iE 150 Marine

Generator, Shore, and BTB

Designer's handbook

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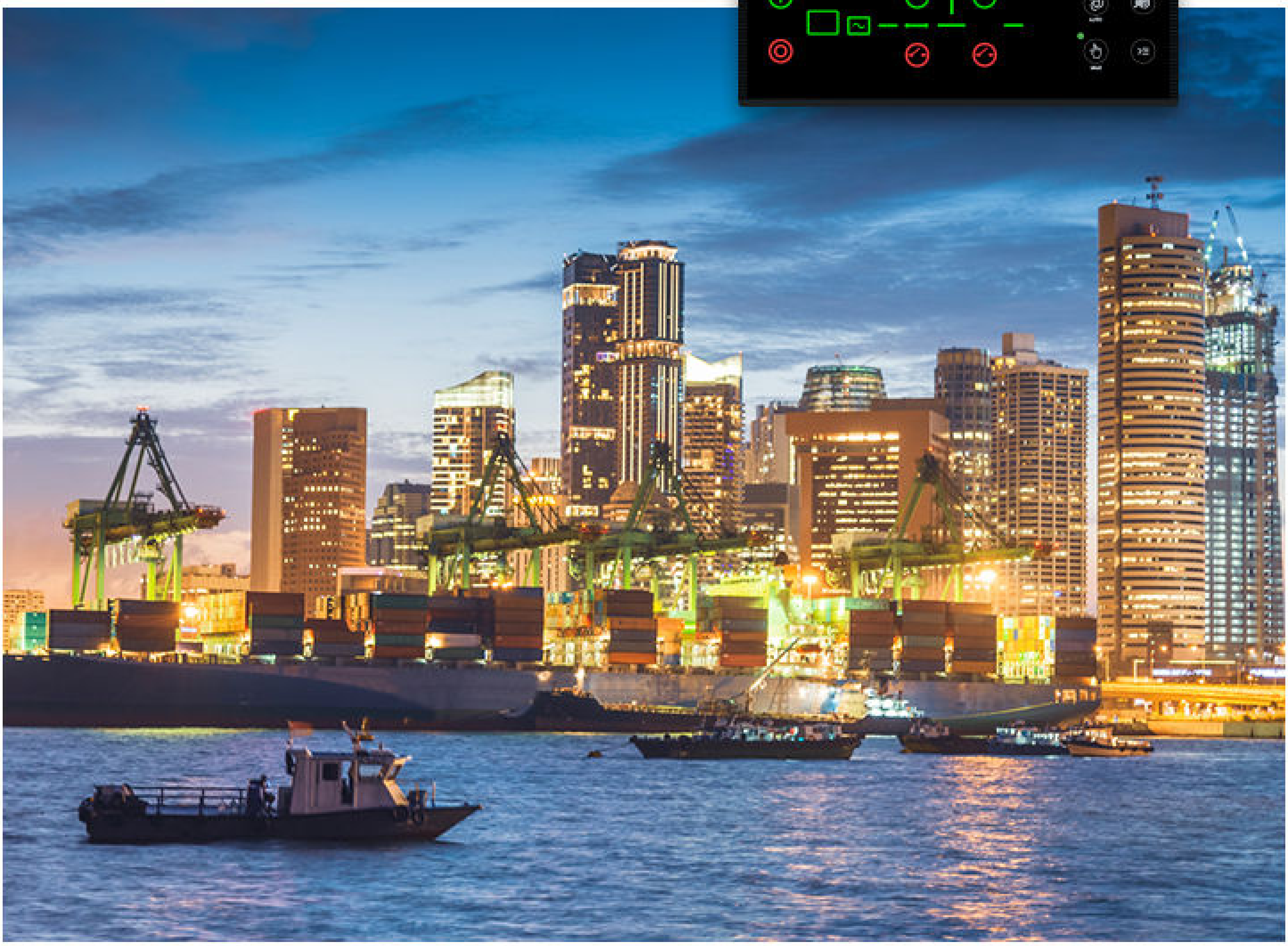
Improve
Tomorrow



4. General functions

5. Engine functions

6. Generator functions

7. Shore functions

8. Bus tie breaker functions

9. AC protections

1. Introduction

1.1 About the controller types

The iE 150 Marine controllers provide reliable asset control and power/energy management on pleasure crafts and non-ocean going vessels, for example, tugs, workboats, crew boats, and riverboats. Several iE 150 Marine controllers can work together to make a power management system (PMS).

The iE 150 Marine is a compact, all-in-one controller. Each controller contains all necessary 3-phase measuring circuits.

The values and alarms are shown on the LCD display screen, which is sunlight-readable. Operators can easily control the gensets and breakers from the display. Alternatively, use the communication options to connect to an HMI/SCADA system. The HMI/SCADA system can then control the system.

Controller type	Controls and protects
iE 150 Marine Generator	An engine, a generator, and a generator breaker.
iE 150 Marine Shore	The system and a shore connection breaker, when a shore connection is connected.
iE 150 Marine BTB	A bus tie breaker.

Up to seven controllers can be added to the energy/power management system:

Controller type	Max. count
iE 150 Marine Generator	2
iE 150 Marine Shore	1
iE 150 Marine BTB	2
iE 150 Marine Battery	2*
iE 150 Marine Solar	2*

* The power management system supports only two sustainable controllers in total. These can be Battery, Solar, or one of each.

NOTE This designer's handbook covers the iE 150 Marine Generator, Shore and BTB controllers. Separate designer's handbook provide corresponding guidance for the iE 150 Battery and Solar controllers.

NOTE Refer to the iE 150 Marine Core Genset Designer’s Handbook for stand-alone (non-sync) genset applications.

1.1.1 Controller types

MARINE configurations

Parameter	Setting	Controller type	Minimum software package
9101	Engine Drive Marine unit	Engine drive controller for marine use	Core
	Genset Marine unit	Non-sync genset controller for marine use	Core
	Genset Marine unit	Genset controller for marine use	Power management
	Shore Marine unit	Shore controller for marine use	Power management
	BTB Marine unit	BTB controller for marine use	Power management
	Battery Marine unit	Battery controller for marine use	Premium
	Solar Marine unit	Solar controller for marine use	Premium

Software packages and controller types

The controller software package determines which functions the controller can use.

- **Core (Stand-alone)**
- **Power management (PM)**
  - You cannot change the controller type to any other controller type.
- **Premium**
  - You can change the controller type to any other controller type.
  - All functions are supported.

You can select the controller type under `Basic settings > Controller settings > Type`.

NOTE For iE 150 controllers for land, see www.deif.com/products/ie-150.

1.2 About the Designer's handbook

General purpose

This document gives information about the controller's functionality and its applications, and for configuring the controller.

CAUTION
Installation errors Read this document before working with the controller. Failure to do this may result in human injury or damage to the equipment.

Intended users of the Designer's handbook

This Designer's handbook is primarily intended for the panel designer in charge. Based on this document, the panel designer can give the electrician the necessary information to install the controller, for example detailed electrical drawings.

The Designer's handbook can also be used during commissioning to check the parameters, and operators may find it useful for understanding the system and for troubleshooting.

List of technical documentation

Document	Contents
Product sheet	• Short description • Controller applications • Main features and functions • Technical data • Protections • Dimensions
Data sheet	• General description • Functions and features • Controller applications • Controller types and variants • Protections • Inputs and outputs • Technical specifications
Designer's handbook	• Principles • General controller sequences, functions and protections • Protections and alarms • Regulation • Hardware characteristics • Communication
Installation instructions	• Tools and materials • Mounting • Minimum wiring for the controller • Wiring information and examples
Operator's manual	• Controller equipment (buttons and LEDs) • Operating the system • Alarms and log

Modbus tables	• Modbus address list
	  ◦ PLC addresses
	  ◦ Corresponding controller functions
	• Descriptions for function codes, function groups

1.2.1 Software versions

The information in this document relates to software version:

Software	Details	Version
iE 150	Controller application	1.34.0

1.3 Warnings and safety

1.3.1 Symbols for hazard statements

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

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

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

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

1.3.2 Symbols for general notes

NOTE This shows general information.

More information
This shows where you can find more information.

Example

This shows an example.

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

Safety during installation and operation

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

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 and settings before using the controller.

Electrostatic discharge

Electrostatic discharge can damage the controller terminals. You must protect the terminals from electrostatic discharge during the installation. When the controller is installed and connected, these precautions are no longer necessary.

Data security

To minimise the risk of data security breaches:

- As far as possible, avoid exposing controllers and controller networks to public networks and the Internet.
- Use additional security layers like a VPN for remote access, and install firewall mechanisms.
- Restrict access to authorised persons.

1.4 Legal information

Third party equipment

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

Warranty

NOTICE
Warranty The controller is not to be opened by unauthorised personnel. If opened anyway, the warranty will be lost.

Disclaimer

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

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

Copyright

2. Utility software

2.1 Download the utility software

The **Multi-line 2 Utility Software v.3.x** is the software interface between a PC and the controller. The software is free of charge. Download it from www.deif.com

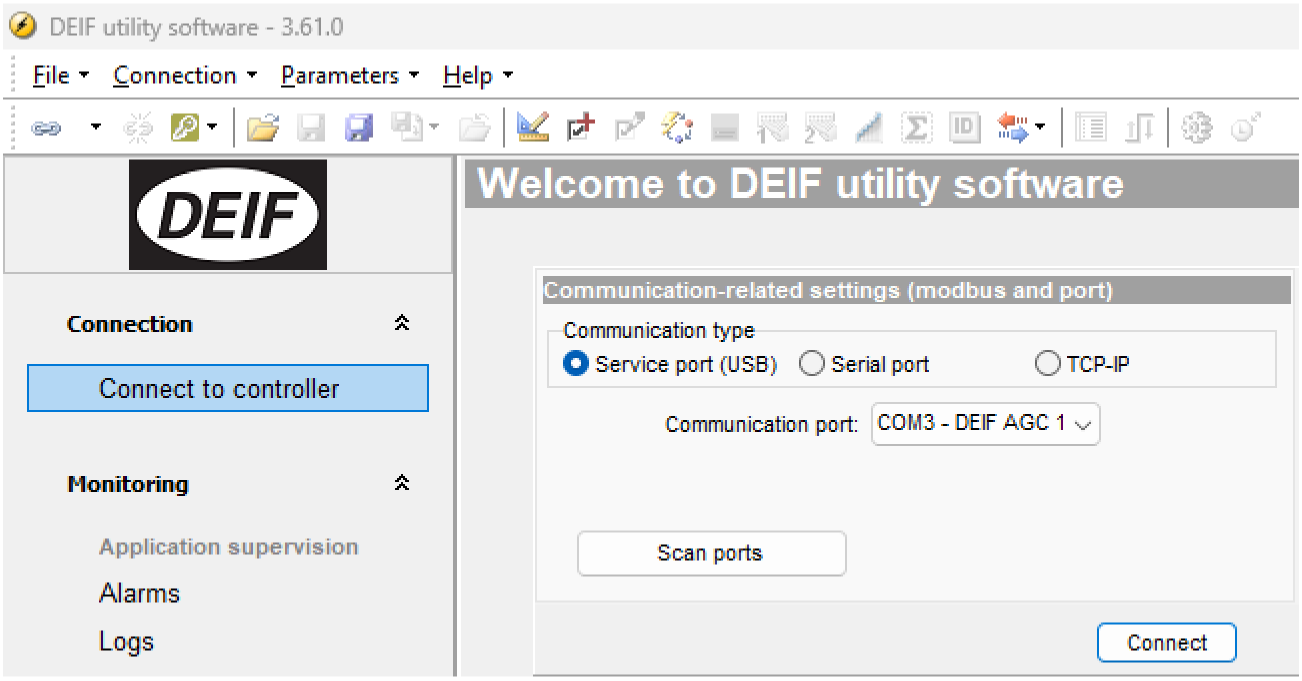
2.2 Connection

You can use a USB connection or TCP/IP to connect to the controller.

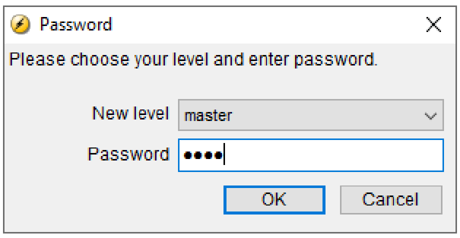
2.2.1 USB connection

You need a USB cable (USB A to B) to connect the controller to a PC.

1. Install the utility software on a PC.
2. Use the USB cable to connect the controller service port to the PC.
3. Start the utility software.



4. If needed, *Scan ports*, then select a service port option.
5. When prompted, select the access level, enter the password, and select OK.



More information
See **General functions, Password** for the default passwords.

2.3 Network connections

2.3.1 TCP connection

You can use TCP/IP communication to connect to the controller. This requires an Ethernet cable, or a connection to the network that includes the controller.

Default controller network address

- IP: 192.168.2.2
- Gateway: 192.168.2.1
- Subnet mask: 255.255.255.0

Configuring the controller IP address using the display unit or a USB connection

When connecting to a controller using TCP/IP, you must know the controller's IP address. Find the IP address on the display under: `Communication > Ethernet setup`.

You can use the display to change the controller's IP address.

Alternatively, you can use a USB connection or an Ethernet connection and the utility software to change the controller IP address.

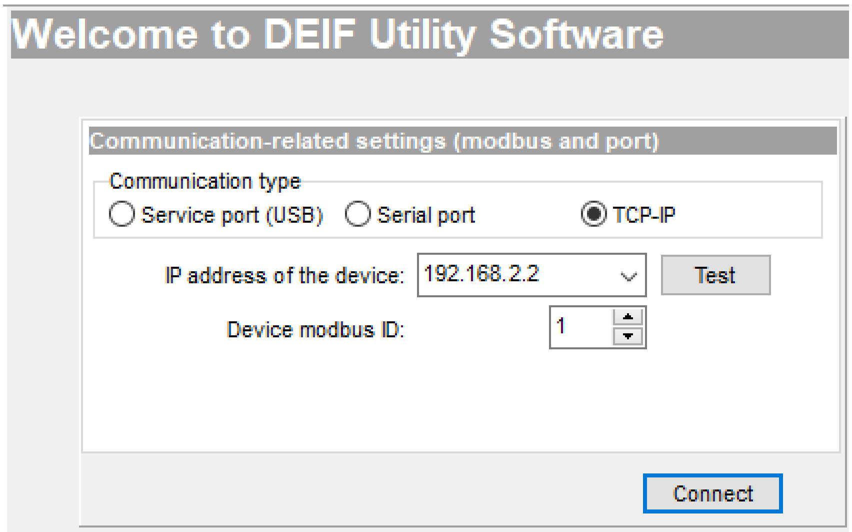
Point-to-point Ethernet connection to the controller

If you do not want to use the display unit or a USB connection to change the IP address, you can use a point-to-point Ethernet connection. The PC must have a static IP address. For the default controller network address, the PC static IP address must be 192.168.2.xxx, where xxx is a free IP-address in the network (note: xxx cannot be 2 (the controller IP address) or 1 (the gateway)).

If you change the controller address (for example, from 192.168.**2**.yyy to 192.168.**47**.yyy) the connection is lost. A new static IP for the PC is needed. In this case, 192.168.47.zzz, where zzz is a free IP-address in the network. The PC address, IP address, and gateway must be in the same subnet.

When the PC has the correct static IP address:

1. Use an Ethernet cable to connect the PC to the controller.
2. Start the utility software.
3. Select *TCP-IP*, and enter the controller IP address.

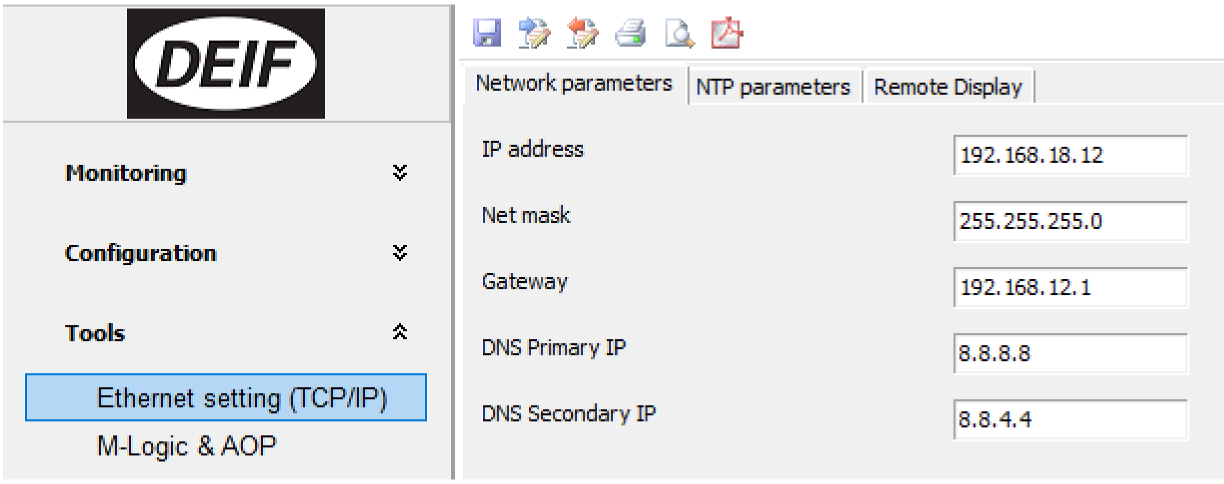


4. You can use the *Test* button to check if the connection is successful.
5. Select *Connect* to connect to the controller using TCP-IP.

Configuring the controller IP address using the utility software

1. Select *Connect* to connect to the controller using TCP-IP.
2. Select *Ethernet setting (TCP/IP)*.

The *Network Parameters* window opens:



When the controller network parameters have been changed, press the *Write to device* button.

The controller receives the new network parameters and reboots the network hardware.

To connect to the controller again, use the new controller IP address (and a correct PC static IP address).

NOTE Please note that not all controllers support DNS and NTP settings. Features described in this document apply only if they are available on the controller.

Using a switch

For a system with multiple controllers, all controllers can be connected to a switch. Create a unique IP address for each controller in the network before connecting the controllers to a switch.

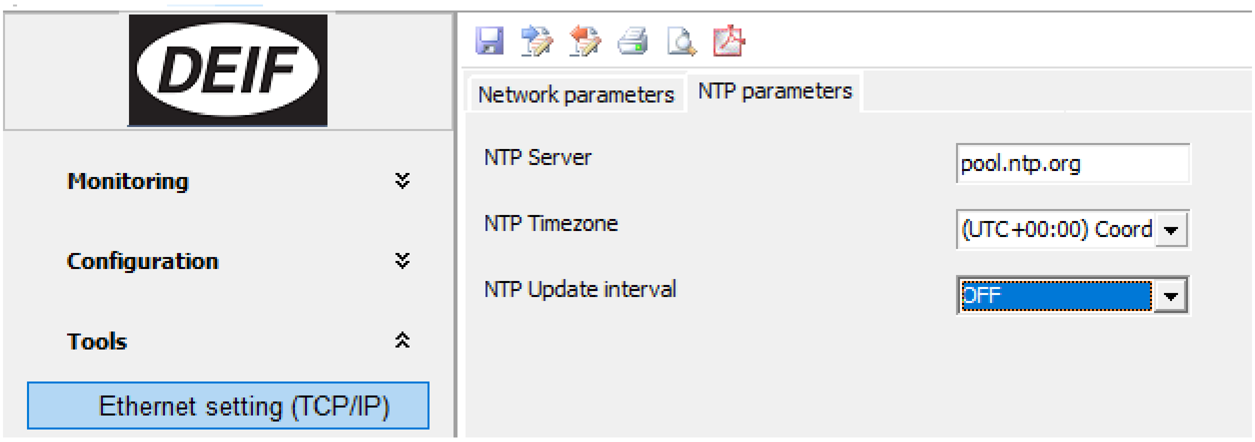
The PC can then be connected to the switch, and the Ethernet cable can be in the same port of the switch at all times. You can enter the controller IP address in the utility software.

The TCP-IP connection is faster than other connections. It also allows the user to shift between controllers in the application supervision window in the utility software.

2.3.2 Using NTP

To ensure that the controller always has the right time, you can use the network time protocol (NTP) function.

Select *Ethernet setting (TCP/IP)* in the Utility software, then select the *NTP parameters* tab in the *Network Parameters* window:



You can select an NTP server, a time zone and an update interval. Write the changes to the controller to activate the NTP function.

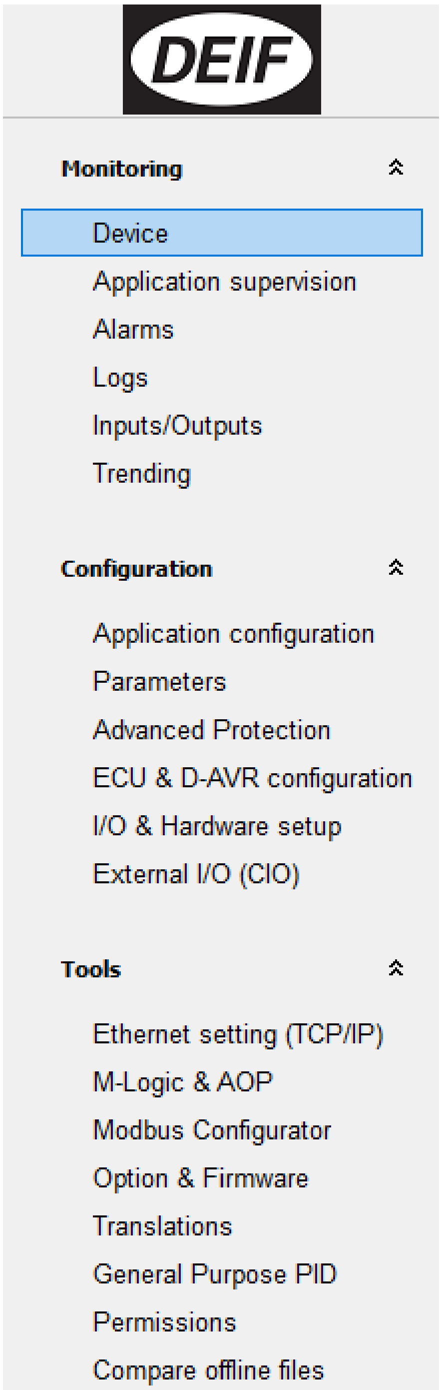
NOTE The selected NTP server must be available in the network.

2.4 Utility software interface

2.4.1 Top toolbar

1. Start communication with the device.
2. Disconnect from a controller.
3. Change your user level.
4. Application settings.
5. Upgrade options (create an option code and send it to support@deif.com).
6. Write new options (received from DEIF support).
7. Write a firmware to the device.
8. AOP 1: Not used for this controller.
9. AOP 2: Configure the AOP-2 buttons and LEDs (Additional Operator Panel).
10. Counters: Read the controller counters.
11. Identifiers: Information on the controller and the software.
12. Batch read and write: Read, write, backup, and restore the device.
13. Show/Hide the real-time readings window.
14. Send a command to the controller.
15. Synchronise the clock of the device with the connected PC.

2.4.2 Left menu



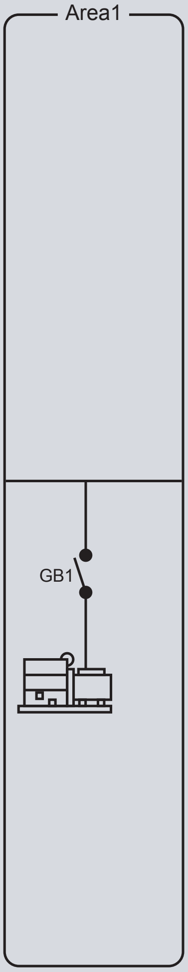
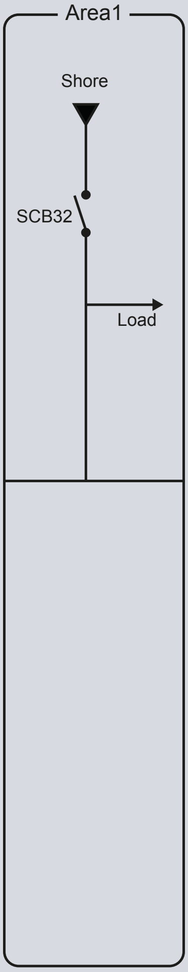
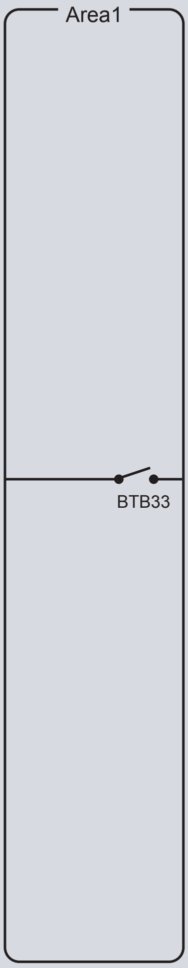
- **DEIF**
    - Link to www.deif.com
- **Monitoring**
    - Device
        - See operating information for the connected controller.
    - Application supervision
        - See the plant operation, including how much power each genset produces.
    - Alarms
        - An overview of the active alarms.
        - See the history for the alarms that are activated while the PC is connected.
    - Logs
        - See the alarms and events logs from the controller.
    - Inputs/Outputs
        - The controller input and output status.
    - Trending
        - See real-time operation.
        - Trending is possible when a PC is connected and the trending window is open. The controller cannot save the data.
- **Configuration**
    - Application configuration
        - Create the application single-line drawing(s).
    - Parameters
        - Configure and view parameters. You can view the parameters as a list or in a tree structure.
    - Advanced protection
        - Advanced protection settings, such as capability curves, droop, and more.
    - ECU & D-AVR configuration
        - EIC general configuration, for example Engine I/F and EIC start/stop.
        - ECU alarms
        - ECU regeneration
        - SPN ignore list
        - DAVR configuration
        - DAVR alarms
    - I/O & Hardware setup
        - Configure the inputs and outputs.
    - External I/O (CIO)
        - Detect and configure the external inputs and outputs.
- **Tools**
    - Ethernet setting (TCP/IP)
        - Configure Ethernet settings and communication.
    - M-Logic & AOP
        - Configure M-Logic and additional operator panels.
        - Modbus Configurator
            - Configure the configurable Modbus addresses.
    - Option & Firmware

  - See available options.
- Translations
  - Customise or translate the text in the controller.
- General Purpose PID
  - Configure the general purpose PID settings.
- Permissions
  - See and change the user permissions.
- Compare the offline files
  - Compare files.

2.5 Setup of applications

2.5.1 Pre-configured applications

The controller comes with four pre-configured standard applications.

Genset controller Application	Shore controller Application	BTB controller Application
		
Standard plant (power management)	Standard plant (power management)	Standard plant (power management)

`Basic settings > Application type > Standalone or PM > Application select`

Parameter	Text	Range	Default
9161	Active application	1 to 4	-
9162	Viewed application	1 to 4	-

Parameter	Text	Range	Default
9163	Name	Not configurable, dependent on the chosen application.	
9164	Status	Not configurable, dependent on the chosen application.	
9165	Number of gensets	Not configurable, dependent on the chosen application.	
9166	Number of Shores	Not configurable, dependent on the chosen application.	
9167	Number of BTBs	Not configurable, dependent on the chosen application.	

The standard applications can be changed with the utility software.

2.5.2 Determine the application type

Application type	Plant type	Configuration characteristics
Stand-alone	Single controller	In a stand-alone application setup, the controller cannot communicate with other controllers. In a stand-alone application, a genset controller can operate 1 genset and 1 GB. To prevent faulty synchronisation, there must be no other gensets or power sources. See the **iE 150 Marine Core Generator Designer's handbook**.
Power management	Standard	In a power management configuration, the controllers can be in applications with up to 2 Genset, 1 Shore and 2 BTB controllers (a total of 5 controllers). See Application configuration

3. Power management

3.1 Introduction to power management

To supply the required power to the load efficiently, safely and reliably, the power management system:

- Balances loads in the system
- Implements plant logic
- Ensures safety

The power management system is monitored from a graphical supervision page. The supervision page can show running status, hours in operation, breaker status, the state of the shore connection and busbars, and so on.

By default, CAN port B is used for power management.

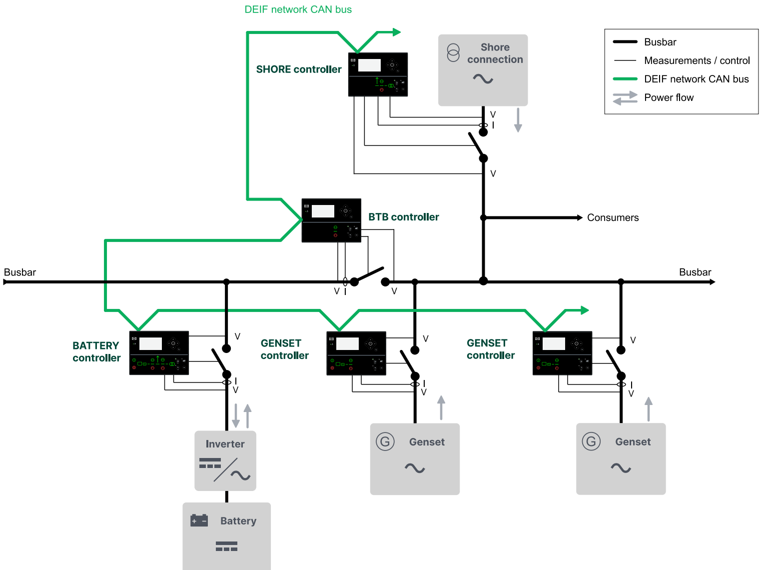
Multi-master system

For increased reliability, the power management system is designed as a multi-master system. In a multi-master system all vital data is transmitted between the controllers, so that all the controllers in the application know the power management status (calculations and position). This means that the application does not depend on a single master controller, which makes the controller suitable for a wide range of applications, including emergency standby and critical power applications.

3.2 Applications

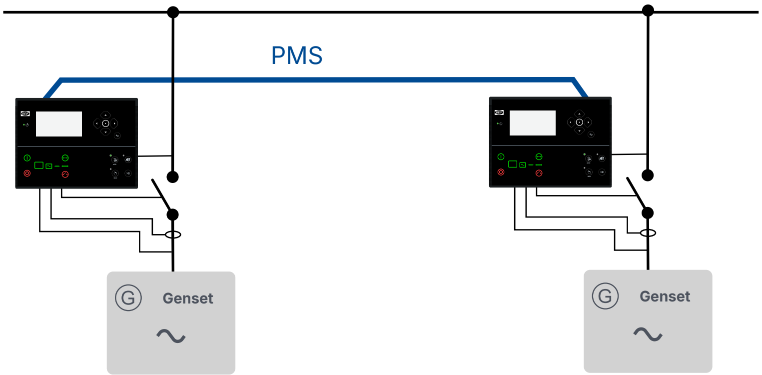
3.2.1 Power management applications

Example 1



- The plant includes shore, battery, bus tie breaker (BTB) and genset controllers.
- Up to two hybrid (battery or solar) controllers can be added.
- The feedbacks from the externally controlled BTBs must be wired to a controller.
- In this example, the gensets can run parallel to the grid.

Example 2



- Island application.
- The controllers communicate with each other for power management.
- If one controller is having a problem or is taken out for a service, the other controller takes over.

3.3 Setup

3.3.1 Select controller type

Make sure that each controller is the right type, and, if required, change the controller type.

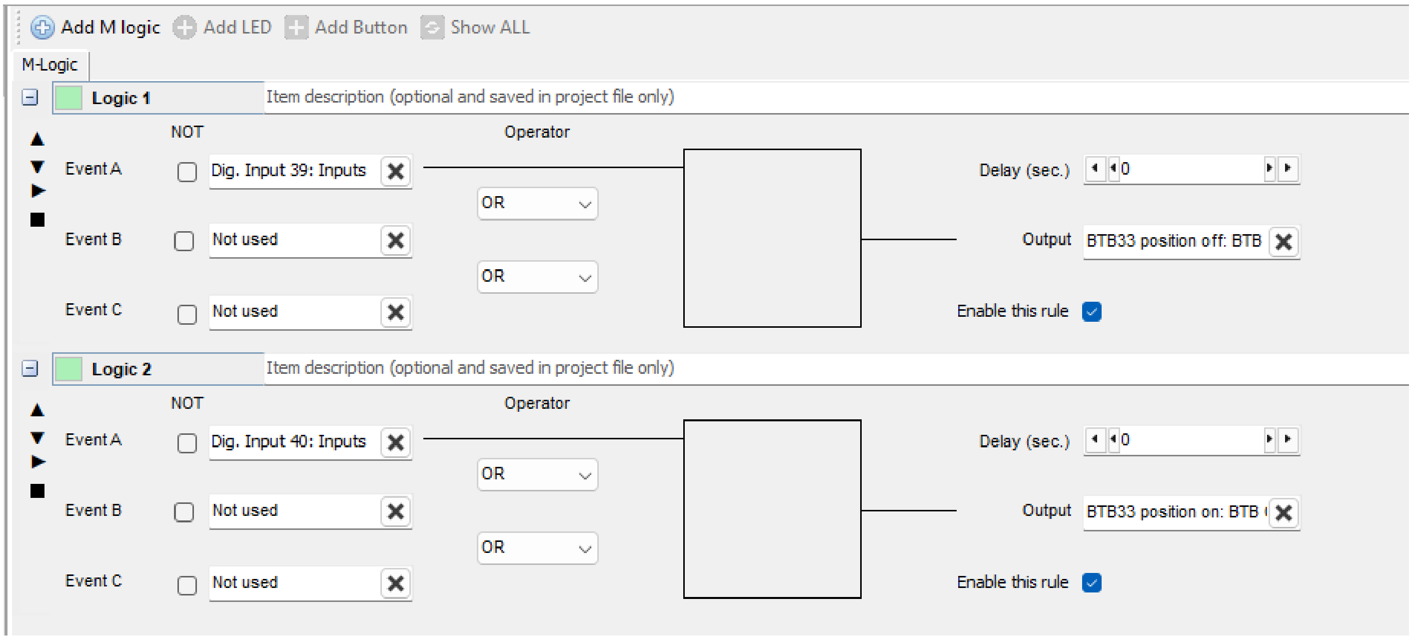
NOTE When the controller type is changed, the controller is reset to factory settings. Select the controller type before starting the configuration.

3.3.2 Breaker feedback

1. **Generator breaker (GB)**: For a genset controller, connect the feedbacks of the generator breaker to terminals 49 and 50.
2. **Shore connection breaker (SCB)**: For a shore controller, connect the feedbacks of the shore breaker to terminals 47 and 48.
   - If there is no SCB, select this in the utility software under *Application configuration*.
3. **Bus tie breaker (BTB)**: For a BTB controller, you must connect the feedbacks of the bus tie breaker to terminals 49 and 50.

For an externally controlled bus tie breaker, the breaker feedbacks must be connected to one or more controllers. Use *M-Logic Output, BTB Cmd* to configure the digital inputs.

Example of externally controlled bus tie breaker feedbacks in M-Logic



Busbar blocked

The *Busbar blocked* alarm prevents power sources from connecting when the breaker feedback is missing.

If a position failure alarm is present on a dead bus from a power source connected to the busbar, a *Busbar blocked* alarm is shown on all the controllers in the same section, preventing any breaker in the section from connecting to the busbar.

- The status text XXXX BUSBAR BLOCKED is shown in all the controllers connected to a busbar where the position failure is present. XXXX identifies the controller with the position failure.
- The *Busbar blocked* function only affects the controllers in the same section as the position failure.
- The busbar is not blocked while a position failure is present when
  - SCB position failure.
  - BTB position failure.
  - Any breaker position failure while the busbar's voltage and frequency are within the nominal settings.

3.3.3 CAN connections

The CAN line wiring between controllers must be a daisy chain connection. The line must be a continuous communication bus, and it cannot be mixed with the other communication.

More information
See **CAN bus power management system** in the **Installation instructions** for wiring recommendations.

3.3.4 CAN failure mode

If there is a failure on the CAN controlling the power management, the system can be set up to respond in a variety of ways.

`Power management > Communication failures`

Parameter	Text	Range	Default	Details
7532	CAN fail mode	SWBD MANUAL mode No mode change	SWBD	The controller mode if there is a CAN failure. See below.
7533	Miss. all units	Fail classes	Warning	The controller cannot detect any other controllers.
7534	Fatal CAN error	Fail classes	Warning	More controllers are missing than configured in parameter 8800.

Parameter	Text	Range	Default	Details
7535	Any GEN missing	Fail classes	Warning	The controller cannot detect at least one genset controller.
7536	Any SHORE miss.	Fail classes	Warning	The controller cannot detect at least one shore controller.
7871	Any BTB missing	Fail classes	Warning	The controller cannot detect at least one BTB controller.
7874	Appl. Hazard	Fail classes	Warning	
7875	Any SOLAR miss.	Fail classes	Warning	The controller cannot detect at least one solar controller.
7876	Any STORAG miss.	Fail classes	Warning	The controller cannot detect at least one storage/battery controller.
8800	CAN miss amount	2 to 32	2	The setting for the fatal CAN error.

SWBD mode

If *SWBD* mode is selected, the controllers change to switchboard control mode when a fatal CAN error occurs. In this mode, the PMS is disabled, but AC protections remain active.

More information
See **Mode overview** for description of SWBD mode.

MANUAL mode

If *MANUAL* mode is selected, the controllers change to MANUAL mode when a fatal CAN error occurs. The regulators in the controllers are still active. This means that power sources (for example, gensets) that are visible to each other are able to share load.

CAUTION

Unsynchronised gensets or energy storage systems can be connected

If a fatal CAN error is present, it is possible to start two gensets or energy storage systems and close the breakers onto the busbar at the same time (even though they are not synchronised).

No mode change

If *No mode change* is selected, the controllers are kept in the mode they were in before the fatal CAN error occurred. In an application with several controller types, if one power source controller is not visible anymore, the rest of the system can still behave almost like normal and continue in AUTO mode.

3.3.5 CAN bus alarms

Alarm	Description
Any GEN missing	Activated when one or more genset controllers are missing. Activates the fail class in parameter 7535.
Any SHORE missing	Activated when shore controller is missing. Activates the fail class in parameter 7536 (also used when a BTB controller is missing).
Appl. Hazard	The application configuration is not the same in all the controllers in the system. The power management system cannot operate correctly. If enabled, this alarm activates the fail class in parameter 7872.
Duplicate CAN ID	Activated when two or more controllers have the same internal communication ID. The power management system cannot operate.
Missing all units	Activated only when a controller cannot "see" any other controllers on the CAN bus line. Activates the fail class in parameter 7533.
CAN bus communication failures	The *XXX missing* alarms, the alarm is activated on all other controllers in the application.

Alarm	Description
CAN ID X P missing	The controller has lost CAN bus communication to CAN ID on *PM Primary*.
CAN SHORE X P missing	The controller has lost CAN bus communication to a shore controller with ID X on *PM Primary*.
CAN BTB X P missing	The controller has lost CAN bus communication to a BTB controller with ID X on *PM Primary*.
CAN ID X S missing	The controller has lost CAN bus communication to CAN ID on *PM Secondary*.
CAN SHORE X S missing	The controller has lost CAN bus communication to a shore controller with ID X on *PM Secondary*.
CAN BTB X S missing	The controller has lost CAN bus communication to a BTB controller with ID X on *PM Secondary*.
CAN setup CH: 784x	The controller can detect power management communication on a CAN port, but the correct protocol is not set. For a genset controller, this alarm also monitors the CAN setup between the engine communication protocol and CAN port.

3.3.6 Controller IDs

After connecting the CAN bus communication, each controller must have a unique internal communication ID.

- GENSET: 1-2
- SOLAR + BATTERY: 25-28
- SHORE: 32
- BTB: 33-34

For manual setup, you must set the controller ID.

`Communication > Power management ID`

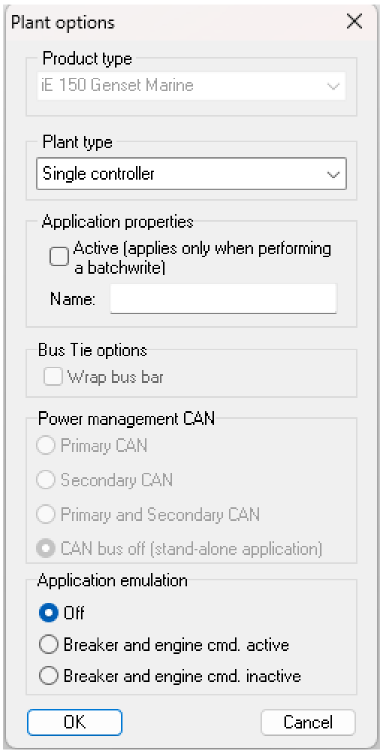
Parameter	Text	Range	Default
7531	Int. comm. ID	1 to 32	1

3.3.7 Application configuration

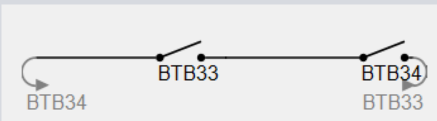
When the IDs are configured, you can configure the application with the utility software. Connect to a controller with the PC utility software, then select *Application configuration*.

In the top taskbar, select *New plant configuration*

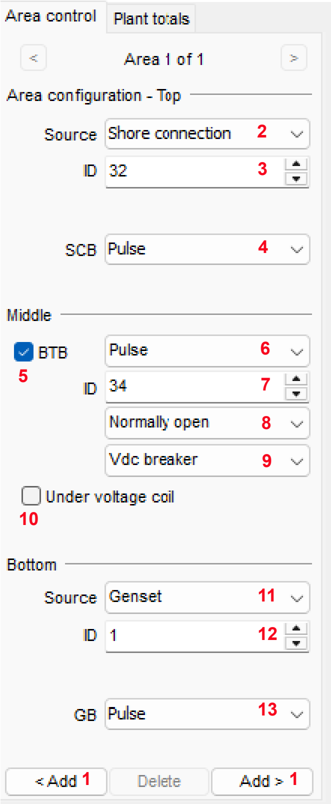
The *Plant options* window opens.



Plant options

	Description	Comments
Product type	The controller type is selected here.	This function is greyed out if a controller is already connected.
Plant type	• Single controller • Standard	Select *Standard* for power management systems. If *Single controller* is selected, the CAN ports for power management communication are turned off.
Application properties	The application is activated when it is written to the controller. Name the application.	Naming the application can be helpful, if the controller is in a plant where the controller will switch between applications. The controllers can switch between four different applications. Controllers connected to each other by CAN bus communication cannot have different applications or numbers.
Bus tie options	Select the *Wrap bus bar* option.	Activate this option if the busbar is connected as a ring connection in the application. When the wrap busbar is selected, it is shown like this: 
Power management CAN	Primary CAN Secondary CAN Primary and secondary CAN CAN bus off	*Primary CAN* must be used, if the Power Management CAN bus is wired to CAN port B on each controller. *CAN bus off* should only be used if the controller is in a stand-alone application.
Application emulation	Off Breaker and engine cmd. active Breaker and engine cmd. inactive	The emulation is started here. For *Breaker and engine cmd. active*, the controllers activate the relays and try to communicate with an ECU. If the controllers are mounted in a real installation, the breakers will open/close and the engine start/stop. This does not happen if *Breaker and engine cmd. inactive* is selected. In real installations, emulation can be used during the commissioning. When the commissioning is done, switch off emulation.

You can now create the application drawing in the controllers. From the left side of the page, you can add controllers to the configuration. You can also select the type of breakers in the application.

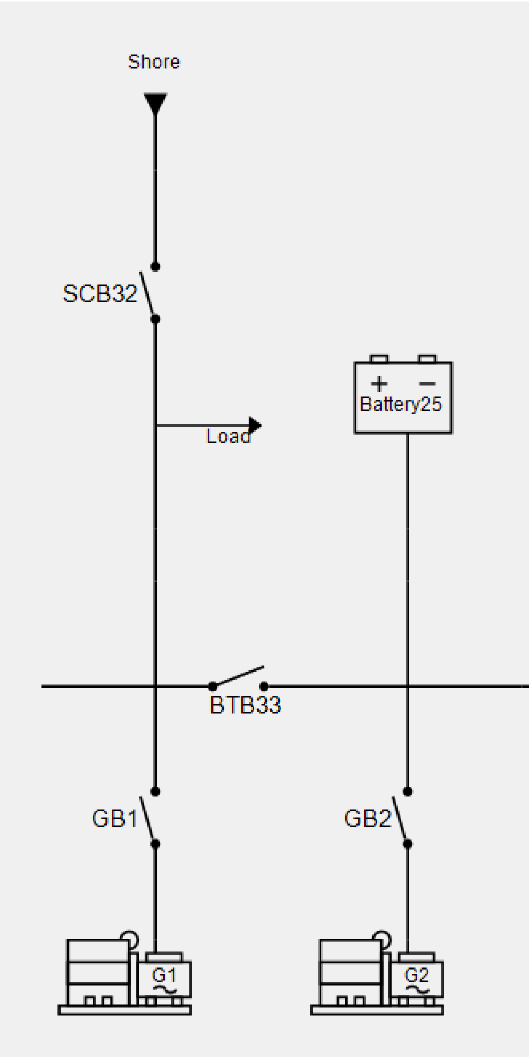


Plant configuration options

No.	Name	Description
1	Add/Delete	Add and delete areas. Adding areas makes the application configuration/plant bigger.
2	Source	Select the type of power source for the top area (None, Shore connection, Genset, Photovoltaic or Battery).
3	ID	Set the ID. This ID should correspond to the internal communication ID (parameter 7531) in the controller.
4	SCB	Shore connection is selected as the source (no. 2), so it is possible to select the type of breaker* for the shore connection breaker (Pulse, Continuous NE, Compact, None, Continuous ND).
5	BTB	Select to add a BTB controller.
6	-	The type of bus tie breaker* (Pulse, Ext, Continuous NE, Compact). Select *Ext* for an externally controlled BTB, that is, there is no AGC BTB controller. The bus tie breaker position feedbacks must be connected to any controller in the power management system.
7	ID	Set the ID. This ID should correspond to the internal communication ID (parameter 7531) in the controller.
8	-	Select whether the BTB is *Normally open* or *Normally closed*.
9	-	If *Vdc breaker* is selected, the breaker can open and close when there is no voltage on the busbar. If *Vac breaker* is selected, voltage must be present on the busbar before the breaker can be handled.
10	Under voltage coil	Select this if the BTB has an under-voltage coil.
11	Source	Select the type of power source for the bottom area (None, Shore connection, Genset, Photovoltaic or Battery).

No.	Name	Description
12	ID	Set the ID. This ID should correspond to the internal communication ID (parameter 7531) in the controller.
13	GB	Genset is selected as the source, so it is possible to select the type of breaker* for the genset breaker (Pulse, Continuous NE, Compact).

Application configuration example



After you have created the application, send it to the controllers. Select *Write plant configuration to the device*. After this, only the controller connected to the PC utility software has the application configuration.

The application configuration can then be sent from this controller to all the other controllers. Select *Broadcast plant application*

3.4 Power management general functions

3.4.1 Command unit

The power management system is a multi-master system. In a multi-master system, the available generator controllers automatically perform the power management control. This means that the system never depends on only one master controller.

If for instance one controller ID is disabled, and this was the command unit, then the next available controller will take over the command functions.

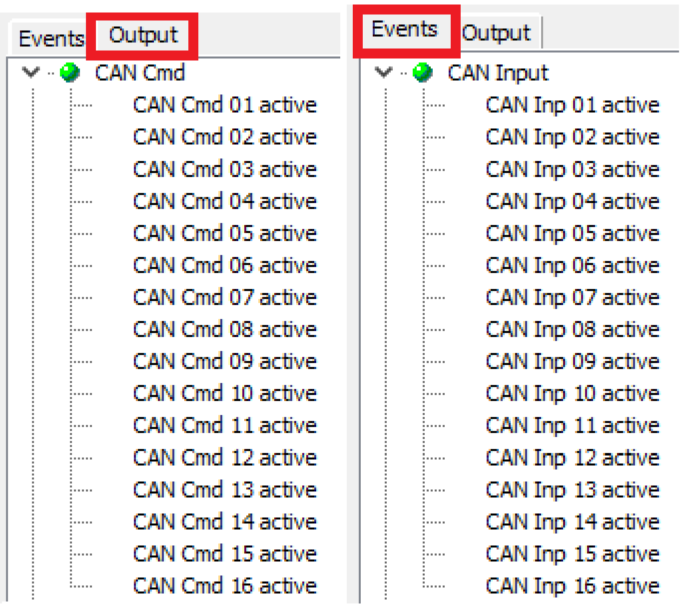
The command unit cannot be selected by the operator. It is automatically selected when power management is used.

3.4.2 CAN flags (M-Logic)

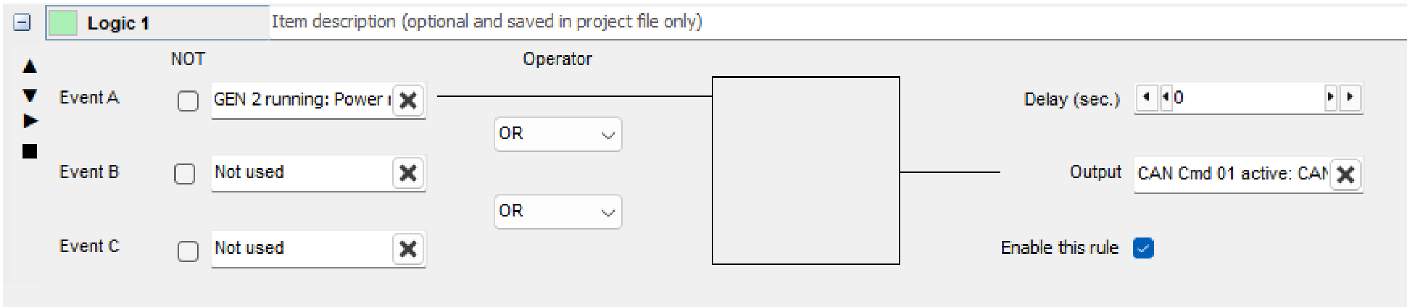
M-Logic has 16 CAN flags for CAN commands. They are like digital inputs. When a CAN command is sent from one controller, the corresponding CAN flag is activated in all the controllers. No wire is needed, as the CAN flags are communicated over the power management CAN bus.

NOTE Only use continuous signals from digital inputs or AOP buttons to activate the CAN inputs. AOP buttons are pulse inputs, so a latch function must be used to create a continuous signal.

M-Logic CAN flag outputs and events



M-Logic CAN command example

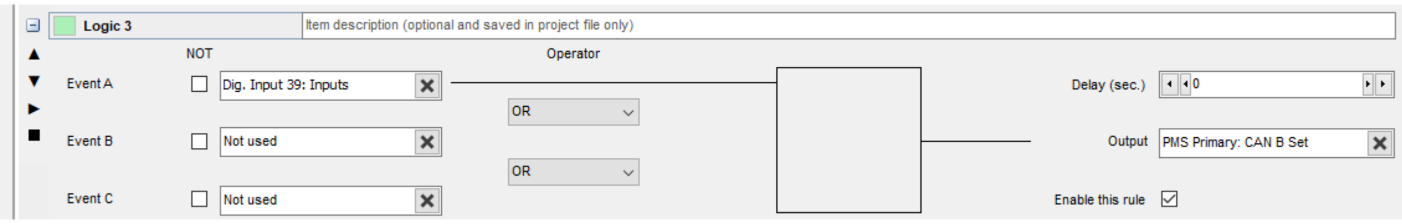


CAN Cmd 01 is activated when GEN 2 is running. *CAN Inp 01 active* is then activated in all controllers in the power management system.

3.4.3 CAN B Set (M-Logic)

The *CAN B Set* output in M-Logic allows you to change the set point for the CAN B protocol. For the protocol set point, you can select *PM Primary* or *PM Secondary*.

M-Logic CAN B output example



3.4.4 Common PF control

Configure common PF control in a shore controller. These set points are sent through the power management CAN bus to all the genset controllers in the system. The genset controllers then each adjust their PF control according to the set point.

`Power set points > Cos phi or Q`

Parameter	Text	Range	Default
7055	CtrlSet cos phi or Q	OFF Superior (PMS)	OFF

NOTE Inductive/capacitive set points can be set up from M-Logic.

3.4.5 Mode update

The *Mode update* function is used to define if the change of running mode affects all controllers connected on the power management CAN line, or only the local unit where the running mode is change.

`Power management > Additional power management settings`

Parameter	Name	Range	Default
8022	Mode update	Update local Update all	Update all

For *Update all*, when a mode change is done on one controller, a mode change on a different controller is ignored for approximately 2 seconds.

3.5 Power management genset functions

3.5.1 Safety stop

In genset controllers with power management, the *Safety stop* fail class prioritises the load. This means that when an alarm occurs, the faulty genset stays connected to the busbar until the next priority genset is started and synchronised to the bus.

When the incoming genset has taken the load, the faulty genset ramps down the power, followed by trip of the breaker, cooling down of the engine and finally stop. If the faulty genset has the last priority, or no standby gensets are available, then it stays connected to the busbar and does not trip.

NOTE If no genset can start in a safety stop situation, then the faulty genset is not stopped. Therefore it is important that the safety stop is backed up, for example, by a trip and stop alarm, or a shutdown alarm.

3.5.2 Manual priority selection

An important part of the power management system is the priority selection. With prioritisation it can be decided in which order the gensets or groups should start. The priority selection can be used to balance the running hours between the gensets, or simply make sure that the gensets always start and stop in a specific order. The prioritisation can be done manually or the power management system can do the prioritisation automatically.

`Power management > Priority > Type`

Parameter	Text	Range	Default
8031	Priority select	Manual abs. Running hours abs. Manual rel. Running hours rel.	Manual abs.

Alternatively, use *M-Logic, Output, Command Power management, First priority* to give the controller the first priority. You can use *M-Logic, Output, Inhibits/Activate/Deactivate Power management, Block priority swapping* to ensure that the start list is not changed.

Manual priority

You can manually adjust the priority order. Set the priority in each genset.

`Power management > Priority > Manual`

Parameter	Text	Range
8081	Priority 1	1 to 2
8082	Priority 2	1 to 2

The priority settings can be changed in one genset controller and then sent to the other gensets with the transmit function.

`Power management > Priority > Manual`

Parameter	Text	Range	Default
8083	Transmit	OFF Manual update Running hour update	OFF

Manual absolute

If the gensets are in AUTO mode, when *Manual abs.* is selected in parameter 8031, the power management system dynamically calculates the priority for each controller. If the sections are separated by opening a BTB, the two sections are treated as two independent applications.

Manual relative

Selecting manual relative makes sense if there is a shore connection on one side of the BTB. When sections are separated by opening a BTB and the gensets are in AUTO mode, selecting Manual rel. in parameter 8031 means that the power management system automatically changes the priorities. The priorities depend on the position of the BTB.

3.5.3 Running hours priority

The purpose of the priority selection based on running hours is to ensure that the gensets have the same (or nearly the same) running hours. Every time the priority update hour setting is reached, a new priority order is calculated. The gensets with first priorities are started (if not already running), and the gensets with the last priorities will stop.

Priority select based on running hours can be absolute or relative. The choice between the absolute and relative routine determines whether an offset for the running hours is included in the priority calculation. For example, an offset can be used if a controller is replaced.

Running hours type

- Total: The controller counts the running hours.
- Trip: The running hours counter can be reset to 0 with parameter 8113.

`Power management > Priority > Running hours`

Parameter	Text	Range	Default
8111	Priority update hour	1 to 20,000 hour	175 hour
8112	Run. hours type	Total Trip Load profiled	Total
8113	Rel. counter	OFF ON	OFF

Absolute running hours

The gensets with the lowest number of running hours have the highest priority. The initial running hours are configured in each genset controller in parameters 6101 and 6102. This allows each controller to display the correct total running hours for each genset.

Absolute running hours can be impractical if the application consists of old gensets together with new gensets. In that situation the new gensets are the first priorities, until they have reached the same number of running hours as the old gensets. To avoid this, use relative running hours instead.

You can select absolute running hours using *M-Logic, Output, Command Power management, Abs prio handling*.

Relative running hours

When *Running hours rel.* is selected, all gensets in AUTO mode participate in the priority calculation independent of the running hours settings. This selection allows the operator reset the priority calculation. If *Enable* is selected in the *Trip counter*, the relative running hour counter in the controller is reset to 0 hours. At the next priority selection the calculation is based on the reset values.

You can select relative running hours using *M-Logic, Output, Command Power management, Rel prio handling*.

NOTE For relative running hours, if a BTB closes to join two sections, then only the section with first priority is used.

3.5.4 Load-dependent start and stop

This function ensures that sufficient power is always available on the busbar. Gensets are automatically started and stopped so that only the required number of gensets run. This optimises fuel usage and the maintenance intervals.

The load-dependent start/stop function is active when the plant is in AUTO mode. The starting and stopping of the gensets is done automatically according to the configured set points and priority selection.

`Power management > Load dep Strt/Stp conf`

Parameter	Text	Range	Default
8881	Ld. start/stop unit	kW kVA	kW
8882	Ld. start/stop type	Value Percentage	Value
8006	Load dep. scale	1 kW : 1 kW 1 kW : 10 kW 1 kW : 100 kW 1 kW : 1000 kW	1 kW : 1 kW
8140	Stop noncon. GEN	10.0 to 600.0 s	60.0 s
8350	Ld. stop no delay	1 to 100 %	20 %

This means that the load-dependent start/stop function can be designed for operating dependent on how loaded the gensets is in kW or percentage before the next genset is started or stopped.

The easiest way to configure the load-dependent start/stop function is by using the percentage method. However, when there are more than three gensets, there can be a situation where a genset is running, even though it could be stopped to save fuel. Both types are described below.

Power management > Start/Stop for Island

Parameter	Text	Range	Default
8021	Start/stop	Remote Local	Remote

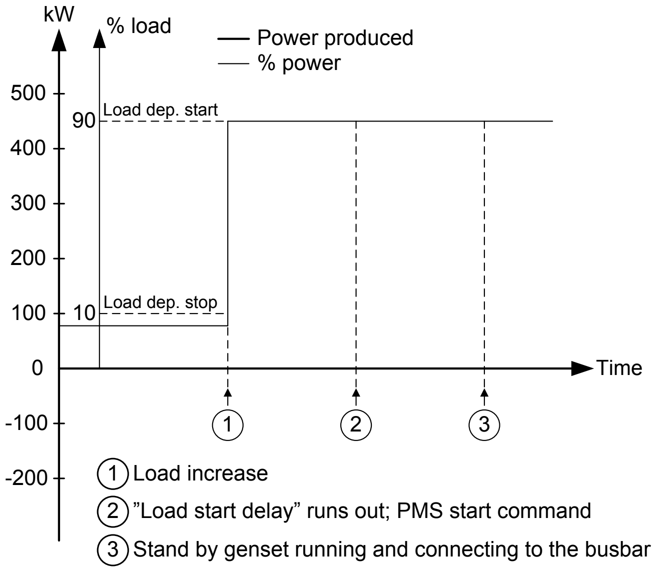
Terminology

Short	Description	Comment
$P_{AVAILABLE}$	Available power	P_{TOTAL} - $P_{PRODUCED}$
P_{TOTAL}	Total power	$\Sigma P_{NOMINAL}$ of running sets with GBs closed
$P_{PRODUCED}$	Produced power	
$P_{NOMINAL}$	Nominal power	
$P_{NOMINAL-STOP}$	Nominal power of the genset to stop	Priority-dependent

Produced power method

This method is effective if parameter 8882 is set to *Percentage* as basis for the start/stop calculation.

- If the load % of a generator exceeds the *Start next* set point, the start sequence of the lowest priority generator in stand-by is initiated.
- If the load % of a generator drops below the *Stop next* set point, the stop sequence of the running generator with the highest priority number is initiated.
- If the load of the plant can decrease so much that the generator with the highest priority number can be stopped. An available power of at least the stop set point in % must be available, then the stop sequence for the generator is initiated.



Available power method

This method is effective if P [kW] or S [kVA] is selected as basis for the start/stop calculation.

- Independent of the selection (P [kW] or S [kVA]), the functionality is basically identical; therefore the example of the functionality below is given for the load-dependent start function with selected rated power (P) value.
- The apparent power set point is typically selected if the connected load has an inductive character and the power factor is below 0.7.

Nominal power

The rated power of the genset that can be read on the type plate of the generator.

Total power

The sum of the rated nominal power of each individual genset. In the example the plant consists of two GENs:

GEN1 =	1500 kW
GEN2 =	1000 kW
That is a total of	2500 kW

Produced power

The existing load on the busbar. In the example the produced power is shown as the hatched area, and the total of the two gensets = 1450 kW.

Available power

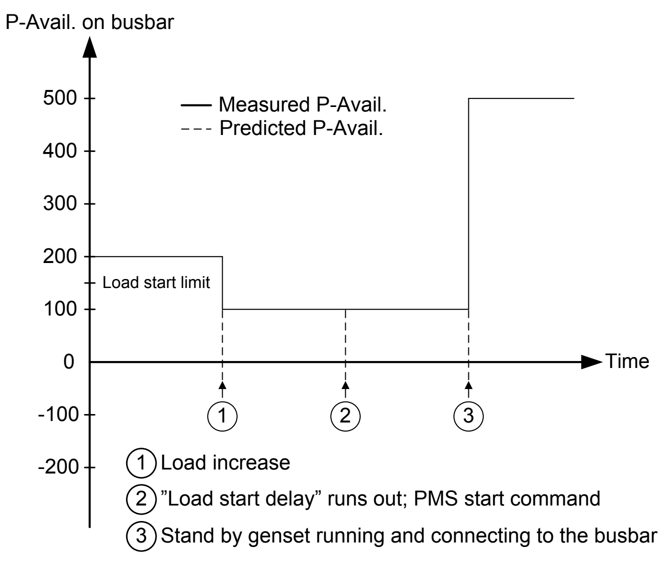
The difference between the maximum possible power produced by the gensets and the actual produced power.

In the example the plant consists of three gensets, in total 2500 kW. The load consumes 1450 kW in total. Since the total load P_{TOTAL} is 2500 kW, and the produced load $P_{PRODUCED}$ is 1450 kW, then the available power $P_{AVAILABLE}$ is 1050 kW, meaning that the gensets can handle this load if it should be added to the busbar.

3.5.5 Adjusting load-dependent start and stop

Example: Adjusting load-dependent start

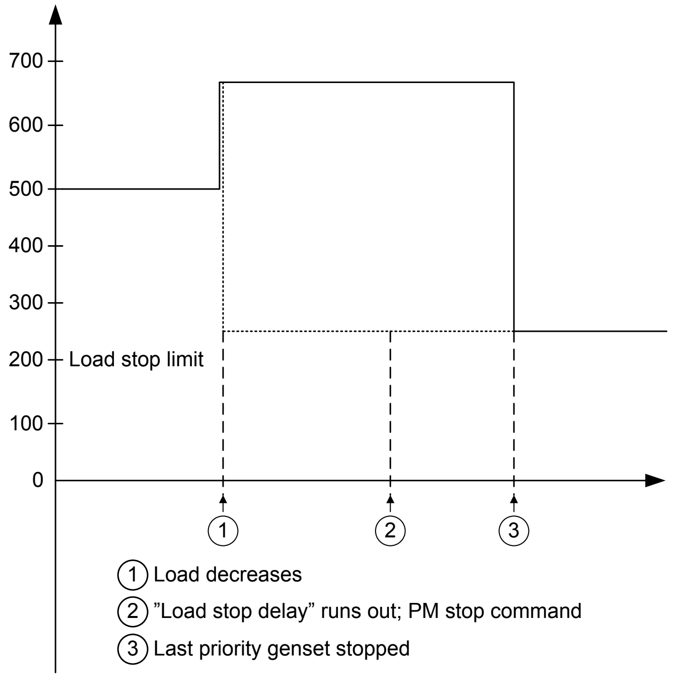
The available power is 200 kW. When the load increases, the available power drops below the start limit. The stand-by genset will start when the start timer runs out, and after the synchronising the available power increases (in this example to 500 kW).



Example: Adjusting load-dependent stop

The available power is 500 kW. When the load decreases, the available power increases to 750 kW. The controller calculates what happens if the last priority genset is stopped. The last priority genset is 400 kW which means that it can be stopped, because the available power will still be above the stop level.

Now the difference between the stop level and the available power is 50 kW. This means that only if the genset, which now has the last priority, is 50 kW, it can be stopped!



NOTE If the priority order is changed, but does not seem to change as expected, it is because the load-dependent stop function is not able to stop the lowest priority after having started the new first priority. That would cause two GENs to be running at low load instead of one GEN.

3.5.6 Two sets of start/stop settings

There are two sets of parameters for load-dependent starting and stopping.

`Power management > Load dependent start [1 or 2]`

Parameter	Text	Range	Default
8001 or 8301	Ld. start limit P	1 to 20,000 kW	100 kW
8002 or 8302	Ld. start limit S	1 to 20,000 kVA	100 kVA
8003 or 8303	Ld. start limit %	1 to 100 %	90 %
8004 or 8304	Ld. start timer	0.0 to 990.0 s	10.0 s

`Power management > Load dependent stop [1 or 2]`

Parameter	Text	Range	Default
8011 or 8311	Ld. stop limit P	1 to 20,000 kW	200 kW
8012 or 8312	Ld. stop limit S	1 to 20,000 kVA	200 kVA
8013 or 8313	Ld. stop limit %	1 to 100 %	70 %
8014 or 8314	Ld. stop timer	5.0 to 990.0 s	30.0 s

Having two sets of parameters enables the genset to act differently on different load curves. For example, if the load increases fast, you can configure a short timer (s) and a low P (kW) set point to get the genset faster online to prevent the genset from being overloaded.

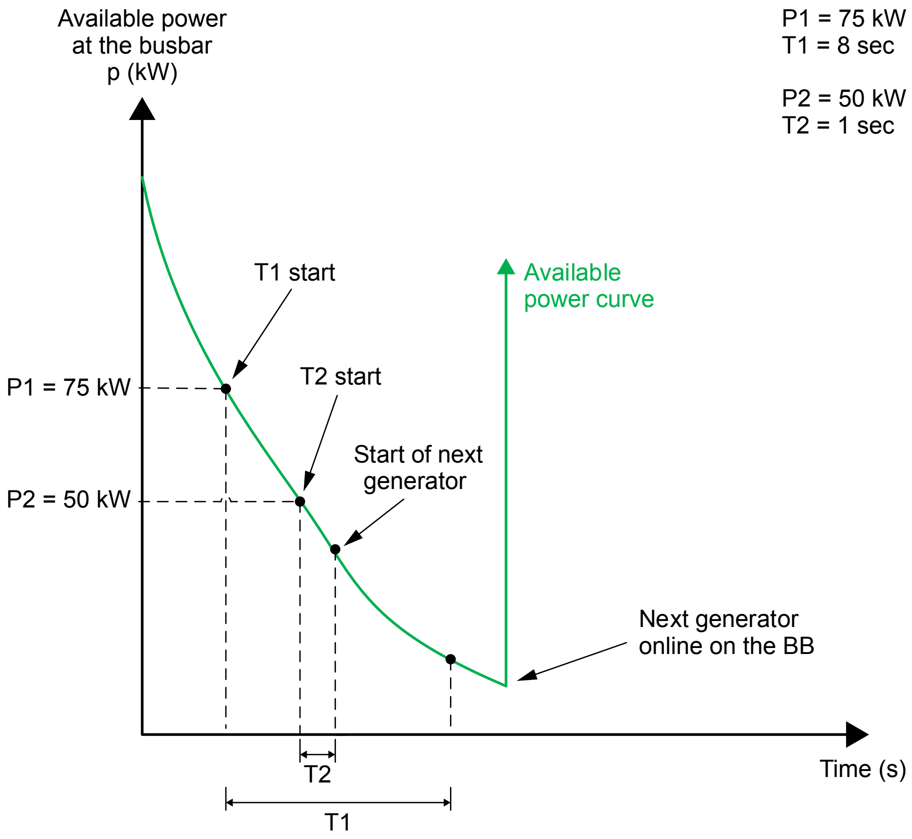
Load-dependent stop without delay function

It is possible to configure load-dependent stop without delay in parameter 8350. When this function is enabled, the load-dependent delay timer is ignored, and the load-dependent stop is carried out when the set point is exceeded. To use this function, the load-dependent start/stop type must be set to *Percentage* in parameter 8882.

The configuration examples show load-dependent start. The principle for load-dependent stop is the same.

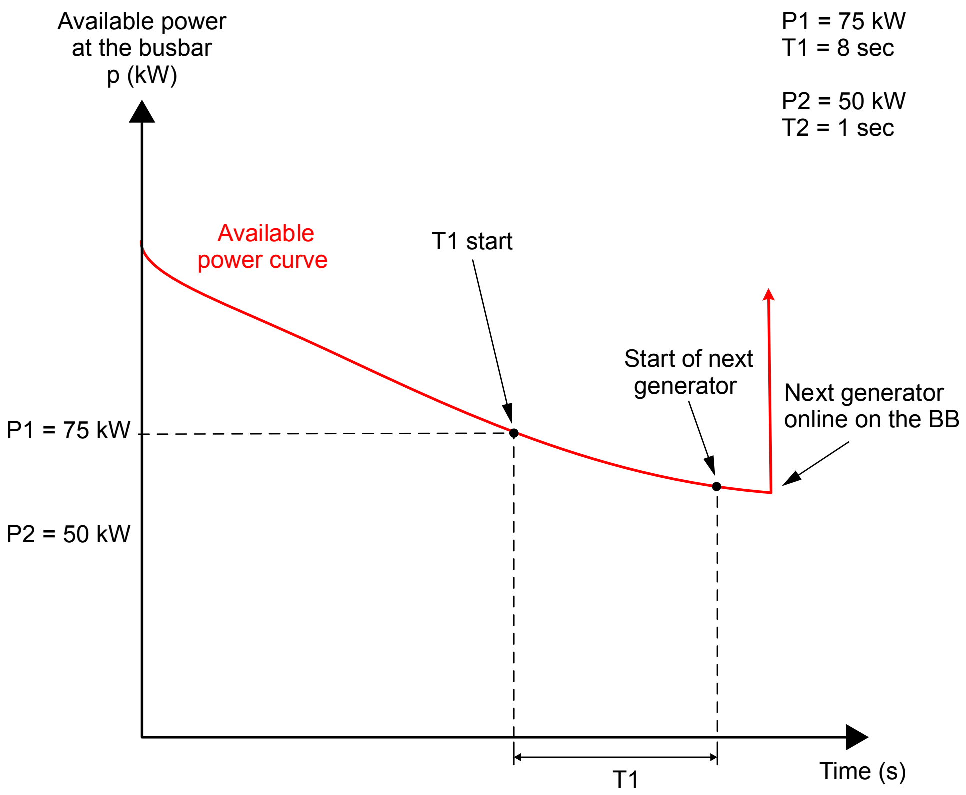
Configuration example 1

The diagram shows that timer 1 starts at 75 kW and timer 2 at 50 kW. Because timer 2 runs out before timer 1, it is timer 2 that starts the genset.



Configuration example 2

The diagram shows that timer 1 starts at 75 kW, and when timer 1 runs out the genset starts. Timer 2 will not be started, because the load does not go under 50 kW (P2).



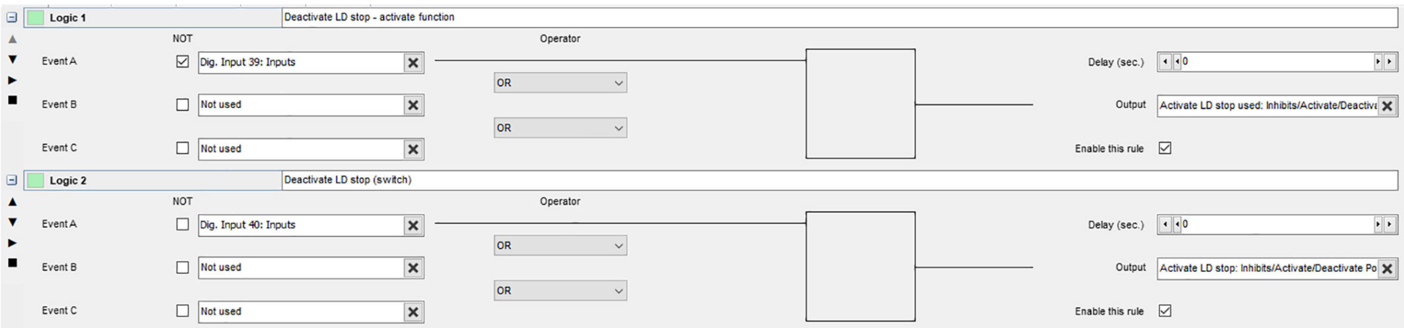
3.5.7 Activate/deactivate load-dependent start/stop with M-Logic

By default, the first set of load-dependent start/stop settings is active. You can use M-Logic inhibits to deactivate set 1 and M-Logic output commands to activate or deactivate set 2.

Set 1: Deactivate load-dependent stop

The set 1 load-dependent stop can be deactivated using *M-Logic, Output, Inhibits/Activate/Deactivate Power management, Activate LD stop*.

In this example, the function *M-Logic, Output, Inhibits, Activate LD stop used* is activated by terminal 39. Now the operator can switch the load-dependent stop ON or OFF using a switch connected to terminal 40.



The controller uses the following logic:

- *Activate LD stop used* = True and *Activate LD stop* = False: The system cannot load-dependent stop.
- *Activate LD stop used* = True and *Activate LD stop* = True: Load-dependent stop is possible.
- *Activate LD stop used* = False and *Activate LD stop"* = False: The system uses the first set of load-dependent stop parameters.*

NOTE * Unless the second set of load-dependent stop parameters is activated in 8314.

Set 2: Activate/deactivate load-dependent start/stop

To activate/deactivate the set 2 load-dependent start/stop parameters, you can select **On** or **Off** in *Ld. start timer 2* (parameter 8304) and *Ld. stop timer 2* (parameter 8314). Alternatively, you can use the following *M-Logic, Output, Command*:

- Activate Load Depend Start/Stop setting 2
- Deactivate Load Depend Start/Stop setting 2
- Activate Load Depend Start setting 2
- Deactivate Load Depend Start setting 2
- Activate Load Depend Stop setting 2
- Deactivate Load Depend Stop setting 2

3.5.8 Load sharing

When the power management communication is running, the load sharing is done using CAN bus communication between the controllers.

3.5.9 Load sharing controllers

The controller uses the load sharing controllers, when the generator breaker is closed, and not parallel to the grid. The controller tries to maintain the frequency at the nominal value. The controller also communicates with other controllers to make sure that the gensets share the load equally.

For the AVR, the controller tries to maintain the voltage at the nominal value. The controller also balances the reactive power between the controllers for load sharing.

Both the P LS-controller and the Q LS-controller have a weight factor that can be adjusted. By default the load sharing regulators will primarily be regulating towards the nominal settings for the frequency and voltage. The weight factor then decides how much the active and reactive power should have as impact on the load sharing controllers. If the weight factor is turned up, the load sharing between the controllers will be faster, but the regulation towards the nominals will be slower. So, if a smooth load sharing is required, the weight factor can be turned up, but the regulation towards the nominals will be slower. If the weight factor is turned up to 100 %, the regulation weights the frequency/voltage and the load sharing equally.

When the controller has synchronised a generator breaker and closed it, the power of the genset will by default be ramped up, following a power ramp setting. This makes it possible to have an aggressive regulation which can handle load impacts quite fast, but be quite controlled when ramping up in power to minimise the risk of instability in the other gensets.

Be aware if relay regulation is used, that there is a deadband both for the frequency and load sharing for the governor in load share control. For the AVR, there is a deadband for both the voltage and load sharing in load share control. The relay regulation also includes a weight factor for load sharing control.

`Engine > Speed control > Speed PID > Load share`

Parameter	Text	Range	Default	Comment
2541	P loadsh. f Kp	0.00 to 60.00	2.50	Analogue and EIC parameters.
2542	P loadsh. f Ti	0.00 to 60.00 s	1.50 s	Analogue and EIC parameters.
2543	P loadsh. f Td	0.00 to 2.00 s	0.00 s	Analogue and EIC parameters.
2544	P LS P weight	0.0 to 100.0 %	10.0 %	Analogue and EIC parameters.
2591	P LS f deadband	0.2 to 10.0 %	1.0 %	Relay parameters.
2592	P ls. f Kp rel.	0 to 100	10	Relay parameters.

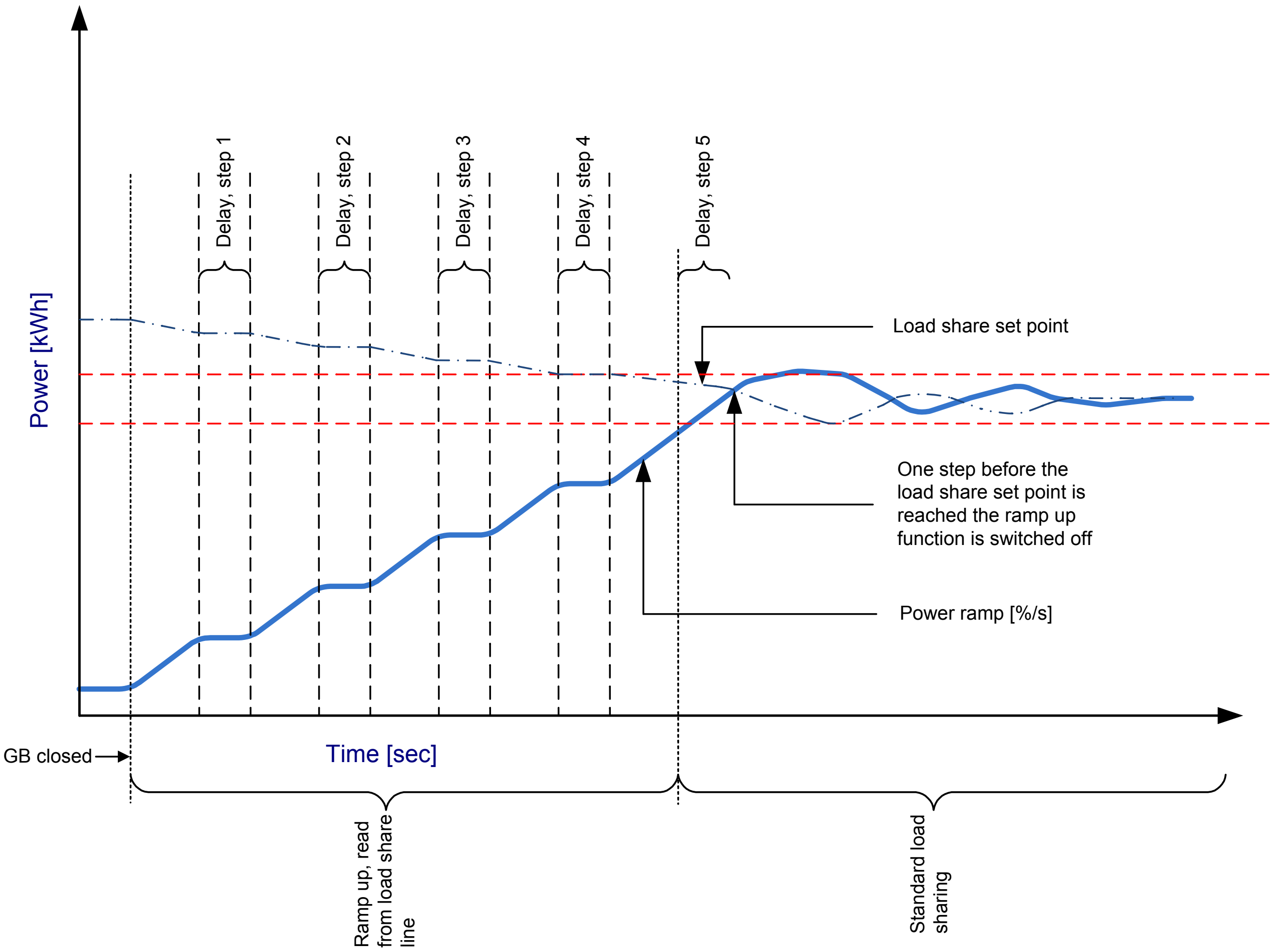
Parameter	Text	Range	Default	Comment
2593	P LS P deadband	0.2 to 10.0 %	2.0 %	Relay parameters.
2594	P LS P weight	0.0 to 100.0 %	10.0 %	Relay parameters.

`Generator > AVR> Voltage PID > Load share`

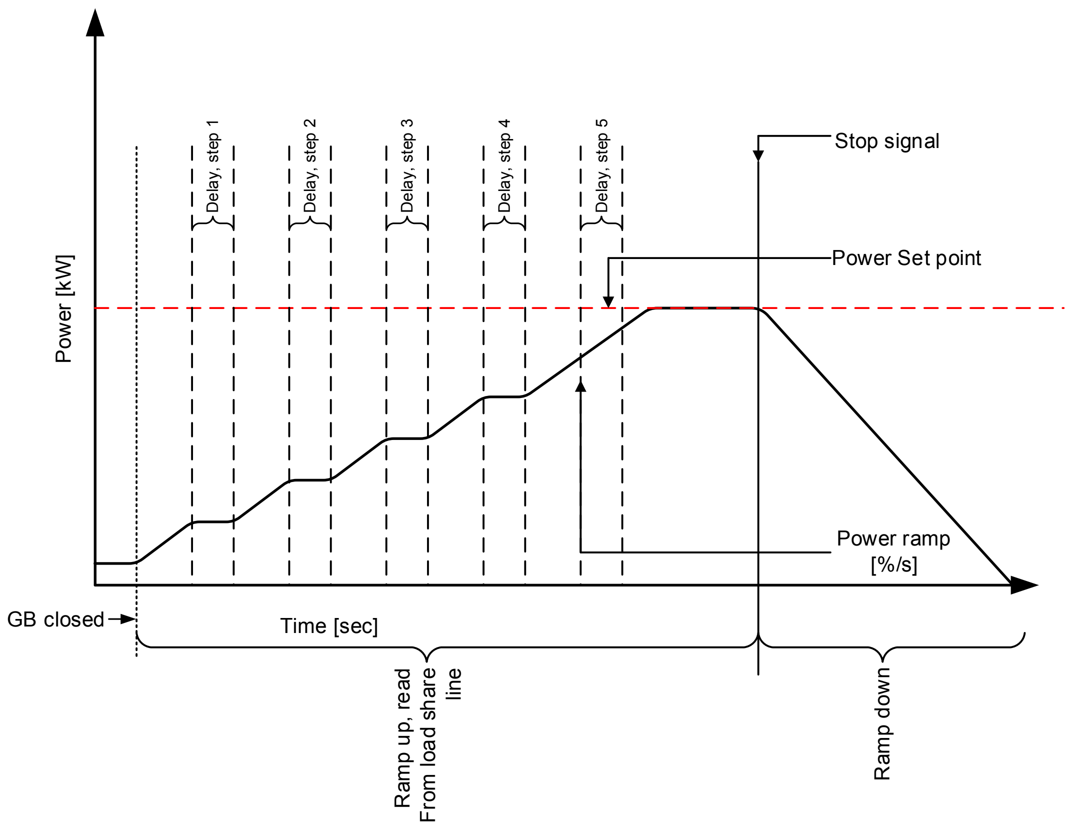
Parameter	Text	Range	Default	Comment
2661	Q loadsh. U Kp	0.00 to 60.00	2.50	Analogue and EIC parameters.
2662	Q loadsh. U Ti	0.00 to 60.00 s	1.50 s	Analogue and EIC parameters.
2663	Q loadsh. U Td	0.00 to 2.00 s	0.00 s	Analogue and EIC parameters.
2664	Q LS Q weight factor	0.0 to 100.0 %	10.0 %	Analogue and EIC parameters.
2711	Q LS U deadband	0.2 to 10.0 %	1.0 %	Relay parameters.
2712	Q LS U Kp rel.	0 to 100	10	Relay parameters.
2713	Q LS Q deadband	0.2 to 10.0 %	2.0 %	Relay parameters.
2714	Q LS Q weight	0.0 to 100.0 %	10.0 %	Relay parameters.

3.5.10 Ramp up

Island ramp up with load steps



Fixed power ramp up with load steps



When *Island ramp* is enabled, the power set point continues to rise in ramp up steps towards the load sharing set point. The ramp up will continue until the load sharing set point is reached and then switch the regulator to standard load sharing mode.

If the delay point is set to 20 % and the number of load steps is set to 3, the genset will ramp to 20 %, wait the configured delay time, ramp to 40 %, wait, ramp to 60 %, wait and then ramp to the system set point. If the set point is at 50 %, the ramp will stop at 50 %.

`Power set points > Loading/Deloading ramps > kW ramp up speed`

Parameter	Text	Range	Default
2611	Ramp	0.1 to 20.0 %/s	2.0 %/s
2612	Delay point	1 to 100 %	10 %
2613	Delay	0 to 9900 s	10 s
2614	Island ramp	OFF ON	OFF
2615	Steps	0 to 100	1

Freeze power ramp

A way to define the ramp up steps is to use the freeze power ramp command in M-Logic.

Freeze power ramp active:

- The power ramp will stop at any point of the ramp, and this set point will be kept as long as the function is active.
- If the function is activated while ramping from one delay point to the other, the ramp will be fixed until the function is deactivated again.
- If the function is activated while the delay timer is timing out, the timer will be stopped and will not continue until the function is deactivated again.

3.5.11 Secured mode

In secured mode the power management system starts one more genset than required by the load-dependent start.

`Power management > Secured mode`

Parameter	Text	Range	Default
8921	Mode	Secured mode OFF Secured mode ON	Secured mode OFF

3.5.12 Multi-start gensets

The multi-start function can be used to determine the number of gensets to start. This means that when the start sequence is initiated, the adjusted numbers of gensets will start.

This function is typically used with applications where a certain number of gensets is required to supply the load.

Configuration

The multi-start function can be adjusted to operate with two different settings. These settings consist of set points for how many gensets to start and the minimum number of running gensets.

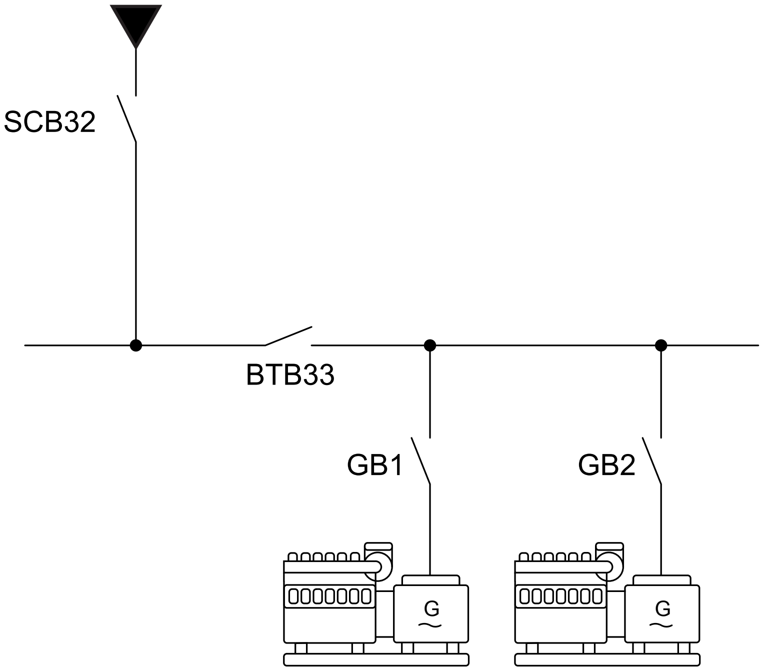
`Power management > Multi start set`

Parameter	Text	Range	Default
8922	Multistart set 1	Auto calculation Start 1-2 GEN	Auto calculation
8923	Min. run. set 1	0 to 32*	1
8924	Multistart conf	Multiple start set 1 Multiple start set 2	Multiple start set 1
8925	Multistart set 2	Auto calculation Start 1-2 GEN	
8926	Min. run. set 2	0 to 32*	1

NOTE Although the defined range is 0–32, the actual selectable values are limited to 0–2.

Multi-start all sections

This function can be used to start the generator section faster or to force the section to start if there is a power failure. The application must include BTBs, with the generators in a section with no shore controller (as shown below).



The multi-start settings determine how many gensets start in the section. A genset only starts if:

- It is in island mode.
- The function is activated in the genset controller using *M-Logic, Output, Command Power management, Multi start all sections - this section*.

Multi-start timer

You can use the multi-start timer in parameter 8360 to only connect the minimum number of gensets. The multi-start function starts and connects all the configured number of gensets, but if you enable the multi-start timer, only the necessary gensets connect to the busbar. For example, when the first genset connects to the busbar, another genset only connects if the load-dependent start threshold is exceeded. If the load is below the load-dependent start threshold, the gensets that are not connected to the busbar are stopped based on configured load-dependent stop parameters (8011-8014, and 8311 to 8314).

`Power management > Multi start set > Multistart timer`

Parameter	Text	Range	Default	Description
8360	Set point	Use fixed timer Use LD stop timer	Use fixed timer	Configure the time for the fixed timer with parameter 8362. The LD stop timer is configured with parameters 8014 and 8314.
	Timer	2 to 990 s	10 s	Use this parameter to configure the fixed timer.
	Enable	ON OFF	OFF	Select ON to enable this parameter.

3.5.13 Load management

You can use the outputs of the *Available power* alarms to activate relays for load management. This function allows the controllers to connect load groups.

In each of the gensets, five levels can be configured:

- Available power 1
- Available power 2

- Available power 3
- Available power 4
- Available power 5

`Power management > Load adding > Available power [1 to 5]`

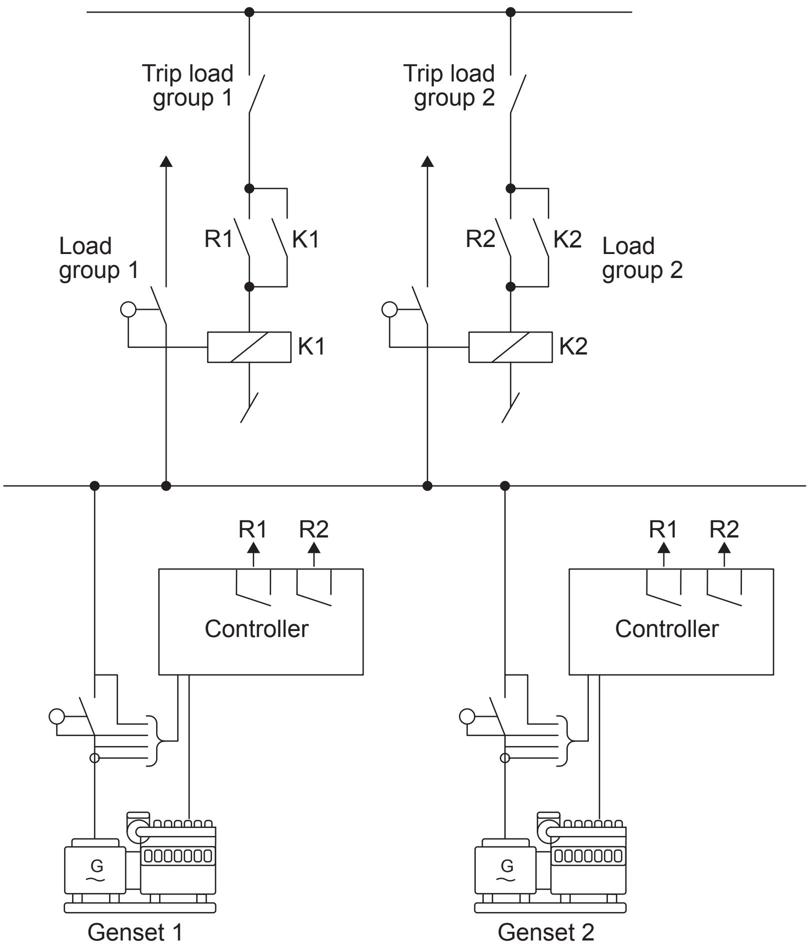
Parameter	Text	Range	Default
8220, 8230, 8240, 8250 or 8260	Set point	10 to 20,000 kW	1000 kW
	Timer	1.0 to 999.9 s	10.0 s
	Output A	Relays and M-Logic	Not used
	Output B	Relays and M-Logic	Not used
	Enable	OF ON	OFF

These set points can activate a relay when the specific amount of available power is reached. The relay output can be used for connecting load groups. The relays activate when the available power is higher than the set point. Note that when the load groups are connected, the available power decreases. The relay(s) deactivate if the available power is below the set point. An external holding circuit is therefore necessary.

Load management example

It is possible to configure different levels of available power in all gensets. This allows several load groups.

In this simplified diagram, generator 1 is started followed by generator 2. The two load groups are connected by the available power relays R1 and R2 on the controller.



Busbar measurement failure

If a genset controller loses voltage detection on the busbar and other controllers can detect voltage on the busbar, the alarm *BB meas failure* is activated in the controller with no voltage measurement. This alarm prevents that controller from closing the GB.

3.5.14 Stop of non-connected gensets

If peak shaving is selected and the imported power increases above the start set point, the genset(s) start. If the load now drops below the start set point, it remains disconnected from the busbar but does not stop, because the imported power is higher than the stop set point. The function stop of non-connected GEN makes sure that the gensets stop after the adjusted time.

`Power management > Load dep Strt/Stp conf > Stop noncon. DG`

Parameter	Text	Range	Default
8140	Stop noncon. GEN, Timer	10.0 to 600.0 s	60.0 s

In other modes, the generator is also stopped if it is in AUTO mode without the GB closed.

3.6 M-Logic for power management

3.6.1 Power management events

Power management - common

Event	Activated when ...
PM auto-start active GEN	Auto start is active for genset controller(s).
PM auto-start active SHORE	Auto start is active for shore controller(s).
PM auto-start active BATTERY	Auto start is active for battery controller(s).
All GB's opened	All GBs in the application are open.
Any GB closed	Any GB in the application is closed.
Any SCB closed	Any SCB in the application is closed.
Unit has command status	The controller is the command unit for PMS.
First priority	The genset controller is the First priority.
First standby	The genset controller is the First standby.
Secured mode	The genset controller is running in secured mode.
LD start timer expired	The load-dependent start timer has expired.
LD stop timer expired	The load-dependent stop timer has expired.
Any shore on busbar	Any shore connection is connected to the busbar (the shore connection breaker is closed).
Any SCB synchronising	The PMS is regulating the gensets to synchronise to any shore.
Any BTB deloading	The PMS is regulating the gensets to deload the bus tie breaker.

Power management - GEN

Event	Activated when ...
GEN [1-2] GB closed	The GB of the specified genset controller is closed.
GEN [1-2] GB opened	The GB of the specified genset controller is opened.
GEN [1-2] volt/freq okay	The voltage and frequency from the specified genset is within the required range.
GEN [1-2] running	There is running feedback for the specified genset.

Event	Activated when ...
GEN [1-2] ready to auto start	The PMS can automatically start the specified genset if required.
GEN [1-2] GB Synchronising	The specified genset controller is synchronising the genset to the busbar (by regulating the specified genset).

Power management - ID alarms

Event	Activated when ...
PM ID [1-2, 25-28, 32] has any alarm present	The controller with the specified PM ID has at least one active alarm.

Power management - SHORE

Event	Activated when ...
Shore 32 SCB closed	The SCB of the shore controller is closed.
Shore 32 SCB opened	The SCB of the shore controller is opened.
Shore 32 mains volt/freq okay	The voltage and frequency measured by the shore controller is within the required range.
Shore 32 AUTO	The shore controller is in AUTO mode.
Shore 32 SCB Synchronising	The PMS is synchronising the busbar to the shore (by regulating the gensets).
Shore 32 mains failure	The shore controller detects a blackout on the mains.
Shore 32 in BLOCK	The shore controller is in block mode (the controller cannot close the shore connection breaker).

Power management - BTB

Event	Activated when ...
BTB [33-34] BTB closed	The specified BTB is closed.
BTB [33-34] BTB opened	The specified BTB is opened.
BTB [33-34] BTB Synchronising	The PMS is synchronising across the specified BTB (by regulating the gensets).

Events Power management

Event	Activated when ...
Multi-start set [1-2] selected	Selection of gensets to be started upon blackout.
Dynamic section equal static section	There are no closed BTBs in the section (the dynamic section is a static section).
My ID to run selected	
Update mode local selected	If the mode is changed (for example, from MANUAL to AUTO), the mode is only changed on the controller where the change was made.
Update mode on all selected	If the mode is changed (for example, from MANUAL to AUTO), the mode is changed on all the controllers in the application.
Absolute prio used	For running hours start priority, power management uses absolute running hours.
Relative prio used	For running hours start priority, power management uses relative running hours.
Load depend Start/Stop setting 2 activated	

Event	Activated when ...
Load depend Start/Stop setting 2 deactivated	
Load depend Stop no delay activated	

Events Plant

Event	Activated when ...
Application [1-4] activated	
Single Gen selected	The plant type is *Single controller*.
Power management selected	
Test application selected with output cmd enabled	
Test application selected with output cmd disabled	

Modes

Event	Activated when ...
Power management	Power management is enabled.
AUTO	The controller is in AUTO mode.
MANUAL	The controller is in MANUAL mode.
SWBD	The controller is in Switchboard control mode.
BLOCK	The controller is in BLOCK mode.

3.6.2 Power management commands

Output > Command Power Management

Command	Effect when activated
Update mode local	If the mode is changed (for example, from MANUAL to AUTO), the mode only changes on the controller where the change was made.
Update mode on all	If the mode is changed (for example, from MANUAL to AUTO), the mode changes on all the controllers in the application.
Store common settings	Only relevant for BTB controllers. During commissioning (or when other system changes are made), using the command stores the power management settings for the static section that the controller is in. When the BTB closes, the new dynamic section creates one new, consistent set of settings and updates the parameters. When the BTB opens again, the common settings stored by this command are restored in the static section.

Output > BTB Cmd

Command	
BTB [33-34] open cmd	The controller sends a command to the specified BTB controller to open its breaker. If the BTB controller is in MANUAL mode, it deloads and opens its breaker. If the BTB controller is in AUTO mode, the BTB controller ignores the command.
BTB [33-34] close cmd	The controller sends a command to the specified BTB controller to open its breaker. If the BTB controller is in MANUAL mode, it synchronises and closes its breaker. If the BTB controller is in AUTO mode, the BTB controller ignores the command.

Output > Inhibits

Command	Controller	Effect when activated
Inh. BTB close request	Genset or shore	The BTB controller will not close its breaker (the section cannot ask for help).
Inh. request for section	Genset or shore	The power management system stops the section from helping other sections (a close request from an adjacent section that needs help is ignored).

4. General functions

4.1 Password

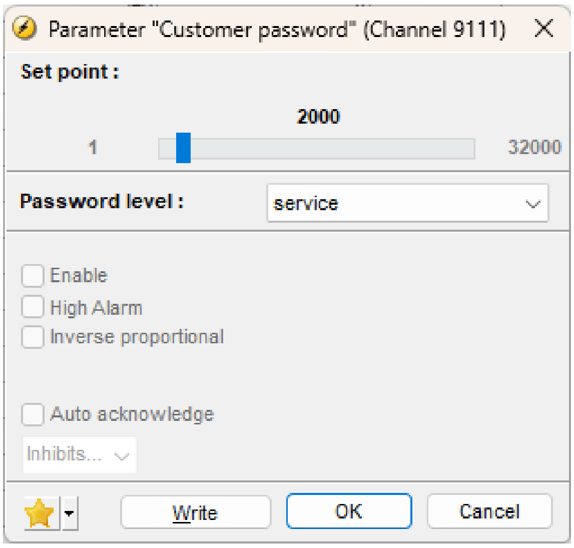
The controller has three password levels that can be configured on the controller or from the utility software. Parameter settings cannot be changed with a lower ranking password, but are shown on the display.

Parameters

`Basic settings > Controller settings > Password`

Parameter	Name	Range	Default	Customer access	Service access	Master access
9111	Customer password	00001 to 32000	2000	●		
9112	Service password	00001 to 32000	2001	●	●	
9113	Master password	00001 to 32000	2002	●	●	●

With the utility software it is possible to protect each parameter with a specific password level. Enter the parameter and select the correct password level.



The password level can also be changed from the parameter view in the Level column:

1. Right-click the appropriate field in the Level column.
2. Select *Change access level*.
3. Select the required access level.
   - *Customer*
   - *Service*
   - *Master*

You can see and edit permissions in the utility software on the *Tools > Permissions* page.

4.2 AC measurement systems

The controller is designed for measurement of voltages in systems with nominal voltages between 100 and 690 V AC. The AC system can be three-phase, single-phase, or split phase.

More information
See the **Installation instructions** for how to wire the different systems.

CAUTION

Incorrect configuration is dangerous
Configure the correct AC configuration. If in doubt, contact the switchboard manufacturer for information.

Basic settings > Measurement setup > Wiring connection > AC configuration

Parameter	Text	Range	Default
9131	AC configuration	3 phase 3W4 3 phase 3W3 2 phase L1/L3* 2 phase L1/L2* 1 phase L1*	3 phase 3W4
9132	AC configuration BB	3 phase 3W4 3 phase 3W3	3 phase 3W4

NOTE * If this is selected, the same system is used for the busbar, and parameter 9132 is disabled.

4.2.1 Three-phase system

The three-phase system is the default setting for the controller. When this is used, all three phases must be connected to the controller.

The following configuration is required for three-phase measuring.

Basic settings > Nominal settings > Voltage > Generator/Shore nominal U

Parameter	Text	Range	Adjust to value
6004	Nom. U 1	100 to 25000 V	U_{NOM}

Basic settings > Measurement setup > Voltage transformer > Generator/Shore VT

Parameter	Text	Range	Adjust to value
6041	G primary U	100 to 25000 V	Primary VT
6042	G secondary U	100 to 690 V	Secondary VT

Basic settings > Nominal settings > Voltage > Busbar nominal U

Parameter	Text	Range	Adjust to value
6053	BB nominal U 1	100 to 25000 V	U_{NOM}

Basic settings > Measurement setup > Voltage transformer > Busbar VT

Parameter	Text	Range	Adjust to value
6051	BB primary U 1	100 to 25000 V	Primary VT
6052	BB second. U 1	100 to 690 V	Secondary VT

NOTE The controller has two sets of busbar transformer settings, which can be enabled individually in this measurement system.

4.2.2 Split-phase system

The split-phase system is a special application, where two phases and neutral are connected to the controller. The controller shows phases L1 and L2/L3 in the display. The phase angle between L1 and L3 is 180 °. Split-phase is possible between L1-L2 or L1-L3.

The following configuration is required for the split phase measuring (example 240/120 V AC).

`Basic settings > Nominal settings > Voltage > Generator nominal U`

Parameter	Text	Range	Adjust to value
6004	Nom. U 1	100 to 25000 V	120 V AC

`Basic settings > Measurement setup > Voltage transformer > Generator VT`

Parameter	Text	Range	Adjust to value
6041	G primary U	100 to 25000 V	U_{NOM}
6042	G secondary U	100 to 690 V	U_{NOM}

`Basic settings > Nominal settings > Voltage > Busbar nominal U`

Parameter	Text	Range	Adjust to value
6053	BB nominal U 1	100 to 25000 V	U_{NOM}

`Basic settings > Measurement setup > Voltage transformer > Busbar VT`

Parameter	Text	Range	Adjust to value
6051	BB primary U 1	100 to 25000 V	U_{NOM}
6052	BB second. U 1	100 to 690 V	U_{NOM}

The measurement U_{L3L1} shows 240 V AC. The voltage alarm set points refer to the nominal voltage 120 V AC, and U_{L3L1} does not activate any alarm.

NOTE The controller has two sets of busbar transformer settings, which can be enabled individually in this measurement system.

4.2.3 Single-phase system

The single-phase system consists of one phase and the neutral.

The following configuration is required for the single-phase measuring (example 230 V AC).

`Basic settings > Nominal settings > Voltage > Generator nominal U`

Parameter	Text	Range	Adjust to value
6004	Nom. U 1	100 to 25000 V	230 V AC

`Basic settings > Measurement setup > Voltage transformer > Generator VT`

Parameter	Text	Range	Adjust to value
6041	G primary U	100 to 25000 V	$U_{NOM} \times \sqrt{3}$
6042	G secondary U	100 to 690 V	$U_{NOM} \times \sqrt{3}$

Basic settings > Nominal settings > Voltage > Busbar nominal U

Parameter	Text	Range	Adjust to value
6053	BB nominal U 1	100 to 25000 V	$U_{NOM} \times \sqrt{3}$

Basic settings > Measurement setup > Voltage transformer > Busbar VT

Parameter	Text	Range	Adjust to value
6051	BB primary U 1	100 to 25000 V	$U_{NOM} \times \sqrt{3}$
6052	BB second. U 1	100 to 690 V	$U_{NOM} \times \sqrt{3}$

NOTE The voltage alarms refer to U_{NOM} (for example, 230 V AC).

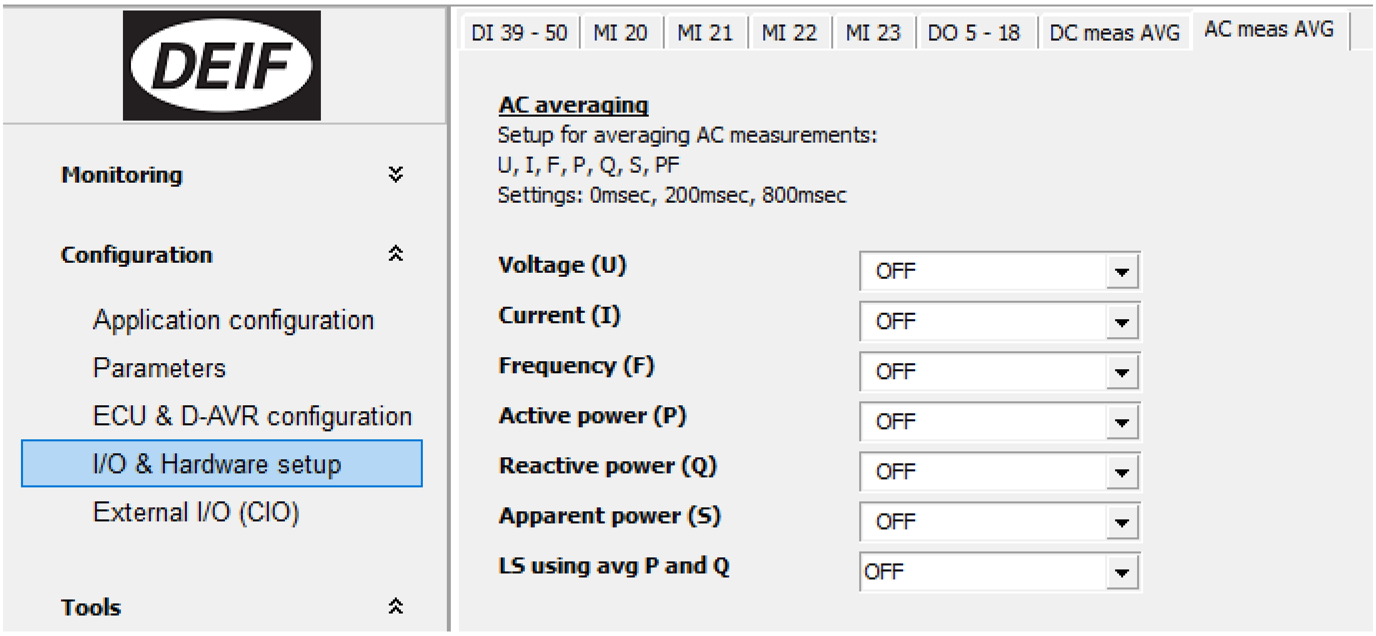
The controller has two sets of busbar transformer settings, which can be enabled individually in this measurement system.

4.2.4 AC measurement averaging

You can use the utility software to set up averaging for a number of AC measurements. The averaged values are then shown on the display unit and in the Modbus values. However, the controller continues to use real-time measurements.

In the utility software, under *I/O & Hardware setup*, select the *AC meas AVG* tab. For each measurement, you can select no averaging (0 ms), averages calculated over 200 ms, or averages calculated over 800 ms.

From the *AC meas AVG* tab, you can also set up averaging for load-sharing using active power (P) and reactive power (Q) measurements. Set *LS using avg P and Q* to ON, and select 200 ms or 800 ms for the *Active power (P)* and *Reactive power (Q)* measurements.



4.3 Nominal settings

The controller has four sets of nominal settings for the generator and two sets for the busbar. The four sets of nominal generator settings can be individually configured.

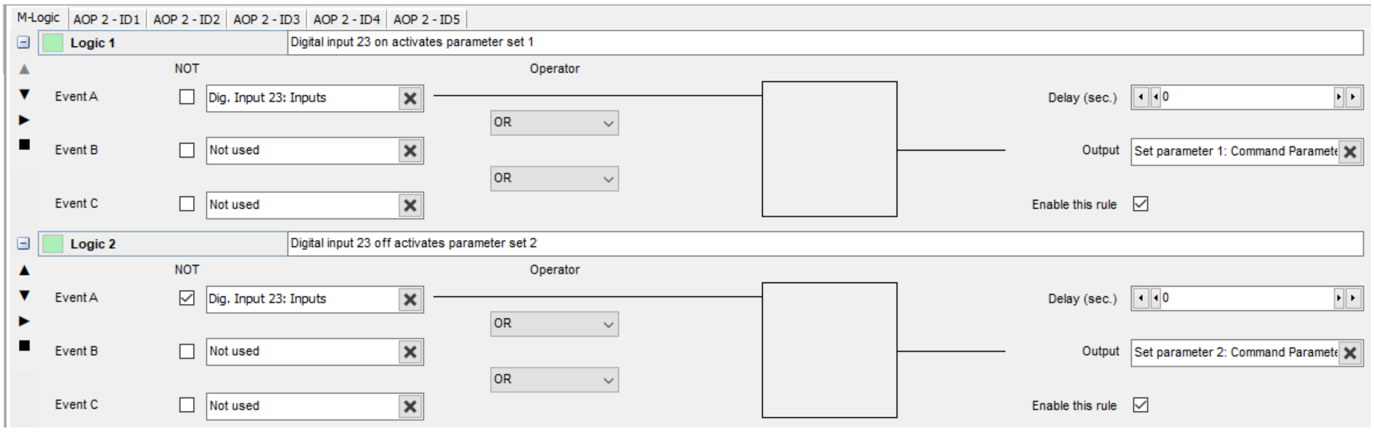
Alternative configuration > Generator nominal settings

Parameter	Text	Range	Default
6006	Enable nom. set	Nominal setting [1 to 4]	Nominal setting 1

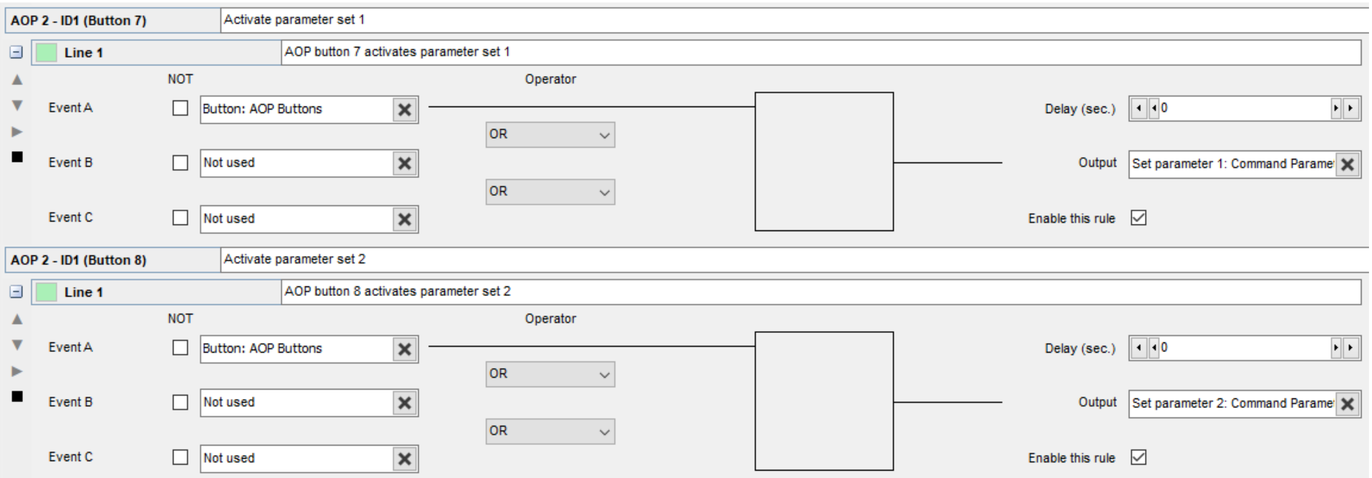
Switch between the nominal settings

You can use the following to switch between the four sets of nominal settings:

1. **Digital input**: M-Logic is used when a digital input is needed to switch between the four sets of nominal settings. Select the required input among the input events, and select the nominal settings in the outputs. For example:



2. **AOP**: M-Logic is used when the AOP is used to switch between the four sets of nominal settings. Select the required AOP button among the input events, and select the nominal settings in the outputs. For example:



3. **Menu settings**: On the controller or with the utility software.

Block nominal settings change

Use the *block nom chang* function to stop the nominal settings for the generator and busbar being changed. Go to parameter *6017* and change the set point to *ON* to enable the function.

4.3.1 Default nominal settings

The default nominal settings are settings 1.

Basic settings > Nominal settings

Parameter	Text	Range	Default
6001	Nom. f 1	48.0 to 62.0 Hz	50 Hz
6002	Nom. P 1	10 to 20000 kW	480 kW
6003	Nom. I 1	0 to 9000 A	867 A

Parameter	Text	Range	Default
6004	Nom. U 1	100 to 25000 V	400 V
6005	Nom. RPM 1	100 to 4000 RPM	1500 RPM
6007	Nom. I E/N/SC 1	0 to 9000 A	867 A
6053	BB nominal U 1	100 to 25000 V	400 V
6055	4th CT nom. P 1	10 to 9000 kW	480 kW

4.3.2 Alternative nominal settings

`Alternative config. > Generator nominal settings > Nominal settings [2 to 4] > Basic settings`

Parameter	Text	Range	Default
6011, 6021 or 6031	Nom. f [2-4]	48.0 to 62.0 Hz	50 Hz
6012, 6022 or 6032	Nom. P [2-4]	10 to 20000 kW	480 kW
6013, 6023 or 6033	Nom. I [2-4]	0 to 9000 A	867 A
6014, 6024 or 6034	Nom. U [2-4]	100 to 25000 V	400 V
6015, 6025 or 6035	Nom. RPM [2-4]	100 to 4000 RPM	1500 RPM
6016, 6026 or 6036	Nom. I E/N/SC [2-4]	0 to 9000 A	867 A

`Alternative config. > Generator nominal settings > Nominal settings [2 to 4] > Offset control signals`

Parameter	Text	Range	Default
2552, 2553 or 2554	GOV output offset [1-4]	0 to 100 %	50 %
2672, 2673 or 2674	AVR output offset [1-4]	0 to 100 %	50 %

4.3.3 Scaling

For applications above 25000 V and below 100 V, adjust the input range to match the actual value of the primary voltage transformer.

Changing the voltage scaling also affects the nominal power scaling.

`Basic settings > Measurement setup > Scaling`

Parameter	Text	Range	Default	Notes
9030	Scaling	10 to 2500 V 100 to 25000 V 10 to 160000 V 0.4 to 75000 V	100 to 25000 V	**10 to 2500 V**: This is recommended for power sources up to 150 kVA. The nominal power must be less than 900 kW. **100 to 25000 V**: This is recommended for power sources over 150 kVA.

NOTICE
Incorrect configuration is dangerous
Correct all nominal values and the primary VT settings after the scaling (parameter 9030) is changed.

4.4 Mode overview

The controller has four running modes and one block mode:

- **AUTO**: The controller operates automatically, and the operator cannot initiate any sequences manually.
- **MANUAL**: The operator has to initiate all sequences. This can be done using the buttons, Modbus commands or digital inputs. When started, the genset runs at nominal values.
- **SWBD**: The digital increase/decrease inputs can be used (if they have been configured) as well as the *Start* and *Stop* buttons. When starting, the genset starts without any subsequent regulation.
- **BLOCK**: The controller cannot initiate any sequences, for example the start sequence. Block mode must be selected when maintenance work is carried out on the genset.

NOTICE

Sudden genset stop

If block mode is selected while the genset is running, the genset shuts down.

4.4.1 AUTO mode

The controller can be operated in AUTO mode. This means that the controller will automatically initiate sequences based on system conditions, unlike MANUAL mode. It will start and stop generators, control breakers, and manage load sharing without external signals.

Not in AUTO mode

This function activates an alarm if the system is not in AUTO mode.

`Functions > Not in Auto`

Parameter	Text	Range	Default
6541	Timer	10.0 to 900.0 s	300.0 s
6544	Enable	OFF ON	OFF
6545	Fail class	Fail classes	Warning

4.4.2 MANUAL mode

The controller can be operated in MANUAL mode. This means that the controller will not initiate any sequences automatically, as is the case with the AUTO mode. It will only initiate sequences, if external signals are given.

An external signal may be given in three ways:

1. Buttons on the display are used
2. Digital inputs are used
3. Modbus command

NOTE The controller has a limited number of digital inputs. See **Digital inputs** for availability.

When the genset is running in MANUAL mode, the controller controls the speed governor and the AVR.

MANUAL mode commands

Command	Description
Start engine	The start sequence is initiated and continues until the genset starts or the maximum number of start attempts is reached. The frequency (and voltage) will be regulated to make the GB ready to close.
Stop engine	The genset is stopped. Without the running signal, the stop sequence continues to be active in the Extended stop time period. The genset is stopped with cooling down time. The cooling down time is cancelled if the *Stop* button is activated twice.

Command	Description
GB close	The controller closes the generator breaker if the shore connection breaker is open, or synchronise and close the generator breaker if the shore connection breaker is closed. When EDG mode is selected, the controller will not regulate after breaker closure.
GB open	The controller ramps down and opens the generator breaker at the Breaker open point if the shore connection breaker is closed. The controller opens the generator breaker instantly if the shore connection breaker is open or the genset mode is island mode.
SCB close	The controller closes the shore connection breaker if the generator breaker is open, or synchronises and closes the shore connection breaker if the generator breaker is closed.
SCB open	The controller opens the shore connection breaker instantly.
BTB close	The controller closes the bus tie breaker.
BTB open	The controller opens the bus tie breaker.
Alarm Acknowledge	Acknowledges all present alarms, and the alarm LED on the display stops flashing.
AUTO mode	Changes the running mode to AUTO.

4.4.3 SWBD mode

When SWBD mode is selected, the controller does not regulate the genset automatically. This means that the controller cannot perform governor or AVR control sequences on its own. All adjustments must be carried out manually from the switchboard.

In SWBD mode, the controller does not initiate any start or stop sequences. Breaker operations are also handled externally. The mode is intended for situations where full manual control is required, such as maintenance or troubleshooting.

Manual governor and AVR adjustments are available on the controller display:

- Man Gov Up: Increases engine speed manually.
- Man Gov Down: Decreases engine speed manually.
- Man AVR Up: Raises generator voltage manually.
- Man AVR Down: Lowers generator voltage manually.

NOTE Protective functions remain active in SWBD mode. However, no automatic load sharing, power management or blackout recovery is performed.

4.4.4 Block mode

When the block mode is selected, the controller is locked for certain actions. This means that the controller cannot start the genset or do any breaker operations.

To change the running mode from the display, the user will be asked for a password before the change can be made. It is not possible to select Block mode when running feedback is present.

If the digital inputs are used to change the mode, it is important that the input configured to *Block mode* is a constant signal:
- When the signal is ON, the controller is blocked.
- When the signal is OFF, the controller returns to the mode selected before block mode.

If block mode is selected using the display after the digital block input is activated, the controller will stay in block mode after the block input is deactivated. The block mode must now be changed using the display. The block mode can only be changed locally by display or digital input. Alarms are not influenced by block mode selection.

NOTE The genset shuts down if block mode is selected while the genset is running.

CAUTION
Be careful when starting the genset Before the running mode is changed, check that people are clear of the genset and that the genset is ready for operation. If possible, start the genset from the local engine control panel (if installed), rather than local cranking and starting of the genset.

4.5 Breakers

4.5.1 Breaker types

There are five breaker type settings. Set the breaker type with the utility software under *Application configuration*.

More information
See **Utility software** for how to set up applications.

Continuous NE
Continuous NE is a normally energised signal. This setting is usually used in combination with a contactor.

The controller only uses the *Close breaker* output:

- Closed: This closes the contactor.
- Open: This opens the contactor.

The *Open breaker* output can be configured for another function.

Pulse
This setting is usually used in combination with a circuit breaker. The controller uses these outputs:

- To close the circuit breaker, the *Close breaker* output is activated (until there is breaker close feedback).
- To open the circuit breaker, the *Open breaker* output is activated (until there is breaker open feedback).

External
This setting is used to show the position of the breaker, but the breaker is not controlled by the controller.

Compact
This setting is usually used in combination with a direct controlled motor driven breaker. The controller uses these outputs:

- The *Close breaker* output closes briefly to close the compact breaker.
- The *Open breaker* output closes to open the compact breaker. The output stays closed long enough to recharge the breaker.

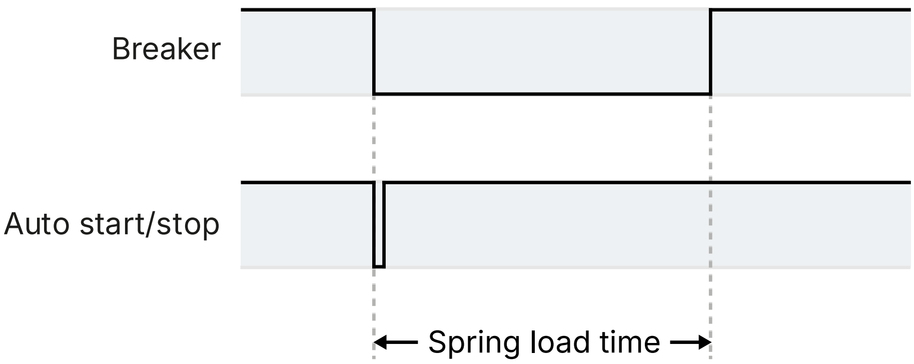
If the compact breaker is tripped externally, it is recharged automatically before next closing.

4.5.2 Breaker spring load time

To avoid breaker close failures in situations where the breaker close command is given before the breaker spring has been loaded, the spring load time can be adjusted.

Principle
You could have a close failure if:
1. A genset is in AUTO mode, the Auto start/stop input is active, the genset is running, and the GB is closed.
2. The Auto start/stop input is deactivated, the stop sequence is executed, and the GB is opened.
3. If the Auto start/stop input is activated again before the stop sequence is finished, the controller activates a GB close failure, since the GB needs time to load the spring before it is ready to close.

The diagram shows an example where a single genset in island mode is controlled by the Auto start/stop input.



- When the Auto start/stop input deactivates, the GB opens.
- The Auto start/stop is re-activated immediately after the GB has opened, for example by the operator using a switch in the switchboard.
- The controller waits a while before sending the close signal again, because the spring load time must expire.

Ensuring time to reload

If the breaker needs time to reload the spring after it has opened, the controller can take this delay into account. This can be controlled through timers in the controller or through digital feedbacks from the breaker, depending on the breaker type:

1. **Timer-controlled.** A load time set point for the GB and SCB control for breakers with no feedback indicating that the spring is loaded. After the breaker has been opened it will not be allowed to close again before the delay has expired. When the timer is running, the remaining time is shown in the display.
2. **Digital input.** Two configurable inputs are used for feedbacks from the breakers: One for GB spring loaded and one for SCB spring loaded. After the breaker has been opened it cannot close before the configured inputs are active.

If both a timer and breaker feedbacks are used, both requirements must be met before the breaker is allowed to close.

4.5.3 Breaker position failure

The breaker position failure alarm is activated if a controller has no breaker position feedback, or if both feedbacks from the breaker are high.

When a controller has a breaker position failure, it informs the other controllers in the application. The system then blocks the section with the breaker position failure. Sections that are not affected by the breaker position failure can continue to operate.

You can assign a fail class to try to trip the faulty breaker when the controller discovers a breaker position failure.

4.6 Alarms

4.6.1 Fail classes

All activated alarms must have a fail class. The fail classes define the category of the alarms and the subsequent alarm action.

More information
See each controller type for its Fail classes.

The fail class can be selected for each alarm function, either from the controller or using the utility software.

To change the fail class using the utility software, open the alarm in the parameter list, then select the fail class from the list.

4.6.2 Inhibits

You can use the utility software to configure inhibits for each alarm. Open the alarm in the parameter list, then select the inhibit(s) from the list.

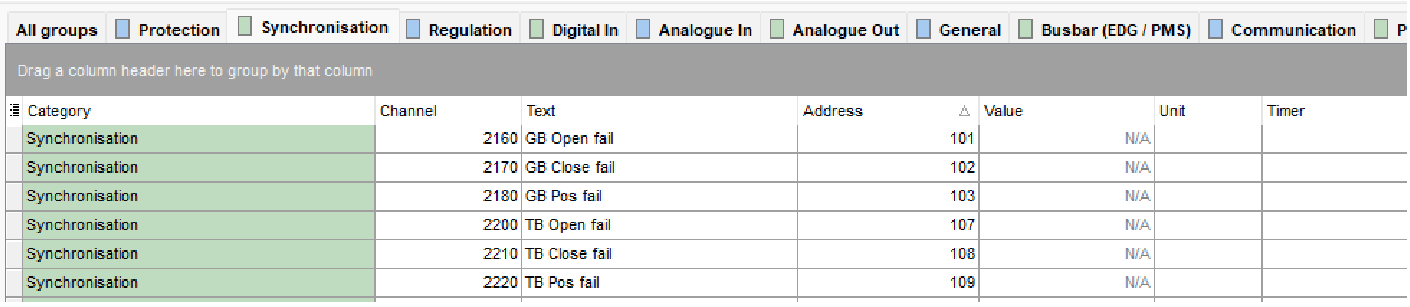
More information
See each controller type for its inhibits.

Only alarms can be inhibited. Function inputs such as running feedback, remote start or access lock are never inhibited.

4.6.3 Alarm list monitoring

Alarm list monitoring allows you to view all active alarms using Modbus, which is useful for remote monitoring and touch screen devices, for example AGI and SCADA/BMS systems. The alarms are in Modbus addresses 28000 to 28099 and these are not listed in the *Input register (04)*.

The Modbus address for an active alarm corresponds to the address value in the utility software. For example, Modbus address 109 is equal to parameter 2220 TB Pos fail as the address in the utility for this parameter is 109.



Category	Channel	Text	Address	Value	Unit	Timer
Synchronisation	2160	GB Open fail	101	N/A		
Synchronisation	2170	GB Close fail	102	N/A		
Synchronisation	2180	GB Pos fail	103	N/A		
Synchronisation	2200	TB Open fail	107	N/A		
Synchronisation	2210	TB Close fail	108	N/A		
Synchronisation	2220	TB Pos fail	109	N/A		

4.7 M-Logic

The main purpose of M-Logic is to give the operator/designer more flexibility.

M-Logic is used to execute different commands at predefined conditions. M-Logic is not a PLC but substitutes one, if only very simple commands are needed.

M-Logic is a simple tool based on logic events. One or more input conditions are defined, and at the activation of those inputs, the defined output will occur. A great variety of inputs can be selected, such as digital inputs, alarm conditions and running conditions. A variety of the outputs can also be selected, such as relay outputs, change of modes.

You can configure M-Logic in the utility software.

4.7.1 General shortcuts

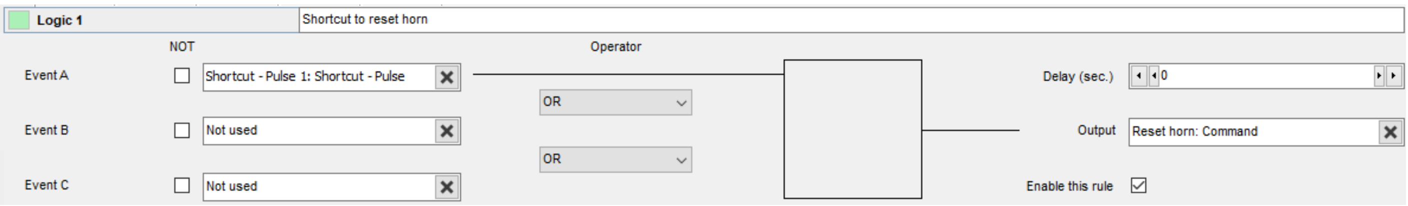
You can configure your own shortcuts with M-Logic in the utility software. You can see the configured shortcuts when you push the *Shortcut*  button and select *General shortcuts*. If you have not configured a shortcut, then the *General shortcuts* menu is empty.

For a pulse shortcut, the command is sent each time you select the shortcut and press OK in the display menu.

For a switch shortcut, the switch is toggled (on/off) each time you select the shortcut.

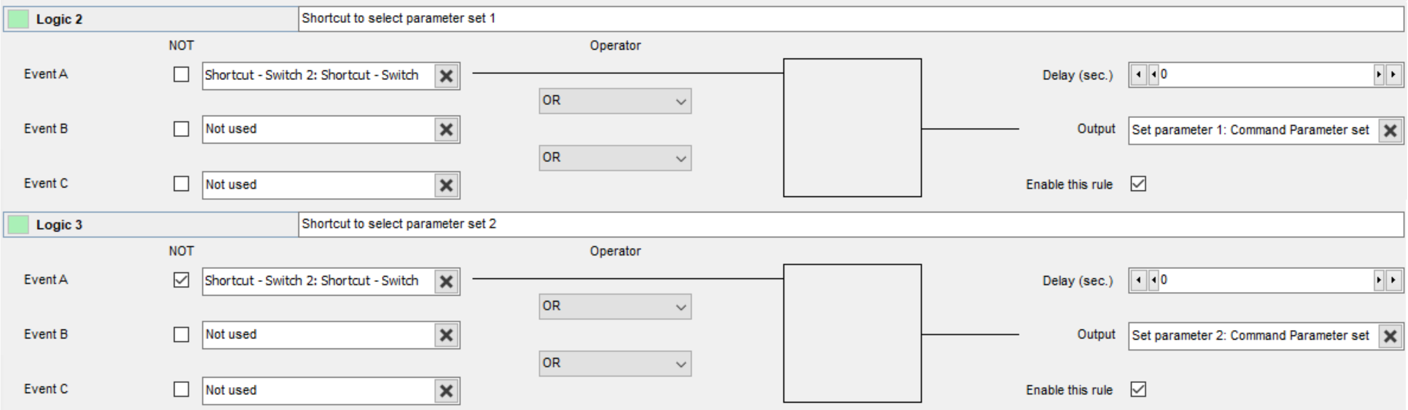
Use the *Translations* interface to rename the shortcut.

Example of shortcut pulse



Rename *SC Pulse 1* to *Reset horn*.

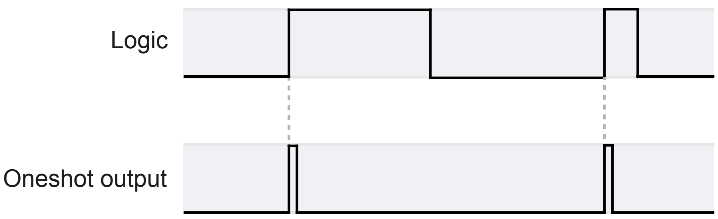
Example of shortcut switch



Rename *SC Switch 2 on* to *Use parameter set 1*. Rename *SC Switch 2 off* to *Use parameter set 2*.

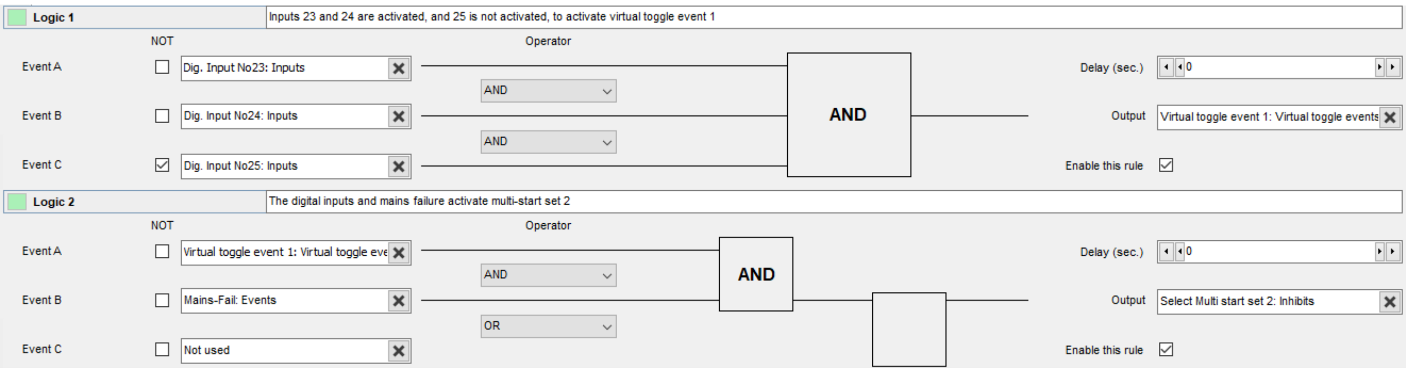
4.7.2 Oneshots

Description	Notes
Oneshot set [1-16]	The oneshot is activated for a short time (about 100 ms) when the logic is true. If the logic remains true, the oneshot is not activated again. When the logic is false, the function is reset.



4.7.3 Virtual event outputs

Virtual event outputs are used to expand the number of outputs in a logic sequence. For example, the output of Logic 1 can be used to continue the sequence in Logic 2.



- The *Logic 1* output is set to *Virtual event output 1*.
- *Event A* in *Logic 2* is *Virtual event output 1*.

Up to five outputs that can be used in this logic sequence (A + B + C in Logic 1 and B + C in Logic 2).

Virtual event outputs

Description	Notes
Virtual event output [1-96]*	Virtual event outputs 1 to 96 can be activated by Modbus. They can also be used in multiple lines of logic to increase the number of events possible in one sequence.

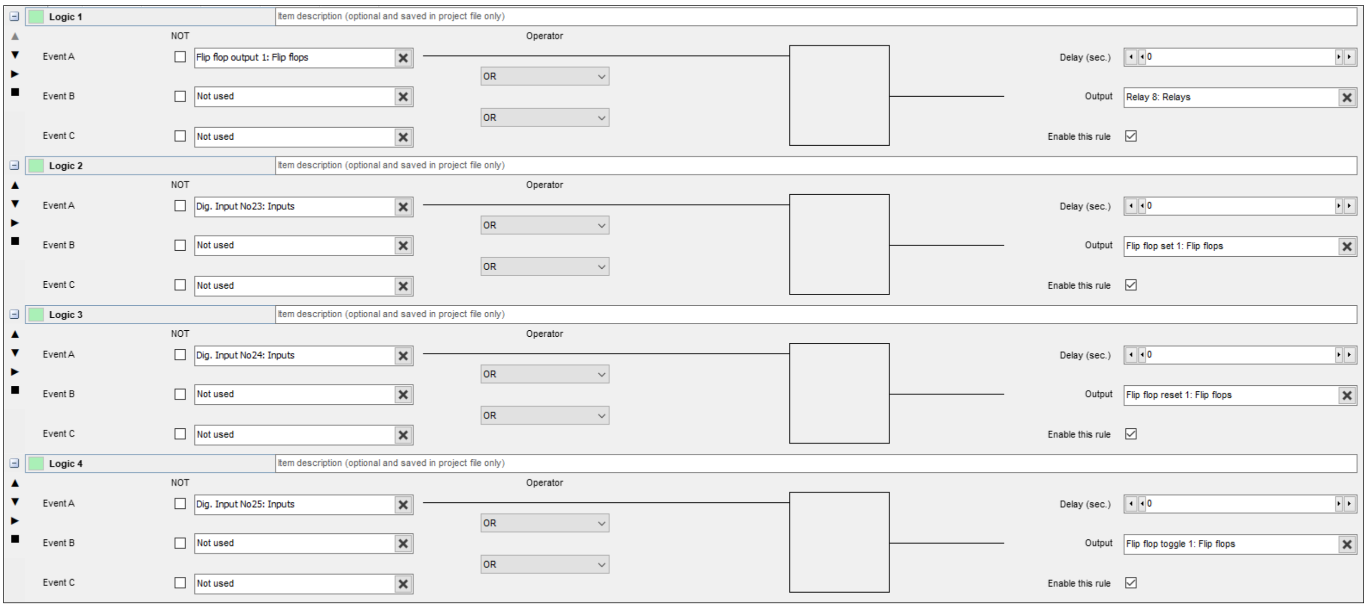
NOTE * Previously *Virtual toggle event [1-96]*.

4.7.4 Flip flop function

The flip flop function makes it easy for a pulse input to latch an output, for example a relay.

The Event selects a flip flop output [1-16], and the Output selects the output function:
- Flip flop set [1-16] = Change the flip flop output state to High.
- Flip flop reset [1-16] = Change the flip flop output state to Low.
- Flip flop toggle [1-16] = Shift the flip flop output state from Low to High or from High to Low.

Example



The example shows how flip flop set 1 could be configured to set relay 8:
- Logic 1: Flip flop output 1 is selected to set the relay output.

- Logic 2: Digital input 23 is used to trigger flip flop set 1 and thus sets the relay output active.
- Logic 3: Digital input 24 is used to deactivate the relay output by triggering flip flop reset 1.
- Logic 4: Digital input 25 is used to toggle the flip flop output state.
- Relay 8 must be set to *M-Logic / Limit relay*.

If reset and set are active at the same time, the flip flop will prioritise the reset command. The set or reset function may not be active when the toggle function is used.

The flip flops are also accessible from Modbus.

4.7.5 Virtual toggle outputs

Description	Notes
Virtual toggle output [1-32] *	Virtual toggle outputs 1 to 32 can be activated by Modbus. They can also be used in multiple lines of logic to increase the number of events possible in one sequence.

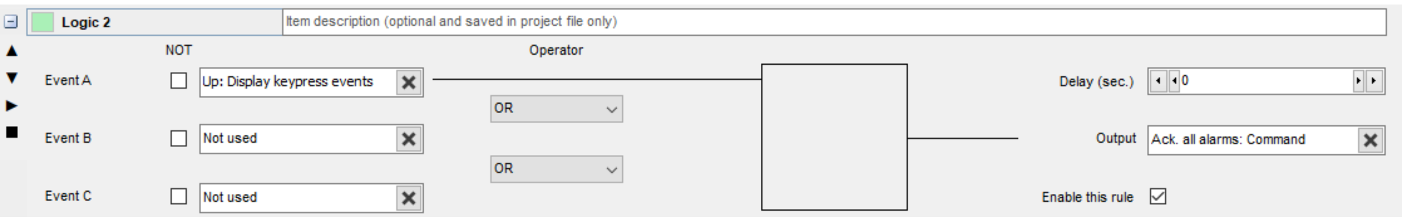
NOTE * Previously *Virtual switch event [1-32]*

4.7.6 M-Logic event counters

Description	Notes
M-logic event counter limit [1-8]	The event counter has reached the limit selected in the *Counters > M-logic event counter* window.
M-logic event reset counter [1-8]	The event counter has been reset. The reset conditions are in the *Counters > M-logic event counter* window.

4.7.7 Display keypress events

Use the display keypress events to activate an output with the display buttons. For example, you can configure the *UP* button to acknowledge all alarms when you push it.



The function can also be used to detect when a button is pushed.

4.8 Timers and counters

4.8.1 Command timers

Command timers are used to execute a command at a specific time. For example, to start and stop the genset automatically at specific times on certain weekdays. In AUTO mode, this function is available in island operation.

Up to four command timers can be configured with M-Logic. Each command timer can be set for the following time periods:
- Individual days (MO, TU, WE, TH, FR, SA, SU)
- MO, TU, WE, TH
- MO, TU, WE, TH, FR
- MO, TU, WE, TH, FR, SA, SU

• SA, SU

To start in AUTO mode, the Auto start/stop command can be programmed in M-Logic or in the input settings. The time-dependent commands are flags that are activated when the command timer is in the active period.

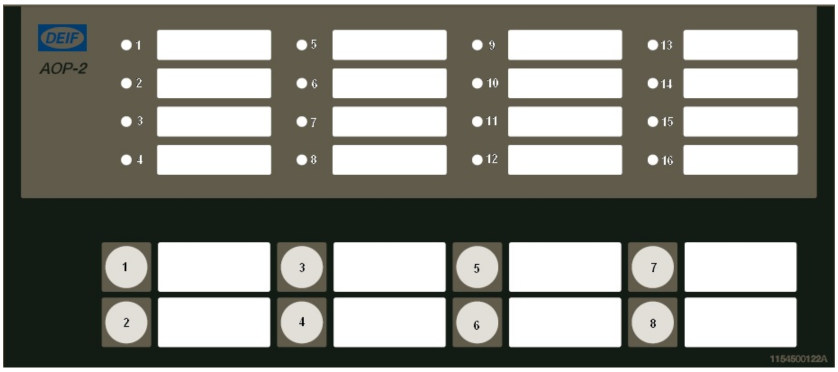
4.8.2 Diagnostics timer

Diagnostics mode is activated when the diagnostics timer expires. Use diagnostics to read ECU data without starting the engine. To configure the timer and enable diagnostics, go to *Parameters* in the utility software, and select parameter 6701.

4.9 Interfaces

4.9.1 Additional operator panel, AOP-2

The AOP-2 is an additional operator panel that can be connected to the controller using a CAN bus communication port. It can be used as an interface to the controller for indication of status and alarms together, and with buttons for, for example, alarm acknowledge and mode selection.



The configurable LEDs are named 1 to 16, and the buttons are named 1 to 8.

CAN Node ID configuration

The CAN Node ID for the AOP-2 can be set to 1-9:

1. Press buttons 7 and 8 simultaneously to activate the CAN ID change menu. The LED for the present CAN ID number is ON, and LED 16 is flashing.
2. Use button 7 (increase) and button 8 (decrease) to change the CAN ID according to the table below.
3. Press button 6 to save the CAN ID and return to normal operation.

CAN ID	Indication of CAN ID selection
0	LED 16 flashes (CAN bus OFF)
1	LED 1 ON. LED 16 flashes (default value).
2	LED 2 ON. LED 16 flashes.
3	LED 3 ON. LED 16 flashes.
4	LED 4 ON. LED 16 flashes.
5	LED 5 ON. LED 16 flashes.

Programming

Use the utility software to program the AOP-2. See the **Help** in the utility software.

4.9.2 Access lock

With the access lock on, the operator cannot change controller parameters or running modes. The input to be used for the access lock function is defined in the utility software.

Access lock is typically activated from a key switch installed behind the door of the switchboard cabinet. As soon as access lock is activated, changes from the display cannot be made.

Access lock only locks the display and does not lock any AOP or digital input. AOP can be locked by using M-Logic. It is still possible to read all parameters, timers and the state of inputs in the service menu.

You can read alarms, but not acknowledge them when access lock is activated. Nothing can be changed from the display.

This function is ideal for rental or critical equipment. The operator cannot change anything. If there is an AOP-2, the operator is still able to change up to 8 different predefined things.

NOTE The *Stop* button is not active in MANUAL and SWBD mode when the access lock is activated. For safety reasons, an emergency stop switch is recommended.

4.9.3 Language selection

The controller can show several languages. The default master language is English, which cannot be changed. Different languages can be configured with the utility software.

Basic settings > Controller settings > Language

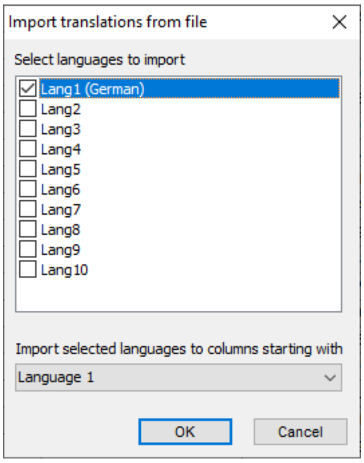
Parameter	Text	Range	Default
6081	Language selection	English Language [1 to 11]	English

4.9.4 Translations

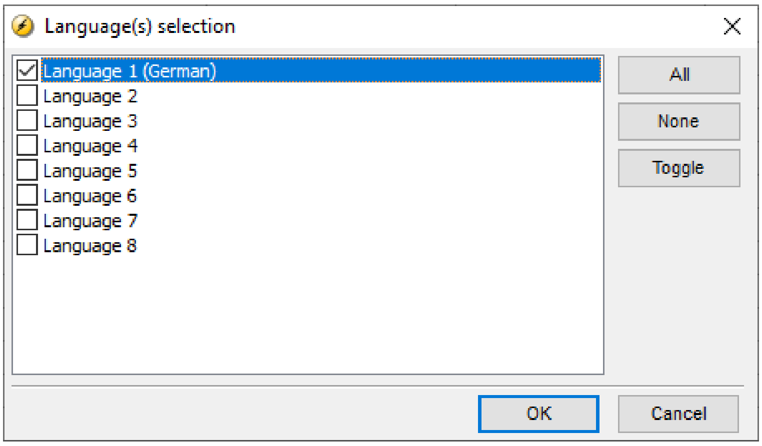
You can translate and customise the text in the controller with the utility software.

Translate the text in the controller

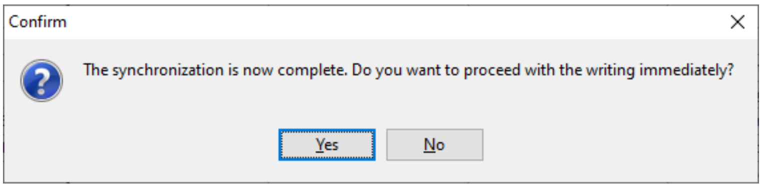
1. Go to the *Translations* tab in the left toolbar.
2. Click the *Import translations from file*  icon.
3. From the pop-up window, select the language file you want to import.
4. Select the language to import (lang1), and select the column to import the translations to.



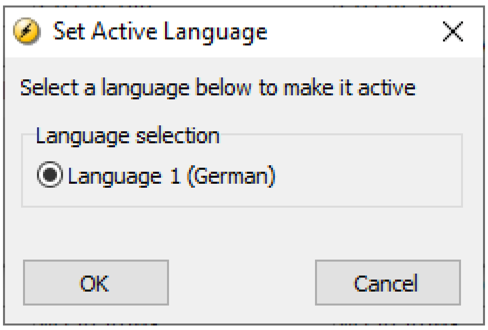
5. Once the translations are imported, you might get a warning stating that *Some translations were not imported*. Click *OK*.
6. To write the imported translations to the controller, click the *Write to controller* icon.
7. In the pop-up window, select the language you want to write to the controller.



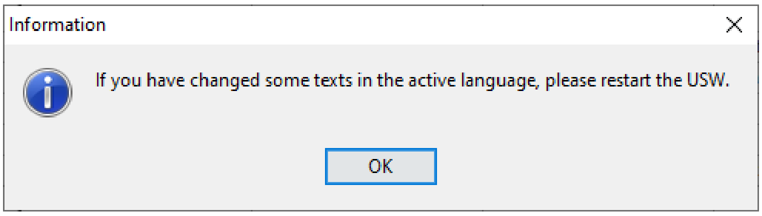
8. Click *OK*.
9. Select *Yes* to confirm you want to continue the writing procedure.



10. In the pop-up window, select the language you want to activate and click *OK*.



11. Click the *OK* button on the information message and if necessary, restart the utility software.



12. The text in the controller is now updated.

Customise the translations

To customise the translations, click on the cell with the text you want to edit. You can now edit the text. The text is automatically saved when you have finished editing.

You can also double-click on the phrase or word you want to edit in the *Master language* column. In the pop-up window, you can edit that particular phrase for all the language columns.

Change the placement of the translations

1. Select the *Edit language sequence* icon.
2. From the list on the left, select the language you want as the first in the sequence (after the master language), and click the > button to move the selected language.
3. Repeat step 2 for the remaining languages in the current sequence.
4. To change the position of a language in the new sequence, click on the language you want to move, and use the *Up* and *Down* buttons to move the language.
5. Click *OK* when you have finished.

NOTE You cannot edit the Master language.

5. Engine functions

5.1 Engine sequences

The engine START and STOP sequences are started automatically if:

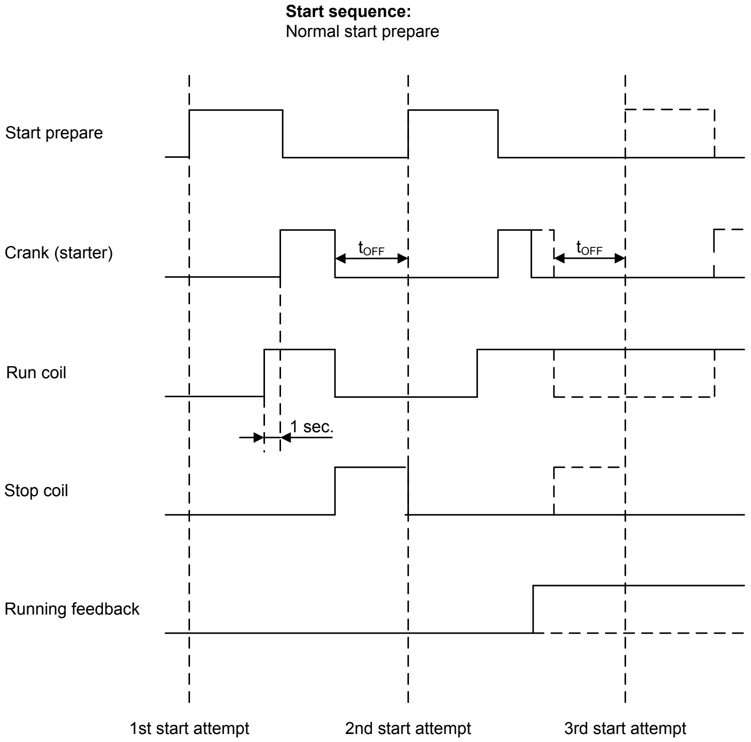
- AUTO mode is selected.
- MANUAL mode: The command is selected.
  - Only the selected sequence is started. For example, when the *START* button is pressed, the engine starts.

5.2 Engine start functions

5.2.1 Start sequence

Normal start prepare or extended start prepare are the possible start sequences for the engine. In both cases, the running coil is activated 1 s before the start relay (starter).

Normal start prepare sequence



The run coil opens between the start attempts, because the run coil type is set to pulse. When the engine receives running feedback, the run coil is closed until the stop sequence is started. If the run coil type is set to continuous, the run coil is closed between the start attempts until start failure, or the stop sequence opens it.

`Engine > Start sequence > Before crank > Run coil`

Parameter	Text	Range	Default
6151	Run coil delay	0.0 to 600.0 s	1.0 s
6152	Run coil type	Pulse Continuous	Pulse

Engine > Start sequence > Before crank > Start prepare

Parameter	Text	Range	Default
6181	Start prepare	0.0 to 600.0 s	5.0 s
6182	Ext. start prepare	0.0 to 600.0 s	0.0 s

Double starter

In some emergency installations, the prime mover is equipped with an extra start motor. Dependent on the configuration, the double starter function can toggle between the two starters or try several attempts with the standard starter before switching to the *double starter*. The function is set up in parameters 6191 and 6192, and a relay for cranking with the alternative starter is chosen in the *I/O & Hardware setup*.

Engine > Start sequence > Crank > Start attempts

Parameter	Text	Range	Default
6191	Starter attempts	1 to 100	3
6192	Double starter	0 to 10	0

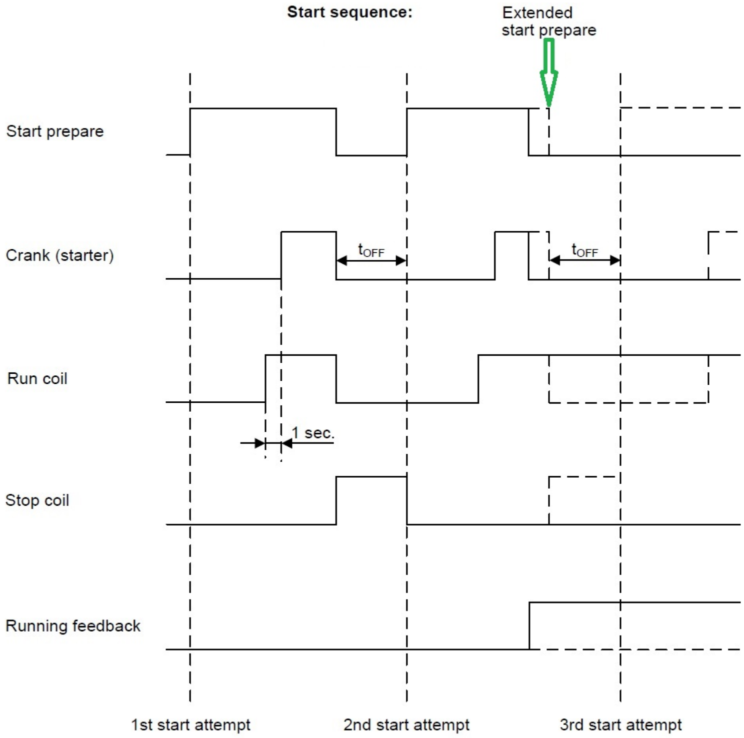
Choose a value that is more than zero in parameter 6192. This value determines the amount of attempts on each starter before switching to the next. The standard starter has first priority. When the maximum allowed number of attempts is reached, the start attempts stop and the alarm Start failure appears. Select the maximum number of attempts with parameter 6191.

- A value of 1 in parameter 6192 results in a toggle function with 1 attempt on each starter between toggling.
- A value of 2 in parameter 6192 results in a toggle function with 2 attempt on each starter between toggling.

Engine > Start sequence > Crank > Crank timers

Parameter	Text	Range	Default
6183	Start ON time	1.0 to 600.0 s	5.0 s
6184	Start OFF time	1.0 to 99.0 s	5.0 s

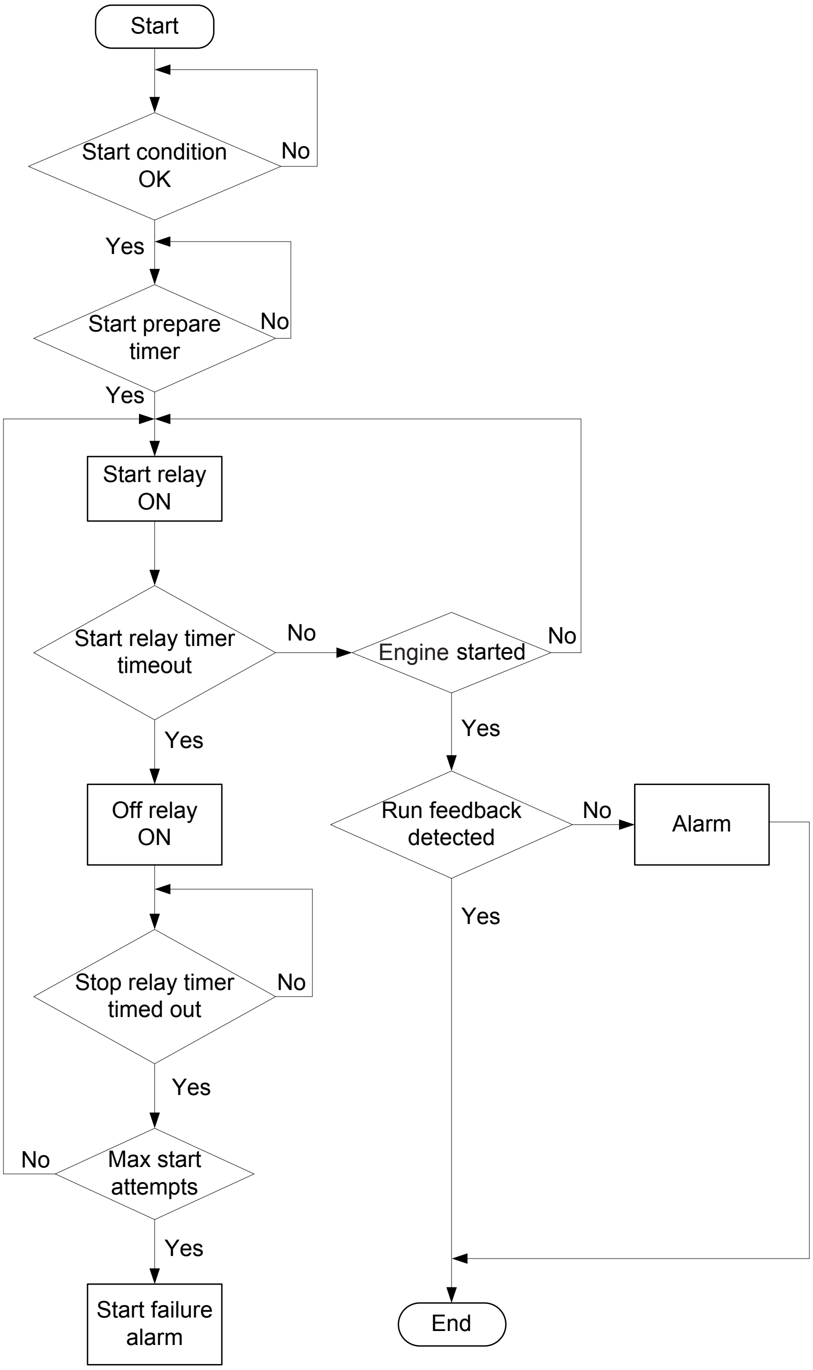
Extended start prepare sequence



You can activate the run coil 0 to 600 s before crank (starter) is executed. In this example, the timer is set to 1.0 s.

The extended start prepare function keeps the start prepare relay closed until remove starter or running detection is reached. This function is helpful if booster pumps for start fuel are used, because they are kept on until the engine is running.

Start sequence flowchart



5.2.2 Start sequence conditions

The start sequence initiation is controlled by these multi-input conditions:

- RMI oil pressure
- RMI water temperature
- RMI fuel level
- RMI Custom
- Binary input

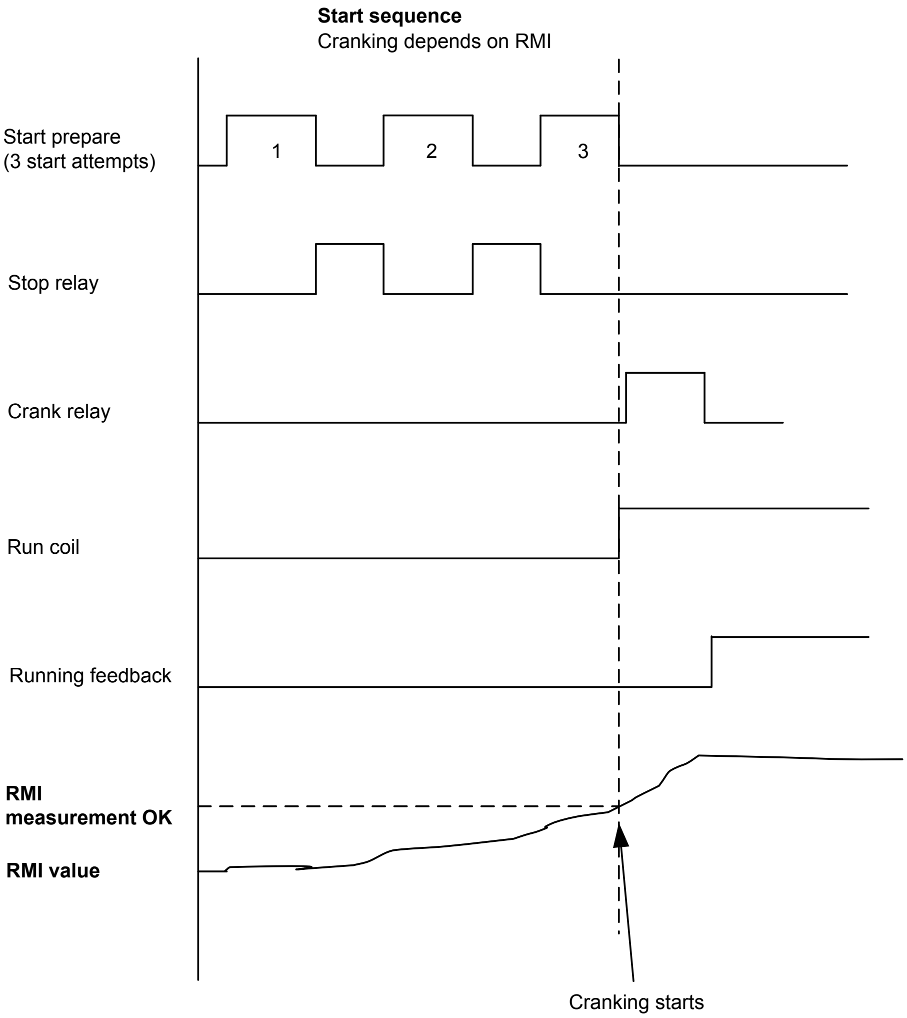
This means that if, for example, the oil pressure is not primed to the sufficient value, the crank relay will not engage the starter motor.

You can only configure these multi-input conditions with the utility software.

> **More information**
> See Inputs and outputs for how to configure the inputs.

If the binary start threshold is used, the input is chosen from the I/O list in the utility software.

The diagram below shows an example where the RMI oil pressure signal builds up slowly and starting is initiated at the end of the third start attempt.

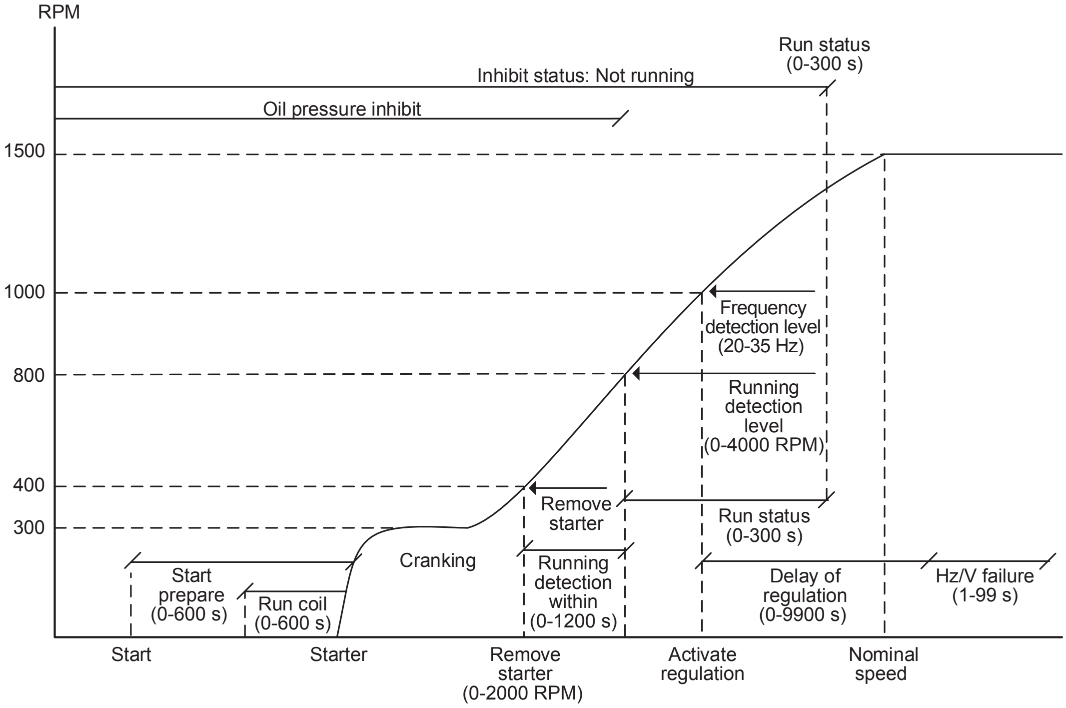


The start is initiated as soon as the start threshold limit is reached. By default, the controller waits until the start prepare timer is over and the start threshold conditions are correct before the crank relay/start is initiated. You can configure this in parameter 6185. You can change the start prepare type to interrupt start prepare, which means the controller is permitted to interrupt the start prepare and initiate the start when the start threshold conditions are correct.

`Engine > Start sequence > Before crank > Start threshold`

Parameter	Text	Range	Default
6185	Start threshold type	Multi-input [20 to 23]	Multi-input 20
6186	Start threshold	0.0 to 300.0	0.0

5.2.3 Start-up overview



Set points related to the start sequence

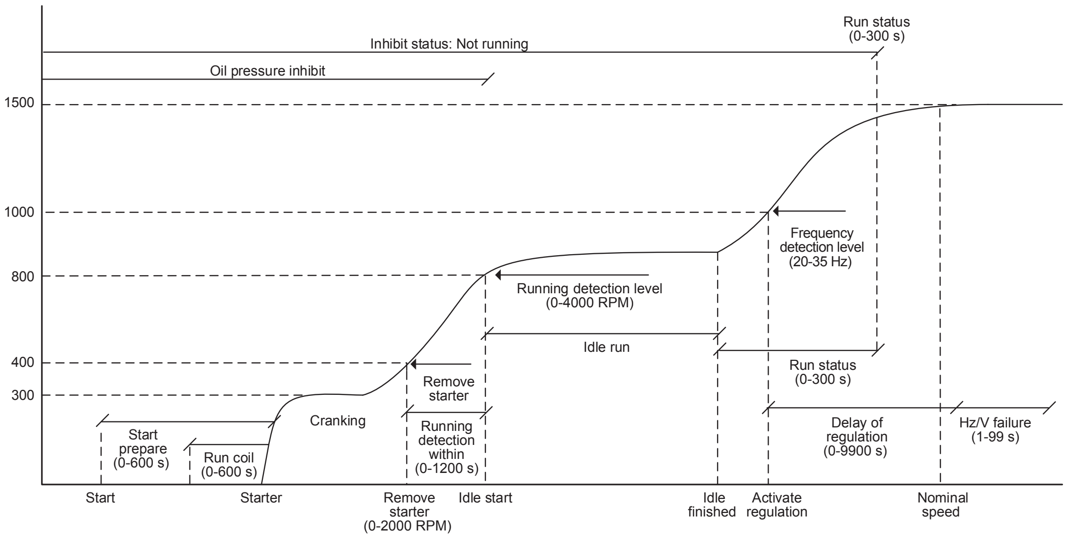
Parameter	Text	Description
6181	Start prepare	Start prepare is used for start preparation, for example pre-lubrication or pre-glowing. The start prepare relay is activated when the start sequence is initiated, and deactivated when the start relay is activated. If the timer is set to 0.0 s, the start prepare function is deactivated.
6182	Ext. start prepare	Extended prepare activates the *Start prepare* relay when the start sequence is initiated. The relay is activated until the specified time has expired. If the extended prepare time exceeds the *Start ON time*, the *Start prepare* relay is deactivated when the start relay deactivates. If the timer is set to 0.0 s, the extended prepare function is deactivated.
6183	Start ON time	The starter is activated for this period when cranking.
6184	Start OFF time	The pause between two start attempts.
6151	Run coil delay	The timer for the run coil is a set point for how long the run coil will be activated before cranking the engine. This gives the ECU time to start up before cranking.
6174	Remove starter	The starter is removed, when the RPM set point is reached. This function is only active if the running detection type is configured as either MPU or EIC RPM. For MPU, if the configured number of teeth is 0, the controller calculates the genset speed from the frequency.
6173	Running detect	The set point defines the running detection level in RPM (only when the running detection type is configured as either MPU or EIC RPM).
6351	Run detection	This timer is set to make sure that the engine goes from the RPM level, Remove starter and Running detection level (only when the running detection type is configured as either MPU or EIC RPM). If other running detection types than MPU or EIC RPM are used, the starter is ON until the frequency detection level is reached. If the timer is exceeded, and the level is not reached, the start sequence is repeated, using a start attempt. If all start attempts are used, the *Start failure* alarm is activated.
6165	Freq. Detect Lvl	When the configured level is reached, the regulators start working to reach the nominal values. The regulators can be delayed using *Delay regulation*.

Parameter	Text	Description
2740	Delay reg.	The regulation start can be delayed with this timer. If the setup is running on nominal settings, and delay regulation is set to 0, the genset overshoots the nominal frequency on start-up, as the regulators start increasing as soon as they are turned on. If this timer is used, the regulation is delayed until the timer has expired. The timer is usually set so the generator can reach the nominal frequency and voltage within the time frame.
6160	Run status	The timer starts when the running detection/frequency detection level is reached. When the timer runs out, the *Not running* inhibit is deactivated, and the running alarms and failures are enabled.

Alarms related to the start sequence

Parameter	Text	Description
4530	Crank failure alarm	This alarm is activated, if MPU is configured as the primary running feedback and the specified RPM is not reached before the delay has expired.
4540	Run feedback fail	This alarm is activated, if there is a failure on the primary running feedback. For example, if the primary running feedback is configured to digital input without running detection, and an active secondary running feedback detects the engine to be running. The delay to be set is the time from the secondary running detection until the alarm is activated.
4560	Hz/V failure	This alarm is activated, if the frequency and voltage are not within the limits configured in Blackout df/dUmax, after the running feedback is received.
6352	External engine stop	This alarm is activated, if the running sequence is active and the engine is below the running detection and frequency detection level without any command from the controller.

Start up overview with idle run



The set points and alarms are the same as above, except for the idle run function.

More information
See Idle running.

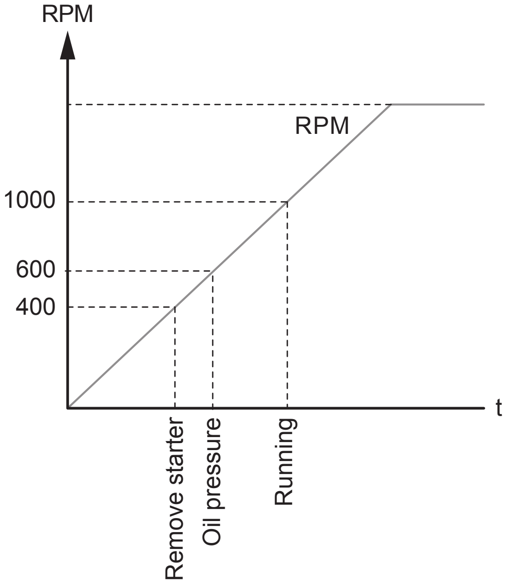
5.2.4 Start functions

The controller starts the engine when the start command is given. The start sequence is deactivated when the remove starter event occurs or when the running feedback is present.

The reason for having two possibilities to deactivate the start relay is to be able to delay the alarms with run status.

If it is not possible to activate the run status alarms at low revolutions, the remove starter function must be used.

An example of a critical alarm is the oil pressure alarm. Normally, it is configured according to the shutdown fail class. However, if the starter motor has to disengage at 400 RPM, and the oil pressure does not reach a level above the shutdown set point before 600 RPM, then the engine shuts down if the specific alarm is activated at the preset 400 RPM. In that case, the running feedback must be activated at a higher number of revolutions than 600 RPM.

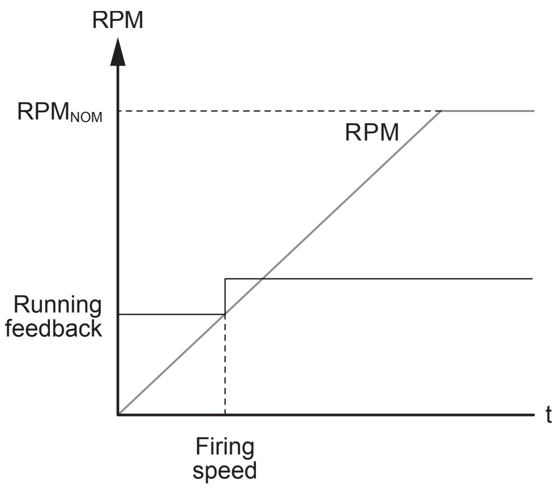


5.2.5 Digital feedbacks

If an external running relay is installed, then the digital control inputs for running detection or remove starter can be used.

Running feedback

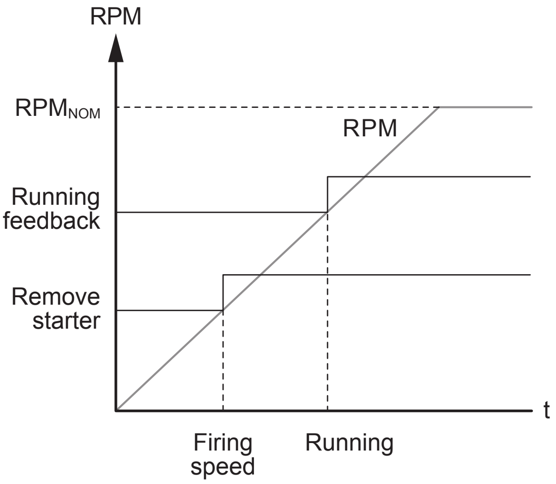
When the digital running feedback is active, the start relay is deactivated and the starter motor will be disengaged.



The diagram shows how the digital running feedback is activated when the engine has reached its firing speed.

Remove starter

When the digital remove starter input is present, the start relay is deactivated and the starter motor will be disengaged.



The diagram shows how the remove starter input is activated when the engine has reached its firing speed. At the running speed, the digital running feedback is activated.

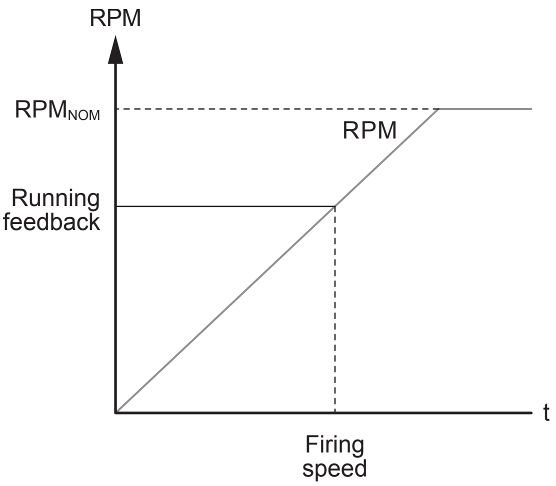
NOTE The remove starter input must be configured from a number of available digital inputs.

5.2.6 Analogue tacho feedback

When a magnetic pickup (MPU) is being used, the specific level of revolutions for deactivation of the start relay can be adjusted.

Running feedback

The diagram shows how the running feedback is detected at the firing speed level. The factory setting is 1000 RPM.



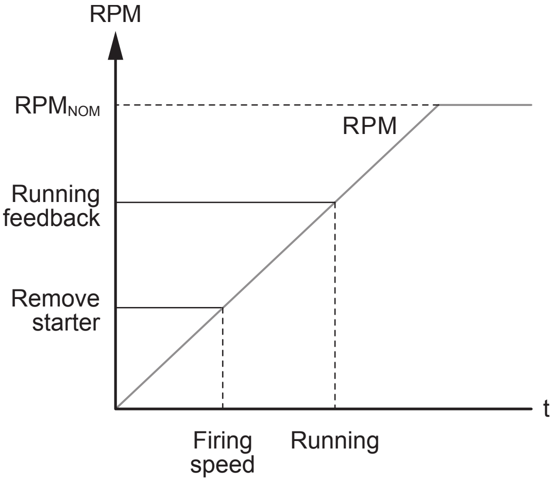
⚠ CAUTION

Caution

The factory setting of 1000 RPM is higher than the RPM level of typical starter motors. Adjust the setting to a lower value to avoid damage of the starter motor.

Remove starter input

The diagram shows how the set point of the remove starter is detected at the firing speed level. The factory setting is 400 RPM.



The number of teeth on the flywheel must be configured when the MPU input is used. If zero, for the remove starter function, the controller calculates the speed from the genset frequency.

Engine > Start sequence > After crank > Remove starter

Parameter	Text	Range	Default
6174	Remove start	1 to 2000 RPM	400 RPM

NOTE The *Remove starter* function can use the MPU or a digital input.

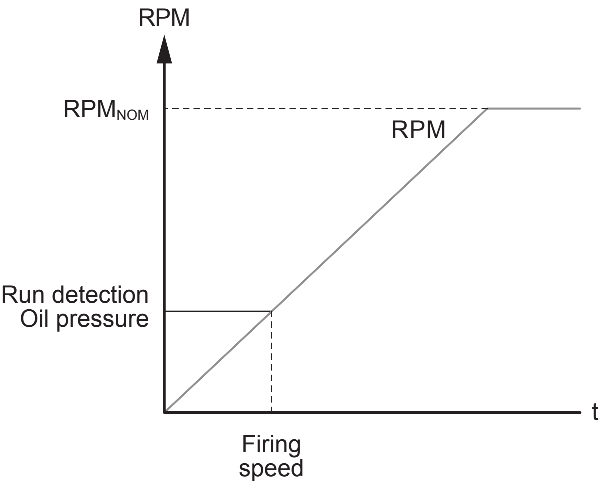
5.2.7 Oil pressure

The multi-inputs on terminals 20, 21, 22 and 23 can be used for the detection of running feedback. The terminal in question must be configured as an RMI input for oil pressure measurement. This is done with the utility software:

1. Select *I/O & Hardware setup* tab.
2. Select the relevant multi-input tab.
3. For *Input type*, select *RMI oil pressure*.

When the oil pressure increases above the adjusted value, running is detected, and the start sequence is ended.

Running feedback



More information
See **Running feedback** for how to configure the parameters.

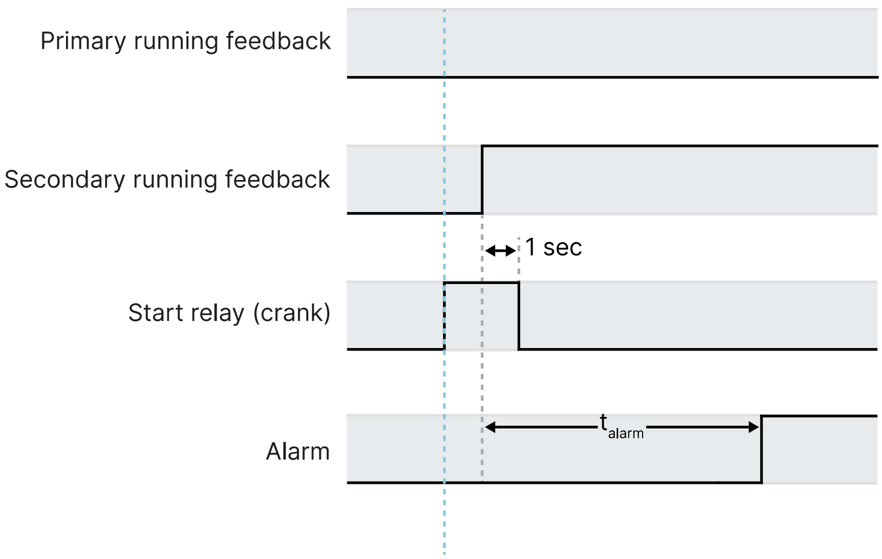
5.3 Running feedback

The controller uses running feedback to detect whether the engine is running:

- A digital input
- RPM, measured by magnetic pick-up (set point 0 to 4000 RPM)
- EIC
- Frequency measurement (20 to 35 Hz)

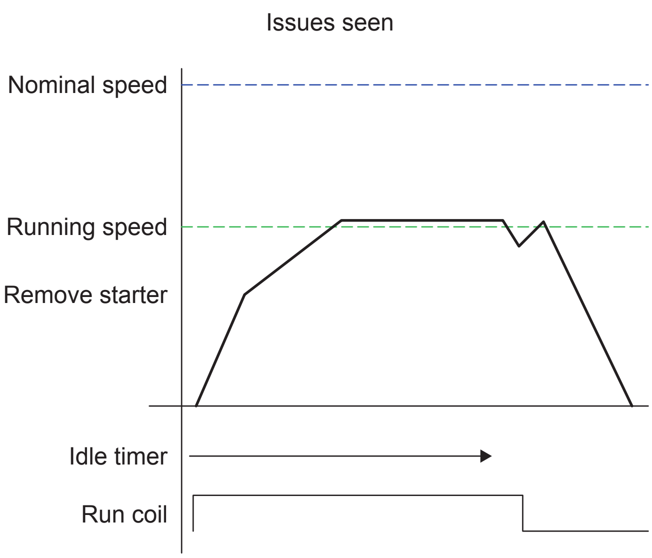
The selected running feedback is the primary feedback. However, all available running feedback is used for running detection. If the primary running feedback does not detect any running feedback, the starter relay stays activated for one additional second.

5.3.1 Start sequence running feedback



- If a running feedback is detected based on one of the secondary choices, the engine will start.
- If no running feedback is detected, the start sequence is interrupted.
- In parameter 6176 you can configure a delay time, before the start sequence is stopped.

5.3.2 Not running delay time



The engine will still be functional, even though a tacho sensor is damaged or dirty.

As soon as the engine is running, the running detection will be based on all available types.

5.3.3 Interruption of the start sequence

The start sequence is interrupted in the following situations:

Event	Notes
Stop signal	
Start failure	
Remove starter feedback	Tacho set point.
Running feedback	Digital input.
Running feedback	Tacho set point.
Running feedback	Frequency measurement is between 30.0 and 35.0 Hz. The frequency measurement requires a voltage measurement of 30 % of U_{NOM}. The running detection based on the frequency measurement can replace the running feedback based on tacho or digital input or engine communication.
Running feedback	Oil pressure set point.
Running feedback	EIC (engine communication).
Emergency stop	
Alarm	Alarms with Shutdown or Trip and stop fail class.
Stop button on the display	Only in MANUAL or SWBD mode.
Modbus stop command	MANUAL or SWBD mode.
Digital stop input	MANUAL or SWBD mode.
Deactivate the Auto start/stop	AUTO mode in the genset modes Island operation.
Running mode	It is not possible to change the running mode to Block as long as the genset is running.

Engine > Running detection

Parameter	Text	Range	Default
6171	Number of teeth	0 to 500 teeth	0 teeth*
6172	Run detect type	Digital input MPU input Frequency EIC Multi-input 20 to 23	Frequency
6173	Running detect	0 to 4000 RPM	1000 RPM
6175	Oil pressure level	0.0 to 150.0 bar	0.0 bar
6176	Not running delay	0.0 to 5.0 s	0.0 s

NOTE * If there is no MPU (that is, parameter 6171 is 0), the controller calculates the genset speed from the frequency. This value is used for the remove starter function, and the overspeed and underspeed protections.

5.3.4 MPU wire break

The MPU wire break function is only active when the engine is not running. In this case, an alarm is activated if the wire connection between the controller and the MPU breaks. The MPU wire alarm is activated, when there is more than 400 kΩ.

`Engine > Running detection > MPU wirebreak`

Parameter	Text	Range	Default
4551	MPU sensor type	Tacho sensor Hall sensor*	Tacho sensor
4552	MPU wirebreak	Fail classes	Warning

NOTE * There is no wire break on a Hall sensor.

5.3.5 D+ (Charger generator fail)

When the D+ function is enabled, the start relay is deactivated. The D+ turns off when the start disengages. The alarm is activated if there is no D+ feedback from the charging alternator after the delay time runs out.

`Engine > Running detection > Charger Gen fail`

Parameter	Text	Range	Default
4990	Set point	5.50 to 30.00 V	6.00 V
	Timer	0.0 to 999.0 s	10.0 s
	Output A	Relays and M-Logic	Not used
	Output B	Relays and M-Logic	Not used
	Enable	OFF ON	OFF
	Fail class	Fail classes	Warning

`Engine > Start sequence > After crank > Remove starter`

Parameter	Text	Range	Default
6174	Remove starter	1 to 2000 RPM	400 RPM

5.3.6 Running output

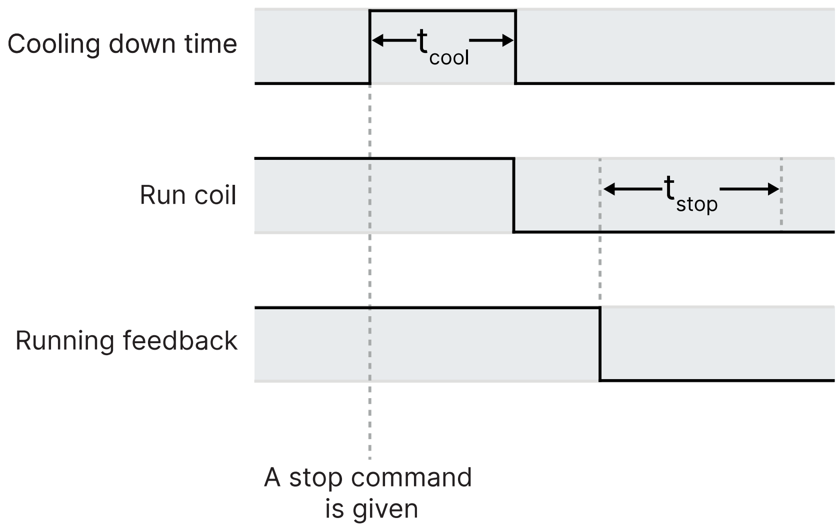
The run status timer can be configured to activate a digital output when the engine is running.

Configure the run status under `Functions > Run status` (parameter 6160). Configure the timer for the time that running detection must be present before *Run status* is activated. If the timer for run status is changed, it also affects the alarm inhibit for *Not run status*.

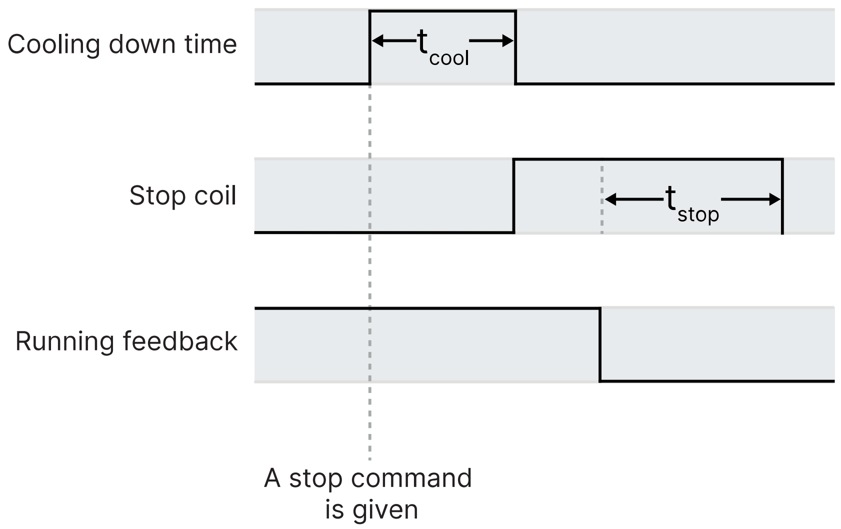
5.4 Engine stop functions

5.4.1 Stop sequence

Stop sequence: Run coil



Stop sequence: Stop coil



The stop sequence is activated if a stop command is given. The stop sequence includes the cooling down time if the stop is a normal or controlled stop.

`Engine > Stop sequence > Cooldown`

Parameter	Text	Range	Default
6211	Cooldown time	0 to 9900 s	240 s

5.4.2 Stop sequence commands for the generator

Description	Cooling down	Stop	Notes
AUTO mode stop	●	●	
Trip and stop alarm	●	●	
Stop button on the display	(●)	●	MANUAL or SWBD mode. Cooling down is interrupted if the *Stop* button is activated twice.
Emergency stop		●	GB opens and engine shuts down.

Interruption of the stop sequence can only occur during the cooling down period. If the status of the genset is engine stopping, then starting a new start sequence is only possible when the genset is stopped.

Interruption of the cool down period can occur in these situations

Event	Notes
Blackout	AUTYO and MANUAL mode: Controllers skip the cool down and restore the busbar.
Start button is pressed/remote command is given	MANUAL mode: Engine will run in idle/nominal speed.
Digital start input	MANUAL mode.
GB close button is pressed/remote command is given	MANUAL and SWBD modes only.

NOTE When the engine is stopped, the analogue speed governor output is reset to the offset value.

5.4.3 Set points related to the stop sequence

`Engine > Stop sequence > Stop failure`

Parameter	Text	Range	Default
4580	Stop failure timer	10.0 to 120.0 s	30.0 s
	Stop failure, Output A	Relays and M-Logic	Not used
	Stop failure, Output B	Relays and M-Logic	Not used
	Activation of the stop failure alarm	OFF ON	ON
	Stop failure alarm fail class	Fail classes	Shutdown

`Engine > Stop sequence > Extended stop`

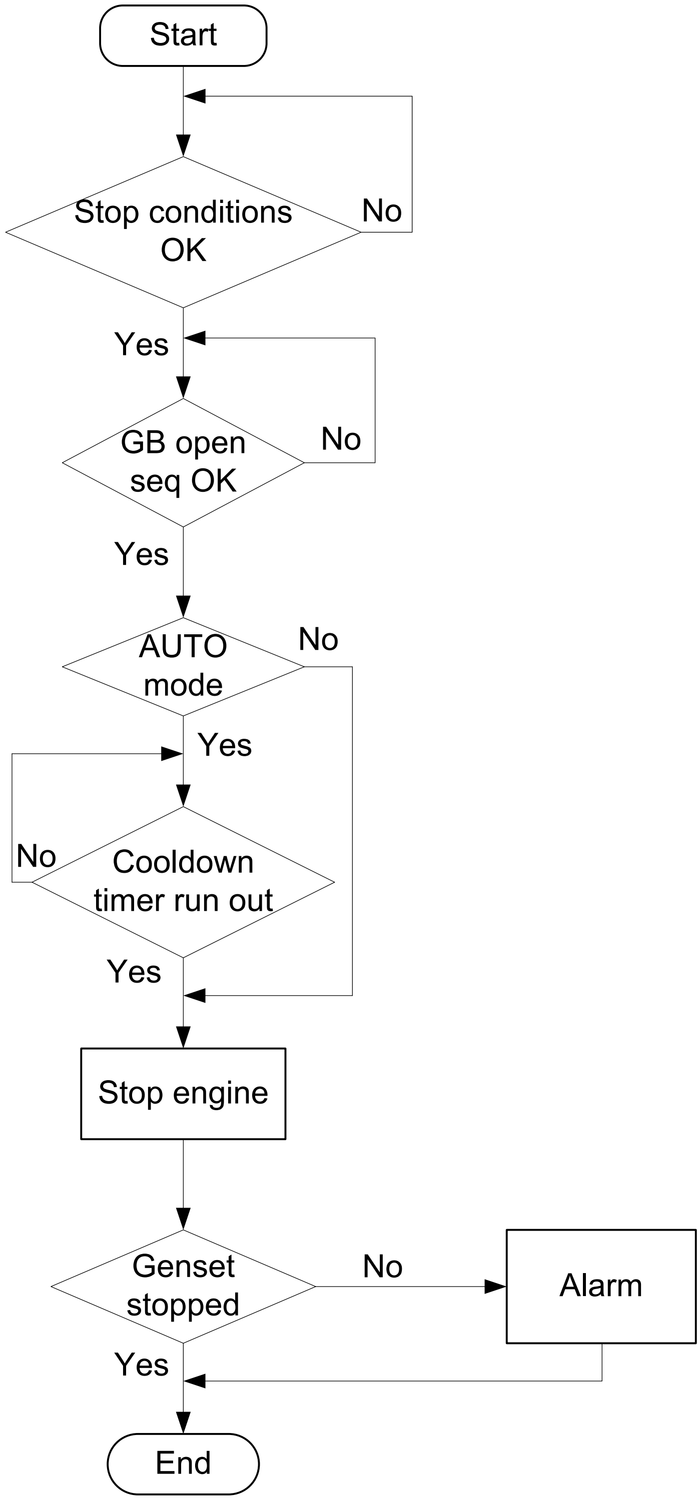
Parameter	Text	Range	Default
6212	Extended stop time	0 to 300.0 s	5.0 s

`Engine > Stop sequence > Stop threshold`

Parameter	Text	Range	Default
6213	Stop threshold type	Multi input 20 to 23 M-Logic EIC temp. inputs	Multi input 20
6214	Stop threshold	0 to 482 °	0 °

NOTE If the cooling down timer is set to 0.0 s, the cooling down sequence will be infinite.

5.4.4 Stop sequence flowchart



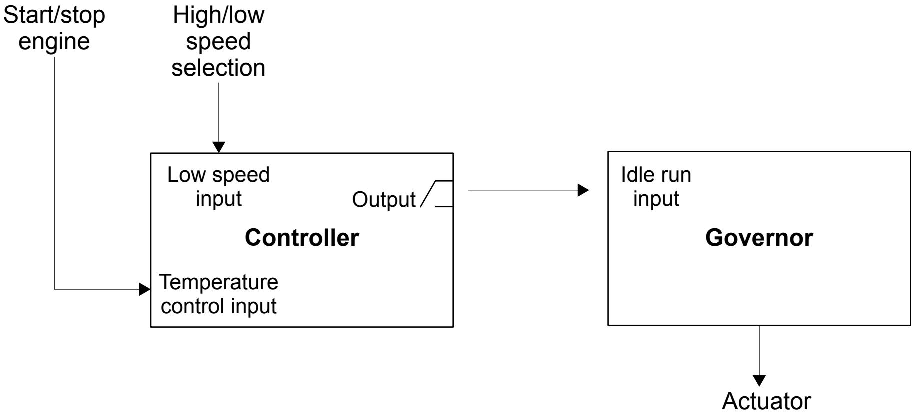
5.5 Idle running

Idle running changes the start and stop sequences so the engine can run at low temperature conditions.

The function is typically used in installations where the engine has to operate at low temperatures. This can cause starting problems or damage the engine. You can also use the function when the engine has to run at low RPM until a specified temperature is reached.

It is possible to use the idle run function with or without timers. Two timers are available, one timer is used in the start sequence, and one timer is used in the stop sequence. The timers make the function flexible.

You must prepare the speed governor for the idle run function using a digital signal from the controller.



When the function is enabled, two digital inputs are used for control purposes:

1. Low speed input. This input is used to change between idle speed and nominal speed. This input does not prevent the engine from stopping. It is only a selection between idle and nominal speed.
2. Temperature control input. When this input is activated, the engine starts. It is not able to stop as long as this input is activated.

You can use the low speed input together with a timer to select the idle run function. If an input and a timer are used at the same time, the digital input is prioritised. For example, if the idle run function is activated with the low speed input and the start timer is enabled, the idle run function is still active if the timer expires before the digital input is deactivated.

NOTE Turbo chargers not originally prepared for operating in the low speed area can be damaged if the engine is running in idle run for too long.

It is possible to interrupt the idle run sequence in MANUAL mode with parameter 6297 enabled. If you push the *START* button, the engine regulates to nominal values, and if you push the *STOP* button, the engine is stopped.

`Engine > Start sequence > Idle run`

Parameter	Text	Range	Default
6291	Idle start timer	0.0 to 999.0 min	300.0 min
6292	Idle start enable	OFF ON	OFF
6295	Output A	Relays and M-Logic	Not used
6296	Enable idle run	OFF ON	OFF
6297	Idle interrupt	OFF ON	OFF

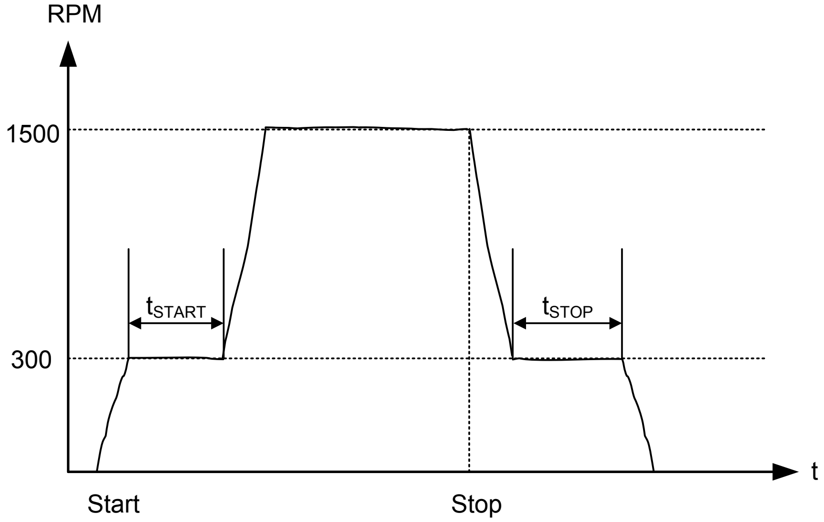
`Engine > Stop sequence > Idle stop`

Parameter	Text	Range	Default
6293	Stop timer	0.0 to 999.0 min	300.0 min
6294	Enable stop	OFF ON	OFF

Examples

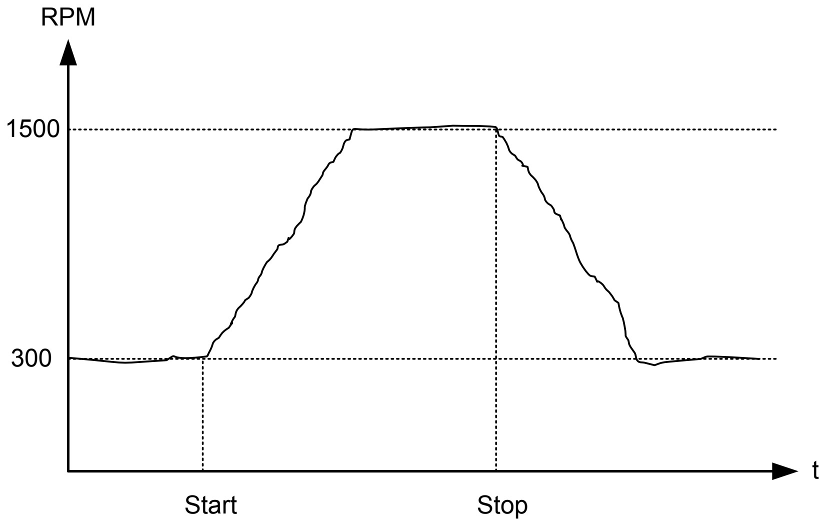
Idle speed during starting and stopping

* Both the start and the stop timers are activated.
* The start and stop sequences are changed to let the engine stay at the idle level before speeding up.
* It also decreases the speed to the idle level for a specified delay time before stopping.



Idle speed with a digital input configured to low speed

* The idle speed with low speed activated runs in idle speed until the low speed input is deactivated, and then the engine regulates to nominal values.
* To prevent the engine from stopping, then the digital input *Temp control* must be left ON at all times. The engine speed-time curve then looks like this:



NOTE The oil pressure alarm (RMI oil) is enabled during idle run if set to ON.

5.5.1 Temperature-dependent idle start-up

This is an example of a system that will start up in idle run, if the coolant temperature is below a specified value. When the temperature exceeds the specified value, the engine will ramp up to nominal values.

For this function to work, you must turn idle running ON and configure the digital output.

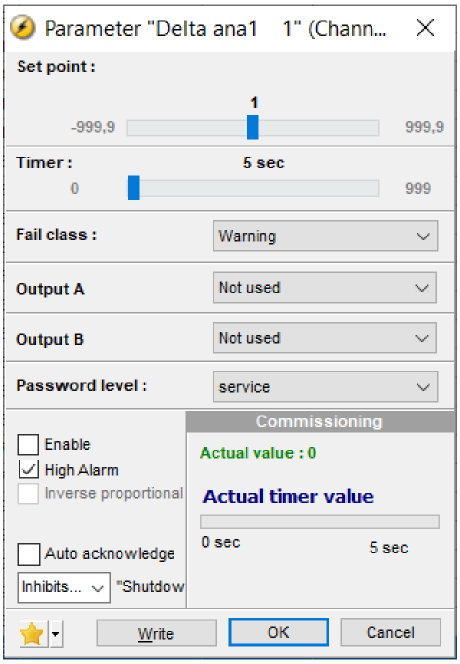
`Engine > Start sequence > Idle run`

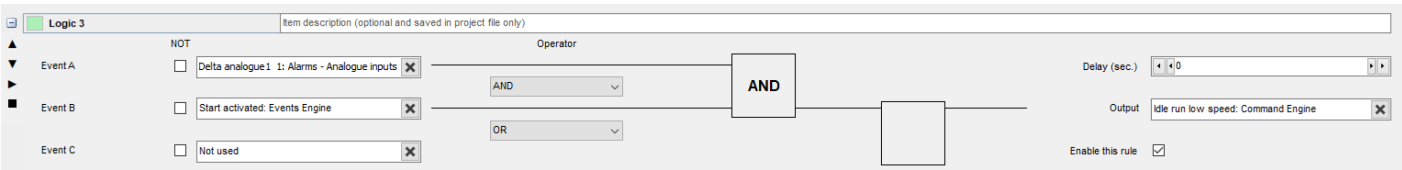
Parameter	Text	Range	Set value to
6295	Idle active	OFF	ON

Parameter	Text	Range	Set value to
		ON	

Example

The function uses delta analogue 1 (parameters 4601, 4602, 4610 and 4620) and one M-Logic line. After starting, when the coolant temperature is below 110 °C, the controller idles. Once the temperature reaches 110 °C, the controller automatically ramps up to full speed.





5.5.2 Inhibit

The alarms that are deactivated by the inhibit function are inhibited in the usual manner, except for the oil pressure alarms, RMI oil 20, 21, 22 and 23. These alarms are active during Idle run as well.

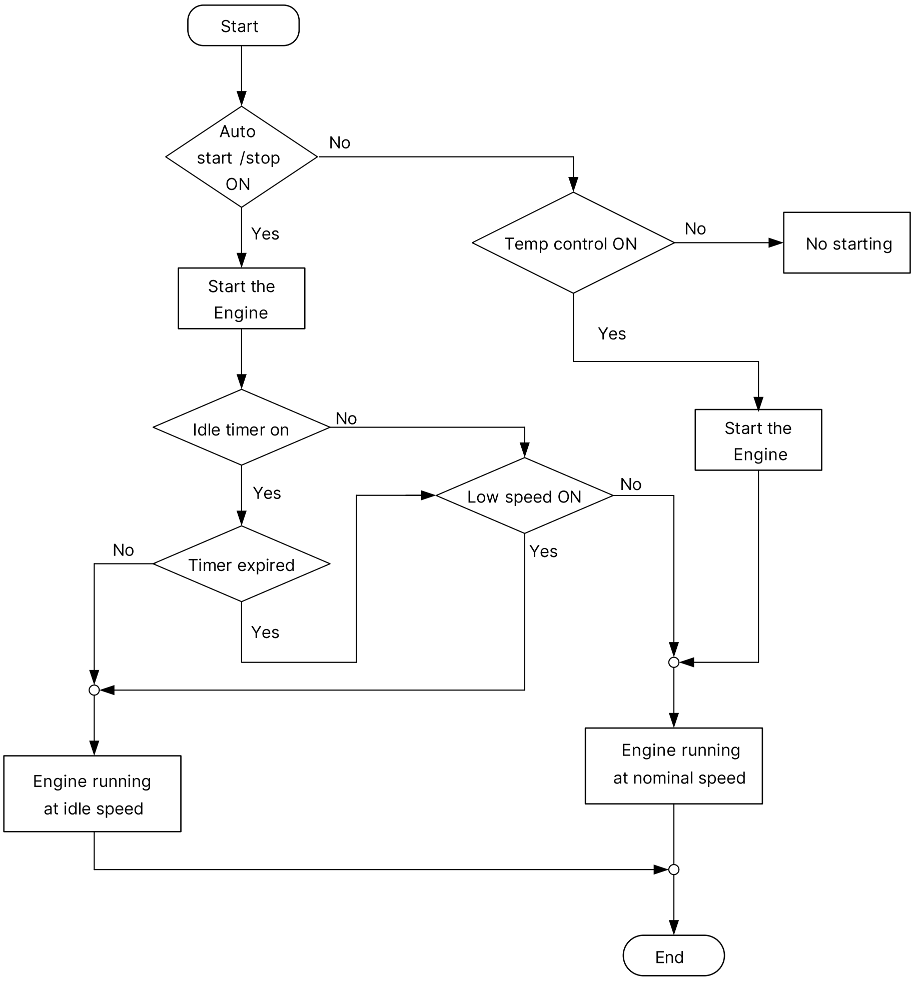
5.5.3 Running signal

You must activate the running feedback when the engine is running in idle mode.

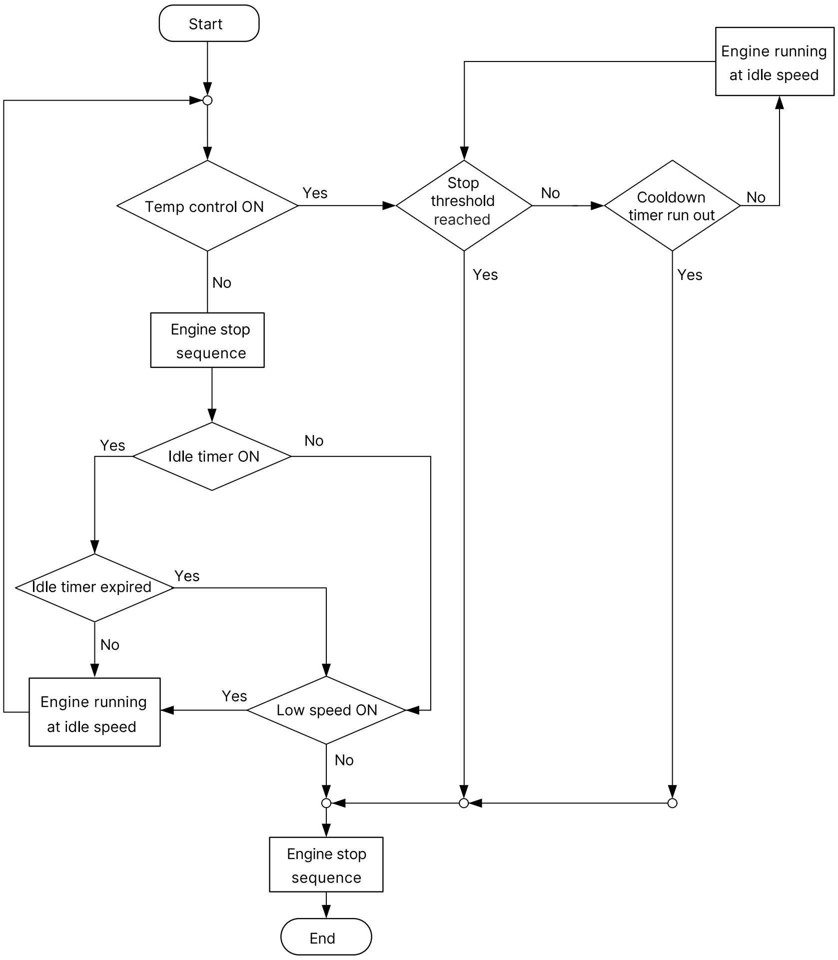
5.5.4 Idle speed flowcharts

The flowcharts show the start and stop of the engine by the inputs *Temp control* and *Low speed*.

Start flowchart



Stop flowchart



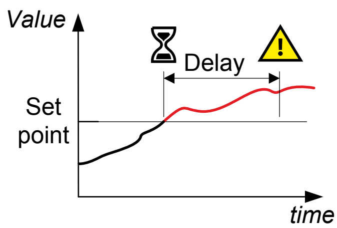
5.6 Engine protections

Protection	IEC symbol (IEC 60617)	ANSI (IEEE C37.2)	Operate time	Alarms
Over-speed	-	12	-	2
Under-speed	-	14	-	1

5.6.1 Overspeed

These alarms alerts the operator that the engine is running too fast.

The alarm response is based on the engine speed as a percentage of the nominal speed. If the engine speed rises above the set point for the delay time, the alarm is activated.



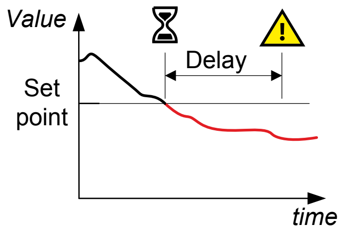
Engine > Protections > RPM-based protections > Overspeed > Overspeed [1 or 2]

Parameter	Text	Range	Overspeed 1	Overspeed 2
4510 or 4520	Set point	100 to 150 %	110 %	120 %
	Timer	0 to 3200 s	5 s	1 s
	Output A	Relays and M-Logic	Not used	Not used
	Output B	Relays and M-Logic	Not used	Not used
	Enable	OFF ON	OFF	OFF
	Fail class	Fail classes	Warning	Shutdown

5.6.2 Underspeed

This alarm alerts the operator that the engine 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, the alarm is activated.



Engine > Protections > RPM-based protections > Underspeed > Underspeed

Parameter	Text	Range	Default
4590	Set point	50 to 100 %	90 %
	Timer	0 to 3200 s	5 s
	Output A	Relays and M-Logic	Not used
	Output B	Relays and M-Logic	Not used
	Enable	OFF ON	OFF
	Fail class	Fail classes	Warning

5.6.3 EIC Overspeed

EIC overspeed (parameter 7600) alarm can be activated on the ECU & D-AVR configuration tab on the left menu in the USW.

5.7 Engine Alarms

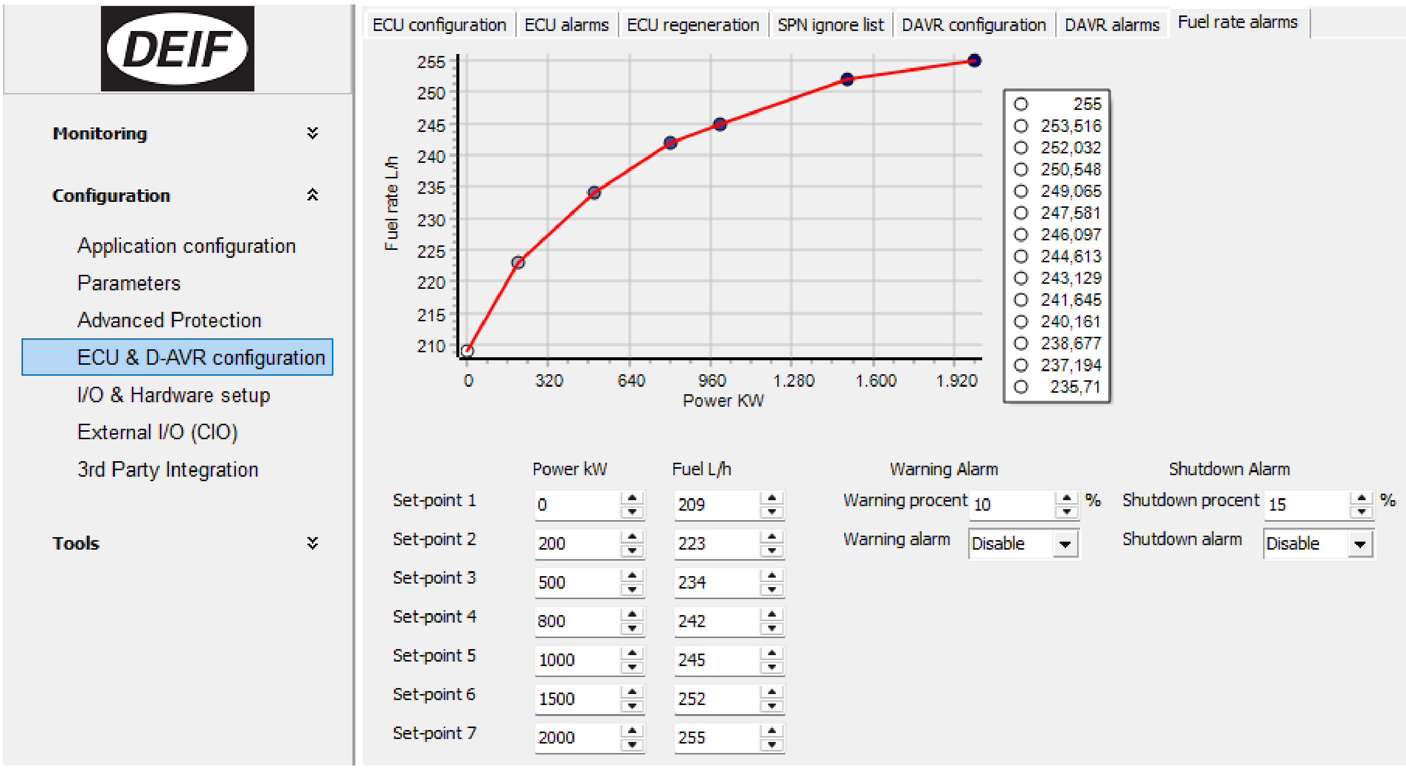
5.7.1 Fuel rate alarm

To ensure that the fuel consumption remains within the expected range, the controller has alarms for the fuel rate.

The fuel rate function lets you configure the expected fuel use relative to the generator power. If the fuel rate is above the expected range, the controller can activate alarms. The controller uses the fuel rate from the ECU.

Use the utility software to configure the fuel rate-power curve. You can define the ranges that activate the warning alarm and shutdown alarm.

ECU & DAVR configuration > Fuel rate alarms



5.8 Engine communication

The controller supports J1939 and can communicate with any engine that uses generic J1939. In addition, the controller can communicate with a wide range of ECUs and engines.

More information
See **iE 150 AGC 150 Engine communication** for a full list of supported ECUs and engines, along with detailed information for each protocol.

Exhaust after-treatment (Tier 4/Stage V)

The controller supports Tier 4 (Final)/Stage V requirements. It provides monitoring and control of the exhaust after-treatment system, as required by the standard.

More information
See the **Operator's manual** for a description of the exhaust after-treatment.

5.9 Fan logic

The controller can control four different fans. For example, air supply fans for an engine in a closed enclosure, or radiator fans for air cooling.

1. Priority according to running hours of the fans.
   - A priority routine ensures that the running hours of the available fans are evened out.
2. Temperature-dependent start and stop.
   - The controller measures a temperature, for example the cooling water temperature, and uses the measured values to switch on and off relays, which are engaging the fan(s) itself.

The fan control function is active as long as running is detected.

5.9.1 Input for fan control

The fan control requires a temperature input to start and stop the fans based on a temperature measurement.

The multi-inputs can be wired to, for example, a Pt100 sensor that measures an engine- or ambient temperature. If EIC is selected, the controller uses the highest measured temperature of the cooling water and oil temperatures.

Based on the selected input, the fan(s) are started and stopped.

Functions > Fan > Multiple fan start/stop > Fan configuration

Parameter	Text	Range	Default
6561	Fan input	Multi-input 20 to 23 EIC temp. inputs	Multi-input 20

5.9.2 Fan start and stop

Functions > Fan > Multiple fan start/stop > Start temperature

Parameter	Text	Range	Default
6563	1st level fan setp.	20 to 250 °C	70 °C
6564	1st level fan hyst.	0 to 50 °C	10 °C
6565	2nd level fan setp.	0 to 250 °C	90 °C
6566	2nd level fan hyst.	0 to 50 °C	10 °C
6571	3rd level fan setp.	0 to 250 °C	110 °C
6572	3rd level fan hyst.	0 to 50 °C	10 °C
6573	4th level fan setp.	0 to 250 °C	130 °C
6574	4th level fan hyst.	0 to 50 °C	10 °C

5.9.3 Fan output

The purpose of the fan output relays is to give a signal to the fan starter cabinet. The relay must be energised for the fan to run.

Functions > Fan > Multiple fan start/stop > Fan outputs

Parameter	Text	Range	Default
6581	Fan A output	Not used Terminal 5, 6 and 9 to 18 Limits	Not used
6582	Fan B output		
6583	Fan C output		
6584	Fan D output		

5.9.4 Fan start delay

If two or more fans are requested to be started at the same time, it is possible to add a start delay between each fan start. The reason for this is to limit the peak start current, so all fans will not contribute with a start current at the same time.

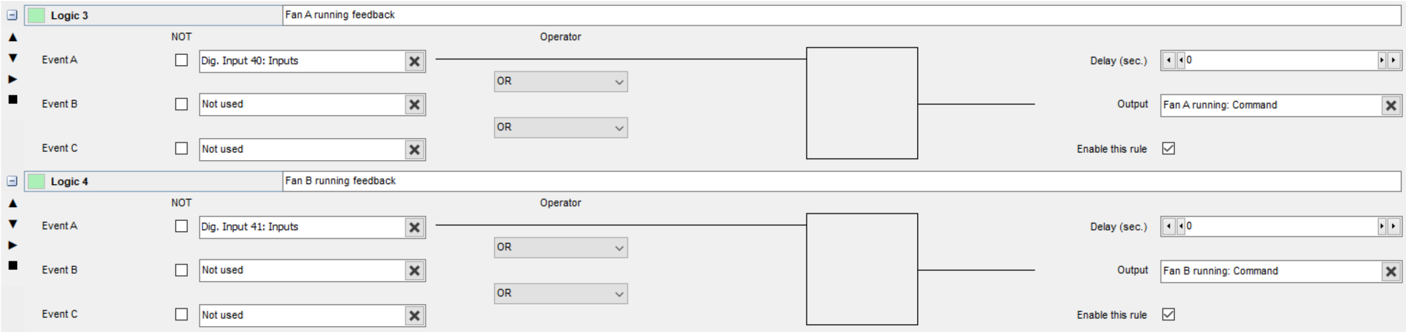
Functions > Fan > Multiple fan start/stop > Start delay

Parameter	Text	Range	Default
6586	Fan start delay	0 to 30 s	10 s

5.9.5 Fan running feedback

To make sure that the fan is running, it is possible to assign a digital input as a fan running feedback. The running feedback has to be programmed through M-Logic in the utility software.

Example



The Fan A/B/C/D running command output tells the controller that the fan is running.

5.9.6 Fan failure alarm

It is possible to enable an alarm for Fan A to D if the fan does not start. The fan failure alarm is activated if there is no running feedback from the fan.

`Functions > Fan > Multiple fan start/stop > Failures > Fan [A to D]`

Parameter	Text	Range	Default
6590, 6600, 6610 or 6620	Fan [A to D] timer	0.1 to 300.0 s	10.0 s
	Output A	Relays and M-Logic	Not used
	Output B	Relays and M-Logic	Not used
	Enable	OFF ON	OFF
	Fail class	Fail classes	Warning

5.9.7 Fan priority (running hours)

The priority of the fans A to D rotates automatically from first to fourth priority. This is done automatically, because the running hours of the fans are detected and are used for the rearranging.

`Functions > Fan > Multiple fan start/stop > Running hours`

Parameter	Text	Range	Default
6585	Fan Run.H reset	OFF Fan A to D hours reset	OFF

`Functions > Fan > Multiple fan start/stop > Priority`

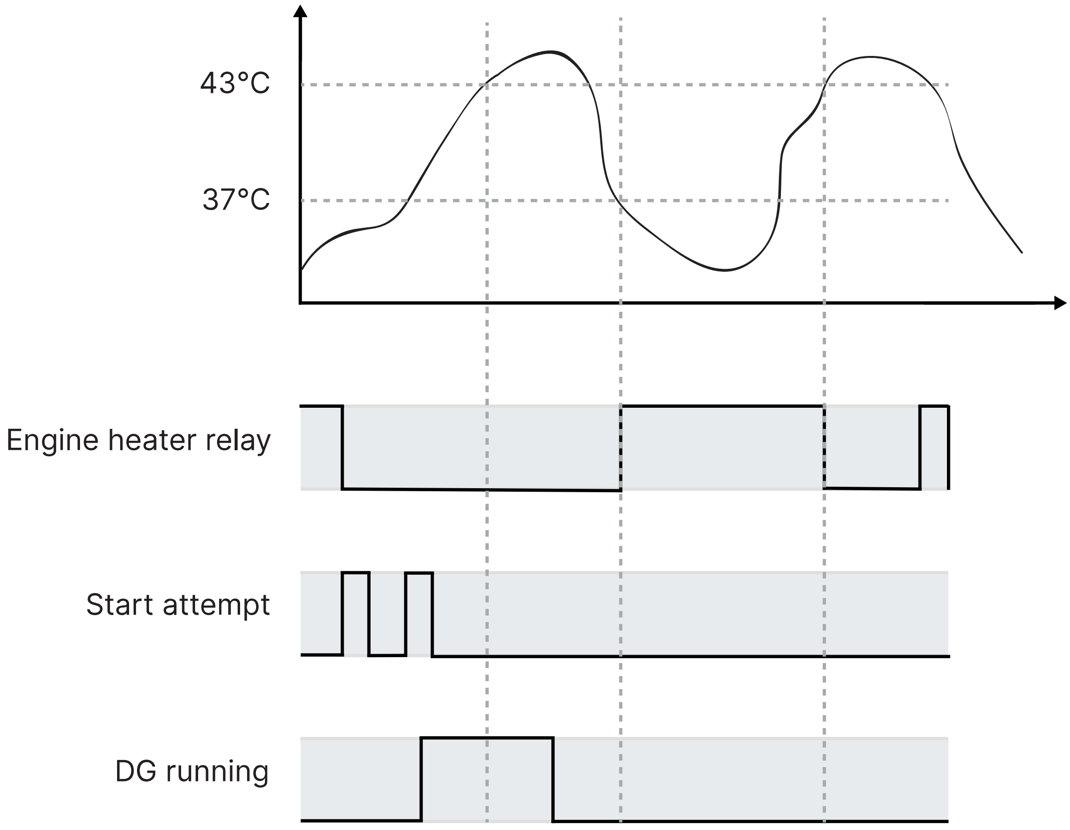
Parameter	Text	Range	Default
6562	Fan prio update	0 to 200 hours	0 hours

The fan priority update rate determines the hours between priority rearrangement. If it is set to 0 hours, the priority order is fixed: Fan A, fan B, fan C, then fan D.

5.10 Engine pre-heater

This function is used to control the temperature of the engine. A temperature sensor is used to activate an external heating system to keep the engine at a minimum temperature. This function is only active when the engine is stopped.

Example: Engine pre-heater sequence



The function includes a set point and a hysteresis. In the example, the set point is 40 °C with a hysteresis of 3 °C. The controller opens the engine heater relay when the engine has reached 43 °C, and closes when the engine temperature is 37 °C.

A relay must be chosen for the engine heater. If a slave relay of the chosen relay is wanted, this can be programmed in M-Logic.

If the engine heater is active, and the manual control command has been activated, the engine heater relay is opened. When the command is activated again, the heater relay closes if the temperature is below the set point.

`Functions > Engine heater`

Parameter	Text	Range	Default
6321	Engine heater setp	20 to 250 °C	40 °C
6322	Engine heater relay	Relays and M-Logic	Not used
6323	Engine heater input	Multi-input 20 to 23 EIC temp. inputs	Multi-input 20
6324	Engine heater hyst	1 to 70 °C	3 °C

5.10.1 Engine heater alarm

The engine heater alarm has a temperature set point and a timer. If the temperature gets below the set point, and the engine heater relay is closed, the timer starts. If the timer expires, and the temperature is below the set point, the alarm is activated.

Functions > Engine heater > Engine heater 1

Parameter	Text	Range	Default
6330	Set point	10 to 250 °C	30 °C
	Timer	1.0 to 300.0 s	10.0 s
	Output A	Relays and M-Logic	Not used
	Output B	Relays and M-Logic	Not used
	Enable	OFF ON	OFF
	Fail class	Fail classes	Warning

5.11 Ventilation

The ventilation function is used to control the cooling of the engine. The purpose is to use a multi-input for measuring the cooling water temperature. This way an external ventilation is activated to keep the engine below a maximum temperature.

Select the type of input to use in parameter 6323 *Engine heater*.

Functions > Fan > Single fan start/stop > Fan configuration > Max ventilation

Parameter	Text	Range	Default
6460	Max ventilation setp	20 to 250 °C	90 °C
6461	Max ventilation conf	Terminals and limits	Not used
	Enable	ON OFF	OFF
6463	Max ventilation hyst	1 to 70 °C	5 °C

5.11.1 Max. ventilation alarms

There are two ventilation alarms.

Functions > Fan > Single fan start/stop > Fan Alarms

Parameter	Text	Range	Default
6470 and 6480	Set point	20 to 250 °C	95 °C
	Timer	0 to 60 s	1 s
	Output A	Terminals and limits	Not used
	Output B	Terminals and limits	Not used
	Enable	ON OFF	OFF
	Fail class	Fail classes	Warning

5.12 Fuel pump logic

5.12.1 Fuel pump logic

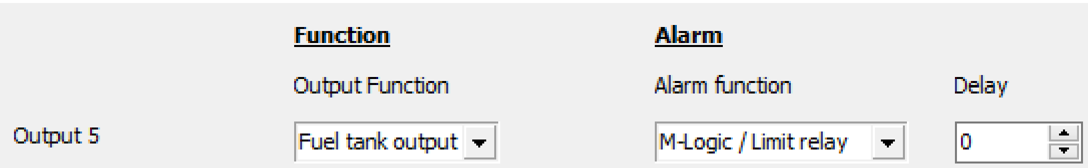
The fuel pump logic is used to start and stop the fuel supply pump to keep the fuel in the service tank at the required level. The fuel level is detected from one of the three multi-inputs.

Parameters

Parameter	Name	Range	Default	Details
6551	Fuel pump log. start	0 to 100 % 1 to 10 s	20 % 1 s	Fuel transfer pump start point.
6552	Fuel pump log. stop	0 to 100 %	80 %	Fuel transfer pump stop point.
6553	Fuel fill check	0.1 to 999.9 s Fail classes	60 s Warning	Fuel transfer pump alarm timer and fail class. The alarm is activated if the fuel pump relay is activated, but the fuel level does not increase by 2 % within the delay time.
6554	Fuel pump log. input	Multi input [102/105/108], Ext. Ana. In [1 to 8], Auto detection	Auto detection	The multi-input or external analogue input for the fuel level sensor. Configure the input in the utility software under *I/O & Hardware setup*. Select the multi-input if 4-20 mA is used. Select *Auto detection* if a multi input with RMI fuel level is used.
6557	Fuel fill slope	1 to 10%	2%	The fuel fill slope percentage.

Relay output

In the utility software under *I/O & Hardware setup*, select the output relay to control the fuel pump, as shown in the following example. If you do not want an alarm whenever the output is activated, configure the output relay as a limit relay.

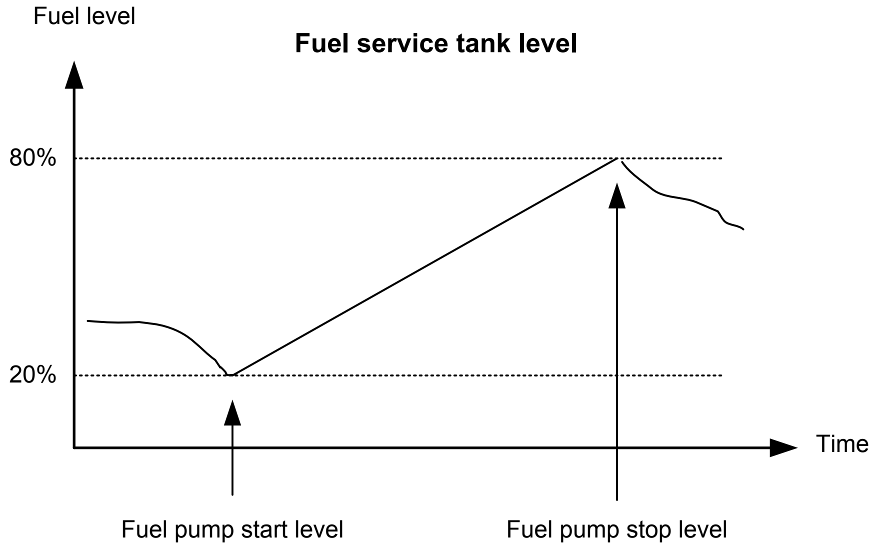


The controller activates the relay when the fuel level is below the start limit. The controller deactivates the relay when the fuel level is above the stop limit.

NOTE The fuel pump relay can be activated using M-Logic (`Output > Command > Activate Fuel Pump`).

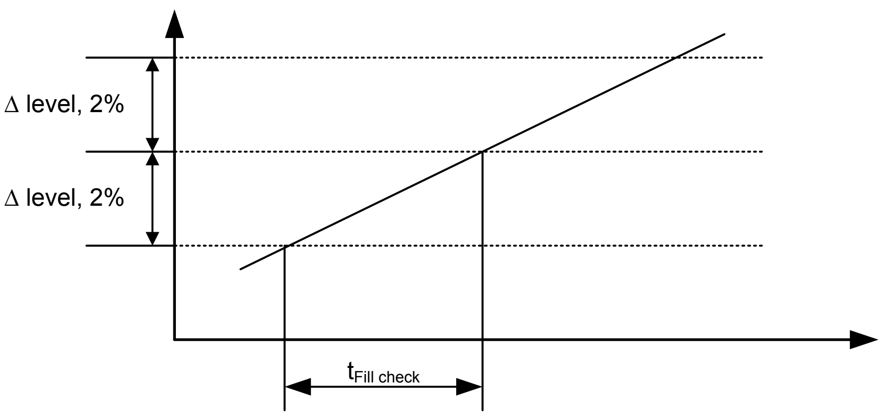
How it works

The diagram below shows how the fuel pump is started when the fuel level is 20 % and stopped again when the level is 80 %.



Fuel fill check

When the fuel pump is running, the fuel level must increase by 2 % within the **Fuel fill check** timer set in menu 6553. If the fuel level does not increase by 2 %, the controller deactivates the fuel pump relay and activates a **Fuel fill alarm**.



NOTE The level increase is fixed at 2 % and cannot be changed.

5.12.2 DEF pump logic

The DEF pump logic can start and stop the DEF pump to keep the DEF at the required level. For this function, engine interface communication (EIC) must provide the DEF level. If the EIC cannot provide the DEF level, you can use the generic fluid pump logic instead.

Parameters

Parameter	Name	Range	Default	Details
6721	DEF pump log. start	0 to 100 % 1 to 10 s	20 % 1 s	DEF transfer pump start point.
6722	DEF pump log. stop	0 to 100 %	80 %	DEF transfer pump stop point.
6723	DEF fill check	0.1 to 999.9 s Fail classes	60 s Warning	DEF transfer pump alarm timer and fail class. The alarm is activated if the DEF pump relay is activated, but the DEF level does not increase by the DEF fill slope (see 6724) within the delay time.
6724	DEF fill slope	1 to 10 %	2 %	When the DEF pump relay is activated, this is the amount by which the DEF level must increase in the time defined in 6723.

Relay output

In the utility software under *I/O & Hardware setup*, select the output relay to control the DEF pump, as shown in the following example. If you do not want an alarm whenever the output is activated, configure the output relay as a limit relay.

The controller activates the relay when the DEF level is below the start limit. The controller deactivates the relay when the DEF level is above the stop limit.

NOTE The DEF pump relay can be activated using M-Logic (`Output > Command > Activate DEF Pump`).

5.12.3 Generic pump logic

The fluid pump logic can start and stop a pump to keep any fluid at the required level.

Parameters

Parameter	Name	Range	Default	Details
6731	Fluid pump start	0 to 100 % 1 to 10 s	20 % 1 s	Fluid transfer pump start point.
6732	Fluid pump stop	0 to 100 %	80 %	Fluid transfer pump stop point.
6733	Fluid check	0.1 to 999.9 s Fail classes	60 s Warning	Fluid transfer pump alarm timer and fail class. The alarm is activated if the fluid pump relay is activated, but the fluid level does not increase by the fluid fill slope (see 6735) within the delay time.
6734	Fluid pump log.	Multi input [102/105/108], Ext. Ana. In [1 to 8]	Multi input 102	Select the analogue input for the fluid level. Configure the input in the utility software under *I/O & Hardware setup*.
6735	Fluid fill slope	1 to 10 %	2 %	When the fluid pump relay is activated, this is the amount by which the fluid level must increase in the time defined in 6733.

Relay output

In the utility software under *I/O & Hardware setup*, select the output relay to control the fluid pump, as shown in the following example. If you do not want an alarm whenever the output is activated, configure the output relay as a limit relay.

The controller activates the relay when the fluid level is below the start limit. The controller deactivates the relay when the fluid level is above the stop limit.

NOTE The fluid pump relay can be activated using M-Logic (`Output > Command > Activate Generic Pump`).

5.13 SDU 104 integration

The Shut Down Unit 104 (SDU 104) provides safety and redundancy for marine engines. It keeps the engine running if the main controller fails and can safely shut it down when overspeed or emergency conditions occur. SDU 104 also prepares the engine for start but cannot start the engine. You can use the SDU 104 together with the following controllers:

Controller	Variant
iE 150 Marine	Generator, Engine drive
iE 150	Generator
AGC 150 Marine	Generator, Engine drive
AGC 150	Generator

How to configure the controller for use with the SDU 104

1. Go to the *I/O & Hardware setup* tab.
2. Select the *DI 39-40-41* tab.
3. Configure the digital inputs:
    - Digital input 39: SDU comm error
    - Digital input 40: SDU status OK
    - Digital input 41: SDU warning
4. Go to the *DO 5 - 18* tab.
5. Configure *Output 13* and *Output 14*:
    - Output 13: SDU watchdog
    - Output 14: SDU fault reset
6. Go to the *Parameters* tab to configure SDU parameters 18000, 18010, and 18020. These parameters are the alarms for the digital inputs.

By default, digital output 11 is configured as *Status OK*. This output must be configured for the SDU watchdog output to work.

More information
See the **SDU 104 Installation instructions** for how to connect the SDU 104 to the controller. You can also see how to configure the SDU 104.

5.14 Other functions

5.14.1 Service timers

The controller has two service timers to monitor maintenance intervals. Click the icon in the utility software to see the service timers.

The timer function is based on running hours. When the adjusted time expires, the controller displays an alarm. The running hours are counted when there is running feedback. An alarm occurs when the running hours or days expires.

The controller remembers the last reset on each service timer.

`Engine > Maintenance > Service timer [1 to 2]`

Parameter	Text	Range	Default
6111 or 6121	Service timer [1 to 2] hour	0 to 9000 hours	500 hours
6113 or 6123	Service timer [1 to 2] day	1 to 1000 days	365 days
6116 or 6126	Service timer [1 to 2] res	OFF	OFF

Parameter	Text	Range	Default
		ON	

5.14.2 Keyswitch

Output function

Under **I/O & Hardware setup, DO**, configure the *Keyswitch* function.

Wiring

Wire the keyswitch relay output to the ECU power. When the keyswitch relay is open, the ECU has no power.

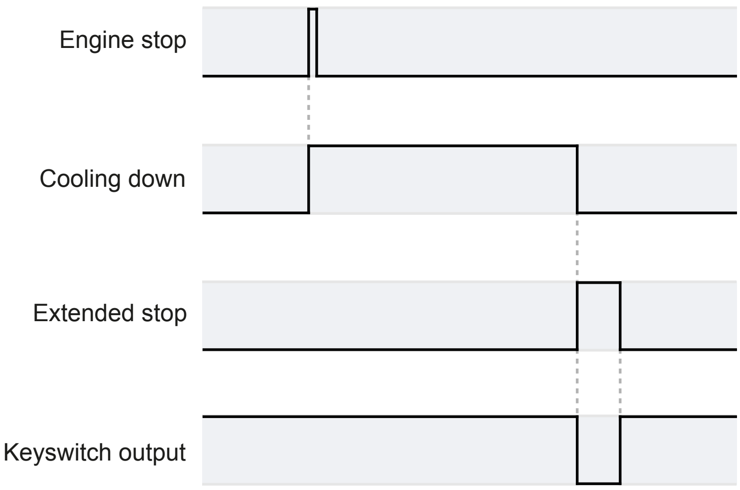
How it works

For the first 5 seconds after the controller is powered on, the keyswitch relay is open.

When the keyswitch relay is open, the controller inhibits the engine interface communication error alarm.

The keyswitch function works as follows:

1. There is an engine stop command.
2. The *Cooling down* (parameter 6211) timer starts.
3. When the cooling down timer runs out, the controller starts the *Extended stop* (parameter 6212) timer, and opens the keyswitch relay.
4. The keyswitch relay stays open until the extended stop timer runs out.



NOTE The keyswitch function does not require engine communication.

5.14.3 Unsupported application

The controller has configuration limitations. If a configuration rule is broken, the controller activates the *Unsupported application* alarm or *Wrong breaker config.* alarm. The alarm value shows which rule was broken. You can see the alarm value in the alarm log in the utility software.

Alarm value	Configuration rule
0	For standard controller applications, the controller must have the power management option.
2	It is not possible to configure a single controller application with a shore controller or a BTB controller.
7	Unknown application type.
8	The controller must have the emulation option enabled to activate emulation.
10	The number of controllers in a plant exceeds the maximum number of allowed controllers.

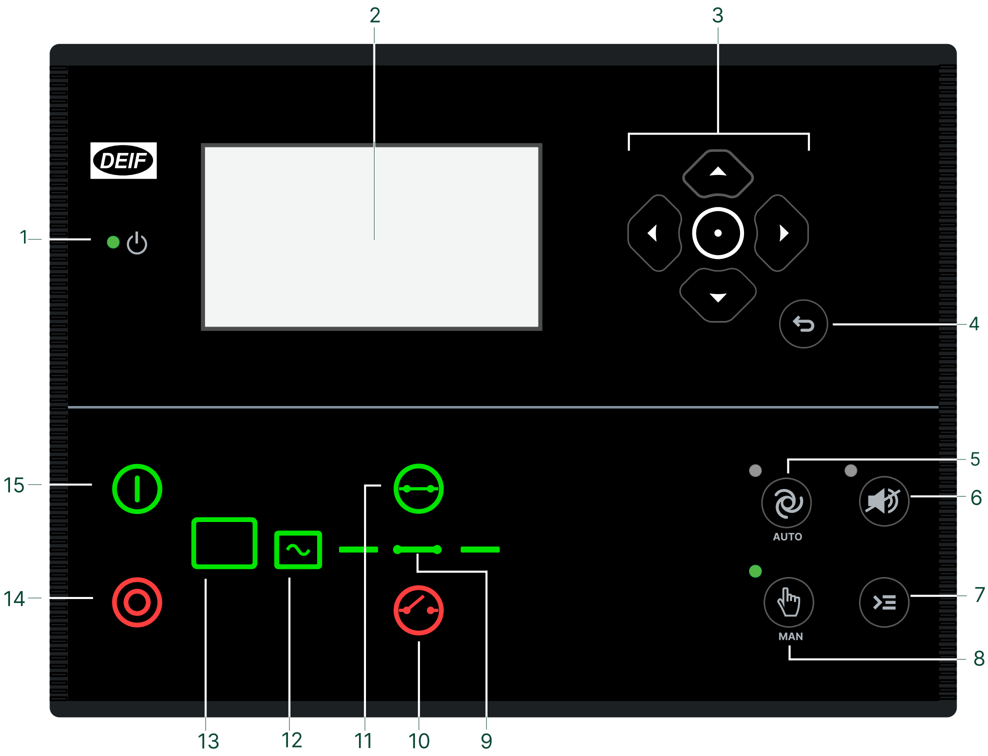
Alarm value	Configuration rule
12	For single controller applications with an external generator breaker both feedbacks must be configured.
14	Single controller applications with no generator breaker or external generator are not supported by controllers with options S2, S3, and S4.
29	There is an internal CAN protocol conflict.
33	Option S10 (Sustainability) is required for using Battery and Solar variants.
34	Only default AC scaling allowed on Battery and Solar controllers if BB Meas origin is inverter communication
45	It is only allowed to use internal digital inputs (39-50) and multi inputs (20-23) for breaker feedbacks.
46	Secure that GEN Marine with option S1 cannot be used for PMS.
47	GEN Marine PMS (CORE + EXTENDED + PREMIUM) do not accept single controller with shore (EDG).
48	Secure max number of units in MARINE plant
51	LAND and MARINE units in same application is not allowed.
52	Battery: Dynamic ST/ST not allowed to run with PV in plant.

Alarm log example

2023-07-13 08:33:39.415	2	Unsupported appl.	0	0	0	0	0	0	0	0	0	0	0	400	400	400	5000	0	0	1200	120	120	120	0	14
2023-07-13 08:37:11.735	3	GB Pos fail	2180	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1200	120	120	120	0	1
2023-07-13 08:37:20.415	4	Unsupported appl.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1200	120	120	120	0	14
2023-07-13 08:49:19.915	5	Unsupported appl.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1200	120	120	120	0	14

6. Generator functions

6.1 Display layout



No.	Name	Function
1	Power	Green: The controller power is ON. OFF: The controller power is OFF.
2	Display screen	Resolution: 240 x 128 px. Viewing area: 88.50 x 51.40 mm. Six lines, each with 25 characters.
3	Navigation buttons	Move the selector up, down, left and right on the screen.
	Enter button	Confirms the selection
4	Back button	Go to the previous page.
5	AUTO mode	The controller automatically starts and stops (and connects and disconnects) gensets. No operator actions are needed. The controllers use the power management configuration to automatically select the power management action.
6	Silence horn	Stops an alarm horn (if configured) and enters the Alarm menu.
7	Shortcut menu	Access the Engine and General shortcuts, Jump menu, Mode selection, Test, Lamp test, First priority selection, Store common settings, and Regulator shortcut.
8	Manual mode	The operator or an external signal can start, stop, connect or disconnect the genset. The generator controller cannot automatically start, stop, connect or disconnect the genset. The controller automatically synchronises before closing a breaker, and automatically deloads before opening a breaker.
9	Breaker symbols	Green: Breaker is closed. Green flashing: Synchronising or deloading.

No.	Name	Function
		Red: Breaker failure.
10	Open breaker	Push to open the breaker.
11	Close breaker	Push to close the breaker.
12	Generator	Green: Generator voltage and frequency are OK. The controller can synchronise and close the breaker. Green flashing: The generator voltage and frequency are OK, but the V&Hz OK timer is still running. The controller cannot close the breaker. Red: The generator voltage is too low to measure.
13	Engine	Green: There is running feedback. Green flashing: The engine is getting ready. Red: The engine is not running, or there is no running feedback.
14	Stop	Stops the genset if manual mode is selected.
15	Start	Starts the genset if manual mode is selected.

6.2 Generator alarms

6.2.1 Fail classes

Fail class/Action	Alarm horn relay	Alarm display	Deload	Trip GB	Trip TB	Cooling down genset	Stop genset
Block	●	●					
Warning	●	●					
Trip GB	●	●		●			
Trip + stop	●	●		●		●	●
Shutdown	●	●		●			●
Trip TB (EDG)	●	●			●		
Safety stop	●	●	(●)			●	●
Trip TB/GB (EDG)	●	●		(●)	●		
Controlled stop	●	●	●	●		●	●

The table shows the action of the fail classes. For example, if an alarm is configured with the *Shutdown* fail class, the following occurs:

- The alarm horn relay activates.
- The alarm is displayed on the alarm info screen.
- The generator breaker opens instantly.
- The genset is stopped instantly.
- The genset cannot be started from the controller (see next table).

The *Safety stop* fail class only deloads the genset if it is possible. An extra genset can start up and replace the faulty one, or the others have spinning reserve enough to stop the faulty genset.

In stand-alone applications, *Safety stop* has no effect in Island and Emergency Diesel Generator (EDG) modes.

Trip TB/GB only trips the generator breaker if the genset controller controls a tie breaker. This means that a genset controller can only trip a tie breaker in a stand-alone application that contains a tie breaker. Otherwise, the fail class always trips the generator breaker.

When the engine is stopped

Fail class/Action	Block engine start	Block TB sequence	Block GB sequence
Block	●		●
Warning			
Trip GB	●		●
Trip + stop	●		●
Shutdown	●		●
Trip TB		●	
Safety stop	●		●
Trip TB/GB*	(●)	●	(●)
Controlled stop	●		●

NOTE *The fail class *Trip TB/GB* does not block *Start* and *Block GB* sequences if the genset controller is in a stand-alone application with a tie breaker.

6.2.2 Inhibits

Function	Notes
Inhibit 1	M-Logic outputs: Conditions are programmed in M-Logic.
Inhibit 2	
Inhibit 3	
GB ON	The generator breaker is closed.
GB OFF	The generator breaker is open.
Run status	Running detected and the timer has expired*.
Not run status	Running not detected or the timer has not expired*.
Generator voltage > 30 %	Generator voltage is above 30 % of nominal.
Generator voltage < 30 %	Generator voltage is below 30 % of nominal.
Shutdown override	The shutdown override input is activated.

NOTE * The run status timer is configured under `Functions > Run status > Timer`. With binary running feedback the timer is not used.

6.3 Generator breaker

6.3.1 Breaker settings

`Synchronisation > Dynamic sync.`

Parameter	Text	Range	Default
2025	Sync. time GB	40 to 300 ms	50 ms

`Breakers > Generator breaker > Breaker configuration`

Parameter	Text	Range	Default
6231	GB close delay	0.0 to 30.0 s	2.0 s
6232	GB Load time	0.0 to 30.0 s	0.0 s

6.3.2 Breaker sequences

The controller activates the breaker sequences according to the selected mode.

Controller operation modes

Controller running mode	Plant operation mode	Breaker control
AUTO	All	Controlled by the controller
MANUAL	All	Button/remote command
SWBD	All	None
Block	All	None (only possible to open breakers)

NOTE In Island mode, the controller running modes are REMOTE and LOCAL.

More information
See **Application modes** for details.

Voltage and frequency OK

Before closing the breakers, the voltage and frequency must be stabilised within a defined time frame.

`Generator > AC configuration > Voltage and freq. OK > Hz/V OK timer`

Parameter	Text	Range	Default
6220	Hz/V OK	0.0 to 99.0 s	5.0 s

`Generator > AC configuration > Voltage and freq. OK > Blackout / Hz/V OK*`

Parameter	Text	Range	Default
2111	Blackout / f <	0.0 to 5.0 Hz	3.0 Hz
2112	Blackout / f >	0.0 to 5.0 Hz	3.0 Hz
2113	Blackout / U <	2 to 20 %	5 %
2114	Blackout / U >	2 to 20 %	5 %

NOTE * The settings are used for both Hz/V OK and Blackout.

`Generator > AC configuration > Voltage and freq. OK > Hz/V failure`

Parameter	Text	Range	Default
4560	Timer	1.0 to 99.0 s	30.0 s
	Output A	Relays and M-Logic	Not used
	Output B	Relays and M-Logic	Not used
	Enable	OFF ON	OFF
	Fail class	Fail classes	Shutdown

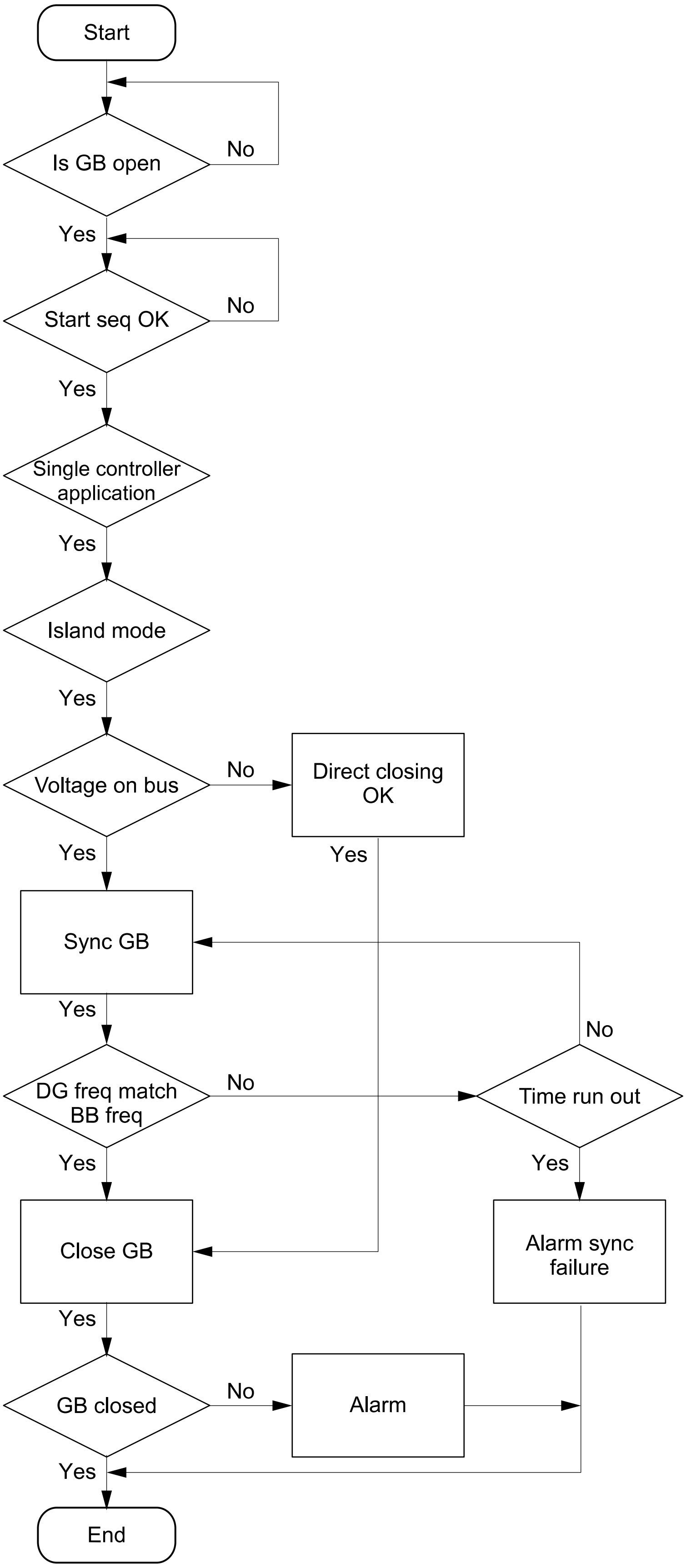
Conditions for breaker operations

The breaker sequences depend on the breaker positions and the frequency/voltage measurements.

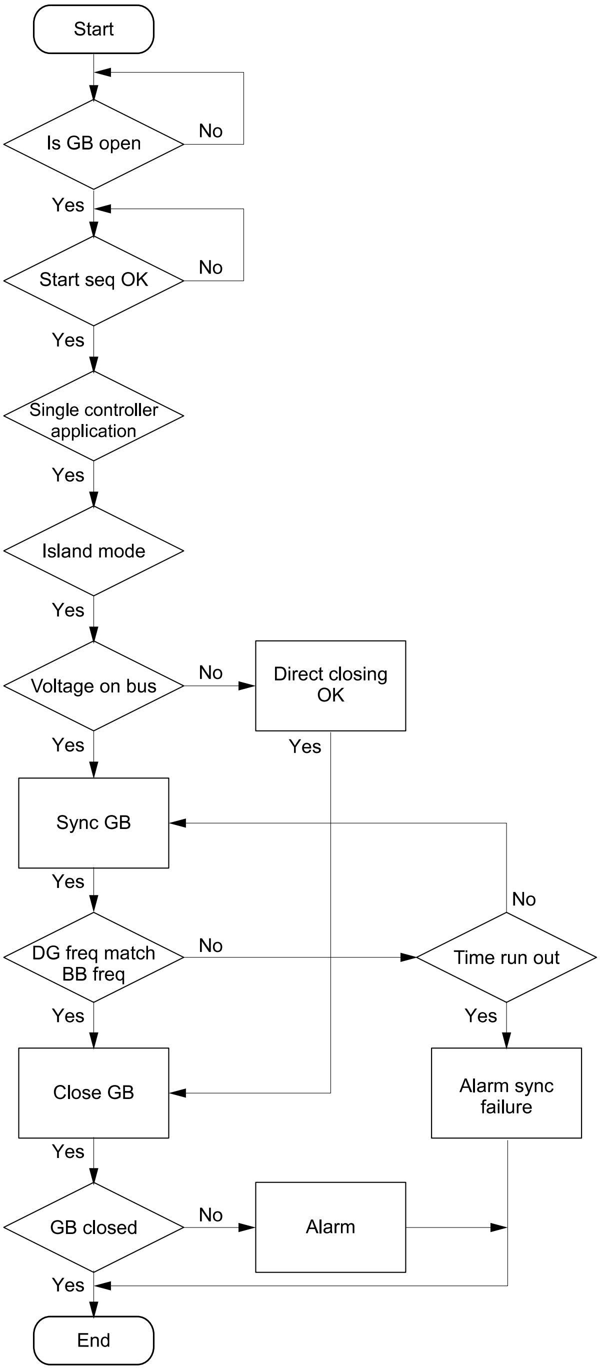
Sequence	Condition
GB ON, direct closing	Running feedback Generator frequency/voltage OK SCB open
GB ON, synchronising	Running feedback Generator frequency/voltage OK SCB closed No generator failure alarms
GB OFF, direct opening	SCB open
GB OFF, de-loading	SCB closed

6.3.3 Flowcharts

GB open sequence flowchart



GB close sequence flowchart



6.3.4 Breaker failures

`Breakers > Generator breaker > Breaker monitoring > GB Open fail`

Parameter	Text	Range	Default
2160	Timer	1.0 to 10.0 s	2.0 s
	Output A	Relays and M-Logic	Not used
	Output B	Relays and M-Logic	Not used
	Enable	ON	ON
	Fail class	Fail classes	Warning

`Breakers > Generator breaker > Breaker monitoring > GB Close fail`

Parameter	Text	Range	Default
2170	Timer	1.0 to 10.0 s	900 s
	Output A	Relays and M-Logic	Not used
	Output B	Relays and M-Logic	Not used
	Enable	ON	ON
	Fail class	Fail classes	Warning

`Breakers > Generator breaker > Breaker monitoring > GB Pos fail`

Parameter	Text	Range	Default
2180	Timer	1.0 to 5.0 s	1.0 s
	Output A	Relays and M-Logic	Not used
	Output B	Relays and M-Logic	Not used
	Enable	ON	ON
	Fail class	Fail classes	Warning

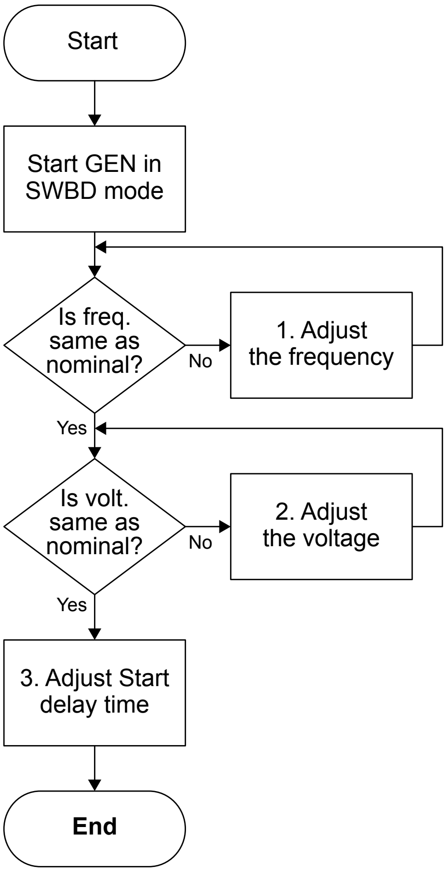
6.4 Governor and AVR configuration

6.4.1 Configuration of controller with EIC governor and analogue AVR

Initial settings

No.	Setting	Path	Parameter
1	Set the GOV type to EIC	`Engine > Speed control > General configuration`	2781
2	Select the engine type	`Engine > ECU configuration > Engine type`	7561
3	Set the EIC controls to ON	`Engine > ECU configuration > EIC controls`	7563
4	Set the AVR type to Analogue	`Generator > AVR > General configuration`	2782
5	Set the AVR output to Ana Out 55	`Generator > AVR > Analogue configuration > AVR output`	5991

Adjustments in SWBD mode

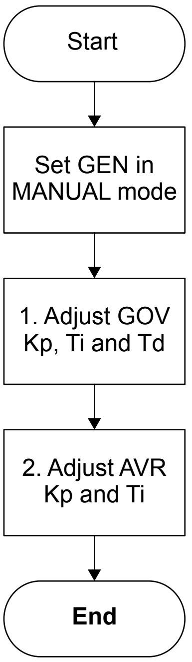


1. Adjust the frequency:
`Engine > Speed control > Offset for control signal` (2551).

2. Adjust the voltage:
`Generator > AVR > Offset for control signal` (2671).

3. If needed, adjust the start regulation delay time:
`Engine > Start sequence > After crank > Reg. delay at start > Delay reg.` (2741).

Adjustments in MANUAL mode



1. Adjust GOV Kp, Ti and Td:

- Island settings: `Engine > Speed control > Speed PID > Island` (2511, 2512 and 2513).
- Shore parallel settings: `Engine > Speed control > Speed PID > Shore parallel` (2531, 2532 and 2533).
- Load share settings: `Engine > Speed control > Speed PID > Load share` (2541, 2542 and 2543).
- Sync. regulator settings: `Synchronisation > Sync. regulator` (2041, 2042 and 2043).

2. Adjust AVR Kp and Ti:

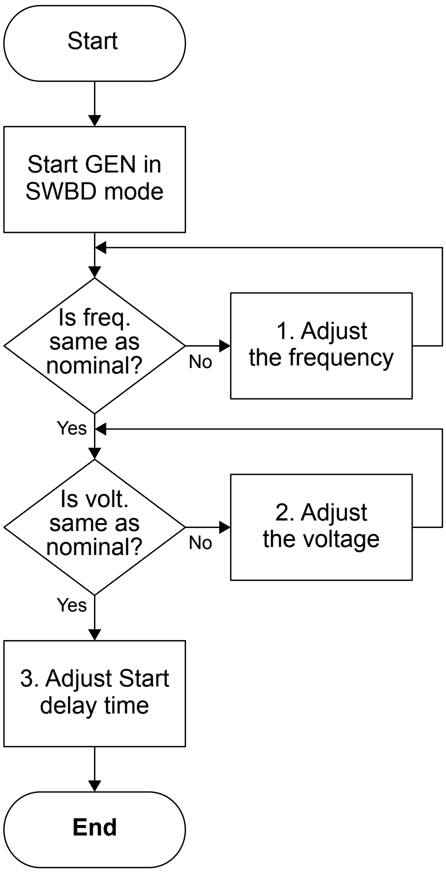
- Island settings: `Settings > Generator > AVR > Voltage PID > Island` (2641 and 2642).
- Shore parallel settings: `Generator > AVR > Voltage PID > Shore parallel` (2651 and 2652).
- Load share settings: `Generator > AVR > Voltage PID > Load share` (2661 and 2662).

6.4.2 Configuration of controller with analogue governor and analogue AVR

Initial settings

No.	Setting	Path	Parameter
1	Set the GOV type to Analogue	`Engine > Speed control > General configuration`	2781
2	Set the AVR type to Analogue	`Generator > AVR > General configuration`	2782
3	Set the GOV output to Ana Out 52	`Engine > Speed control > Analogue configuration > Governor output`	5981
4	Set the AVR output to Ana Out 55	`Generator > AVR > Analogue configuration > AVR output`	5991

Adjustments in SWBD mode

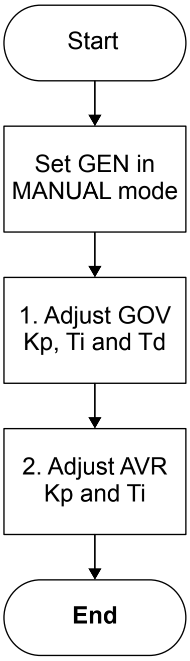


1. Adjust the frequency:
`Engine > Speed control > Offset for control signal` (2551).

2. Adjust the voltage:
`Generator > AVR > Offset for control signal` (2671).

3. Adjust the Start delay time:
`Engine > Start sequence > After crank > Reg. delay at start > Delay reg.` (2741).

Adjustments in MANUAL mode



1. Adjust GOV Kp, Ti and Td:

- Island settings: `Engine > Speed control > Speed PID > Island` (2511, 2512 and 2513).
- Load share settings: `Engine > Speed control > Speed PID > Load share` (2541, 2542 and 2543).
- Sync. regulator settings: `Synchronisation > Sync. regulator` (2041, 2042 and 2043).

2. Adjust AVR Kp and Ti:

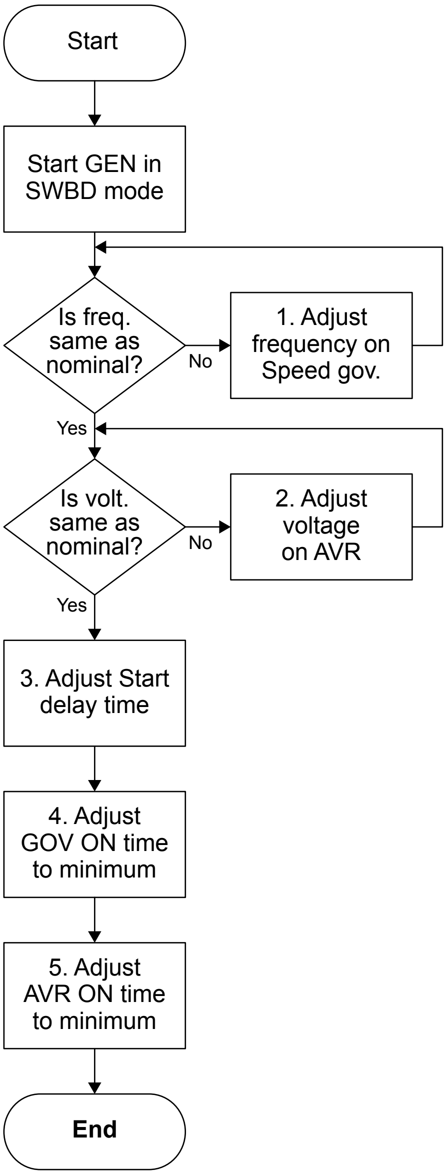
- Island settings: `Generator > AVR > Voltage PID > Island` (2641 and 2642).
- Load share settings: `Generator > AVR > Voltage PID > Load share` (2661 and 2662).

6.4.3 Configuration of controller with relay governor and relay AVR

Initial settings

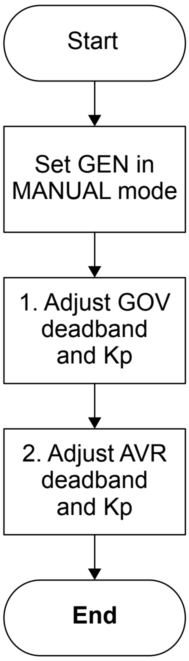
No.	Setting	Path	Parameter
1	Set the GOV type to Relay	`Engine > Speed control > General configuration`	2781
2	Set the AVR type to Relay	`Generator > AVR > General configuration`	2782
3	Select the Increase relay for AVR	`Generator > AVR > Relay configuration > Output and period`	2723
4	Select the Decrease relay for AVR	`Generator > AVR > Relay configuration > Output and period`	2724
5	Select the Increase relay for GOV	`Engine > Speed control > Relay configuration > Output and period`	2603
6	Select the Decrease relay for GOV	`Engine > Speed control > Relay configuration > Output and period`	2604

Adjustments in SWBD mode



1. Adjust the frequency on the external Speed governor.
2. Adjust the voltage on the external AVR.
3. Adjust the Start delay time:
   `Engine > Start sequence > After crank > Reg. delay at start > Delay reg.` (2741).
4. Adjust the GOV ON time to minimum:
   `Engine > Speed control > Relay configuration > Output and period` (2601).
5. Adjust the AVR ON time to minimum:
   `Generator > AVR > Relay configuration > Output and period` (2721).

Adjustments in MANUAL mode



1. Adjust GOV deadband and Kp:

- Island settings: `Engine > Speed control > Speed PID > Island` (2571 and 2572).
- Shore parallel settings: `Engine > Speed control > Speed PID > Shore parallel` (2581 and 2582).
- Load share settings: `Engine > Speed control > Speed PID > Load share` (2591, 2592, 2593 and 2594).
- Sync. regulator settings: `Synchronisation > Sync. regulator` (2051).

2. Adjust AVR deadband and Kp:

- Island settings: `Generator > AVR > Voltage PID > Island` (2691 and 2692).
- Shore parallel settings: `Generator > AVR > Voltage PID > Shore parallel` (2701 and 2702).
- Load share settings: `Generator > AVR > Voltage PID > Load share` (2711, 2712, 2713 and 2714).

6.4.4 Manual governor and AVR control

This function can be activated in MANUAL/SWBD mode by the digital inputs or the *AOP* buttons for governor or AVR control. The function must be configured through M-Logic, and it gives the commissioning engineer a helpful tool for adjustment of the regulation.

When using digital inputs or an *AOP* button to increase/decrease the GOV/AVR signal, the length of the pulse can be adjusted.

The manually controlled regulator is not active as long as a manual step signal is active. When the manual step signal has expired, the normal regulator will be active again.

Example: A genset is running with the GB open. An AOP is configured with manual up and down and a signal length of 5 s. When the AOP button is pressed for manual GOV up, the RPM for the genset will increase for five seconds. The GOV regulator is deactivated for five seconds. When the five seconds have expired, the normal regulator will regulate the genset down again to the nominal set point.

Governor settings

`Engine > Speed control > General configuration`

Parameter	Text	Range	Default
2781	Reg. output GOV	Relay Analogue EIC	EIC

`Engine > Speed control > Manual step`

Parameter	Text	Range	Default
2783	Man. Step GOV	0.1 to 10.0 s	5.0 s

`Engine > Speed control > Offset for control signal`

Parameter	Text	Range	Default
2551	GOV output offset 1	0 to 100 %	50

AVR settings

`Generator > AVR > General configuration`

Parameter	Text	Range	Default
2782	Reg. output AVR	Relay Analogue EIC	EIC

`Generator > AVR > Manuel step`

Parameter	Text	Range	Default
2784	Man. Step AVR	0.1 to 10.0 s	5.0 s

6.4.5 External set points

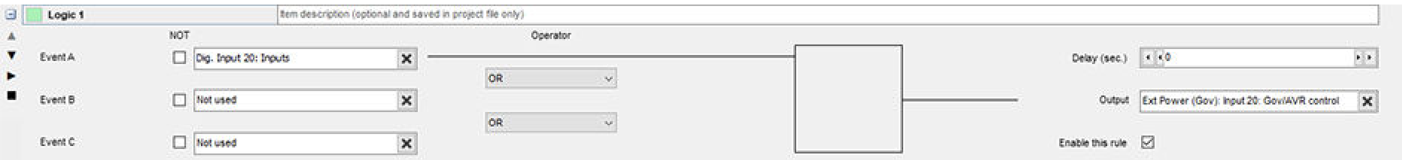
It is possible to control the governor and the AVR externally. A multi-input can be configured to receive a signal with the desired set point. The external control is enabled through M-Logic. The internal set point is discarded when the external control is enabled.

The governor can be controlled using the modes *External frequency control* and *External power control*. The AVR can be controlled using the modes *External voltage control*, *External reactive power control* and *External cos phi control*.

The signal used to control the modes can be set up within the limitations of the multi-inputs. The inputs are configured with the utility software. See the utility software help function (F1) for more details.

Example: Configuring M-Logic

In M-Logic, external power control from input 20 is enabled as an output by using the command *Ext Power (Gov): Input 20: Gov/AVR control*. Commands relevant for external governor/AVR control are found under *Gov/AVR control*. Any relevant events can be used to activate the command.



M-Logic outputs that activate external Gov/AVR control

GOV/AVR control	M-Logic output	Multi-input selection
GOV Ext. frequency	Input: When mA is selected, a 4 to 20 mA signal is used for control and the nominal frequency is 12 mA	Multi-input 20 Multi-input 21 Multi-input 22 Multi-input 23
GOV Ext. power	Input: When mA is selected, a 12 to 20 mA signal is used for control (0 to 100 %)	
AVR Ext. voltage	Input: When mA is selected, a 4 to 20 mA signal is used for control	
AVR Ext. cos phi	Input: When mA is selected, a 12 to 20 mA signal is used for control	
AVR Ext. var	Input: When mA is selected, a 4 to 20 mA signal is used for control	

NOTE When external control is enabled, the internal set point is discarded.

`Power set points > Ext. power set point`

Parameter	Text	Range	Default
7501	Comm bus control P	OFF	OFF

Parameter	Text	Range	Default
		ON	
7502	Comm bus control f	OFF ON	OFF
7503	Comm bus control U	OFF ON	OFF
7504	Comm bus control cos phi	OFF ON	OFF
7505	Comm bus control Q	OFF ON	OFF

Range of regulation for external set points

Parameter	Input voltage	Description	Comment
Frequency	4 to 20 mA	f_{NON} ± 10 %	Active when SCB is OFF.
Power	4 to 20 mA	P_{NON} ± 100 %	
Voltage	4 to 20 mA	U_{NOM} ± 10 %	Active when GB is OFF.
Reactive power	4 to 20 mA	Q_{NOM} ± 100 %	
Power factor	4 to 20 mA	0.6 capacitive to 1 to 0.6 inductive	

More information
The external set point can also be controlled using Modbus. See the **Modbus tables** on deif.com.

6.4.6 Regulation failure

The controller has alarms for regulation failure. The alarm set point is a deviation percentage, as explained in this example:

A genset has the nominal of 440 V AC. In a situation where there is an inductive load, it is not possible for the genset to regulate up to its nominal voltage. If the genset is capable of regulating up to 400 V AC, there is a deviation of 9.1 %. If the regulation failure alarm deadband is 9 %, the controller activates a regulation failure alarm, if the voltage is not back within the range before the timer expires. However, if the deadband is 9.2 %, no alarm is activated.

The regulation failure alarms can be used to detect that the controller has been regulating towards the set point, and may be at its maximum, but has not been able to reach the set point. The regulation failure alarm can also be activated if the regulation is too slow.

`Engine > Speed control > Regulation failure > GOV reg. fail`

Parameter	Text	Range	Default
2560	Deadband	1.0 to 100.0 %	30.0 %
	Timer	10.0 to 300.0 s	60.0 s
	Output A	Terminals and M-Logic	Not used
	Output B	Terminals and M-Logic	Not used
	Fail class	Fail classes	Warning

Generator > AVR > Regulation failure > AVR reg. fail

Parameter	Text	Range	Default
2680	Deadband	1.0 to 100.0 %	30.0 %
	Timer	10.0 to 300.0 s	60.0 s
	Output A	Terminals and M-Logic	Not used
	Output B	Terminals and M-Logic	Not used
	Fail class	Fail classes	Warning

6.4.7 DAVR configuration

Generator > AVR > DAVR configuration > DAVR type > Digital AVR

Parameter	Text	Range	Default
7565	DAVR type	OFF Caterpillar CDVR Leroy Somer D510C DEIF DVC310 DEIF DVC350 DEIF DVC550 NIDEC D550	OFF

Generator > AVR > DAVR configuration > DAVR AC configuration

Parameter	Text	Range	Default
7741	DAVR Gen U primary	400 to 32000 V	400 V
7742	DAVR Gen U secondary	50 to 600 V	400 V
7743	DAVR Bus U primary	400 to 32000 V	400 V
7744	DAVR Bus U secondary	50 to 600 V	400 V
7745	Enable	OFF ON	OFF
7746 *	DAVR AC config	Follow AGC AC config Split phase W-U (L1L3) Split phase V-W (L2L3) 3-phase U-V-W (L1L2L3)	Follow AGC AC config

NOTE * See the **DVC 550 Designer's handbook** for phase selection for the DAVR when used with DVC 550.

6.5 Synchronisation principles

The controller can be used for synchronisation of the generator and the shore connection breaker (if installed).

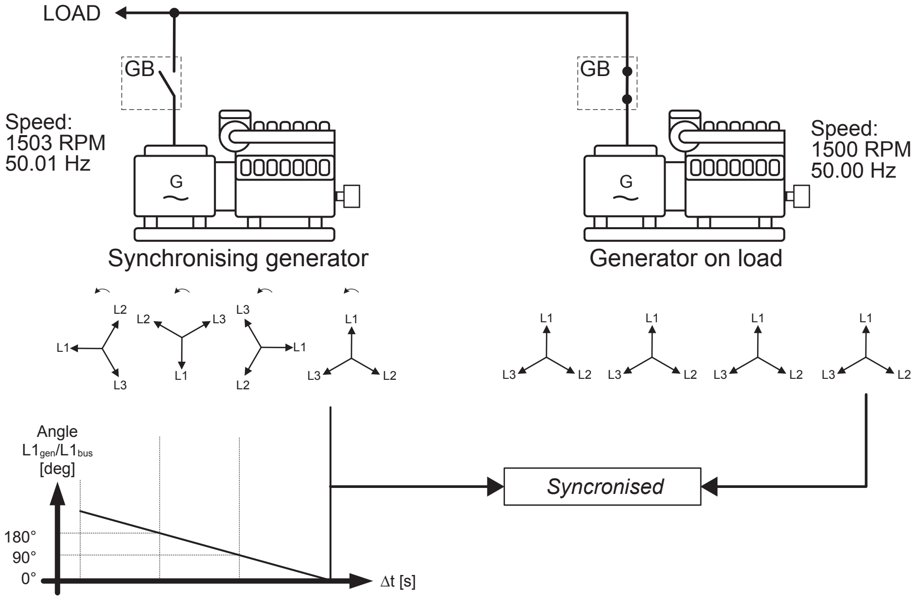
Two different synchronisation principles are available: static and dynamic synchronisation. Dynamic synchronisation is the default setting. You can change to static synchronisation: **Synchronisation > Sync. type**

NOTE Static and dynamic synchronisation can also be switched using M-Logic.

6.6 Dynamic synchronisation

With dynamic synchronisation, the synchronising genset is running at a different speed than the generator on the busbar. This speed difference is called slip frequency. Typically, the synchronising genset has a positive slip frequency (a higher speed than the generator on the busbar). The objective is to avoid a reverse power trip after the synchronisation.

Dynamic principle



In this example, the synchronising genset is running at 1503 RPM ~ 50.1 Hz. The generator on load is running at 1500 RPM ~ 50.0 Hz. This gives the synchronising genset a positive slip frequency of 0.1 Hz.

Synchronising means to decrease the phase angle difference between the two rotating systems, the three-phase generator system and the three-phase busbar system. In the diagram above, phase L1 of the busbar is always pointing at 12 o'clock, whereas phase L1 of the synchronising genset is pointing in different directions due to the slip frequency.

NOTE Both three-phase systems are rotating, but to simplify the diagram the vectors for the generator on load are not shown to be rotating.

When the generator is running with a positive slip frequency of 0.1 Hz compared to the busbar, the two systems can be synchronised every 10 seconds.

$$t_{SYNC} = \frac{1}{50.1 - 50.0} = 10 \sec$$

In the example above, the phase angle difference between the synchronising set and the busbar gets smaller and is eventually zero. Then the genset is synchronised to the busbar, and the breaker is closed.

6.6.1 Settings for dynamic synchronisation

`Synchronisation > Dynamic sync.`

Parameter	Text	Range	Default
2021	Sync. dfMax	0.0 to 0.5 Hz	0.3 Hz
2022	Sync. dfMin	-0.5 to 0.3 Hz	0.0 Hz
2023	Sync. dUMax	2 to 10 %	5 %
2024	Sync. dUMin	-10 to 0 %	-5 %
2025	Sync. time GB	40 to 300 ms	50 ms
2026	Sync. time TB	40 to 300 ms	50 ms

Dynamic synchronisation is recommended where fast synchronisation is required, and where the incoming gensets are able to take load just after the breaker has been closed.

Dynamic synchronisation is relatively fast because of the adjusted minimum and maximum slip frequencies. When the controller is aiming to control the frequency towards the set point, synchronising can still occur as long as the frequency is within the limits of the slip frequency settings.

6.6.2 Close signal

The controller calculates when to close the breaker to get the most accurate synchronisation. This means that the close breaker signal is actually issued before being synchronised (read L1 phases exactly at 12 o'clock).

The breaker close signal will be issued depending on the breaker closing time and the slip frequency (response time of the circuit breaker is 250 ms, and the slip frequency is 0.1 Hz):

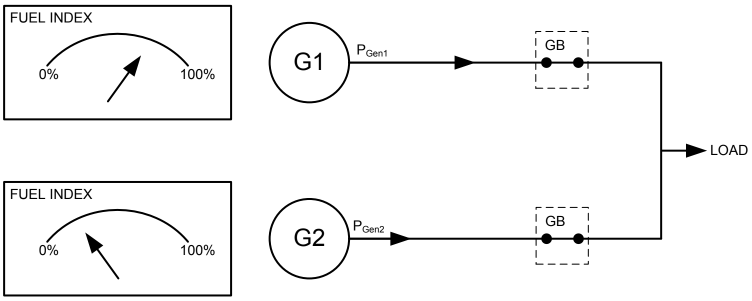
- deg close = 360*tCB*fSLIP
- deg close = 360∗0.250∗0.1
- deg close = 9 deg

The length of the synchronisation pulse is the response time + 20 ms. The synchronisation pulse is always issued, so the closing of the breaker will occur at the 12 o'clock position.

6.6.3 Load picture after synchronising

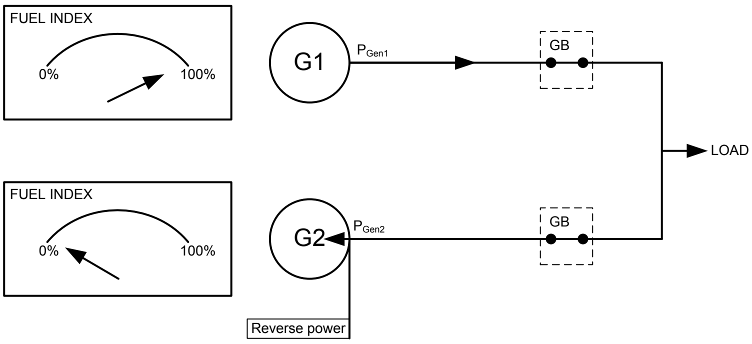
When the incoming genset has closed its breaker, it will take a portion off the load depending on the actual position of the fuel rack.

Positive slip frequency



The diagram shows that at a given positive slip frequency, the incoming genset *exports* power to the load.

Negative slip frequency



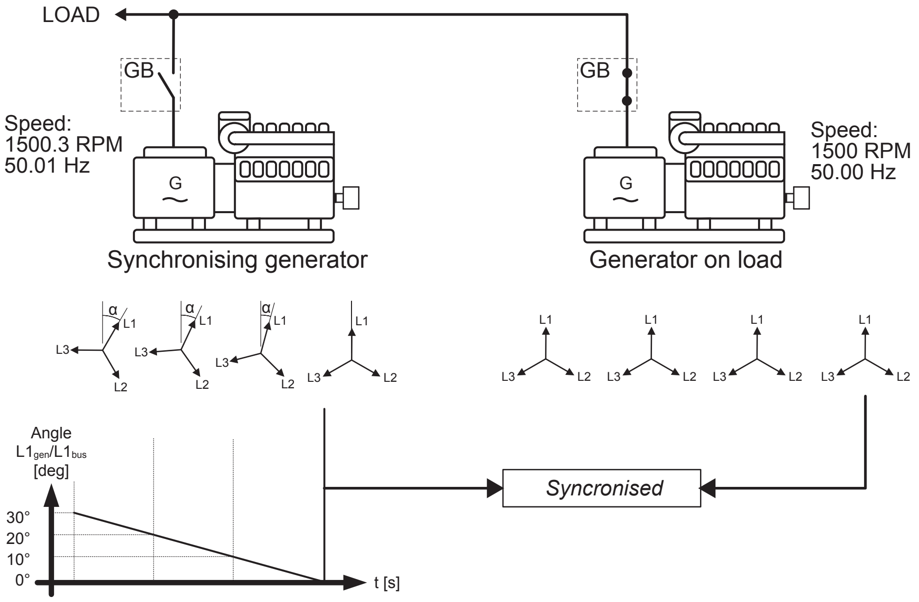
The diagram shows that at a given negative slip frequency, the incoming genset *receives* power from the original genset (reverse power).

NOTE To avoid nuisance trips caused by reverse power, configure a positive slip frequency.

6.7 Static synchronisation

When static synchronisation is activated, the frequency controller brings the genset frequency towards the busbar frequency. When the genset frequency is within 50 mHz of the busbar frequency, the phase controller takes over.

Static principle



The frequency controller uses the angle difference between the generator system and the busbar system as control parameter. This is shown in the example above, where the phase controller brings the phase angle from 30 to 0 °.

6.7.1 Settings for static synchronisation

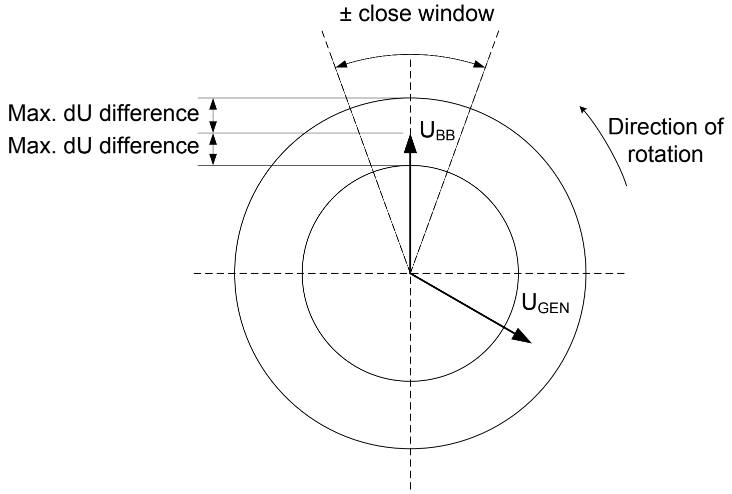
Synchronisation > Static sync > Static sync

Parameter	Text	Range	Default
2031	Sync. dfMax	0.00 to 0.50 Hz	0.10 Hz
2032	Sync. dfMin	1 to 10 %	5 %
2033	Close window	0.1 to 20.0 °	10°
2034	Timer	0.1 to 99.0 s	1.0 s
2035	GB type	Breaker sync Infinite sync	Breaker sync
2036	TB type	Breaker sync Infinite sync	Breaker sync

6.7.2 Close signal

The controller sends the close signal when phase L1 of the synchronising generator is close to the 12 o'clock position relative to the busbar which is also in 12 o'clock position. It is not relevant to use the response time of the circuit breaker when using static synchronisation, because the slip frequency is very small or non-existent.

To get faster synchronisation, a close window can be configured. The close signal can be sent when the phase angle U_{GENL1}-U_{BBL1} is within the adjusted set point. The range is ±0.1 to 20.0 °. This is shown in the diagram below.



The pulse is sent according to the settings for static synchronisation, depending on whether the GB or the SCB is to be synchronised.

6.7.3 Load picture after synchronisation

The synchronised genset will not be exposed to an immediate load after the breaker closure, if the maximum df setting is a low value. Since the fuel rack position almost equals what is required to run at the busbar frequency, no load jump will occur.

After synchronising, the controller will change the controller set point according to the requirements of the selected genset mode.

Static synchronisation is recommended where a slip frequency is not accepted, for instance if several gensets synchronise to a busbar with no load groups connected.

Static and dynamic synchronisation can be switched by with M-Logic.

6.8 Generator PID controller

6.8.1 Description of PID controller

The controller uses a PID controller. It consists of a proportional regulator, an integral regulator and a differential regulator. The PID controller is able to eliminate the regulation deviation and can easily be tuned in.

6.8.2 Regulators

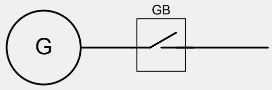
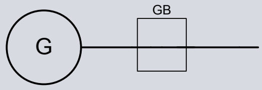
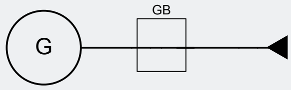
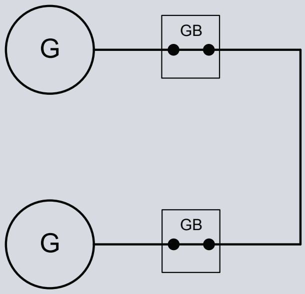
There are three regulators for the governor regulation and also three regulators for the AVR regulation.

Regulators for GOV and AVR

Regulator	GOV	AVR	Note
Frequency	●		Regulates the frequency.
Power	●		Regulates the power.
P load sharing	●		Regulates the active power load sharing.
Voltage		●	Regulates the voltage.
Var		●	Regulates the power factor.
Q load sharing		●	Regulates the reactive power load sharing.

The table below shows when each of the regulators is active. The regulator can be tuned when the running situation is present.

Active regulator

Governor			AVR			Schematic
Frequency	Power	PLS	Voltage	Q (var)	QLS	
●			●			
●			●			
	●			●		
		●			●	

6.8.3 Automatic selection

The controller switches between the PID controllers automatically (P-controllers for relay regulation). The controllers have different set points and inputs for the control loops.

The controller automatically switches between the different PID controllers according to the situation and position of the breakers in the application.

Governor

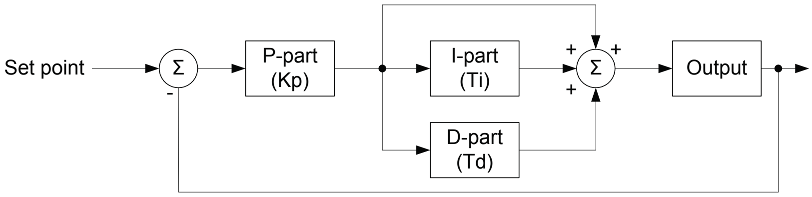
	Generator breaker open Island	Generator breaker closed but not parallel to grid Load share
Fixed frequency (f-controller)	●	
kW sharing with fixed frequency (P LS-controller)		●
Fixed kW (P-controller)		

AVR

	Generator breaker open Island	Generator breaker closed but not parallel to grid Load share
Fixed voltage (U-controller)	●	
kvar sharing with fixed voltage (Q LS-controller)		●
Fixed cos phi (Q-controller)		

6.8.4 Principle diagram

The diagram below shows the basic principle of the PID controller.



$$PID(s) = Kp \cdot \left(1 + \frac{1}{Ti \cdot s} + Td \cdot s\right)$$

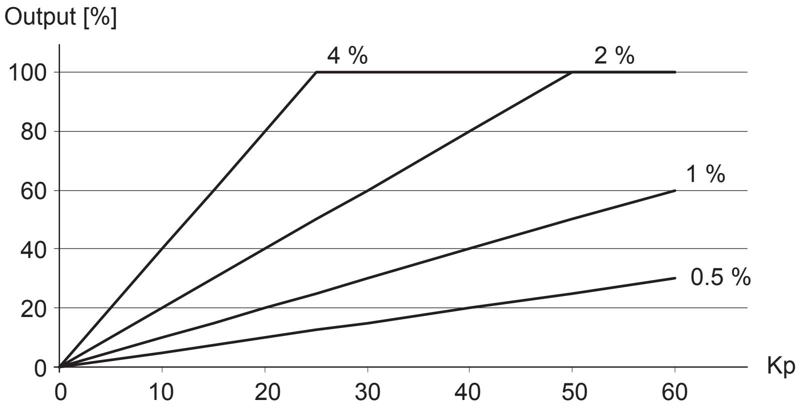
Each regulator (P, I and D) gives an output which is summarised to the total controller output. The adjustable settings for the PID controllers are:

- Kp: The gain for the proportional part.
- Ti: The integral action time for the integral part.
- Td: The differential action time for the differential part.

6.8.5 Proportional part of the regulator

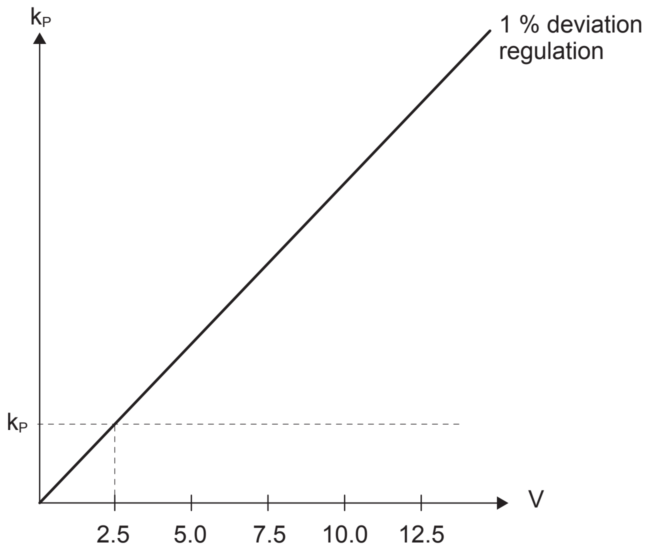
When the regulation deviation occurs, the proportional part causes an immediate change of the output. The size of the change depends on the gain Kp.

The diagram shows how the output of the P regulator depends on the Kp setting. The change of the output at a given Kp setting is doubled if the regulation deviation doubles.



Speed range

Because of the characteristics above, it is recommended to use the full range of the output to avoid an unstable regulation. If the output range used is too small, a small regulation deviation will cause a rather big output change. This is shown in the diagram below.



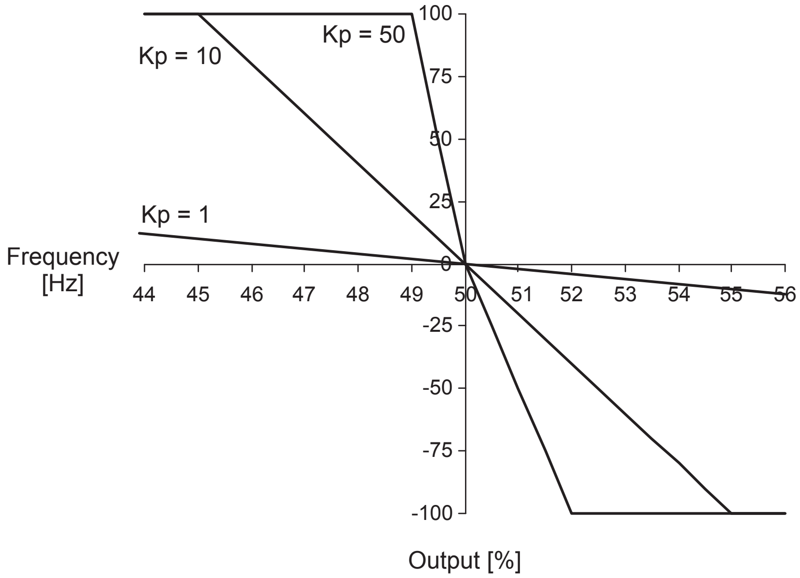
A 1 % regulation deviation occurs. With the Kp setting adjusted, the deviation causes the output to change 2.5 V. The table shows that the change in the output of the controller is relatively high if the maximum speed range is low.

Max. speed range	Output change	Calculations	Output change in % of max. speed range
5 V	2.5 V	2.5/5 · 100 %	50 %
10 V	2.5 V	2.5/10 · 100 %	25 %

DEIF recommends the bias range for the speed signal to be ±4 Hz, and the voltage can be regulated ±10 % of the nominal voltage.

Dynamic regulation area

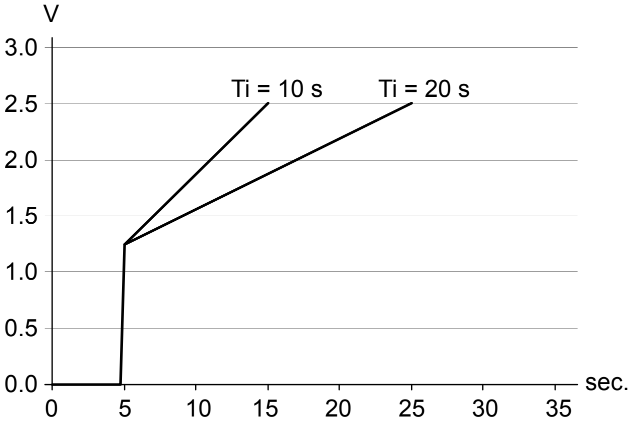
The diagram below shows the dynamic regulation area at given values of Kp. The dynamic area gets smaller if the Kp is adjusted to a higher value.



6.8.6 Integral part of the regulator

The main function of the integral regulator part is to eliminate offset. The integral action time Ti is defined as the time the integral regulator part uses to replicate the momentary change of the output caused by the proportional regulator part.

In the diagram below, the proportional regulator part causes an immediate change of 1.25 V. The integral action time (Ti) is then measured when the output reaches 2 x 1.25 V = 2.5 V.



The output reaches 5 mA twice as fast at a Ti setting of 10 s than with a setting of 20 s.

The integrating function of the I-regulator is increased if the integral action time is decreased. This means that a lower setting of the integral action time Ti results in a faster regulation.

NOTE If Ti is 0 s, the I-regulator is switched OFF.

The integral action time, Ti, must not be too low. This will make the regulation hunt similar to a too high proportional action factor, Kp.

6.8.7 Differential part of the regulator

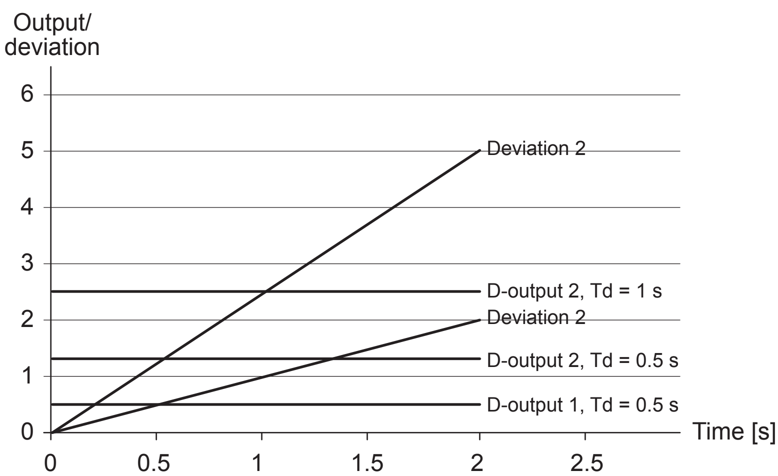
The main purpose of the differential regulator part is to stabilise the regulation, thus making it possible to set a higher gain and a lower integral action time Ti. This will make the overall regulation eliminate deviations much faster.

In most cases, the differential regulator part is not needed; however, in case of very precise regulation situations, for example static synchronisation, it can be very useful.

The output from the differential regulator part can be explained with the equation: $D = Td \cdot Kp \cdot \frac{de}{dt}$, where

- D = Regulator output
- Kp = Gain
- de/dt = Slope of the deviation (how fast does the deviation occur).

This means that the differential regulator part output depends on the slope of the deviation, the Kp and the Td setting. In the following example Kp= 1.



Deviation:

- Deviation 1: A deviation with a slope of 1.
- Deviation 2: A deviation with a slope of 2.5 (2.5 times bigger than deviation 1).
- D-output 1, Td=0.5 s: Output from the differential regulator part when Td = 0.5 s and the deviation is according to Deviation 1.
- D-output 2, Td=0.5 s: Output from the differential regulator part when Td = 0.5 s and the deviation is according to Deviation 2.
- D-output 2, Td=1 s: Output from the differential regulator part when Td = 1 s and the deviation is according to Deviation 2.

The example shows that the bigger deviation and the higher Td setting, the bigger output from the differential regulator part. Since this is responding to the slope of the deviation, it also means that when there is no change, the D-output will be zero.

NOTE When commissioning, please keep in mind that the Kp setting has influence on the differential regulator part output.

If the Td is adjusted to 0 s, the differential regulator part is switched OFF.

The differential action time, Td, must not be too high. This will make the regulation hunt similar to a too high proportional action factor, Kp.

6.8.8 Open GB controllers

When the genset is started and the generator breaker is open, the controller uses frequency control for the governor, and voltage control for the AVR. The controller regulates these values towards the nominal frequency and nominal voltage, and tries to maintain them at the nominal values.

During the start sequence, it is possible to delay the regulation. This makes it possible to have the controller's regulators kept at the offset until a timer has expired. This delay is started when running is detected. The timer in the delay of regulation function is always active and is by default set to 0 sec. If delay of regulation is enabled, the controller will give an alarm when the delay of regulation is active. If it is not enabled, it is possible to set the timer and not have an alarm.

`Engine > Speed control > Speed PID > Island`

Parameter	Text	Range	Default
2511	f Kp (Gain)	0.00 to 60.00	2.50
2512	f Ti (Stability)	0.00 to 60.00 s	1.50 s
2513	f Td (Derivative)	0.00 to 2.00 s	0.00 s
2514	f Droop	0.0 to 10.0 %	4 %

`Generator > AVR > Voltage PID > Island`

Parameter	Text	Range	Default
2641	U Kp (Gain)	0.00 to 60.00	2.50
2642	U Ti (Stability)	0.00 to 60.00 s	1.50 s
2643	U Td (Derivative)	0.00 to 2.00 s	0.00 s
2644	U Droop	0.0 to 10.0 %	4 %

`Engine > Speed control > Speed PID > Island`

Parameter	Text	Range	Default
2571	f deadband	0.2 to 10.0 %	1.0 %
2572	f Kp relay (Gain)	0 to 100	10
2573	f Droop relay	0.0 to 10.0 %	4.0 %

Engine > Speed control > Speed PID > Island

Parameter	Text	Range	Default
2691	U deadband	0.0 to 10.0 %	2.0 %
2692	U Kp relay (Gain)	0 to 100	10
2693	U Droop relay	0.0 to 10.0 %	4.0 %

Engine > Start sequence > After crank > Regulator delay at start > Delay reg.

Parameter	Text	Range	Default
2740	Delay timer	0 to 9900 s	3 s
	Output A	Terminals and M-Logic	Not used
	Output B	Terminals and M-Logic	Not used
	Enable	OFF ON	OFF

6.8.9 Parallel to grid controllers

When in MANUAL mode, generator and shore supply may run in parallel indefinitely while the breaker is closed

Engine > Speed control > Speed PID > Busbar parallel

Parameter	Text	Range	Default	Comment
2531	P Kp (Gain)	0.00 to 60.00	2.50	Analogue and EIC parameters.
2532	P Ti (Stability)	0.00 to 60.00 s	1.50 s	Analogue and EIC parameters.
2533	P Td (Derivative)	0.00 to 2.00 s	0.00 s	Analogue and EIC parameters.
2581	P deadband	0.2 to 10.0 %	2.0 %	Relay parameters.
2582	P Kp relay (Gain)	0 to 100	10	Relay parameters.

Generator > AVR > Voltage PID > Busbar parallel

Parameter	Text	Range	Default	Comment
2651	Q Kp (Gain)	0.00 to 60.00	2.50	Analogue and EIC parameters.
2652	Q Ti (Stability)	0.00 to 60.00 s	1.50 s	Analogue and EIC parameters.
2653	Q Td (Derivative)	0.00 to 2.00 s	0.00 s	Analogue and EIC parameters.
2701	Q deadband	0.2 to 10.0 %	2.0 %	Relay parameters.
2702	Q Kp relay (Gain)	0 to 100	10	Relay parameters.

6.8.10 Synchronising controllers

The synchronising controller is used whenever synchronising is activated. After a successful synchronisation, the frequency controller is deactivated and the relevant controller is activated. This could, for example, be the load sharing controller.

`Synchronisation > Sync. type`

Parameter	Text	Range	Default
2000	Type	Dynamic sync. Static sync.	Dynamic sync.

Dynamic synchronising

When dynamic synchronising is used, the f_{SYNC} controller is used during the entire synchronising sequence. One of the advantages of dynamic synchronising is that it is relatively fast. To improve the speed of the synchronising further, the generator is sped up between the points of synchronisation (12 o'clock to 12 o'clock) of the two systems. Normally, a slip frequency of 0.1 Hz gives synchronism each 10 seconds, but with this system on a steady engine, the time between synchronism is reduced.

`Synchronisation > Sync. regulator`

Parameter	Text	Range	Default
2041	f sync. Kp (Gain)	0.00 to 60.00	2.50
2042	f sync. Ti (Stability)	0.00 to 60.00 s	1.50 s
2043	f sync. Td (Derivative)	0.00 to 2.00 s	0.00 s
2050	f sync. Kp relay (Gain)	0 to 100	10

Static synchronisation

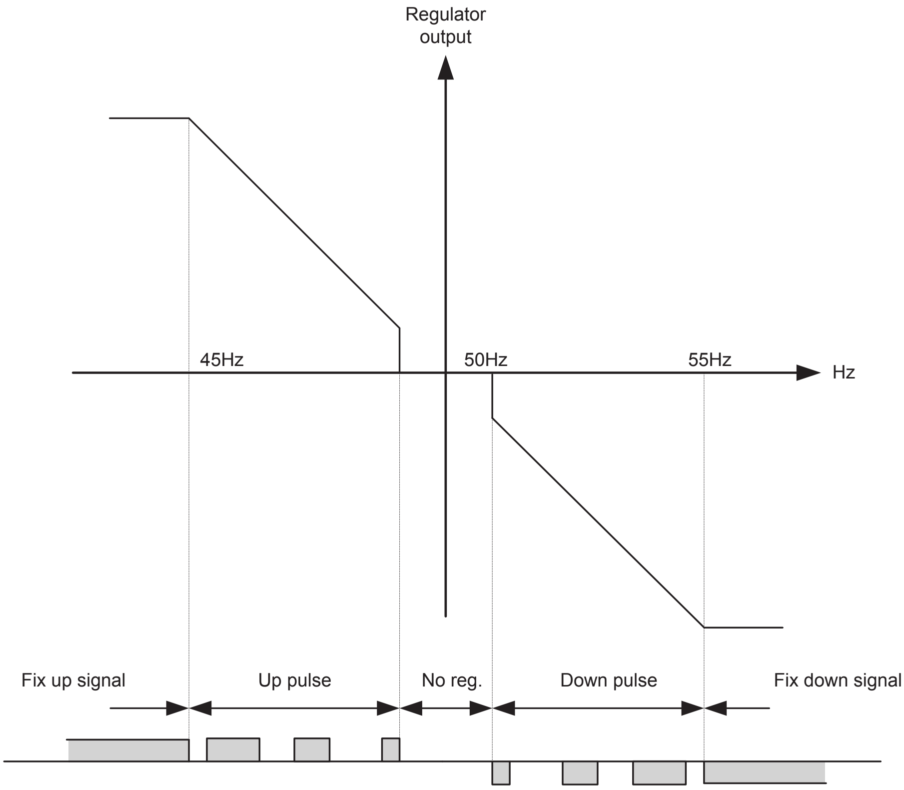
When synchronising is started, the synchronising controller f_{SYNC} controller is activated and the generator frequency is controlled towards the busbar frequency. The phase controller takes over when the frequency deviation is so small that the phase angle can be controlled.

`Synchronisation > Static sync > Sync. regulator`

Parameter	Text	Range	Default
2061	Phase Kp (Gain)	0.00 to 60.00	0.50
2062	Phase Ti (Stability)	0.00 to 60.00 s	3.00 s
2063	Phase Td (Derivative)	0.00 to 2.00 s	0.00 s
2070	Phase Kp relay (Gain)	0 to 100	10

6.8.11 Relay control

When the relay outputs are used for control purposes, the regulation works like this:



The regulation with relays can be split up into five steps.

No.	Range	Description	Note
1	Static range	Fix up signal	The regulation is active, but the increase relay is activated constantly because of the size of the regulation deviation.
2	Dynamic range	Up pulse	The regulation is active, and the increase relay pulses to eliminate the regulation deviation.
3	Deadband area	No reg.	In this range, there is no regulation. Having a predefined deadband area increases the lifetime of the relays.
4	Dynamic range	Down pulse	The regulation is active, and the decrease relay pulses to eliminate the regulation deviation.
5	Static range	Fix down signal	The regulation is active, but the decrease relay is activated constantly because of the size of the regulation deviation.

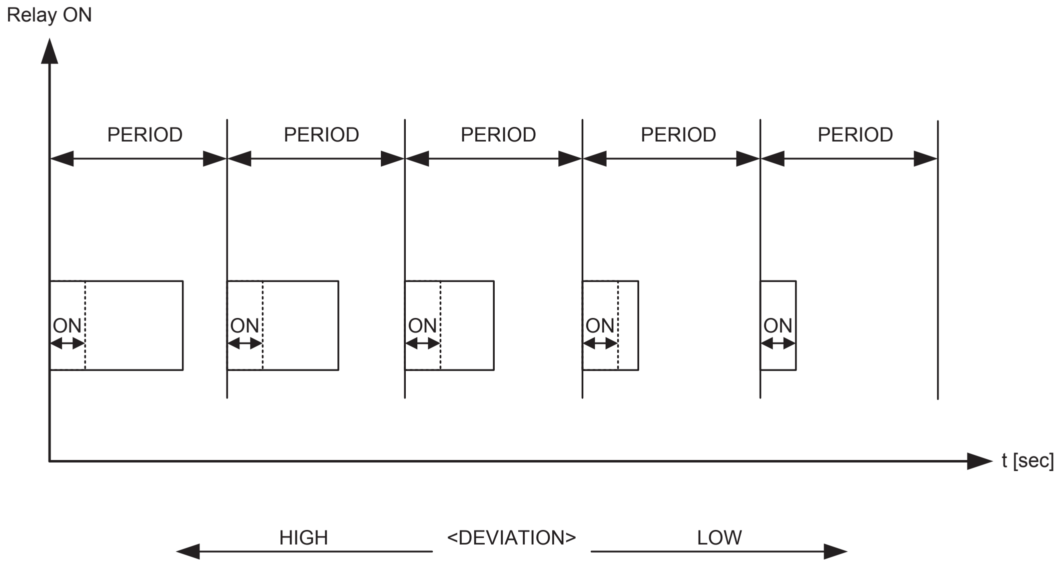
As the diagram shows, the relays are fixed ON if the regulation deviation is big, and they pulse if it is closer to the set point. In the dynamic range, the pulses get shorter and shorter when the regulation deviation gets smaller. Just before the deadband area, the pulse is as short as it can get. This is the *GOV ON time*/(*AVR ON time*). The longest pulse is at the end of the dynamic range (45 Hz in the example above).

Relay adjustments

The time settings for the regulation relays can be configured in the control setup.

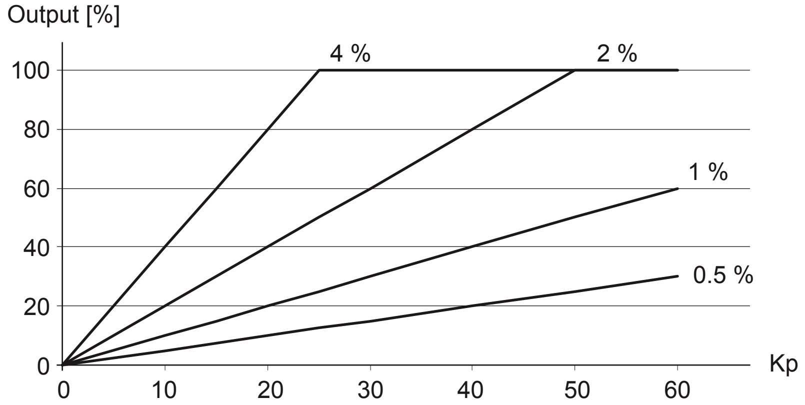
Adjustment	Description	Note
Period time	Maximum relay time	The time between the start of two subsequent relay pulses.
ON time	Minimum relay time	The minimum length of the relay pulse. The relays are never activated for a shorter time than the ON time.

The length of the relay pulse depends on the regulation deviation. If the deviation is big, then the pulses are long (or a continued signal). If the deviation is small, then the pulses are short.



Signal length

The signal length is calculated compared to the adjusted period time. The diagram below shows the effect of the proportional regulator.



In this example, there is a 2 % regulation deviation and an adjusted value of the Kp = 20. The calculated regulator value of the controller is 40 %. Now the pulse length can be calculated with a period time = 2500 ms:

- eDEVIATION/100*tPERIOD
- 40/100∗2500 = 1000 ms

The length of the period time is never shorter than the adjusted ON time.

6.9 Power ramp

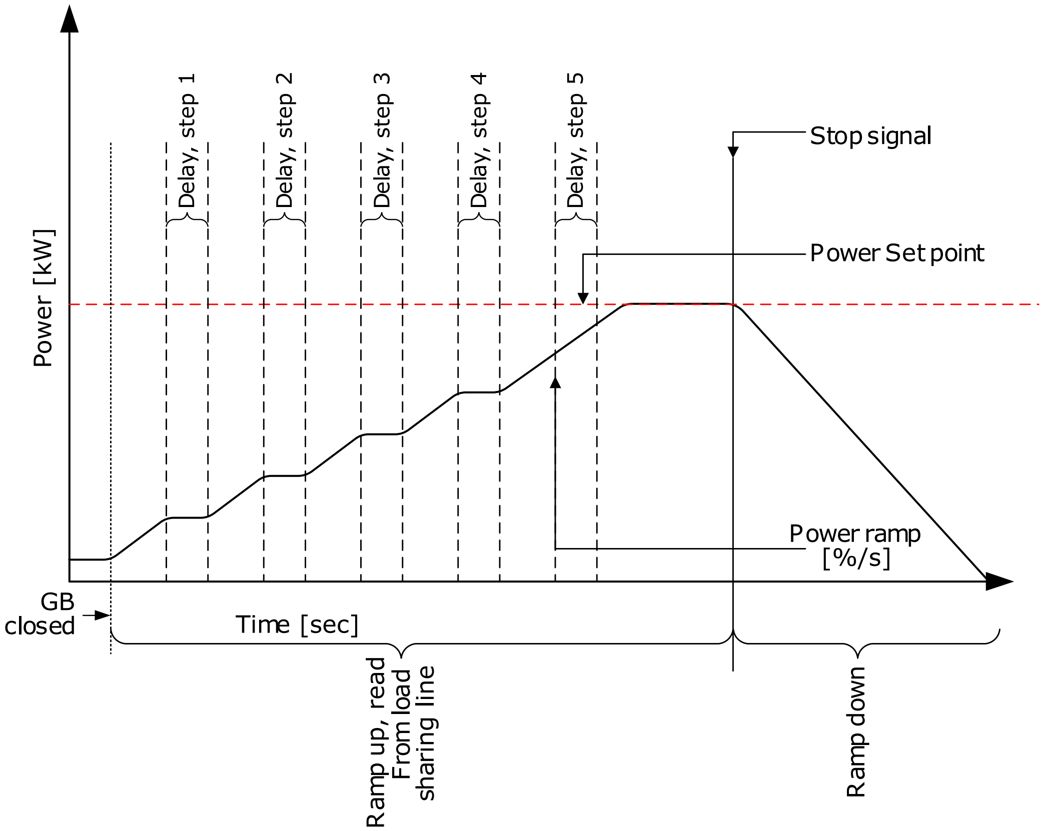
The power ramp function is used to ramp up or down towards the set points. For example, when a breaker has just been closed, and a genset is parallel to the grid. The power ramp then ramps up towards the power set point.

Power ramp is set in %/s, which determines how fast the controller should ramp up towards the set point. The regulators can then be fine tuned, so the genset is kept on the power ramp when going up or down towards the set point. When the set point is reached, the regulators keep the power set point even though there are frequency deviations.

In island running mode, the power ramp is also used. For example, when a genset is started in an AMF situation to help other running genset(s). When the generator breaker is closed, the incoming genset takes load with the power ramp as slope.

The power ramp up can have load steps. You can configure how many steps the power ramp should have from 0 to 100 % power, and how many percent between each step. When each step is reached, there can be a delay time, before regulating further up on the power ramp. The power ramp up speed and power ramp down speed are configured individually, and are used in all running modes.

The diagram below gives an overview of how the speed and power ramp function can be configured.



`Power set points > Loading/Deloading ramps > kW ramp up speed`

Parameter	Text	Range	Default
2611	Power ramp up speed 1	0.1 to 20.0 %/s	2.0 %/s
2612	Power ramp up delay point	1 to 100 %	10 %
2613	Power ramp up delay at each step	0 to 9900 s	10 s
2614	GEN LS ramp	OFF ON	OFF
2615	Power ramp up steps	0 to 100	1
2616	Power ramp up speed 2	0.1 to 20.0 %/s	0.1 %/s

Power ramp 1 is the primarily used power ramp. Power ramp 1 is only ignored during frequency-dependent power droop or if power ramp 2 is activated with M-Logic.

Power ramp 2 is a secondary power ramp. It is normally used for frequency-dependent power droop, but it can also be activated using any M-Logic event. Set *Auto Ramp Select* to OFF, if Power ramp 2 should be activated by M-Logic.

`Power set points > Loading/Deloading ramps > Auto Ramp Select`

Parameter	Text	Range	Default
2624	Auto Ramp Select	OFF ON	OFF

Ramp up with load steps

When the GB is closed, the power set point continues to rise in steps (determined by the setting in parameter 2615). If the delay point is set to 20 %, the delay time to 10 seconds, and the number of load steps is set to 3:

1. The genset ramps to 20 %
2. Wait 10 seconds
3. Ramp to 40 %
4. Wait 10 seconds
5. Ramp to 60 %
6. Wait 10 seconds
7. Ramp to the power set point

`Power set points > Loading/Deloading ramps > kW ramp down speed`

Parameter	Text	Range	Default
2621	Power ramp down speed 1	0.1 to 20.0 %/s	3.3 %/s
2623	Power ramp down speed 2	0.1 to 20.0 %/s	0.1 %/s

Freeze power ramp

A way to define the ramp up steps is to use the freeze power ramp command in M-Logic.

Freeze power ramp active: The power ramp stops at any point of the power ramp, and this set point is maintained as long as the function is active. If the function is activated while ramping from one delay point to another, the ramp is fixed until the function is deactivated again.

6.10 Droop mode

6.10.1 Principle and setup

Droop mode can be used when a new genset is installed together with existing gensets which operate in droop mode. This ensures equal load sharing with the existing gensets. Droop mode can be used when the generator frequency must (or should) drop with increasing load.

The droop mode parameters can be adjusted between 0-10 % droop. If the value is different from 0 %, the droop percentage is applied on top of the regulation output of the governor (f) or AVR (U).

Frequency droop is determined as a percentage of the nominal frequency:
- If the active power is 0 %, the reference frequency is equal to the nominal frequency.
- If the active load is 100 %, the reference frequency is 96 % of the nominal frequency.

Voltage droop is determined as a percentage of the nominal voltage:
- If the reactive power is 0 %, the reference voltage is equal to the nominal voltage.
- If the reactive inductive load is 100 %, the reference voltage is 96 % of the nominal voltage.
- If the reactive capacitive load is 100 %, the reference voltage is 104 % of the nominal voltage.

`Engine > Speed control > Speed PID > Island`

Parameter	Text	Range	Default
2514	f droop	0.0 to 10.0 %	4.0 %
2573	f droop relay	0.0 to 10.0 %	4.0 %

`Generator > AVR > Voltage PID > Island`

Parameter	Text	Range	Default
2644	U droop	0.0 to 10.0 %	4.0 %
2693	U droop relay	0.0 to 10.0 %	4.0 %

NOTE When using droop mode, the frequency PID (f) and voltage PID (U) is active.

Activating droop regulation with M-Logic commands

The following M-Logic commands are used to activate droop regulation. This gives more options to activate the droop regulation with, for example, a digital input, AOP button, or an event.

M-Logic output	M-Logic command	Note
GOV/AVR control	Act. frequency droop regulation	Activates the use of frequency droop parameters mentioned above.
GOV/AVR control	Act. voltage droop regulation	Activates the use of voltage droop parameters mentioned above.

NOTE The command *Inhibit analogue loadshare* must be activated in M-Logic to force the controller from load sharing PID to frequency PID (f) and voltage PID (U). Otherwise, the droop function does not work.

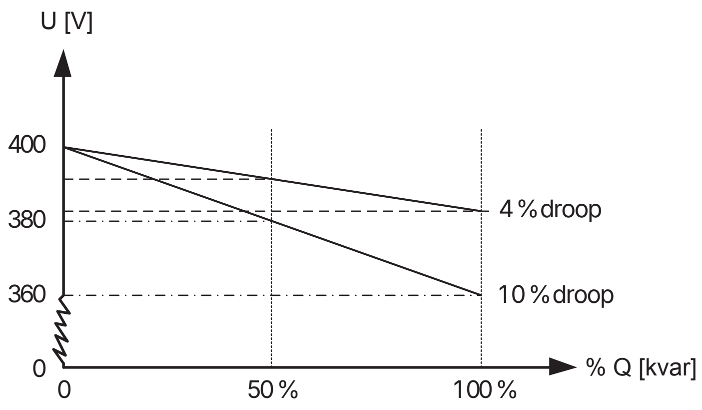
Application configuration

When operating in droop mode, the controller must have a single genset application drawing. This is done with the utility software. Use one of the pre-configured applications, or configure a single genset application.

More information
See **Setup of applications** for application configuration.

6.10.2 Voltage droop example

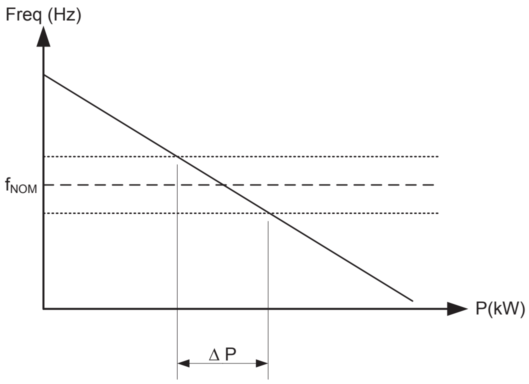
The diagram below shows an example for one generator where the voltage droop setting is 4 % and 10 % in proportion to the reactive power, Q (kvar). As it is shown in the example, the voltage drops as the load increases. The principle is the same with generators in parallel where the generators will use the droop to share the load and allow the voltage/frequency to drop accordingly.



6.10.3 Droop settings

High droop setting

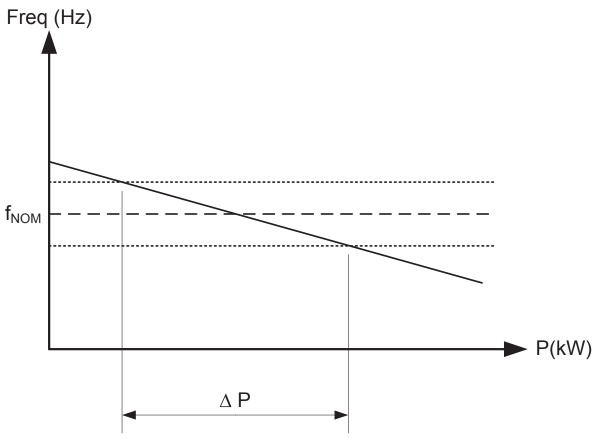
The diagram below shows how a frequency variation gives a change in the load. The principle is the same with voltage regulation. The load change is marked as ΔP.



This can be used if the generator must operate base-loaded.

Low droop setting

In this diagram, the load change (ΔP) is larger than before. This means that the generator load varies more than with the higher droop setting.



This can be used if the generator must operate as a peak load machine.

6.10.4 Compensation for isochronous governors

When the genset is equipped with a governor only providing isochronous operation, the droop setting can be used to compensate for the missing droop setting possibility on the governor.

6.11 Load shedding and adding

You can create up to five load groups. Load group 1 has the highest priority.

Wiring

You need a digital output for each load group. For each digital output, configure the function *Load group [1 to 5]*. The controller activates the digital output when enough power is available for the load group.

Generator start

To minimise the generator's start load, configure how many load groups the controller connects before the genset breaker is closed (parameter 6381).

Adding load(s) while the generator is running

If the generator load is below the *Load adding return* set point (parameter 6384):

1. The controller starts the *Load adding return timer* (parameter 6385).
2. If the timer has expired, the controller activates the highest priority load group output.

3. If the load remains below the set point, steps 1 and 2 repeat, until all the load groups are connected.

Shedding load(s) while the generator is running

If the generator load is above the *Load shedding trip* set point (parameter 6382):

1. The controller starts the *Load shedding trip timer* (parameter 6383).
2. If the timer has expired, the controller deactivates the lowest priority load group output.
3. If the load remains above the set point, steps 1 and 2 repeat, until all the load groups are disconnected.

Generator stop

The controller disconnects all the load groups when it opens the generator breaker.

`Functions > Load shedding/adding`

Parameter	Text	Range	Default
6381	Load group start	0 to 5	3
6382	Load shedding trip set point	30 to 100 %	80 %
6383	Load shedding trip timer	1 to 100 s	5 s
6384	Load adding return set point	30 to 100 %	70 %
6385	Load adding return timer	1 to 100 s	5 s
6386	Load she/add enable	OFF ON	OFF

6.12 Derate function

The derate function is used to reduce the maximum output power and/or reactive power of the genset. The derate function is typically used when cooling problems are expected. For example:

1. If the ambient temperature increases to a level that exceeds the cooling capacity, it will be necessary to reduce the power of the genset.
2. If the temperature in the generator gets to high, the reactive power must be derated to avoid alarms and shutdown.

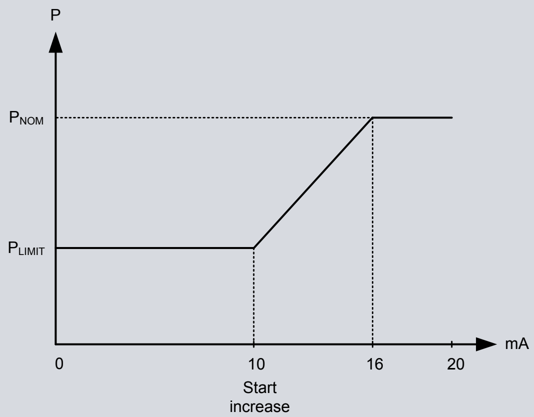
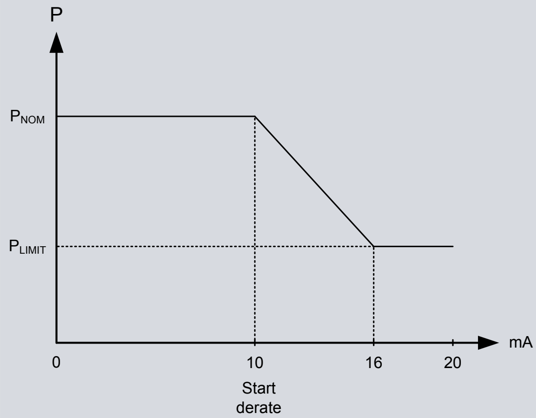
Up to three power derate curves and two reactive power curves can be made to derate the genset. The first active curve will derate the genset to the adjusted set point.

Derate function inputs

Input	Notes
Multi-input 20	0-10 V DC 4-20 mA Pt100 RMI Digital
Multi-input 21	
Multi-input 22	
Multi-input 23	
M-Logic	
EIC	Water temperature Oil temperature Ambient temperature Intercooler temperature Fuel temperature

6.12.1 Power derate parameters (P-derate)

The parameters that define the power derate characteristics are:

Parameter name	Description
Start derate point	Starting point for the derate. Depending on the input, the unit can be 4-20 mA or ºC (max. 200 ºC).
Derate slope	Adjust the derate speed in percent per unit. This means that if the 4-20 mA input is used, the derating will be in %/mA, and if the Pt100/RMI input is used, then the derating will be in %/ºC. The 4-20 mA input can be configured with different minimum and maximum settings. In this case, the settings Start derate point and Slope use these new settings.
Derate limit	The lowest derate level in percent. It can be selected whether the characteristic of the derate should be proportional or inverse proportional. The genset is derated when the control value is lower than the set point (in the example above the control value is an mA signal). **Proportional**  **Inverse proportional** 

Engine > Protections > Power derate > Power derate [1 to 3]

Parameter	Text	Range	Default
6241, 6251 or 6261	Power derate input type	Multi-input 20 to 23 M-Logic EIC temperature inputs Ext. I/O Analogue 1 to 8	Multi-input 20
6242, 6252 or 6262	Start derate at . . .	0 to 20000 units	16 units
6243, 6253 or 6263	Derate slope	0.1 to 100.0 %/unit	5.0 %/unit
6246, 6256 or 6266	Derate limit	0.0 to 100.0 %	80 %

6.13 4th current transformer input

The 4th current transformer input (terminals 60-61) can be used for one of these functions:

- **Neutral line over-current protections**: Place the CT on the N line from the genset.
- **Filtered Neutral line over-current protections**: Place the CT on the N line from the genset. The function includes third harmonics filtering of the signal.

Basic settings > Measurement setup > Current transformer > 4th CT

Parameter	Text	Range	Default
6045	I primary E/N/SC	5 to 9000 A	1000 A
6046	I secondary E/N/SC	1 A 5 A	1 A

4th CT input selection

Select what the 4th current transformer input is used for.

Parameter	Text	Range	Default
14201	4th CT trip select	OFF BB/EDG busbar current Neutral current Earth fault current	OFF

6.14 Inputs and outputs

6.14.1 Digital input functions

Default

Function	Details	AUTO mode	MANUAL mode	SWBD mode	Block mode	Type*
PMS control	When the digital input configured for PMS (Power Management System) control is disabled, the controller shifts to SWBD mode. This means that automatic PMS functions are no longer active, and the genset must be controlled manually from the switchboard.	●	●	●	●	C
GB position ON	The input function is used as an indication of the generator breaker position. The controller requires this feedback when the breaker is closed or a position failure alarm occurs.	●	●	●	●	C
GB position OFF	The input function is used as an indication of the generator breaker position. The controller requires this feedback when the breaker is opened or a position failure alarm occurs.	●	●	●	●	C

Configurable

Function	Details	AUTO mode	MANUAL mode	SWBD mode	Block mode	Type*
Start enable	This input must be activated to be able to start the engine. When the genset is started, the input can be removed.	●	●	●		C
Remote start	This input initiates the start sequence of the genset when MANUAL or SWBD mode is selected.		●			C
Remote stop	This input initiates the stop sequence of the genset when MANUAL or SWBD mode is selected. The genset stops without cooling down.		●			C
Remove starter	The start sequence is deactivated. This means the start relay deactivates, and the starter motor disengages.	●	●			C
Low speed	Disables the regulators and keeps the genset running at a low RPM. The governor must be prepared for this function.	●	●			C
Binary running detection	The input is used as a running indication of the engine. When the input is activated, the start relay is deactivated.	●	●		●	C
Oil pressure alarm	The oil pressure alarm is activated if the oil pressure exceeds the set point. The function automatically sets *Not run status* as the inhibit, the alarm input as *Low*, and *Shutdown* as the fail class.	●	●	●	●	C
Water temperature alarm	The water temperature alarm is activated if the water temperature exceeds the set point. The function automatically sets *Shutdown override* as the inhibit, the alarm input as *Low*, and *Shutdown* as the fail class.	●	●	●	●	C

Function	Details	AUTO mode	MANUAL mode	SWBD mode	Block mode	Type*
Remote GB ON	The generator breaker close sequence is initiated and the breaker synchronises if the shore connection breaker is closed, or close without synchronising if the shore connection breaker is open.		●			P
Remote GB OFF	The generator breaker open sequence is initiated. If the shore connection breaker is open, then the generator breaker opens instantly. If the shore connection breaker is closed, the generator load is deloaded to the breaker open limit followed by a breaker opening.		●			P
Remote start and GB close	Manual start and synchronise command.		●			P
Remote GB open and stop	Manual de-load, open breaker and stop.		●			P
GB close inhibit	When this input is activated, the generator breaker cannot close.	●	●		●	C
GB racked out	The breaker is considered as racked out when pre-requirements are met and this input is activated.		●			C
GB spring loaded	The controller does not send a close signal before this feedback is present.	●	●		●	C
GB OFF and BLOCK	The generator breaker opens, and the genset activates the stop sequence. When the genset is stopped, it is blocked for start.		●			P
Enable GB black close	When the input is activated, the controller is allowed to close the generator on a black busbar, providing that the frequency and voltage are inside the limits in parameter 2110.	●	●		●	C
MANUAL mode	Changes the running mode to MANUAL.	●			●	P
AUTO mode	Changes the running mode to AUTO.		●		●	P
1. Priority		●	●			C
Block mode		●	●	●	●	C
Deload	A running genset starts to ramp down the power.	●				C
Man. GOV up	In MANUAL mode, the governor output is increased.			●		C
Man. GOV down	In MANUAL mode, the governor output is decreased.			●		C
Man. AVR up	In MANUAL mode, the AVR output is increased.			●		C
Man. AVR down	In MANUAL mode, the AVR output is decreased.			●		C
Reset Ana GOV output	Reset analogue GOV/AVR outputs. The analogue ±20 mA controller outputs are reset to 0 mA.	●	●		●	C
Ext. Frequency control	The controller allows an external system to adjust the genset frequency.	●	●			C
Ext. Power control	The controller allows an external system to adjust the genset power.	●	●			C
Ext. Voltage control	The controller allows an external system to adjust the genset voltage.	●	●			C
Ext. cosphi control	The controller allows an external system to adjust the genset cosphi.	●	●			C

Function	Details	AUTO mode	MANUAL mode	SWBD mode	Block mode	Type*
Ext. Var control	The controller allows an external system to adjust the genset Var.	●	●			C
Access lock	Activating the access lock input deactivates the control display buttons. It is only possible to view measurements, alarms and the log.	●	●	●	●	C
Remote alarm ack.	Acknowledges all activated alarms, and the alarm LED on the display stops flashing.	●	●	●	●	C
Shutdown override	This input deactivates all protections except the over-speed protections, the emergency stop input, the fast over-current protection, and the EIC over-speed protection. A special cool down timer is used in the stop sequence after activation of this input. Active alarms for deactivated protections are shown in the alarm list and log, but the fail class is still inhibited.	●	●	●		C
Battery test	Activates the starter without starting the genset. If the battery is weak, the test makes the battery voltage to drop more than acceptable, and an alarm is activated.	●	●			P
Temperature control	This input is part of the idle mode function. When the input is high, the genset starts. It starts at high or low speed, depending on the activation of the low speed input. When the input is deactivated, the genset goes to idle mode (low speed = ON), or it stops (low speed = OFF).	●	●			C
SDU status OK	Status of the shutdown unit (SDU).	●	●	●	●	C
SDU warning	Warning status from the shutdown unit (SDU).	●	●	●	●	C
SDU comm error		●	●	●	●	C
Secured mode ON	Starts secured running mode. Secured mode adds an extra generator to the system, this means that one generator too many is running when comparing with the actual power requirement.	●	●		●	P
Secured mode OFF	Ends secured running mode. Secured mode adds an extra generator to the system, this means that one generator too many is running when comparing with the actual power requirement.	●	●		●	P
Allow safe regeneration	Refer to **iE 150 AGC 150 Engine communication** for details.	●	●			C
Simulate start button push	This input is used to simulate the start button being pushed.		●			P
Simulate stop button push	This input is used to simulate the stop button being pushed.		●			P
Simulate GB close button push	This input is used to simulate the close breaker (generator) button being pushed.		●			P
Simulate GB open button push	This input is used to simulate the open breaker (generator) button being pushed.		●			P

Function	Details	AUTO mode	MANUAL mode	SWBD mode	Block mode	Type*
Simulate AUTO mode button push	This input is used to simulate the AUTO mode button being pushed.		●			P
Simulate MANUAL mode button push	This input is used to simulate the MANUAL mode button being pushed.		●			P
Simulate alarm list button push	This input is used to simulate the alarms button being pushed.		●			P

NOTE * C = Continuous, P = Pulse
NOTE See **iE 150 AGC 150 Engine communication** for digital inputs for specific engine protocols.

6.14.2 Differential measurement

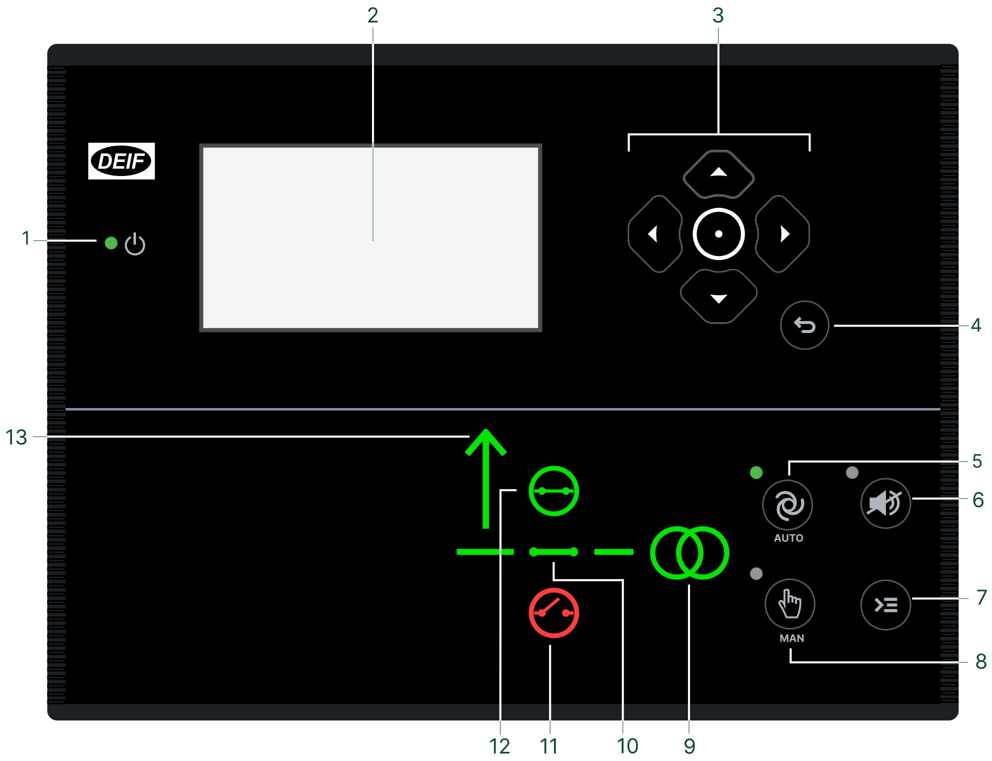
You can use a variety of measurements in the six differential measurement functions. The following table lists some of the measurements. See the utility software for the complete list.

Measurement	Notes
Multi input [20 to 23]	The value measured by the multi input. Multi input 20 is the default.
EIC Oil pres. (SPN 100)	The EIC oil pressure.
EIC Cooling water temp. (SPN 110)	The EIC cooling water temperature.
EIC Oil temp. (SPN 175)	The EIC oil temperature.
EIC Ambient temp. (SPN 171)	The EIC ambient temperature.
EIC Intercool temp. (SPN 52)	The EIC intercooler temperature.
EIC Fuel temp. (SPN 174)	The EIC fuel temperature.
EIC Fuel delivery pres. (SPN 5579)	The EIC fuel delivery pressure.
EIC Air filter1 diff. pres. (SPN 107)	The EIC air filter 1 differential pressure.
EIC Air filter2 diff. pres. (SPN 2809)	The EIC air filter 2 differential pressure.
EIC Fuel supply pump pres. (SPN 1381)	The EIC fuel supply pump pressure.
EIC Fuel filter diff. pres. SS (SPN 1382)	The EIC fuel filter SS differential pressure.
EIC Oil filter diff. pres. (SPN 99)	The EIC oil filter differential pressure.
EIC T. Exhaust left (SPN 2434)	The EIC left exhaust temperature.
EIC T. Exhaust right (SPN 2433)	The EIC right exhaust temperature.
EIC Fuel filter diff. pres. (SPN 95)	The EIC fuel filter differential pressure.
EIC T. Winding Highest	The EIC winding highest temperature.
EIC T. Winding Lowest	The EIC winding lowest temperature.
EIC T. Winding [1 to 3]	The EIC winding temperature.
EIC DEF Level (SPN 1761)	The EIC DEF level.
EIC DEF Temp (SPN 3031)	The EIC DEF temperature.
DEIF DVC 550 PT100_[1 to 5]	The temperature read by the Pt100 thermocouple in the DVC 550.

Measurement	Notes
EIC Speed (SPN 190)	The EIC engine speed.
MPU speed	The engine speed measured by the MPU connected to the controller.

7. Shore functions

7.1 Display layout



No.	Name	Function
1	Power	Green: The controller power is ON. OFF: The controller power is OFF.
2	Display screen	Resolution: 240 x 128 px. Viewing area: 88.50 x 51.40 mm. Six lines, each with 25 characters.
3	Navigation buttons	Move the selector up, down, left and right on the screen.
	Enter button	Confirms the selection
4	Back button	Go to the previous page.
5	AUTO mode button	The controller automatically connects and disconnects the shore connection. No operator actions are needed. The controllers use the power management configuration to automatically select the power management action.
6	Silence horn button	Stops an alarm horn (if configured) and enters the Alarm menu.
7	Shortcut menu button	Access the General shortcuts, Jump menu, Mode selection, Test, and Lamp test.
8	Manual mode button	The operator or an external signal can connect or disconnect the shore connection. The shore controller cannot automatically connect or disconnect the shore connection. The controller automatically synchronises before closing a breaker, and automatically deloads before opening a breaker.

No.	Name	Function
9	Shore connection symbol	Green: The voltage and frequency are OK. The controller can synchronise and close the breaker. Red: Shore connection failure.
10	Breaker symbols	Green: Breaker is closed. Green flashing: Synchronising or deloading. Red: Breaker failure.
11	Open breaker	Push to open the breaker.
12	Close breaker	Push to close the breaker.
13	Load symbol	OFF: Power management application. Green: The supply voltage and frequency are OK. Red: Supply voltage/frequency failure.

7.2 Shore alarms

7.2.1 Fail classes

Fail class/Action	Alarm horn relay	Alarm display	Trip SCB
Block	●	●	
Warning	●	●	
Trip SCB	●	●	●

The fail classes have different impacts on the system. If a breaker is in open position, the alarms have the following impact:

Fail class/Action	Block SCB sequence
Block	
Warning	
Trip SCB	●

7.2.2 Inhibits

Function	Notes
Inhibit 1	M-Logic outputs: Conditions are programmed in M-Logic.
Inhibit 2	
Inhibit 3	
SCB close	The shore connection breaker is closed.
SCB open	The shore connection breaker is open.

7.3 Shore connection breaker

7.3.1 Breaker settings

`Synchronisation > Dynamic sync.`

Parameter	Text	Range	Default
2026	Sync. time SCB	40 to 300 ms	50 ms

`Breakers > Shore breaker > Breaker configuration`

Parameter	Text	Range	Default
7082	SCB close delay	0.0 to 30.0 s	0.5 s
7085	SCB Load time	0.0 to 30.0 s	0.0 s

7.3.2 Breaker sequences

Set points for SCB control

Parameter	Text	Description
7082	SCB close delay	The time from GB OFF to SCB ON, when back synchronisation is OFF.
7083	Back Synchronising	Enables synchronisation from shore to generator. **With back synchronisation**: When the *GB* or *SCB* button is activated, the controller starts synchronising if the generator or shore voltage is present. The GB can close directly if the SCB is open, and the SCB can close directly if the GB is open. **Without back synchronisation**: The GB can only be closed if the SCB is open. The SCB can only be closed if the GB is open.
7084	Sync. to shore	Enables synchronisation from generator to shore.
7085	SCB Load time	After opening the breaker, the SCB ON sequence is not initiated before this delay has expired.

If there is no SCB in the application drawing (see *Application configuration* in the utility software), then the relays for opening/closing and inputs for feedbacks normally used for SCB control/supervision become configurable.

NOTE You can use the following measurements in the six differential measurement functions.

`Breakers > Shore breaker > Breaker configuration`

Parameter	Text	Range	Default
7082	SCB close delay	0.0 to 30.0 s	0.5 s
7085	SCB Load time	0.0 to 30.0 s	0.0 s

SCB opening

If the controller operates in Shore Failure, it is necessary to select the functionality of the shore connection breaker opening function. This can be helpful, when the SCB can only be operated with voltage on the shore or on the busbar.

`Shore > Shore functions > Shore timer`

Parameter	Text	Range	Default
7061	U shore failure	0.5 to 990.0 s	5.0 s
7062	Shore OK Delay U	2 to 9900 s	60 s
7071	f shore failure	0.5 to 990.0 s	5.0 s
7072	Shore OK Delay f	2 to 9900 s	60 s

`Shore > Voltage and frequency limits > Voltage settings`

Parameter	Text	Range	Default
7066	Unbalance voltage	2 to 100 %	100 %

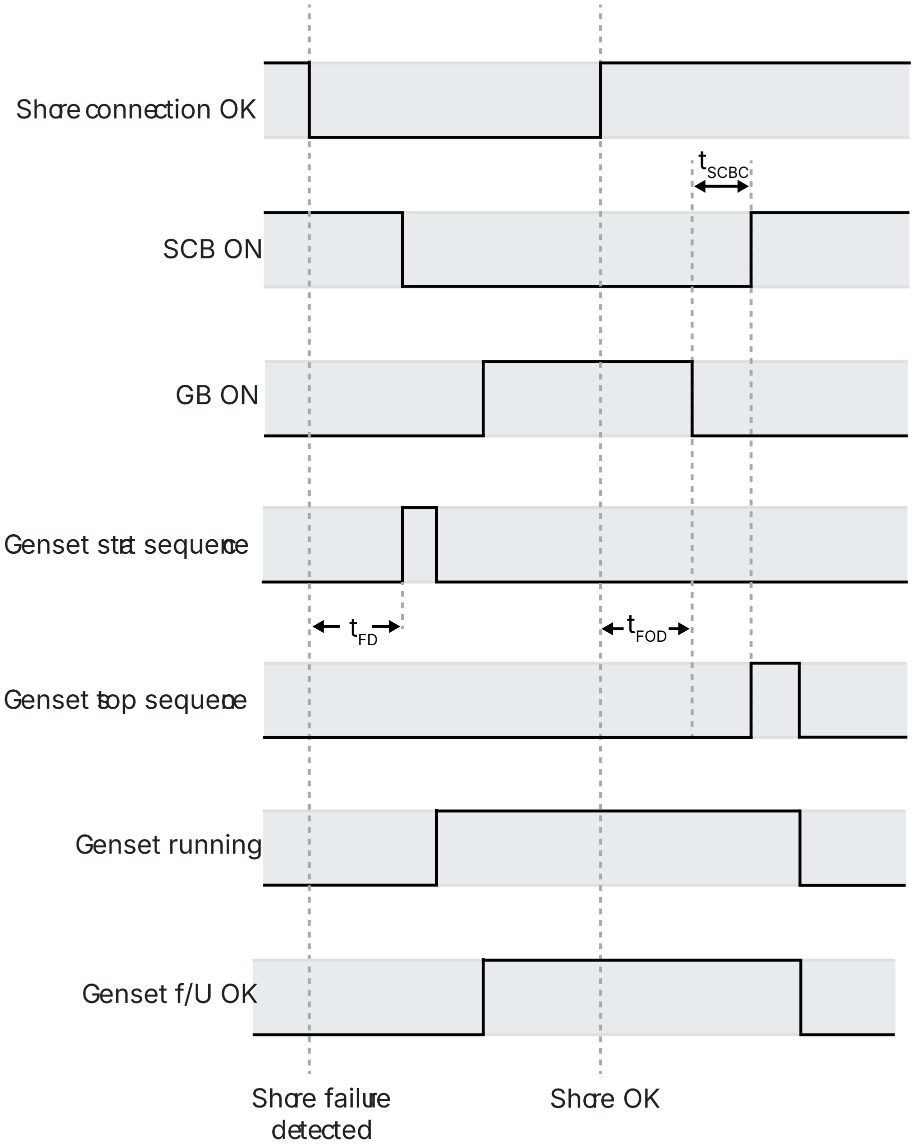
The voltage unbalance must be below the unbalance set point before the controller can treat the voltage as okay. The lower the set point, the less voltage imbalance is accepted before a shore supply failure occurs.

`Breakers > Shore breaker > Breaker configuration`

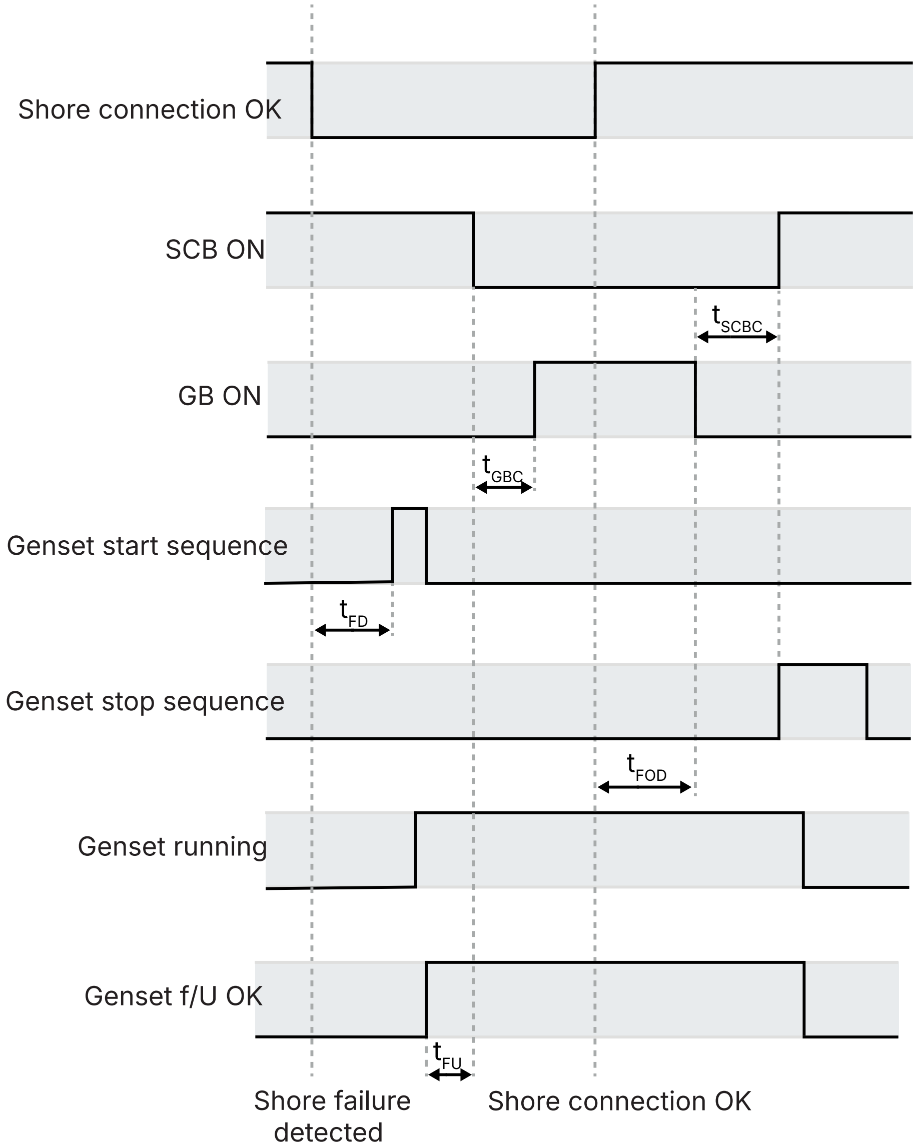
Parameter	Text	Range	Default
7082	SCB close delay	0.0 to 30.0 s	0.5 s
7085	SCB Load time*	0.0 to 30.0 s	0.0 s

NOTE * The *Load time* timer is only active if back synchronisation is deactivated.

Example 1: Shore fail control (Start engine and open SCB)



Example 2: Shore fail control (Start engine)



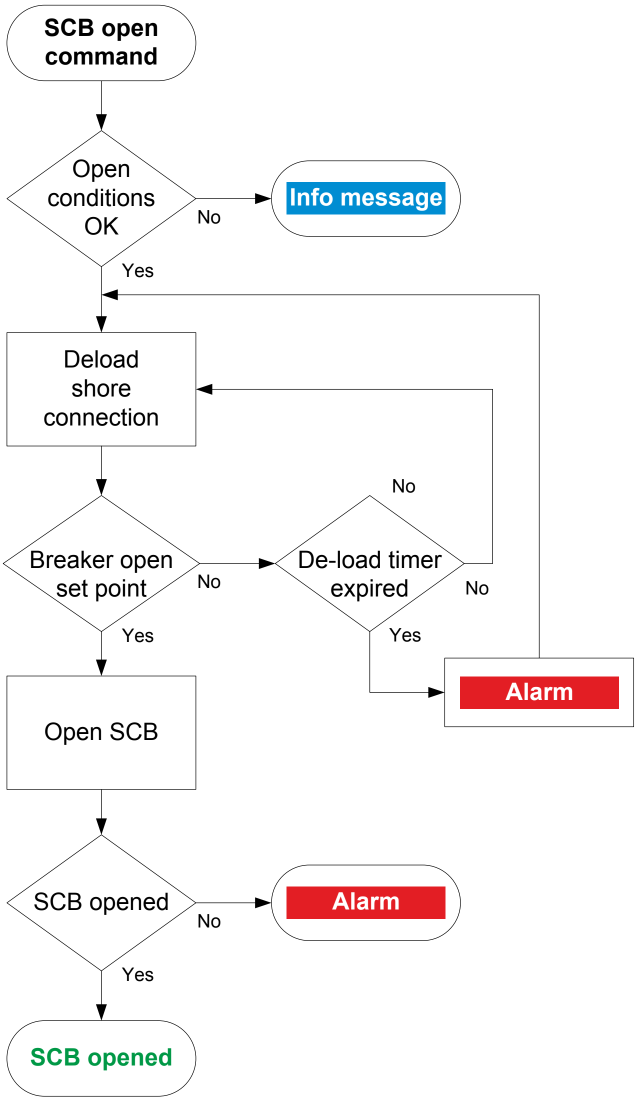
Conditions for breaker operations

The breaker sequences depend on the breaker positions and the frequency/voltage measurements.

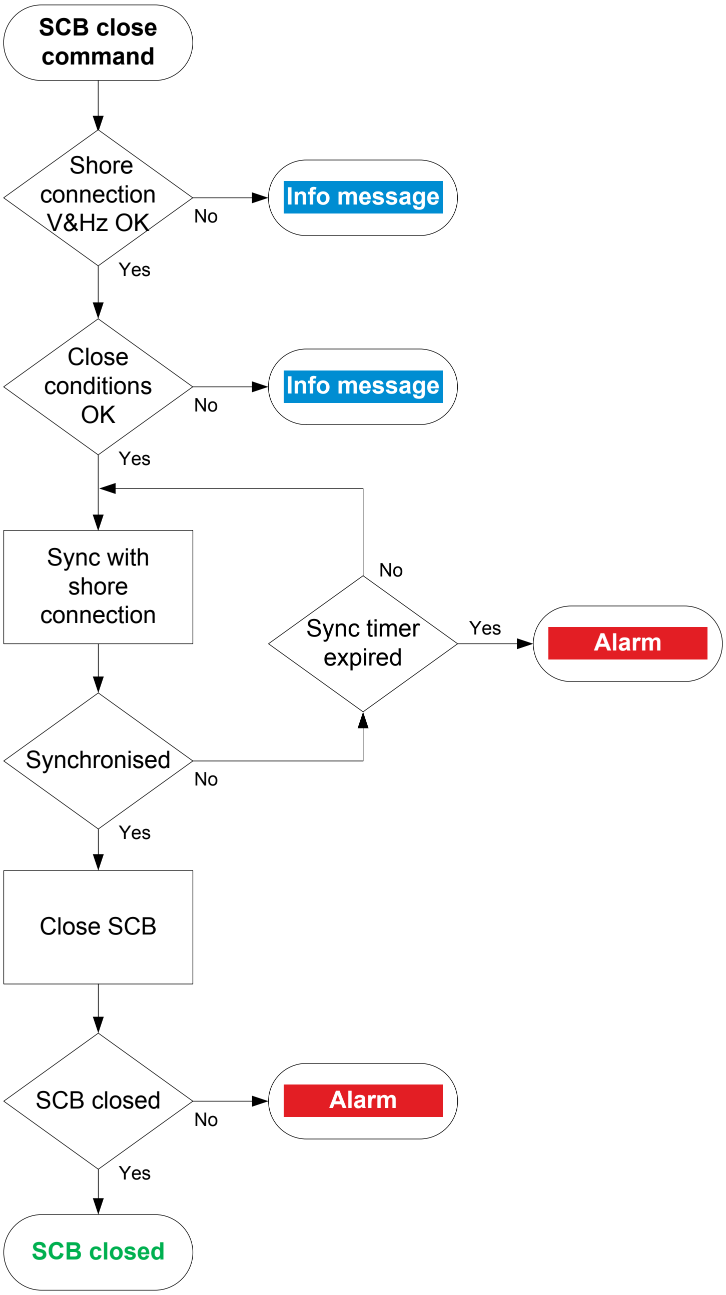
Sequence	Condition
SCB ON, direct closing	Shore frequency/voltage OK GB open
SCB ON, synchronising	Shore frequency/voltage OK GB closed No generator failure alarms
SCB OFF, direct opening	Alarms with fail classes: Shut down or Trip SCB alarms
SCB OFF, deloading	Alarms with fail class: Trip and stop

7.3.3 Flowcharts

SCB open sequence flowchart



SCB close sequence flowchart



7.3.4 Breaker failures

`Breakers > Shore breaker > Breaker monitoring > SCB Open fail`

Parameter	Text	Range	Default
2200	Timer	1.0 to 10.0 s	2.0 s
	Output A	Terminals and M-Logic	Not used
	Output B	Terminals and M-Logic	Not used
	Enable	ON	ON
	Fail class	Fail classes	Warning

`Breakers > Shore breaker > Breaker monitoring > SCB Close fail`

Parameter	Text	Range	Default
2210	Timer	1.0 to 5.0 s	2.0 s
	Output A	Terminals and M-Logic	Not used
	Output B	Terminals and M-Logic	Not used
	Enable	ON	ON
	Fail class	Fail classes	Warning

`Breakers > Shore breaker > Breaker monitoring > SCB Pos fail`

Parameter	Text	Range	Default
2220	Timer	1.0 to 5.0 s	1.0 s
	Output A	Terminals and M-Logic	Not used
	Output B	Terminals and M-Logic	Not used
	Enable	ON	ON
	Fail class	Fail classes	Warning

7.4 Input and output functions

7.4.1 Digital input functions

Default

Function	Details	AUTO mode	MANUAL mode	SWBD mode	Block mode	Type*
PMS control	This input function enables PMS logic to automatically manage shore connection and load transfer when the digital input signal is active.	●	●	●	●	C
SCB position ON	The input function is used as an indication of the generator breaker position. The controller requires this feedback when the breaker is closed or a position failure alarm occurs.	●	●	●	●	C
SCB position OFF	The input function is used as an indication of the generator breaker position. The controller requires this feedback when the breaker is opened or a position failure alarm occurs.	●	●	●	●	C

Configurable

Function	Details	AUTO mode	MANUAL mode	SWBD mode	Block mode	Type*
Remote SCB On	The shore connection breaker close sequence is initiated and the breaker synchronises if the generator breaker is closed, or closes without synchronising if the generator breaker is open.		●			P
Remote SCB Off	The shore connection breaker open sequence is initiated, and the breaker opens instantly.		●			P
SCB close inhibit	When this input is activated, the shore connection breaker cannot close.	●	●		●	C

Function	Details	AUTO mode	MANUAL mode	SWBD mode	Block mode	Type*
SCB racked out	The breaker will be considered as racked out when the pre-requisites are met and this input is activated.		●	●		C
SCB spring loaded	The controller does not send a close signal before this feedback is present.	●	●		●	C
Ext. SCB open	Choose the terminal used for ext. SCB open.	●	●	●	●	C
Enable separate sync.	Activate to split the breaker close and the breaker synchronisation functions in two different relays. The breaker close function remain on the relays dedicated for breaker control. The synchronisation function is moved to a configurable relay.	●	●		●	C
MANUAL mode	Changes the running mode to MANUAL.	●			●	P
AUTO mode	Changes the running mode to AUTO.		●		●	P
Trip + Block mode	Changes the running mode to Block.	●	●	●		P
Access lock	Activating the access lock input deactivates the controller display buttons. It is only possible to view measurements, alarms and the log.	●	●	●	●	C
Remote alarm ack	Acknowledges all activated alarms, and the alarm LED on the display stops flashing.	●	●	●	●	C
Simulate SCB close button push	This input is used to simulate the close breaker (shore) button being pushed.		●			P
Simulate SCB open button push	This input is used to simulate the open breaker (shore) button being pushed.		●			P
Simulate AUTO mode button push	This input is used to simulate the AUTO mode button being pushed.		●			P
Simulate MANUAL mode button push	This input is used to simulate the MANUAL mode button being pushed.		●			P
Simulate alarm list button push	This input is used to simulate the alarms button being pushed.		●			P

NOTE * C = Continuous, P = Pulse

7.4.2 Differential measurement

You can use the following measurements in the six differential measurement functions.

Measurement	Notes
Multi input [20 to 23]	The value measured by the multi input. Multi input 20 is the default.

7.5 Power management

7.5.1 Plant mode

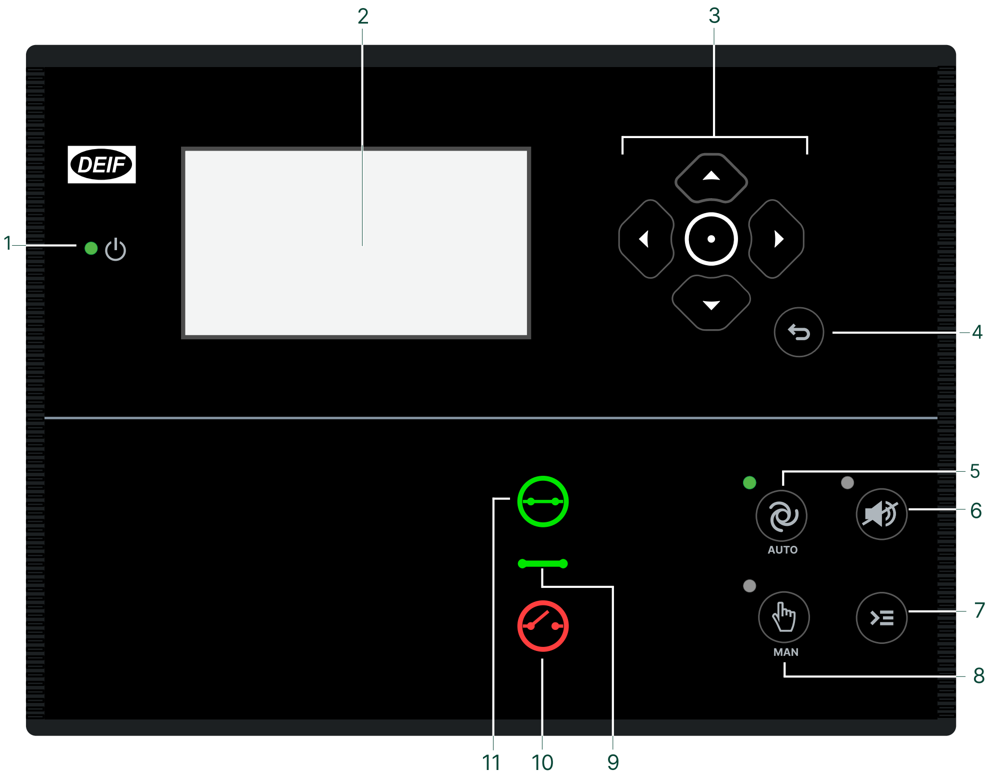
For power management to work in shore controllers, the controller must be in AUTO mode.

`Basic settings > Application type > Plant type > Plant mode`

Parameter	Text	Range	Default
6070	Plant mode	SC Supply GEN Supply	SC Supply

8. Bus tie breaker functions

8.1 Display layout



No.	Name	Function
1	Power	Green: The controller power is ON. OFF: The controller power is OFF.
2	Display screen	Resolution: 240 x 128 px. Viewing area: 88.50 x 51.40 mm. Six lines, each with 25 characters.
3	Navigation buttons	Move the selector up, down, left and right on the screen.
	Enter button	Confirms the selection
4	Back button	Go to the previous page.
5	AUTO mode button	The controller automatically joins and splits the busbar. No operator actions are needed. The controllers use the power management configuration to automatically select the power management action.
6	Silence horn button	Stops an alarm horn (if configured) and enters the Alarm menu.
7	Shortcut menu button	Access the General shortcuts, Jump menu, and Lamp test.
8	Manual mode button	The operator or an external signal can join or split the busbar. The BTB controller cannot automatically join or split the busbar. The controller automatically synchronises before closing a breaker, and automatically deloads before opening a breaker.
9	Breaker symbols	Green: Breaker is closed. Green flashing: Synchronising or deloading.

No.	Name	Function
		Red: Breaker failure.
10	Open breaker	Push to open the breaker.
11	Close breaker	Push to close the breaker.

8.2 BTB alarms

8.2.1 Fail classes

Fail class/Action	Alarm horn relay	Alarm display	Trip BTB
Block	●	●	
Warning	●	●	
Trip BTB	●	●	●

If the BTB is open, the alarms have the following impact:

Fail class/Action	Block BTB sequence
Block	
Warning	
Trip BTB	●

8.2.2 Inhibits

Function	Notes
Inhibit 1	
Inhibit 2	M-Logic outputs: Conditions are programmed in M-Logic.
Inhibit 3	
BTB ON	The bus tie breaker is closed.
BTB OFF	The bus tie breaker is open.
BA voltage > 30 %	The busbar A voltage is above 30 % of nominal.
BA voltage < 30 %	The busbar A voltage is below 30 % of nominal.

8.3 Inputs and outputs

8.3.1 Digital input functions

Default

Function	Details	MANUAL mode	SWBD mode	Block mode	Type*
PMS control	The input function enables PMS to automatically control the Bus Tie Breaker for safe load sharing between marine bus sections.	●	●	●	C
Gen supply active	The input function indicates that the generator breaker is closed and the generator is supplying power to the bus.	●	●	●	C
Shore supply active	The input function indicates that the shore connection breaker is closed and the shore supply is feeding the bus.	●	●	●	C
BTB position ON	The input function is used as an indication of the generator breaker position. The controller requires this feedback when the breaker is closed or a position failure alarm occurs.	●	●	●	C
BTB position OFF	The input function is used as an indication of the generator breaker position. The controller requires this feedback when the breaker is opened or a position failure alarm occurs.	●	●	●	C

Configurable

Function	Details	MANUAL mode	SWBD mode	Block mode	Type*
Remote BTB On	The BTB ON sequence is initiated and the breaker synchronises if the BTB is closed, or close without synchronising if the BTB is opened.	●			P
Remote BTB Off	The BTB OFF sequence is initiated and the breaker opens instantly.	●			P
BTB close inhibit	When this input is activated, the bus tie breaker cannot close.	●	●	●	C
BTB racked out	The breaker is considered as racked out when pre-requisites are met and this input is activated.	●	●		C
BTB spring loaded	The controller does not send a close signal before this feedback is present.	●	●	●	C
MANUAL mode	Changes the running mode to MANUAL.		●	●	P
Block mode	Changes the running mode to Block.	●	●		P
Access lock	Activating the access lock input deactivates the controller display buttons. It is only possible to view measurements, alarms and the log.	●	●		C
Remote alarm ack	Acknowledges all activated alarms, and the alarm LED on the display stops flashing.	●	●		P

NOTE * C = Continuous, P = Pulse

8.3.2 Differential measurement

You can use the following measurements in the six differential measurement functions.

Measurement	Notes
Multi input [20 to 23]	The value measured by the multi input. Multi input 20 is the default.

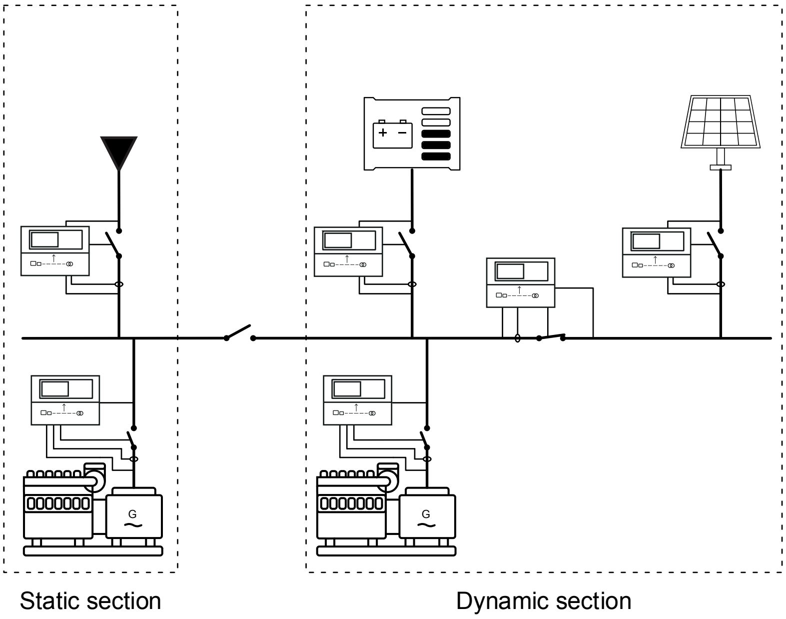
8.4 BTB power management

8.4.1 Static and dynamic sections

The power management application can be divided into sections, using Bus Tie Breakers (BTBs). If a BTB is open, the two sections can almost be considered as separate applications.

The BTB can be controlled with a BTB controller. If only the status is required, the feedback can be wired to a different controller in the system.

Difference between a static and a dynamic section



Static section: This part of the application cannot be divided further by BTBs. If there are no BTBs in the application, the whole application will be a static section.

Dynamic section: A dynamic section consists of at least two static sections. A dynamic section will always include a closed BTB, because this defines a dynamic section.

8.4.2 BTB controller fail classes

The BTB controller fail classes are:
- Block: An open BTB cannot close.
- Warning.
- Trip BTB: The bus tie breaker is opened.

8.4.3 Handling settings for sections

For applications with bus tie breakers, sections can have different power management settings. The power management settings for the sections therefore need special attention.

Common settings

Common settings refers to the power management settings that must be the same for all the controllers in a section. These include the load-dependent start-stop settings, and the shore connection controller plant mode.

Principles

The section settings handling follows these principles:

- In a static section, every change to the common settings automatically changes and stores the common settings in all the controllers in the section.
- When a BTB closes and a dynamic section is formed, the power management system ensures that all the controllers have the same common settings (see below). The user can also change parameters to make changes to the common settings. However, these common settings are not stored.
- When a BTB opens and a static section is formed, all the controllers in the static section return to their stored common settings.

Dynamic sections

The power management system ensures that all the controllers have the same common settings.

When the BTB closes, the power management system uses the application information in a weighted calculation to decide which section's settings to use. If the sections have the same weight, the power management settings in the right busbar section (BB) inherit the values from the left section (BA).

The stored common settings are not automatically updated when there are changes in the dynamic section. The changed dynamic section settings are lost when the BTB opens, since each controller returns to its stored common settings.

8.4.4 Breaker power supply

The bus tie breaker power supply must be specified in the application configuration.

DC breaker

A direct current (DC) breaker is supplied from the switchboard power supply. Select Vdc breaker. It can operate if there is a blackout.

AC breaker

An alternating current (AC) breaker is supplied from the busbar. Select Vac breaker. It cannot operate if there is a blackout on both busbars. The breaker can operate when either of the busbars is live.

If there is a blackout on both busbars and the operator tries to close the BTB, then the power management system will start a genset.

8.4.5 Plant mode

For a bus tie breaker controller, the plant mode defines when a shore controller can request help.

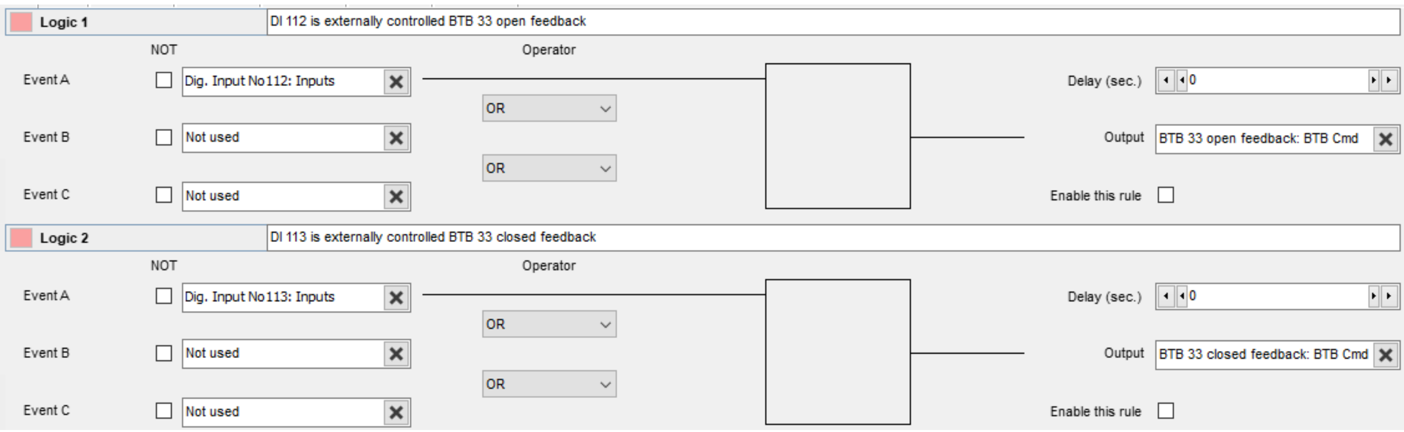
- SC supply
- Gen supply

8.4.6 Externally controlled BTB

The application can include externally controlled BTBs. These BTBs are assigned an ID number in the application configuration. In total, there can only be 2 BTBs (BTB controllers and externally controlled) in the application.

The breaker feedbacks for each externally controlled BTB must be wired up to a controller in the power management system. The feedbacks are configured with M-Logic.

Example of externally controlled BTB feedbacks



The power management system monitors the external controlled BTB feedbacks and responds to changes in the breaker position. For example, when the BTB is opened, power management detects that there are new busbar sections.

9. AC protections

9.1 About protections

9.1.1 Protections in general

All protection set points are a percentage of the nominal values.

For most of the protections a set point and time delay is selected. When the timer runs out, the output is activated. The operate time is the delay setting + the reaction time.

When setting up the controller, the measuring class of the controller and an adequate safety margin has to be taken into consideration, for example:

- A power generation system must not reconnect to a network when the voltage is < 85 % of U_{NOM} ±0 % or > 110 % ±0 %. To ensure reconnection within this interval, the controller's tolerance/accuracy has to be taken into consideration. If the reconnection tolerance is ±0 %, set a controller's set points 1-2 % higher/lower than the actual set point.

General parameter ranges for protections

Setting	Range
Output A Output B	Not used 12 relays: 5, 6, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18 External I/O: Relays available in the connected CIO(s) Limits
Enable	OFF ON
Fail class	See the controller type

Inhibits

You can only select inhibits using the utility software. Each alarm has a selection list for the inhibit conditions. Inhibit of the alarm is active as long as one of the selected inhibit functions are active.

9.1.2 Phase-neutral voltage trip

If the voltage alarms are to work based on phase-neutral measurements, the voltage detection type for both generator and busbar must be set to phase neutral.

`Generator > Voltage protections > Voltage detect. type`

Parameter	Text	Range	Default
1201	G U detection type	Phase - Phase Phase - Neutral	Phase - Phase

`Busbar > Voltage protections > Voltage detect. type`

Parameter	Text	Range	Default
1202	BB U detection type	Phase - Phase Phase - Neutral	Phase - Phase

As shown in the vector diagram below, there is a difference in voltage values at an error situation for the phase-neutral voltage and the phase-phase voltage.

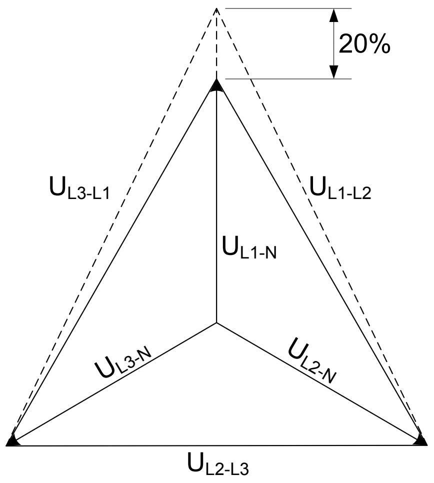
Example: Actual measurements at a 10 % under-voltage situation in a 400/230 volt system

	Phase-neutral	Phase-phase
Nominal voltage	400/230	400/230
Voltage, 10 % error	380/207	360/185

The alarm will occur at two different voltage levels, even though the alarm set point is 10 % in both cases.

The 400 V AC system below shows that the phase-neutral voltage must change 20 %, when the phase-phase voltage changes 40 volts (10 %).

Example



U_{NOM} = 400/230 V AC

Error measurements

- U_{L1L2} = 360 V AC
- U_{L3L1} = 360 V AC
- U_{L1-N} = 185 V AC
- ΔU_{PH-N} = 20 %

9.1.3 Phase sequence error and phase rotation

The controller continuously checks the L1 and L2 line voltage phasors 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 differs from expected by more than 40°, the alarm is activated. This means that the alarm will also detect if the phase rotation is different from the direction of rotation defined in the controller. There are two alarms for each controller. These alarms correspond to the controller's AC measurements. There is one alarm for the voltage from the A-side, and another alarm for the voltage on the B-side. The alarm action is Trip breaker and cannot be changed

Voltage terminals

- A-side (Generator) voltage terminals: 62 to 65
- B-side (Busbar) voltage terminals: 66 to 69

The controller has two alarms for phase sequence error (with different fail classes).

`Generator > AC configuration > Phase sequence error`

Parameter	Text	Range	Default
2153	Fail class	Fail classes	Block

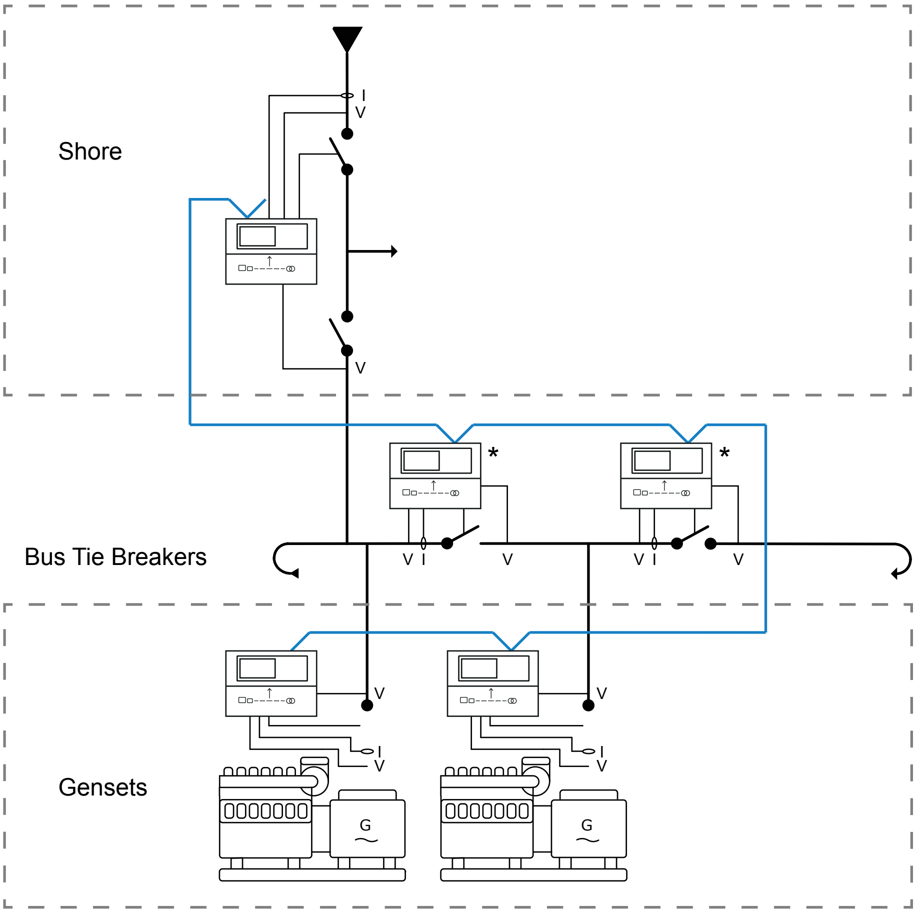
`Generator > AC configuration > Phase direction`

Parameter	Text	Range	Default
2154	Rotation	L1/L2/L3 L1/L3/L2	L1/L2/L3

Busbar > AC configuration > Phase sequence error

Parameter	Text	Range	Default
2156	Fail class	Fail classes	Block

Power management controller applications



9.2 A-side protections

A-side protections refer to protective functions for the **generator, shore power or busbar A side** of the system.
NOTE Depending on the controller, the parameter is located under **Generator**, **Shore** or **Busbar A** in the controller menu.

The number of protections depend on the software option.

More information
See the **Data sheet** for the protections for each software option.

The *operate time* is defined in IEV 447-05-05 (from the instant when the need for protection arises, to when the controller output has responded). For each protection, the *operate time* is given for the minimum user-defined time delay.

A-side protections

Protection	IEC symbol (IEC 60617)	ANSI (IEEE C37.2)	Operate time	Alarms	Generator	Shore	BTB
Over-voltage	U>, U>>	59	< 100 ms	2	●	●	●
Under-voltage	U<, U<<	27P	< 100 ms	3	●	●	●
Voltage unbalance	UUB>	47	< 200 ms*	1	●	●	●
Negative sequence voltage high		47	< 200 ms*	1	●		

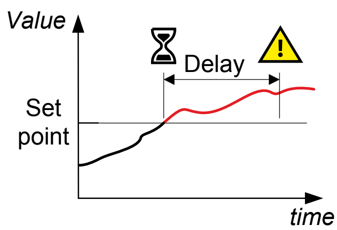
Protection	IEC symbol (IEC 60617)	ANSI (IEEE C37.2)	Operate time	Alarms	Generator	Shore	BTB
Zero sequence voltage high		$59U_0$	< 200 ms*	1	●		
Over-current	3I>, 3I>>	50TD	< 100 ms	4	●	●	●
Fast over-current	3I>>>	50P	< 40 ms	2	●	●	●
Current unbalance	IUB>	46	< 200 ms*	2	●	●	●
Directional over-current		67	< 100 ms	2	●		
IEC/IEEE inverse time over-current	It>	51	-	1	●	●	●
Negative sequence current high		$46I_2$	< 200 ms*	1	●		●
Zero sequence current high		$51I_0$	< 100 ms	1	●		●
Over-frequency	f>, f>>	81O	< 100 ms	3	●	●	●
Under-frequency	f<, f<<	81U	< 100 ms	3	●	●	●
Overload	P>, P>>	32	< 100 ms	4	●	●	●
Low power	-	-	< 100 ms	1	●		
Reverse power	P<, P<<	32R	< 100 ms	2	●	●	●
Over-excitation or reactive power export	Q>, Q>>	32FV	< 100 ms	1	●	●	●
Under-excitation or reactive power import	Q<, Q<<	32RV	< 100 ms	1	●	●	●

NOTE * These operate times include the minimum user-defined delay of 100 ms.

9.2.1 Over-voltage (ANSI 59)

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

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



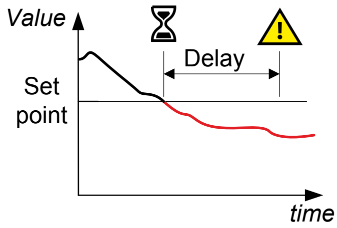
`Generator > Voltage protections > Over-voltage > G U> [1 or 2]`

Parameter	Text	Range	G U> 1	G U> 2
1150 or 1160	Set point	100 to 130 %	103 %	105 %
	Timer	0.1 to 100 s	10 s	5 s
	Enable	OFF ON	OFF	OFF
	Fail class	Fail classes	Warning	Warning

9.2.2 Under-voltage (ANSI 27P)

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

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.



Generator > Voltage protections > Under-voltage > G U< [1 to 3]

Parameter	Text	Range	G U< 1	G U< 2	G U< 3
1170, 1180 or 1190	Set point	40 to 100 %	97 %	95 %	95 %
	Timer	0.1 to 100 s	10 s	5 s	5 s
	Enable	OFF ON	OFF	OFF	OFF
	Fail class	Fail classes	Warning	Warning	Warning

NOTE Under-voltage protection is inhibited, when the controller is in idle mode.

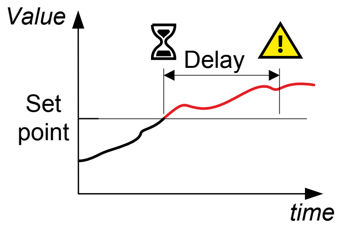
9.2.3 Voltage unbalance (ANSI 47)

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

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

The alarm response is based on the highest difference between any of the three phase-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.



Generator > Voltage protections > Voltage unbalance > G Unbalance U

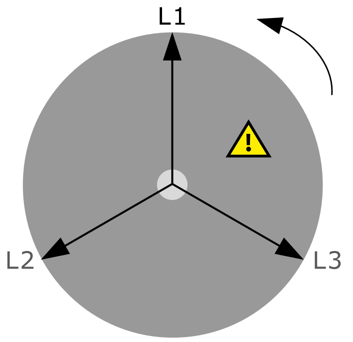
Parameter	Text	Range	Default
1510	Set point	0 to 50 %	10 %
	Timer	0.1 to 100 s	10 s
	Enable	OFF ON	OFF
	Fail class	Fail classes	Trip GB

9.2.4 Negative sequence voltage high (ANSI 47)

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

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

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



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

Negative sequence currents can cause overheating inside the generator. This is because these currents produce a magnetic field 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 voltage phasors, as measured from the source.

Generator > Voltage protections > Negative seq. voltage > G neg. seq. U

Parameter	Text	Range	Default
1550	Set point	1 to 100 %	5 %
	Timer	0.2 to 100 s	0.5 s
	Enable	OFF ON	OFF
	Fail class	Fail classes	Trip TB (EDG)

Generator > Voltage protections > Negative seq. voltage > Neg. seq select

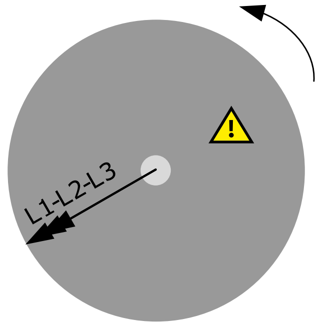
Parameter	Text	Range	Default
1560	Type	G measurement BB measurement	G measurement

9.2.5 Zero sequence voltage high (ANSI $59U_0$)

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

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

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



This protection is used for detecting earth faults.

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

Generator > Voltage protections > Zero sequence voltage > G zero seq. U

Parameter	Text	Range	Default
1580	Set point	0 to 100 %	5 %
	Timer	0.2 to 100 s	0.5 s
	Enable	OFF ON	OFF
	Fail class	Fail classes	Trip TB (EDG)

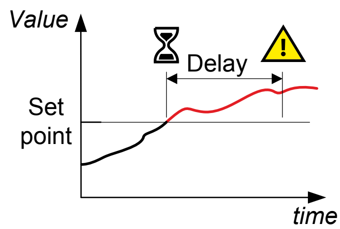
Generator > Voltage protections > Zero sequence voltage > Zero seq select

Parameter	Text	Range	Default
1590	Zero seq. select	G measurement BB measurement	G measurement

9.2.6 Over-current (ANSI 50TD)

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

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



Generator > Current protections > Over-current > I> [1 to 4]

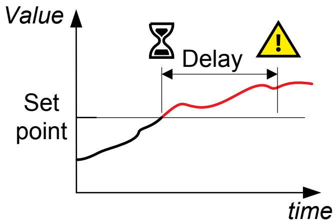
Parameter	Text	Range	I> 1	I> 2	I> 3	I> 4
1030, 1040, 1050 or 1060	Set point	50 to 200 %	115 %	120 %	115 %	120 %
	Timer	0.1 to 3200 s	10 s	5 s	10 s	5 s
	Enable	OFF ON	ON	ON	ON	ON
	Fail class	Fail classes	Warning	Trip GB	Trip GB	Trip GB

9.2.7 Fast over-current (ANSI 50P)

Protection	IEC symbol (IEC60617)	ANSI (IEEE C37.2)	Operate time
Fast over-current	3I>>>	50P*	< 40 ms

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

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



`Generator > Current protections > Fast over-current > I>> [1 or 2]`

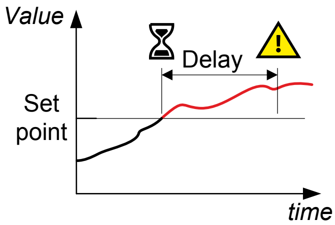
Parameter	Text	Range	I>> 1	I>> 2
1130 or 1140	Set point	150 to 300%	150%	200%
	Timer	0 to 3200 s	2 s	0.5 s
	Enable	OFF ON	OFF	OFF
	Fail class	Fail classes	Trip GB	Trip GB

9.2.8 Current unbalance (ANSI 46)

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

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

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



`Generator > Current protections > Unbalance current > Unbalance I [1 or 2]`

Parameter	Text	Range	Unbalance I 1	Unbalance I 2
1500 or 1710	Set point	0 to 100 %	30 %	40 %
	Timer	0.1 to 100 s	10 s	10 s
	Enable	OFF ON	OFF	OFF
	Fail class	Fail classes	Trip GB	Trip GB

Generator > Current protections > Unbalance current > Type

Parameter	Text	Range	Default
1203	Unbalance I	Ref. to Nominal Ref. to Average	Ref. to Nominal

NOTE The *Average method* is very sensitive at low loads.

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.

Average method example

The 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 %.

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

Nominal method example

The 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 %.

9.2.9 Voltage dependent over-current (ANSI 50V)

Protection	IEC symbol (IEC60617)	ANSI (IEEE C37.2)	Operate time
Voltage-dependent over-current	Iv>	50V	-

This is a voltage-dependent over-current alarm for generators without permanent magnets. This protection occurs when a short circuit is present and the voltage drops. The current rises briefly, before it falling to a lower level.

The short circuit current level can drop below the rated current of the generator, and thus the short circuit will not be tripped, if a standard ANSI 50/50TD is used. When the short circuit is present, the voltage will be low. This can be used for tripping at a lower current, when the voltage is low.

Generator > Current protections > Voltage dep. over-curr.

Parameter	Text	Range	Default
1101	G Iv> (50 %)	50 to 200 %	110 %
1102	G Iv> (60 %)	50 to 200 %	125 %
1103	G Iv> (70 %)	50 to 200 %	140 %
1104	G Iv> (80 %)	50 to 200 %	155 %
1105	G Iv> (90 %)	50 to 200 %	170 %

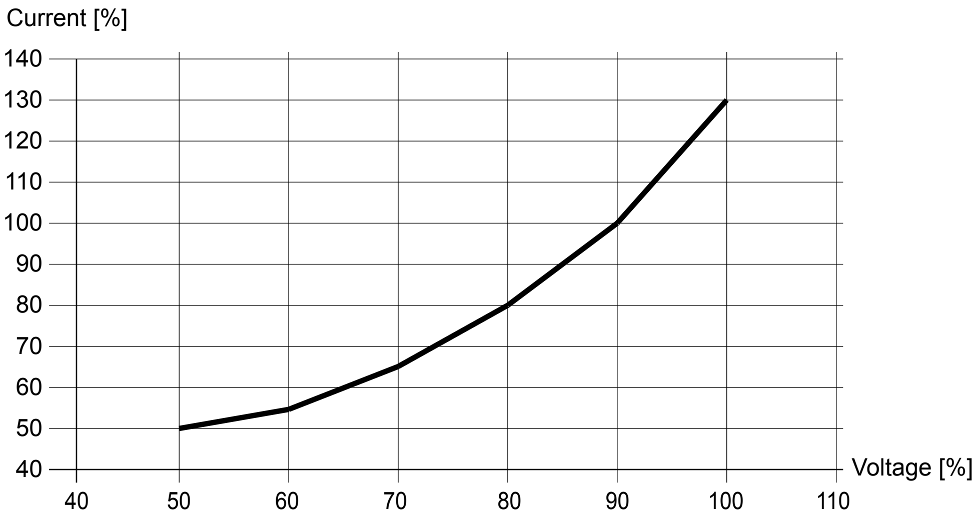
Parameter	Text	Range	Default
1106	G Iv> (100 %)	50 to 200 %	200 %
1110	Fail class	Fail classes	Trip GB

Example

There are six current and voltage level set points. The voltage levels are pre-set, so only the current levels must be set. All values are in percentage of the nominal settings. The default values are shown in the table below.

Parameter	Voltage level (not adjustable)	Current level (adjustable)
1101	50 %	50 %
1102	60 %	55 %
1103	70 %	65 %
1104	80 %	80 %
1105	90 %	100 %
1106	100 %	130 %

The set points can be shown on a curve:

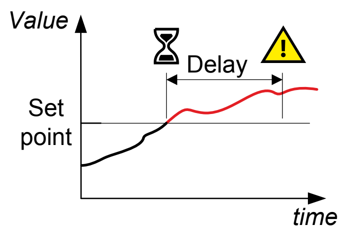


When the operating values are above the curve, the breaker is tripped. The generator breaker also trips when the generator voltage is below 50 % of rated, and the current is above 50 % of rated.

9.2.10 Directional over-current (ANSI 67)

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

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



`Generator > Current protections > Direct. over-current > I> direct. [1 or 2]`

Parameter	Text	Range	I> direct. 1	I> direct. 2
1600 or 1610	Set point	-200 to 200 %	120 %	130 %
	Timer	0 to 3200 s	0.1 s	0.1 s
	Enable	OFF ON	OFF	OFF
	Fail class	Fail classes	Trip TB (EDG)	Trip TB (EDG)

NOTE 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*.

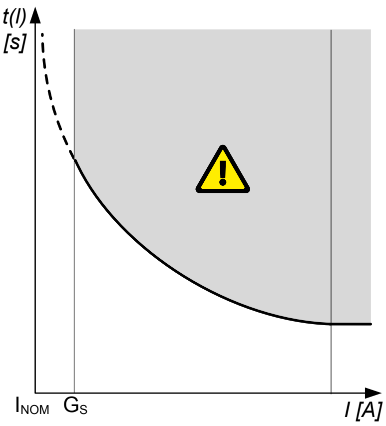
9.2.11 IEC/IEEE inverse time over-current (ANSI 51)

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

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

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

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



Inverse time over-current calculation method

The controller uses this equation from IEC 60255-151 to calculate the time that the current measurement may be over the set point before the inverse time over-current alarm is activated:

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

where:

- t(G) = Theoretical operating time value at 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 ($G_S = I_{nom} \bullet LIM / 100\ \%$)
- TMS = Time multiplier setting

`Generator > Current protections > Inv. time over-current`

Parameter	Text	Range	Default
1081	I> inverse Type	IEC Inverse IEC Very Inverse IEC Extremely inverse IEEE Moderately Inv. IEEE Very Inverse	IEC Inverse

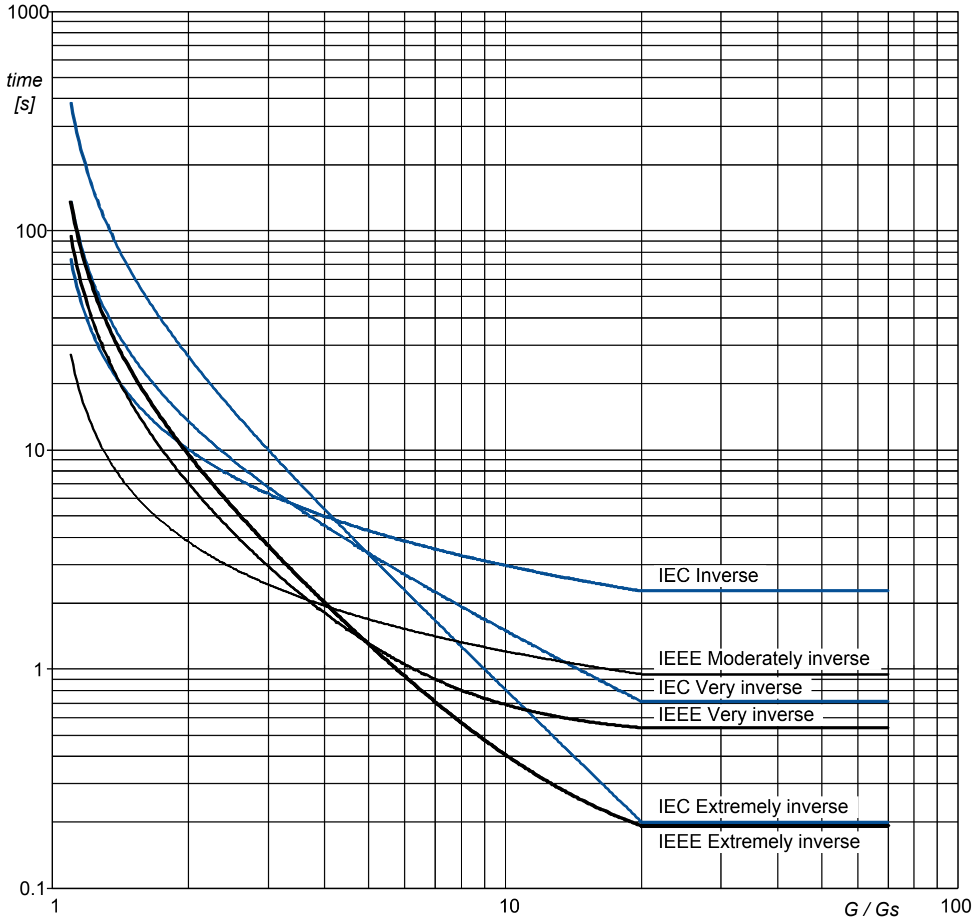
Parameter	Text	Range	Default
		IEEE Extremely Inv. Custom	
1082	I> inverse Limit	50 to 200 %	110 %
1083	I> inverse TMS	0.01 to 100.00	1.00
1084	I> inverse k	0.001 to 32.000 s	0.140 s
1085	I> inverse c	0.000 to 32.000 s	0.000 s
1086	I> inverse a	0.001 to 32.000 s	0.020 s

Standard inverse time over-current curves

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

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

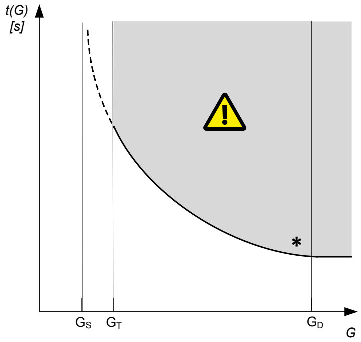
Standard curve shapes for inverse time over-current, with time multiplier setting (TMS) = 1



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 $G_D = 20 \times G_S$.

Inverse time over-current time characteristic graph



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 1500 A.

- Because the secondary current rating is 5 A, the formula to calculate the measurable G_D is $G_D = 3 \times I_{CT\ primary}$.
- $G_D = 3 \times I_{CT\ primary} = 3 \times 500 = 1500$ A

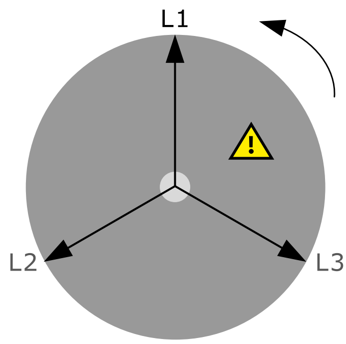
NOTE If the performance of the inverse time over-current protection is important, use a current transformer that is rated for a 1 A secondary current (that is, -/1 A).

9.2.12 Negative sequence current high (ANSI 46I_2)

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

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

Negative sequence currents arise when the virtual representation of the phase rotation for an unbalanced system appears negative.
Negative sequence currents can occur where there are single phase loads, unbalanced line short circuits and open conductors, and/or unbalanced phase-phase or phase-neutral loads.
This protection is used to prevent the generator from overheating. Negative sequence currents produce a magnetic field in the generator counter-rotating to the rotor. This field crosses the rotor at twice the rotor velocity, inducing double-frequency currents in the field system and in the rotor body.
The alarm response is based on the estimated phase-to-neutral current phasors, from the source, as measured by the controller.



Generator > Current protections > Negative seq. current > Negative. seq. I.

Parameter	Text	Range	Default
1540	Set point	1 to 100 %	20 %
	Timer	0.2 to 100 s	0.5 s
	Enable	OFF ON	OFF
	Fail class	Fail classes	Trip TB (EDG)

9.2.13 Zero sequence current high(ANSI 50I_0)

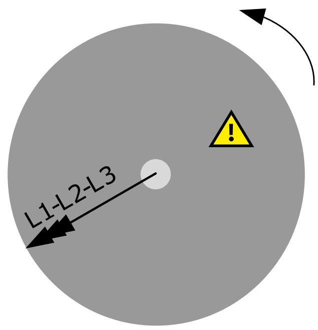
Protection	IEC symbol (IEC60617)	ANSI (IEEE C37.2)	Operate time
Zero sequence current high		50I_0	< 200 ms*

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

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

This protection is used for detecting earth faults.

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



Generator > Current protections > Zero sequence current > Zero seq. I

Parameter	Text	Range	Default
1570	Set point	0 to 100 %	20 %
	Timer	0.2 to 100 s	0.5 s
	Enable	OFF ON	OFF
	Fail class	Fail classes	Trip TB (EDG)

9.2.14 Inverse time neutral over-current (ANSI 50N)

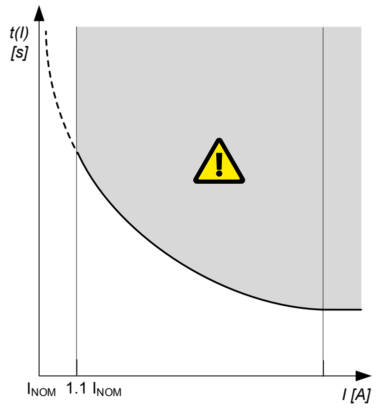
Protection	IEC symbol (IEC60617)	ANSI (IEEE C37.2)	Operate time
Inverse time neutral over-current		50N	-

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.



`Generator > Current protections > Neutral inverse time over-current (4th CT)`

Parameter	Text	Range	Default
1721	In> inverse Type	IEC Inverse IEC Very Inverse IEC Extremely inverse IEEE Moderately Inv. IEEE Very Inverse IEEE Extremely Inv. Custom	IEC Inverse
1722	In> inverse Limit	2. to 120 %	30 %
1723	In> inverse TMS	0.01 to 100.00	1.00
1724	In> inverse k	0.001 to 32.000 s	0.140 s
1725	In> inverse c	0.000 to 32.000 s	0.000 s
1726	In> inverse a	0.001 to 32.000 s	0.020 s
1727	Enable	OFF ON	OFF
	Fail class	Fail classes	Trip GB

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

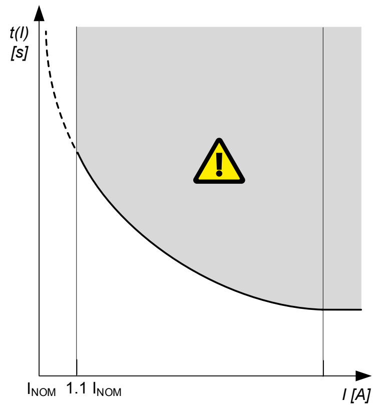
9.2.15 Inverse time filtered neutral over-current (ANSI 50G)

Protection	IEC symbol (IEC60617)	ANSI (IEEE C37.2)	Operate time
Inverse time filtered neutral over-current		50G	-

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).

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



Generator > Current protections > Filtered neutral inverse time over-current (4th CT)

Parameter	Text	Range	Default
1731	Ie> inverse Type	IEC Inverse IEC Very Inverse IEC Extremely inverse IEEE Moderately Inv. IEEE Very Inverse IEEE Extremely Inv. Custom	-
1732	Ie> inverse Limit	2 to 120 %	10 %
1733	Ie> inverse TMS	0.01 to 100.00	1.00
1734	Ie> inverse k	0.001 to 32.000 s	0.140 s
1735	Ie> inverse c	0.000 to 32.000 s	0.000 s
1736	Ie> inverse a	0.001 to 32.000 s	0.020 s
1737	Enable	OFF ON	OFF
	Fail class	Fail classes	Trip GB

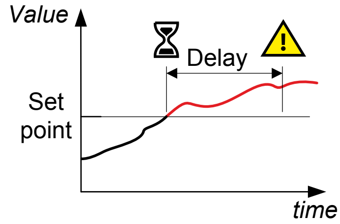
More information
See **Inverse time over-current (ANSI 51)** for the calculation method, the standard curves, and information about the definite time characteristic.

9.2.16 Neutral over-current (4th CT)

Protection	IEC symbol (IEC60617)	ANSI (IEEE C37.2)	Operate time
Neutral over-current (4th CT)	In>	-	-

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

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



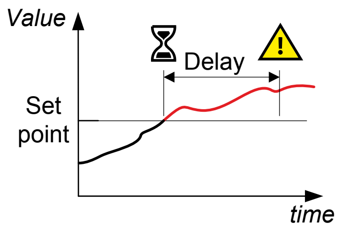
Generator > Current protections > Neutral over-current (4th CT) > 4th CT In> [1 or 2]

Parameter	Text	Range	In> 1	In> 2
14210 or 14220	Enable	OFF ON	OFF	OFF
	Set point	2 to 120 %	30 %	30 %
	Timer	0.1 to 3200 s	10 s	10 s
	Fail class	Fail classes	Warning	Warning

9.2.17 Filtered neutral fault over-current (4th CT)

Protection	IEC symbol (IEC60617)	ANSI (IEEE C37.2)	Operate time
Filtered neutral fault over-current (4th CT)	Ie>	-	-

This is the over-current alarm for the neutral current measurement.
The alarm response is based on the neutral current, as measured by the 4th current measurement filtered to attenuate the third harmonic (at least 18 dB).



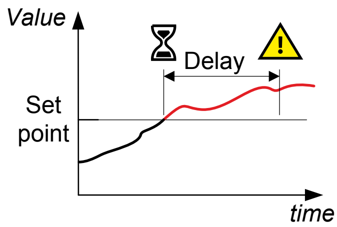
Generator > Current protections > Filtered neutral fault over-current (4th CT) > 4th CT Ie> [1 or 2]

Parameter	Text	Range	Ie> 1	Ie> 2
14230 or 14240	Enable	OFF ON	OFF	OFF
	Set point	2 to 120 %	10 %	10 %
	Timer	0.1 to 3200 s	10 s	10 s
	Fail class	Fail classes	Warning	Warning

9.2.18 Over-frequency (ANSI 81O)

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

The alarm response is based on the fundamental frequency (based on phase voltage), due to the selection made in parameter 1204.



`Generator > Frequency protections > Over-frequency > G f> [1 to 3]`

Parameter	Text	Range	G f> 1	G f> 2	G f> 3
1210, 1220 or 1230	Set point	100 to 120 %	103 %	105 %	105 %
	Timer	0.2 to 100 s	10 s	5 s	5 s
	Enable	OFF ON	OFF	OFF	OFF
	Fail class	Fail classes	Warning	Warning	Warning

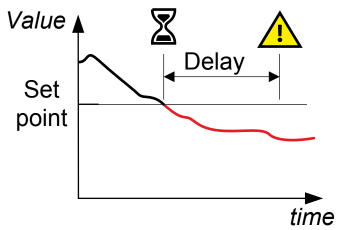
`Generator > Frequency protections > Frequency detect. type`

Parameter	Text	Range	Default
1204	Freq. detect type	L1 L2 L3 L1 or L2 or L3 L1 and L2 and L3	L1 or L2 or L3

9.2.19 Under-frequency (ANSI 81U)

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

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.



`Generator > Frequency protections > Under-frequency > G f< [1 to 3]`

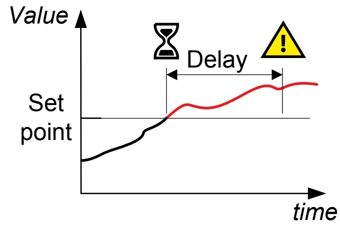
Parameter	Text	Range	G f< 1	G f< 2	G f< 3
1240, 1250 or 1260	Set point	80 to 100 %	97 %	95 %	95 %
	Timer	0.2 to 100 s	10 s	5 s	5 s
	Enable	OFF ON	OFF	OFF	OFF
	Fail class	Fail classes	Warning	Warning	Warning

NOTE Under-frequency protection is inhibited, when the controller is in idle mode.

9.2.20 Overload (ANSI 32F)

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

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



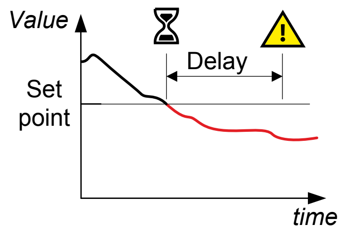
`Generator > Power protections > Overload > P> [1 to 4]`

Parameter	Text	Range	P> 1	P> 2	P> 3	P> 4	P> 5
1450, 1460, 1470 or 1480	Set point	-200 to 200 %	100 %	110 %	100 %	110 %	100 %
	Timer	0.1 to 3200 s	10 s	5 s	10 s	5 s	10 s
	Enable	OFF ON	OFF	OFF	OFF	OFF	OFF
	Fail class	Fail classes	Warning	Trip GB	Trip GB	Trip GB	Trip GB

9.2.21 Low power

Protection	IEC symbol (IEC60617)	ANSI (IEEE C37.2)	Operate time
Low power	-	-	< 100 ms

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



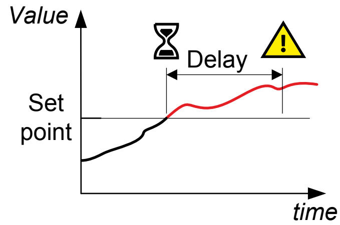
`AC configuration and protections > Power protections > Overload > P< 5`

Parameter	Text	Range	P<
1490	Set point	-200 to 200 %	30 %
	Timer	0.1 to 3200 s	3200 s
	Enable	OFF ON	OFF
	Fail class	Fail classes	Trip GB

9.2.22 Reverse power (ANSI 32R)

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

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



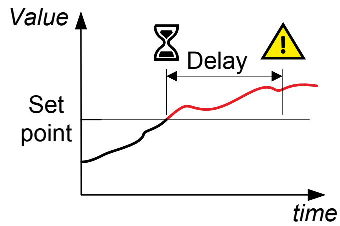
`Generator > Power protections > Reverse power > -P> [1 to 3]`

Parameter	Text	Range	-P> 1	-P> 2	-P > 3
1000, 1010 or 1070	Set point	-200 to 0 %	-5 %	-5 %	-5 %
	Timer	0.1 to 100 s	10 s	10 s	10 s
	Enable	OFF ON	ON	ON	OFF
	Fail class	Fail classes	Trip GB	Trip GB	Trip GB

9.2.23 Over-excitation or reactive power export (ANSI 32FV)

Protection	IEC symbol (IEC60617)	ANSI (IEEE C37.2)	Operate time
Over-excitation or reactive power export	Q>, Q>>	32FV	< 100 ms

The alarm response is based on the reactive power (Q) from the source, as measured and calculated by the controller. Reactive power export is when the generator is feeding an inductive load.



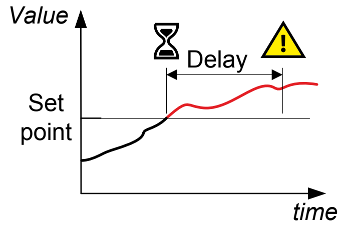
`Generator > Reactive power protect. > Overexcitation > Q>`

Parameter	Text	Range	Default
1530	Set point	0 to 100 %	60 %
	Timer	0.1 to 100 s	10 s
	Enable	OFF ON	OFF
	Fail class	Fail classes	Warning

9.2.24 Under-excitation or reactive power import (ANSI 32RV)

Protection	IEC symbol (IEC60617)	ANSI (IEEE C37.2)	Operate time
Under-excitation or reactive power import	Q<, Q<<	32RV	< 100 ms

The alarm response is based on the reactive power (Q) to the source, as measured and calculated by the controller. Reactive power import is when the generator is feeding a capacitive load.



Generator > Reactive power protect. > Underexcitation > -Q>

Parameter	Text	Range	Default
1520	Set point	0 to 150 %	50 %
	Timer	0.1 to 100 s	10 s
	Enable	OFF ON	OFF
	Fail class	Fail classes	Warning

9.3 B-side standard protections

B-side protections refer to protective functions for the **load** or **busbar side** of the system.
NOTE Depending on the controller, the parameter is located under **Busbar** or **Busbar B** in the controller menu.

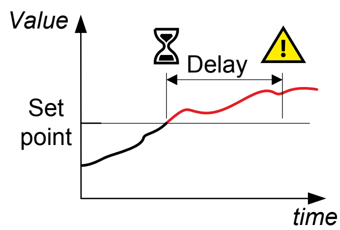
Protection	IEC symbol (IEC 60617)	ANSI (IEEE C37.2)	Operate time	Alarms
Over-voltage	U>, U>>	59	< 50 ms	3
Under-voltage	U<, U<<	27	< 50 ms	4
Voltage unbalance	UUB>	47	< 200 ms*	1
Over-frequency	f>, f>>	81O	< 50 ms	3
Under-frequency	f<, f<<	81U	< 50 ms	4

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

9.3.1 Busbar over-voltage (ANSI 59)

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

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



Busbar > Voltage protections > Over-voltage > BB U> [1 to 3]

Parameter	Text	Range	BB U> 1	BB U> 2	BB U> 3
1270, 1280 or 1290	Set point	100 to 120 %	103 %	105 %	105 %
	Timer	0.04 to 99.99 s	10 s	5 s	5 s
	Enable	OFF ON	OFF	OFF	OFF
	Fail class	Fail classes	Warning	Warning	Warning

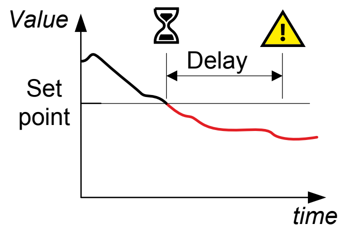
Busbar > Voltage protections > Voltage detect. type

Parameter	Text	Range	Default
1202	BB U detect. type	Phase-Phase Phase-Neutral	Phase-Phase

9.3.2 Busbar under-voltage (ANSI 27)

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

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



Busbar > Voltage protections > Under-voltage > BB U< [1 to 4]

Parameter	Text	Range	BB U< 1	BB U< 2	BB U< 3	BB U< 4
1300, 1310, 1320 or 1330	Set point	40 to 100 %	97 %	95 %	97 %	95 %
	Timer	0.04 to 99.99 s	10 s	5 s	10 s	5 s
	Enable	OFF ON	OFF	OFF	OFF	OFF
	Fail class	Fail classes	Warning	Warning	Warning	Warning

Busbar > Voltage protections > Voltage detect. type

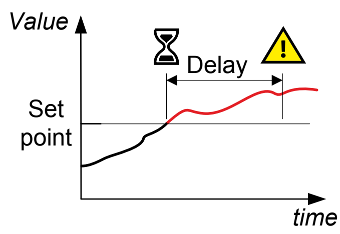
Parameter	Text	Range	Default
1202	BB U detect. type	Phase-Phase Phase-Neutral	Phase-Phase

9.3.3 Busbar voltage unbalance (ANSI 47)

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

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

The alarm response is based on the highest difference between any of the three 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.

`Busbar > Voltage protections > Voltage unbalance > BB Unbalance U`

Parameter	Text	Range	Default
1620	Set point	0 to 50 %	6 %
	Timer	0.1 to 100 s	10 s
	Enable	OFF ON	OFF
	Fail class	Fail classes	Warning

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.

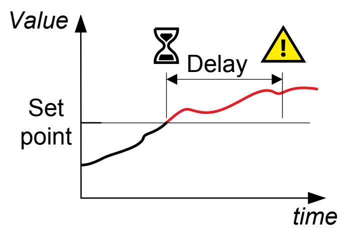
The average voltage is 223.3 V. The difference between the phase-to-phase voltage and the average is 12.7 V for L1-L2, 2.7 V for L2-L3 and 13.3 V for L3-L1.

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

9.3.4 Busbar over-frequency (ANSI 81O)

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

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.



`Busbar > Frequency protections > Over-frequency > BB f> [1 to 4]`

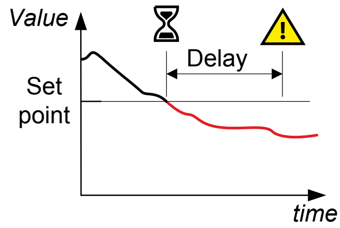
Parameter	Text	Range	BB f> 1	BB f> 2	BB f> 3	BB f> 4
1350, 1360, 1370 or 1920	Set point	100 to 120 %	103 %	105 %	105 %	102 %
	Timer	0.04 to 99.99 s	10 s	5 s	5 s	5600 s*
	Enable	OFF ON	OFF	OFF	OFF	OFF
	Fail class	Fail classes	Warning	Warning	Warning	Warning

NOTE * The range for this alarm is 1500 to 6000 s.

9.3.5 Busbar under-frequency (ANSI 81U)

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

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.



Busbar > Frequency protections > Under-frequency > BB f< [1 to 5]

Parameter	Text	Range	BB f< 1	BB f< 2	BB f< 3	BB f< 4	BB f< 5
1380, 1390, 1400, 1410 or 1930	Set point	80 to 100 %	97 %	95 %	97 %	95 %	95 %
	Timer	0.04 to 99.99 s	10 s	5 s	10 s	5 s	5600 s*
	Enable	OFF ON	OFF	OFF	OFF	OFF	OFF
	Fail class	Fail classes	Warning	Warning	Warning	Warning	Warning

NOTE * The range for this alarm is 1500 to 6000 s.

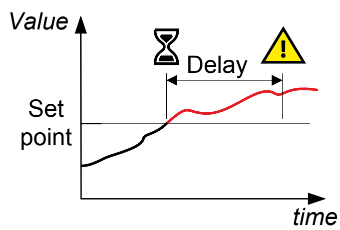
9.4 Other protections

Protection	IEC symbol (IEC 60617)	ANSI (IEEE C37.2)	Operate time	Alarms
Busbar over-current (4th CT)	I>	-	-	2
Neutral over-current (4th CT)	In>	-	-	2
Filtered neutral over-current	Ie>	-	-	2
Overload (4th CT)	-P> , P>	-	-	2

9.4.1 Busbar over-current (4th CT)

Protection	IEC symbol (IEC60617)	ANSI (IEEE C37.2)	Operate time
Busbar over-current (4th CT)	I>	-	-

This is the over-current alarm for the busbar current measurement using the fourth current transformer (CT).
The alarm response is based on the busbar current, as measured by the 4th CT.



Generator > Current protections > Neutral over-current (4th CT) > 4th CT I> [1 or 2]

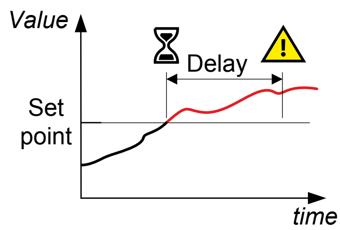
Parameter	Text	Range	I> 1	I> 2
14250 or 14260	Enable	OFF ON	OFF	OFF
	Set point	2 to 120 %	30 %	30 %
	Timer	0.1 to 3200 s	10 s	10 s
	Fail class	Fail classes	Warning	Warning

9.4.2 Neutral over-current (4th CT)

Protection	IEC symbol (IEC60617)	ANSI (IEEE C37.2)	Operate time
Neutral over-current (4th CT)	In>	-	-

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

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



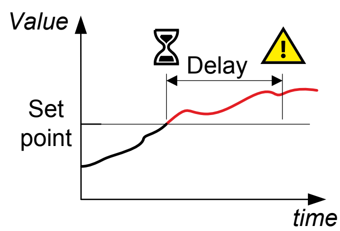
Generator > Current protections > Neutral over-current (4th CT) > 4th CT In> [1 or 2]

Parameter	Text	Range	In> 1	In> 2
14210 or 14220	Enable	OFF ON	OFF	OFF
	Set point	2 to 120 %	30 %	30 %
	Timer	0.1 to 3200 s	10 s	10 s
	Fail class	Fail classes	Warning	Warning

9.4.3 Filtered neutral fault over-current (4th CT)

Protection	IEC symbol (IEC60617)	ANSI (IEEE C37.2)	Operate time
Filtered neutral fault over-current (4th CT)	Ie>	-	-

This is the over-current alarm for the neutral current measurement.
The alarm response is based on the neutral current, as measured by the 4th current measurement filtered to attenuate the third harmonic (at least 18 dB).



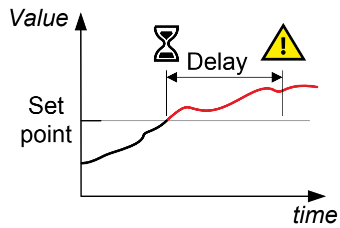
Generator > Current protections > Filtered neutral fault over-current (4th CT) > 4th CT Ie> [1 or 2]

Parameter	Text	Range	Ie> 1	Ie> 2
14230 or 14240	Enable	OFF ON	OFF	OFF
	Set point	2 to 120 %	10 %	10 %
	Timer	0.1 to 3200 s	10 s	10 s
	Fail class	Fail classes	Warning	Warning

9.4.4 Overload (4th CT)

Protection	IEC symbol (IEC60617)	ANSI (IEEE C37.2)	Operate time
Overload (4th CT)	-P>, P>	-	-

This is the overload alarm for the busbar current measurement using the fourth current transformer (CT).
The alarm response is based on the busbar current, as measured by the 4th CT.



Shore > Power protections > Overload 4th CT > 4th CT -P> [1 or 2] or P> [1 or 2]

Parameter	Text	Range	I> 1	I> 2
14270, 14280, 14290 or 14300	Enable	OFF ON	OFF	OFF
	Set point	2 to 120 %	30 %	30 %
	Timer	0.1 to 3200 s	10 s	10 s
	Fail class	Fail classes	Warning	Warning

10. General purpose PID

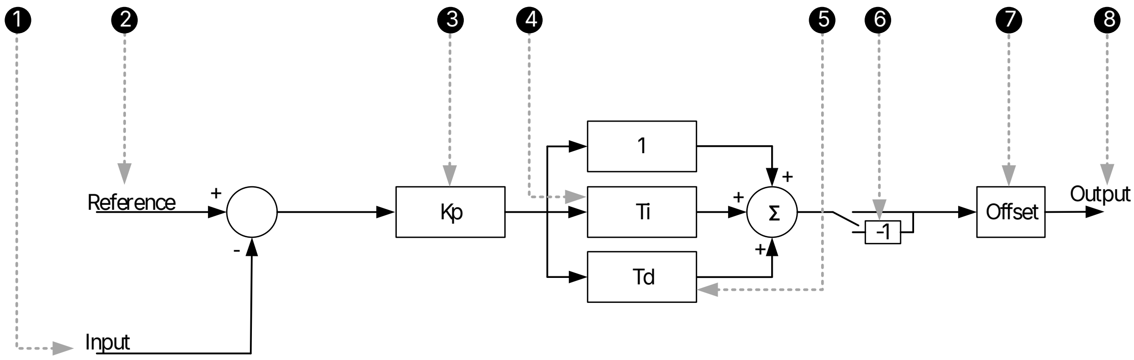
10.1 Introduction

The general purpose PID controllers are principally similar to the PID controllers for regulation. They consist of a proportional, an integral and a differential part, and the integral and differential parts are dependent on the proportional gain.

The general purpose PIDs are slightly less responsive. They are meant to control temperature, fans and so on. Configuration of the general purpose PIDs is documented by describing the possibilities of the general purpose PID interface, and with examples of configuration for different purposes.

10.1.1 General purpose PID analogue loop

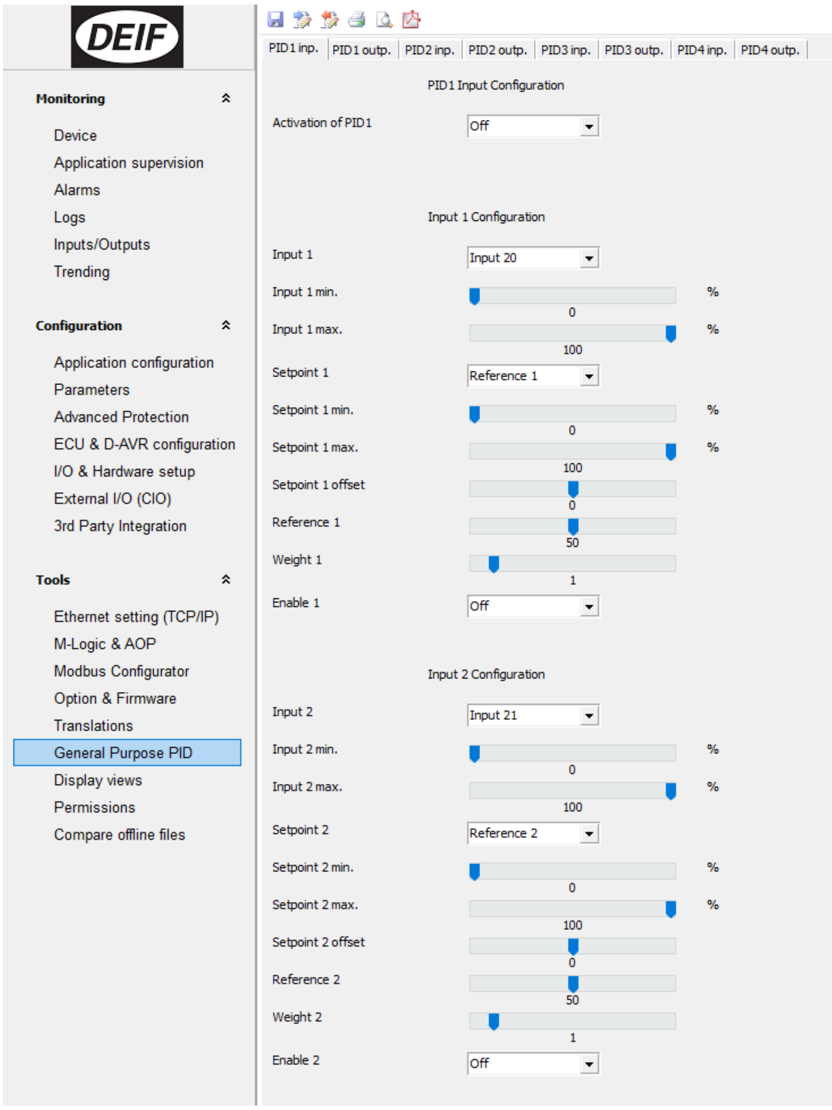
The analogue regulation in the general purpose PIDs is handled by a PID loop. The diagram below shows which elements the PID loop consists of.



1. **Input:** This is the analogue input that measures the process the controller is trying to regulate.
2. **Reference:** This is the set point that the controller is trying to bring the input to match.
3. **Kp:** The proportional gain of the PID loop.
4. **Ti:** The integral gain of the PID loop.
5. **Td:** The derivative gain of the PID loop.
6. **Inverse:** Enabling inverse will give the output a negative sign.
7. **Offset:** The offset is added on the function and displaces the regulation range.
8. **Output:** This is the final output from the PID, controlling the transducer.

10.1.2 General purpose PID interface in the utility software

Configure the four general purpose PID’s input and output settings using the PID interface in the utility software. This cannot be done from the controller.



10.2 Inputs

Each output can have up to three inputs. Only one input at a time is used for calculation of the output signal.

Explanation of general purpose PID settings

1. **Activation**: Enable the PID, or allow it to be enabled from M-Logic.
2. **Input 1**: Select the source of this input here.
3. **Input 1 min. and Input 1 max.**: Define the scale of the input value evaluated.
4. **Setpoint 1**: Select **Reference 1** to define the set point in this box. Alternatively, select a set point source (from the same options as Input 1).
5. **Setpoint 1 min. and Setpoint 1 max.**: Define the scale of the set point value evaluated.
6. **Setpoint 1 offset**: The offset for set point 1.
7. **Reference 1**: Select the set point for this input. **Reference 1** must be selected for **Setpoint 1**.
8. **Weight 1**: The input value is multiplied by the weight factor.
   - A weight factor of 1 means that the real input value is used in calculations.
   - A weight factor of 3 means that the input value is treated as three times as big in calculations.
9. **Enable**:
   - On: This input will be evaluated.
   - Off: This input will not be evaluated.

10.2.1 Dynamic input selection

Each general purpose PID holds the possibility of up to three active inputs. All activated inputs are evaluated constantly, and the input causing the greatest or smallest output is selected. Priority of great or small output is selected in the output settings.

Example: Dynamic input selection Ventilation of a container fitted with a genset inside is a realistic example for use of the dynamic input selection. The following three variables depend on the ventilation, hence it makes sense to let them share the output.

- The container is fitted with a temperature sensor for internal container temperature. Due to lifetime of electronics inside the container, maximum maintained temperature is desired to be 30 °C. (Input 1).
- The engine air intake is located inside the container, hence turbo compressor inlet temperature depends on the air temperature in the container. Maximum maintained intake air temperature is 32 °C. (Input 2).
- The alternator is cooled by air in the container, hence the alternator winding temperature depends on the air temperature in the container. Maximum maintained winding temperature is 130 °C. (Input 3).

This is the data that is used to configure the inputs in the screenshot in the previous paragraph (Inputs). All inputs are configured with both full range of measurement (0 to 100 %) and a weight factor of 1. The common output to the ventilator speed drive is configured to prioritise maximum output as explained in the next chapter, “Output”. This configuration is meant to ensure that none of the input set points are continuously exceeded, unless maximum ventilation is reached.

A scenario of operation could be that the controller has been using input 1, and a temperature of 30 °C is maintained in the container. At a point, the air filter housing is heated by radiation from the engine, causing input 2 to rise more above 32 °C than input 1 is above 30 °C. This means that input 2 now has the greatest positive deviation. All inputs are configured with a weight factor of 1 and maximum output is prioritised, hence the greatest positive deviation results in maximum output, or, to put it in another way, input 2 is now the one selected.

The genset is running at full load with a maximum of reactive load, and the alternator windings heat up beyond the 130 °C set point due to high currents. At some point, input 3 will result in maximum output and hence be selected as the input used in output calculation. Ventilation is increased and the winding temperature may reach a steady state of 130 °C with a container room temperature of 27 °C and a compressor inlet temperature of 30 °C. As long as this is the situation, input 3 will remain the selected input, as this is the input causing the greatest output.

In case of high ambient temperatures, the ventilation might not be able to influence the temperature enough, and the temperatures start to rise above set point. The output will stay at 100 % as long as any of the inputs are continuously above their set points.

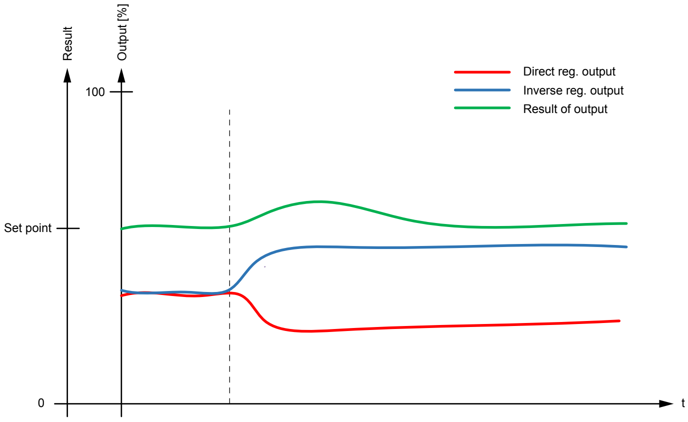
Weight factor applies to dynamic input selection as well. In the event that different weight factors have been configured for any of the three inputs, maximum deviation cannot be equated to maximum output. If two inputs with similar deviation to their respective set points are configured with weight factors of 1 and 2 respectively, the latter will result in twice the output as the first.

10.3 Outputs

10.3.1 Explanation of output settings

Explanation of general purpose PID settings

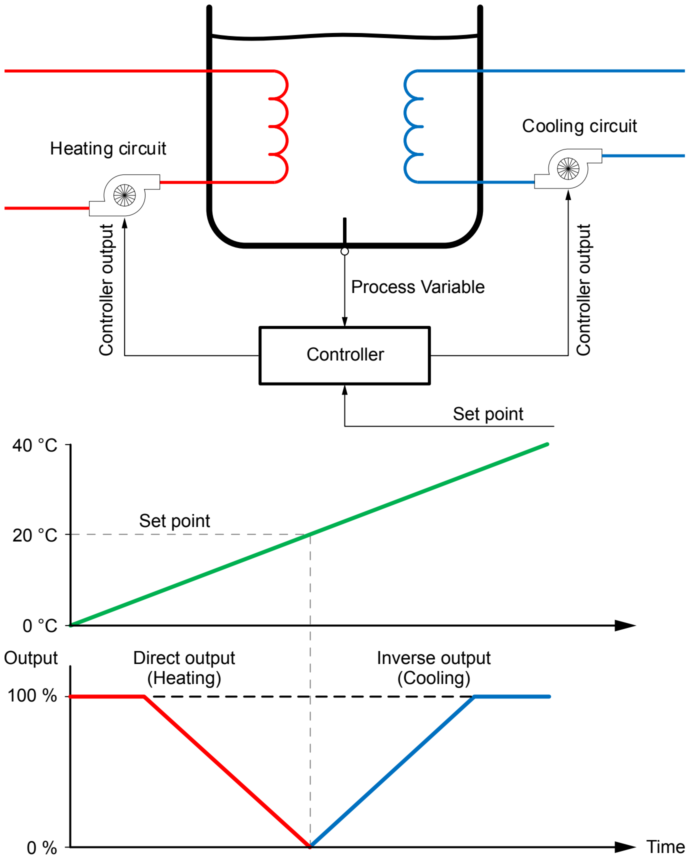
1. **Priority**: This setting determines whether the min. or max. output that is prioritised. This setting is used for the dynamic input selection feature. Maximum output results in selection of the input that gives the greatest output. Minimum output results in selection of the input that gives the smallest output.
2. **Output type**: Choose between relay or analogue output. The following parameters marked "analogue" only apply to the use of analogue regulation, in the same way as parameters marked "relay" only apply to relay regulation.
3. **Analogue Kp**: This is the proportional gain value. Increase this to give a more aggressive reaction. Adjusting this value also affects the integral and derivative output. If Kp needs adjustment without affecting the Ti or Td part, adjust these accordingly.
4. **Analogue Ti**: Increase the Ti for a less aggressive integral action.
5. **Analogue Td**: Increase the Td for a more aggressive derivative action.
6. **Analogue output**: Choose the physical internal or external output.
7. **Analogue output inverse**: Enable this to invert the output function.



Direct error = SP - PV
Direct output is used in applications where a rise in analogue output increases the process variable.

Inverse error = PV - SP
Inverse output is used in applications where a rise in analogue output decreases the process variable.

Example explaining direct and indirect regulation

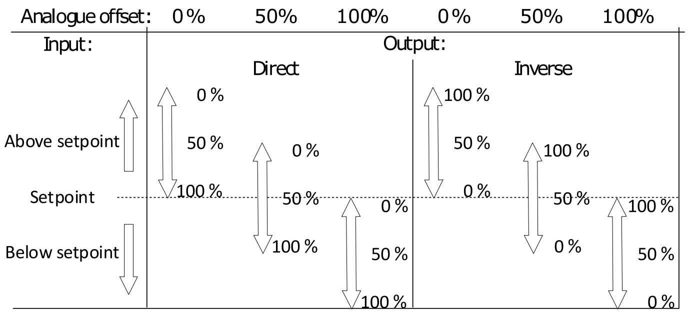


Typically, heating applications use direct output and cooling applications use inverse output. Imagine a container of water, which must be kept at a set point of 20 °C at all times. The container can be exposed to temperatures between 0 and 40 °C, hence it is fitted with both a heating coil and a cooling coil. See the diagrams that show this below.

For this application, two controllers must be configured: one with direct output for the heating pump and one with inverse output for the cooling pump. To achieve the inverse output shown, an offset of 100 % is needed. See **Analogue offset** below for more information.

Temperatures below 20 °C then result in a positive output for the heating pump, in the same way as temperatures above 20 °C result in a positive output for the cooling pump, and the temperature is maintained around the set point.

8. **Analogue offset**: Determines the output starting point. The full range of output can be seen as values in the range between 0 and 100 %. The offset displaces this range. 50 % offset centres the range of output at the set point. 0 and 100 % offset result in having the full range of output above or below the set point. See below for how the output behaves according to the input and with different offsets.



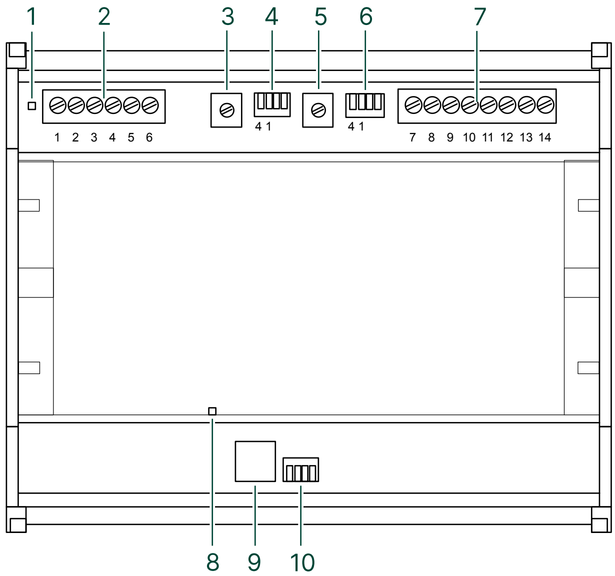
100 % offset is commonly used with inverse output, like in the previous cooling example.

9. **M-Logic min event set point**: The controller activates *Events > General Purpose PID > PID# at min output* in M-Logic.
10. **M-Logic max event set point**: The controller activates *Events > General Purpose PID > PID# at max output* in M-Logic.
11. **Relay Db**: Deadband setting for relay control.
12. **Relay Kp**: Proportional gain value for relay control.
13. **Relay Td**: Derivative output for relay control.
14. **Relay min on-time**: Minimum output time for relay control. Set this to the minimum time that is able to activate the controlled actuator.
15. **Relay period time**: Total time for a relay activation period. When the regulation output is above this period time, the relay output is constantly activated.
16. **Relay increase**: Choose the terminal for the relay used for positive activation.
17. **Relay decrease**: Choose the terminal for the relay used for negative activation.

10.3.2 Additional analogue outputs with IOM 230

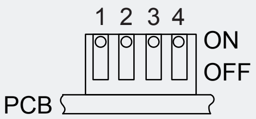
The controller includes two built-in analogue outputs. The controller also supports up to two IOM 230 analogue interface modules, which can provide four additional analogue outputs.

IOM 230 overview



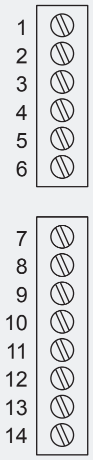
1. IOM 230 status LED (green = system OK, red = system failure)
2. Terminals 1 to 6
3. GOV adjustment
4. GOV output selector
5. AVR adjustment
6. AVR output selector
7. Terminal 7 to 14
8. CAN status LED (green = system OK, red = system failure)
9. PC port
10. IOM 230 CAN ID selector

GOV and AVR output selector settings

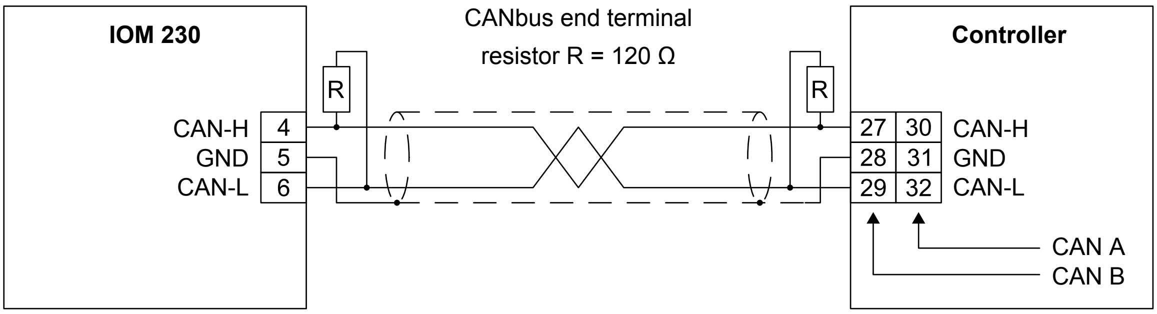
	Output	Switch 1	Switch 2	Switch 3	Switch 4
	+/-25 mA	ON	OFF	Not used	OFF
	0 to 20 mA	OFF	ON		OFF
	+/-12 V DC	ON	OFF		ON
	0 to 10 V DC	OFF	ON		ON

NOTE Switch 1 and 2 cannot have the same position.

IOM 230 Terminals

	Terminal	Description	Comment
	1	+12/24V DC	Power supply
	2	0V DC	
	3	Not used	-
	4	CAN-H	CAN bus interface
	5	CAN-GND	
	6	CAN-L	
	7	GOV out	Governor analogue interface
	8	GOV com	
	9	AVR out	AVR analogue interface
	10	AVR com	
	11	Not used	-
	12	VAr share out	Load sharing lines
	13	Common	
	14	P share out	

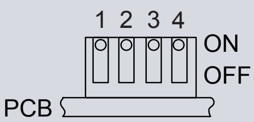
CAN bus connections



The cable shield must not be connected to ground, only to the GND terminals.

Use different CAN addresses for the different IDs. Only ID0 participate in the load share functionality.

IOM 230 CAN ID selector settings

	IOM ID	Switch 1	Switch 2	Switch 3	Switch 4
	ID0	OFF	OFF	OFF	OFF
	ID1*	ON	OFF	OFF	OFF
	ID2*	OFF	ON	OFF	OFF

All other combinations = ID0.

NOTE * ID1 is used for PID1 and PID2. ID2 is used for PID3 and PID4.

10.4 Kp gain compensation

Kp gain compensation is intended for when the controller controls the cooling water system for the genset.

There are two situations where the engine can begin to oscillate, which could shut down the engine:

1. Load impacts.
2. Cold start of engine.

In both situations, it is desired to have a higher gain when the change is needed, but a lower gain when the system has to stabilise. Without Kp gain compensation, the PID settings need to be balanced between reaction and stability. The Kp gain compensation function allows slower PID settings for when there are no changes or stabilising, and when there are significant changes in the system it will increase the reaction of the PID.

The Kp gain compensation consists of two separate functions:

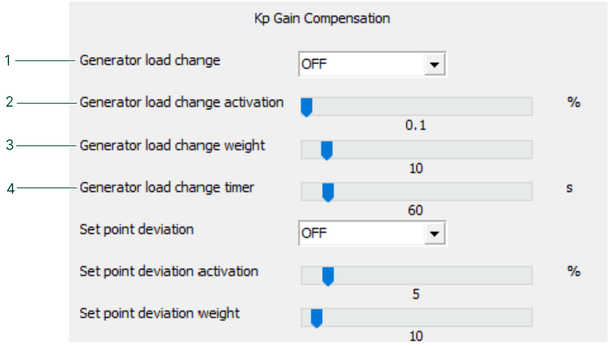
1. The load change gain compensation.
2. Set point deviation compensation.

These two functions, the load-dependent compensation and the set point deviation compensation, can be used separately or together. If they are used together, it is always the one with the highest returned gain that is used.

10.4.1 Load change gain compensation

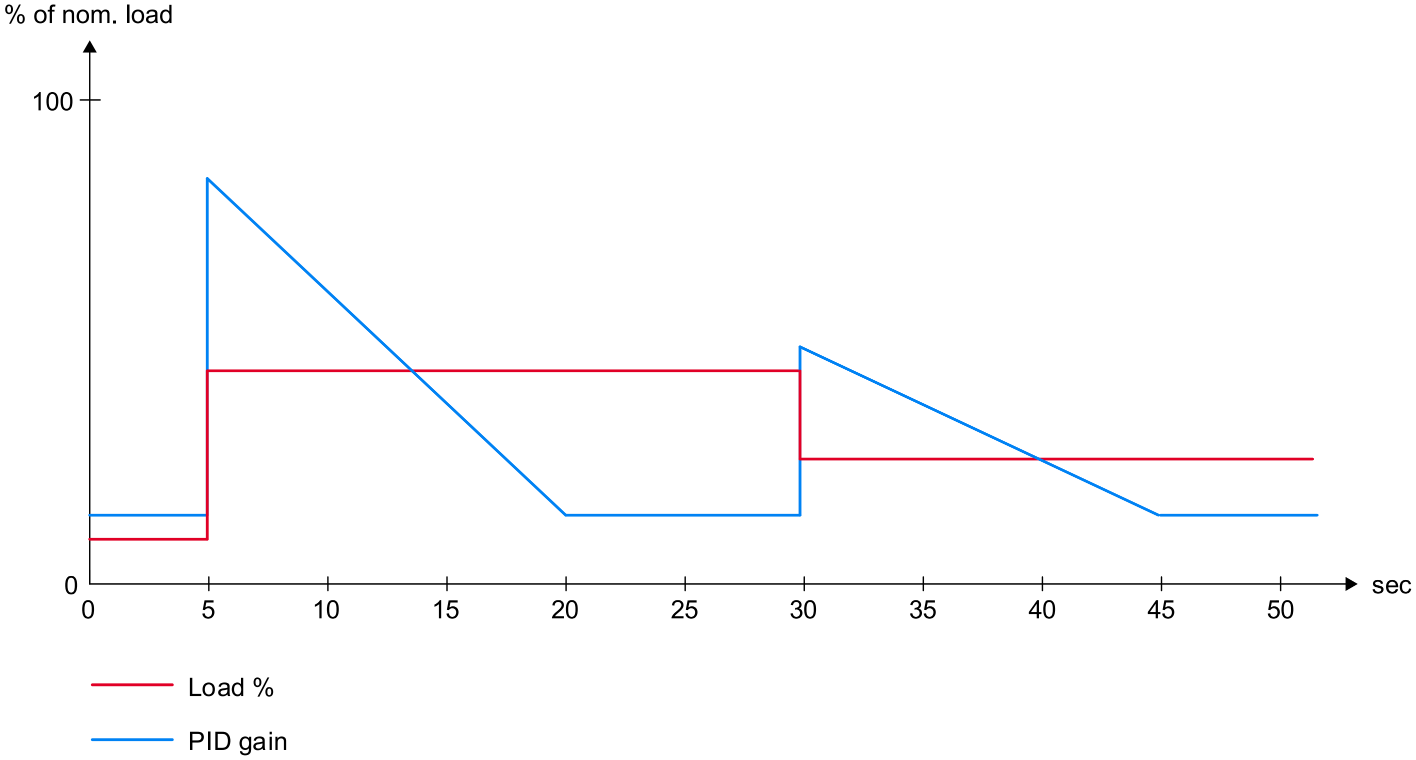
In case of large load impacts or rejections, it can create large deviation in the need of cooling, and thereby create some instability in the cooling system. To alleviate some of this instability, the load change gain compensation will instantaneously increase the gain in relation to the load gain. Larger load changes give a bigger increase in gain. This increase in gain will decrease over a set time till it reaches the nominal gain.

Explanation of settings



1. **Generator load change**: Enables/disables load change compensation.
2. **Generator load change activation**: Load change limit. The controller needs to detect a load change larger than this limit before activating the gain compensation. For example, if the limit is set for 10 %, there must be a load impact or rejection of at least 10 % of the genset nominal power before this function activates.
3. **Generator load change weight**: The gain increase is based on the load change compared to nominal, and this ratio is multiplied by the load weight.
4. **Generator load change timer**: The gain increase will be instantaneous, but it will decrease linearly over the set time until it reaches nominal gain.

Example of load change gain compensation



This diagram shows the reaction of the gain, based on two load changes.

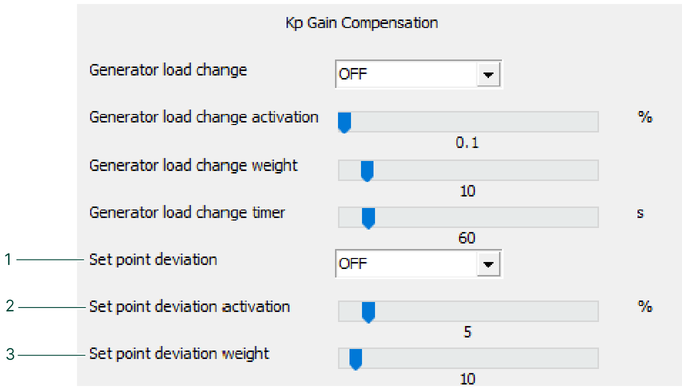
In the first situation, there is a large load impact that triggers the load change gain compensation and increases the gain instantaneously. This increase will decrease, in this case over 15 seconds, and bring the gain back to nominal.

After some seconds, the system drops some load again, but only half of the former impact. Gain is again instantaneously increased, but this time only half as much because the load change is only half as big. The increase will still decrease over 15 seconds.

10.4.2 Set point deviation compensation

This function is intended to help minimise overshoots. Especially in a cooling water system where the set point is often very close to the shutdown limit, it is difficult for a slow system to react in time to avoid a shutdown. This function will drastically increase the gain when the actual value overshoots the set point more than the set deadband, but the further the actual value is from the set point, it will decrease. If the value drops below the set point, the function works reversed. Close to set point, the gain increase is small, but the further the actual value is from the set point, it will increase. This is to avoid that the system starts hunting.

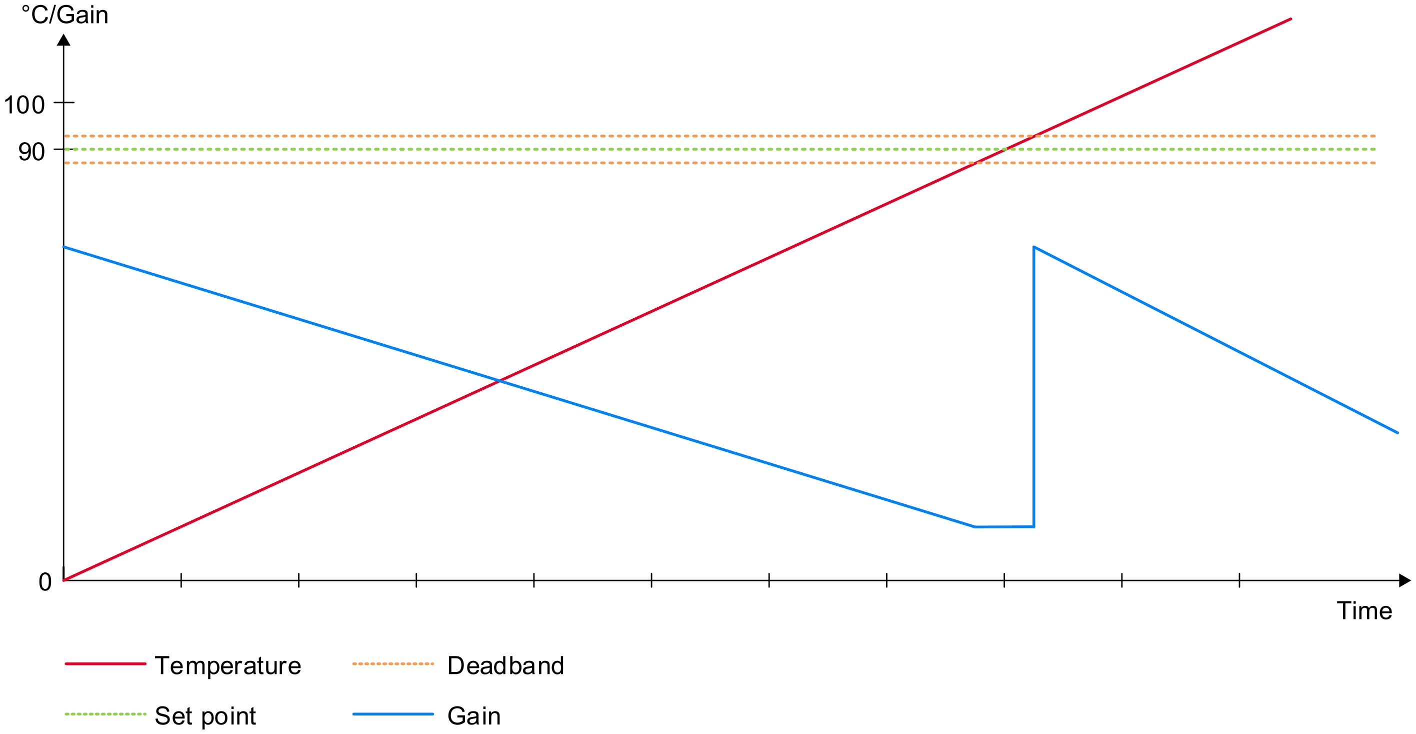
Explanation of settings



1. **Set point deviation**: Enables/disables set point deviation compensation.

2. **Set point deviation activation**: Deviation deadband. As long as the actual value does not deviate more than the deadband in this parameter, the function is not activated.
3. **Set point deviation weight**: The gain increase is based on the set point deviation compared to nominal, and this ratio is multiplied by the weight factor.

Example of set point deviation compensation



This diagram shows how the reaction to a set point deviation could look.

This situation could be rising cooling water temperature in a genset. Below the set point, the gain is very high, but as the temperature is getting closer to the set point, it decreases the gain compensation. Within the activation limit, the gain is at nominal value.

As the temperature keeps rising, it exceeds the activation limit again, and when it is above set point the gain is increased instantaneously. As the temperature keeps rising, the gain compensation decreases again.

10.5 M-Logic

All functions of the general purpose PIDs can be activated and deactivated using M-Logic. In the following, events and commands regarding the general purpose PIDs are described.

`M-Logic > Events > General Purpose PID`

Events

- **PID (1-4) active**: This event is active when the related PID is activated.
- **PID (1-4) at min output**: This event is active when the output is below the output parameter M-Logic min event set point.
- **PID (1-4) at max output**: This event is active when the output is above the output parameter M-Logic max event set point.
- **PID (1-4) output frozen**: This event is active when the output is frozen.
- **PID1 using input (1-3)**: This event is active when dynamic input selection has selected input 1 for output calculation.
- **PID2 using input (1-3)**: This event is active when dynamic input selection has selected input 2 for output calculation.
- **PID3 using input (1-3)**: This event is active when dynamic input selection has selected input 3 for output calculation.
- **PID4 using input (1-3)**: This event is active when dynamic input selection has selected input 4 for output calculation.
- **PID (1-4) Modbus control**: This event is active when remote Modbus control of this PID is requested.

`M-Logic > Output > General Purpose PID commands`

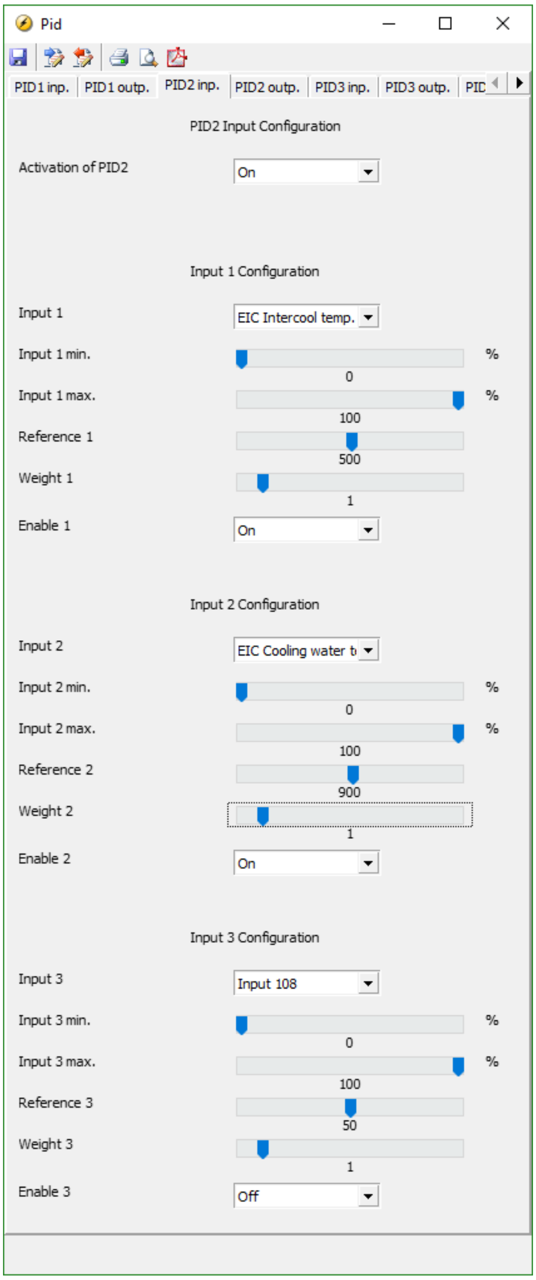
Commands

- **PID1 Manual reg ON**: This command activates manual regulation.
- **PID (1-4) Activate**: This command activates the PID controller.
- **PID (1-4) force min. outp.** : This command forces the output to the value set in the output parameter *M-logic min event setpoint*.
- **PID (1-4) force max. outp.** This command forces the output to the value set in the output parameter *M-logic max event setpoint* (for example, for post-cooling purposes).
- **PID (1-4) reset**: This command forces the output to the value set in the output parameter Analogue offset.
- **PID (1-4) freeze output**: This command freezes the output at the current value.
- **PID1 activate input (1-3)**: This command activates input 1.
- **PID2 activate input (1-3)**: This command activates input 2.
- **PID3 activate input (1-3)**: This command activates input 3.
- **PID4 activate input (1-3)**: This command activates input 4.
- **PID1 deactivate input (1-3)**: This command deactivates input 1.
- **PID2 deactivate input (1-3)**: This command deactivates input 2.
- **PID3 deactivate input (1-3)**: This command deactivates input 3.
- **PID4 deactivate input (1-3)**: This command deactivates input 4.

10.6 Example: Use of a general purpose PID

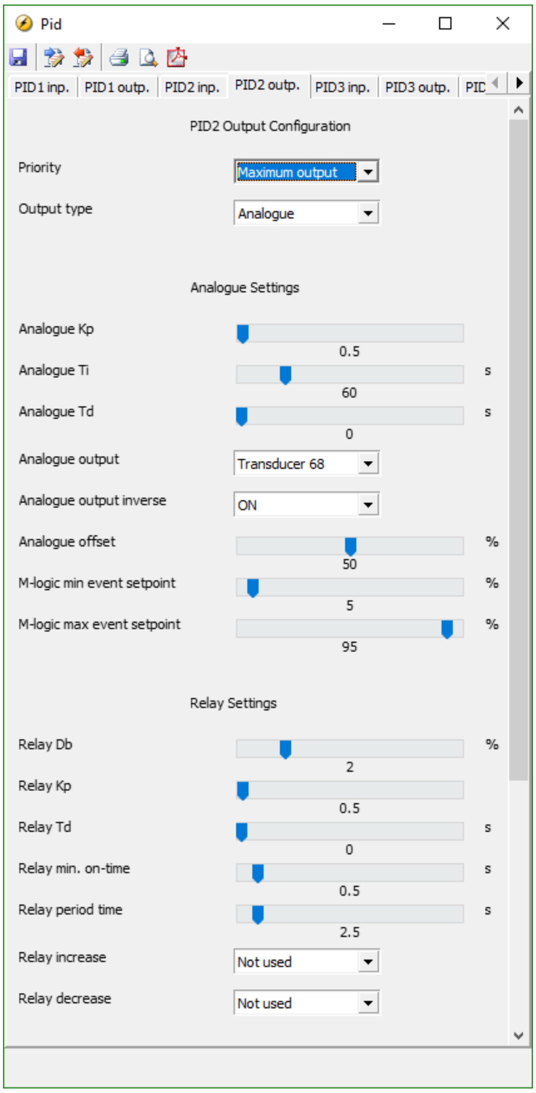
In this example a general purpose PID is used for analogue fan control.

The fan is mounted on a radiator “sandwich” construction. The fan drags air through two radiators, one for cooling of the intercooler coolant and one for cooling of the jacket water. As these two systems have different temperature set points, the dynamic set point selection is used. PID2 is used in this example, and the picture shows an example of input settings.



The ECM (Engine Control Module) measures both the intercooler coolant temperature as well as the jacket cooling water temperature. The generator controller receives these values by an EIC option (Engine Interface Communication).

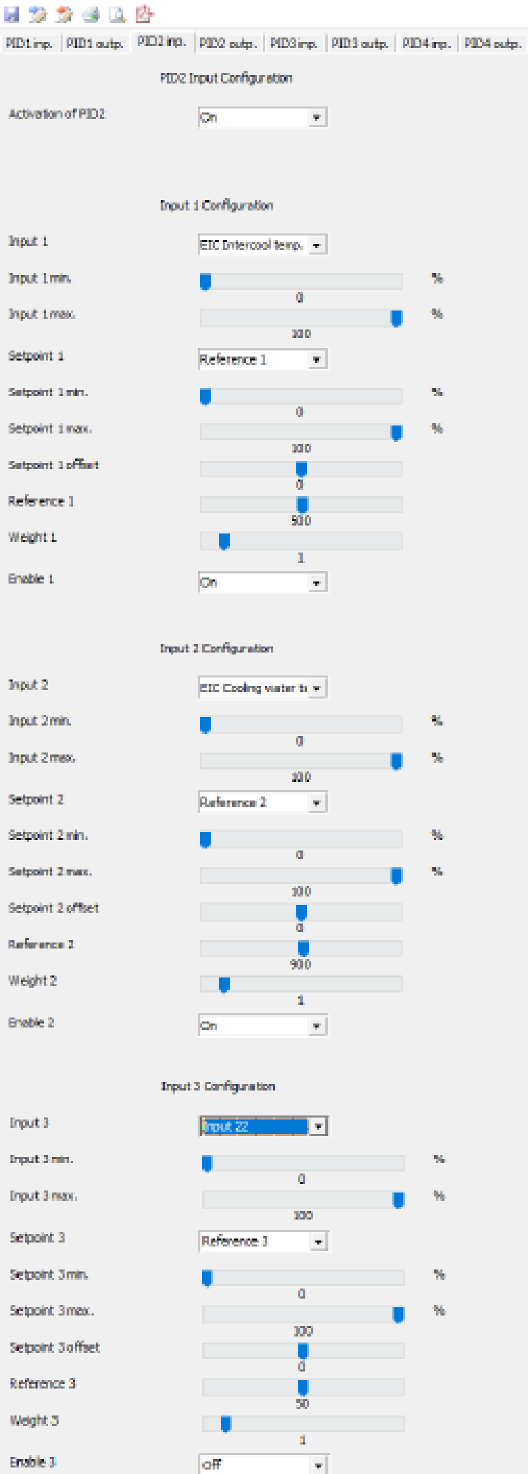
EIC Intercool temp. is selected as input 1, and EIC Cooling water temp. as input 2. Min. and max. values are configured for full range. Input 1 reference set point is set at 500 to achieve a temperature set point of 50.0 °C for intercooler coolant. Input 2 has a reference set point set at 900 to achieve a set point of 90.0 °C jacket water coolant. To achieve equal weighting of the inputs when calculating the output, both weight factors are set to a value of 1. Both desired inputs are activated, leaving input 3 to be deactivated.



In this application, it is desired to ensure that none of the temperatures permanently exceed their set points. This is achieved by selecting maximum output as priority for the dynamic input selection:

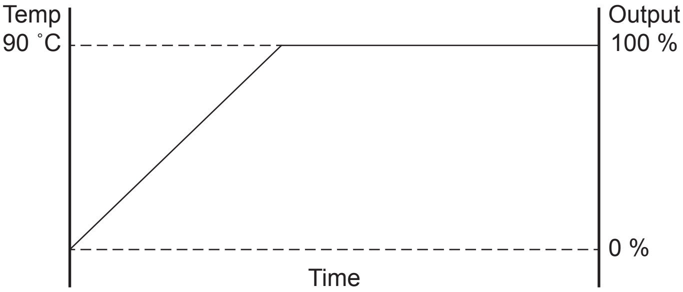
- Analogue is selected as output type, and the physical output is selected to be transducer 68.
- Inverse output is activated to obtain a rise in analogue output to the fan when the temperature rises.
- An offset of 100 % is chosen to achieve 100 % output at the set point.
- Full range of output is selected. As this is output for a fan, it may be preferred to use a minimum output.
- Standard settings are used for M-Logic min./max. events.
- No relay settings are configured, as this is an analogue function.

Below is an example of M-Logic lines for this application. Logic 1 makes sure that the regulation is active and the output is calculated as long as the engine is running. Logic 2 forces the fan to maximum speed during cool-down to ensure efficient cool-down.



When the engine is started and running, the regulation is activated and an output is calculated. When either the intercooler or jacket water coolant exceeds their set point, the output starts to increase from 0 %. The input that results in calculation of greatest output is prioritised at all times, making sure that both systems are supplied with adequate cooling. During stop sequence, the fan is forced to max. output, ensuring most possible cooling. The output remains at 0 % until the engine is started again.

This is an example that uses inverse output combined with 0 % offset. The application is an engine with electric thermostat control. During engine start-up, it is preferred to start the output before the set point is reached, to help avoid overshooting the set point too much. This is obtained by using inverse output with no offset. The diagram below shows this function if the controller is configured as straight proportional without integral or derivative action. With these settings, the output is 100 % when the set point is reached, and the beginning of the output is determined by the proportional gain.


Temp
90 ˚C
Output
100 %
0 %
Time

11. Inputs and outputs

11.1 Digital inputs

11.1.1 Standard digital inputs

The controller has as standard 12 digital inputs, located on the terminals 39 to 50. All inputs are configurable.

Digital inputs

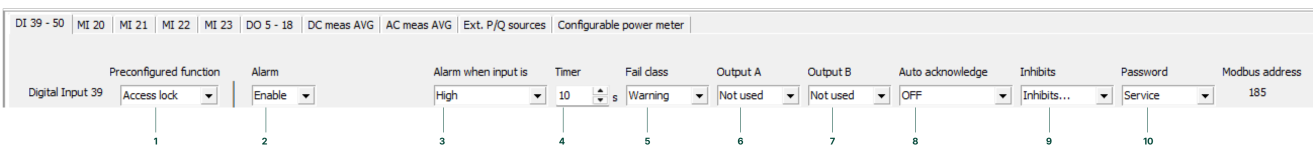
Input	Text	GEN	SHORE	BTB	Technical data
39	In	PMS control	PMS control	PMS control	Negative switching only, < 100 Ω
40	In	Configurable	Configurable	Gen supply active	Negative switching only, < 100 Ω
41	In	Configurable	Configurable	Shore supply active	Negative switching only, < 100 Ω
42	In	Configurable	Configurable	Configurable	Negative switching only, < 100 Ω
43	In	Configurable	Configurable	Configurable	Negative switching only, < 100 Ω
44	In	Configurable	Configurable	Configurable	Negative switching only, < 100 Ω
45	In	Configurable	Configurable	Configurable	Negative switching only, < 100 Ω
46	In	Configurable	Configurable	Configurable	Negative switching only, < 100 Ω
47	SCB on	Configurable	SCB Postion On	Configurable	Negative switching only, < 100 Ω
48	SCB off	Configurable	SCB Position off	Configurable	Negative switching only, < 100 Ω
49	GB/BTB on	GB Position On	Configurable	BTB Position On	Negative switching only, < 100 Ω
50	GB/BTB off	GB Position Off	Configurable	BTB Position Off	Negative switching only, < 100 Ω

11.1.2 Configuring digital inputs

The digital inputs can be configured from the controller or with the utility software (some parameters can only be accessed with the utility software).

Configure a digital input with the utility software

In the utility software, in *I/O & Hardware setup*, select the digital input to configure.



No.	Text	Description
1	Preconfigured function	Select a function for the digital input.
2	Alarm	Enable the alarm function.
3	Alarm when input is	The alarm is activated when the input is high or low.
4	Timer	The timer setting is the time from the alarm level is reached until the alarm occurs.
5	Fail class	Select the required fail class from the list. When the alarm occurs, the controller reacts according to the selected fail class.
6	Output A	Select the terminal (or *Limits*) to be activated by an alarm. Limits make the alarm usable as an input event in M-Logic.
7	Output B	Select the terminal (or *Limits*) to be activated by an alarm. Limits make the alarm usable as an input event in M-Logic.
8	Auto acknowledge	ON: The alarm is automatically acknowledged when the alarm conditions are no longer met.
9	Inhibits	Select the exceptions to when the alarm must be activated.
10	Password level	Select the password level that is needed to modify this parameter.

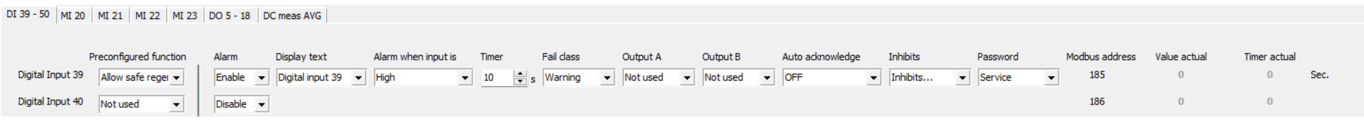
Select *Write to device* to write the settings to the controller.

11.1.3 Custom alarms

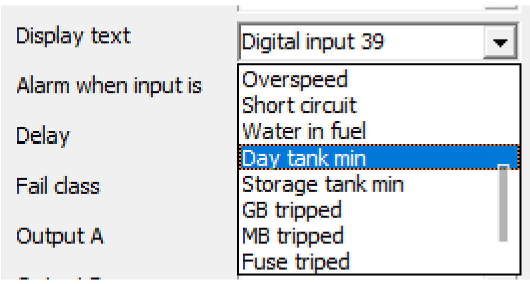
You can configure custom alarms for the digital inputs using the utility software or on the controller.

In the utility software

1. Select the *I/O & Hardware setup* tab.
2. Select one of the digital input tabs.
3. You can configure custom alarms for each active digital input. You must select *Enable* from the *Alarm* drop-down menu to see the alarm options.

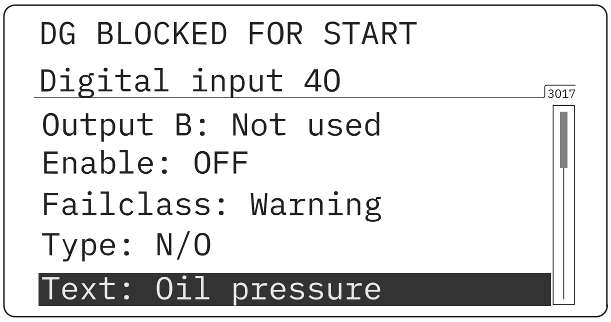


4. Pre-defined display text options are available for the custom alarms:



On the controller

Go to `Parameters > I/O settings > Inputs > Digital inputs > Digital input XX > Text`. Select from a range of pre-defined text options.



11.2 DC relay outputs

The controller has 12 x DC relay outputs as standard. The outputs are divided in two groups with different electrical characteristics.

All outputs are configurable, unless stated otherwise.

Relay outputs, group 1

Electrical characteristics

- Voltage: 0 to 36 V DC
- Current: 15 A DC inrush, 3 A DC continuous

Relay	Genset default setting	Shore default setting	BTB default setting
Relay 05	Run coil	Not used	Not used
Relay 06	Starter (Crank)	Not used	Not used

Relay outputs, group 2

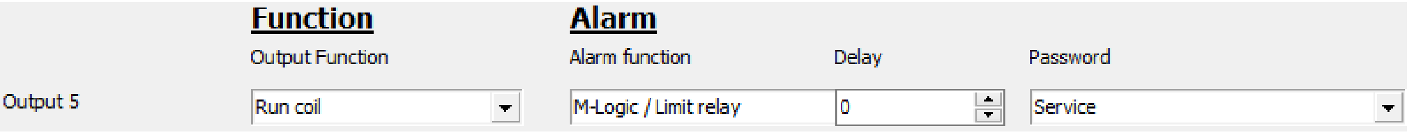
Electrical characteristics

- Voltage: 4.5 to 36 V DC
- Current: 2 A DC inrush, 0.5 A DC continuous

Relay	Genset default setting	Shore default setting	BTB default setting
Relay 09	Start prepare	Not used	Not used
Relay 10	Stop coil	Not used	Not used
Relay 11	Status OK	Status OK	Status OK
Relay 12	Horn	Horn	Horn
Relay 13	Not used	Not used	Not used
Relay 14	Not used	Not used	Not used
Relay 15	Not used	Not configurable	Not used
Relay 16	Not used	Not configurable	Not used
Relay 17	Not configurable	Not used	Not configurable
Relay 18	Not configurable	Not used	Not configurable

11.2.1 Configure a relay output

Use the utility software, under *I/O & Hardware setup, DO 5 - 18* to configure the relay outputs.



Setting	Description
Output function	Select an output function.
Alarm function	Alarm relay NE M-Logic / Limit relay Alarm relay ND
Delay	The alarm timer.
Password	Select the password level to modify this configuration (cannot be edited by a user with lower privileges).

11.3 Analogue inputs

11.3.1 Introduction

The controller has four analogue inputs (also known as multi-inputs): Multi-input 20, multi-input 21, multi-input 22, and multi-input 23. Terminal 19 is the common ground for the multi-inputs.

The multi-inputs can be configured as:
- 4-20 mA
- 0-10 V DC
- Pt100
- RMI oil pressure
- RMI water temperature
- RMI fuel level
- RMI Custom
- Binary/digital input

The function of the multi-inputs can only be configured with the utility software.

Wiring

The wiring depends on the measurement type (current, voltage, or resistance).

More information
See **Wiring** in the **Installation instructions** for examples of wiring.

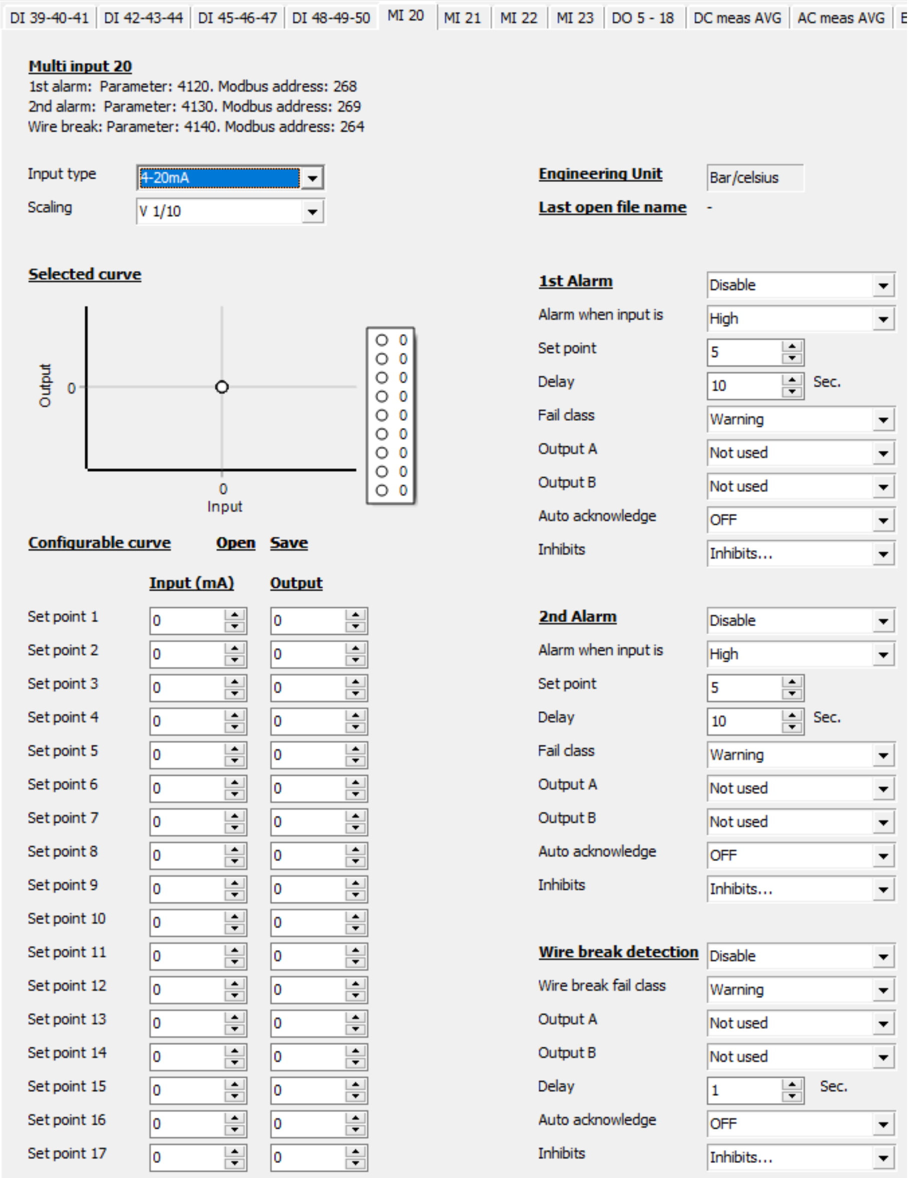
11.3.2 Application description

The multi-inputs can be used in different applications, for example:
- Power transducer. If you want to measure the current to a load, across a TB or something else, a power transducer sending a 4-20 mA signal could be connected to multi-input 20.
- Temperature sensor. Pt100 resistors are often used to measure temperature. In the utility software, you can choose whether the temperature should be shown as Celsius or Fahrenheit.
- RMI inputs. The controller has three RMI types; oil, water and fuel. It is possible to choose different types within each RMI type. There is also a configurable type.
- An extra button. If the input is configured as digital, it works like an extra digital input.
- Max. difference between ambient and generator temperature. Differential measurement can be used to give an alarm, if two values are too far apart.

11.3.3 Configuring multi-inputs

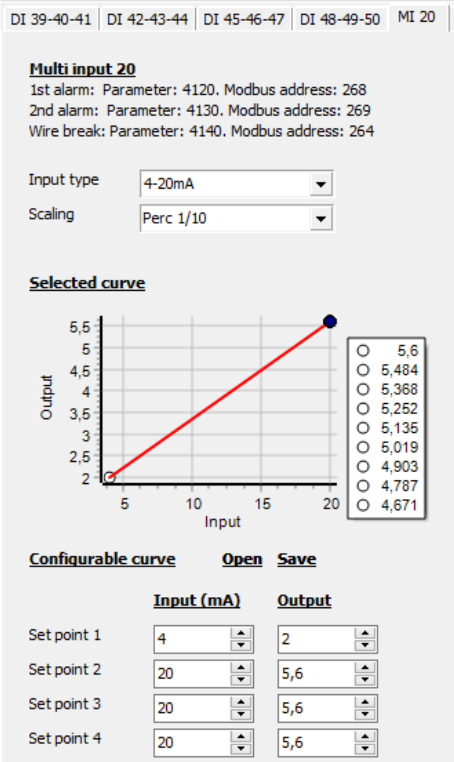
Configure each multi-input to match the connected sensor.

1. In the utility software, select *I/O & Hardware setup*, then select *MI 20 / 21 / 22 / 23*.

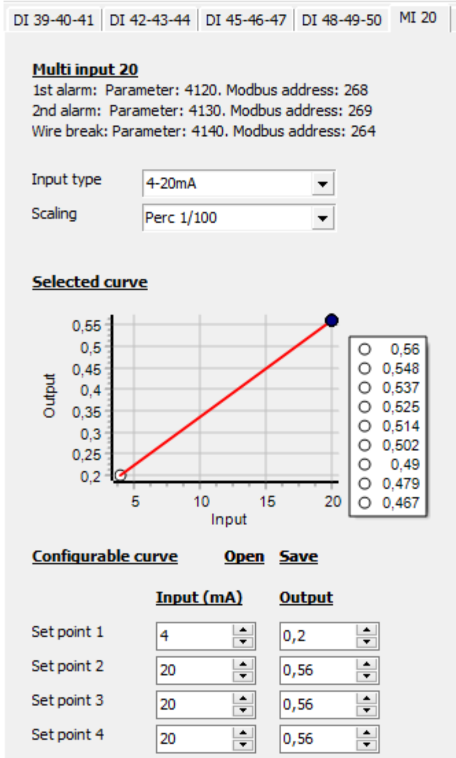


2. Select the appropriate *Scaling*.

Examples



Scaling 1/10

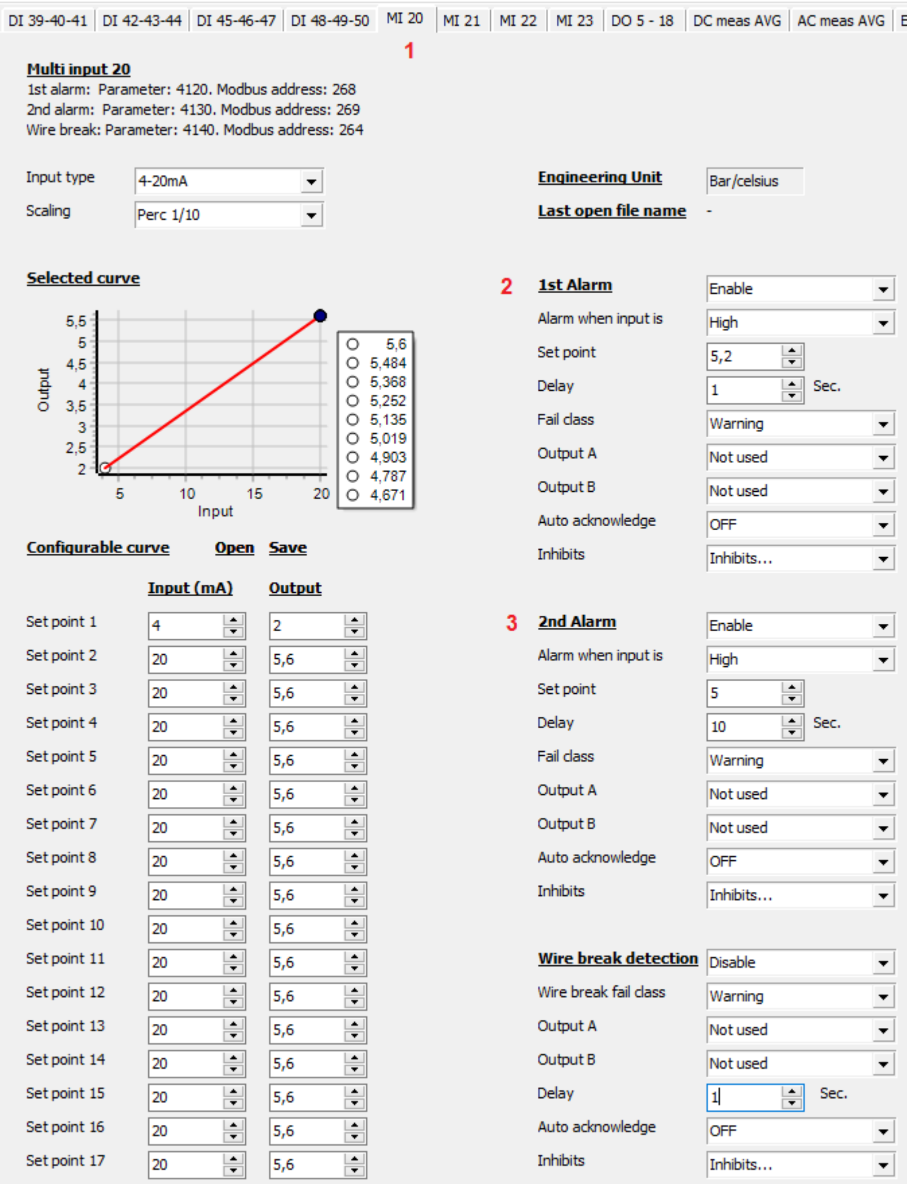


Scaling 1/100

11.3.4 Alarms

For each multi-input, two alarm levels are available. With two alarms it is possible to have the first alarm reacting slow, while the second alarm can react faster. For example, if the sensor measures generator current as protection against overload, a small overload is acceptable for a shorter period, but in case of a large overload, the alarm should activate quickly.

Use the utility software to configure the multi-input alarms. Select *I/O & Hardware setup*, then select *MI 20 / 21 / 22 /23*.



1. Select the desired multi-input tab.
2. Configure the parameters for 1st alarm.
3. Configure the parameters for 2nd alarm.

Sensors with max. output less than 20 mA

If a sensor has a maximum output less than 20 mA, it is necessary to calculate what a 20 mA signal would indicate.

Example: A pressure sensor gives 4 mA at 0 bars and 12 mA at 5 bar.

- (12 - 4) mA = 8 mA = 5 bar
- 1 mA = 5 bar/8 = 0.625 bar
- 20 - 4 mA = 16 × 0.625 bar = 10 bar

Configuring multi-input alarms from the display

Alternatively, you can use the display to configure the multi-input alarms: `I/O settings > Inputs > Multi input > Multi input [20 to 23].1 / 2`

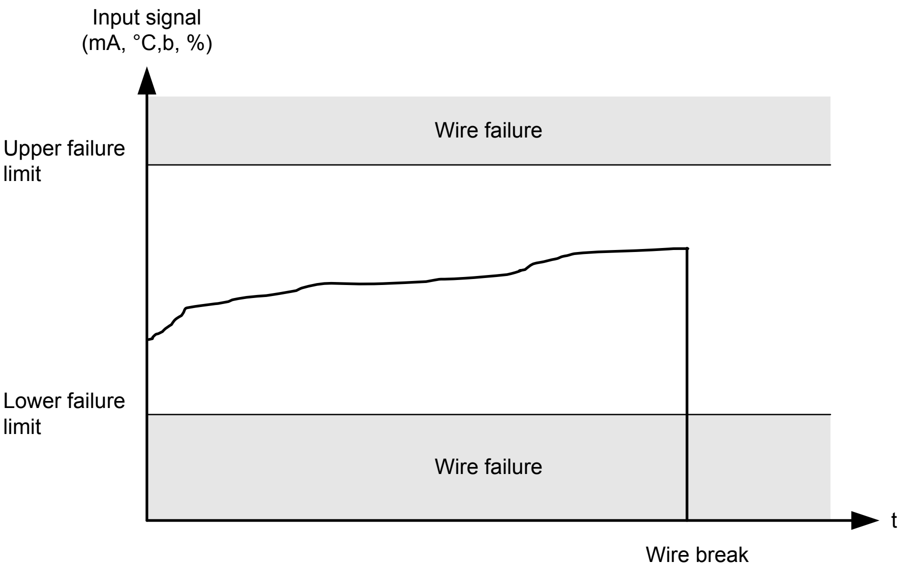
11.3.5 Wire break

To supervise the sensors/wires connected to the multi-inputs and analogue inputs, you can enable the wire break function for each input. If the measured value on the input is outside the normal dynamic area of the input, it is detected as a short circuit or a break. An alarm with a configurable fail class is activated.

Input	Wire failure area	Normal range	Wire failure area
4-20 mA	<3 mA	4-20 mA	>21 mA
0-10 V DC	≤0 V DC	-	N/A
RMI Oil, type 1	<10.0 Ω	-	>184.0 Ω
RMI Oil, type 2	<10.0 Ω	-	>184.0 Ω
RMI Oil, type 4	<33.0 Ω	-	240.0 Ω
RMI Temp, type 1	<10.0 Ω	-	>1350.0 Ω
RMI Temp, type 2	<18.2 Ω	-	>2400.0 Ω
RMI Temp, type 3	<3.6 Ω	-	>250.0 Ω
RMI Temp, type 4	<32.0 Ω	-	>2500.0 Ω
RMI Fuel, Type 1	<1.6 Ω	-	>78.8 Ω
RMI Fuel, Type 2	<3.0 Ω	-	>180.0 Ω
RMI Fuel, type 4	<33.0 Ω	-	>240.0 Ω
RMI configurable	<lowest resistance	-	>highest resistance
RMI Custom	<lowest resistance	-	>highest resistance
Pt100	<82.3 Ω	-	>194.1 Ω
Level switch	Only active if the switch is open		

Principle

The diagram shows that when the wire of the input breaks, the measured value drops to zero, and the alarm is activated.



Configuring wire break alarms from the utility software or display

You can use the utility software to configure wire break alarms. Alternatively, you can use the display to configure wire break alarms: `I/O settings > Inputs > Multi input > Wire fail [20 to 23]`

11.3.6 RMI sensor types

The multi-inputs can be configured as RMI inputs.

The available RMI input types are:

- RMI oil pressure

- RMI water temperature
- RMI fuel level
- RMI Custom

For each RMI input type, you can select different curves, including a configurable curve. The configurable curve has up to 20 set points. The resistance and the pressure can be adjusted.

NOTE The sensor range is 0 to 2500 Ω.

NOTE If the RMI input is used as a level switch, then no voltage must be connected to the input. If any voltage is applied to the RMI inputs, it will be damaged.

11.3.7 Differential measurement

Differential measurement compares two measurements, and gives an alarm or trip if the difference between two measurements become too large (or too small). To have the alarm activate if the difference between the two inputs is lower than the alarm's set point, remove the check mark from *High Alarm* in the alarm configuration.

It is possible to have up to six comparisons. Two alarms can be configured for each comparison.

Using differential measurement to create an extra analogue alarm

If the same measurement is selected for input A and input B, the controller uses the value of the input for the differential measurement alarm.

`Functions > Delta alarms > Set [1 to 6]`

Parameter	Text	Range	Default
4601, 4603, 4605, 4671, 4673 or 4675	Input A for comparison set [1 to 6]	See the controller	Multi-input 20
4602, 4604, 4606, 4672, 4674 or 4676	Input B for comparison set [1 to 6]		

`Functions > Delta alarms > Set [1 to 6] > Delta ana[1 to 6] [1 or 2]`

Parameter	Text	Range	Default
4611, 4631, 4651, 4681, 4701 or 4721	Set point 1	-999.9 to 999.9	1.0
4621, 4641, 4661, 4691, 4711 or 4731	Set point 2	-999.9 to 999.9	1.0
4612, 4632, 4652, 4682, 4702 or 4722	Timer 1	0.0 to 999.0 s	5.0 s
4622, 4642, 4662, 4692, 4712 or 4732	Timer 2	0.0 to 999.0 s	5.0 s
4613, 4633, 4653, 4683, 4703 or 4723	Output A set 1	Relays and M-Logic	-
4623, 4643, 4663, 4693, 4713 or 4733	Output A set 2		
4614, 4634, 4654, 4684, 4704 or 4724	Output B set 1		
4624, 4644, 4664, 4694, 4714 or 4734	Output B set 2		
4615, 4635, 4655, 4685, 4705 or 4725	Enable set 1	OFF ON	OFF
4625, 4645, 4665, 4695, 4715 or 4735	Enable set 2		
4616, 4636, 4656, 4686, 4706 or 4726	Fail class set 1	Fail classes	Warning
4626, 4646, 4666, 4696, 4716 or 4736	Fail class set 2		

11.4 Analogue outputs

The controller has two analogue outputs that are active and galvanically separated. No external supply can be connected.

Function	ANSI no.
Selectable ±10 V DC or relay output for speed control (governor)	77
Selectable ±10 V DC or relay output for voltage control (AVR)	77
PWM speed control output for CAT® engines	77

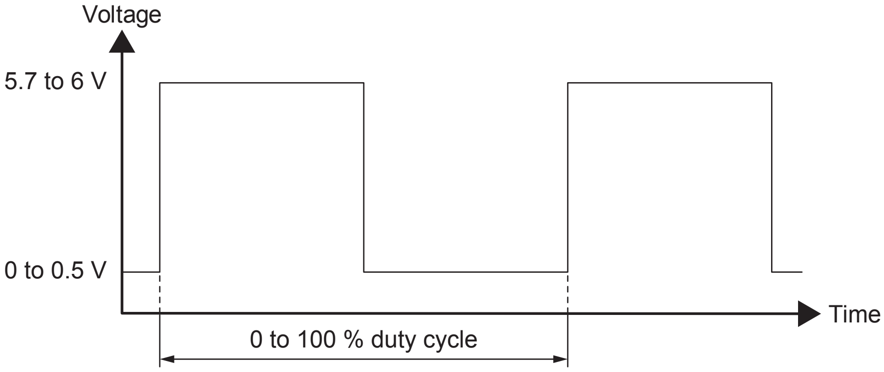
Duty cycle

The PWM signal has a frequency of 500 Hz ±50 Hz. The resolution of the duty cycle is 10,000 steps. The output is an open collector output with a 1 kΩ pull-up resistor. Frequency and amplitude are configurable.

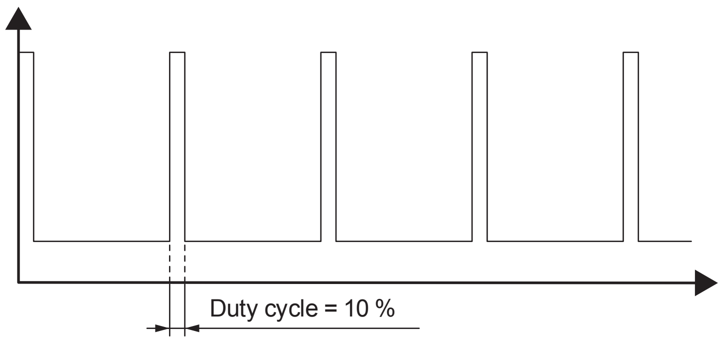
`Engine > Speed control > Analogue configuration > PWM 52 setup`

Parameter	Text	Range	Default
5721	Limits minimum	0 to 50 %	10 %
5722	Limits maximum	50 to 100 %	90 %
5723	GOV type	Adjustable Caterpillar: 6 V/500 Hz	Adjustable
5724	Amplitude set point	1.0 to 10.5 V	5.0 V
5725	Frequency set point	1 to 2500 Hz	500 Hz

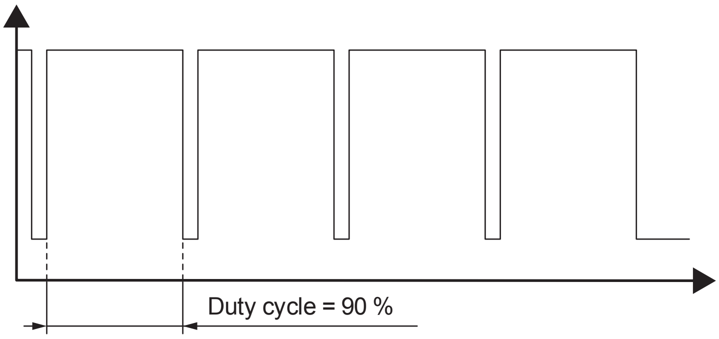
Duty cycle (min. level 0 to 0.05 V, max. level 5.7 to 6.0 V)



Example: 10 % duty cycle



Example: 90 % duty cycle



11.4.1 Using an analogue output as a transducer

If transducers 52 and/or 55 are not selected for regulation, you can configure them to transmit values to an external system. The values include the controller's set points, and AC measurements. The transducer output range is -10 to 10 V.

You can select a scale for some of the values. For example, for the busbar voltage (parameter 5913), select the minimum in 5915, and select the maximum in 5914.

NOTE These values are also available using Modbus.

Parameters for using an analogue output as a transducer

Parameter	Value	Details
5693	P ref	The controller's power set point.
5713	cos phi ref	The controller's cos phi set point
5823, 5824, 5825	P1	Genset active power
5853, 5854, 5855	S	Genset apparent power
5863, 5864, 5865	Q	Genset reactive power
5873, 5874, 5875	PF	Power factor of the power from the genset
5883, 5884, 5885	f	Genset frequency
5893, 5894, 5895	U	Genset L1-L2 voltage
5903, 5904, 5905	I	Genset L1 current
5913, 5914, 5915	U BB	Busbar L1-L2 voltage
5923, 5924, 5925	f BB	Busbar frequency
5933, 5934, 5935	Input 20	The value received by analogue input 20.
5943, 5944, 5945	Input 21	The value received by analogue input 21.
5953, 5954, 5955	Input 22	The value received by analogue input 22.
5963, 5964, 5965	P total consumed	The total power produced in the power management system.
5973, 5974, 5975	P total available	The additional power that the power management system could supply without starting more gensets.

Available power transducer setup example

To set up transducer 55 to transmit the available power (0 to 10 MW) as a -10 to 10 V signal:

In menu 5973, for *Set point*, select **-10 to 10 V**. For *Transducer A*, select **Transducer 55**.
In menu 5974, select the maximum value (this corresponds to 10 V), that is, **10000 kW**.
In menu 5975, select the minimum value (this corresponds to -10 V), that is, **0 kW**.