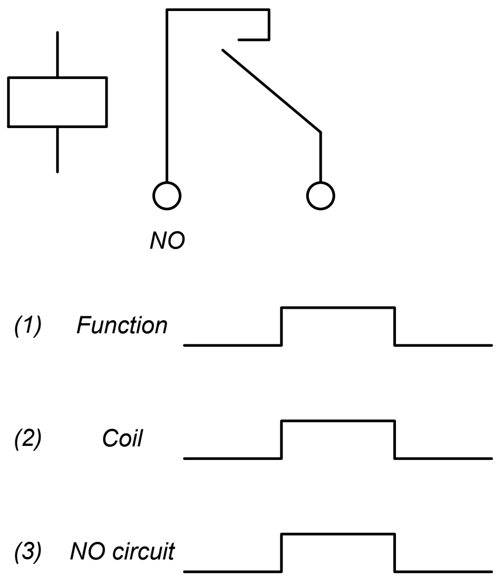
- IOM3.1 terminals 4,5
- IOM3.1 terminals 7,8
- IOM3.1 terminals 10,11
- IOM3.2 terminals 1,2
- IOM3.2 terminals 3,4
- IOM3.2 terminals 5,6
- IOM3.2 terminals 7,8
- All EIM3.1 relays
- All GAM3.1 relays
- All GAM3.2 relays

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

Coil state

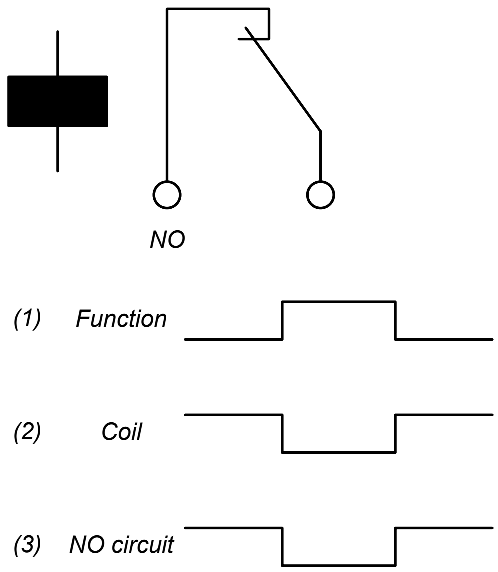
You can configure the normal coil state in the display unit or PICUS. Under **Configure > Input/output**, select the terminals, then select *Normally de-energised* (the default) or *Normally energised* for the *Coil state*.

Table 16.2 Relay, normally de-energised coil



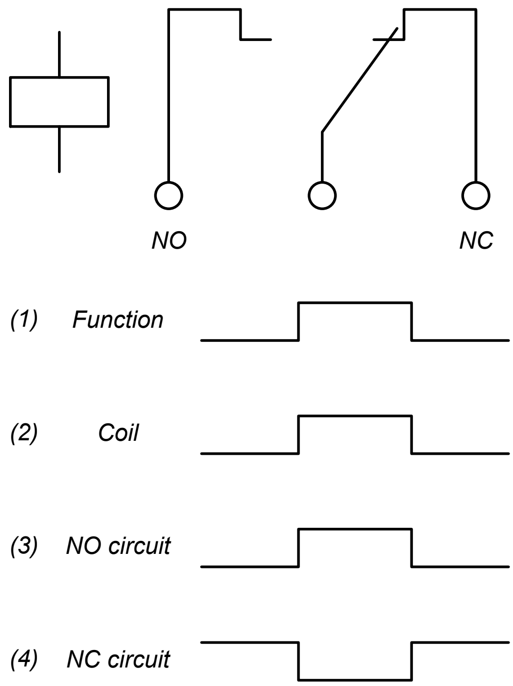
1. **Function**: The digital output function assigned to the terminals. The controller software activates the function. For example: *Breakers* > *[Breaker]* > *Command* > *[*B] Close*.
2. **Coil**: The controller energises the relay coil when the function is activated.
3. **Normally open circuit**: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

Table 16.3 Relay, normally energised coil



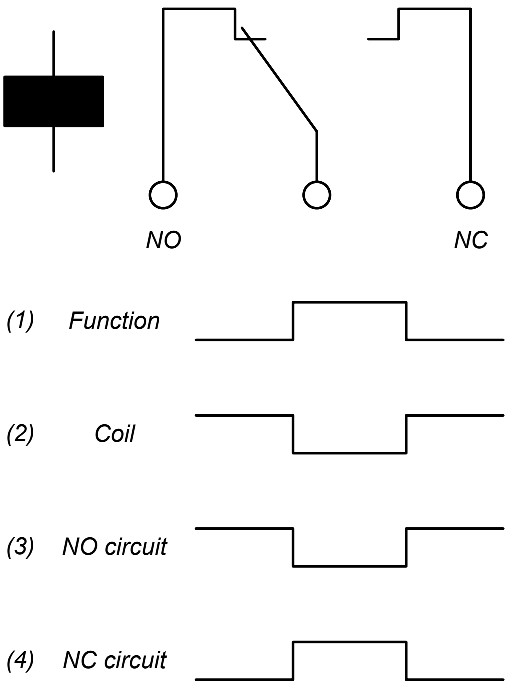
1. **Function**: The digital output function assigned to the terminals. The controller software activates the function. For example: *Breakers* > *[Breaker]* > *Command* > *[*B] Close*.
2. **Coil**: The controller de-energises the relay coil when the function is activated.
3. **Normally open circuit**: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

Table 16.4 Changeover relay, normally de-energised coil



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

Table 16.5 Changeover relay, normally energised coil



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

16.1.4 Digital input characteristics and configuration

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

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

Polarity

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

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

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

Configuration

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

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

You can also create responses to digital inputs using CustomLogic. You can also activate some digital input functions using a Modbus command.

Controller types and single-line diagram

The controller type determines which digital input functions are available.

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

Controller operation

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

16.1.5 Analogue input characteristics and configuration

Symbol	Hardware modules
I/V →	GAM3.1 (current or voltage inputs)
R/I →	EIM3.1 (current or resistance inputs)

The controller can use an analogue input to receive operating data. The controller can also activate alarms based on the analogue input.

Analogue input function

Assigning a function to the analogue input is optional.

You can assign one (or more) of the controller's analogue input functions to the input. You can only select functions that use the same units.

Alternatively, if you want to use the analogue input as a supervised binary input, you can assign one (or more) of the controller's digital input functions to the input.

Analogue input sensor setup

The sensor setup is required.

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

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

More information
See the **Appendix: Pre-configured curves** for the curve details.

INFO
If you choose a *Pt100* pre-configured curve, for the sensor output you must select *Pt100 ohm*. Similarly, if you choose a *Pt1000* pre-configured curve, for the sensor output you must select *Pt1000 ohm*.

Sensor failure

You can configure customised alarms for sensor failure. The *Below range alarm* is activated when the analogue input is below the specified value. Similarly, the *Above range alarm* is activated when the analogue input is above the specified value.

INFO
Do not use the sensor failure alarms to respond to ordinary operating data. Configure customised analogue input alarms instead.

Supervised binary input

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

Use an analogue input curve to define the supervised binary input. As shown in the examples, for the supervised binary input the curve is a step function. That is, the curve consists of a horizontal line (with the value 0 or 1), a vertical line (the point where the curve changes), and another horizontal line (with the value 1 or 0).

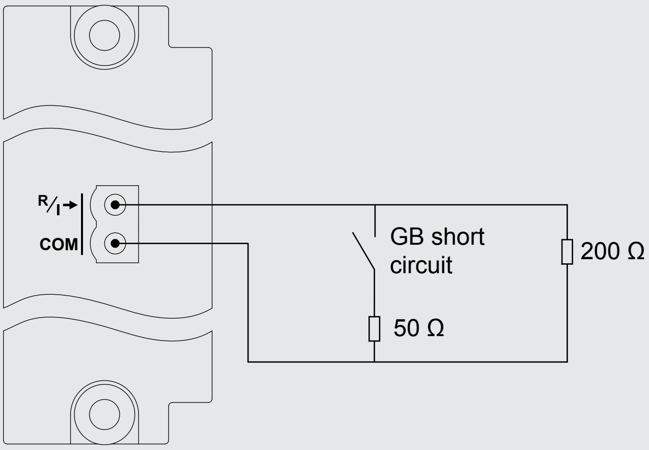
If the sensor output corresponds to the change point, the controller uses the last point specified in the curve. For the **Supervised *GB short circuit* example**, if the sensor output is exactly 150 Ω, then the function input is 0.

To avoid instability, configure the curve so that the change point is far away from the input closed and open values.

If the analogue input measurement corresponds to a function input that is **not zero**, then the controller uses **one** as the function input.

Supervised *GB short circuit* example

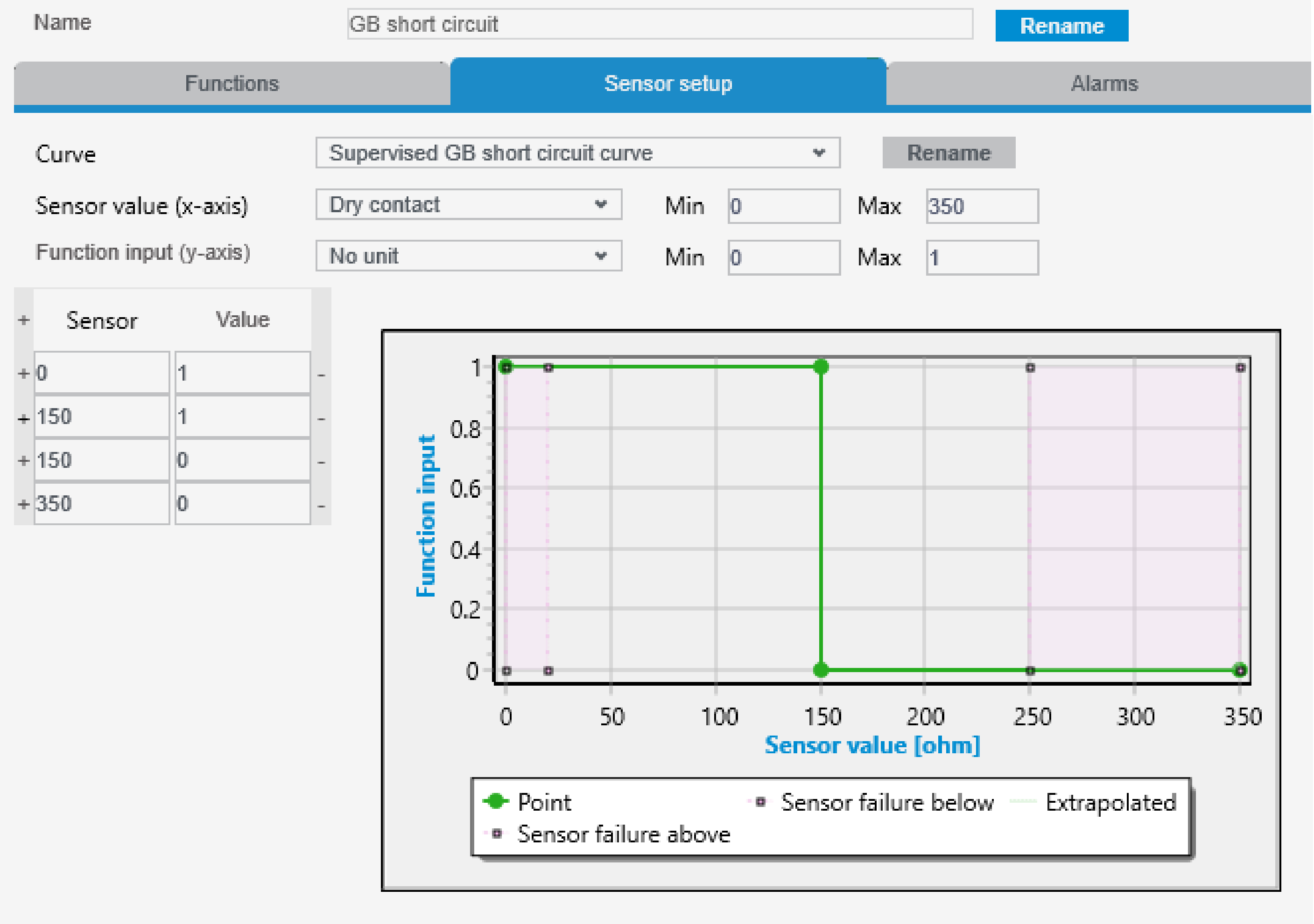
The designer creates the following wiring for a *GB short circuit* digital input:



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

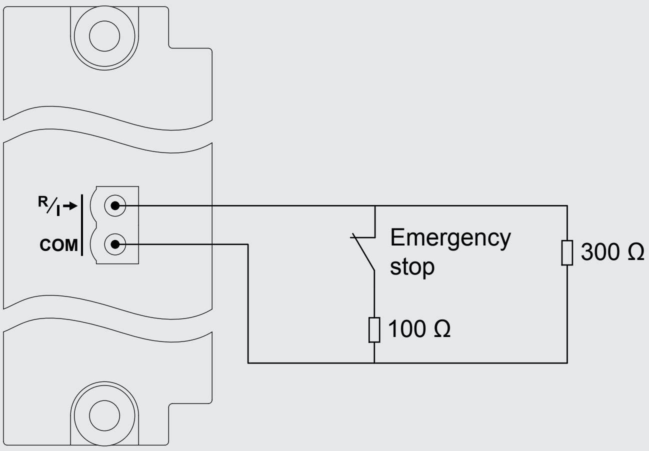
If the *GB short circuit* digital input is activated, the controller activates the *GB short circuit* alarm.

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



Supervised *Emergency stop* example

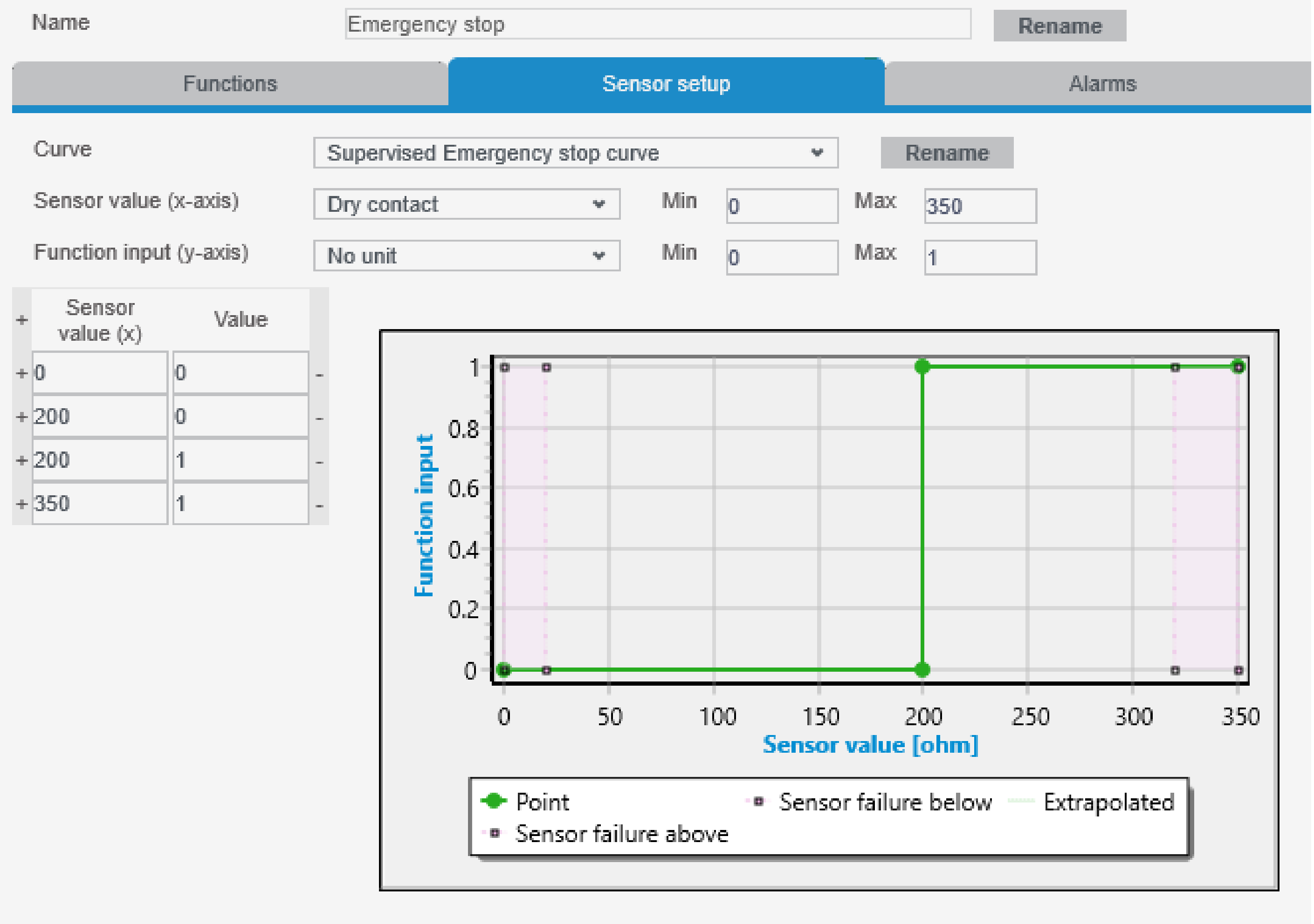
The designer creates the following wiring for an *Emergency stop* digital input:



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

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

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



Analogue input alarms

You must complete the *Sensor setup* before configuring any analogue input alarms.

You can configure any number of alarms for an analogue input. However, you cannot exceed the maximum number of customised alarms for the controller.

16.1.6 Analogue output characteristics and configuration

Symbol	Hardware modules
	GAM3.1 (PWM) GAM3.2 (PWM)
	GAM3.1 (current or voltage) GAM3.2 (current or voltage)

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

Analogue output function

Assign one function to the analogue output.

Analogue output setup

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

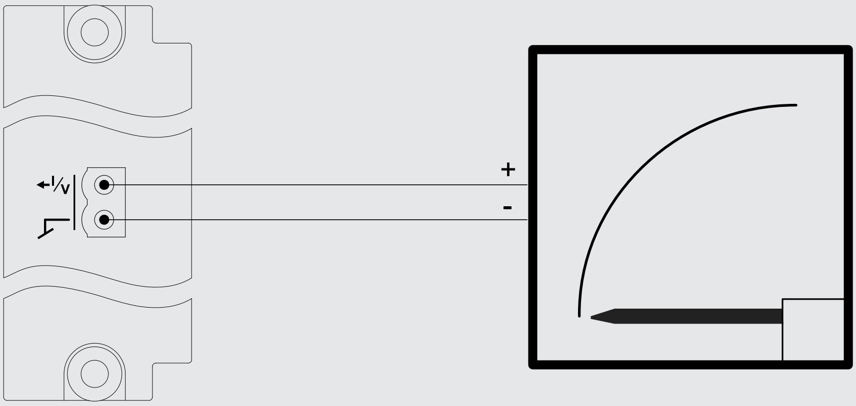
You can select a previously customised curve, select a pre-configured curve, or customise a curve.

More information
See the **Appendix: Pre-configured curves** for the curve details.

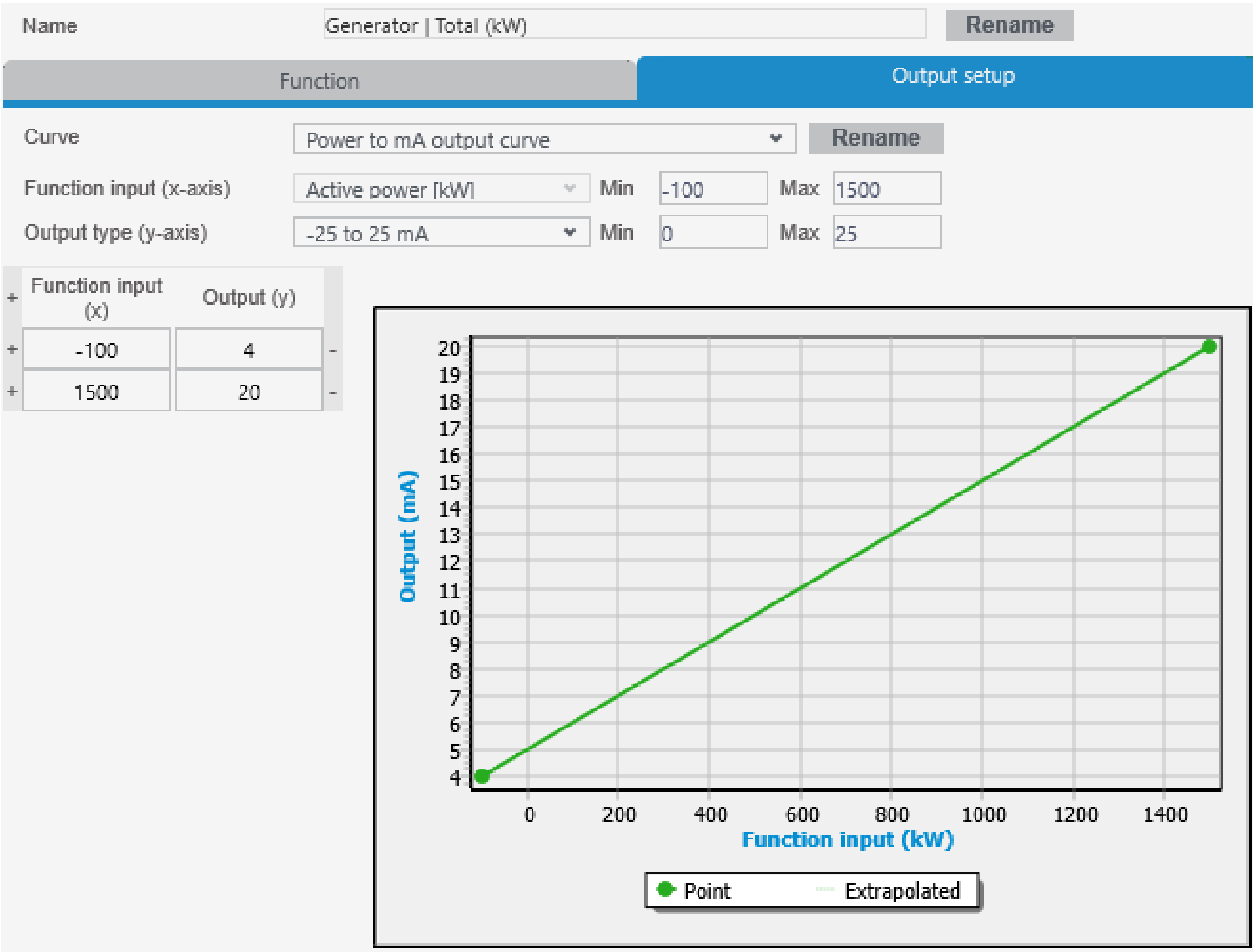
Output for a switchboard instrument

Output *Generator power* example

The customer has a 1 MW genset, and wants to display the power from the genset on the switchboard. He uses a DEIF DQ-96x with a scale from -100 to 1500 kW.
The designer creates the following wiring for a *Generator* > *Power (P)* > *Generator* | *Total [kW]* analogue output:



The designer configures a customised function curve with an output of 4 mA for -100 kW, and 20 mA for 1500 kW.



16.2 Power supply module PSM3.1

16.2.1 Power supply voltage as an analogue output

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

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

Table 16.6 Power supply voltage function

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

Application

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

16.2.2 Relay output characteristics

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

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

More information
See **Hardware characteristics and configuration**, **General characteristics**, **Relay output characteristics and configuration** for more information.

16.2.3 Internal communication

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

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

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

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

Internal communication restrictions

- Up to five extension units can be connected to each other in each network chain or ring.
- Only *Network chain* or *Network ring* controller configurations are supported.
  - Do not connect switches or other non-DEIF network equipment as part of the network chain or ring.
- The Ethernet cables must not be longer than 100 metres, point-to-point.
- The Ethernet cables must meet or exceed the SF/UTP CAT5e specification.

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

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

- A hardware module is replaced by the same type of hardware module, in the same position.

- Two of the same type of hardware modules swap position.
- An extension rack is replaced with an extension rack with identical hardware.

Factory settings

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

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

Topology examples

More information
See **Wiring the communication, DEIF internal communication, Topology examples** in the **Installation instructions** for more information.

16.3 Power supply module PSM3.2

16.3.1 Power supply voltage as an analogue output

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

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

Table 16.7 Power supply voltage function

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

Application

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

16.3.2 Relay output characteristics

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

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

More information
See **Hardware characteristics and configuration**, **General characteristics**, **Relay output characteristics and configuration** for more information.

16.3.3 Internal communication

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

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

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

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

Internal communication restrictions

- Up to five extension units can be connected to each other in each network chain or ring.
- Only *Network chain* or *Network ring* controller configurations are supported.
  - Do not connect switches or other non-DEIF network equipment as part of the network chain or ring.
- The Ethernet cables must not be longer than 100 metres, point-to-point.
- The Ethernet cables must meet or exceed the SF/UTP CAT5e specification.

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

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

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

Factory settings

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

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

Topology examples

More information
See **Wiring the communication, DEIF internal communication, Topology examples** in the **Installation instructions** for more information.

16.4 Alternating current module ACM3.1

16.4.1 Voltage measurement characteristics

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

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

16.4.2 Current measurement characteristics

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

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

16.5 Differential current module ACM3.2

16.5.1 Current measurement characteristics

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

16.6 Input/output module IOM3.4

16.6.1 Digital output characteristics and configuration

Symbol	Hardware modules
	IOM3.4

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

Configuration

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

You can program customised transistor output functions using CustomLogic.

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

Controller types and single-line diagram

The controller type determines which digital output functions are available.

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

Transistor state

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

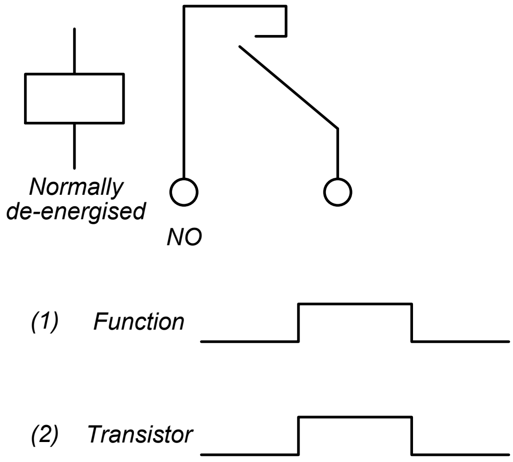
Table 16.8 Transistor state

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

Configured state

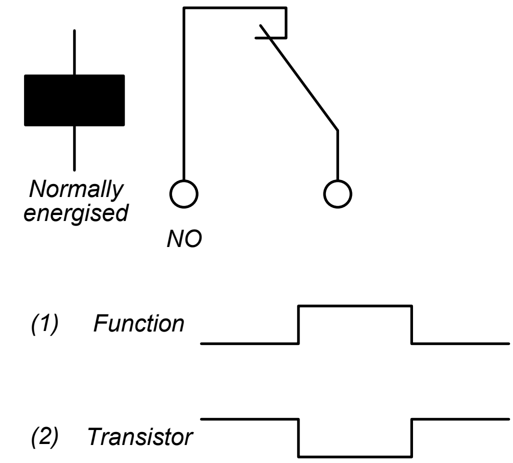
You can configure the normal transistor state in software in the display unit or PICUS. Under **Configure > Input/output**, select the terminals, then select *Normally de-energised* (the default) or *Normally energised* for the *Coil state*.

Table 16.9 Transistor, configured in software as normally de-energised



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

Table 16.10 Transistor, configured in software as normally energised



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

16.6.2 Digital input characteristics

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

More information
See **Hardware characteristics and configuration**, **General characteristics**, **Digital input characteristics and configuration** for more information.

16.7 Engine interface module EIM3.1

16.7.1 Power supply characteristics

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

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

More information
See **Hardware characteristics and configuration**, **General characteristics**, **Power supply characteristics** for more information.

16.7.2 Auxiliary power supply voltage as an analogue output

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

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

Table 16.11 Auxiliary power supply voltage function

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

Application

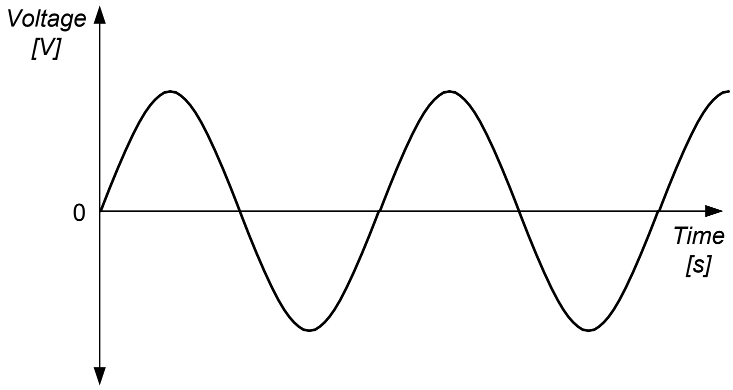
An analogue output with the power supply voltage may be wired to a switchboard instrument. The operator can then see if the auxiliary power supply fails.

16.7.3 Magnetic pickup unit (MPU) input characteristics

Figure 16.2 MPU (inductive) voltage-time graph

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

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



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

Parameters

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

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

Notes on an MPU input

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

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

16.7.4 W input characteristics

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

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

Figure 16.3 W voltage-time graph

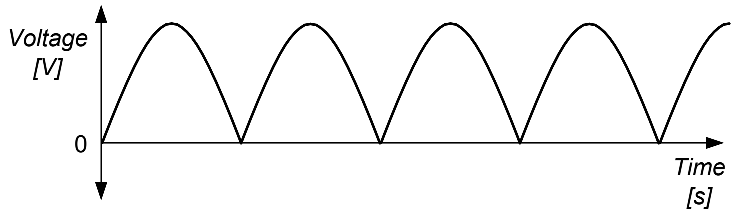
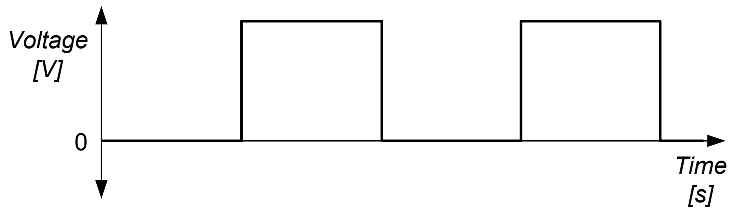


Figure 16.4 NPN/PNP (Hall sensor) voltage-time graph



INFO
You cannot use the MPU and W input at the same time. That is, if you use the W input, you cannot also use the MPU input.

Parameters

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

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

Notes on a W input

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

Notes on an NPN/PNP input

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

16.7.5 Analogue input (AI) characteristics

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

More information
See **Hardware characteristics and configuration**, **General characteristics**, **Analogue input characteristics and configuration**.

Maximum voltage

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

Current input

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

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

Resistance input

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

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

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

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

16.7.6 Relay output with wire break detection characteristics

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

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

More information
See **Wiring for the hardware modules**, **Engine interface module EIM3.1**, **Relay output with wire break detection** in the **Installation instructions** for examples of relay wiring and more information about the wire break detection current.

More information
See **Hardware characteristics and configuration**, **General characteristics**, **Relay output characteristics and configuration** for more information.

16.7.7 EIM3.1 standalone

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

Passive mode (normal operation)

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

Active mode (standalone)

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

Configure the safety shutdown under **Configure > Parameters > Engine > Safety shutdown**.

Table 16.12 Default parameters

Parameter	Range	Default	Notes
Enable	Not enabled, Enabled	Not enabled	**Not enabled** : The EIM operates in *Passive* mode and the application controls alarms and actions. **Enabled** : The EIM operates in *Active* mode and controls alarms and actions.
Keep stop coil active	Not enabled, Enabled	Not enabled	Keeps the stop coil activated. This is used only in the shutdown sequence with manual reset. See below.

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

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

Required configuration for Active standalone mode

The configuration for the standalone mode must include the following:

1. Inputs
   a. Running feedback
      - Digital input, MPU or oil pressure.
      - At least 1 is mandatory and up to 3 are possible.

   b. Inhibits
      - Up to 3 are possible.

   c. Shutdown override
      - Up to 1 is possible.

   d. Manual reset
      - Up to 1 is possible.
      - This is only relevant for alternative shutdown sequence (see below).
2. Outputs
   a. Stop coil
      - Up to 4 are possible.

   b. Run coil
      - Up to 4 are possible.
3. Alarms
   a. At least 1 alarm with trip and shutdown or trip AVR and shutdown on EIM inputs
   b. Requires the same parameters as in the normal application.
4. Extended stop timer
5. Keep stop coil active until manual reset
   - This is only relevant for shutdown sequence with manual reset (see below).
6. Inhibit values
   a. For example Engine running.

Engine analogue inputs

See **Engine analogue input alarms** below for the alarms related to these inputs.

Table 16.13 Engine analogue inputs

Function	I/O	Type	Notes
Engine > Measurements > Pressure > Oil pressure	Analogue input		When configured, the controller receives the oil pressure level from this analogue input.
Engine > Measurements > Temperature > Coolant water	Analogue input		When configured, the controller receives the coolant wanter temperature from this analogue input.
Engine > Measurements > Temperature > Oil temperature	Analogue input		When configured, the controller receives the oil temperature from this analogue input.
Engine > Measurements > Level > Coolant	Analogue input		When configured, the controller receives the coolant level from this analogue input.

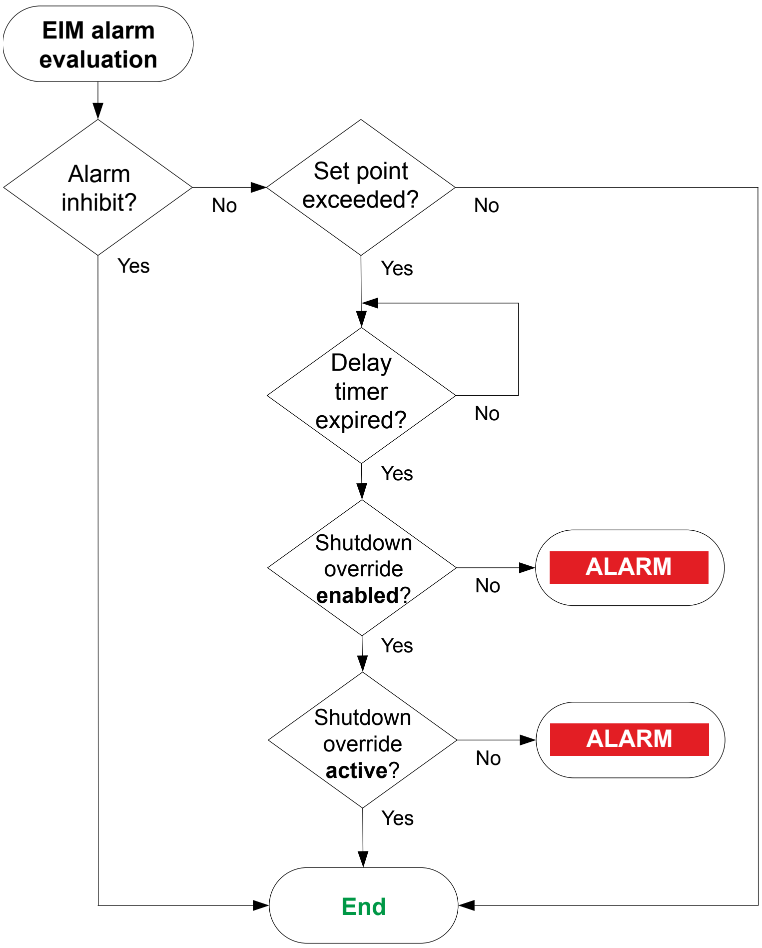
Safety shutdown status digital output

Table 16.14 Digital output

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

Alarm handling and alarms

Figure 16.5 How alarms are evaluated in standalone mode



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

- Relay 4 supervision

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

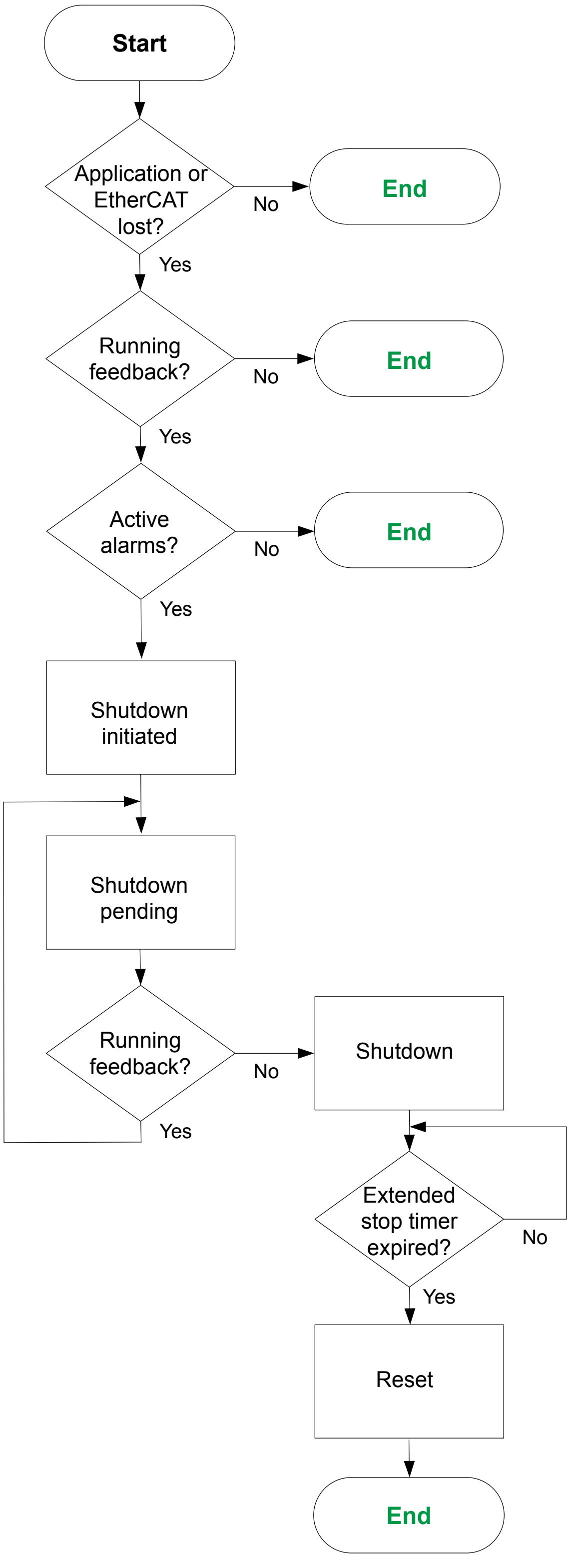
Table 16.15 Engine analogue input alarms

Alarm	Set point	Action	Notes
Oil pressure 1	2.0 bar	Warning	
Oil pressure 2	1.0 bar	Trip generator breaker and shutdown engine	
Oil temperature 1	120.0 C	Warning	
Oil temperature 2	140.0 C	Trip generator breaker and stop engine	
Coolant pressure 1	20.0 %	Warning	
Coolant pressure 2	10.0 %	Trip generator breaker and stop engine	
Coolant pressure 3	5.0 %	Trip generator breaker and shutdown engine	
Coolant temperature 1	100.0 C	Warning	
Coolant temperature 2	110.0 C	Trip generator breaker and stop engine	
Coolant temperature 3	115.0 C	Trip generator breaker and shutdown engine	

Shutdown sequences

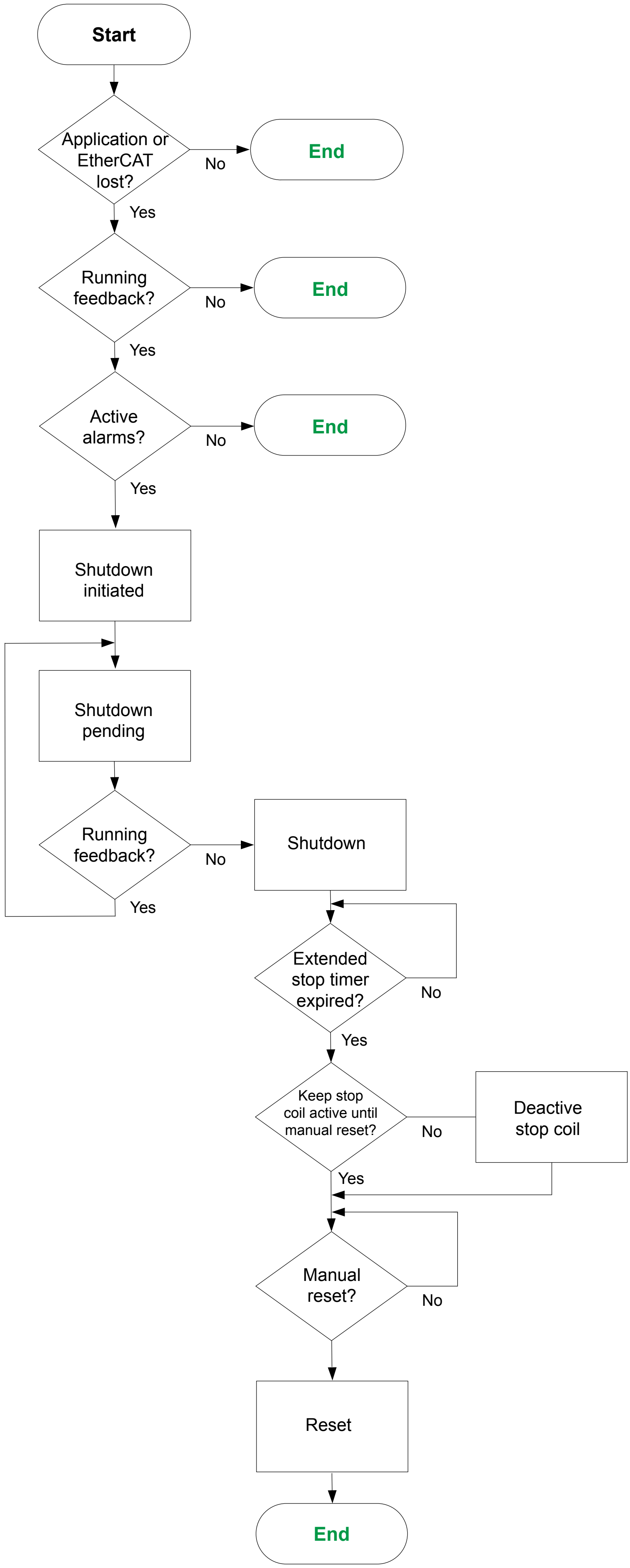
The shutdown sequence can be configured with or without a manual reset. The shutdown sequence with manual reset, which must be both configured and operated before the shutdown is completed. The manual reset is configured by using the parameter **Configure > Parameters > Engine > Safety shutdown > Keep stop coil active** (see above). It is important to remember that with a manual reset configured, the EIM must have a manual reset in order to complete the sequence. If no manual reset occurs the engine remains stopped and can only be restarted by power cycling.

Figure 16.6 Shutdown sequence



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

Figure 16.7 Shutdown sequence with manual reset



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

Additional standalone alarms

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

Table 16.16 Additional alarms

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

16.8 Governor and AVR module GAM3.1

16.8.1 Analogue output (AO) characteristics

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

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

More information
See **Hardware characteristics and configuration**, **General characteristics**, **Analogue output characteristics and configuration**.

Using an analogue output with a switchboard instrument

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

16.8.2 Pulse width modulation (PWM) output characteristics

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

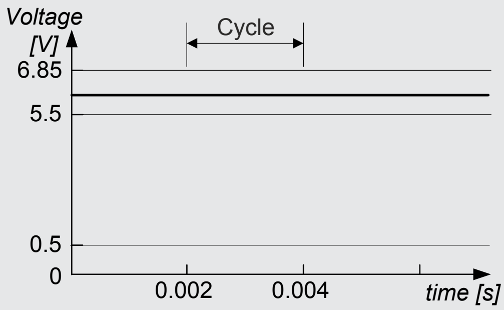
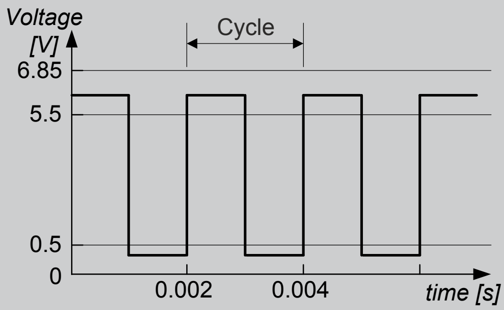
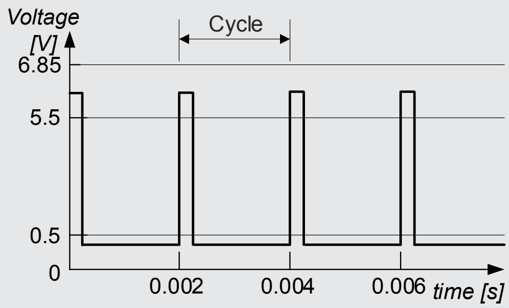
The PWM output (0 to 100 %) is configured as a curve, in the same way as the other analogue outputs.

More information
See **Hardware characteristics and configuration**, **General characteristics**, **Analogue output characteristics and configuration**.

Duty cycles

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

Table 16.17 Relationship between duty cycles and the PWM output

Duty cycle	Graph
100 %	
50 %	
12.5 %	

16.8.3 Analogue input (AI) characteristics

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

More information
See **Hardware characteristics and configuration**, **General characteristics**, **Analogue input characteristics and configuration**.

Galvanic connection

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

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

Current input

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

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

Voltage input

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

16.9 Governor and AVR module GAM3.2

16.9.1 Analogue output (AO) characteristics

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

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

More information
See **Hardware characteristics and configuration**, **General characteristics**, **Analogue output characteristics and configuration**.

Using an analogue output with a switchboard instrument

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

16.9.2 Pulse width modulation (PWM) output characteristics

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

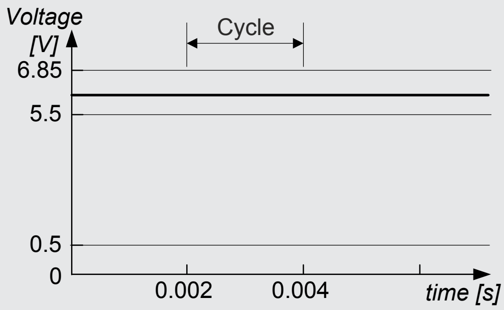
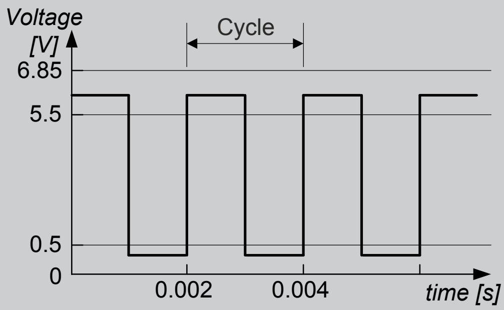
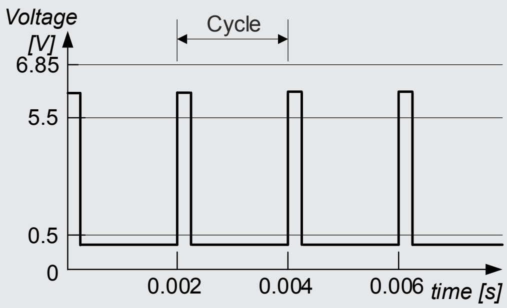
The PWM output (0 to 100 %) is configured as a curve, in the same way as the other analogue outputs.

More information
See **Hardware characteristics and configuration**, **General characteristics**, **Analogue output characteristics and configuration**.

Duty cycles

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

Table 16.18 Relationship between duty cycles and the PWM output

Duty cycle	Graph
100 %	
50 %	
12.5 %	

16.9.3 Relay output characteristics

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

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

More information
See **Hardware characteristics and configuration**, **General characteristics**, **Relay output characteristics and configuration** for more information.

16.10 Processor and communication module PCM3.1

16.10.1 PCM3.1 clock battery

PCM3.1 includes an internal battery for timekeeping during a power supply failure. If there is no power supplied to the controller or the PCM module, the controller uses the battery power for its internal clock.

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

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

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

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

More information
See **Hardware**, **Controller hardware**, **Processor and communication module PCM3.1** in the **Data sheet** for more information about the type of battery.

More information
See **Maintenance**, **PCM3.1 internal battery**, **Changing the battery** in the **Operator's manual** for information about changing the battery.

16.11 Display unit DU 300

16.11.1 Relay output characteristics

Changeover relay, terminals 3,4,5

For future use. You cannot configure this relay.

Status OK relay, terminals 6,7

The relay output on terminals 6,7 is used for the display unit *Status OK*. If the display unit loses communication with the controller, or an internal failure occurs, then the display unit deactivates the relay.

You cannot change the relay configuration. The relay is always energised when the communication is OK.

More information
See **Hardware characteristics and configuration**, **General characteristics**, **Relay output characteristics and configuration** for more information.

16.12 DEIF Ethernet network

16.12.1 Communication

The controllers communicate with each other to manage the system over the DEIF network, an Ethernet network.

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

Controllers must only be connected with *Network chain* or *Network ring* configuration. Do not include display units or other equipment in the chain or ring.

A completely new controller has a *Controller ID* of **0** (zero) initially. It must be configured to the required ID number, otherwise an alarm occurs.

Table 16.19 DEIF network 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 • Configurable Ethernet ports 1 to 5 on PCM3.1 module.
Functions	• Power management communication, including load-dependent start/stop, and de-loading • Load sharing communication • Power management inputs and outputs may be connected to any controller

Category	Details
	• Authentication (non-DEIF equipment cannot disrupt communication) • Connects the controller(s) to: ◦ Controller display unit ◦ Other controllers • Password protection ◦ Customisable permission levels

16.12.2 Controller communication settings

Use either the **Display** or **PICUS** to configure the controller communication under **Tools > Communication**.

Table 16.20 Controller communication settings

Setting	Range	Default	Notes
Controller ID *	1 to 64	1	When you change the controller ID using the display unit, you must also update the controller ID in the PICUS single line diagram. The system can have up to 32 controllers, with controller IDs in the given range.
IPv6 address		No default	
Label	Text	No default	A description label for the controller.
DNS preferred	0.0.0.0, 255.255.255.255 **	No default	
DNS alternate	0.0.0.0, 255.255.255.255 **	No default	
IP address mode **	Static, Auto	Auto	Select Static to specify an IPv4address.
IPv4 address	0.0.0.0, 255.255.255.255 **	No default	Static IPv4 address for the controller.
Netmask	0.0.0.0, 255.255.255.255 **	No default	Depends upon IPv4 address.
Default gateway	0.0.0.0, 255.255.255.255 **	No default	

NOTE * A completely new controller has a **Controller ID** of **0** initially. It must be configured to the required ID number, otherwise the alarm *Controller ID not configured* activates. The **Controller ID** should match the single-line diagram configuration.
** This is the range of addresses that you can select. 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.

The controller must be powered off and powered on again for changes to these settings to take effect.

More information
See **Tools, Communication** in the **Operator's manual** for more information about configuring communication from the display unit.

More information
See **Communication** in the **PICUS manual** for more information about configuring communication from PICUS.

16.12.3 Display unit communication settings

Use the **Display unit** to configure the display unit communication under **Tools > Communication**.

Table 16.21 Display unit communication settings

Setting	Range	Default	Notes
IPv6 address		No default	
DNS preferred	0.0.0.0, 255.255.255.255 *	No default	
DNS alternate	0.0.0.0, 255.255.255.255 *	No default	
IP address mode *	Static, Auto	Auto	Select *Static* to specify an IPv4 address.
IPv4 address	0.0.0.0, 255.255.255.255 *	No default	Static IPv4 address for the controller.
Netmask	0.0.0.0, 255.255.255.255 *	No default	Depends upon IPv4 address.
Default gateway	0.0.0.0, 255.255.255.255 *	No default	

NOTE * This is the range of addresses that you can select. The range of addresses that you can actually use depends on your network design. If you select *Static*, then you must give the controller a unique IPv4 address. In addition, some addresses in this range are reserved.

DANGER!
For changes to communication settings to take effect, all controllers and displays in the same system MUST only be powered off and powered on. 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. Ensure the controllers are not running and in operation, and that the controlled breakers are open before powering off and on the controllers and display units.

More information
See **Tools, Communication** in the **Operator's manual** for more information about configuring communication from the display unit.

More information
See **Communication** in the **PICUS manual** for more information about configuring communication from PICUS.

16.12.4 Controller Ethernet port settings

Topology examples

More information
See **Wiring the communication**, **DEIF Ethernet network communication**, **Topology examples** in the **Installation instructions** for more information.

Use **PICUS** to configure the controller Ethernet port settings under **Tools > Communication**.

Select Port settings:

- 

Table 16.22 Configurable Ethernet port settings

Setting	Range	Default	Notes
Network mode	• Standard node (sub-ring) • Interconnection node (major ring)	Standard node (sub-ring)	**Standard node (sub-ring)** : • Allows only interconnection between ML 300 controllers. **Interconnection node (major ring)** : • Allows only interconnection between Standard (sub-ring)s.
Port # *	• Automatic • Standard (sub-ring) • Interconnection (major ring) • External network/PICUS	Automatic	**Automatic** : • The port automatically detects the type of device or connection. **Standard (sub-ring)**: • Allows only interconnection between ML 300 controllers. • Allows Power Management System (PMS) between controllers. **Interconnection (major ring)**: • Select to specify the port as part of a major ring. • The port does not communicate any Power Management System (PMS) information. **External network/PICUS**: • Select to specify external network (Modbus, external switch, utility software, etc.) or PICUS utility software.

NOTE * Where # is port 1, 2, 3, 4, or 5 on the PCM3.1 module.

At least one Ethernet port will always be configured as either Auto or External network/PICUS.

More information
See **Communication** in the **PICUS manual** for more information about configuring communication from PICUS.

16.12.5 Restrictions

Topology examples

More information
See **Wiring the communication**, **DEIF Ethernet network communication**, **Topology examples** in the **Installation instructions** for more information.

Ethernet restrictions

- Up to 32 controllers can be connected to each other in each network chain or ring.
- Display units can be connected to the controllers, but must not be used as part of the 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.
- It is only possible to run the Power Management System (PMS) on the Standard (sub-ring) network.
- The Interconnection (major ring) can only be used for infrastructure network.

NOTE For marine applications, you can use a marine-approved managed switch to connect the DEIF network to your own network. The switch must support and be enabled for Rapid Spanning Tree Protocol (RSTP), otherwise there will be a network failure.

16.13 DEIF internal communication

16.13.1 Internal communication

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

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

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

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

Internal communication restrictions

- Up to five extension units can be connected to each other in each network chain or ring.
- Only *Network chain* or *Network ring* controller configurations are supported.
  - Do not connect switches or other non-DEIF network equipment as part of the network chain or ring.
- The Ethernet cables must not be longer than 100 metres, point-to-point.
- The Ethernet cables must meet or exceed the SF/UTP CAT5e specification.

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

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

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

Factory settings

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

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

Topology examples

More information
See **Wiring the communication, DEIF internal communication, Topology examples** in the **Installation instructions** for more information.

17. Glossary

17.1 Terms and abbreviations

17.1.1 Terms and abbreviations

Term	Abbreviation	Explanation
Action		The pre-defined set of actions that an alarm initiates. Also known as fail class.
Alarm levels		The number of alarms that can be assigned to an operating value. For example, the Over-current protection by default has two alarm levels.
Alarm monitoring system	AMS	Third party equipment used to monitor the controller system's alarms, for example, by using Modbus TCP/IP communication.
Alternating current	AC	
Alternating current module 3.1	ACM3.1	A replaceable PCB with voltage and current measurement inputs. Used in the DEIF controller.
American National Standards Institute	ANSI	
American wire gauge	AWG	A standardised wire gauge system, also known as the Brown & Sharpe wire gauge.
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 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 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.
Automatic voltage regulator	AVR	Regulates the genset voltage. The AVR is external equipment. The AVR can have a fixed voltage set point. Alternatively, the DEIF controller can control the AVR.
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.
Bi-directional input		The wiring to a controller's digital input and common terminals may be swapped around without affecting the input's operation.
Blackout		The busbar voltage is less than 10 % of the nominal voltage, and all generator breakers are open.
Blind module		A hardware module that consists of only a module faceplate. These are installed over empty slots, to protect the controller electronics.
Breaker		A mechanical switching device that closes to connect power sources to the busbar, or to connect busbar sections. The breaker opens to disconnect the power sources or to split the busbar.
Busbar		The copper conductors which connect the power sources to the power consumers. Represented on the single-line diagram as the line that connects all the power sources and power consumers. If the bus tie breaker is open, there are two separate and independent busbar sections. Similarly, if the bus tie breaker is closed, there is only one busbar.
[Busbar]		The busbar side of the breaker. For a SHORE connection controller, this is the ship busbar. For a BUS TIE breaker controller, this is Busbar B.

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 generator 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.
Diesel generator	DG	A GENSET controller can control a diesel generator.
Differential current module	ACM3.2	A replaceable PCB with current measurement inputs on consumer and neutral sides. Used in the DEIF controller.
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 diesel generator	EDG	An EMERGENCY genset controller can control an emergency diesel generator.
EMERGENCY genset controller		Controls and protects the emergency genset (normally a diesel generator). This includes control of the generator breaker and the tie breaker. If the system loses power, the controller ensures that the emergency genset supplies power to the emergency busbar.
Emulation		A controller test environment, accessible from PICUS, that does not require live AC power. A virtual operation mode, to simulate the effect of various real world actions.

Term	Abbreviation	Explanation
Endian		Endian refers to how the order of bytes in a multi-byte value is perceived or acted upon. It is the system of ordering the individual elements in a digital word in a computer's memory as well as describing the order of transmission of byte data over a digital link.
Engine interface module 3.1	EIM3.1	A replaceable PCB, with its own power supply. This module includes 4 relay outputs, 4 digital inputs, an MPU and W input, and 3 analogue inputs.
European Norm	EN	Standards issued by the European Committee for Standardisation (also known as Comité Européen de Normalisation).
Firmware		Software that is installed in the controller. This software enables the controller to: process inputs and outputs, display operating data, keep track of the equipment status, and so on.
Generator breaker	GB	The breaker between a generator (for example, a genset) and the busbar. The GENSET and EMERGENCY genset controllers can control a generator breaker.
Generator tacho (measurement/output)	W	A generator tacho measurement. This can be used as a backup measurement for generator speed.
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.
Governor and AVR module 3.1	GAM3.1	A replaceable PCB, which includes load sharing capability. This module also includes 4 relay outputs, 2 analogue current or voltage outputs, a pulse width modulation output, and 2 analogue current or voltage inputs.
Governor and AVR module 3.2	GAM3.2	A replaceable PCB with its own power supply, two analogue outputs, a pulse width modulation output, five digital inputs, a status relay output, and four relay outputs.
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.
Heavy consumer	HC	When a request is made, the power management system reserves and manages the power required by the heavy consumer(s).
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 and protects an inverter with battery energy storage and the inverter breaker. The Power Management System can automatically start and stop the inverter to ensure that the required power is available.
Hysteresis		An offset added to prevent rapid switching when a value is near the control point.
Ingress Protection Rating, or International Protection Rating	IP	The degree of protection against solids and water provided by mechanical casings and electrical enclosures.
Inhibit		A pre-defined condition that inhibits the alarm action. For example, for the inhibit ACM wire break, if the controller detects a wire break on the voltage measurements, the voltage unbalance alarm is prevented from occurring. Inhibited alarms are not shown in the alarm display.
Input output module 3.1	IOM3.1	A replaceable PCB, with 4 relay outputs, and 10 digital inputs.
Input output module 3.2	IOM3.2	A replaceable PCB, with 4 relay outputs, 4 analogue multifunctional outputs, 4 digital inputs, and 4 analogue multifunctional inputs.

Term	Abbreviation	Explanation
Input output module 3.3	IOM3.3	A replaceable PCB, with 10 analogue multifunctional inputs.
Input output module 3.4	IOM3.4	A replaceable PCB, with 12 transistor outputs, and 16 digital inputs.
Institute of Electrical and Electronics Engineers	IEEE	
International Association of Classification Societies	IACS	
International Electrotechnical Commission	IEC	
International Organization for Standardization	ISO	
Internet Protocol version 4	IPv4	A protocol for communication across networks. IPv4 currently routes the most traffic on the Internet, but will gradually be replaced by IPv6.
Internet Protocol version 6	IPv6	A protocol for communication across networks. Among other things, IPv6 has a much larger address space than IPv4.
	JEM-TR177	Japan Electrical Manufacturers Association's noise standard.
Latch		An extra layer of protection that keeps the alarm action activated. When the alarm is not active and acknowledged, it can be unlatched.
Light emitting diode	LED	Used to show the controller and equipment status and alarms.
Liquid crystal display	LCD	The screen of the display unit. The information displayed varies, depending on the controller mode, the equipment operation and the operator input.
Load sharing		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.
Mean Time Between Failures	MTBF	
Mean Time To Failure	MTTF	
Module		A standardised, replaceable printed circuit board that is mounted in the rack. For example, PSM3.1 is a hardware module that supplies power to the rest of the rack.
Multi-line 300	ML 300	A DEIF product platform. PPM 300 is part of ML 300.
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, [Source] 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.

Term	Abbreviation	Explanation
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.
Non-essential load	NEL	A load that is not critical to the system. These may be disconnected by the controller in the event of over-load, over-current, or busbar under-current.
	NPN	A type of transistor.
Number	#	Hash represents a number. The description is the same for each item in the range. For example, "Controller ID #" represents any of the possible controller IDs.
Oil pressure	OP	
Operate time		The time that the controller takes to measure, calculate, and change the controller output. For each alarm, the reaction time is based on the minimum setting for the time delay.
Out of service		A state that an alarm can be assigned to by an operator. Out of service alarms are inactive alarms. Out of service alarms do not automatically return to service and require operator action.
Parameter		A value, or set point, used to determine the controller's operation. Parameters include nominal values, the configuration options for the configurable inputs and outputs, and alarm settings.
Personal computer	PC	Used to run the PICUS software. For example, a laptop computer.
Phase L1	L1	The power line for one phase of a three-phase electrical system. Corresponds to R in Germany, Red in the UK and Pacific, Red in New Zealand, Black in the USA, and U on electrical machine terminals. The above colour codes are for guidance only. If uncertain perform a phase measurement.
Phase L2	L2	The power line for one phase of a three-phase electrical system. Corresponds to S in Germany, Yellow in the UK and Pacific, White in New Zealand, Red in the USA, and V on electrical machine terminals. The above colour codes are for guidance only. If uncertain perform a phase measurement.
Phase L3	L3	The power line for one phase of a three-phase electrical system. Corresponds to T in Germany, Blue in the UK and Pacific, Blue in New Zealand, Blue in the USA, and W on electrical machine terminals. The above colour codes are for guidance only. If uncertain perform a phase measurement.
Phasor		A complex plane representation (that is, a magnitude and direction) of a sinusoidal wave.
Power	P	The 3-phase active power, measured in kW.
Power factor	PF	The 3-phase power factor.
Power in Control Utility Software	PICUS	The DEIF utility software, used to design, configure, troubleshoot and monitor a system.
Power management system	PMS	The controllers share information and work together to ensure enough power to supply the load.
Power supply module 3.1	PSM3.1	A replaceable PCB that powers the controller. This module includes three relay outputs for status signals. Used in the DEIF controller.
Power take home	PTH	The shaft generator is used as a motor to drive the ship's propellor.
Power take in	PTI	A mode only on the HYBRID controller where power is taken in to the inverter (example charging a battery energy system).

Term	Abbreviation	Explanation
Power take off	PTO	A mode only on the HYBRID controller where power is taken from the inverter (example discharging a battery energy system).
Printed circuit board	PCB	Supports and electrically connects components.
Processor and communication module 3.1	PCM3.1	A replaceable PCB, which contains the controller processor, as well as the CAN bus connections and Ethernet communication connections. Used in the DEIF controller.
Programmable logic controller	PLC	A digital computer used for the automation of electromechanical processes.
Proportional integral derivative	PID	A feedback controller.
Protection and Power Management	PPM	A versatile controller consisting of several modules and display unit designed for marine use.
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.
Rack		An aluminium box with a rack system that houses the hardware modules. Each controller consists of a rack and a number of hardware modules.
Rapid spanning tree protocol	RSTP	A protocol used to compute the topology of a local area network.
Reactive power	Q	The 3-phase reactive power, measured in kvar.
Resistance measurement input	RMI	Variable resistance device, used for some of the input terminals on genset controllers.
Root mean squared	RMS	Refers to the mean magnitude of a sinusoidal wave. For example, RMS V refers to the mean AC voltage.
Running		A genset is regarded as running if the engine is started and there is running detection. A running engine does not necessarily have to be synchronised with the busbar.
SD card		External memory
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.
SEMI mode		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 equipment.
Shaft generator	SG	A generator installed on the ship's main shaft that produces electricity.
Shaft generator breaker	SGB	The breaker between the shaft generator and the main busbar/switchboard. A SHAFT generator controller can control a shaft generator breaker.
SHAFT generator controller		Controls and protects the power supply from the shaft generator.
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	SC	The ship is supplied with electricity from land while in harbour through the shore connection.

Term	Abbreviation	Explanation
Shore connection breaker	SCB	The breaker between the shore connection and the main busbar/switchboard. A SHORE connection controller can control a shore connection breaker.
SHORE connection controller		Controls and protects the power supply from the shore connection.
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.
[Source]		The source side of the breaker. For GENSET, EMERGENCY genset, and SHAFT generator controllers, this is the generator. For a SHORE connection controller, this is the shore connection. For a BUS TIE breaker controller, this is Busbar A.
Standby		A mode only on the HYBRID controller where the inverter is available to be used but not connected to the system.
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. See Busbar too.
Switchboard control	SWBD control	A controller operating mode. Power management and operator commands to the controller are disabled. The operator controls the system using the switchboard. The controller monitors operation, and the controller protections are active (that is, if an operating value activates an alarm, the controller does the alarm action).
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	Used to connect/disconnect the emergency busbar from the main busbar. The EMERGENCY genset controller can control a tie breaker. (Note: The breaker between two main busbars is called a bus tie breaker.)
Time	t	
Time delay		An alarm must exceed its set point continuously for the period in its Time delay parameter before the alarm is activated.
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

17.2.1 Units

The table below lists the units used in the documentation, as well as the US units where these are different. In the documentation, the US units are given in brackets, for example, 80 °C (176 °F).

Table 17.1 Units used in the documentation

Unit	Name	Measures	US unit	US name	Conversion	Alternative units
A	ampere	Current				
bar	bar	Pressure	psi	pounds per square inch	1 bar = 14.5 psi	1 bar = 0.980665 atmosphere (atm) 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)				

Unit	Name	Measures	US unit	US name	Conversion	Alternative units
V DC	volt (direct current)	Voltage (direct current)				
W	watt	Power				
Ω	ohm	Resistance				

17.3 Symbols

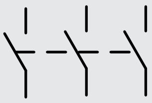
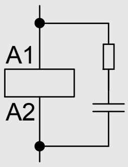
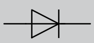
17.3.1 Mathematical symbols

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

17.3.2 Drawing symbols

The drawings use EU symbols.

Table 17.2 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
 F	Fuse
	Ohmmeter

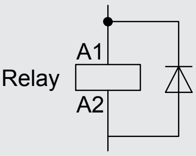
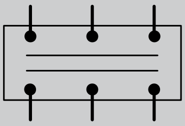
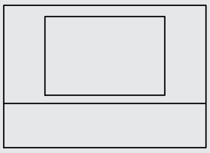
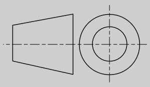
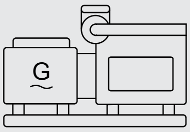
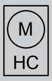
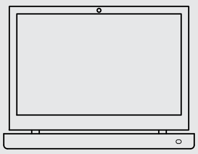
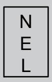
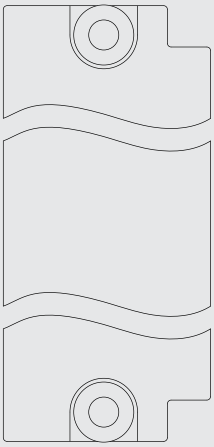
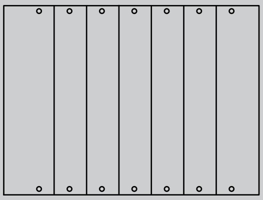
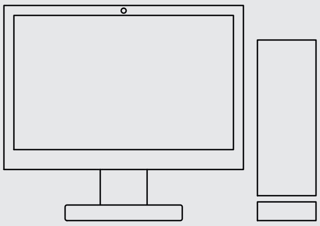
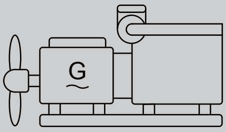
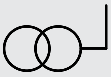
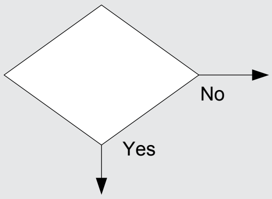
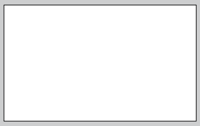
Symbol	Symbol name
	Relay with freewheeling diode
	Resistor (IEC-60617)
	Single-line diagram closed breaker
	Single-line diagram open breaker
○	Temporary connection dot (for example, connection to a meter)
	Voltage transformer. This is a generic voltage transformer, without any information about the transformer connections. These could for example be: open delta, star-star, closed delta, and so on.

Table 17.3 Icons used in drawings

Symbol	Symbol name
	Display unit DU 300
	First-angle projection
	Genset
	Heavy consumer
	Laptop
	Non-essential load

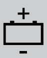
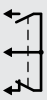
Symbol	Symbol name
	Part of a module faceplate, to show examples of terminal wiring
	Rack R7
	Server or desktop PC
	Shaft generator
	Shore connection

17.3.3 Flowchart symbols

Symbol	Symbol name
	Decision
	Process
	Start or end

17.3.4 Module faceplate symbols

Table 17.4 Terminals

Symbol	Symbol name
	Frame ground
	Power supply
L1, L2, L3 and N	Three-phase voltage measurements
	Current transformer
COM	Common
	Digital input
	Relay output (normally open)
	Relay with wire break detection (normally open)
	Relay output (changeover relay, with normally open and normally closed terminals)
	Analogue current or voltage input
	Analogue current or resistance measurement input (RMI)
	Magnetic pickup (MPU)
W	W input (for a generator tacho output or NPN/PNP sensor)
	Analogue current or voltage output
	Pulse width modulation (PWM) output
	Analogue input ground Analogue output ground Pulse width modulation (PWM) ground

Symbol	Symbol name
	Active P load sharing (future use)
	Reactive Q load sharing (future use)
+	Transistor positive supply
	Transistor output
-	Transistor common
H, CAN-A, L	CAN bus A connection (future use)
H, CAN-B, L	CAN bus B connection (future use)

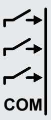
Table 17.5 LEDs

Symbol	Symbol name
CAN-A	CAN bus A (PCM)
CAN-B	CAN bus B (PCM)
	Network and DEIF network (PCM)
	Internal communication in (PSM)
	Internal communication out (PSM)
	Internal communication status (PSM)
⏻	Power supply status (PSM)
	System status (PCM)

Table 17.6 Other

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

Table 17.7 Terminal groups

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