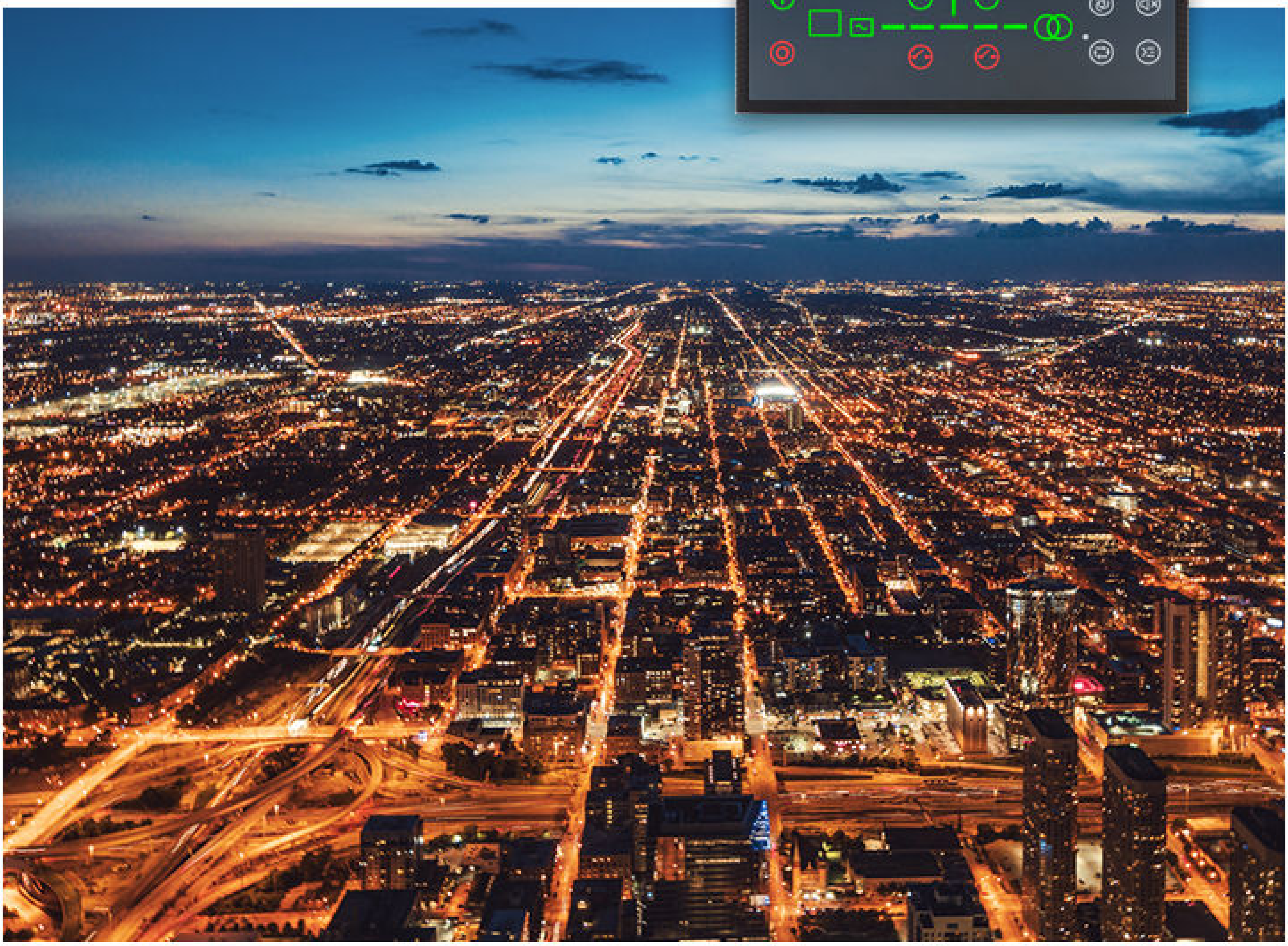
AGC 150

Generator, Mains and BTB

Designer's handbook

4189341307C

Improve Tomorrow



1. Introduction

2. Utility software

3. Applications without power management

4. Power management

6. Engine functions

10. AC protections

1. Introduction

1.1 About

The AGC 150 Generator (Genset), AGC 150 Mains and AGC 150 BTB controllers provide flexible protection and control in a wide range of applications.

In the simplest applications, you can use one AGC 150 Generator controller to control one genset. You can also use AGC 150 Generator controllers for CANshare load sharing by multiple gensets (without power management).

Several AGC 150 controllers can work together to make a power management system (PMS). These applications include synchronisation, island operation, and running parallel to mains. The PMS can automatically start and stop gensets, and open and close breakers. You can also use AGC 150 in power management systems with other DEIF controllers.

The AGC 150 Generator controller contains all the functions needed to protect and control a genset, and the genset breaker. If you do not use power management, the controller can also protect and control the mains breaker.

The AGC 150 Mains controller protects and controls a mains breaker, and a tie breaker.

The AGC 150 BTB controller protects and controls a bus tie breaker. The PMS manages the busbar sections.

The AGC 150 is a compact, all-in-one controller. Each AGC 150 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 units. Alternatively, use the communication options to connect to an HMI/SCADA system. The HMI/SCADA system can then control the plant.

1.1.1 Function overview

This is an overview of the most important functions.

Operation modes

- Island operation
- Automatic Mains Failure (AMF)
- Fixed power/base load
- Peak shaving
- Load take-over
- Mains power export
- Power management
- Dry alternator (in combination with DVC 550 Digital Voltage Controller)
- Ventilation mode (in combination with DVC 550 Digital Voltage Controller)

Engine control

- Start and stop sequences
- Run and stop coil
- Analogue and ECU governor control

Generator protections

- 2 x reverse power (ANSI 32R)
- 5 x overload (ANSI 32F)
- 4 x over-current (ANSI 50TD)
- 2 x over-voltage (ANSI 59P)
- 3 x under-voltage (ANSI 27P)

- 3 x over-frequency (ANSI 81O)
- 3 x under-frequency (ANSI 81U)
- Voltage-dependent over-current (ANSI 51V)
- Unbalanced voltage (ANSI 47)
- Unbalanced current (ANSI 48)
- Under-excitation (ANSI 32RV)
- Over-excitation (ANSI 32FV)
- Multi-inputs (digital, 4-20 mA, 0-10 V DC, Pt100, RMI or binary/digital)
- Digital inputs

Busbar protections
- 3 x over-voltage (ANSI 59P)
- 4 x under-voltage (ANSI 27P)
- 3 x over-frequency (ANSI 81O)
- 3 x under-frequency (ANSI 81U)
- Unbalanced voltage (ANSI 47)

Display
- Prepared for remote mounting
- Buttons for start and stop
- Buttons for breaker operations
- Status texts
- Measurement readings
- ECU data
- Alarm indication

M-Logic
- Simple logic configuration tool
- Selectable input events
- Selectable output commands

1.1.2 Controller types

Parameter	Setting	Controller type	Minimum software
9101	DG unit	Generator controller	S2
	DG unit	Generator Stand-alone controller	S1
	Mains unit	Mains controller	S2
	BTB unit	BTB controller	S2
	DG HYBRID unit	Genset-Solar hybrid controller	S2
	ENGINE DRIVE unit	Engine drive controller	S1
	Remote unit	Remote display	S1
	ENGINE DRIVE MARINE unit	Engine drive controller for marine use	S1
	DG MARINE unit	Stand-alone genset controller for marine use	S1
	ASC 150 Storage*	Battery storage controller	S3
	ASC 150 Solar*	Solar controller	S3
	ATS unit	Automatic transfer switch (open transition)	S1
	ATS unit	Automatic transfer switch (closed transition)	S2
	DG PMS LITE	PMS lite controller	S2

Software packages and controller types

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

- S1 = Stand-alone
  - You can change the controller type to any other controller that uses S1 software.
- S2 = Core
- S3 = Extended
  - You can change the controller type to any other controller type*.
    - * To change to an ASC 150, the controller must have the sustainability option (S10).
- S4 = Premium
  - You can change the controller type to any other controller type*.
    - * To change to an ASC 150, the controller must have the sustainability option (S10).
  - All functions are supported.

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

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 version

This document is based on the AGC 150 software version 1.18.

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 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 the installation or operation of any third party equipment, including the **genset**.

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

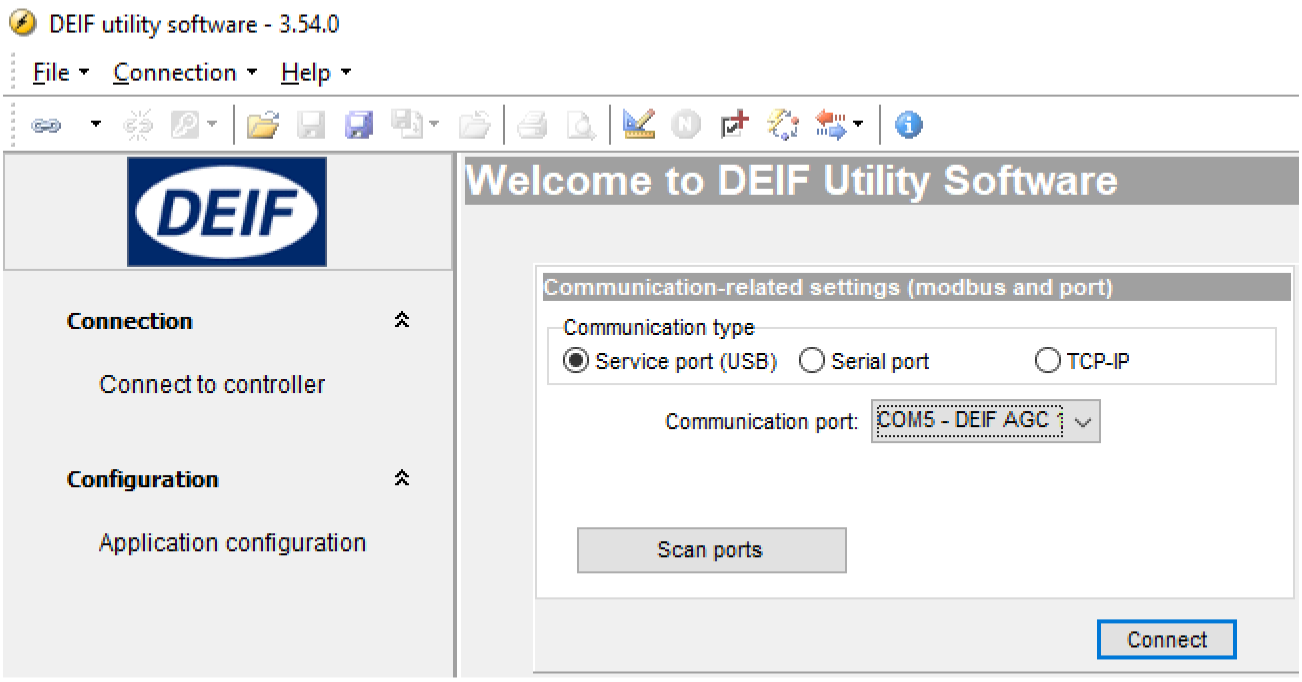
2.2 Connection

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

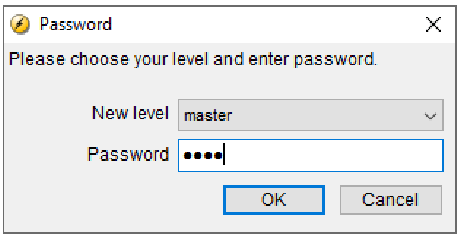
2.2.1 USB connection

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. 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.

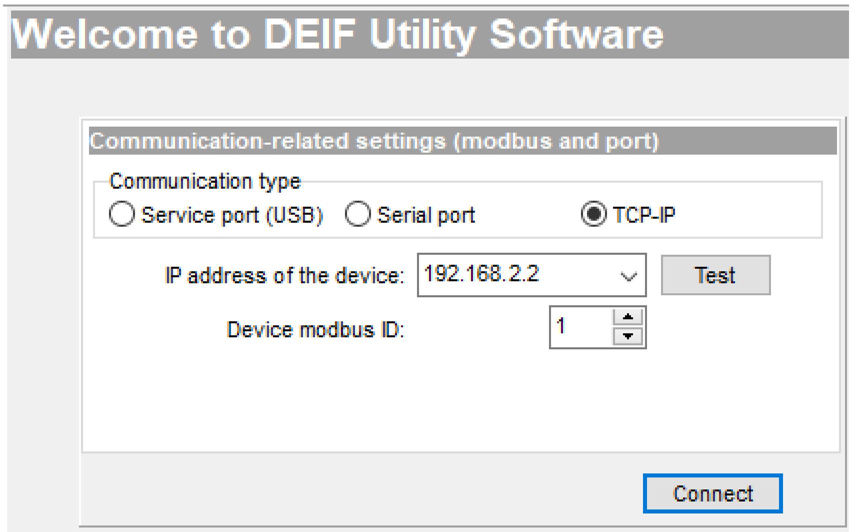
Point-to-point Ethernet connection to the controller

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.

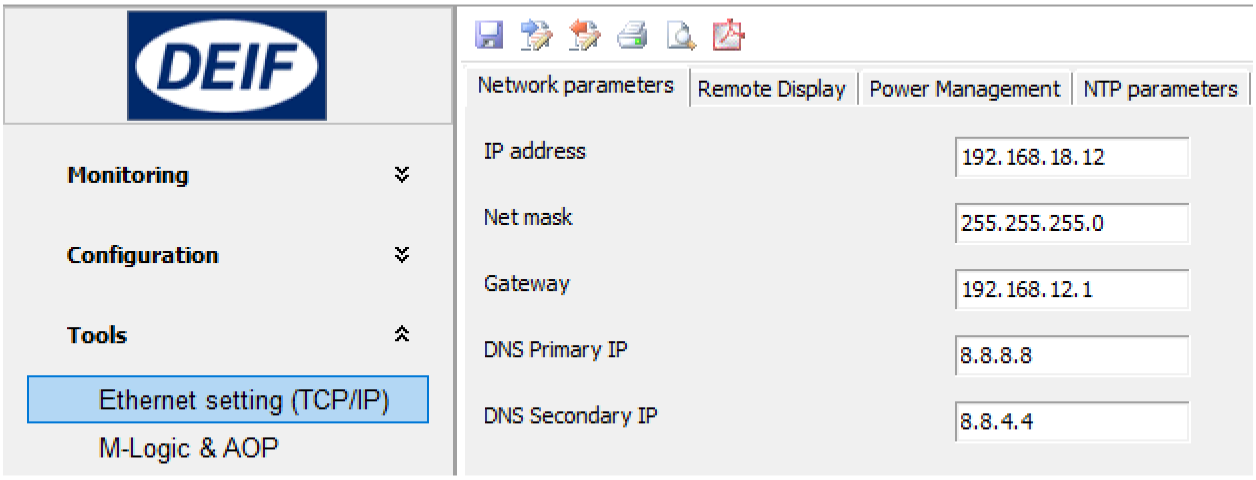


4. You can use the *Test* button to check if the connection is successful.
5. Select *Connect* to connect to the controller using TCP-IP.

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).

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.

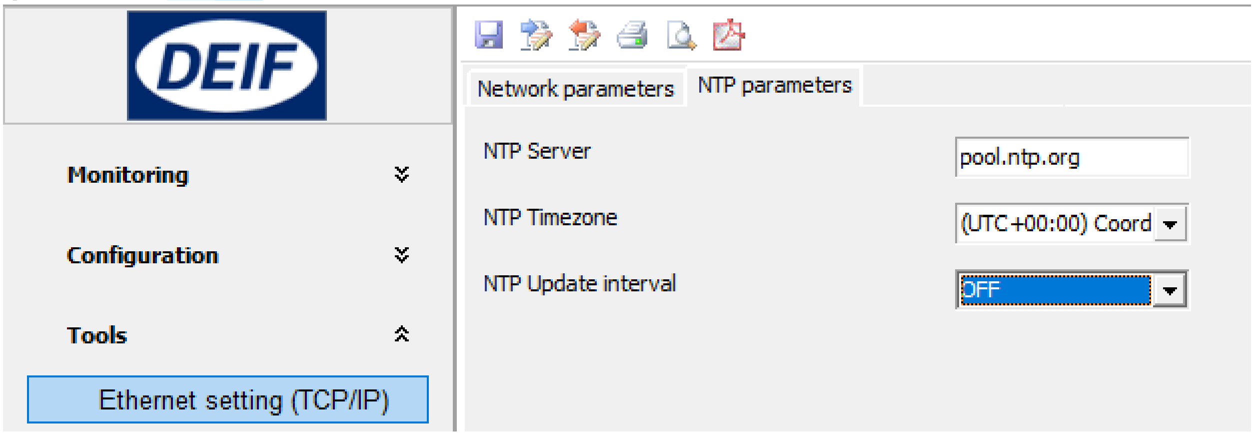
The PC can then be connected to the switch, and the Ethernet cable can be in the same port of the switch at all times. You can enter the controller IP address in the utility software.

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:



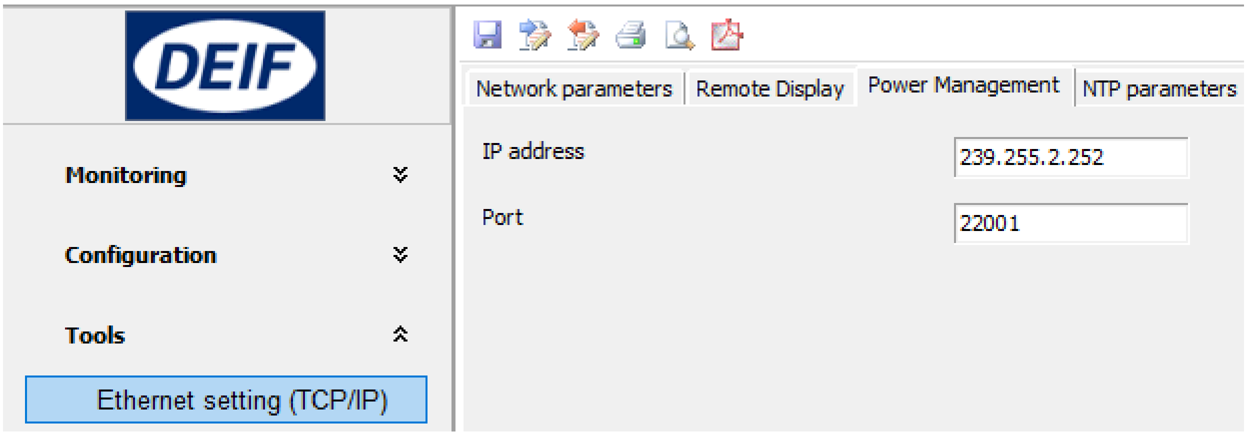
You can select an NTP server, a time zone and an update interval. Write the changes to the controller to activate the NTP function.

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

2.3.3 Using Ethernet for power management

You can use Ethernet connections for power management communication redundancy.

In the utility software, on the *Ethernet setting (TCP/IP)* page, select *Power management*.



For each controller in the power management system:

1. Select the same IP address for the controllers to broadcast to, and the port.
   - The IP address must be in the range 239.255.xxx.xxx.
2. In parameter 7843 (*VCAN C Protocol*), select *PMS Primary* or *PMS Secondary*.

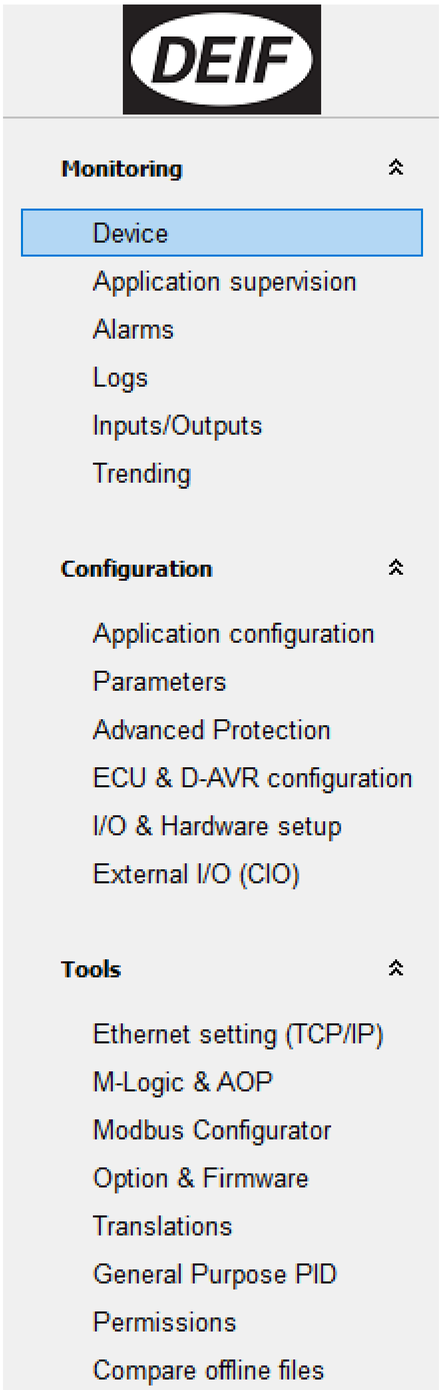
2.4 Utility software interface

2.4.1 Top toolbar

1. Connect to a controller.
2. Disconnect from a controller.
3. Permission level.

4. Application settings.
5. Add options (create an option code and send it to support@deif.com).
6. Enter an upgrade code (received from DEIF support).
7. Update the controller firmware.
8. Configure the display views.
9. Not used for the controller.
10. Configure the AOP-2 buttons and LEDs (Additional Operator Panel).
11. Radio ripple control receiver (RRCR).
12. Read the controller counters.
13. Information on the controller and the software.
14. Read, write, backup, and restore the device.
15. Data tracing (shows the max./min. of a value, as long as the data tracer window is open).
16. Send commands to the controller.
17. Synchronise the controller clock with the connected PC.

2.4.2 Left menu



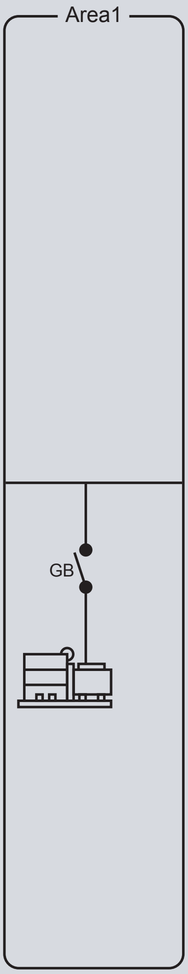
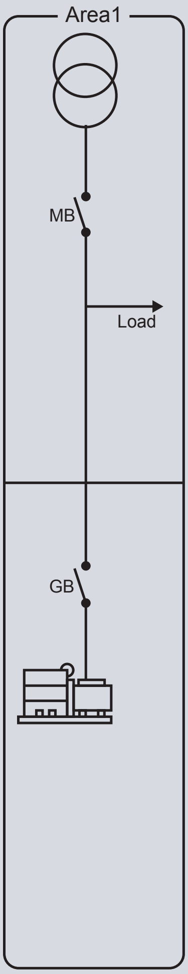
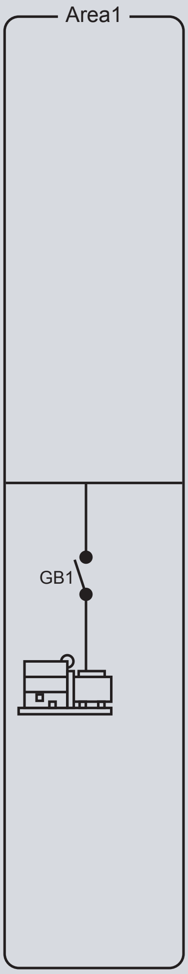
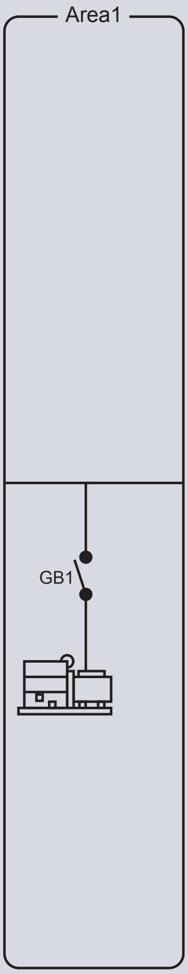
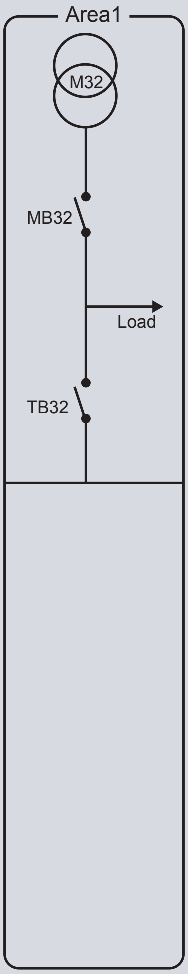
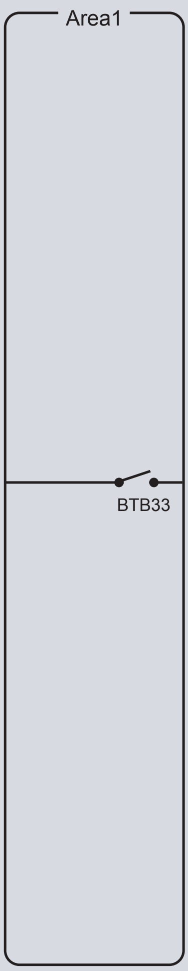
- **DEIF**
  - Link to www.deif.com
- **Monitoring**
  - Device
    - See operating information for the connected controller.
  - Application supervision
    - See the plant operation, including how much power each genset produces.
  - Alarms
    - An overview of the active alarms.
    - See the history 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 six pre-configured standard applications, four for genset, one for mains and one for BTB.

Genset controller Application 1	Genset controller Application 2	Genset controller Application 3	Genset controller Application 4	Mains controller Application 1	BTB controller Application 1
					
Single controller	Single controller	Standard plant (power management)	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	-
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 mains	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

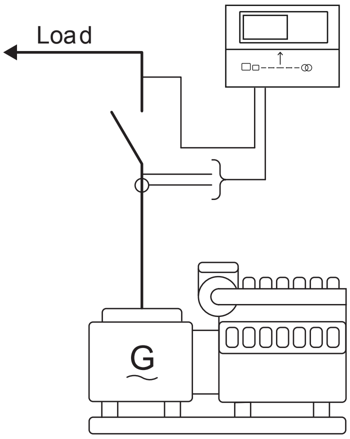
Application type	Plant type	Configuration characteristics
Stand-alone	Single controller	In a stand-alone application setup, the controller cannot communicate with other controllers. However, analogue load sharing is possible. In a stand-alone application, a genset controller can operate one genset, one GB and one MB. To prevent faulty synchronisation, there must be no other gensets or power sources. See Setup of a stand-alone application
Power management	Standard	In a power management configuration, the controllers can be in applications with up to 32 genset/mains controllers and 8 BTB controllers (a total of 40 controllers). See Application configuration

3. Applications without power management

3.1 Simple applications

3.1.1 Island operation

Single-line diagram



NOTE If island operation is selected, the *MB closed* digital input must not be activated.

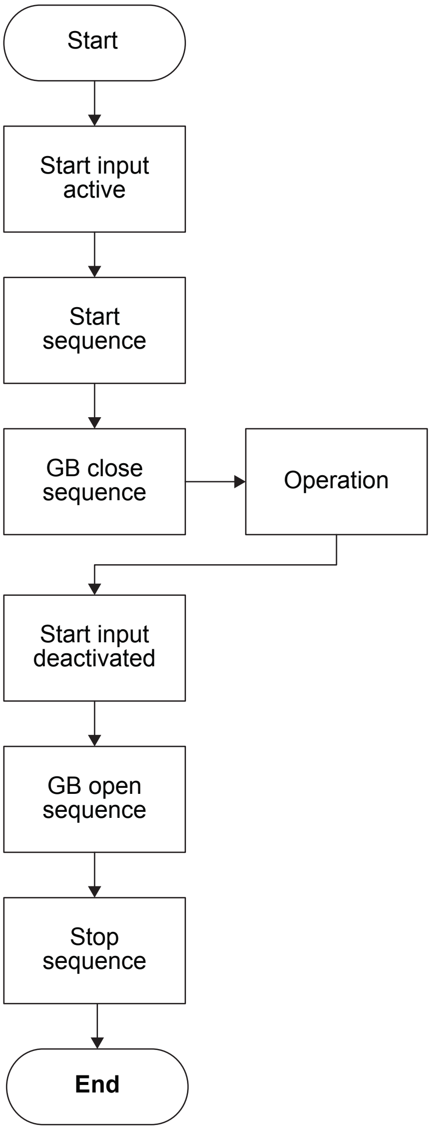
AUTO mode

The controller automatically starts the genset and closes the generator breaker at a digital start command. When the stop command is given, the generator breaker is tripped, and the genset is stopped after a cooling down period. The start and stop commands are used by activating and deactivating a digital input or with the time-dependent start/stop commands. If time-dependent start/stop commands are used, then AUTO mode must also be used. The display buttons cannot be used in AUTO mode.

SEMI-AUTO mode

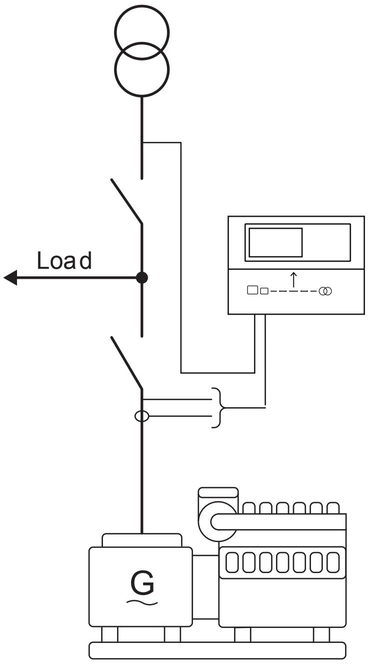
The operator can use the display buttons to start the genset, close the generator breaker, open the generator breaker, and stop the genset.

Island operation flowchart (AUTO mode)



3.1.2 AMF (Automatic Mains Failure)

Single-line diagram



AUTO mode

The controller automatically starts the genset and switches to generator supply at a mains failure after an adjustable delay time. You can adjust the controller to change to genset operation in these ways:

1. The mains breaker is opened at genset start-up.
2. The mains breaker remains closed until the genset is running, and the genset voltage and frequency is OK.

In both cases, the generator breaker is closed when the generator voltage and frequency is OK, and the mains breaker is open.

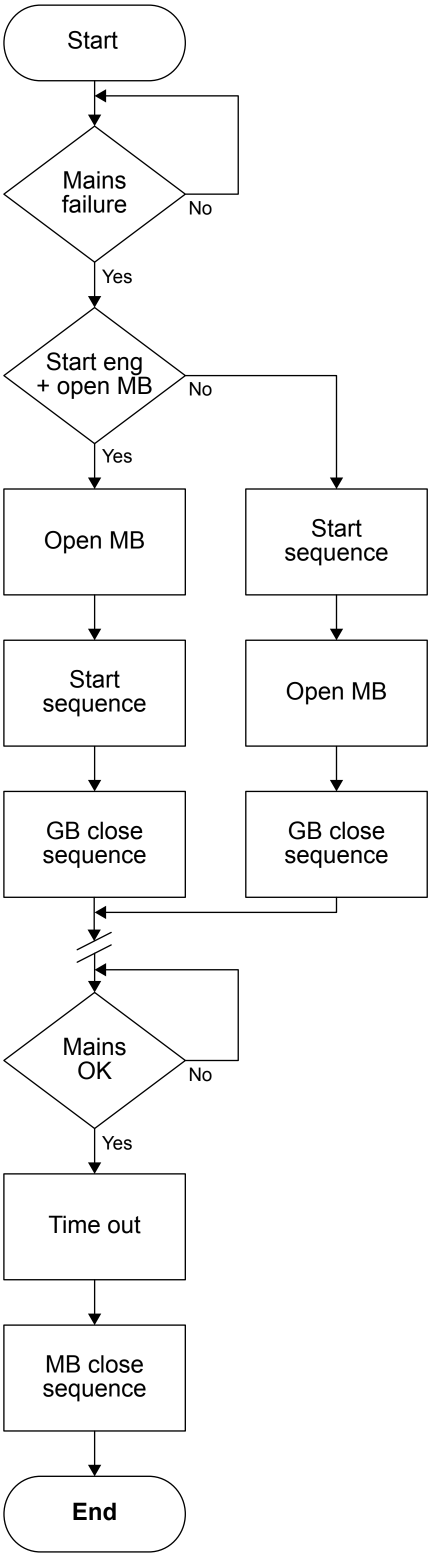
When the mains returns, the controller synchronises the mains breaker to the busbar when the *Mains OK* delay has expired. The genset then cools down and stops.

SEMI-AUTO mode

When the generator breaker is closed and the mains breaker is opened, the controller uses the nominal frequency as the set point for the speed governor. If AVR control is selected, the nominal voltage is used as the set point.

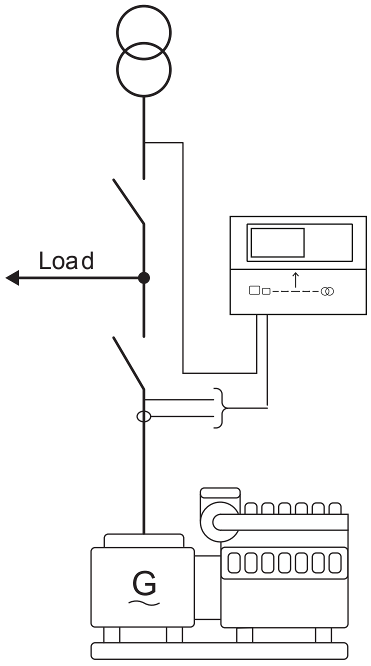
When the generator is paralleled to the mains, the governor regulation is longer active. If AVR control is selected, the set point is the adjusted power factor.

Automatic Mains Failure flowchart



3.1.3 Fixed power/Base load

Single-line diagram

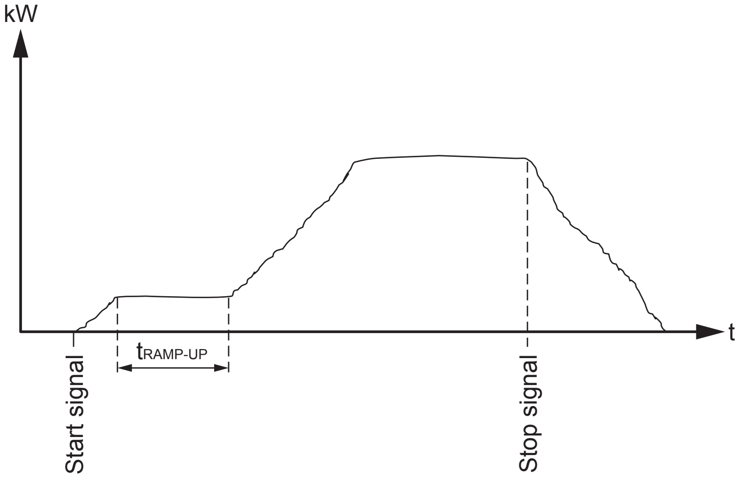


Fixed power in AUTO mode

When the digital input *Auto start/stop* is activated, the controller automatically starts the genset and synchronises to the mains. After the generator breaker closes, the controller ramps up the load to the set point level. When the stop command is given, the genset is deloaded and stopped after the cooling down period.

The start/stop commands are given by a digital input, or by the time-dependent start/stop commands. If the time-dependent start/stop commands are used, AUTO mode must be selected.

Fixed power principle



Fixed power in SEMI-AUTO mode

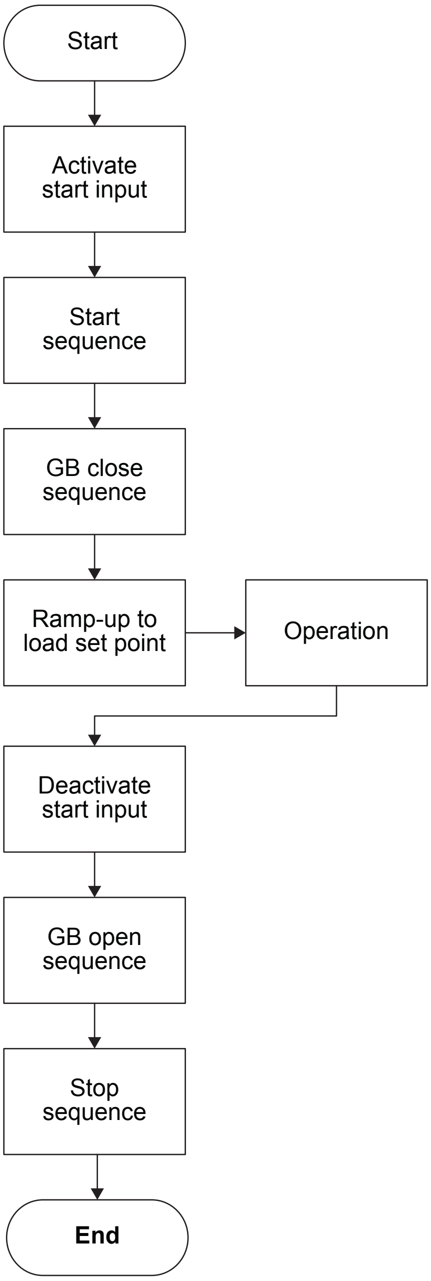
When the generator breaker is closed and the mains breaker is opened, the controller uses the nominal frequency as set point for the speed governor. If AVR control is selected, the nominal voltage is used as set point.

When the generator is paralleled to the mains, the generator power will be increased to the fixed power set point. If AVR control is selected, the set point will be the adjusted power.

`Power set points > Fixed power`

Parameter	Text	Range	Default
7051	Fixed power set	0 to 100 %	100 %

Fixed power flow chart



3.1.4 Dry alternator and ventilation modes

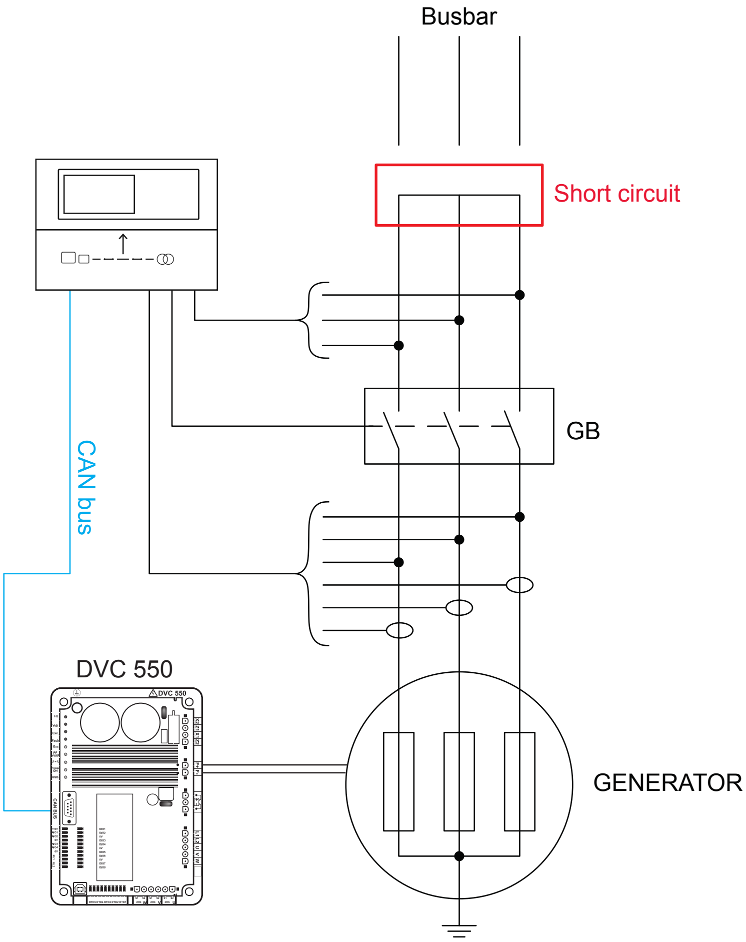
When the genset controller is used with the Digital Voltage Controller DVC 550, there are two more modes:

- Dry alternator mode
- Ventilation mode

The purpose of both modes is to dry the windings in the generator before use. The reason for drying the windings is to prevent the winding insulation from being degraded due to moisture and to prevent arc-over in the windings.

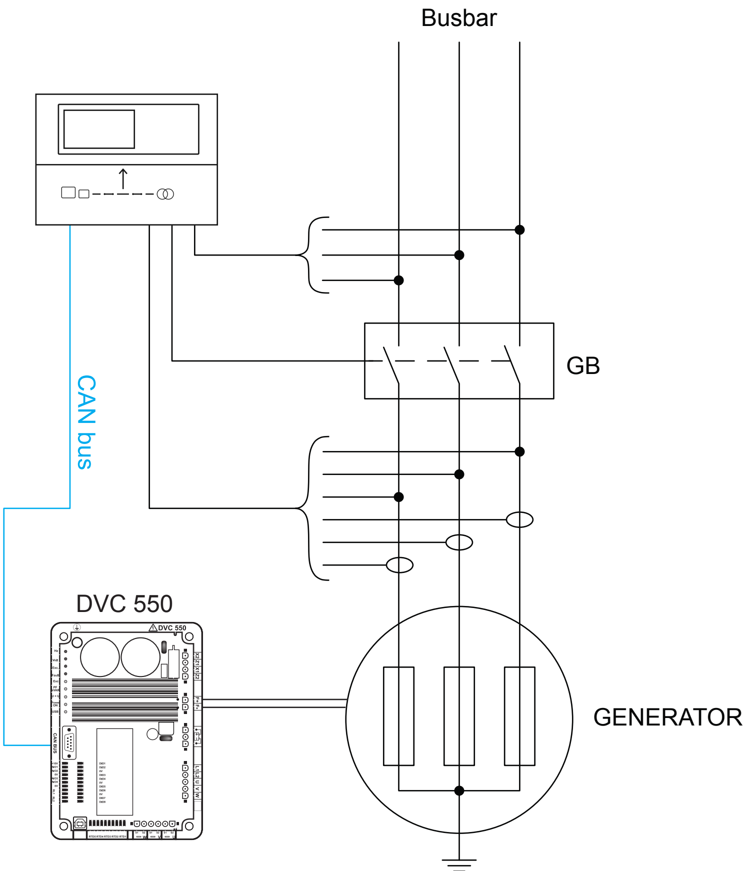
Dry alternator mode

In dry alternator mode, a short circuit of the busbar is created. When the GB closes, the generator supplies an intentional short circuit, which warms up the generator windings.



Ventilation mode

In ventilation mode, the generator is ventilated by fan air, thus drying out the generator windings.



> **More information**
> See **Configure the DVC 550 with AGC, Genset modes** in the **DVC 550 Designer's handbook** for how to configure the dry alternator and ventilation modes.

3.2 Single generator with mains power measurement

If a single generator is used, the controller needs a mains power measurement to do peak shaving, load take-over, and mains power export.

Mains power measurement from the 4th CT

By default, the controller uses the current measurement from the 4th CT to calculate the mains power (parameter 7005).

> **More information**
> See **I4 current** in the **Installation instructions** for wiring of the 4th CT for the mains current measurement.

`Basic settings > Nominal settings > Power > 4th CT nominal [1 or 2]`

Parameter	Text	Range	Default
6055/6064	4th CT Power	10 to 9000 kW	480/230 kW

Mains power measurement from a transducer

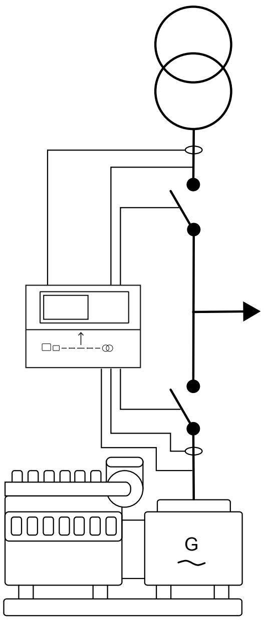
Select *Multi input 20 (transducer)* in parameter 7005. Configure the transducer range in parameters 7003 and 7004, and configure the scaling in 7006.

Configure the input from the transducer under *I/O & Hardware setup, MI 20*.

> **More information**
> See **Analogue inputs** in the **Installation instructions** for wiring a transducer as the mains power measurement.

3.2.1 Peak shaving

Single-line diagram



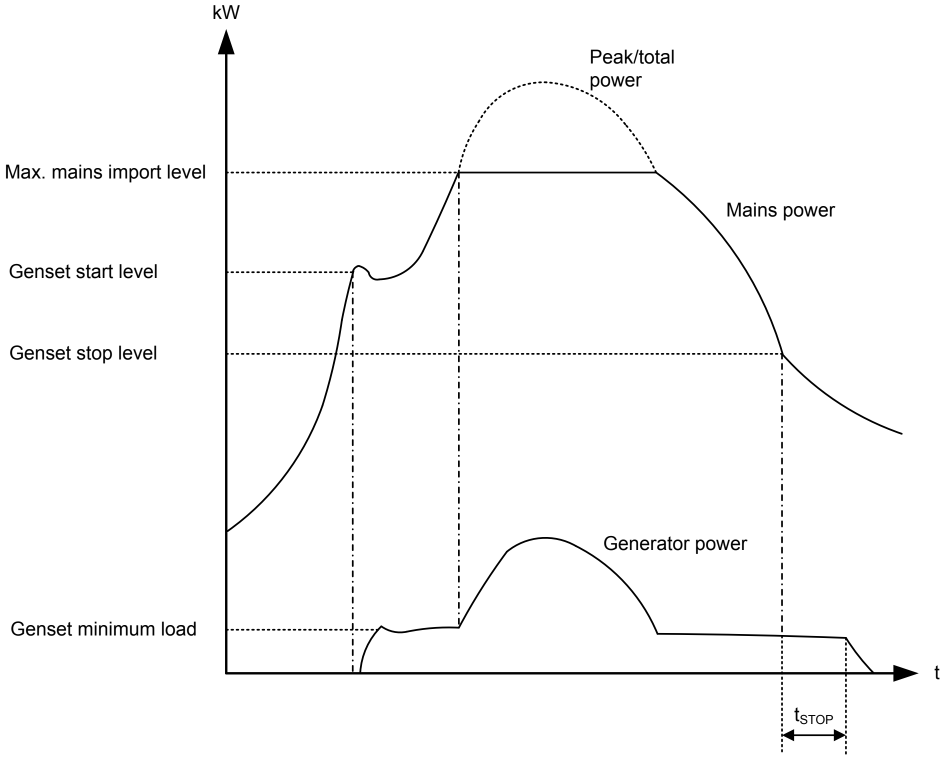
AUTO mode

The genset starts at a predefined mains import level and run at a fixed minimum load, for example 10 %. When the mains import increases above the maximum mains import set point, the genset supplies the extra load, to keep the mains import at the maximum import level.

When the load drops below the maximum mains import set point, the genset runs at minimum load again. When the mains import and the generator load decrease below the stop set point, the genset cools down and stop.

A 4-20 mA transducer or the 4th CT is used to measure the power imported from the mains.

Peak shaving example



SEMI-AUTO mode

When the generator breaker is closed and the mains breaker is opened, the controller uses the nominal frequency as set point for the speed governor. If AVR control is selected, the nominal voltage is used as set point.

When the generator is parallel to the mains, the generator is controlled according to the peak shaving set point. The maximum mains import is not exceeded in spite of the SEMI-AUTO mode. If AVR control is selected, the set point is the adjusted power factor.

`Power set points > Cos phi or Q`

Parameter	Text	Range	Default
7052	Cos phi Set	0.60 to 1.00	1.00
7053	Type	Inductive Capacitive	Capacitive
7054	Reac power set	-100 to 100 %	0 %
7055	Type	OFF Superior (PMS) Fixed Q	OFF

`Power set points > MPE/Peak shaving > Day/Night power set`

Parameter	Text	Range	Default
7001	Mains power, Day	-20000 to 20000kW	750 kW
7002	Mains power, Night	-20000 to 20000kW	1000 kW
7021	Start generator set point	5 to 100 %	80 %

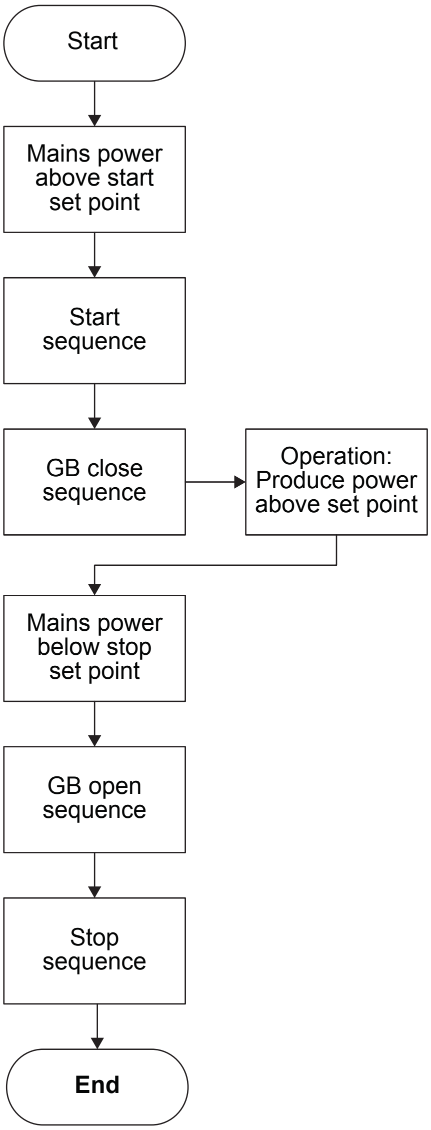
Parameter	Text	Range	Default
7023	Start generator min. load	0 to 100 %	5 %
7031	Stop generator set point	0 to 80 %	60 %

`Power set points > MPE/Peak shaving > Day/Night settings`

Parameter	Text	Range	Default
7011	Daytime period, start hour	0 to 23	8
7012	Daytime period, start min.	0 to 59	0
7013	Daytime period, stop hour	0 to 23	16
7014	Daytime period, stop min.	0 to 59	0

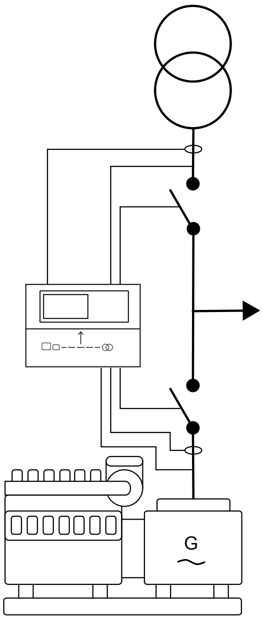
NOTE If power management is used, the load-dependent start and stop parameters are used.

Peak shaving flowchart



3.2.2 LTO (Load take-over)

Single-line diagram

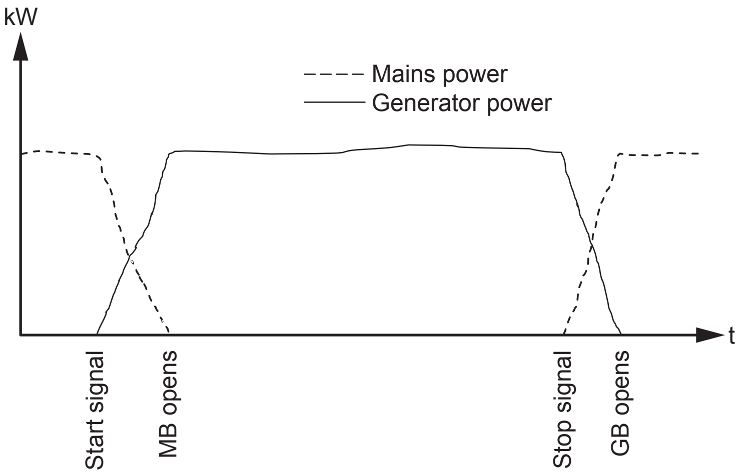


AUTO mode

With back synchronising ON:

- The load take-over mode transfers the load imported from the mains to the genset for operation on generator supply only.
- When the start command is given, the genset will start and synchronise the generator breaker to the busbar that is being supplied by the mains.
- When the generator breaker is closed, the imported load is decreased (the power is being transferred to the genset) until the load is at the open breaker point, and the mains breaker opens.
- When the stop command is given, the mains breaker is synchronised to the busbar and after closure the genset is deloaded, cooled down and stopped.
- A 4-20 mA transducer or the 4th CT is used to measure the power from the mains.

Load take-over example



With back synchronising OFF:

- When the start command is given, the genset will start.
- When the frequency and voltage is OK, the mains breaker is opened and the generator breaker is closed.
- The generator supplies the load until the stop command is given.
- The generator breaker opens and the mains breaker closes.

* The genset cools down and stops.

NOTE If the imported load is higher than the nominal genset power, an alarm is activated and the load take-over sequence is paused.

SEMI-AUTO mode

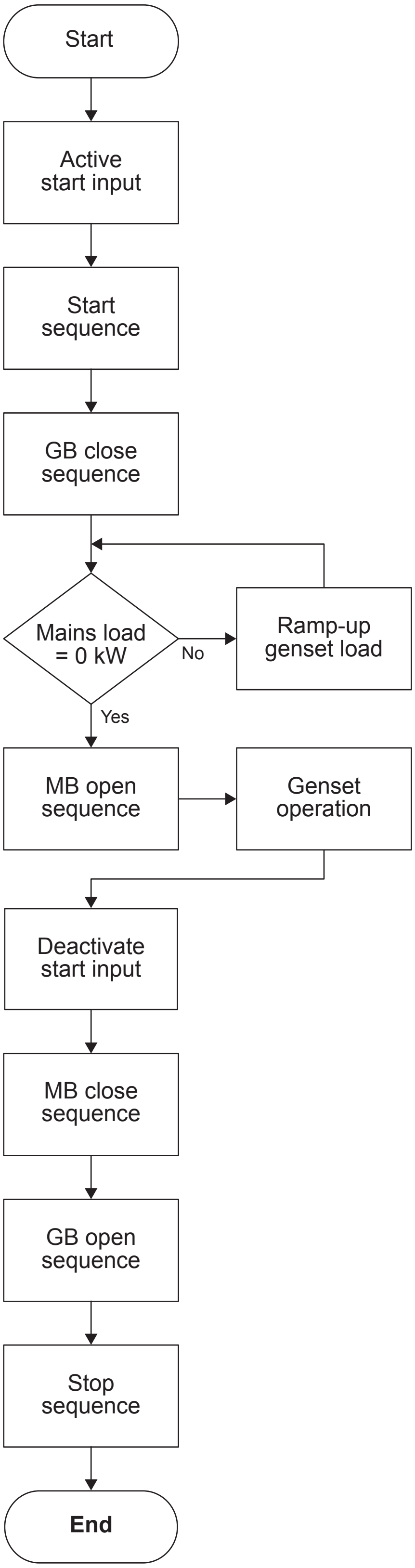
When the generator breaker is closed and the mains breaker is opened, the controller will use the nominal frequency as set point for the speed governor. If AVR control is selected, the nominal voltage is used as set point.

When the generator is paralleled to the mains, it will be controlled so the imported power from the mains will be kept at 0 kW. If AVR control is selected, the set point will be the adjusted power factor.

`Power set points > Cos phi or Q`

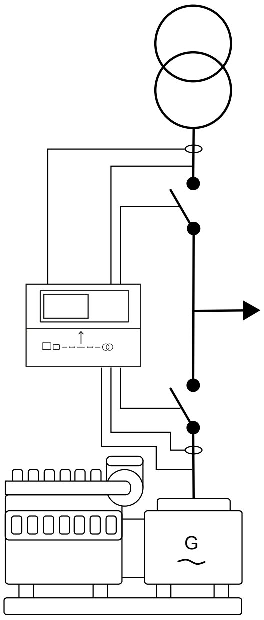
Parameter	Text	Range	Default
7052	Cos phi Set	0.60 to 1.00	1.00
7053	Type	Inductive Capacitive	Capacitive
7054	Reac power set	-100 to 100 %	0 %
7055	Type	OFF Superior (PMS) Fixed Q	OFF

Load take-over flowchart



3.2.3 Mains power export (or import) (MPE)

Single-line diagram



AUTO mode

The mains power export mode can be used to maintain a constant level of power through the mains breaker. The power can be exported to the mains or imported from the mains, but always at a constant level.

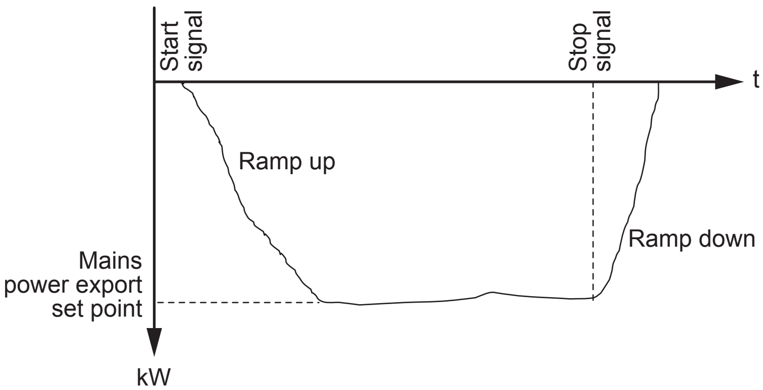
If a fixed level of imported power must be used, it is still the mains power export mode that must be selected! This mode covers import as well as export.

The genset starts as a result of a digital start command. It synchronises to the mains and starts to export power to the mains. The amount of power exported is kept at a fixed level regardless of the load on the busbar (the factory).

The stop command makes the genset deload and trip the generator breaker. Afterwards, it cools down and stop.

A 4-20 mA transducer or the 4th CT is used to measure the power to the mains.

Mains power export example



NOTE The set point of the mains power export can be set to 0 kW. This means that the genset is parallel to the mains but there is no power import or export.

SEMI-AUTO mode

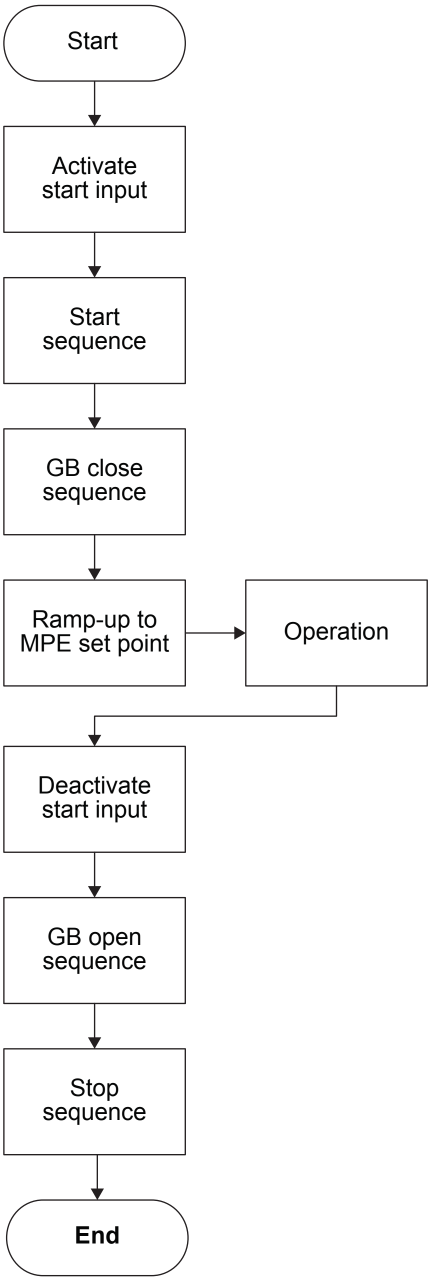
When the generator breaker is closed and the mains breaker is opened, the controller uses the nominal frequency as set point for the speed governor. If AVR control is selected, the nominal voltage is used as set point.

When the generator is paralleled to the mains, it is controlled according to the mains power export set point. If AVR control is selected, the set point is the adjusted power factor.

Power set points > Cos phi or Q

Parameter	Text	Range	Default
7052	Cos phi Set	0.60 to 1.00	1.00
7053	Type	Inductive Capacitive	Capacitive
7054	Reac power set	-100 to 100 %	0 %
7055	Type	OFF Superior (PMS) Fixed Q	OFF

Mains power export flowchart



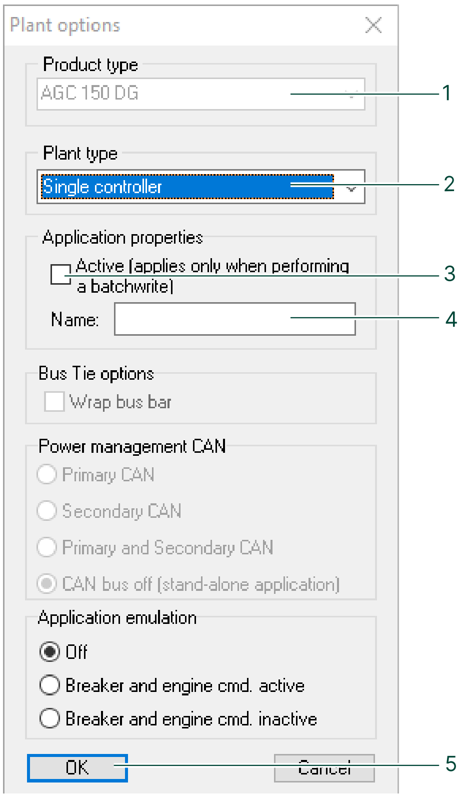
3.3 Stand-alone

3.3.1 Setup of a stand-alone application

In a stand-alone application, the generator controller can control one genset, one generator breaker (GB), and one mains breaker (MB).

When connected to a controller with the utility software:

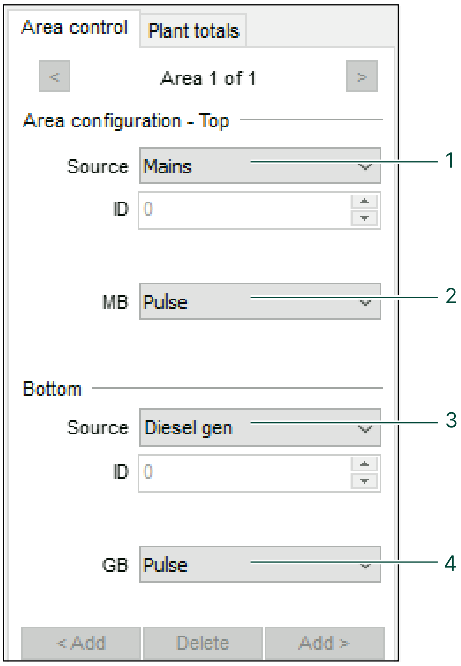
1. Select *Application configuration*.
2. Select *New plant configuration* .
3. The *Plant options* window opens.



Select the plant options:

1. Select the *Product (controller) type*
   - Greyed out when already connected to a controller.
2. Select the *Plant type*: *Single controller*
3. Select to activate the application when it is written to the controller.
4. Write a name for the application.
5. Select OK to save the application.

Example



1. Select one of these types of power source to show in the top area:
   - None
   - Mains
   - Diesel genset
2. Select the breaker type for the mains breaker:
   - Pulse
   - Continuous NE
   - Compact
   - Ext*
   - None
   - Continuous ND
3. Select the power source to show in the bottom area:
   - None
   - Mains
   - Diesel genset
4. Select the breaker type for the generator breaker:
   - Pulse
   - Continuous NE
   - Compact
   - Ext*
   - None

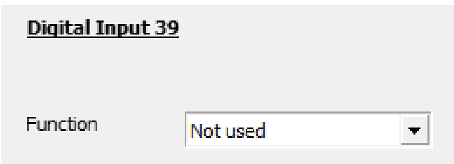
NOTE * External breaker

After the application drawing is created, press *Write plant configuration to device* to send the configuration to the connected controller.

Stand-alone application without a breaker

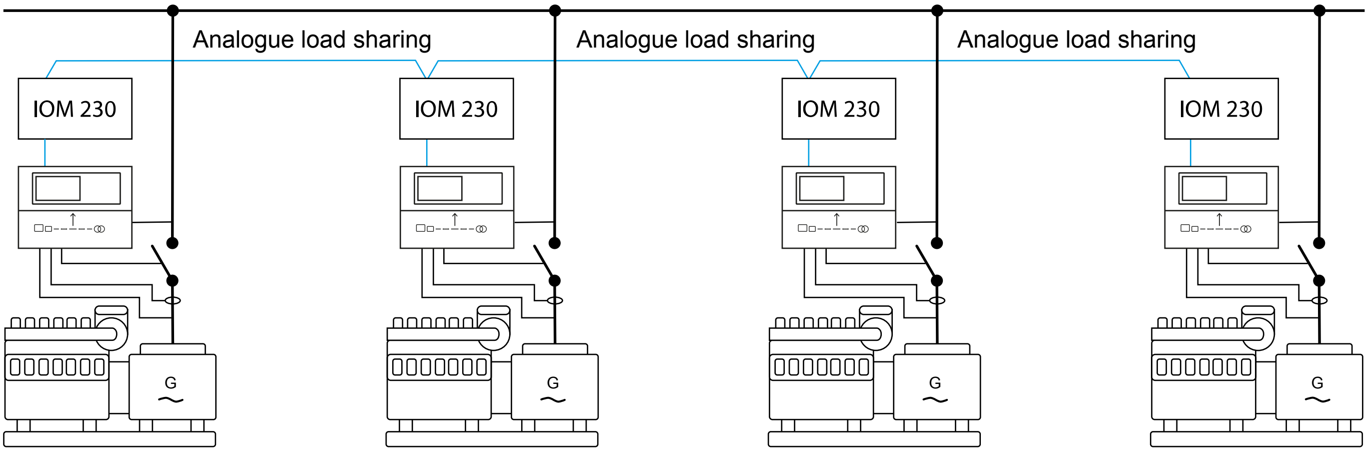
If you created a stand-alone application without a genset breaker, reset any GB feedback in the I/O setup list:

1. In the utility software, select *I/O & Hardware setup*.
2. Change the function to *Not used* for the relevant I/Os, for example:

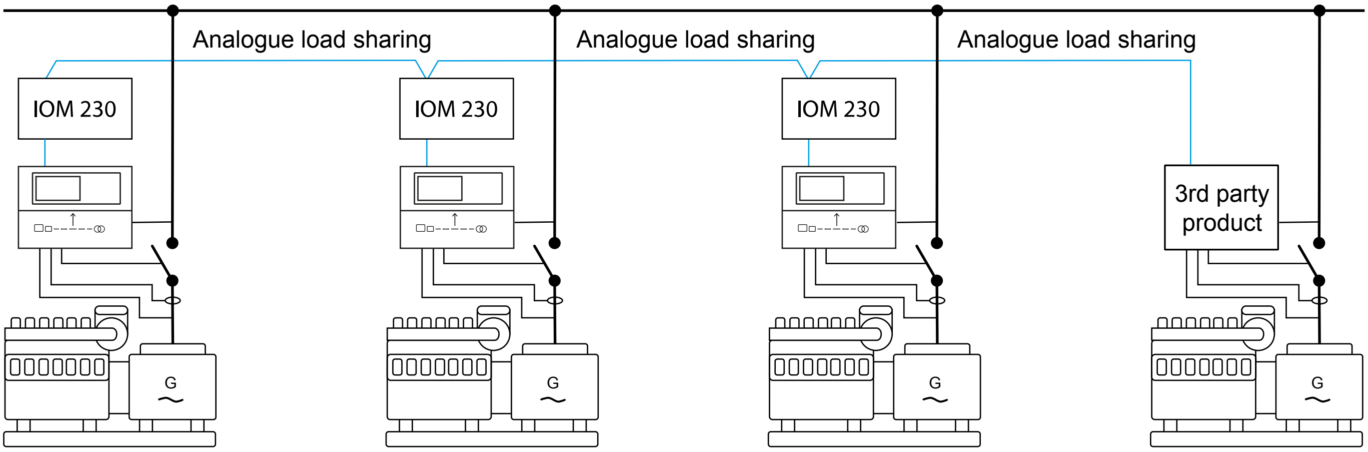


3.4 Multiple gensets, load sharing

Analogue load sharing (with optional IOM 230 external box)*

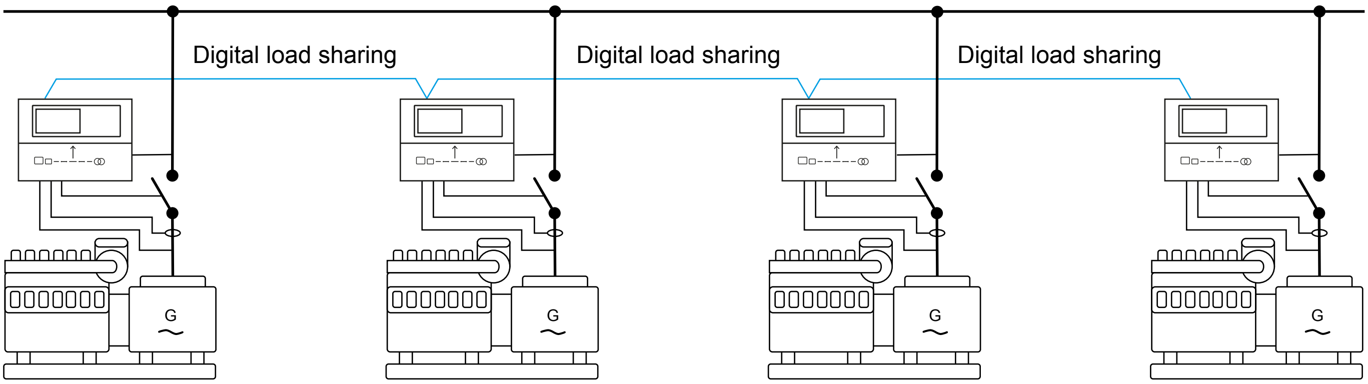


Analogue load sharing with 3rd party controllers*



More information
* See **Additional analogue outputs with IOM 230**.

Digital load sharing (CAN share)



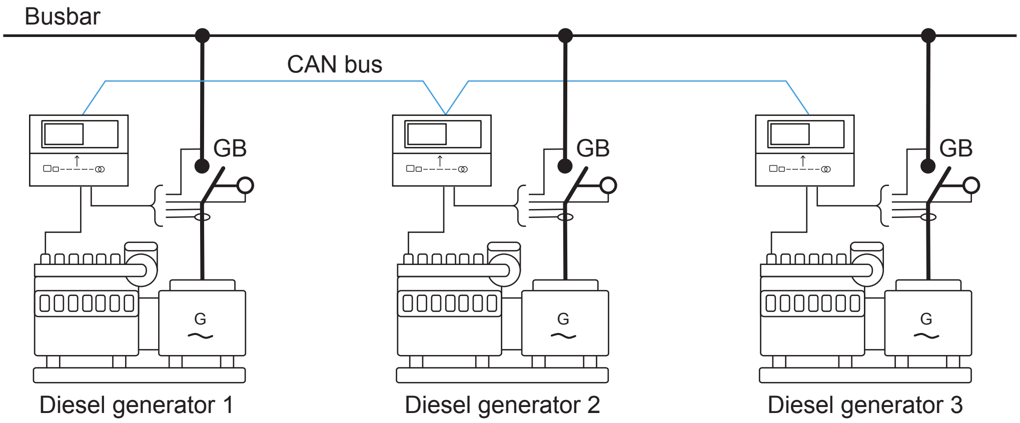
3.5 CANshare

3.5.1 CANshare (digital load sharing)

CANshare (digital load sharing) makes it possible to load share using CAN bus. The function can be used in applications with two or more generators and without power management or mains.

With CANshare it is possible to load share between up to 127 generators with simple installation and setup.

Basic principle of communication between the controllers



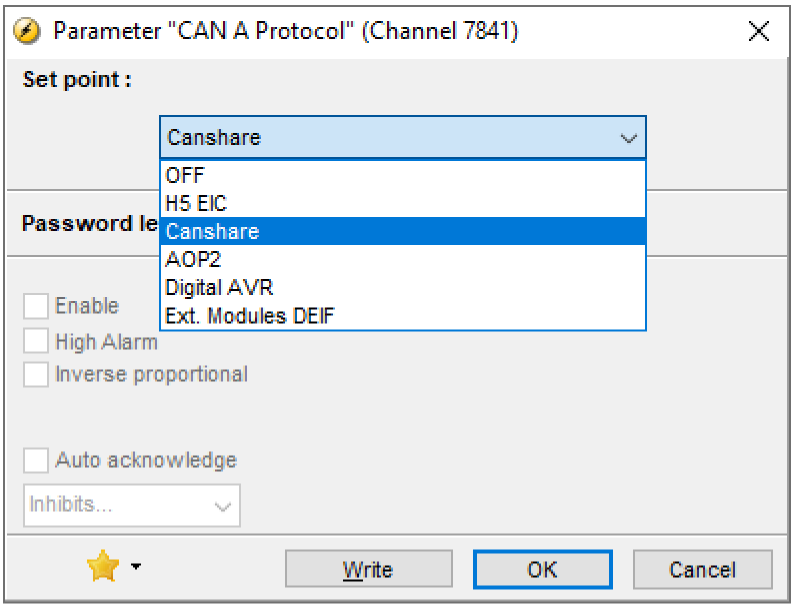
3.5.2 Configure CANshare (digital load sharing)

To configure a controller for CANshare, the controller *Plant type* must be *Single controller*. When connecting to the CAN bus line, the CANshare system automatically assigns the controller an ID. When the controller disconnects from the CAN bus line, the system automatically removes the ID from the load sharing system.

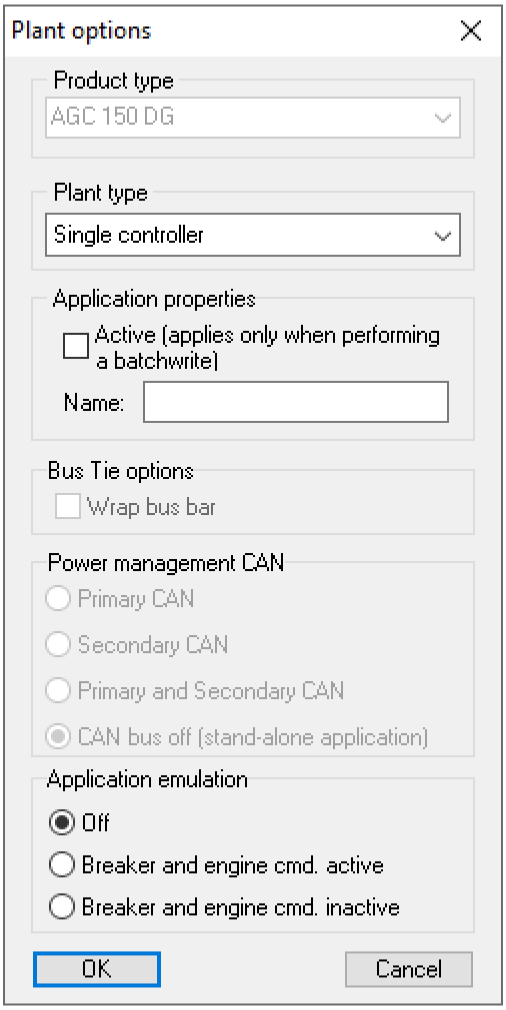
This setup must be done in each controller from the utility software:

1. Select the CAN protocol that corresponds to the CAN terminals that you will use for CANshare:
   - Parameter 7841 for CAN protocol A
   - Parameter 7842 for CAN protocol B

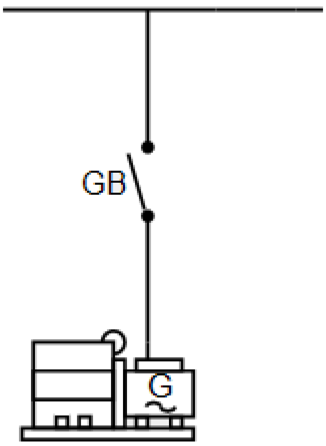
   NOTE You do not need to use the same CAN protocol in each controller.
2. For the set point, select *Canshare*:



3. Create a new plant configuration. Select the plant type *Single controller*:



4. Make an application drawing with a single generator, and write it to the controller:



5. Repeat steps 1 to 4 for each controller.

More information
See **CAN bus CANshare and PMS lite** in the **Installation instructions** for how to wire the CAN terminals.

The system is now ready for CANshare (digital load sharing). More generators can be added to the CANshare line without having to assign CAN IDs.

4. Power management

4.1 Introduction to power management

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

- Optimises fuel consumption
- 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 mains and busbars, fuel consumption, and so on.

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

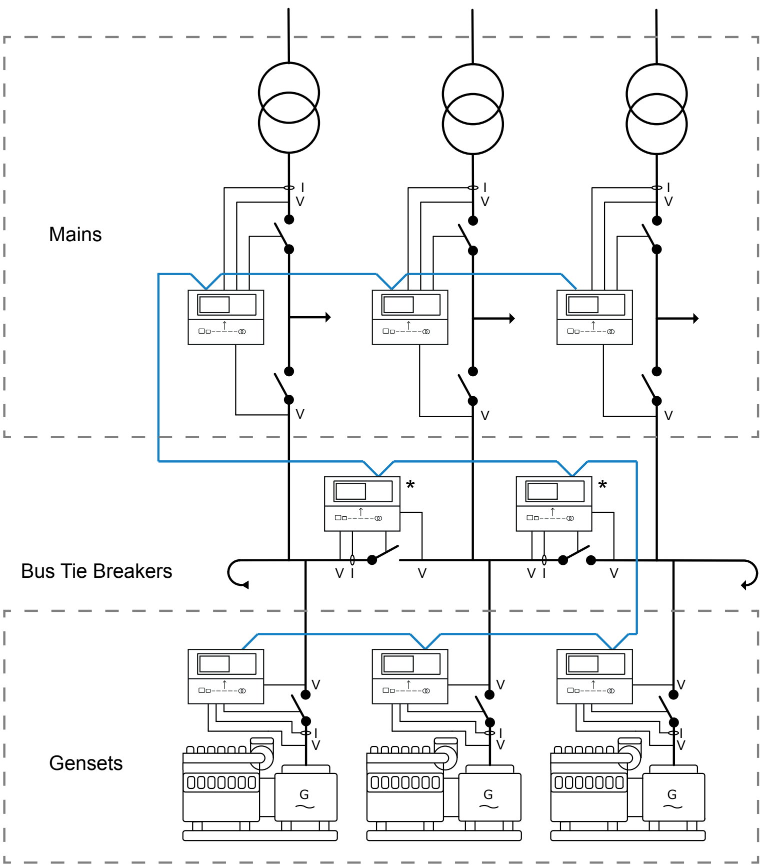
Multi-master system

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.

4.2 Applications

4.2.1 Power management applications

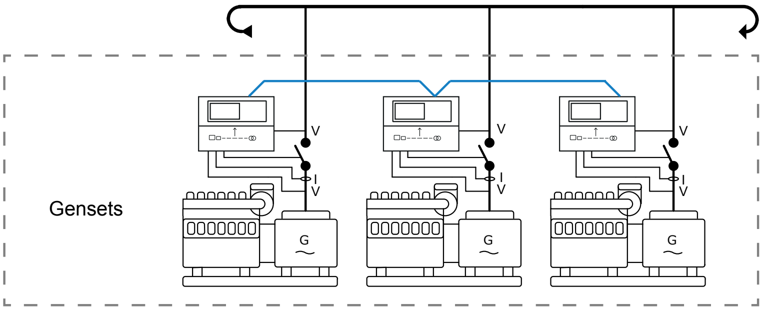
Example 1



- The plant includes mains controllers, bus tie breakers (BTB) and gensets.
- The feedbacks from the externally controlled BTBs must be wired to a controller.
- The busbar is wrapped, but this is not a requirement.

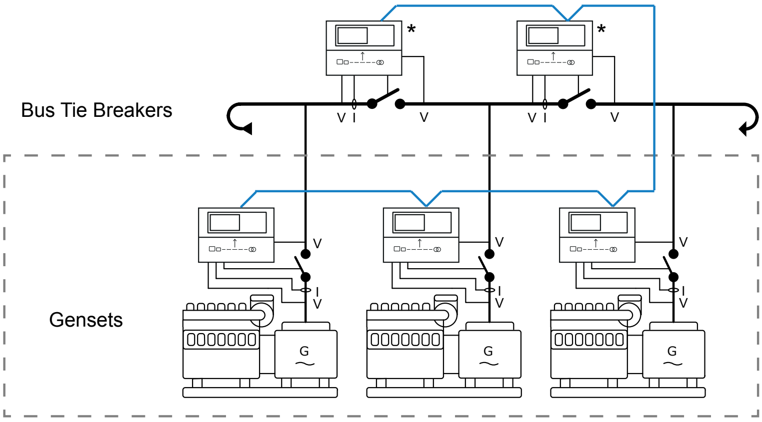
* In this example, the gensets can run parallel to the grid and export a fixed load.

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 controllers take over.
* The busbar is wrapped, but this is not a requirement.
* In this example, the gensets can only run in island mode.

Example 3

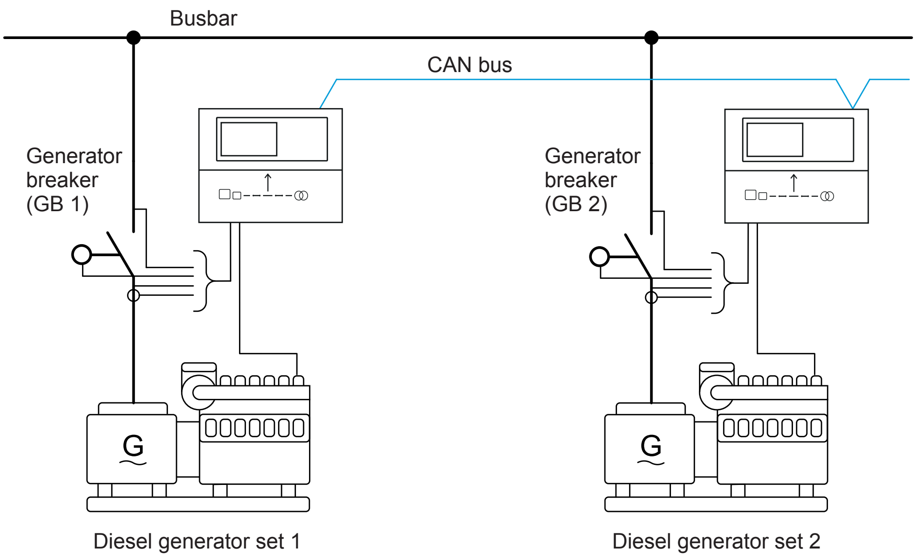


* Island application with bus tie breakers.
* The busbar is wrapped, but this is not a requirement.
* In this example, the gensets can only run in island mode.

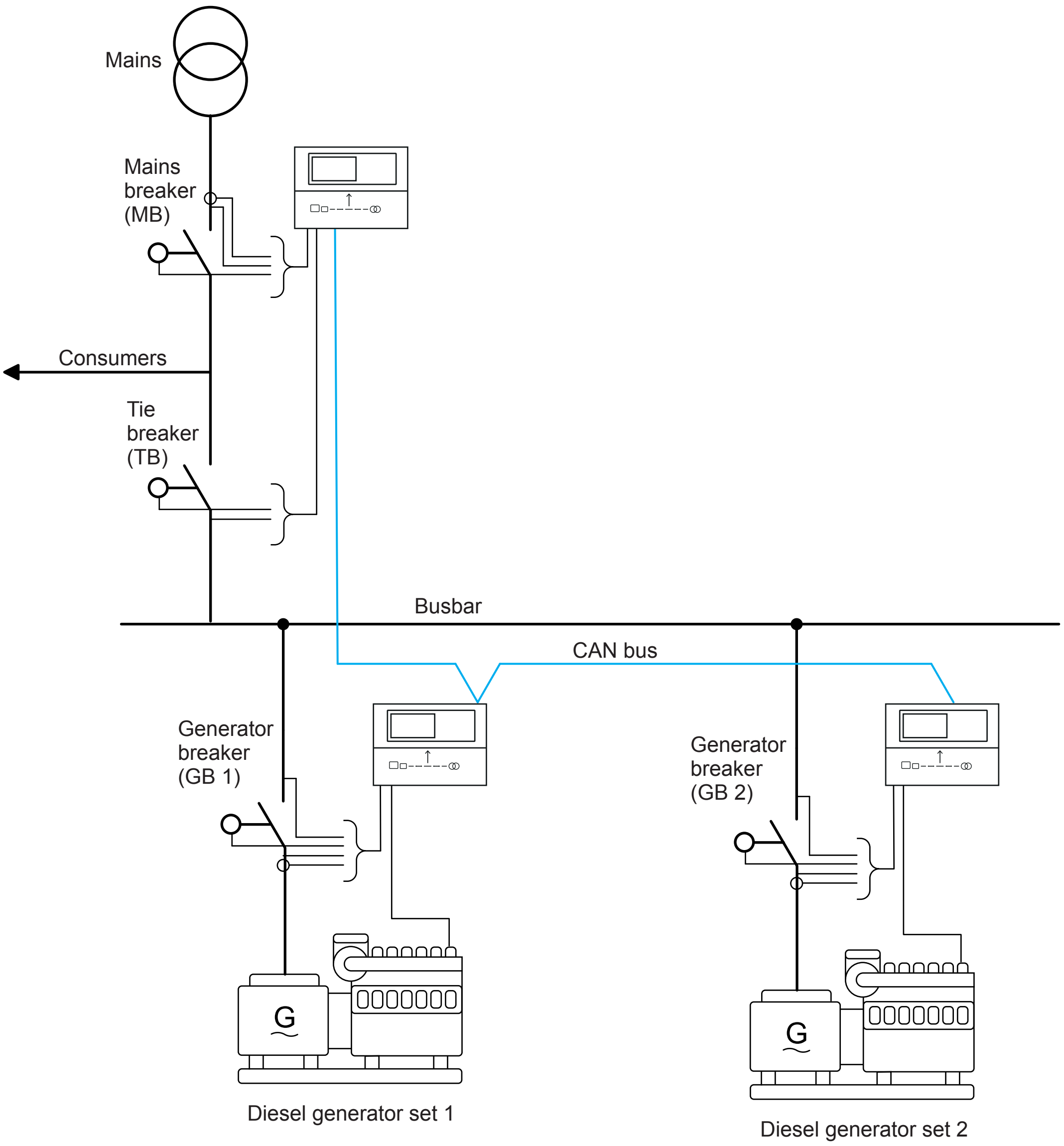
NOTE * Alternatively, you can use an externally controlled bus tie breaker with position feedback.

4.2.2 Multiple gensets, power management

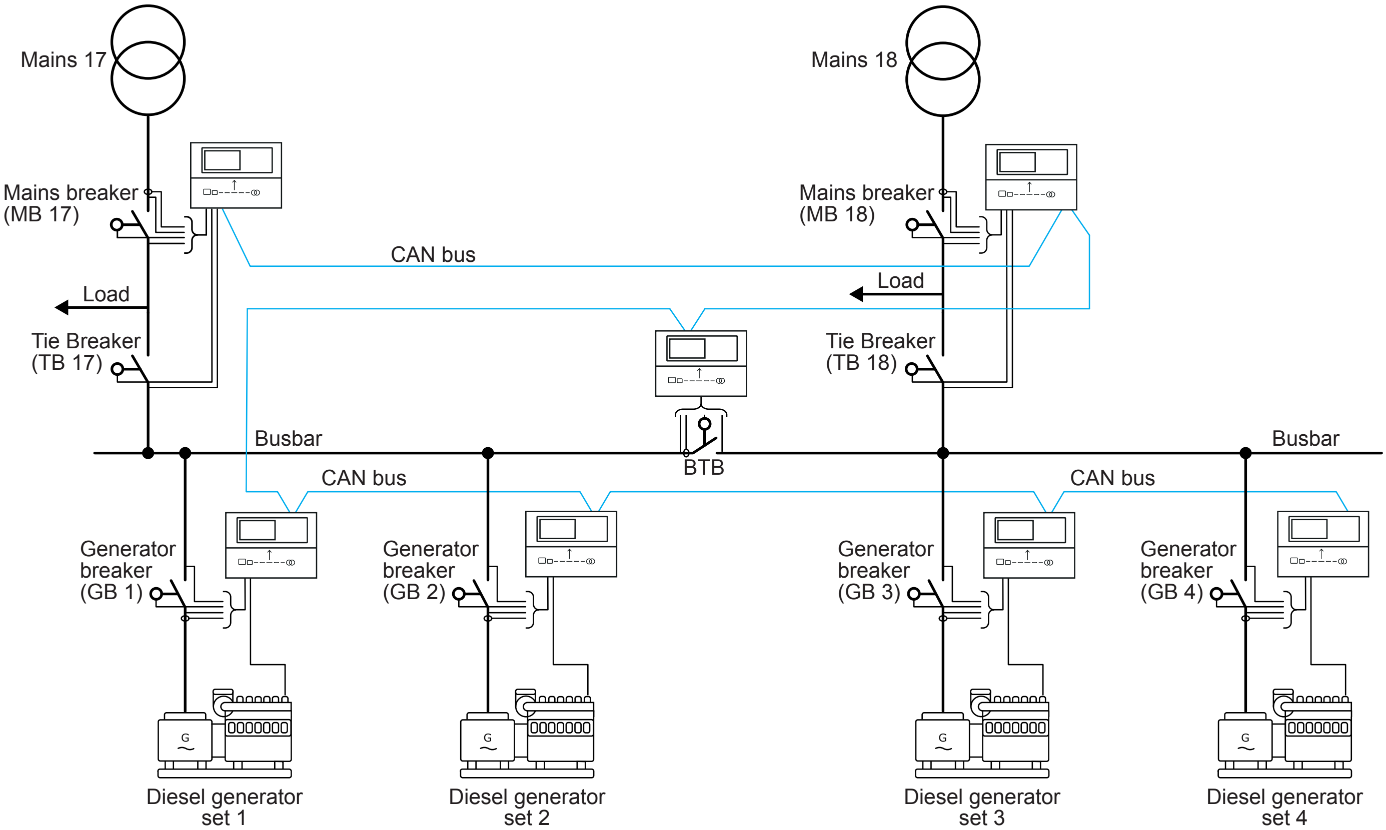
Island mode application



Parallel to mains application

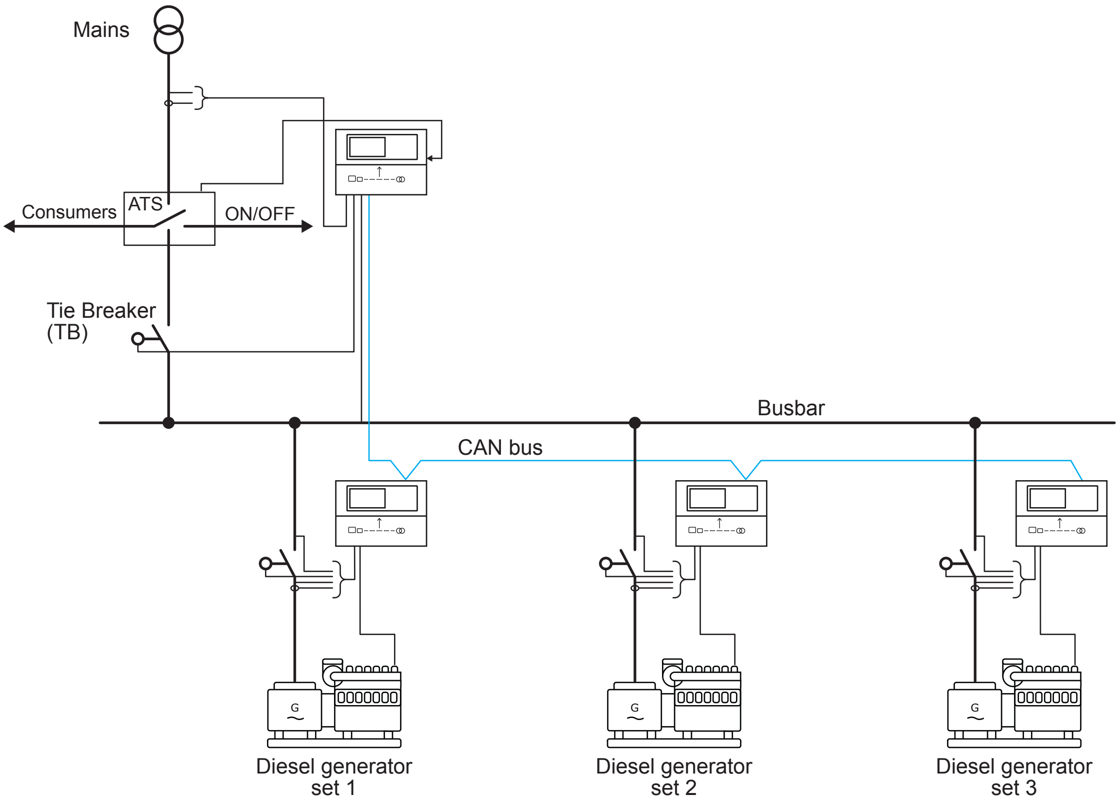


Multi-mains with two mains, two tie breakers, one bus tie breaker and four gensets



NOTE The diagram shows four generators, but the system supports up to 32 connected genset or mains controllers.

ATS plant, mains unit



4.3 Setup

4.3.1 Select controller type

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

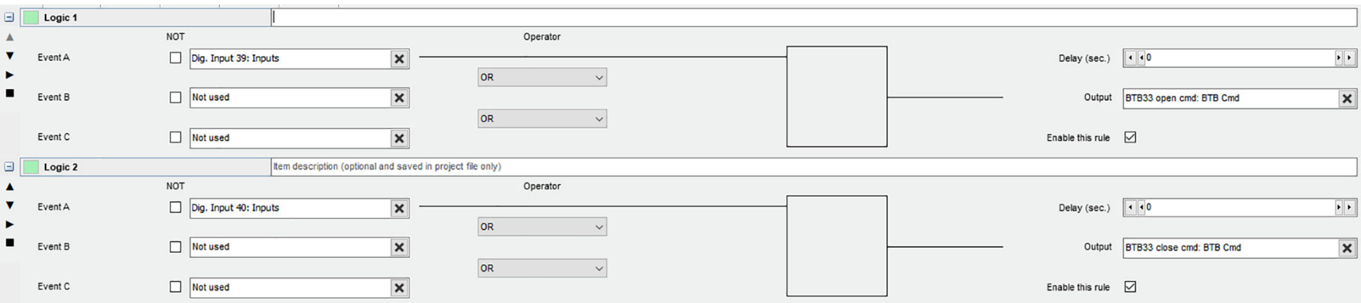
NOTE When the controller type is changed, the controller is reset to factory settings. Select the controller type before starting the configuration.

4.3.2 Breaker feedback

1. **Generator breaker (GB)**: For a genset controller, connect the feedbacks of the generator breaker to terminals 49 and 50.
2. **Mains breaker (MB)**: For a mains controller, connect the feedbacks of the mains breaker to terminals 47 and 48.
   - If there is no MB, select this in the utility software under *Application configuration*.
3. **Tie breaker (TB)**: For a mains controller that controls a TB, connect the feedbacks of the tie breaker to terminals 49 and 50.
   - If there is no TB, select this in the utility software under *Application configuration*.
4. **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
  - MB position failure while the tie breaker is open.
  - BTB position failure.
  - Any breaker position failure while the busbar's voltage and frequency are within the nominal settings.

4.3.3 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.

For *CAN B protocol* (parameter 7842) (under `Communication > CAN protocols`), select either *PM Primary* or *PM Secondary*. The *CAN B protocol* selection must be the same in all controllers. The power management functions are the same for *PM Primary* and *PM Secondary*.

4.3.4 CAN bus setup

If it is critical for the application to have the fastest possible inter-controller communication, configure parameters 9171 and 9172 from the controller display.

Press *Shortcut menu*, select Jump and enter the parameter number:

Parameter	Text	Range	Default
9171	Int CAN units *	≤ 15 units ≤ 20 units ≤25 units ≤ 30 units ≤ 35 units ≤ 40 units	≤ 20 units
9172	Int CAN baud **	125k 250k	125k

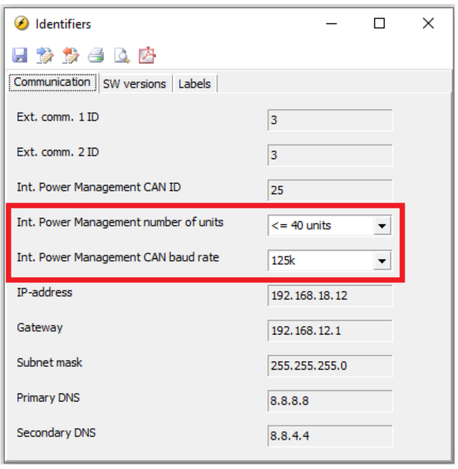
NOTE * The lower the number of units, the faster the power management.

** 125 kbit baud allows cable length up to 300 m, 250 kbit baud allows cable length up to 150 m.

All controllers in the system must have the same settings in parameters 9171 and 9172, otherwise an *Appl. hazard* alarm is displayed. A *Unit number Error* entry is created in the event log, and the controller with the different baud rate is tagged with the alarm value 100 in the alarm log.

The parameters can also be configured with the utility software:

1. In the task bar, select *Identifiers*
2. In the pop-up window, change *Int. Power Management number of units* and *Int. Power Management CAN BAUD rate*.



4.3.5 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	Manual Semi-auto No mode change	Manual	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.
7535	Any DG missing	Fail classes	Warning	The controller cannot detect at least one genset controller.
7536	Any mains missing	Fail classes	Warning	The controller cannot detect at least one mains controller.
7871	Any BTB miss.	Fail classes	Warning	The controller cannot detect at least one BTB controller.
7874	Any LG miss.	Fail classes	Warning	The controller cannot detect at least one load group controller.
7875	Any PV miss.	Fail classes	Warning	The controller cannot detect at least one solar controller.
7876	Any Bat 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.

Manual mode

If *Manual* mode is selected, the controllers change to manual mode when a fatal CAN error occurs. There is a risk of blackout, since there is no load sharing in manual mode.

SEMI-AUTO mode

If *SEMI-AUTO* mode is selected, the controllers change to SEMI-AUTO mode when a fatal CAN error occurs. The regulators in the controllers are still active. This means that gensets 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 mains, BTBs and gensets, if one genset is not visible anymore, the rest of the system can still behave almost like normal and continue in AUTO mode.

4.3.6 CAN bus alarms

Alarm	Description
Any DG missing	Activated when one or more genset controllers are missing. Activates the fail class in parameter 7535.
Any mains missing	Activated when one or more mains controllers are 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.

Alarm	Description
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.
CAN ID X P missing	The controller has lost CAN bus communication to CAN ID on *PM Primary*.
CAN MAINS X P missing	The controller has lost CAN bus communication to a mains 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 MAINS X S missing	The controller has lost CAN bus communication to a mains 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.

4.3.7 Easy connect

If the application consists of only genset, storage and/or solar controllers, Easy connect is a fast and easy way to add more controllers to a new or existing application. Easy connect commands normally come from the display, but they can also be sent from M-Logic and Modbus. You can also use Easy connect to remove genset, storage and/or solar controllers.

Preconditions

- All controllers in the application have the same software version.
  - You can use Easy connect for an application with a mix of AGC-4 Mk II, AGC-4, AGC 150, and ASC 150. All the controllers must support the same Easy connect functions.
- Easy connect is enabled in all controllers in parameter 8023, or *M-Logic Output, Easy connect, Enable Easy connect*.
- For genset controllers, in *Quick setup mode* (parameter 9186), select *Setup plant*.
- For storage and solar controllers, in *Quick setup mode* (parameter 9181), select *Setup plant*.
- The genset, ESS or PV to be added or removed is not running.

Activate Easy connect

If the preconditions are met, the Easy connect sequence is activated whenever:

- Easy connect is enabled in parameter 8023.
- A controller powers up.
- The CAN conditions change (that is, if a controller is added or removed).

`Power management > Easy connect`

Parameter	Text	Range	Default
8023	Easy connect	OFF ON	OFF

Using Easy connect

Once the Easy connect sequence starts, the operator cannot use the display unit to change parameters. Configure the parameters as required before the sequence starts, or use the utility software.

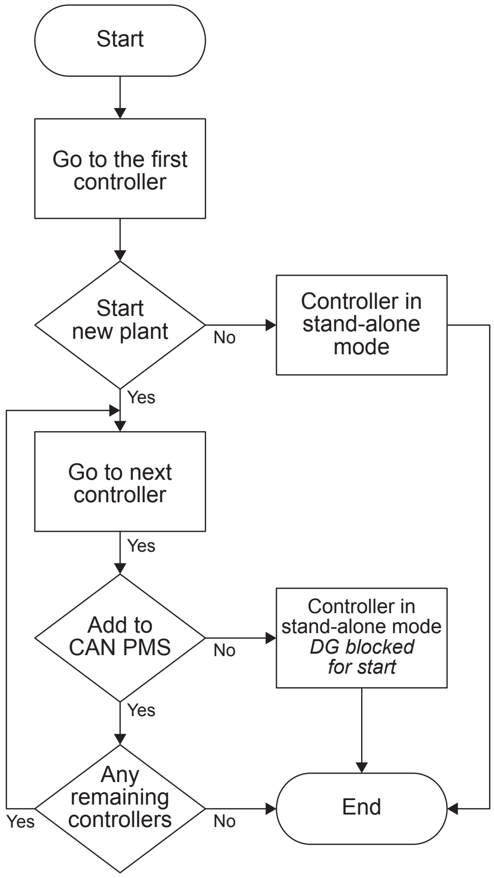
If a controller must be removed and another controller must be added to the plant, always first remove the controller then add the new controller.

NOTICE

Give the controllers enough time to make changes

When a controller is added or removed, the controllers use approx. one minute time to apply the change. When *Receiving application* is shown, do not add or remove more controllers. Making multiple simultaneous changes can reset the application.

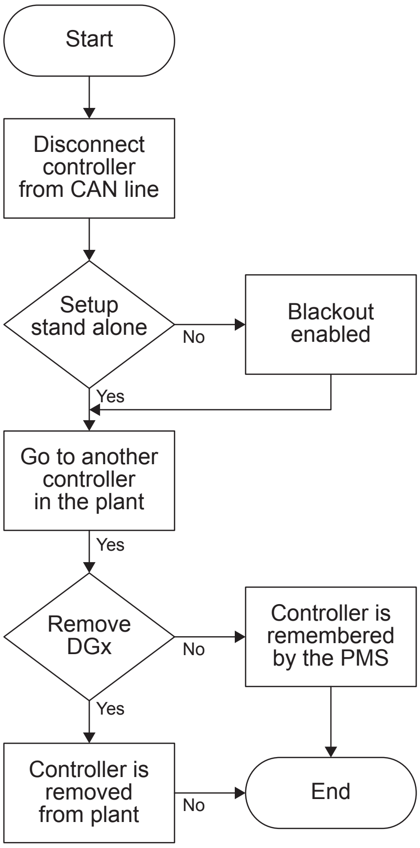
Configuring a new application or adding new genset controllers



1. The preconditions are met, and the Easy connect sequence is activated.
2. **Go to the first controller:** The first controller keeps its CAN ID and is *DG1*.
3. **Start new plant:** The display unit for the first controller prompts *START NEW PLANT?*:
   - Select *Yes*: The first controller starts a new application configuration.
   - Select *No*: The first controller goes into stand-alone mode with *DG blocked for start*.
4. **Go to next controller:** The operator can connect the CAN line and power up the next controller.
5. **Add to CAN PMS:** The new controller checks the PMS CAN line for another controller. The new controller gets the lowest available CAN ID. The new controller prompts *ADD DG TO CAN PMS?*.
   - Select *Yes*: The controller is added to the application.
   - Select *No*: The controller goes into stand-alone mode with *DG blocked for start*.
6. If additional controllers are detected, steps 4 and 5 repeat. Otherwise, the sequence ends.

NOTE If you need to add another controller later, that controller must not be powered before the CAN line is connected. When the controller power is connected, Easy connect is activated, and the controller can be added to the application.

Removing genset controllers



1. **Disconnect controller from CAN line:** The controller to be removed from the plant is disconnected from the CAN bus, or the controller is powered down.
2. **Setup stand-alone:** If still powered, the disconnected controller prompts *SETUP STAND-ALONE?*:
   - Select *Yes*: The controller is disconnected from the plant.
   - Select *No*: The controller waits to be reconnected to the CAN line. When this happens, the controller automatically reestablishes the CAN PMS connection.
3. **Go to another controller in the plant:** The displays of all the remaining controllers in the plant prompt *REM. DG ## CAN PMS?*.
4. **Remove DG ##:** From the display of any remaining controller:
   - Select *Yes*: The disconnected controller is removed from the plant. The related alarms are cleared from all the remaining controllers.
   - Select *No*: The other controllers wait for the disconnected controller to be reconnected to the CAN line. When this happens, the controllers automatically reestablish the CAN PMS connection.

M-Logic commands and events

As an alternative to using the display for Easy connect, the following commands are available under *M-Logic, Output, Easy connect*:

Controller	Command	Description
Genset only	Add DG	The user can connect multiple genset controllers to the CAN bus, then use this command to add each genset controller to the application.
Genset only	Remove DG	The user can use this command to remove a genset controller from the application, without the need to disconnect the CAN bus.
Storage only	Add ESS	The user can connect multiple storage controllers to the CAN bus, then use this command to add each storage controller to the application.
Storage only	Remove ESS	The user can use this command to remove a storage controller from the application, without the need to disconnect the CAN bus.
Solar only	Add PV	The user can connect multiple solar controllers to the CAN bus, then use this command to add each solar controller to the application.
Solar only	Remove PV	The user can use this command to remove a solar controller from the application, without the need to disconnect the CAN bus.
All	Select yes on display	This command selects YES if there is a "YES/NO" prompt on the display.
All	Select no on display	This command selects NO if there is a "YES/NO" prompt on the display.
All	Enable Easy connect	The user can activate the Easy connect function with this command.
All	Disable Easy connect	The user can deactivate the Easy connect function with this command.

The following events are available under *M-Logic, Events, Easy connect*:

Event	Description
Plant active	Activated for an Easy connect plant.
Stand alone	Activated for a stand-alone (single controller) application.

Setting up the controller for a single controller application

You can also use Easy Connect to set up the controller for a single controller application.

- For genset controllers, in *Quick setup mode* (parameter 9186), select *Setup stand alone*.
- For storage and solar controllers, in *Quick setup mode* (parameter 9181), select *Setup stand alone*.

4.3.8 Controller IDs

After connecting the CAN bus communication, each controller must have a unique internal communication ID. With Easy Connect, the controllers set the IDs automatically.

For manual setup, you must set the controller ID.

`Communication > Power management ID`

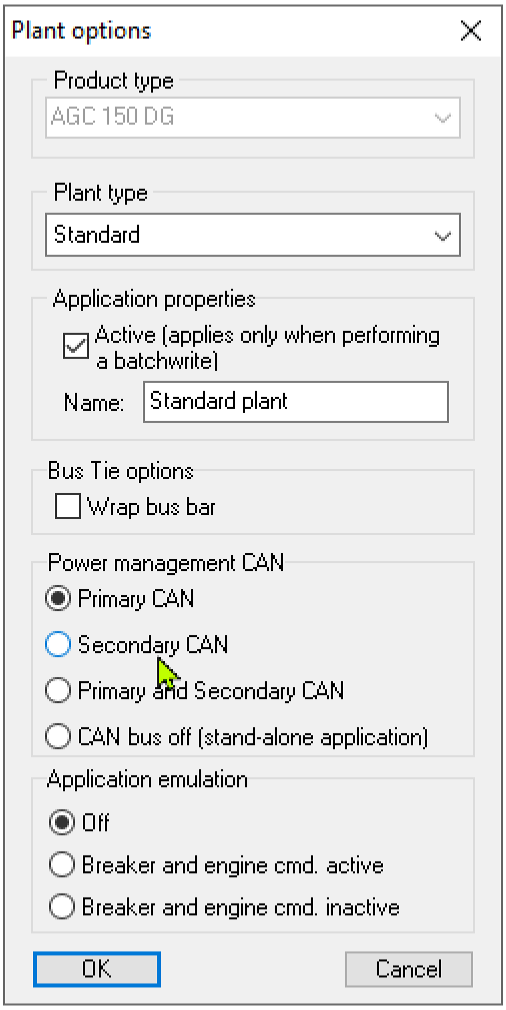
Parameter	Text	Range	Default
7531	Int. comm. ID	1 to 32	1

4.3.9 Application configuration

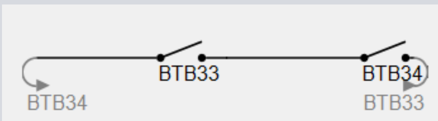
When the IDs are configured, you can configure the application with the utility software. Connect to a controller with the PC utility software, then select *Application configuration*.

In the top taskbar, select *New plant configuration* 

The *Plant options* window opens.

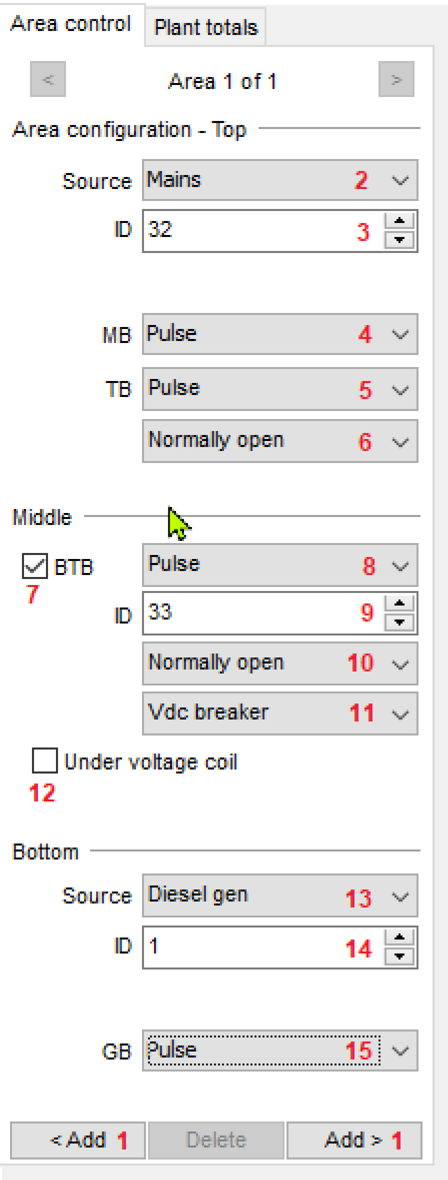


Plant options

	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. *Primary and secondary CAN* is only used for redundant CAN bus communication lines for power management. If this setting is selected and only one line is present, an alarm is activated. This alarm cannot be cleared.

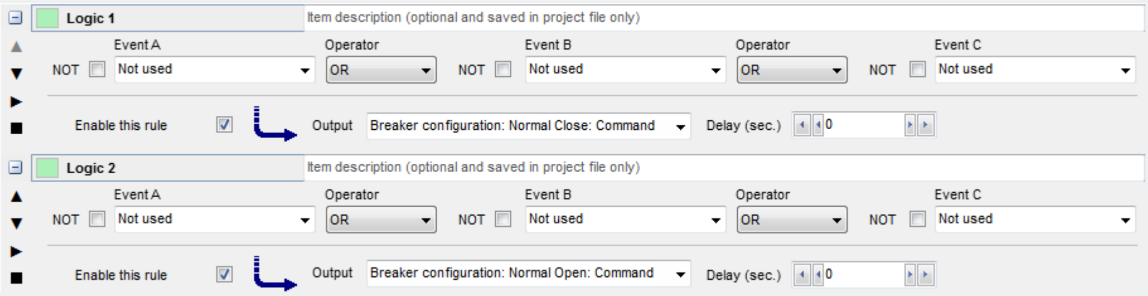
	Description	Comments
		CAN bus off should only be used if the controller is in a stand-alone application.
Application emulation	Off Breaker and engine cmd. active Breaker and engine cmd. inactive	The emulation is started here. For *Breaker and engine cmd. active*, the controllers activate the relays 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.

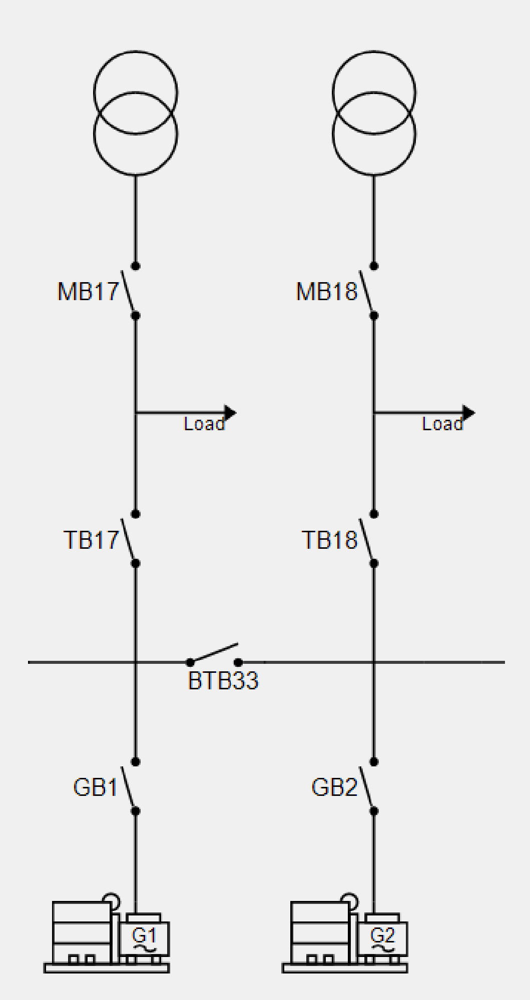


Plant configuration options

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, Mains, Diesel gen, Photovoltaic, LG or Battery).

No.	Name	Description
3	ID	Set the ID. This ID should correspond to the internal communication ID (parameter 7531) in the controller.
4	MB	Mains is selected as the source (no. 2), so it is possible to select the type of breaker* for the mains breaker (Pulse, Ext/ATS no control, Continuous NE, Compact, None, Continuous ND).
5	TB	Mains is selected as the source (no. 2), so it is possible to select the type of breaker* for the tie breaker (Pulse, Continuous NE, Compact, None).
6	-	Select whether the tie breaker is *Normally open* or *Normally closed*.
7	BTB	Select to add a BTB controller.
8	-	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.
9	ID	Set the ID. This ID should correspond to the internal communication ID (parameter 7531) in the controller.
10	-	Select whether the BTB is *Normally open* or *Normally closed*. If needed, this setting can be changed using M-Logic. The normal state of the breaker is selected in the application configuration, and the opposite is activated by M-Logic. 
11	-	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.
12	Under voltage coil	Select this if the BTB has an under-voltage coil.
13	Source	Select the type of power source for the bottom area (None, Mains, Diesel gen, Photovoltaic, LG or Battery).
14	ID	Set the ID. This ID should correspond to the internal communication ID (parameter 7531) in the controller.
15	GB	Diesel genset is selected as the source (no. 15), 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*

4.4 Power management general functions

4.4.1 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 above also applies to the AGC mains controllers – in that case the command unit is called Mains Command Unit (MCU).

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

4.4.2 Local/remote operation

To start the plant in AUTO mode, the controller can use local or remote operation.

Local

The plant can be started from the display (local operator). All operation is done from the display. In island operation any genset controller display can be used.

In load takeover, mains power export and fixed power the mains controller display must be used. The mains controller must be in AUTO mode.

Remote

The plant can be started remotely, for example, by a PLC, a digital input or through Modbus/Profibus communication.

- **Island**: In island mode an Auto start/stop input on any of the genset controllers can be used to start the plant. Any running mode (MAN, AUTO, SEMI, BLOCK) can be selected on the genset controllers. The remote start signal still works for the controller in AUTO mode.
- **Parallel to mains**: In load take-over, mains power export and fixed power mode the Auto start/stop input on the mains controller must be used for starting the plant.

`Power management > Start/Stop for Island`

Parameter	Text	Range	Default
8021	Start/Stop	Remote Local	Remote

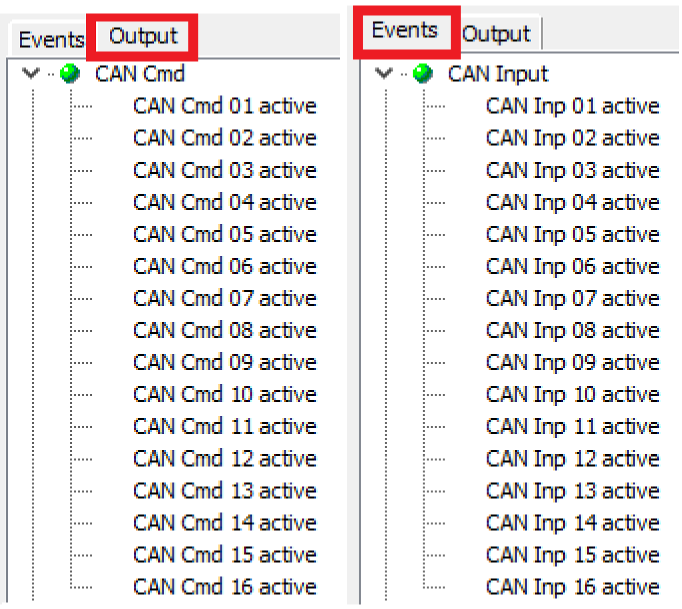
The setting can also be changed in *M-Logic, Output, Command Engine, Set to local start* or *M-Logic, Output, Command Engine, Set to remote start*.

4.4.3 CAN flags (M-Logic)

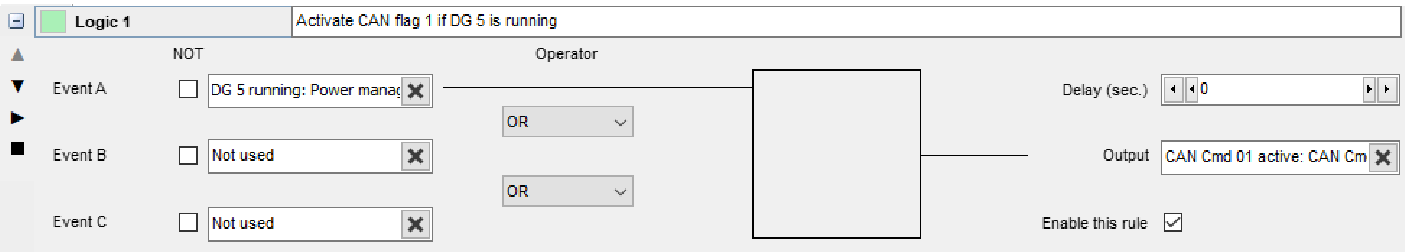
M-Logic has 16 CAN flags for CAN commands. They are like digital inputs. When a CAN command is sent from one controller, the corresponding CAN flag is activated in all the controllers. No wire is needed, as the CAN flags are communicated over the power management CAN bus.

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

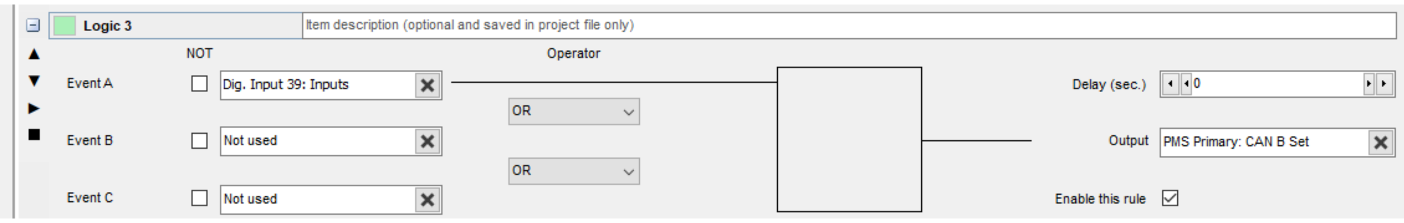


CAN Cmd 01 is activated when DG 5 is running. *CAN Inp 01 active* is then activated in all controllers in the power management system.

4.4.4 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*, *CANshare*, or *PM Secondary*.

M-Logic CAN B output example



4.4.5 Common PF control

Configure common PF control in a mains 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
7052	Cos phi set	0.60 to 1.00	0.90
7053	Type	Inductive Capacitive	Inductive
7054	Reac Power Set	-100 to 100 %	0 %
7055	Type	OFF Superior (PMS) Fixed Q (DG parallel)	OFF

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

4.4.6 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.

4.5 Power management genset functions

4.5.1 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.

4.5.2 Genset controller mode

For power management to work, you must select *Power management* as the genset mode in each genset controller. In addition, each genset controller should be in AUTO mode.

`Basic settings > Application type > Genset type > Genset Mode`

Parameter	Text	Range	Selection
6071	Type	Island operation Auto Mains Failure Peak shaving Fixed power Mains power export Load take over Power management Dry alternator Ventilation	Power management

4.5.3 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 32
8082	Priority 2	1 to 32
8083	Priority 3	1 to 32
8084	Priority 4	1 to 32
8085	Priority 5	1 to 32
8091	Priority 6	1 to 32
8092	Priority 7	1 to 32
8093	Priority 8	1 to 32
8094	Priority 9	1 to 32
8095	Priority 10	1 to 32
8096	Priority 11	1 to 32
8101	Priority 12	1 to 32
8102	Priority 13	1 to 32
8103	Priority 14	1 to 32
8104	Priority 15	1 to 32
8105	Priority 16	1 to 32
8106	Priority 17	1 to 32
8321	Priority 18	1 to 32
8322	Priority 19	1 to 32
8323	Priority 20	1 to 32
8324	Priority 21	1 to 32
8325	Priority 22	1 to 32
8326	Priority 23	1 to 32
8331	Priority 24	1 to 32
8332	Priority 25	1 to 32
8333	Priority 26	1 to 32
8334	Priority 27	1 to 32
8335	Priority 28	1 to 32
8336	Priority 29	1 to 32
8341	Priority 30	1 to 32
8342	Priority 31	1 to 32
8343	Priority 32	1 to 32

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
8086	Transmit	OFF Manual update	OFF

Parameter	Text	Range	Default
		Running hour update	

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 mains connection on each 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.

4.5.4 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	Hours	1 to 20,000 hour	175 hour
8112	Type	Total Trip	Total
8113	Rel. counter Reset	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.

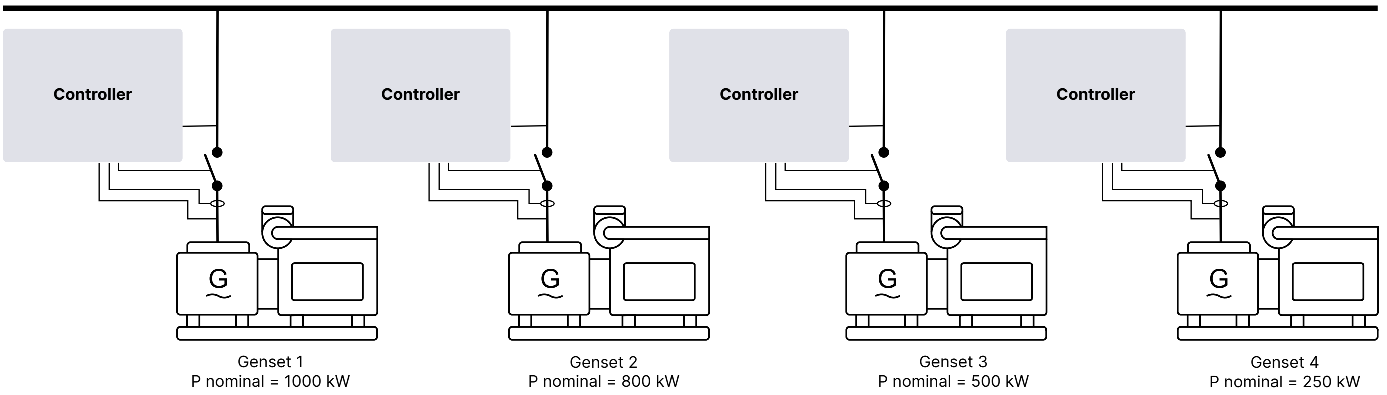
You can select relative running hours using *M-Logic, Output, Command Power management, Rel prio handling*.

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

4.5.5 Fuel optimisation

The fuel optimisation function ensures that the nominal power of the gensets connected to the busbar is as small as possible. At the same time, the function also makes sure that the load can still be carried and the active load-dependent start condition is met. You can use fuel optimisation with gensets of varying sizes as well as Solar and Storage controllers.

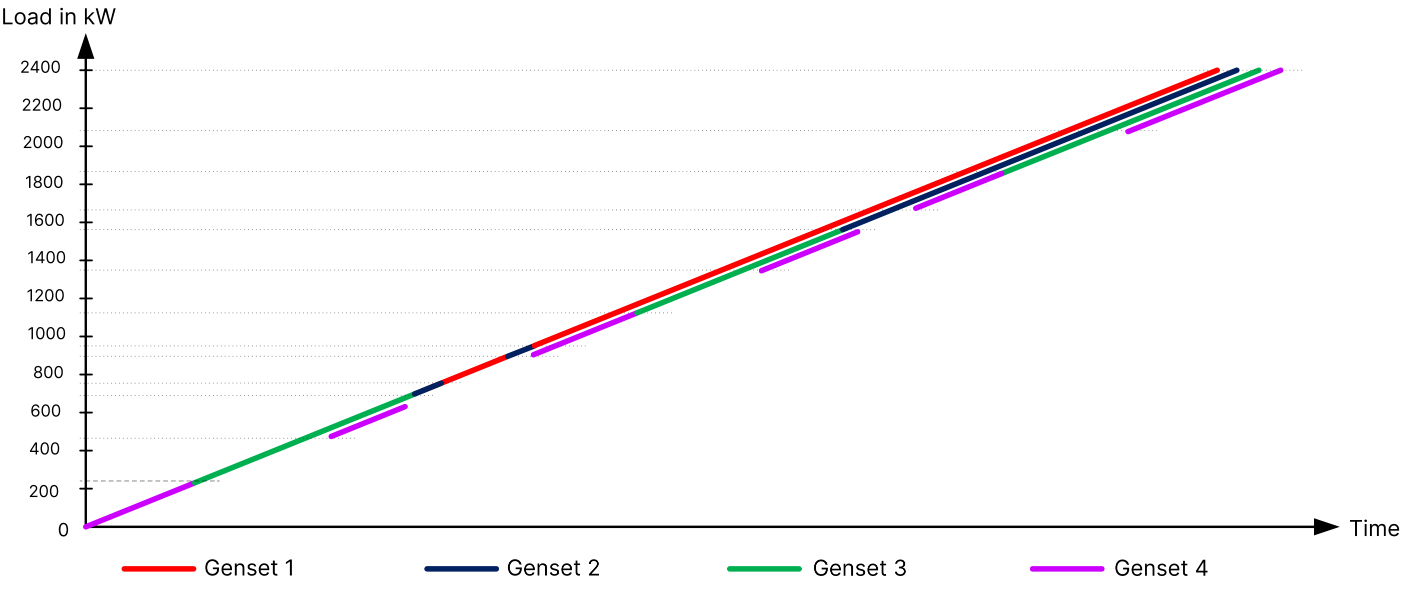
If fuel optimisation is selected in parameter 8031, the genset priorities are disabled, and the gensets start and stop according to the load. The fuel optimisation function can be useful if the application consists of gensets with different nominal powers. The function is best described with an example:



Four gensets, with different nominal powers, are shown above. Fuel optimisation is activated, so there are no priorities. The AGC continuously calculates the optimised set of gensets to run.

The diagram below shows which gensets run as the load increases. In this example the load-dependent start limit is 90 %. That is, when the load increases to 90 % or above, the next genset starts. After the next genset starts, another one may stop to optimise the fuel consumption.

You can use fuel optimisation with percentages or values (kW). If the spinning reserve function is activated, use percentages.



1. For fuel optimisation, the smallest possible genset (number 4) starts.
2. After that, genset 3 takes the load alone, since a bigger genset is not yet required.
3. Next, genset 4 starts again. At this point, two gensets are running, since the nominal power of gensets 3 and 4 is smaller than the nominal power of genset 2.

4. As the load increases, some gensets are stopped, and some bigger one are started.
5. For the maximum load, all the gensets run in parallel.

NOTE With fuel optimisation activated, it is still possible to use asymmetrical load sharing.

Load-dependent stop conditions

The principle for the load-dependent stop function is the same as without fuel optimisation activated. If genset 2 and genset 4 are running in parallel and the load drops below the stop limit of 70 % (default), the genset priority changes. Genset 1 starts and takes the load, and gensets 2 and 4 stops.

4.5.6 Fuel optimisation and running hours

If *Fuel optimisation + running hours* is selected in parameter 8031, the AGC ignores the genset priorities, and the gensets start and stop according to the running hours. If two or more gensets have the same running hours, the optimum genset combination is selected according to the load.

4.5.7 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	Unit selection	kW kvA	kW
8882	Set point type	Value Percentage	Value
8006	Scaling	1 kW : 1 kW 1 kW : 10 kW 1 kW : 100 kW 1 kW : 1000 kW	1 kW : 1 kW
8141	Stop noncon. DG	10.0 to 600.0 s	60.0 s

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 method	Remote Local	Remote

Terminology

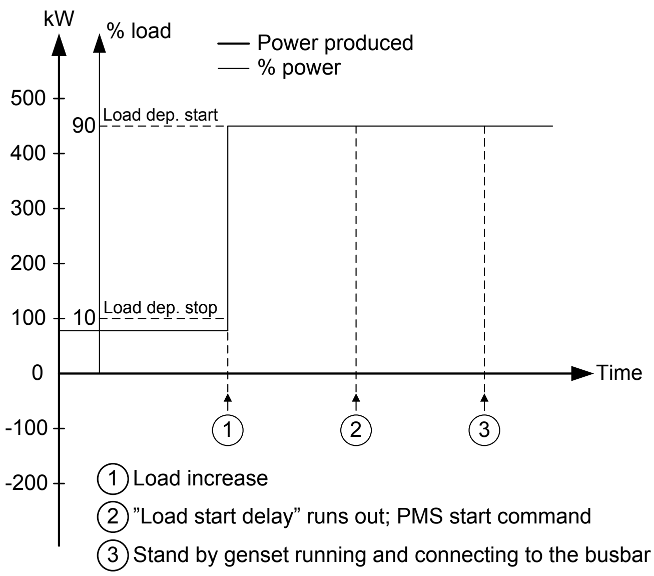
Short	Description	Comment
$P_{AVAILABLE}$	Available power	P_{TOTAL} - $P_{PRODUCED}$
P_{TOTAL}	Total power	$\Sigma P_{NOMINAL}$ of running sets with GBs closed

Short	Description	Comment
$P_{PRODUCED}$	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 three DGs:

DG1 =	1500 kW
DG2 =	1000 kW
DG3 =	1000 kW
That is a total of	3500 kW

Produced power

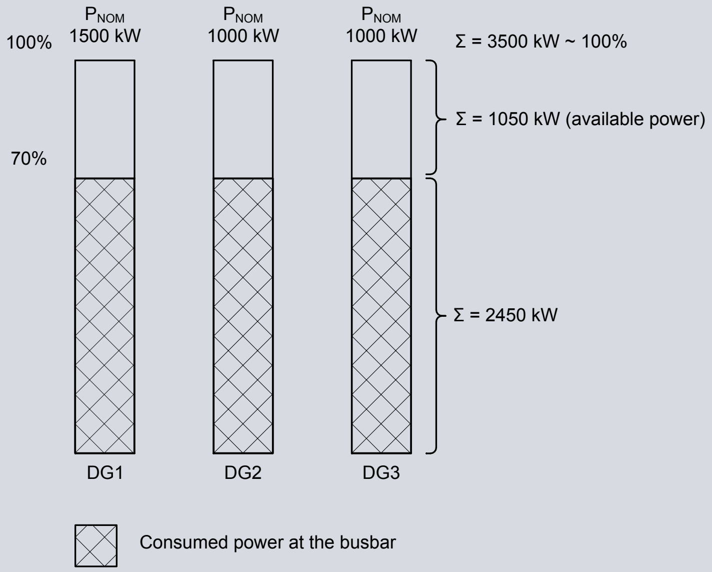
The existing load on the busbar. In the example the produced power is shown as the hatched area, and the total of the three gensets = 2450 kW.

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 3500 kW. The load consumes 2450 kW in total. Since the total load P_{TOTAL} is 3500 kW, and the produced load $P_{PRODUCED}$ is 2450 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.

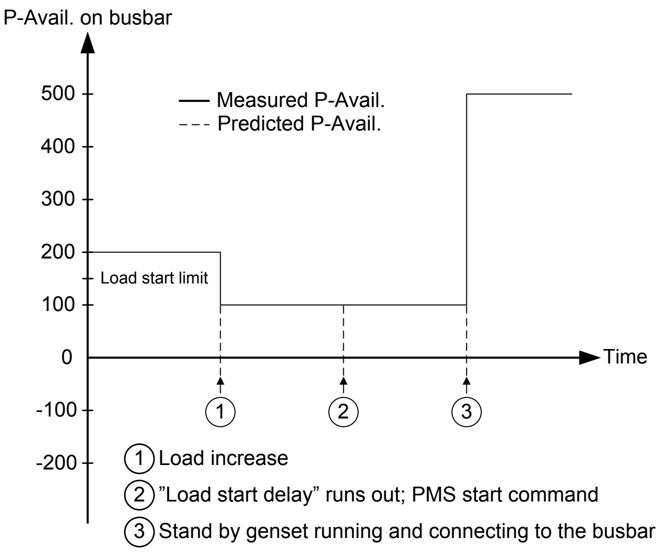
Example to show the terms



4.5.8 Adjusting load-dependent start and stop

Example: Adjusting load-dependent start

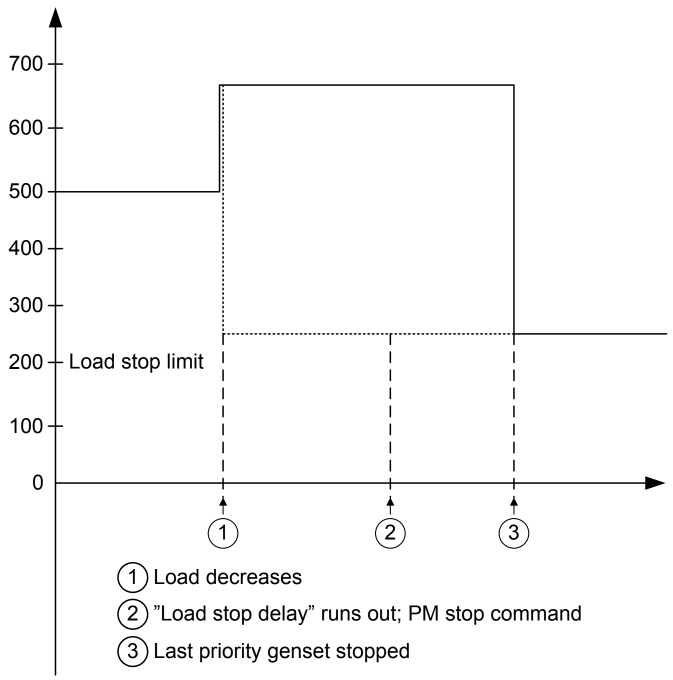
The available power is 200 kW. When the load increases, the available power drops below the start limit. The stand-by genset will start when the start timer runs out, and after the synchronising the available power increases (in this example to 500 kW).



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 DGs to be running at low load instead of one DG.

4.5.9 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	Start lim. P	1 to 20,000 kW	100 kW
8002 or 8302	Start lim. S	1 to 20,000 kVA	100 kVA
8003 or 8303	Start lim. %	1 to 100 %	90 %
8004 or 8304	Timer	0.0 to 990.0 s	10.0 s
8305	Enable	OFF ON	OFF

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

Parameter	Text	Range	Default
8011 or 8311	Stop lim. P	1 to 20,000 kW	200 kW
8012 or 8312	Stop lim. S	1 to 20,000 kVA	200 kVA
8013 or 8313	Stop lim. %	1 to 100 %	70 %

Parameter	Text	Range	Default
8014 or 8314	Timer	5.0 to 990.0 s	30.0 s
8315	Enable	OFF ON	OFF

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.

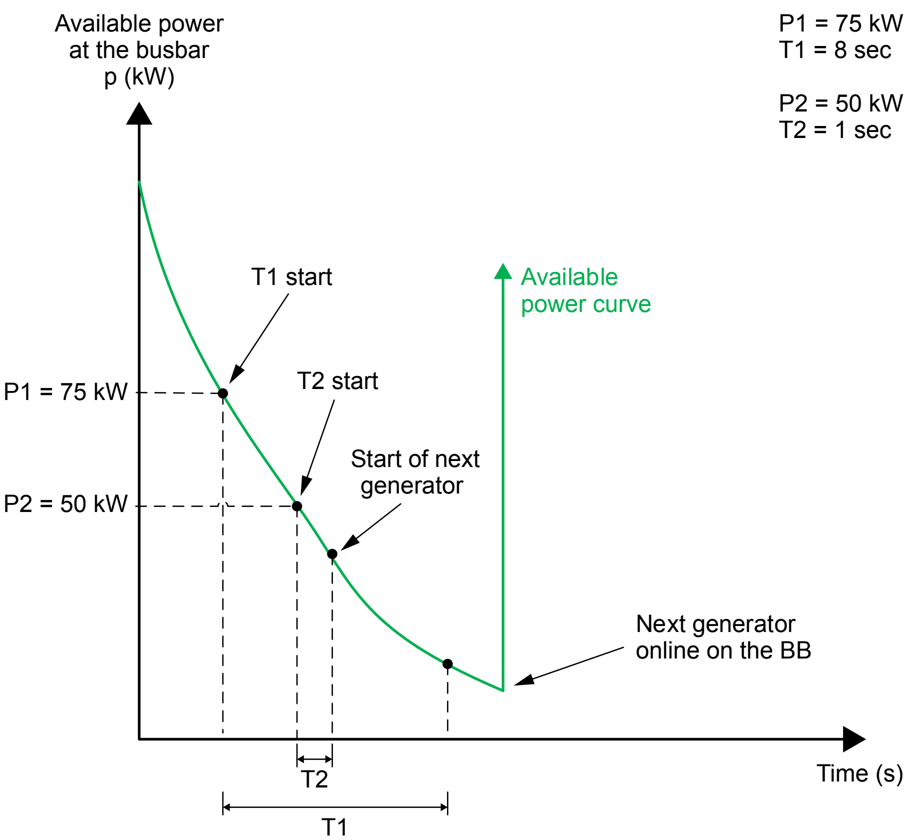
Load-dependent stop without delay function

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.

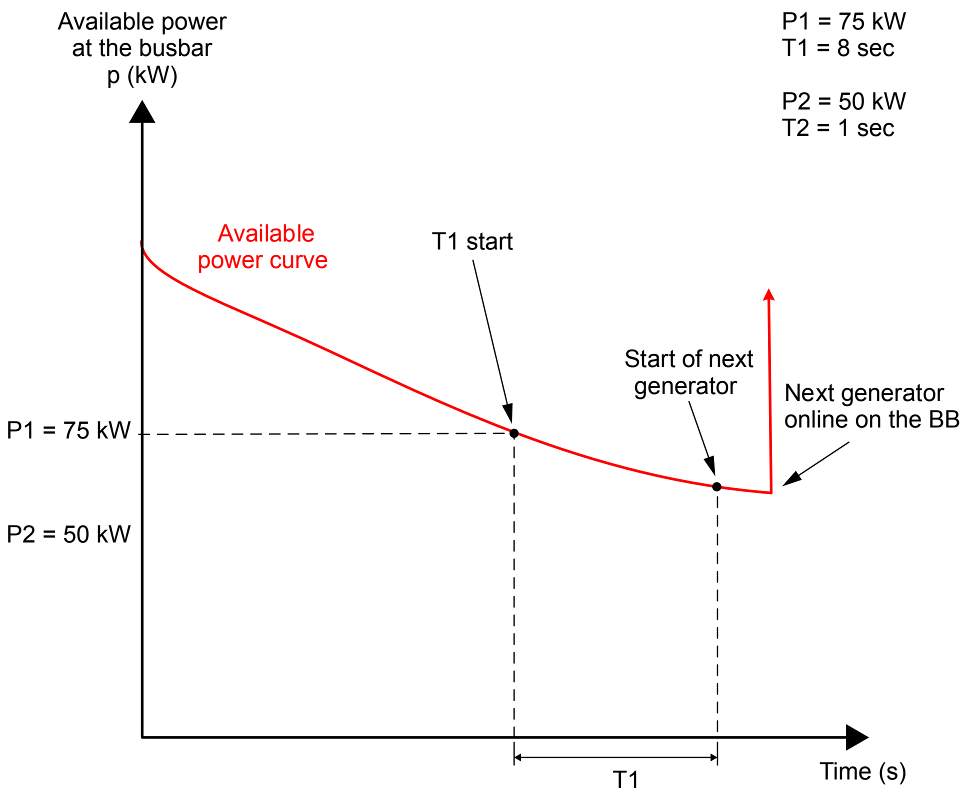
Configuration example 1

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).



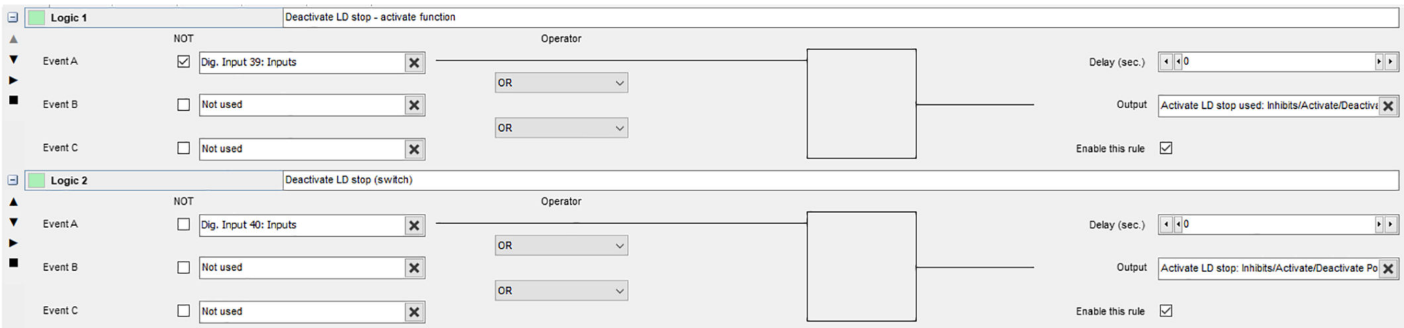
4.5.10 Activate/deactivate load-dependent start/stop with M-Logic

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 43. Now the operator can switch the load-dependent stop ON or OFF using a switch connected to terminal 44.



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

4.5.11 Load sharing

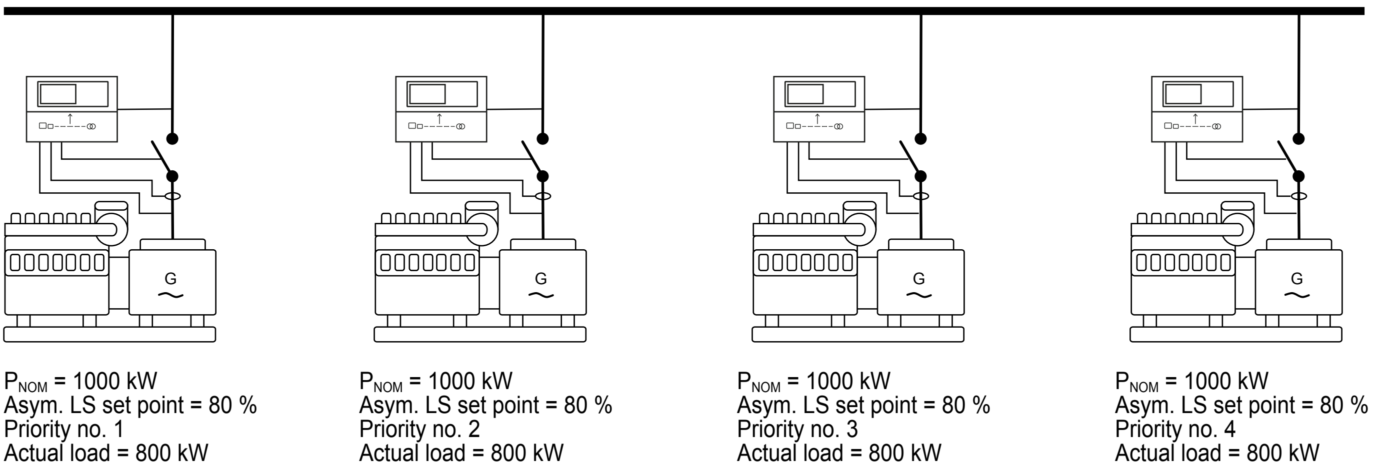
When the power management communication is running, the load sharing is done using CAN bus communication between the controllers. The controller can use analogue load sharing instead, if this is programmed with M-Logic.

Analogue load sharing if CAN bus fails

If both CAN bus lines are disconnected or faulty, the controllers do not automatically switch over to analogue load sharing. This has to be set up in M-Logic: Use *Events, Alarms - Power management, Fatal CAN error* to activate *Output, Command Power management, Use Ana LS instead of CAN*. Now load sharing continues. Power management is lost, but the gensets that are already running remain stable.

4.5.12 Asymmetric load sharing

The controllers can make the gensets share the load asymmetrically. This means that the gensets will be directed towards a specific set point for the load. If four 1000 kW gensets are doing asymmetrical load sharing on 2700 kW load, and the asymmetrical load sharing set point is 80 %, the controllers balance the load between them as below:



When the load is increasing or decreasing, the genset with the last priority will take the deviations, so the other(s) can be kept at a more optimum load point. If the load should exceed 3200 kW in the example above, the load will be shared equally between them. If the load afterwards decreases to a level below 3200 kW again, the three first gensets will regulate towards the 80 % again, and the last will take the deviations.

When using the asymmetrical load sharing, the limits for load-dependent start and stop are still respected. So if the start limit is above 80 %, the running gensets will be loaded above 80 %, until the next genset has started.

`Power management > Asymmetric loadshare`

Parameter	Text	Range	Default
8281	Value	1 to 100 %	80 %
8282	Enable	OFF	OFF

Parameter	Text	Range	Default
		ON	

4.5.13 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	Governor f Kp	0.00 to 60.00	2.50	Analogue and EIC parameters.
2542	Governor f Ti	0.00 to 60.00 s	1.50 s	Analogue and EIC parameters.
2543	Governor f Td	0.00 to 2.00 s	0.00 s	Analogue and EIC parameters.
2544	Governor P weight factor	0.0 to 100.0 %	10.0 %	Analogue and EIC parameters.
2591	Governor Relay f deadband	0.2 to 10.0 %	1.0 %	Relay parameters.
2592	Governor Relay f Kp	0 to 100	10	Relay parameters.
2593	Governor Relay P deadband	0.2 to 10.0 %	2.0 %	Relay parameters.
2594	Governor Relay P weight factor	0.0 to 100.0 %	10.0 %	Relay parameters.

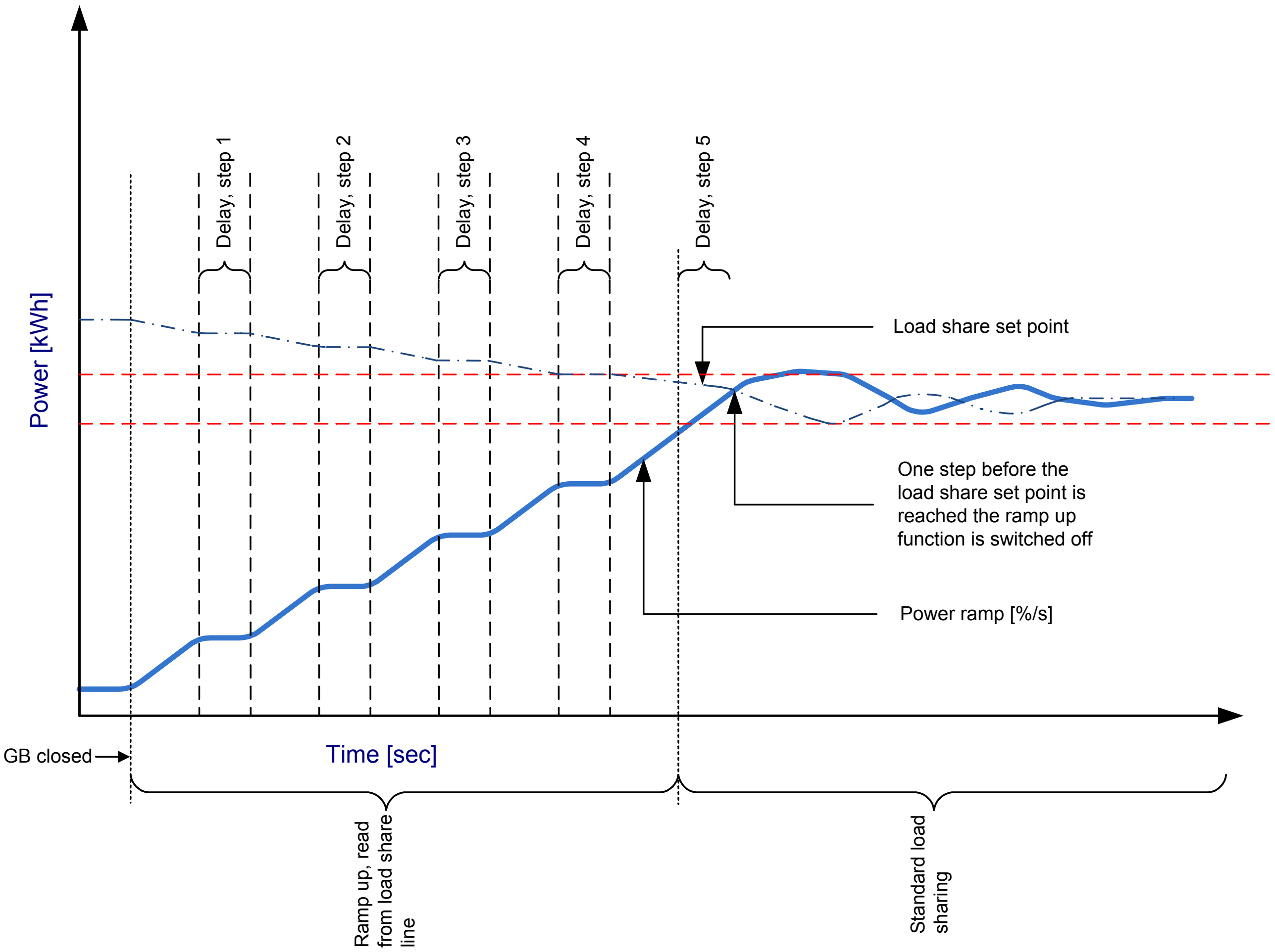
`Generator > AVR> Voltage PID > Load share`

Parameter	Text	Range	Default	Comment
2661	AVR U Kp	0.00 to 60.00	2.50	Analogue and EIC parameters.
2662	AVR U Ti	0.00 to 60.00 s	1.50 s	Analogue and EIC parameters.
2663	AVR U Td	0.00 to 2.00 s	0.00 s	Analogue and EIC parameters.

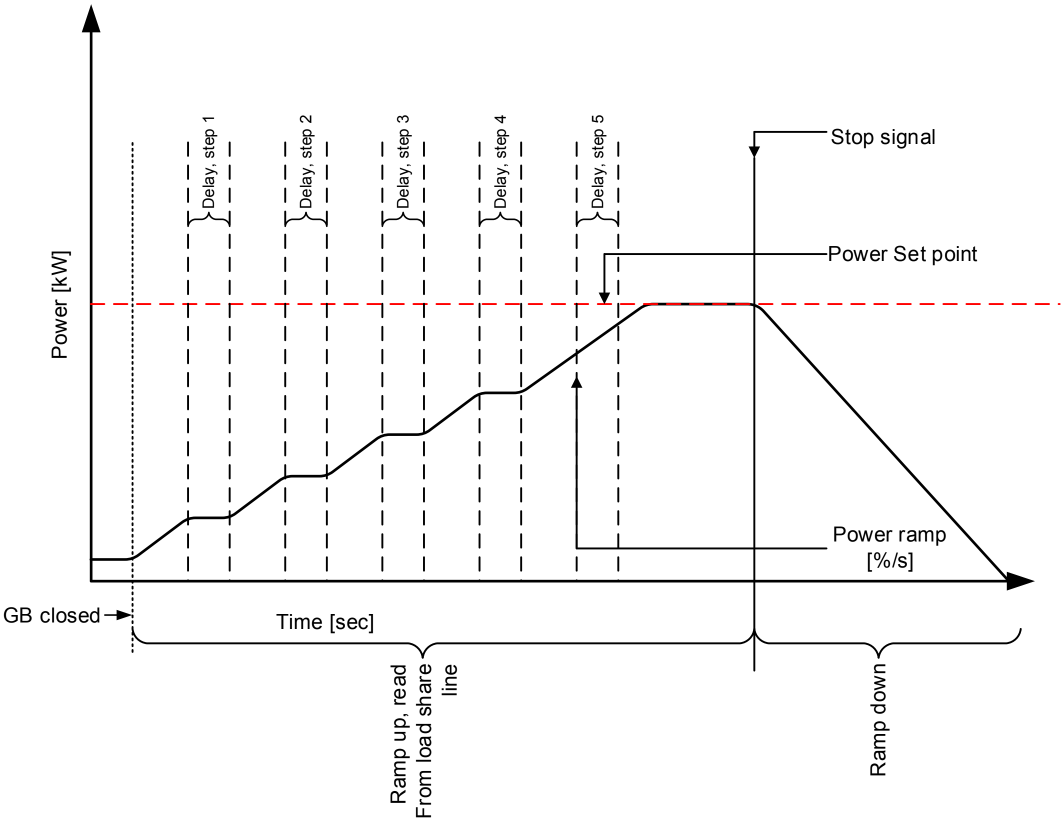
Parameter	Text	Range	Default	Comment
2664	AVR Q weight factor	0.0 to 100.0 %	10.0 %	Analogue and EIC parameters.
2711	AVR Relay U deadband	0.2 to 10.0 %	1.0 %	Relay parameters.
2712	AVR Relay U Kp	0 to 100	10	Relay parameters.
2713	AVR Relay P deadband	0.2 to 10.0 %	2.0 %	Relay parameters.
2714	AVR Relay Q weight factor	0.0 to 100.0 %	10.0 %	Relay parameters.

4.5.14 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.

4.5.15 Secured mode

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

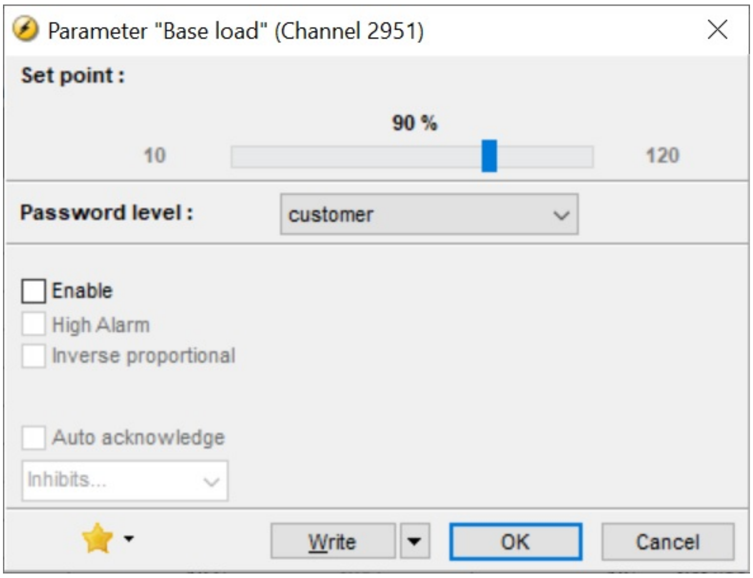
`Power management > Secured mode`

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

4.5.16 Base load

In an island application, one genset controller in a power management system can be selected to run with a base load (enable parameter 2952). The busbar has to be active with one or more gensets connected. Only one AGC controller (per dynamic section) can run in base load at a time. If more than one controller has base load enabled, the controller with the lowest ID runs in base load.

Enable base load from the display unit, using M-Logic (*Outputs, Commands Power management, Activate base load/ Deactivate base load*) or using a digital input. When the controller runs with base load, the status message *FIXED POWER* is shown. Use parameter 2951 to adjust the base load set point (as a percentage of the genset nominal load).



If a generator runs in base load and the total load decreases to a point below the base load set point, the system lowers the base load set point. This is to prevent frequency control problems, as the generator running in base load does not participate in the frequency control. When the generator breaker is closed, the generator power is increased to the base load set point.

If AVR control is selected, the set point is the adjusted power factor.

NOTE The controller for base load is automatically changed to SEMI-AUTO mode.

4.5.17 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.

NOTE In an AMF application with a tie breaker, the tie breaker must not close before the maximum power is available (power capacity set point).

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.

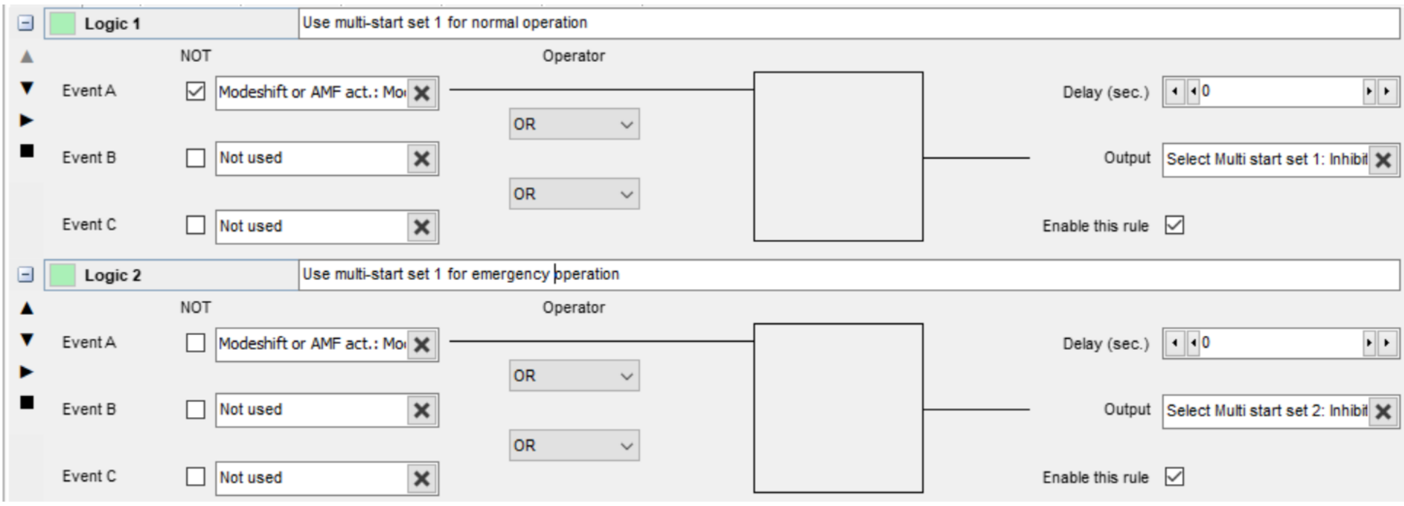
`Power management > Multi start set`

Parameter	Text	Range	Default
8922	Multistart set 1	Auto calculation Start 1-32 DG	Auto calculation
8923	Min. nr. run. 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 1-32 DG	Start 16
8926	Min. nr. run. 2	0 to 32	1

Create the default settings with M-Logic

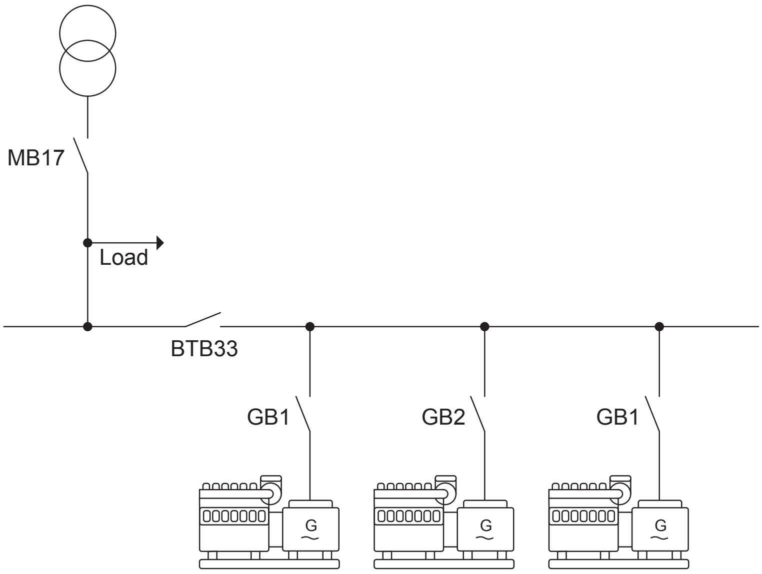
	Start condition	Set point 1	Set point 2	Default setting of DGs to start
Emergency operation	Mains failure	-	X	Start all DGs
Normal operation	No mains failure	X	-	Auto calculate

The default setting of the selection between set point 1 and set point 2 is made so the set point 1 is adjusted to Auto calculation and is used in all modes except for AMF. Set point 2 will automatically be selected in case a mains failure occurs (this is adjusted in *M-Logic*, *Output*, *Inhibits/Activate/Deactivate Power management*, *Select Multi start set [1 or 2]*). Set point 2 is by default configured to 32 gensets, which means that all available gensets will start when the mains failure occurs.



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 mains failure. The application must include BTBs, with the generators in a section with no mains 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 controller requesting help is a mains controller in AMF.
- 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
8361	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.
8362	Timer	2 to 990 s	10 s	Use this parameter to configure the fixed timer.
8363	Enable	ON OFF	OFF	Select ON to enable this parameter.

4.5.18 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 > Available power > Available power [1 to 5]`

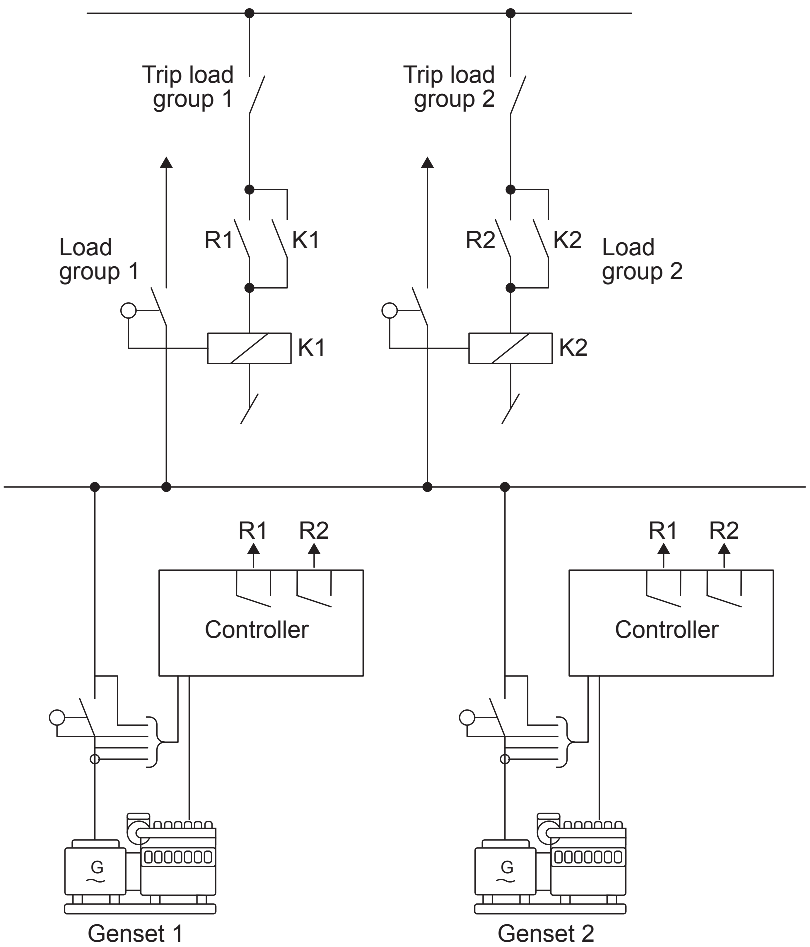
Parameter	Text	Range	Default
8221, 8231, 8241, 8251 or 8261	Set point	10 to 20,000 kW	1000 kW
8222, 8232, 8242, 8252 or 8262	Timer	1.0 to 999.9 s	10.0 s
8223, 8233, 8243, 8253 or 8263	Output A	Relays and M-Logic	Not used
8224, 8234, 8244, 8254 or 8264	Output B	Relays and M-Logic	Not used
8225, 8235, 8245, 8255 or 8265	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.

4.5.19 Ground relay

The ground relay function ensures that the star point of only one connected genset is connected to ground during island operation. This prevents circulating currents between the generators.

NOTE The relay for this function must be selected in each genset controller.

How it works

The ground relay function follows the following principles:

- If the genset is not connected to the busbar, the ground relay does not consider the rest of the system.
  - If the close condition is met, the ground relay is closed.
  - If the open condition is met, the ground relay is open.
- If more than one genset is connected to the busbar, then power management ensures that only the ground relay of the biggest genset stays closed. The ground relays of all other gensets are opened.
  - If the gensets are the same size, then the ground relay of the connected genset with the highest priority is closed.
- A new genset can connect to the busbar. If it is bigger (or the same size and a higher priority) than the genset with the closed ground relay, the new genset keeps its ground relay closed. The other genset opens its ground relay.
- The close condition, open condition and ground relay type are configurable.

Safety

The ground relay function is NOT supported in a **Single controller** application, even if the controller has power management.

NOTE When a genset controller is in racked out breaker mode it is not possible to close the ground relay.

`Power management > Ground relay > Ground relay`

Parameter	Text	Range	Default	Description
8121	Output A	Not used Relay 5, 6 and 9 to 18 Limits	Not used	If a pulse breaker is chosen (see 8126), use this for ground relay open.
8122	Output B		Not used	If a pulse breaker is chosen (see 8126), use this for ground relay close.
8123	Enable	OFF ON	OFF	Enable the ground relay function.
8124	Timer	1.0 to 30.0 s	1.0 s	An alarm for the unusual situation where power management expects a genset's ground relay to close, but it does not. This may be due to a physical fault with the ground relay.
8125	Fail class	Fail classes	Trip GB	
8126	Ground relay type	Continuous Pulse	Continuous	**Continuous**: When the ground relay must be closed, the *Output A* relay selected in 8121 is activated continuously. **Pulse**: Configure Output A to open and Output B to close the ground relay. Ground relay breaker feedback is required.

`Power management > Ground relay > Gnd breaker setting`

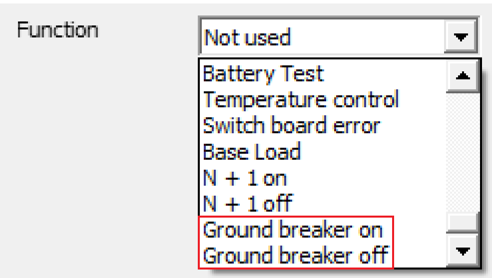
Parameter	Text	Range	Default	Description
8151	Gnd close conf	Hz/V OK	Hz/V OK	Ground relay close condition.

Parameter	Text	Range	Default	Description
		RPM MPU level RPM EIC level Start active		**Hv/V OK**: The ground relay closes if the generator voltage and frequency (parameters 2111 to 2114) are okay. **RPM MPU level**: The ground relay closes when the RPM measured by the MPU reaches the value in 8153. **RPM EIC level**: The ground relay closes when the RPM from the EIC reaches the value in 8153. **Start active**: The ground relay closes when the genset start is active.
8152	Gnd open conf	After cooldown After extended stop	After cooldown	Ground relay open condition. **After cooldown**: The genset breaker is open, and the cooldown must be completed before the controller opens the ground relay. **After extended stop**: The genset breaker is open, the cooldown is complete, and the extended stop must be completed before the controller opens the ground relay.
8153	Gnd close RPM	0 to 4000 RPM	1000 RPM	If *RPM MPU level* or *RPM EIC level* is selected in 8151, the RPM must reach this value before the controller closes the ground relay.

Ground relay with breaker position

Position feedbacks from the ground relay are required for a pulse relay.

- In the utility software, select I/O & Hardware setup.
- In the *Function* list, select the required feedback:



`Power management > Ground relay > Gnd Break fail`

Parameter	Text	Range	Default	Description
8131	Gnd Open fail, Timer	1.0 to 30.0 s	1.0 s	Ground relay open failure. The controller deactivated its output, but the ground relay did not open before the timer ran out.
8132	Gnd open fail, Fail class	Fail classes	Trip GB	
8133	Gnd Close fail, Timer	1.0 to 30.0 s	1.0 s	Ground relay close failure. The controller activated its output, but the ground relay did not close before the timer ran out.
8134	Gnd Close fail, fail class	Fail classes	Block	
8135	Gnd Pos fail, Timer	1.0 to 30.0 s	1.0 s	Ground relay position failure. The breaker feedbacks are inconsistent for the specified time.
8136	Gnd Pos fail, Fail class	Fail classes	Trip GB	

NOTE There is always an overlap where both ground relays are connected when transferring the ground relay from one genset to another.

4.5.20 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 DGs makes sure that the gensets stop after the adjusted time.

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

Parameter	Text	Range	Default
8141	Stop noncon. DG, 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.

4.6 M-Logic for power management

4.6.1 Power management events

Power management - common

Event	Activated when ...
PM auto-start active DG	Auto start is active for genset controller(s).
PM auto-start active MAINS	Auto start is active for mains 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 MB closed	Any MB in the application is closed.
Unit has command status	The controller is the command unit for PMS.
First/Second/Third standby	The genset controller is the First/Second/Third standby.
Secured mode	The genset controller is running in secured mode.
Baseload active	The baseload function is activated in the controller.
Baseload inhibited	The baseload function is inhibited in the controller.
LD start timer expired	The load-dependent start timer has expired.
LD stop timer expired	The load-dependent stop timer has expired.
Any mains on busbar	Any mains connection is connected to the busbar (the main breaker and any tie breaker is closed).
Any MB synchronising	The PMS is regulating the gensets to synchronise to any mains.
Any TB synchronising	The PMS is regulating the gensets to synchronise the tie breaker.
Any TB deloading	The PMS is regulating the gensets to deload the tie breaker.
Any BTB deloading	The PMS is regulating the gensets to deload the bus tie breaker.
Asymmetric LS enabled	Asymmetric load sharing is enabled.
Asymmetric LS active	The PMS is using asymmetric load sharing.
Any mains sync. inhibit	Synchronisation is inhibited for any mains breaker.

Power management - DG

Event	Activated when ...
DG [1-32] GB closed	The GB of the specified genset controller is closed.
DG [1-32] GB opened	The GB of the specified genset controller is opened.
DG [1-32] volt/freq okay	The voltage and frequency from the specified genset is within the required range.
DG [1-32] running	There is running feedback for the specified genset.
DG [1-32] ready to auto start	The PMS can automatically start the specified genset if required.
DG [1-32] 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 [1-32] has any alarm present	The controller with the specified PM ID has at least one active alarm.

Power management - MAINS

Event	Activated when ...
Mains [1-32] MB closed	The MB of the specified mains controller is closed.
Mains [1-32] TB closed	The TB of the specified mains controller is closed.
Mains [1-32] MB opened	The MB of the specified mains controller is opened.
Mains [1-32] TB opened	The TB of the specified mains controller is opened.
Mains [1-32] volt/freq okay	The voltage and frequency measured by the specified mains controller is within the required range.
Mains [1-32] in auto or test	The specified mains controller is in AUTO or TEST mode.
Mains [1-32] MB Synchronising	The PMS is synchronising the busbar to the specified mains (by regulating the gensets).
Mains [1-32] TB Synchronising	The PMS is synchronising across the specified tie breaker (by regulating the gensets).
Mains [1-32] mains failure	The specified mains controller detects a blackout on the mains.
Mains [1-32] in BLOCK	The specified mains controller is in block mode (the controller cannot close the mains breaker).

Power management - BTB

Event	Activated when ...
BTB [33-40] BTB closed	The specified BTB is closed.
BTB [33-40] BTB opened	The specified BTB is opened.
BTB [33-40] 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).
Update mode local selected	If the mode is changed (for example, from SEMI-AUTO to AUTO), the mode is only changed on the controller where the change was made.

Event	Activated when ...
Update mode on all selected	If the mode is changed (for example, from SEMI-AUTO 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.

Events Plant

Event	Activated when ...
Single controller selected	The plant type is *Single controller*.
Multi mains selected	The application has more than one mains.

Modes

Event	Activated when ...
Power management	Power management is enabled.

4.6.2 Power management commands

Output > Command Power Management

Command	Effect when activated
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.
Update mode local	If the mode is changed (for example, from SEMI-AUTO 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 SEMI-AUTO to AUTO), the mode changes on all the controllers in the application.

Output > BTB Cmd

Command	
BTB [33-40] open cmd	The controller sends a command to the specified BTB controller to open its breaker. If the BTB controller is in SEMI-AUTO mode, it deloads and opens its breaker. If the BTB controller is in AUTO mode, the BTB controller ignores the command.
BTB [33-40] close cmd	The controller sends a command to the specified BTB controller to open its breaker. If the BTB controller is in SEMI-AUTO 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 mains	The BTB controller will not close its breaker (the section cannot ask for help).
Inh. request for section	Genset or mains	The power management system stops the section from helping other sections (a close request from an adjacent section that needs help is ignored).
Force DG in quarantine	Only genset	The diesel generator cannot be used by the running hours priorities, unless there is no alternative.

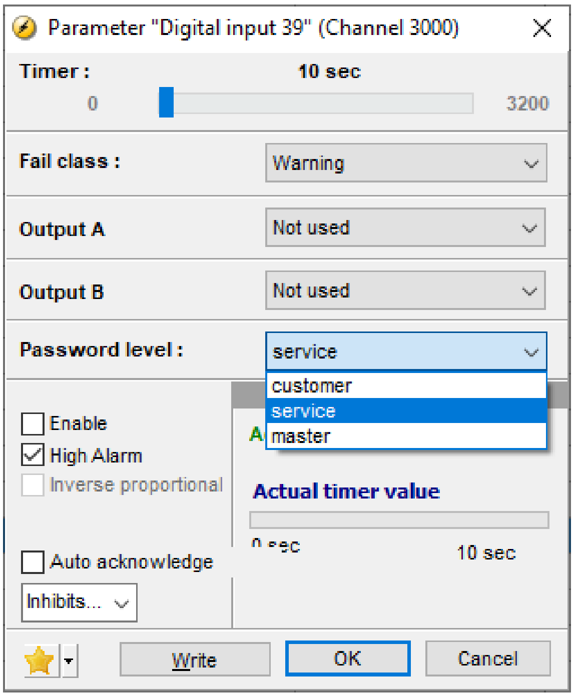
5. General functions

5.1 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.

Password level	Default password	Customer access	Service access	Master access
Customer	2000	●		
Service	2001	●	●	
Master	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.

5.2 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.

5.2.1 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/Mains nominal U`

Parameter	Text	Range	Adjust to value
6004	Generator/Mains nominal U	100 to 25000 V	U_{NOM}

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

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

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

Parameter	Text	Range	Adjust to value
6053	Busbar voltage	100 to 25000 V	U_{NOM}

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

Parameter	Text	Range	Adjust to value
6051	U primary BB	100 to 25000 V	Primary VT
6052	U secondary BB	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.

5.2.2 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	Generator nominal U	100 to 25000 V	120 V AC

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

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

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

Parameter	Text	Range	Adjust to value
6053	Busbar voltage	100 to 25000 V	U_{NOM}

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

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

5.2.3 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	Generator voltage	100 to 25000 V	230 V AC

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

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

Basic settings > Nominal settings > Voltage > Busbar nominal U

Parameter	Text	Range	Adjust to value
6053	Busbar voltage	100 to 25000 V	$U_{NOM} \times \sqrt{3}$

Basic settings > Measurement setup > Voltage transformer > Busbar VT

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

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

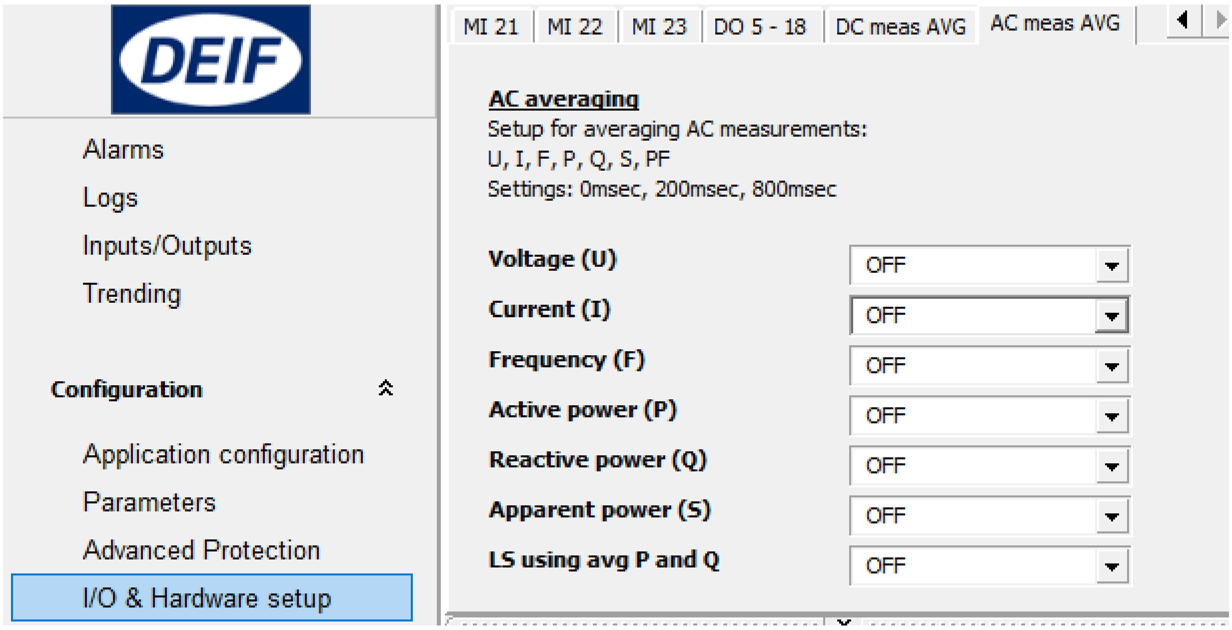
The controller has two sets of busbar transformer settings, which can be enabled individually in this measurement system.

5.2.4 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.



5.3 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.

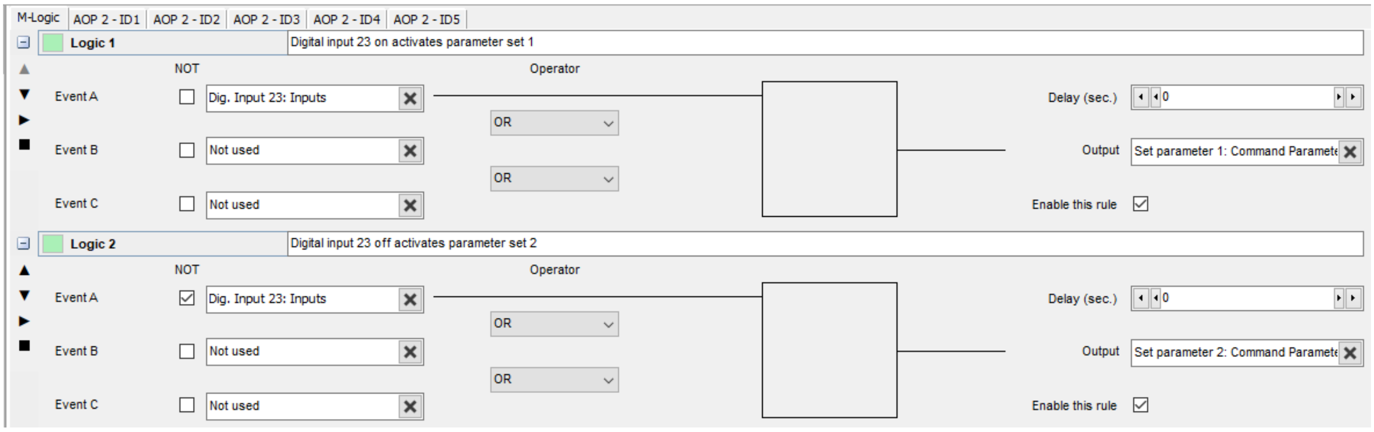
Alternative configuration > Generator nominal settings

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

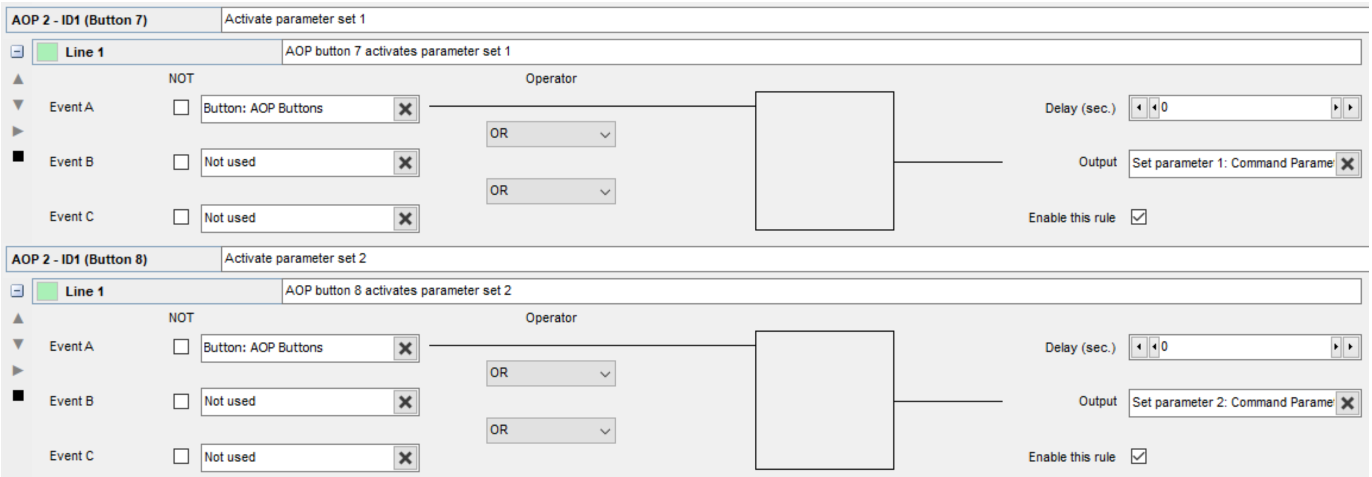
Switch between the nominal settings

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.

5.3.1 Default nominal settings

The default nominal settings are settings 1.

Basic settings > Nominal settings

Parameter	Text	Range	Default
6001	Frequency Nom. f	48.0 to 62.0 Hz	50 Hz
6002	Power Nom. P	10 to 20000 kW	480 kW
6003	Current Nom. I	0 to 9000 A	867 A
6004	Generator nominal U	100 to 25000 V	400 V
6005	Setpoint Nom. rpm	100 to 4000 RPM	1500 RPM
6007	4th current Nom. I	0 to 9000 A	867 A

Parameter	Text	Range	Default
6053	Busbar nominal U	100 to 25000 V	400 V
6055	4th current Nom. P	10 to 9000 kW	480 kW

5.3.2 Alternative nominal settings

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

Parameter	Text	Range	Default
6011, 6021 or 6031	Frequency Nom. f	48.0 to 62.0 Hz	50 Hz
6012, 6022 or 6032	Power Nom. P	10 to 20000 kW	480 kW
6013, 6023 or 6033	Current Nom. I	0 to 9000 A	867 A
6014, 6024 or 6034	Generator nominal U	100 to 25000 V	400 V
6015, 6025 or 6035	Setpoint Nom. rpm	100 to 4000 RPM	1500 RPM
6017, 6027 or 6037	4th current Nom. I	0 to 9000 A	867 A

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

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

Busbar nominal settings 2

The controller has two sets of nominal settings for the busbar. Each set consists of a nominal as well as a primary and secondary voltage value. The U primary and U secondary are used to define the primary and secondary voltage values, if any measurement transformers are installed.

`Alternative config. > Busbar nominal settings > Nom. set. selection`

Parameter	Text	Range	Default
6054	Nominal settings selection	Nominal setting 1 Nominal setting 2 BB Unom = G Unom	Nominal setting 1

If no voltage transformer is installed between generator and busbar, select BB U_{NOM} = G U_{NOM}. With this function activated, none of the busbar nominal settings will be considered. Instead, the nominal busbar voltage will be considered equal to nominal generator voltage.

`Alternative config. > Busbar nominal settings > Nominal settings 2`

Parameter	Text	Range	Default
6061	Busbar primary U	100 to 25000 V	400 V
6062	Busbar secondary U	100 to 690 V	400 V
6063	BB nominal U	100 to 25000 V	400 V
6064	4th CT Power	10 to 9000 kW	230 kW

5.3.3 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
9031	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 generators up to 150 kVA. The nominal power must be less than 900 kW. **100 to 25000 V**: This is recommended for generators over 150 kVA.

NOTICE

Incorrect configuration is dangerous

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

5.4 Step-up and step-down transformers

5.4.1 Step-up transformer

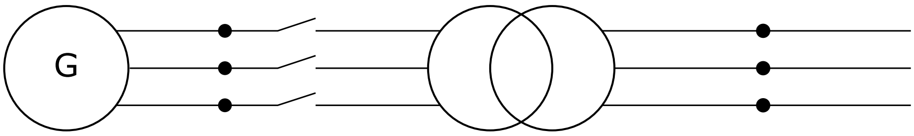
In certain cases, the use of a generator with step-up transformer (called a block) is required. This may be to adapt to the closest grid voltage or to step up the voltage to minimise the losses in cables and also to bring down the cable size. Applications that need a step-up transformer are supported by the controller.

The available functions are:

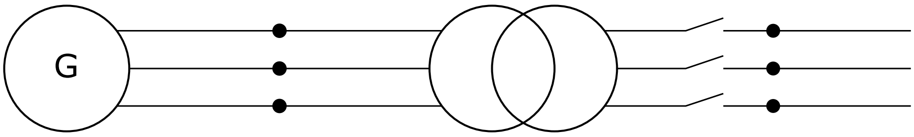
1. Synchronising with or without phase angle compensation
2. Voltage measurement displayed
3. Generator protections
4. Busbar protections

Typically, the synchronising breaker is on the high voltage (HV) side, and there is no breaker (or only a manually operated one) on the low voltage (LV) side. In some applications, the breaker could also be placed on the LV side. This does not influence the setting in the controller, as long as the breaker and the step-up transformer are both placed between the measuring points used by the controller. The measuring points are shown as black dots.

Generator/transformer block, breaker on LV side



Generator/transformer block, breaker on HV side



The phase angle compensation would not be an issue if there was no phase angle shift across the step-up transformer, but in many cases there is. In Europe, the phase angle shift is described using the vector group description. Instead of vector group, this could also be called clock notation or phase shift.

NOTE When voltage measurement transformers are used, these must be included in the total phase angle compensation.

Example

A 10000 V/400 V step-up transformer is installed after a generator with the nominal voltage of 400 V. The nominal voltage of the busbar is 10000 V. Now, the voltage of the busbar is 10500 V. The generator is running 400 V before synchronising starts, but when attempting to synchronise, the AVR set point will be changed to: $U_{BUS\text{-}MEASURED} \cdot U_{GEN\text{-}NOM}/U_{BUS\text{-}NOM}$ = 10500 · 400/10000 = **420 V**

5.4.2 Vector group for step-up transformer

Vector group definition

The vector group is defined by two letters and a number:

- The first letter is an upper case D or Y, defining whether the HV side windings are in Delta or Wye configuration.
- The second letter is a lower case d, y or z, defining whether the LV side windings are in delta, wye or zigzag configuration.
- The number is the vector group number, defining the phase angle shift between HV and LV side of the step-up transformer. The number is an expression of the LV side lag compared to the HV side voltage. The number is an expression of the lag angle divided by 30 °.

Example

Dy11 = HV side: Delta, LV side: Wye, vector group 11: Phase shift = 11x (-30) = -330 °.

Typical vector groups

Vector group	Clock notation	Phase shift	LV lag degrees compared to HV
0	0	0 °	0 °
1	1	-30 °	30 °
2	2	-60 °	60 °
4	4	-120 °	120 °
5	5	-150 °	150 °
6	6	-180 °/180 °	180 °
7	7	150 °	210 °
8	8	120 °	240 °
10	10	60 °	300 °
11	11	30 °	330 °

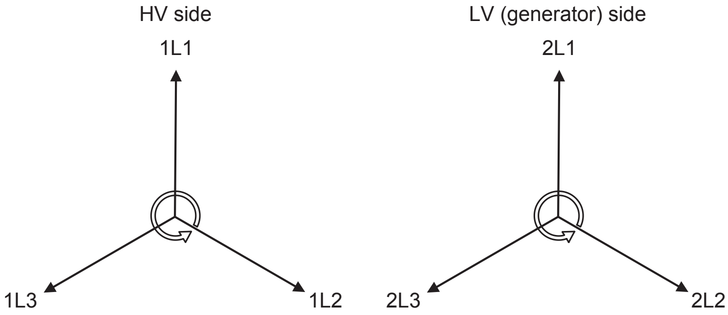
`Synchronisation > Angle offset: GEN/BB`

Parameter	Text	Range	Default	Description
9141	BB (mains)/generator angle compensation 1	-179.0 to 179.0 °	0.0 °	Angle compensation for busbar parameter set 1 (selected in parameter 6054)
9142	BB (mains)/generator angle compensation 2	-179.0 to 179.0 °	0.0 °	Angle compensation for busbar parameter set 2 (selected in parameter 6054)

Vector group 0

The phase angle shift is 0 ° (parameter setting: 0 °).

Yy0 example

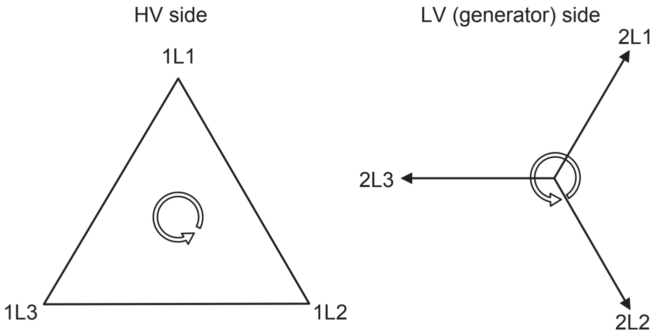


1L1 to 2L1 phase angle is 0 °.

Vector group 1

The phase angle shift is -30 ° (parameter setting: 30 °).

Dy1 example

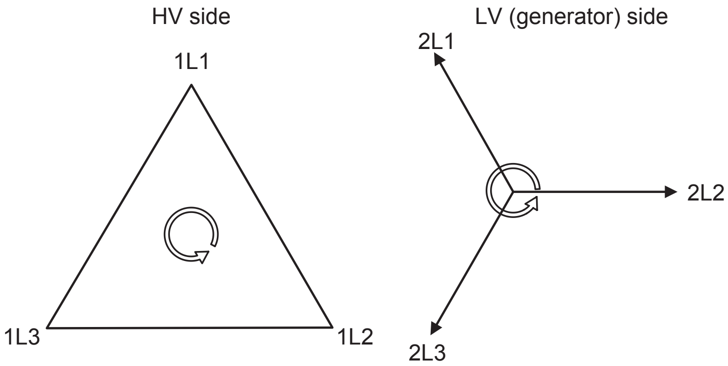


1L1 to 2L1 phase angle is -30 °.

Vector group 11

The phase angle shift is 11 x (-30) = -330/+30 ° (parameter setting: -30 °).

Dy11 example

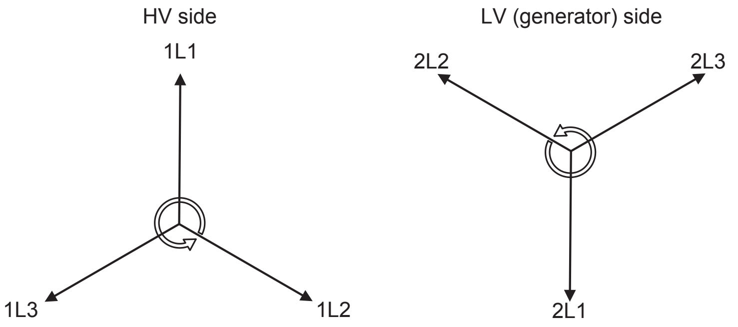


1L1 to 2L1 phase angle is -330/+30 °.

Vector group 6

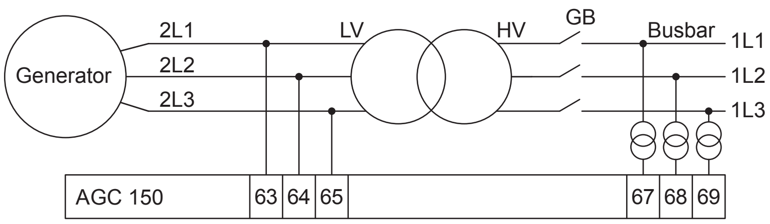
The phase angle shift is 6 x 30 = 180 ° (parameter setting: 180 °).

Yy6 example



1L1 to 2L1 phase angle is -180/+180 °.

Wiring



- The wiring shown in the diagram should always be used when the controller is used for a genset.
- Select 179 ° in parameter 9141 when vector group 6 is used.

Comparison table between different terminologies

Vector group	Clock notation	Phase shift	LV lag degrees compared to HV	LV side lagging	LV side leading
0	0	0 °	0 °	0 °	
1	1	-30 °	30 °	30 °	
2	2	-60 °	60 °	60 °	
4	4	-120 °	120 °	120 °	
5	5	-150 °	150 °	150 °	
6	6	-180 °/180 °	180 °	180 °	180 °
7	7	150 °	210 °		150 °
8	8	120 °	240 °		120 °
10	10	60 °	300 °		60 °
11	11	30 °	330 °		30 °

Table to read parameter 9141 compared to a step-up transformer

Vector group	Step-up transformer types	Parameter 9141
0	Yy0, Dd0, Dz0	0 °
1	Yd1, Dy1, Yz1	30 °
2	Dd2, Dz2	60 °
4	Dd4, Dz4	120 °
5	Yd5, Dy5, Yz5	150 °
6	Yy6, Dd6, Dz6	180 °
7	Yd7, Dy7, Yz7	-150 °
8	Dd8, Dz8	-120 °

Vector group	Step-up transformer types	Parameter 9141
10	Dd10, Dz10	-60 °
11	Yd11, Dy11, Yz11	-30 °

NOTE DEIF does not take responsibility for the compensation being correct. Before closing the breaker, always validate that systems are aligned.

The settings shown in the table above does not include any phase angle shift made by measurement transformers.

The settings shown in the table above are not correct if a step-down transformer is used (see **Setup of step-down and measurement transformers**).

5.4.3 Setup of step-up and measurement transformers

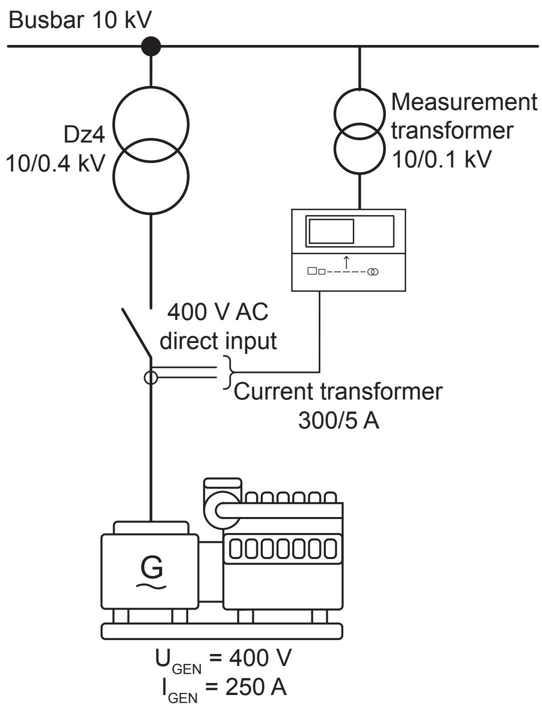
If the HV side of the transformer transforms the voltage up to a voltage level higher than 690 V AC, it will be necessary to use measurement transformers. The setup of all these parameters can be done from the utility software.

Example

The transformer is a Dz4 step-up transformer with nominal settings of 10/400 V. The generator has a nominal voltage of 400 V, a nominal current of 250 A and a nominal power of 140 kW. The measurement transformer has a nominal voltage of 10/100 V and no phase angle twist. The nominal voltage of the busbar (BB) is 10000 V.

Since the generator's nominal voltage is 400 V, there is no need for a voltage measurement transformer on the LV side in this example. The controller can handle up to 690 V, but current transformers must still be set up on the LV side.

In this example, the current transformers have a nominal current of 300/5 A. Because the step-up transformer is a Dz4, there is a phase angle twist of -120 °.



Parameters for step-up and measurement transformers example

Parameter	Path	Comment	Setting
6002	`Basic settings > Nominal settings > Current > 3 phase nominal`	Generator nominal power	140
6003	`Basic settings > Nominal settings > Power > 3 phase nominal`	Generator nominal current	250
6004	`Basic settings > Nominal settings > Voltage > Generator nominal U`	Generator nominal voltage	400
6041	`Basic settings > Measurement setup > Voltage transformer > Generator VT > U primary`	Generator voltage transformer primary side	400
6042	`Basic settings > Measurement setup > Voltage transformer > Generator VT > U secondary`	Generator voltage transformer secondary side	400

Parameter	Path	Comment	Setting
6043	`Basic settings > Measurement setup > Current transformer > 3 phase CT > I primary`	Generator current transformer primary side	300
6044	`Basic settings > Measurement setup > Current transformer > 3 phase CT > I secondary`	Generator current transformer secondary side	5
6051	`Basic settings > Measurement setup > Voltage transformer > Busbar VT > U primary`	Busbar voltage transformer primary side	10000
6052	`Basic settings > Measurement setup > Voltage transformer > Busbar VT > U secondary`	Busbar voltage transformer secondary side	100
6053	`Basic settings > Nominal settings > Voltage > Busbar nominal U`	Busbar nominal voltage	10000
9141	`Synchronisation > Angle comp. GEN and BB > ANGLE`	Phase angle compensation BB/G 1	120 °
9142	`Synchronisation > Angle comp. GEN and BB > ANGLE`	Phase angle compensation BB/G 2	120 °

The controller can handle nominal voltage levels between 100 and 690 V. If the voltage level in the application is higher or lower, you must use measurement transformers to transform the voltage into a number between 100 and 690 V.

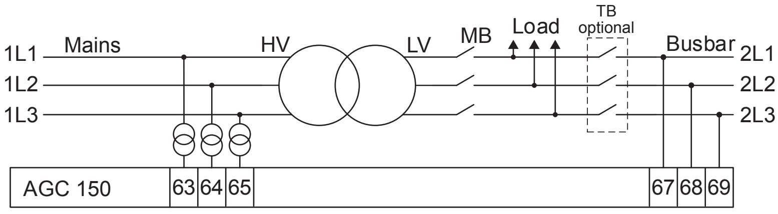
5.4.4 Vector group for step-down transformer

In some applications, a step-down transformer can also be used. This could be to transform a grid voltage down, so the load can handle the voltage level. The controller is able to synchronise the busbar with the mains, even if there is a step-down transformer with a phase angle shift. The transformer must be between the measuring points for the controller.

If a step-down transformer is used, these settings must be set in parameter 9141 to compensate the phase angle shift.

Vector group	Step-down transformer types	Parameter 9141
0	Yy0, Dd0, Dz0	0 °
1	Yd1, Dy1, Yz1	-30 °
2	Dd2, Dz2	-60 °
4	Dd4, Dz4	-120 °
5	Yd5, Dy5, Yz5	-150 °
6	Yy6, Dd6, Dz6	180 °
7	Yd7, Dy7, Yz7	150 °
8	Dd8, Dz8	120 °
10	Dd10, Dz10	60 °
11	Yd11, Dy11, Yz11	30 °

If a step-down transformer and a controller for the mains breaker are mounted, the measurements must be wired to the controller.



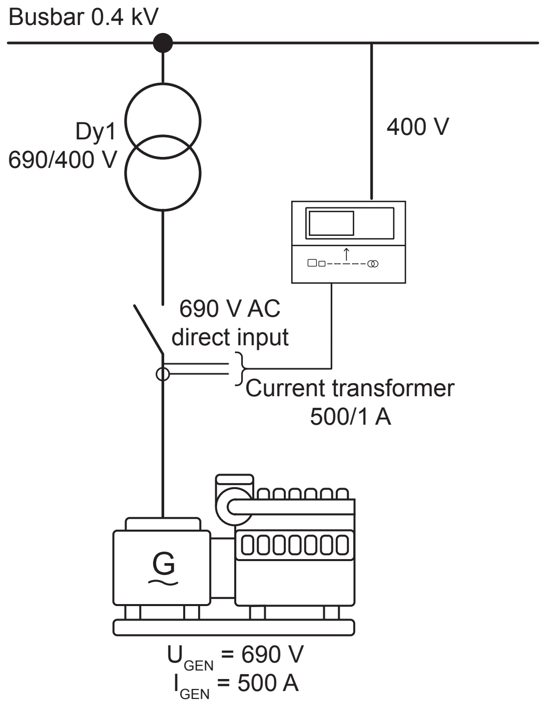
5.4.5 Setup of step-down and measurement transformers

If the HV side of the transformer has a voltage level higher than 690 V AC, measurement transformers are needed. In this example, the HV side is 690 V, and therefore there is no need for a measurement transformer. The step-down transformer can have a phase angle twist that needs to be compensated for.

Example

The transformer is a Dy1 step-down transformer with nominal settings of 690/400 V. The generator has a nominal voltage of 690 V, a nominal current of 500 A and a nominal power of 480 kW. There is no measurement transformer in this application, because the controller can measure the voltage levels directly. The nominal voltage of the busbar (BB) is 400 V.

Current transformers are required. In this example, the current transformers have a nominal current of 500/1 A. The step-down transformer is a Dy1, and there is a phase angle twist of +30 °.



Parameters for step-down and measurement transformers example

Parameter	Path	Comment	Setting
6002	`Basic settings > Nominal settings > Current > 3 phase nominal`	Generator nominal power	480
6003	`Basic settings > Nominal settings > Power > 3 phase nominal`	Generator nominal current	500
6004	`Basic settings > Nominal settings > Voltage > Generator nominal U`	Generator nominal voltage	690
6041	`Basic settings > Measurement setup > Voltage transformer > Generator VT > U primary`	Generator voltage transformer primary side	690
6042	`Basic settings > Measurement setup > Voltage transformer > Generator VT > U secondary`	Generator voltage transformer secondary side	690
6043	`Basic settings > Measurement setup > Current transformer > 3 phase CT > I primary`	Generator current transformer primary side	500
6044	`Basic settings > Measurement setup > Current transformer > 3 phase CT > I secondary`	Generator current transformer secondary side	1
6051	`Basic settings > Measurement setup > Voltage transformer > Busbar VT > U primary`	Busbar voltage transformer primary side	400
6052	`Basic settings > Measurement setup > Voltage transformer > Busbar VT > U secondary`	Busbar voltage transformer secondary side	400
6053	`Basic settings > Nominal settings > Voltage > Busbar nominal U`	Busbar nominal voltage	400

Parameter	Path	Comment	Setting
9141	`Synchronisation > Angle comp. GEN and BB > ANGLE`	Phase angle compensation BB/G 1	-30 °
9142	`Synchronisation > Angle comp. GEN and BB > ANGLE`	Phase angle compensation BB/G 2	-30 °

5.5 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.
- **SEMI-AUTO**: 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.
- **Test**: The test sequence starts.
- **Manual**: 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.

5.5.1 SEMI-AUTO mode

The controller can be operated in SEMI-AUTO 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 SEMI-AUTO mode, the controller controls the speed governor and the AVR.

SEMI-AUTO mode commands

Command	Description
Start	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	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.
Close GB	The controller closes the generator breaker if the mains breaker is open, or synchronise and close the generator breaker if the mains breaker is closed. When AMF mode is selected, the controller will not regulate after breaker closure.
Open GB	The controller ramps down and opens the generator breaker at the Breaker open point if the mains breaker is closed. The controller opens the generator breaker instantly if the mains breaker is open or the genset mode is island mode.

Command	Description
Close MB	The controller closes the mains breaker if the generator breaker is open, or synchronises and closes the mains breaker if the generator breaker is closed.
Open MB	The controller opens the mains breaker instantly.
Manual GOV UP	The regulator is deactivated and the governor output is activated as long as the GOV input is ON.
Manual GOV DOWN	The regulator is deactivated and the governor output is activated as long as the GOV input is ON.
Manual AVR UP	The regulator is deactivated and the governor output is activated as long as the AVR input is ON.
Manual AVR DOWN	The regulator is deactivated and the governor output is activated as long as the AVR input is ON.

5.5.2 Test mode

The test mode function is activated by selecting test with the *Shortcut* button on the display or by activating a digital input.

Power set points > Test

Parameter	Text	Range	Default
7041	Set point	1 to 100	1
7042	Timer	0.0 to 999.0 min	0.0 min
7043	Return mode	Genset: • SEMI-AUTO • AUTO • Manual • No mode change Mains: • SEMI-AUTO • AUTO • No mode change	Genset: No change Mains: AUTO
7044	Type	Simple test Load test Full test	Simple test

NOTE If the timer is set to 0.0 min., the test sequence is infinite.

If the genset controller is in the stop sequence in test mode and the mode is changed to SEMI-AUTO, the genset continues to run.

Test mode in island operation (genset mode selected to island mode) can only run Simple and Full test.

Simple test

The simple test will only start the genset and run it at nominal frequency with the generator breaker open. The test will run until the timer expires.

Load test

The load test will start the genset and run it at nominal frequency, synchronise the generator breaker and produce power according to the set point. The test will run until the timer expires.

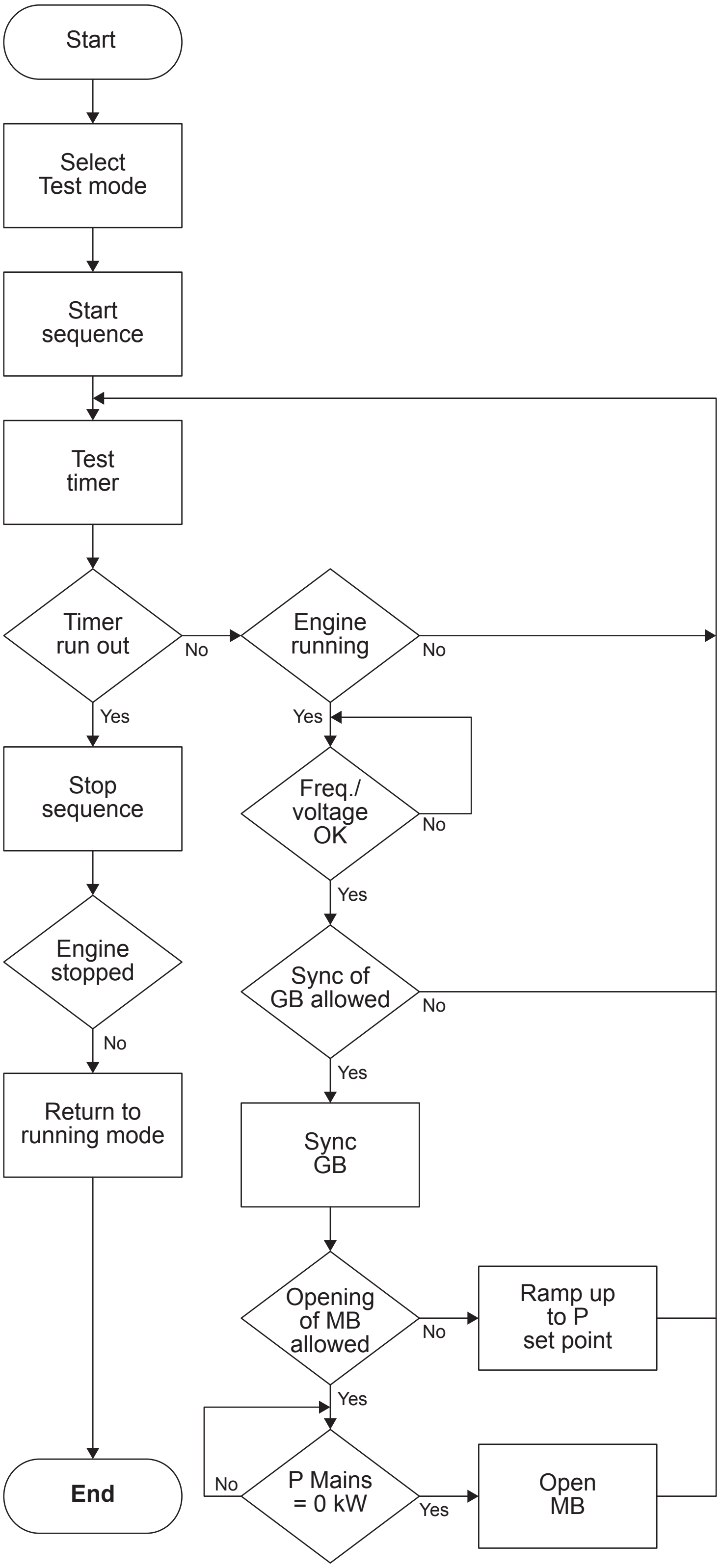
Full test

The full test will start the genset and run it at nominal frequency, synchronise the generator breaker and transfer the load to the generator before opening the mains breaker. When the test timer expires, the mains breaker will be synchronised and the load is transferred back to the mains before the generator breaker is opened and the generator is stopped.

Synchronisation > Mains parallel settings > Sync. to mains

Parameter	Text	Range	Default	Notes
7084	Sync. to mains	OFF ON	OFF	To run a Load test or a Full test, the parameter must be enabled.

Test sequence flowchart



5.5.3 Manual mode

When manual mode is selected, the genset can be controlled from the display and with digital inputs.

Manual mode commands

Command	Description
Start	The start sequence is initiated and continues until the genset starts or the maximum number of start attempts are reached. Note: There is no automatic regulation.
Stop	The genset is stopped. Without the running signal, the stop sequence remains active in the extended stop time period. The genset is stopped with cooling down time.
Close GB	If there is no voltage on the busbar, the controller closes the generator breaker (GB). If there is voltage on the busbar, the operator must manually regulate the genset to synchronise. When synchronised, the controller closes the GB. Note: There is no automatic regulation. Sync. failure is deactivated.
Open GB	The controller opens the generator breaker instantly.
Close MB	If there is no voltage on the busbar, the controller closes the mains breaker (MB). If there is voltage on the busbar, the operator must manually regulate the genset(s) to synchronise. When synchronised, the controller closes the MB. Note: There is no automatic regulation. Sync. failure is deactivated.
Open MB	The controller opens the mains breaker instantly.
Manual GOV UP	The controller gives increase signal to the speed governor.
Manual GOV DOWN	The controller gives decrease signal to the speed governor.
Manual AVR UP	The controller gives increase signal to the AVR.
Manual AVR DOWN	The controller gives decrease signal to the AVR.

5.5.4 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.

5.5.5 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

5.6 Breakers

5.6.1 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 and Continuous ND

Continuous NE is a normally energised signal, and *Continuous ND* is a normally de-energised signal. These settings are 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/ATS no control

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.

5.6.2 Breaker spring load time

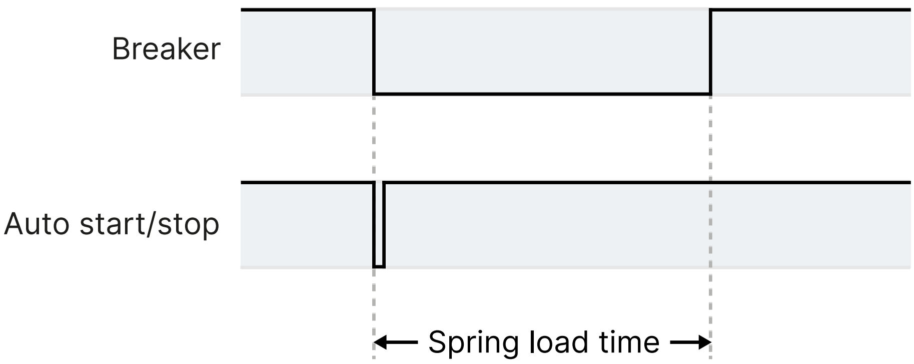
To avoid breaker close failures in situations where the breaker close command is given before the breaker spring has been loaded, the spring load time can be adjusted.

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, TB and MB 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/TB spring loaded and one for MB 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.

5.6.3 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.

5.7 Alarms

5.7.1 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 inhibits.

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.

5.7.2 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.

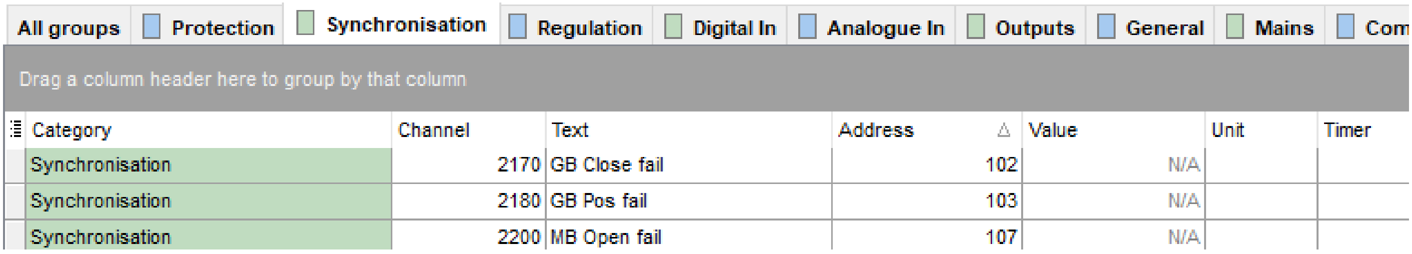
More information
See each controller type for its inhibits.

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

5.7.3 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 MB Pos fail as the address in the utility for this parameter is 109.



Category	Channel	Text	Address	Value	Unit	Timer
Synchronisation	2170	GB Close fail	102	N/A		
Synchronisation	2180	GB Pos fail	103	N/A		
Synchronisation	2200	MB Open fail	107	N/A		

5.8 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.

5.8.1 General shortcuts

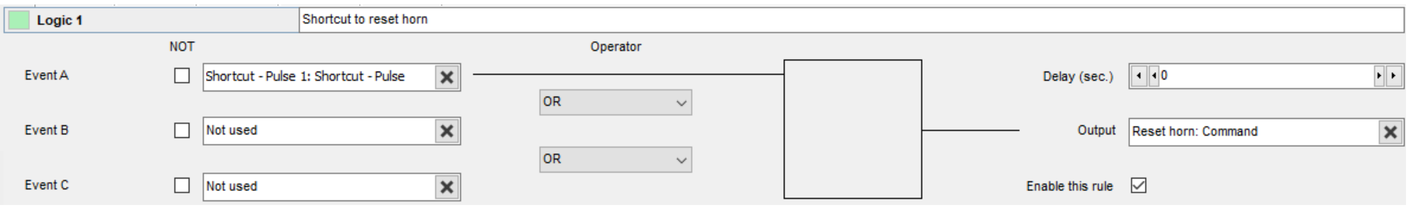
You can configure your own shortcuts with M-Logic in the utility software. You can see the configured shortcuts when you push the *Shortcut* button and select *General shortcuts*. If you have not configured a shortcut, then the *General shortcuts* menu is empty.

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.

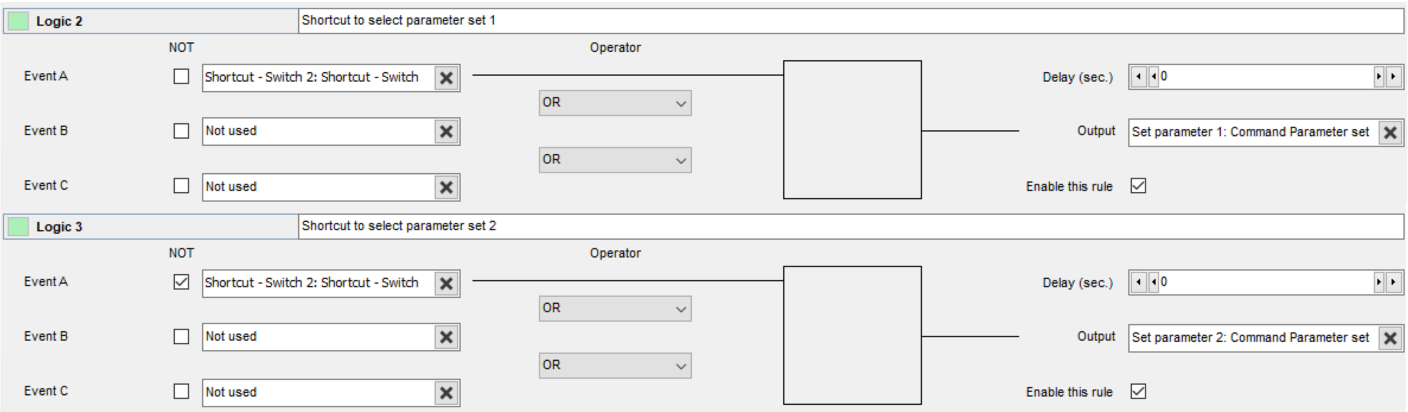
Use the *Translations* interface to rename the shortcut.

Example of shortcut pulse



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

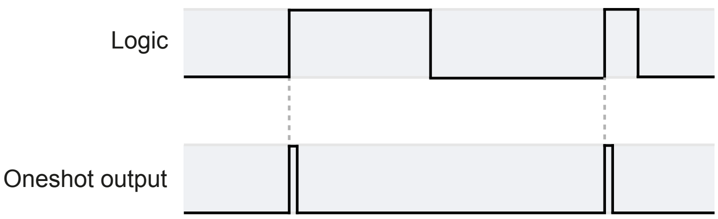
Example of shortcut switch



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

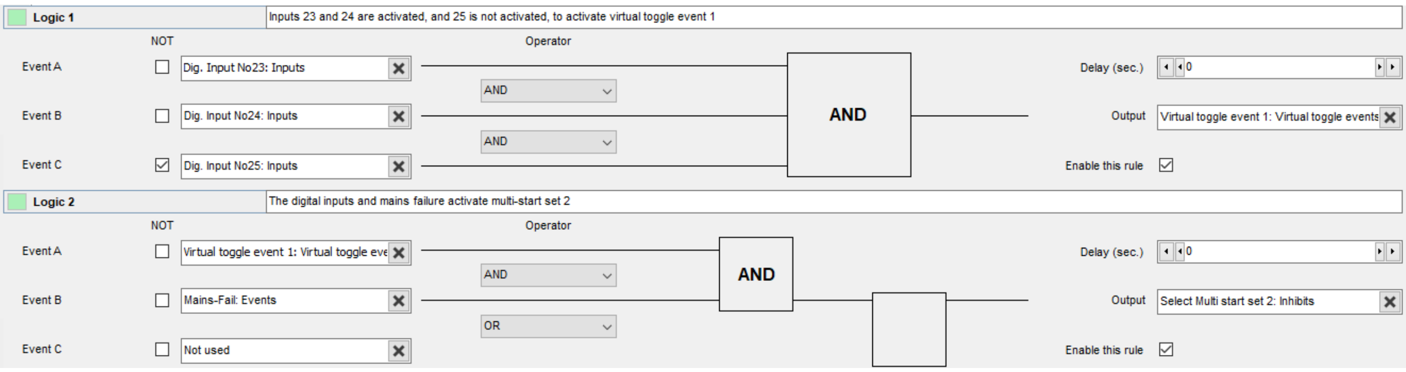
5.8.2 Oneshots

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.



5.8.3 Virtual toggle events

Virtual toggle events are used to expand the number of events 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 toggle event 1*.
- *Event A* in *Logic 2* is *Virtual toggle event 1*.

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

Virtual toggle events

Description	Notes
Virtual toggle event [1-96]*	Virtual toggle events 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 event [1-96]*.

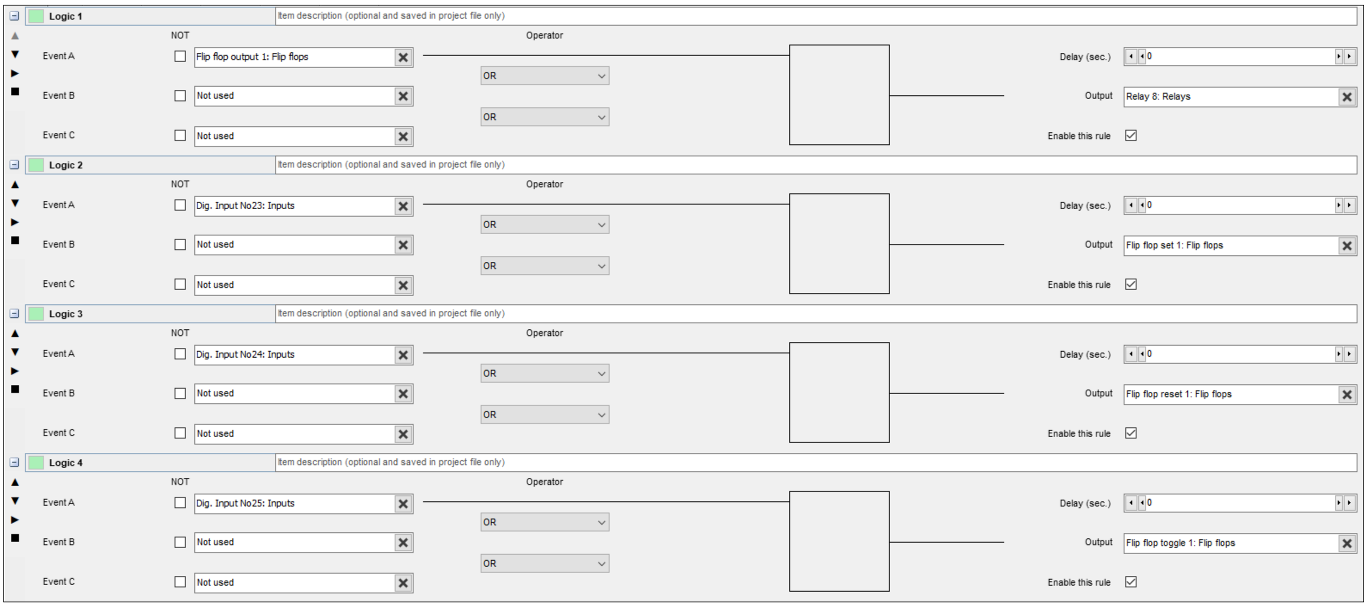
5.8.4 Flip flop function

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.

5.8.5 Virtual switch events

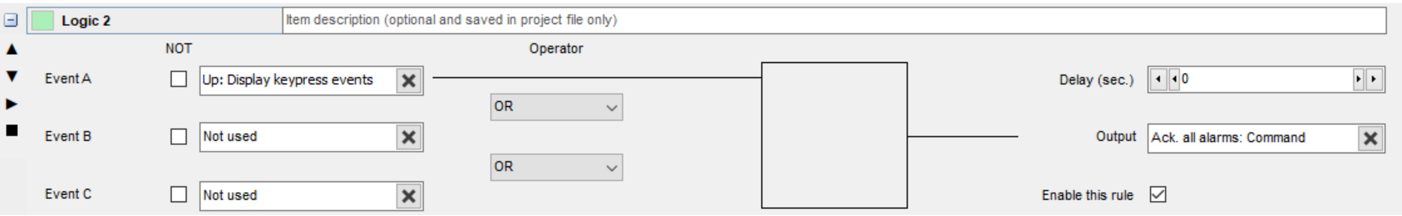
Description	Notes
Virtual switch event [1-32]	Virtual switch events 1 to 32 can be activated by Modbus. They can also be used in multiple lines of logic to increase the number of events possible in one sequence.

5.8.6 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.

5.8.7 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.



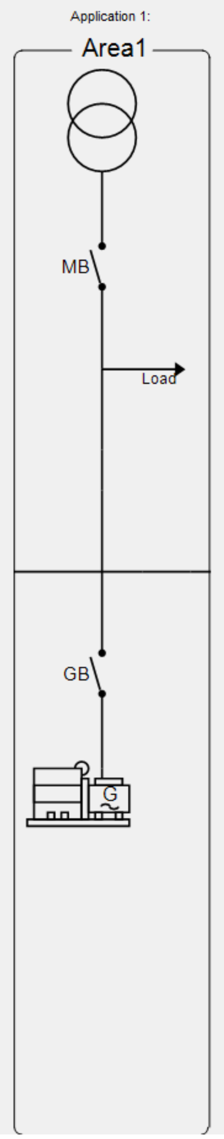
The function can also be used to detect when a button is pushed.

5.8.8 PLC mode control

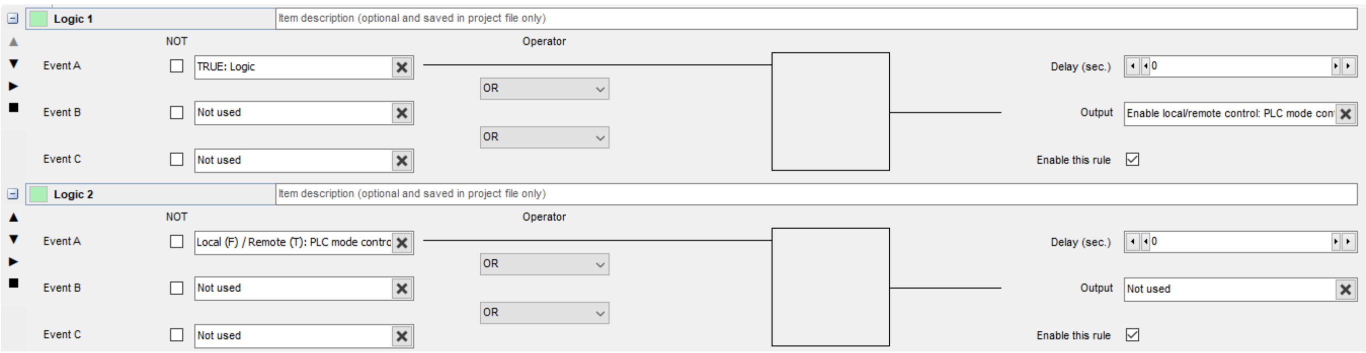
The *PLC mode control* function allows you to remotely control an AGC 150 in AUTO mode using a PLC. When the PLC mode is activated with M-Logic commands, you can control an AGC 150 using a PLC, for example with digital inputs.

Example: How to configure and use PLC mode control

1. Use the application configuration in the utility software to set up an application, for example a generator and mains application.

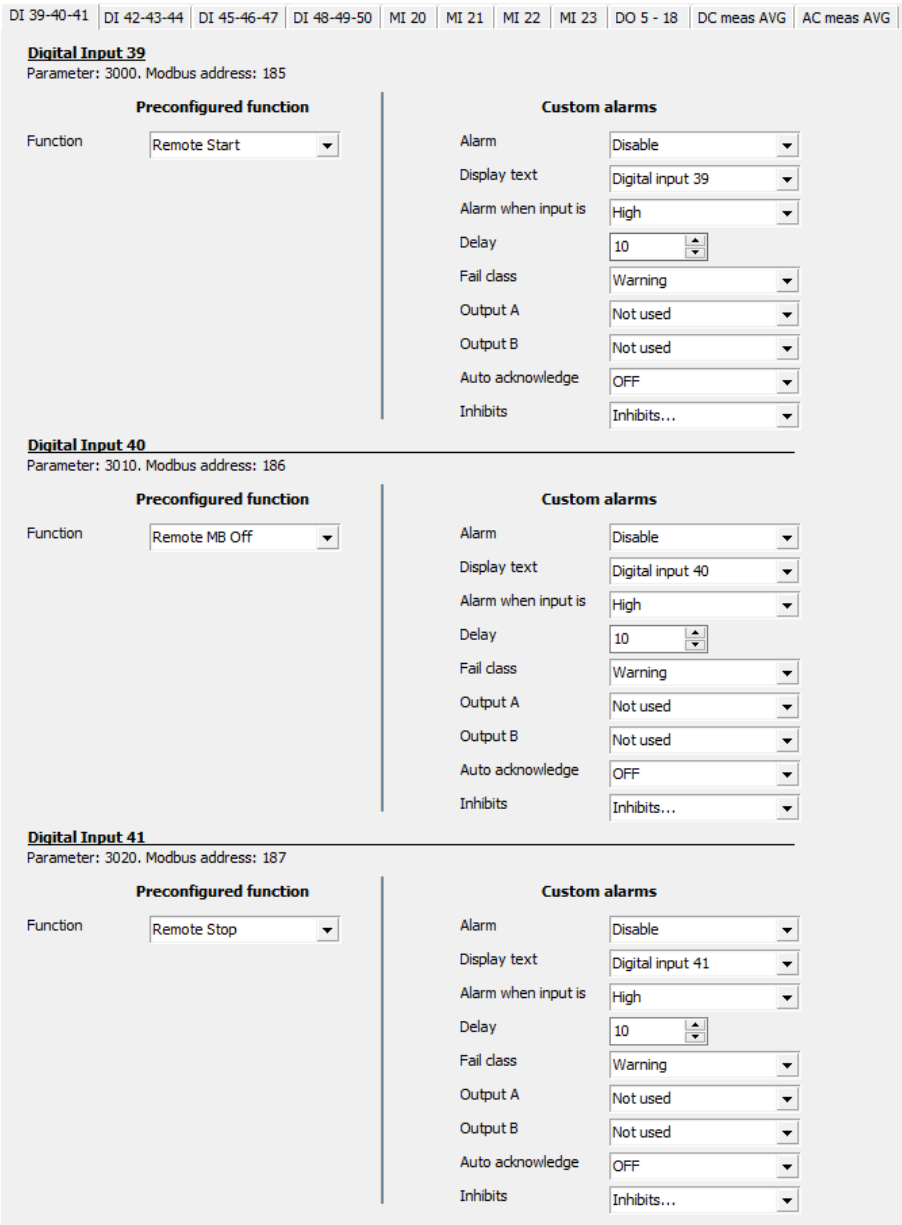


2. Go to the *M-Logic & AOP* tab.
3. Configure these two events in M-Logic:



This allows a PLC to remotely control an AGC 150 in AUTO mode.

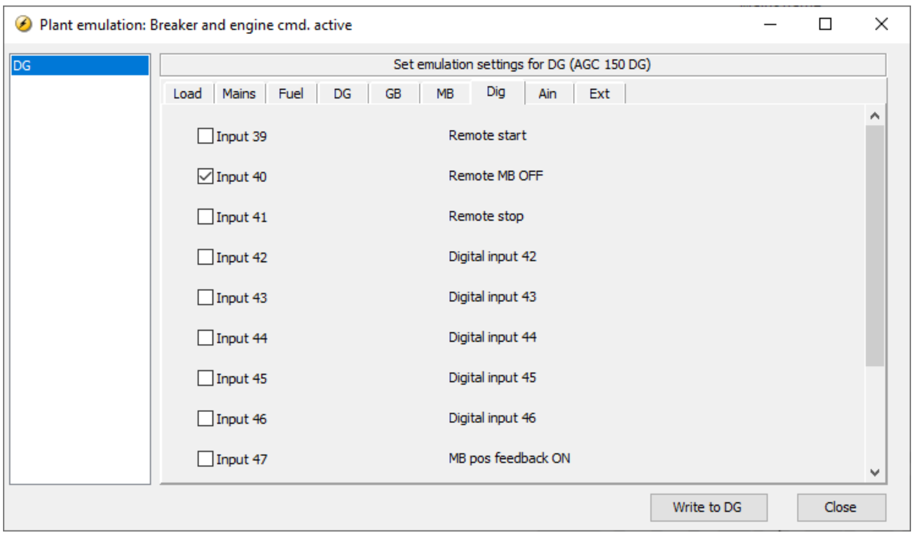
4. Click the  icon to write the M-Logic settings to the controller.
5. Go to the *I/O & Hardware* tab.
6. Configure digital inputs to control the AGC 150, for example:



7. Click the *write parameters to the device* icon to write the settings to the controller.

8. To emulate the digital inputs, go to the *Application supervision* tab and click the *Emulation stimuli* icon.

9. Select the digital input (s) you want to activate, and click the icon to write the settings to the controller.



5.9 Timers and counters

5.9.1 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, load take-over, mains power export, and fixed power operation.

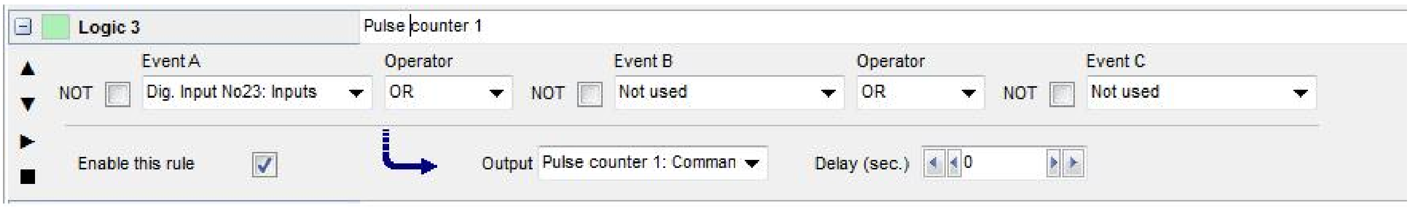
Up to four command timers can be configured with M-Logic. Each command timer can be set for the following time periods:

- 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.

5.9.2 Pulse input counters

Two configurable digital inputs can be used for counter inputs. The two counters can for example be used for fuel consumption or heat flow. The two digital inputs can only be configured for pulse inputs using M-Logic, as shown in the example below.



`Functions > Pulse counters`

Parameter	Text	Range	Default
6851 or 6861	Value	0 to 1000	1
6852 or 6862	Unit type	Unit/pulse Pulse/unit	Unit/pulse
6853 or 6863	Decimal type	No decimals One decimal Two decimals Three decimals	No decimals

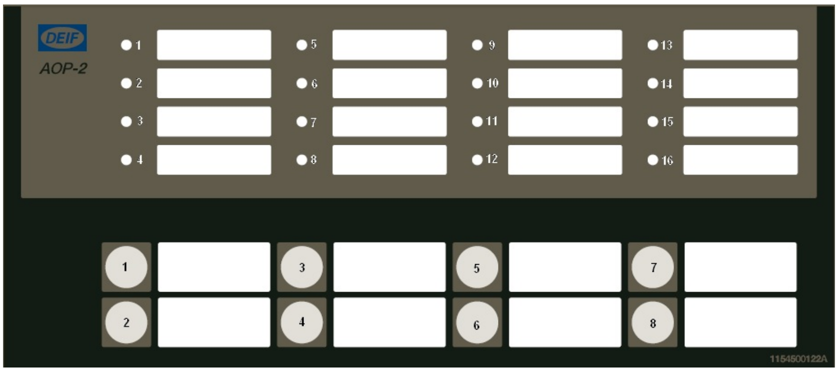
5.9.3 Diagnostics timer

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.

5.10 Interfaces

5.10.1 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.

5.10.2 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 SEMI-AUTO mode when the access lock is activated. For safety reasons, an emergency stop switch is recommended.

5.10.3 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`

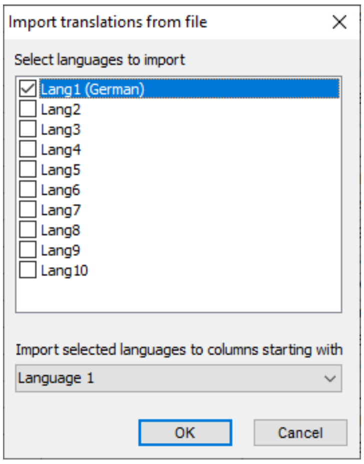
Parameter	Text	Range	Default
6081	Language selection	English Language [1 to 8]	English

5.10.4 Translations

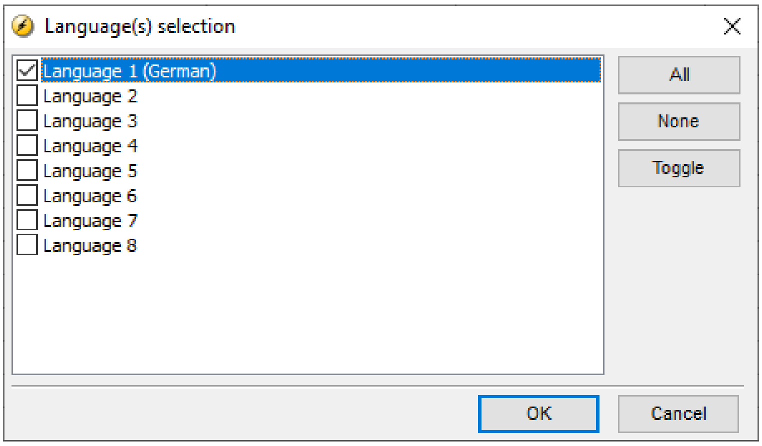
You can translate and customise the text in the controller with the utility software.

Translate the text in the controller

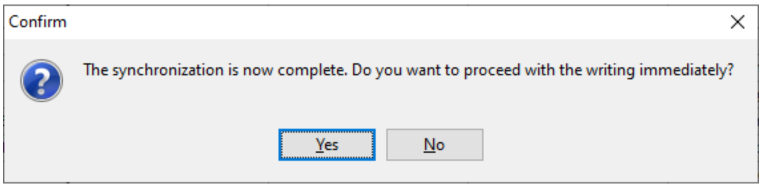
1. Go to the *Translations* tab in the left toolbar.
2. Click the *Import translations from file*  icon.
3. From the pop-up window, select the language file you want to import.
4. Select the language to import (lang1), and select the column to import the translations to.



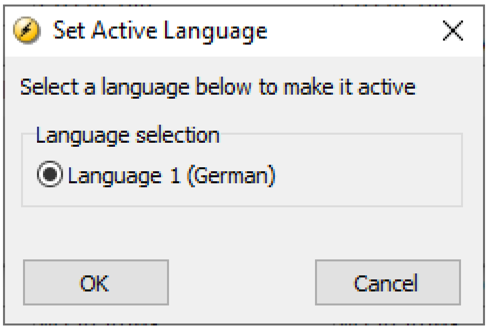
5. Once the translations are imported, you might get a warning stating that *Some translations were not imported*. Click *OK*.
6. To write the imported translations to the controller, click the *Write to controller*  icon.
7. In the pop-up window, select the language you want to write to the controller.



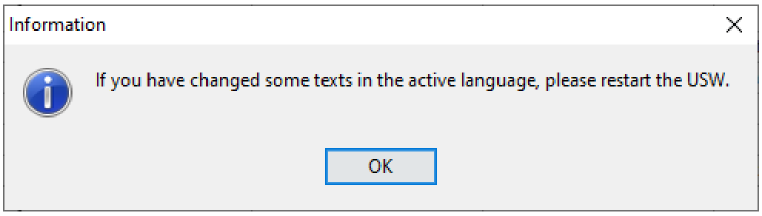
8. Click *OK*.
9. Select *Yes* to confirm you want to continue the writing procedure.



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.

6. Engine functions

6.1 Engine sequences

The engine START and STOP sequences are started automatically if:

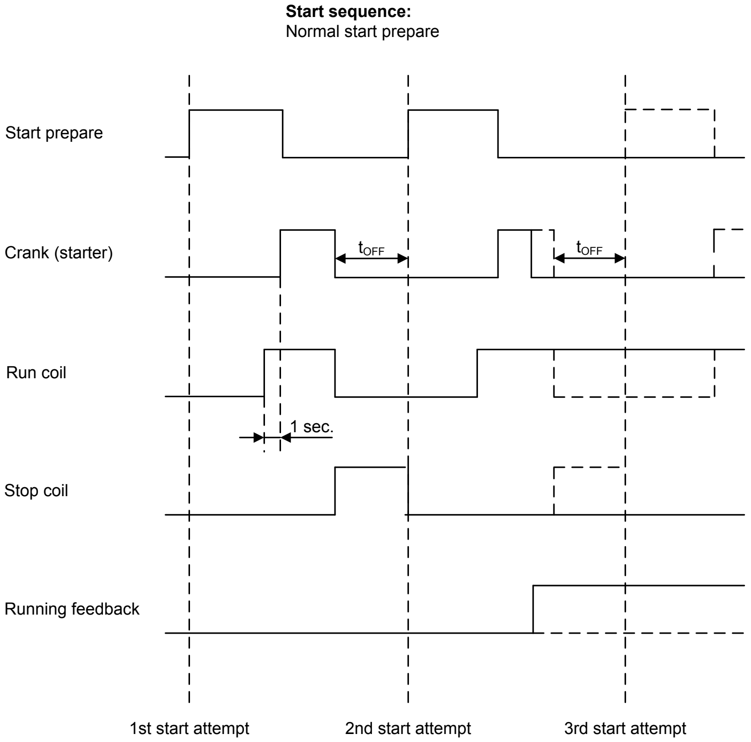
- AUTO mode is selected.
- SEMI-AUTO mode: The command is selected.
    - Only the selected sequence is started. For example, when the *START* button is pressed, the engine starts.

6.2 Engine start functions

6.2.1 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 timer	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. 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	Single starter attempts	1 to 100	3
6192	Double starter attempts	0 to 10	0

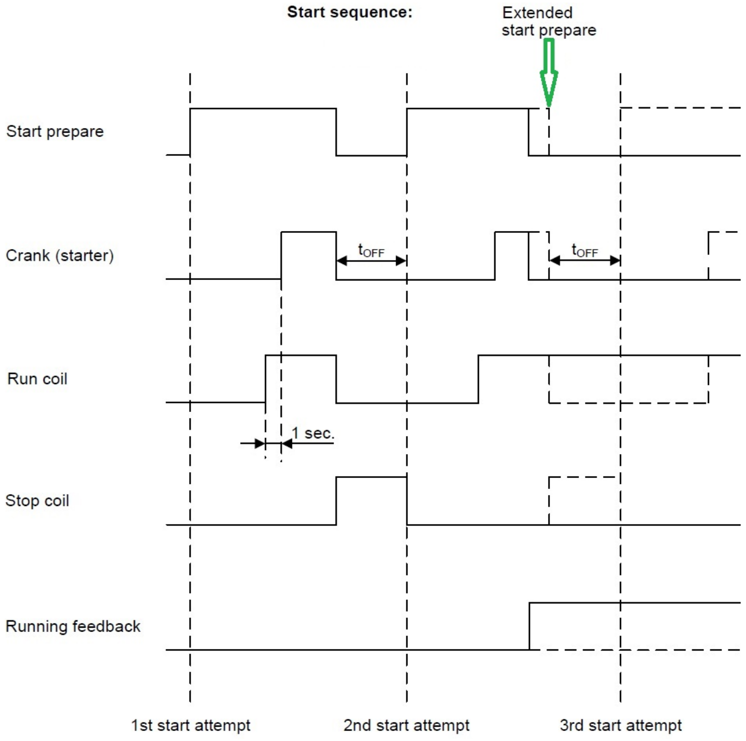
Choose a value that is more than zero in parameter 6192. This value determines the amount of attempts on each starter before switching to the next. The standard starter has first priority. When the maximum allowed number of attempts is reached, the start attempts stop and the alarm Start failure appears.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

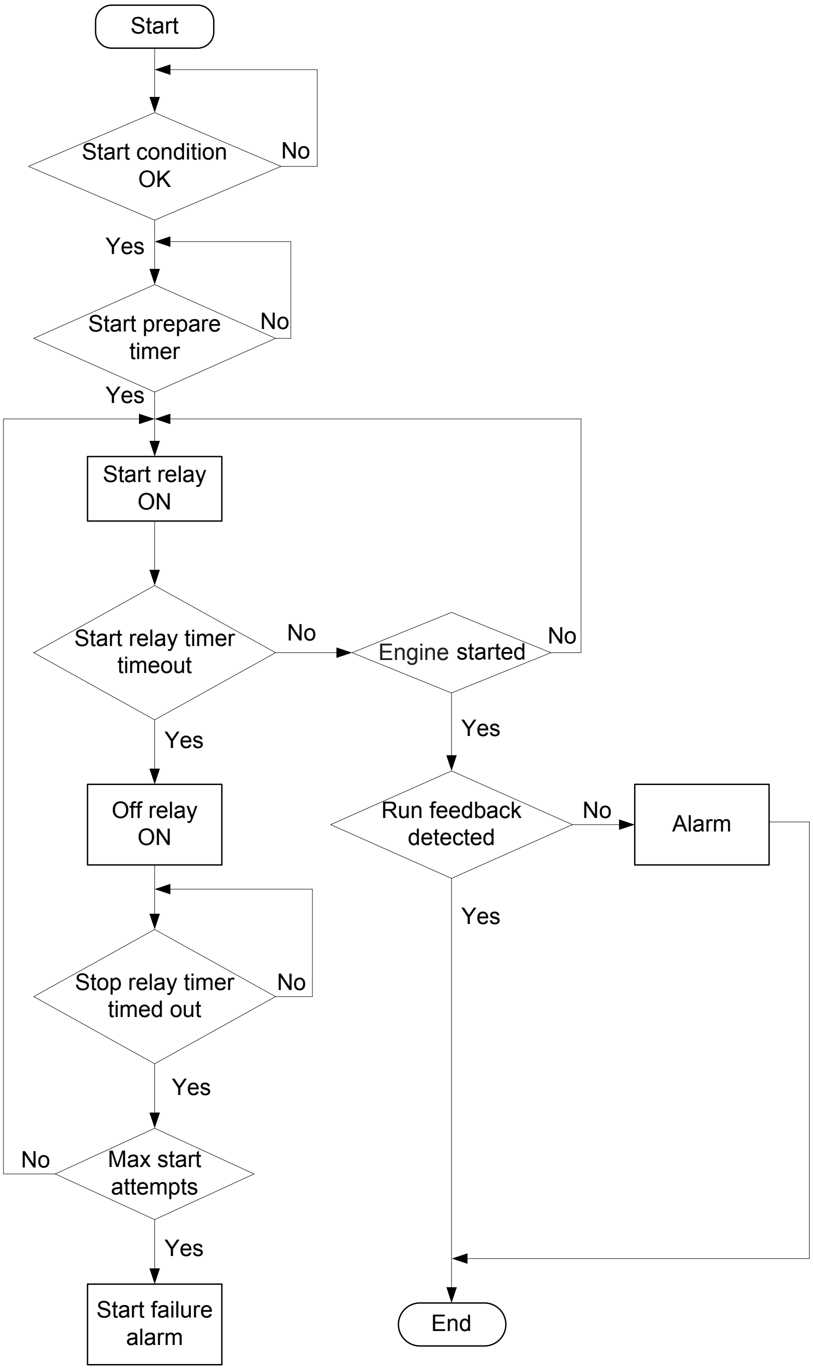
Extended start prepare sequence



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



6.2.2 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

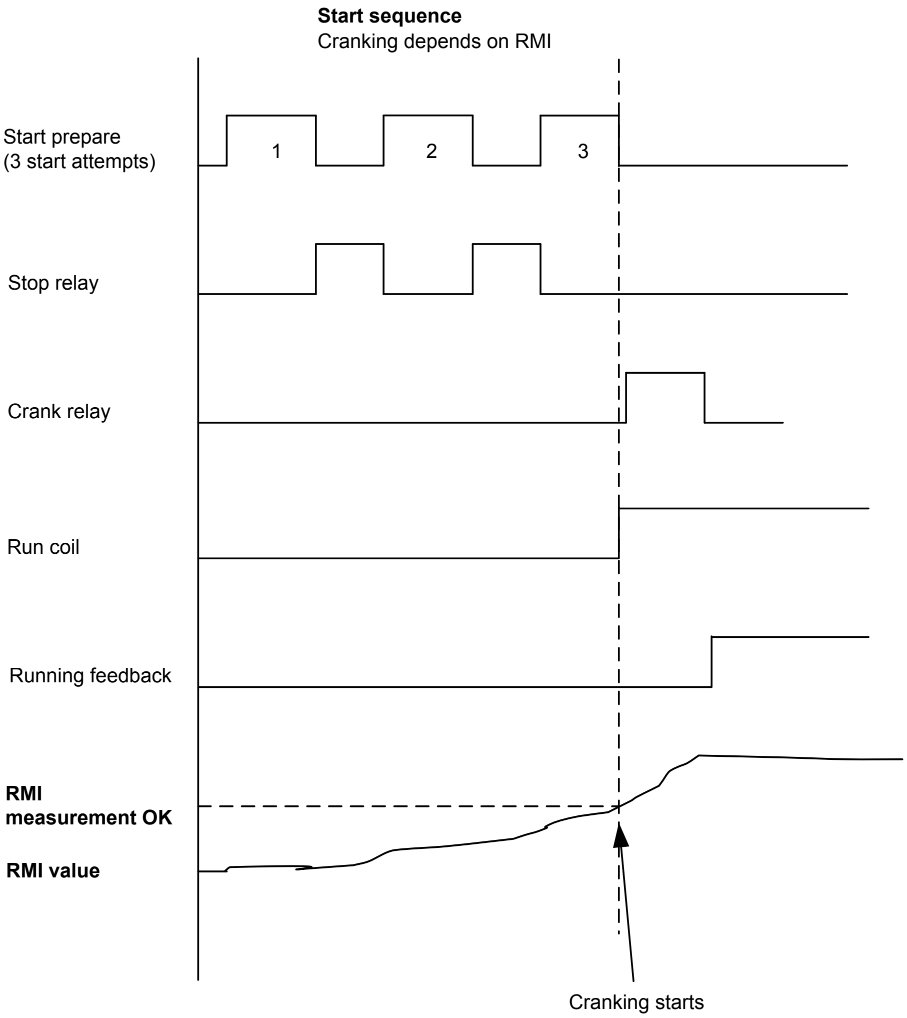
This means that if, for example, the oil pressure is not primed to the sufficient value, the crank relay will not engage the starter motor.

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.

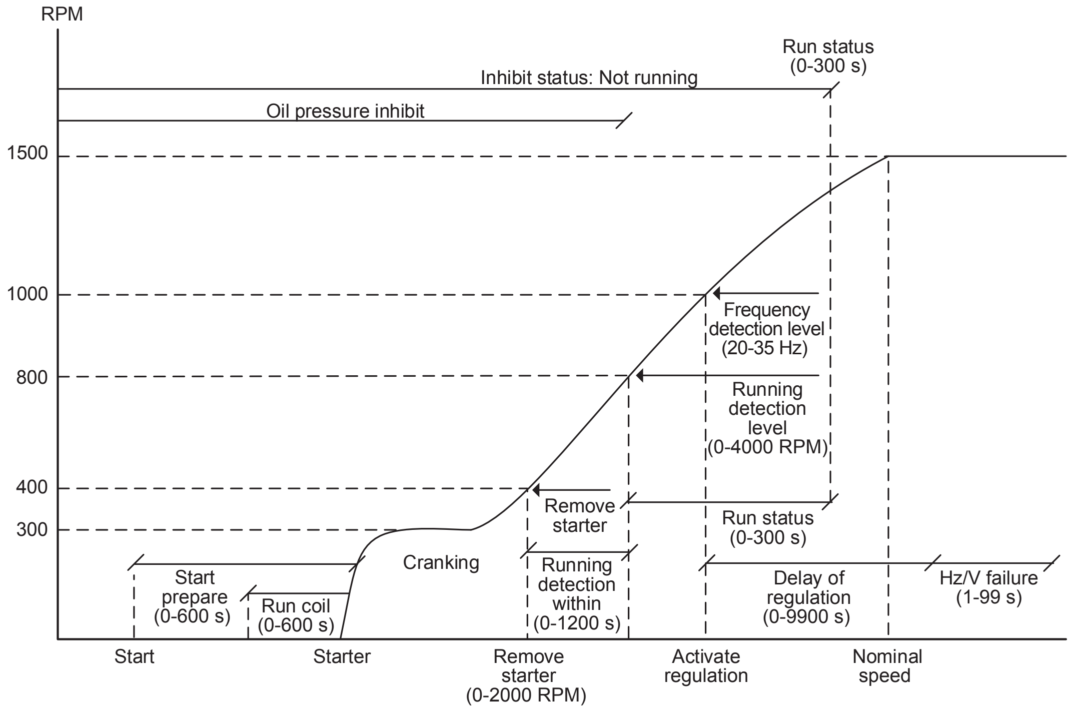


The start is initiated as soon as the start threshold limit is reached. By default, the controller waits until the start prepare timer is over and the start threshold conditions are correct before the crank relay/start is initiated. You can configure this in parameter 6185. You can change the start prepare 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 input type	Multi-input 20 Multi-input 21 Multi-input 22 Multi-input 23	Multi-input 20
6186	Start threshold set point	0.0 to 300.0	0.0

6.2.3 Start-up overview



Set points related to the start sequence

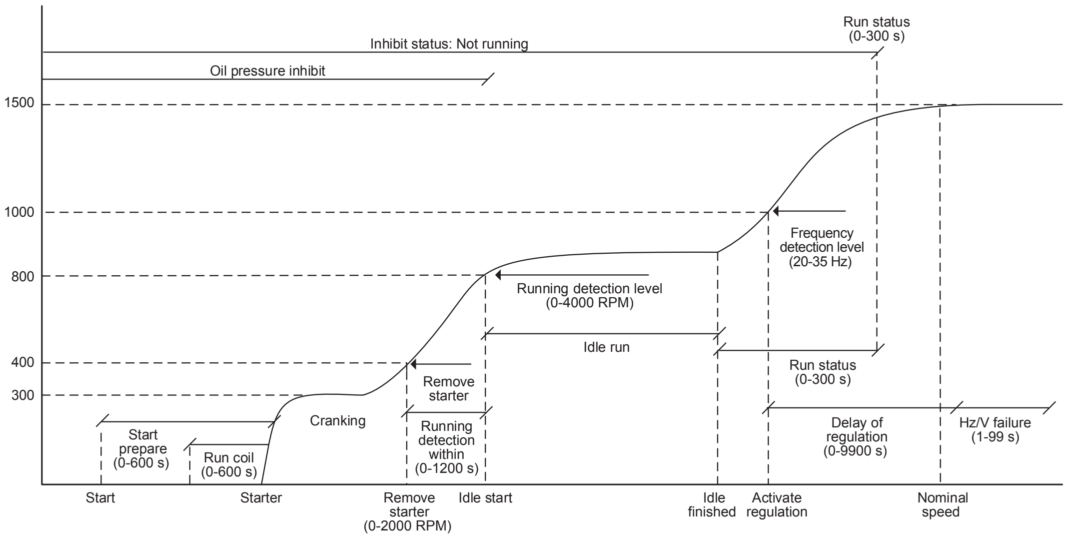
Parameter	Text	Description
6181	Start prepare	Start prepare is used for start preparation, for example pre-lubrication or pre-glowing. The start prepare relay is activated when the start sequence is initiated, and deactivated when the start relay is activated. If the timer is set to 0.0 s, the start prepare function is deactivated.
6182	Extended 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 timer	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 detection RPM level	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	Frequency detection level	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 regulation	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 failure alarm	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 alarm	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	Engine externally stopped	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.

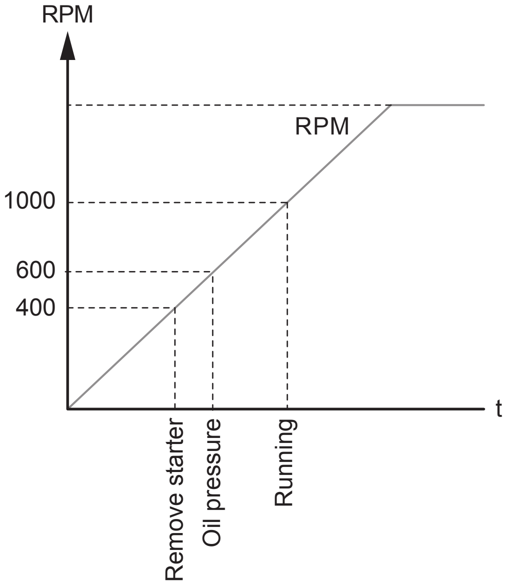
6.2.4 Start functions

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.

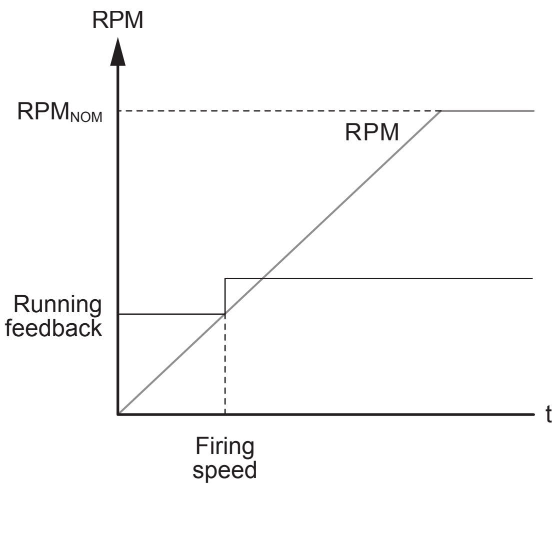


6.2.5 Digital feedbacks

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

Running feedback

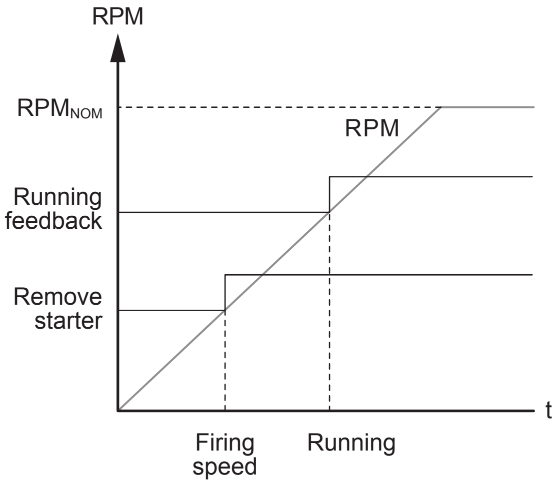
When the digital running feedback is active, the start relay is deactivated and the starter motor will be disengaged.



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.

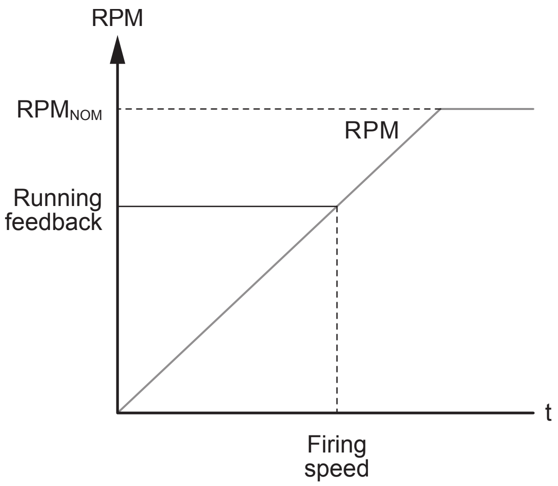
NOTE The remove starter input must be configured from a number of available digital inputs.

6.2.6 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.



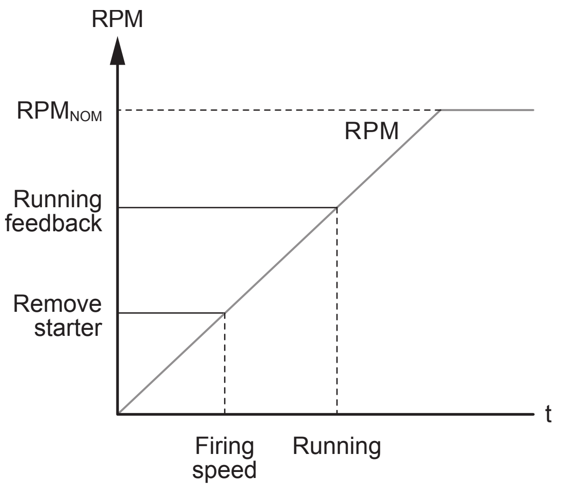
CAUTION

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.

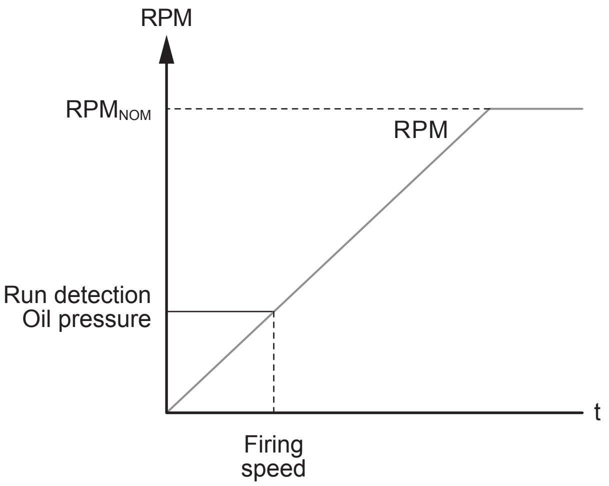
6.2.7 Oil pressure

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.

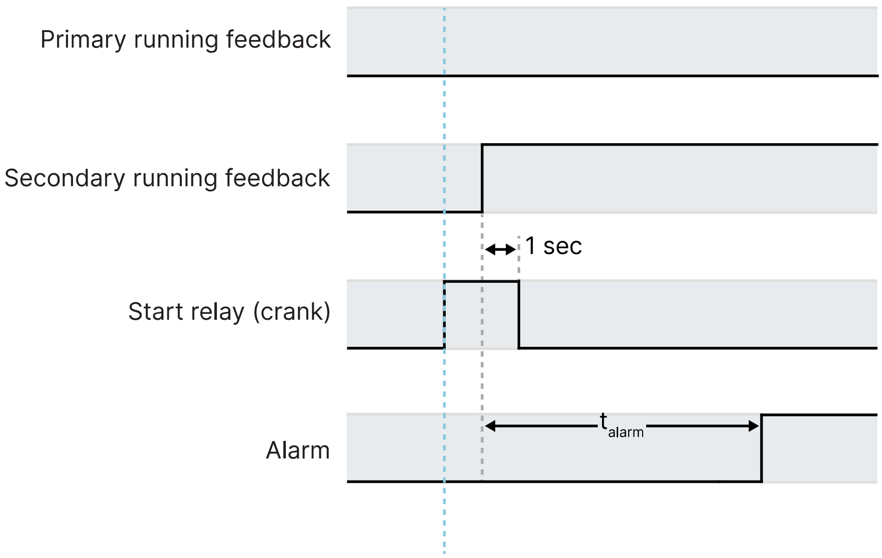
6.3 Running feedback

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)

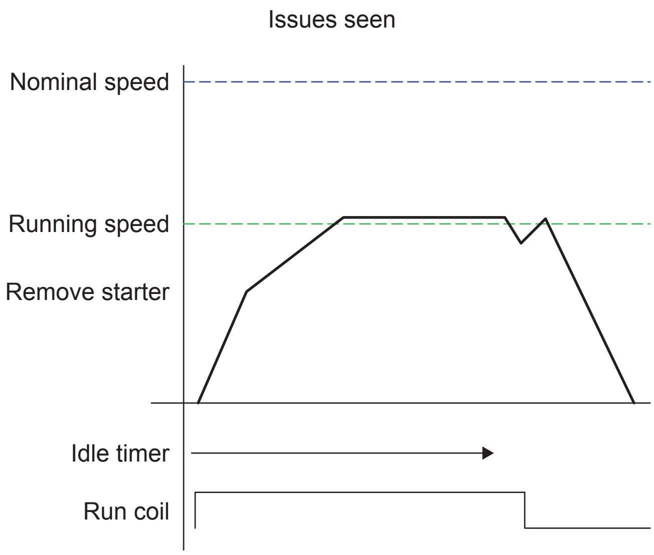
The selected running feedback is the primary feedback. However, all available running feedback is used for running detection. If the primary running feedback does not detect any running feedback, the starter relay stays activated for one additional second.

6.3.1 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.

6.3.2 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.

6.3.3 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 SEMI-AUTO or Manual mode.
Modbus stop command	SEMI-AUTO or Manual mode.
Digital stop input	SEMI-AUTO or Manual mode.
Deactivate the Auto start/stop	AUTO mode in the genset modes Island operation, Fixed power, Load take-over or Mains power export mode.
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 for MPU running detection	0 to 500 teeth	0 teeth*
6172	Primary running detection type	Digital input MPU input Frequency EIC Multi-input 20 to 23	Frequency
6173	Running detection	0 to 4000 RPM	1000 RPM
6175	Oil pressure	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.

6.3.4 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	Tacho sensor	Tacho sensor Hall sensor*	Tacho sensor
4552	Output A	Relays and M-Logic	Not used
4553	Output B	Relays and M-Logic	Not used
4554	Enable	OFF ON	OFF
4555	Fail class	Fail classes	Warning

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

6.3.5 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
4991	Set point	5.50 to 30.00 V	6.00 V
4992	Timer	0.0 to 999.0 s	10.0 s
4993	Output A	Relays and M-Logic	Not used
4994	Output B	Relays and M-Logic	Not used
4995	Enable	OFF ON	OFF
4996	Fail class	Fail classes	Warning

Engine > Start sequence > After crank > Remove starter

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

6.3.6 Running output

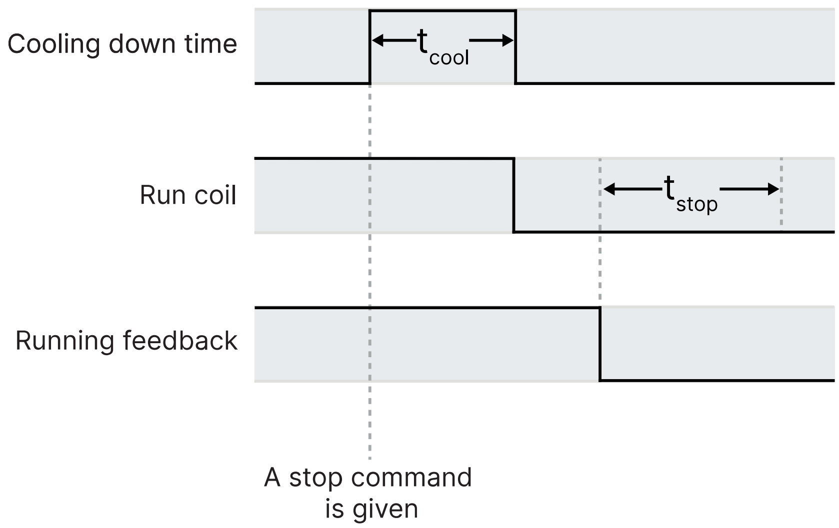
The run status timer can be configured to activate a digital output when the engine is running.

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*.

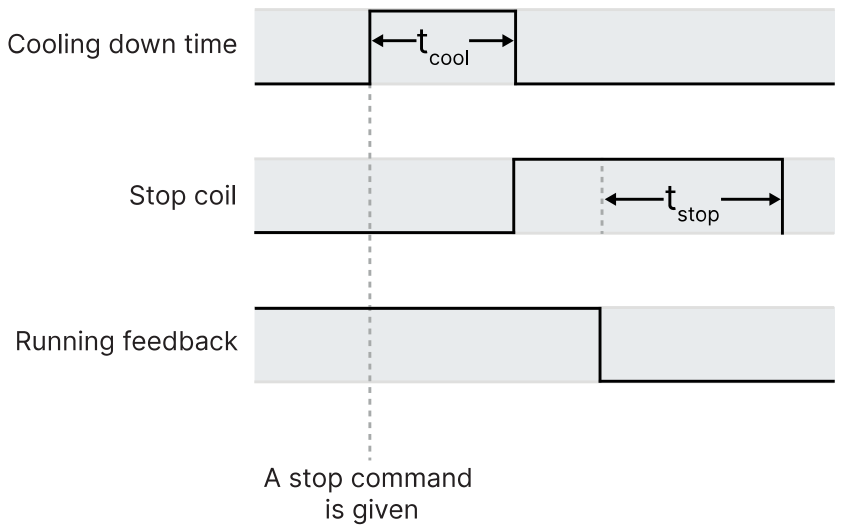
6.4 Engine stop functions

6.4.1 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

6.4.2 Stop sequence commands for the generator

Description	Cooling down	Stop	Notes
AUTO mode stop	●	●	
Trip and stop alarm	●	●	
Stop button on the display	(●)	●	SEMI-AUTO or Manual mode. Cooling down is interrupted if the *Stop* button is activated twice.
Remove Auto start/stop	●	●	AUTO mode: • Island operation • Fixed power • Load take-over • Mains power export
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
Mains failure	AMF mode selected (or mode shift selected ON) and AUTO mode selected.
Start button is pressed/remote command is given	SEMI-AUTO mode: Engine will run in idle/nominal speed.
Digital start input	AUTO mode: Island operation and fixed power, load take-over or mains power export.
Exceeding set point	AUTO mode: Peak shaving.
GB close button is pressed/remote command is given	SEMI-AUTO and Manual modes only.

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

6.4.3 Set points related to the stop sequence

`Engine > Stop sequence > Stop failure`

Parameter	Text	Range	Default
4581	Stop failure timer	10.0 to 120.0 s	30.0 s
4582	Stop failure, Output A	Relays and M-Logic	Not used
4583	Stop failure, Output B	Relays and M-Logic	Not used
4584	Activation of the stop failure alarm	OFF ON	ON
4585	Stop failure alarm fail class	Fail classes	Shutdown

`Engine > Stop sequence > Extended stop`

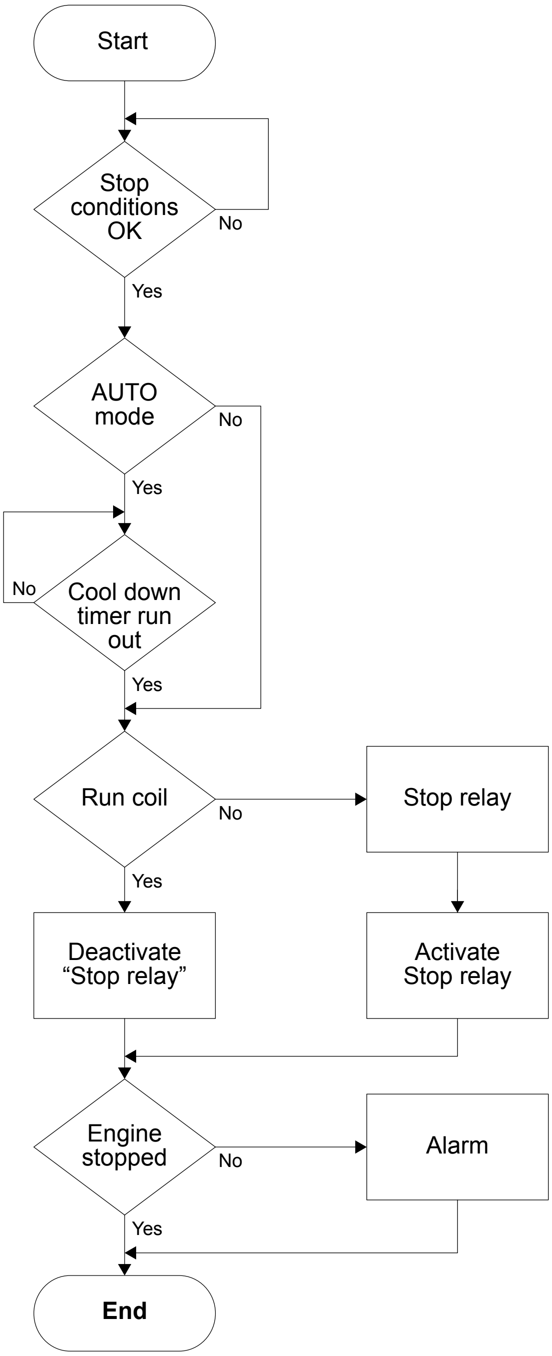
Parameter	Text	Range	Default
6212	Extended stop timer	0 to 300.0 s	5.0 s

Engine > Stop sequence > Stop threshold

Parameter	Text	Range	Default
6213	Input type	Multi input 20 to 23 M-Logic EIC temp. inputs	Multi input 20
6214	Threshold value/set point	0 to 482 °	0 °

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

6.4.4 Stop sequence flowchart



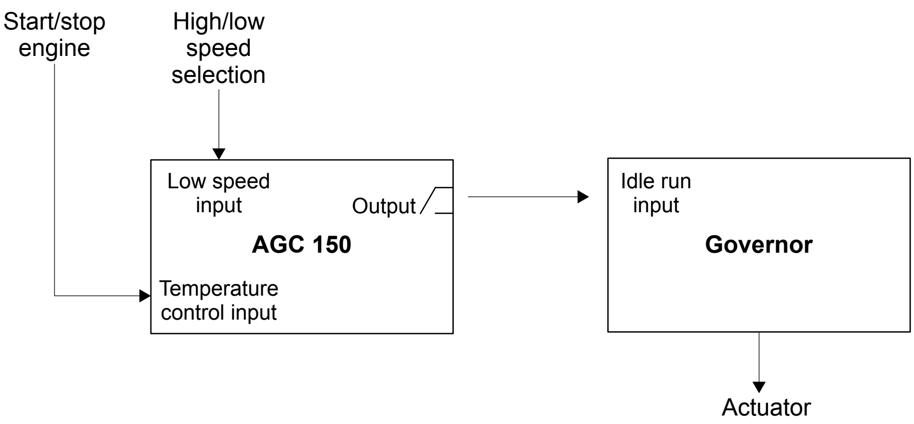
6.5 Idle running

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 SEMI-AUTO 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

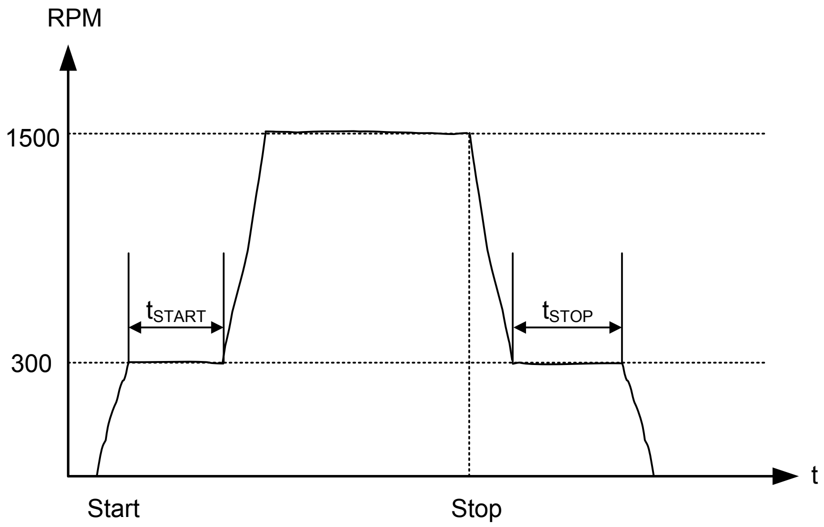
Engine > Stop sequence > Idle stop

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

Examples

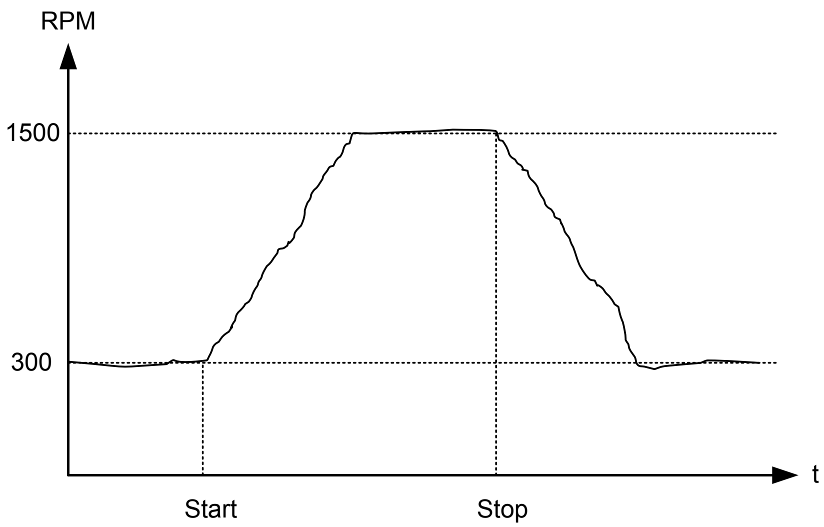
Idle speed during starting and stopping

- 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.

6.5.1 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.

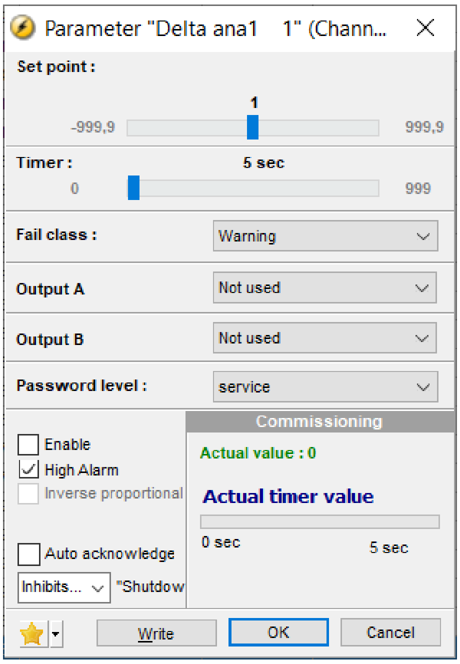
For this function to work, you must turn idle running ON and configure the digital output.

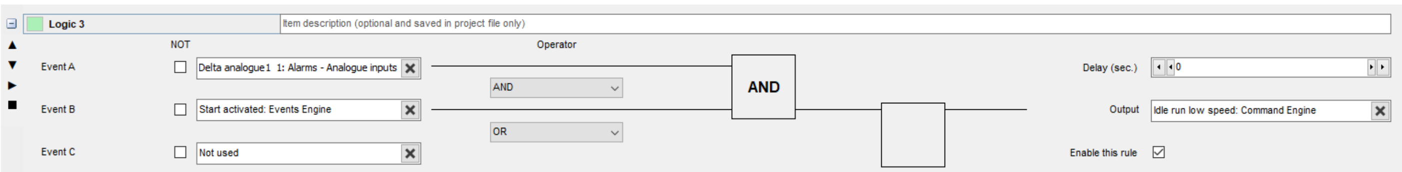
`Engine > Start sequence > Idle run`

Parameter	Text	Range	Set value to
6296	Idle running	OFF ON	ON

Example

The function uses delta analogue 1 (parameters 4601, 4602 and 4610) 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.





6.5.2 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.

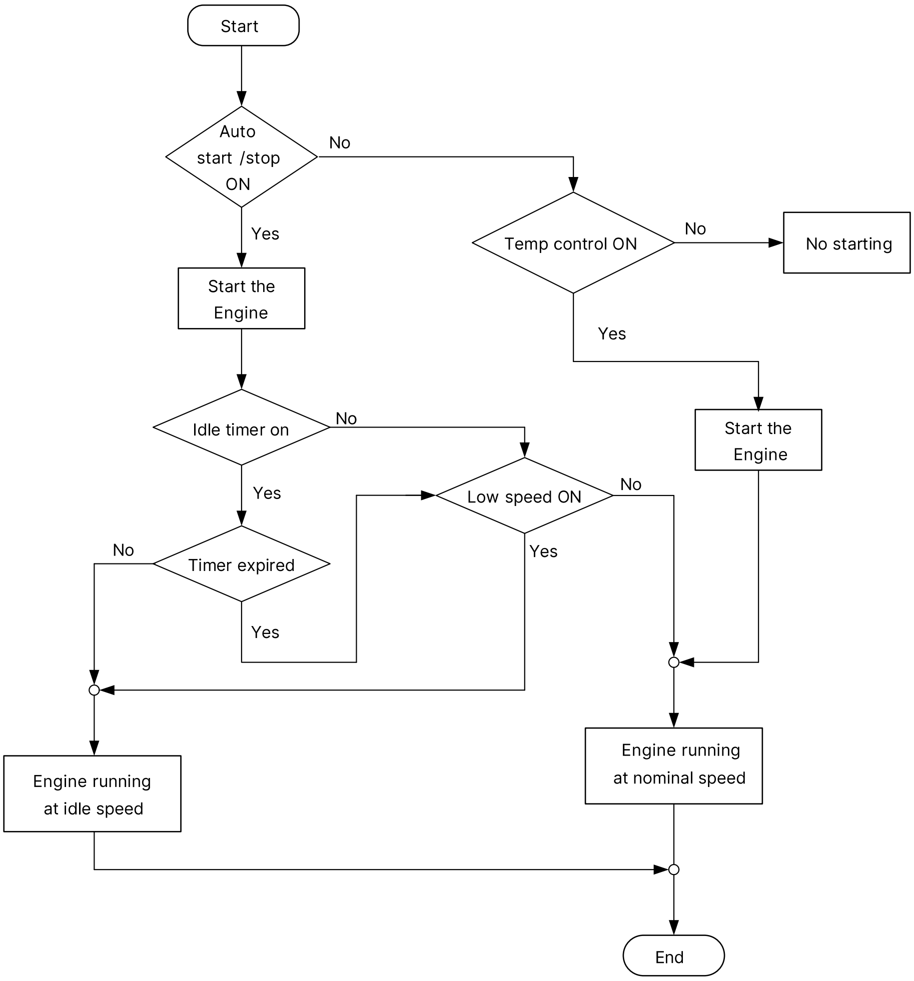
6.5.3 Running signal

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

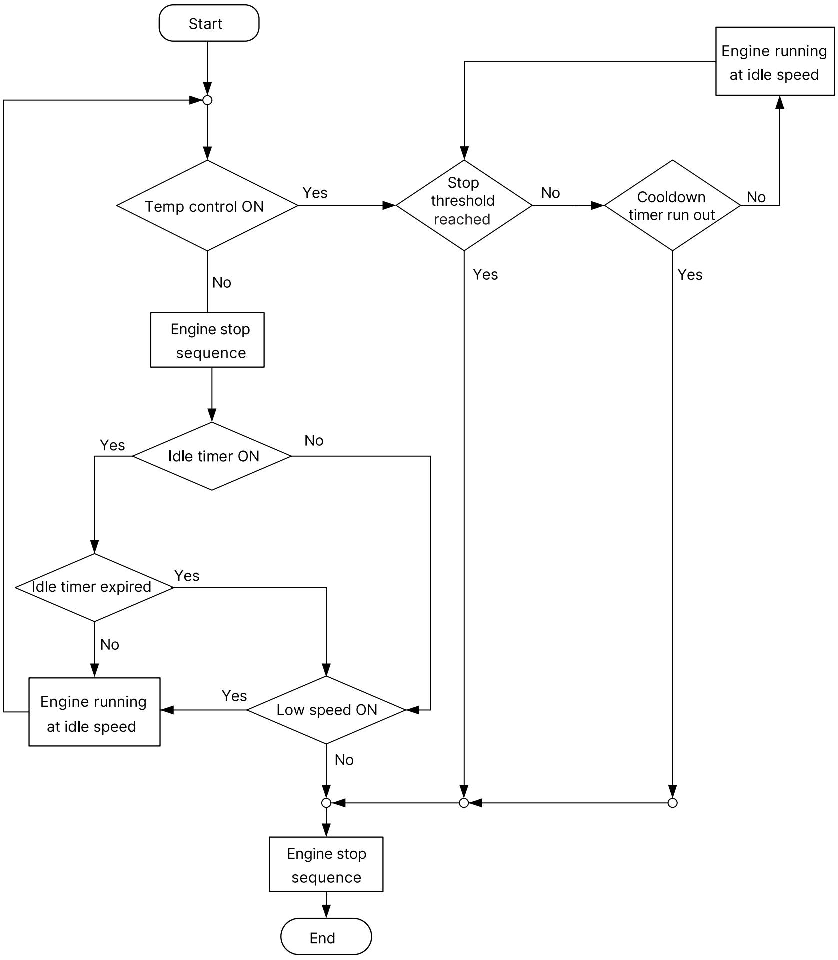
6.5.4 Idle speed flowcharts

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

Start flowchart



Stop flowchart

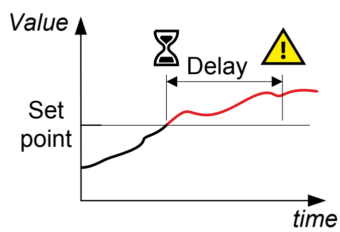


6.6 Engine protections

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

6.6.1 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]`

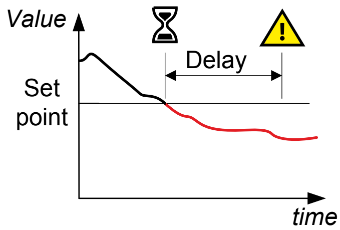
Parameter	Text	Range	Overspeed 1	Overspeed 2
4511 or 4521	Set point	100 to 150 %	110 %	120 %
4512 or 4522	Timer	0 to 3200 s	5 s	1 s
4513 or 4523	Output A	Relays and M-Logic	Not used	Not used
4514 or 4524	Output B	Relays and M-Logic	Not used	Not used

Parameter	Text	Range	Overspeed 1	Overspeed 2
4515 or 4525	Enable	OFF ON	OFF	OFF
4516 or 4526	Fail class	Fail classes	Warning	Shutdown

6.6.2 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
4591	Set point	50 to 100 %	90 %
4592	Timer	0 to 3200 s	5 s
4593	Output A	Relays and M-Logic	Not used
4594	Output B	Relays and M-Logic	Not used
4595	Enable	OFF ON	OFF
4596	Fail class	Fail classes	Warning

6.6.3 EIC overspeed

`Engine > Protections > EIC - based protections > Overspeed > EIC Overspeed`

Parameter	Text	Range	Default
7601	Set point	100.0 to 150.0 %	110.0 %
7602	Timer	0.0 to 3200 s	5.0 s
7603	Output A	Relays and M-Logic	Not used
7604	Output B	Relays and M-Logic	Not used
7605	Enable	OFF ON	OFF
7606	Fail class	Fail classes	Warning

6.7 Engine communication

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

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

Exhaust after-treatment (Tier 4/Stage V)

AGC 150 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.

6.8 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.

6.8.1 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

6.8.2 Fan start and stop

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

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

6.8.3 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 Relay 5, 6 and 9 to 18 Limits	Not used
6582	Fan B output		
6583	Fan C output		
6584	Fan D output		

6.8.4 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.

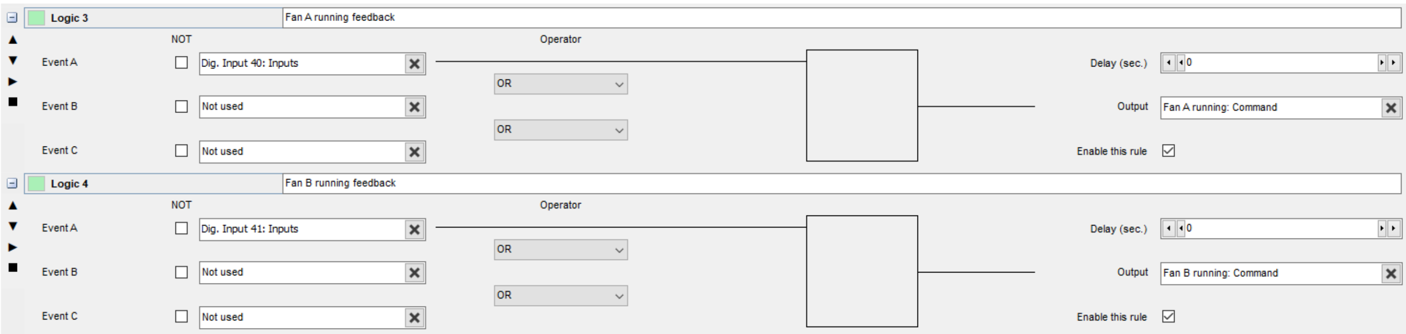
Functions > Fan > Multiple fan start/stop > Start delay

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

6.8.5 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.

6.8.6 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
6591, 6601, 6611 or 6621	Fan [A to D] timer	0.1 to 300.0 s	10.0 s
6592, 6602, 6612 or 6622	Output A	Relays and M-Logic	Not used
6593, 6603, 6613 or 6623	Output B	Relays and M-Logic	Not used
6594, 6604, 6614 or 6624	Enable	OFF ON	OFF
6595, 6605, 6615 or 6625	Fail class	Fail classes	Warning

6.8.7 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`

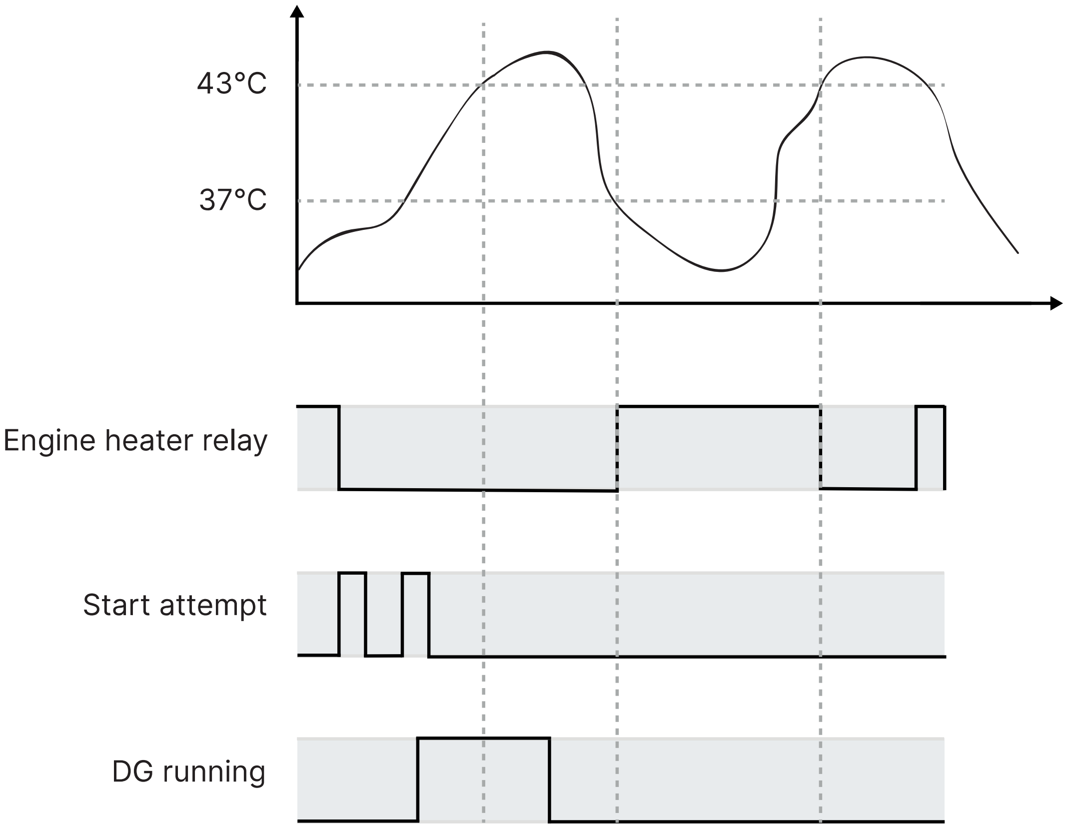
Parameter	Text	Range	Default
6562	Fan prio update	0 to 200 hours	0 hours

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.

6.9 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	Set point	20 to 250 °C	40 °C
6322	Output A	Relays and M-Logic	Not used
6323	Input type	Multi-input 20 to 23 EIC temp. inputs	Multi-input 20
6324	Hysteresis	1 to 70 °C	3 °C

6.9.1 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
6331	Set point	10 to 250 °C	30 °C
6332	Timer	1.0 to 300.0 s	10.0 s
6333	Output A	Relays and M-Logic	Not used
6334	Output B	Relays and M-Logic	Not used
6335	Enable	OFF ON	OFF
6336	Fail class	Fail classes	Warning

6.10 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
6461	Set point	20 to 250 °C	90 °C
6462	Output A	Relays and limits	Not used
6463	Hysteresis	1 to 70 °C	5 °C
6464	Enable	ON OFF	OFF

6.10.1 Max. ventilation alarms

There are two ventilation alarms.

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

Parameter	Text	Range	Default
6471	Set point	20 to 250 °C	95 °C
6472	Timer	0 to 60 s	1 s
6473	Output A	Relays and limits	Not used
6474	Output B	Relays and limits	Not used
6475	Enable	ON OFF	OFF
6476	Fail class	Fail classes	Warning

6.11 Fuel pump logic

6.11.1 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

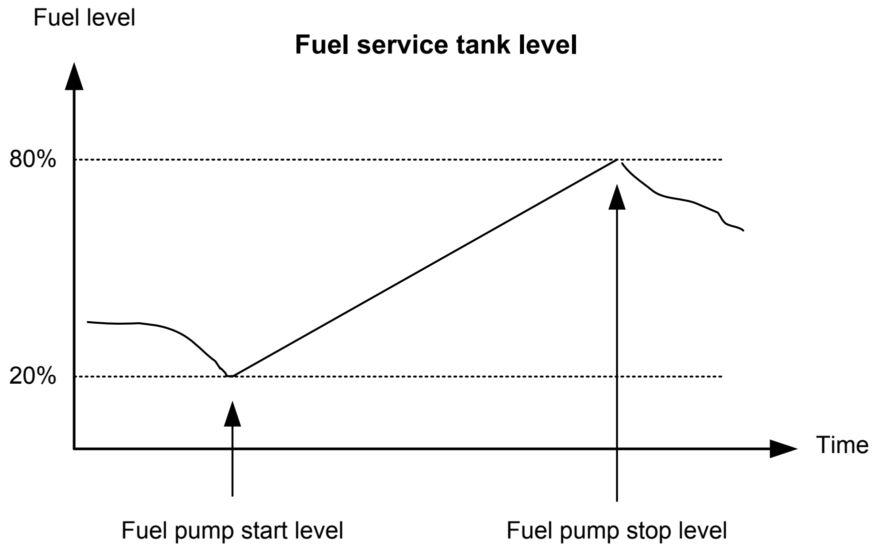
In the utility software under *I/O & Hardware setup*, select the output relay to control the fuel pump, as shown in the following example. If you do not want an alarm whenever the output is activated, configure the output relay as a limit relay.

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`).

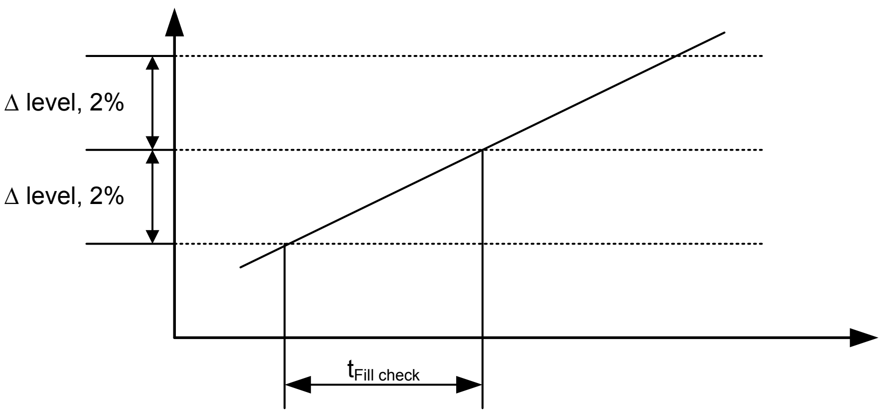
How it works

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.

Fuel tank level and volume

You can set the capacity of the day tank in parameter 6911. The controller uses this value and the fuel level to calculate the fuel volume. The fuel volume is shown in the utility software in *Application supervision, Genset data, General*.

6.11.2 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 %	20 %	DEF transfer pump start point.

Parameter	Name	Range	Default	Details
		1 to 10 s	1 s	
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`).

6.11.3 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`).

6.12 SDU 104 integration

The SDU 104 is a parallel redundancy shutdown unit used for the protection of land and marine engines. You can use the SDU 104 together with the AGC 150 Generator, AGC 150 Engine drive marine, and AGC 150 Generator marine.

How to configure AGC 150 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 11* and *Output 12*:
   - Output 11: SDU watchdog
   - Output 12: 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.

More information
See the **SDU 104 Installation instructions** for how to connect the SDU 104 to the AGC 150. You can also see how to configure the SDU 104.

6.13 Other functions

6.13.1 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	Enable	OFF ON	OFF
6112 or 6122	Running hours	0 to 9000 hours	500 hours
6113 or 6123	Days	1 to 1000 days	365 days

Parameter	Text	Range	Default
6114 or 6124	Fail class	Fail classes	Warning
6115 or 6125	Output A	Relays and M-Logic	Not used
6116 or 6126	Reset	OFF ON	OFF

6.13.2 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.

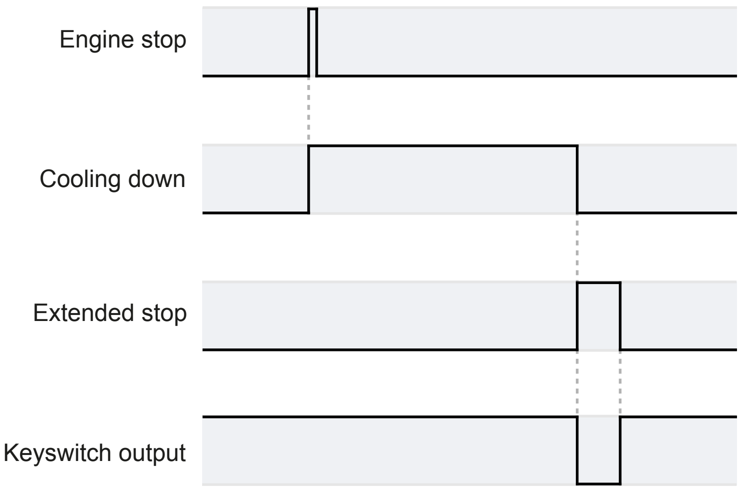
How it works

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

When the keyswitch relay is open, the AGC 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 AGC 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.

6.13.3 Unsupported application

The AGC 150 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 mains controller or a BTB controller.

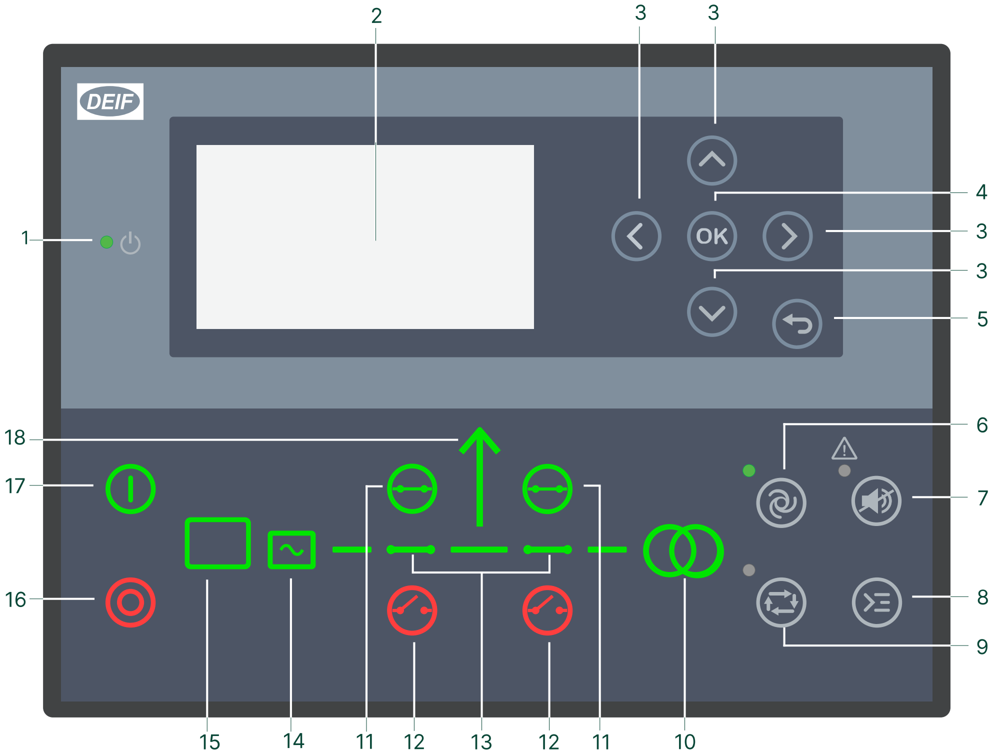
Alarm value	Configuration rule
4	Multi-mains application with either group mains or top mains configured.
7	Unknown application type.
8	The controller must have the emulation option enabled to activate emulation.
10	The number of controllers in a plant exceeds the maximum number of allowed controllers.
12	For single controller applications with an external generator breaker both feedbacks must be configured.
13	For single controller applications with an external mains 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.

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

7. Generator functions

7.1 Display, buttons and LEDs



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	Move the selector up, down, left and right on the screen.
4	OK	Go to the Menu system. Confirm the selection on the screen.
5	Back	Go to the previous page.
6	AUTO mode	For generator controllers, 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.
7	Silence horn	Stops an alarm horn (if configured) and enters the Alarm menu.
8	Shortcut menu	Access the Jump menu, Mode selection, Test, Lamp test.
9	SEMI-AUTO 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.
10	Mains symbol	Green: Mains voltage and frequency are OK. The controller can synchronise and close the breaker. Red: Mains failure.
11	Close breaker	Push to close the breaker.
12	Open breaker	Push to open the breaker.

No.	Name	Function
13	Breaker symbols	Green: Breaker is closed. Green flashing: Synchronising or deloading. Red: Breaker failure.
14	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.
15	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.
16	Stop	Stops the genset if SEMI-AUTO or Manual is selected.
17	Start	Starts the genset if SEMI-AUTO or Manual is selected.
18	Load symbol	OFF: Power management application. Green: The supply voltage and frequency are OK. Red: Supply voltage/frequency failure.

7.2 Application modes

The controller can be used for the following standard application modes:

Genset mode	AUTO	SEMI-AUTO	Test	Manual	Block
Island operation	●	●	●	●	●
Automatic Mains Failure	●	●	●	●	●
Load take-over	●	●	●	●	●
Fixed power/base load	●	●	●	●	●
Mains power export	●	●	●	●	●
Peak shaving	●	●	●	●	●
Multiple gensets, load sharing (analogue load sharing)	●	●	●	●	●
Multiple gensets, power management	●	●	●	●	●

7.3 Generator alarms

7.3.1 Fail classes

Fail class/Action	Alarm horn relay	Alarm display	Deload	Trip GB	Trip MB	Cooling down genset	Stop genset
Block	●	●					
Warning	●	●					
Trip GB	●	●		●			
Trip + stop	●	●		●		●	●
Shutdown	●	●		●			●
Trip MB	●	●			●		

Fail class/Action	Alarm horn relay	Alarm display	Deload	Trip GB	Trip MB	Cooling down genset	Stop genset
Safety stop	●	●	(●)			●	●
Trip MB/GB	●	●		(●)	●		
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 Load take-over, Island and Automatic Mains Failure (AMF) modes.

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

When the engine is stopped

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

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

7.3.2 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.

Function	Notes
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.
MB ON	The mains breaker is closed.
MB OFF	The mains breaker is open.
Parallel	Genset(s) are parallel to grid/utility.
Not parallel	Genset(s) are not parallel to grid/utility.
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.

7.4 Generator breaker

7.4.1 Breaker settings

`Synchronisation > Dynamic sync.`

Parameter	Text	Range	Default
2025	Synchronisation 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	Load time	0.0 to 30.0 s	0.0 s
6234	GB reclose attempts	No reclose attempts 1 reclose attempt 2 reclose attempts 3 reclose attempts	No reclose attempts

7.4.2 Breaker sequences

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

Controller operation modes

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

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

Parameter	Text	Range	Default
6221	Hz/V OK timer	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 dfMin	0.0 to 5.0 Hz	3.0 Hz
2112	Blackout dfMax	0.0 to 5.0 Hz	3.0 Hz
2113	Blackout dUMin	2 to 20 %	5 %
2114	Blackout dUMax	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
4561	Timer	1.0 to 99.0 s	30.0 s
4562	Output A	Relays and M-Logic	Not used
4563	Output B	Relays and M-Logic	Not used
4564	Enable	OFF ON	OFF
4565	Fail class	Fail classes	Shutdown

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

Parameter	Text	Range	Default
6221	Hz/V OK timer	0.0 to 99.0 s	5.0 s

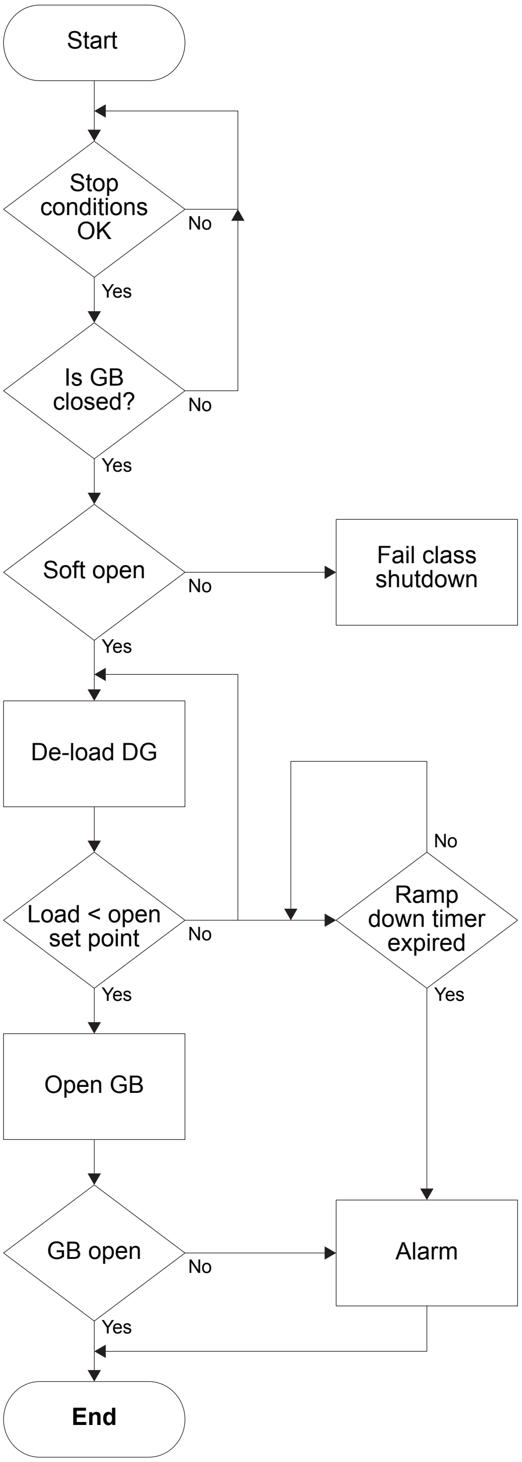
Conditions for breaker operations

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

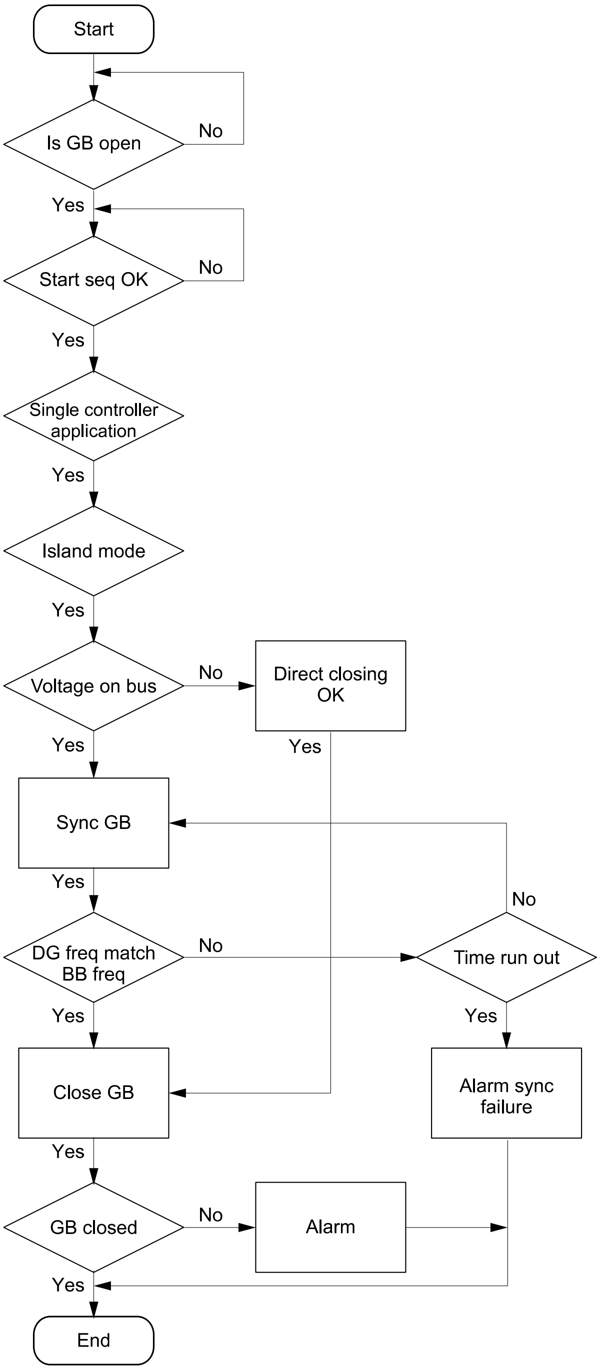
Sequence	Condition
GB ON, direct closing	Running feedback Generator frequency/voltage OK MB open
GB ON, synchronising	Running feedback Generator frequency/voltage OK MB closed No generator failure alarms
GB OFF, direct opening	MB open
GB OFF, de-loading	MB closed

7.4.3 Flowcharts

GB open sequence flowchart



GB close sequence flowchart



7.4.4 Breaker failures

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

Parameter	Text	Range	Default
2161	Timer	1.0 to 10.0 s	2.0 s
2162	Output A	Relays and M-Logic	Not used
2163	Output B	Relays and M-Logic	Not used
2164	Enable	ON	ON
2165	Fail class	Fail classes	Warning

Breakers > Generator breaker > Breaker monitoring > GB Close fail

Parameter	Text	Range	Default
2171	Timer	1.0 to 10.0 s	900 s
2172	Output A	Relays and M-Logic	Not used
2173	Output B	Relays and M-Logic	Not used
2174	Enable	ON	ON
2175	Fail class	Fail classes	Warning

Breakers > Generator breaker > Breaker monitoring > GB Pos fail

Parameter	Text	Range	Default
2181	Timer	1.0 to 5.0 s	1.0 s
2182	Output A	Relays and M-Logic	Not used
2183	Output B	Relays and M-Logic	Not used
2184	Enable	ON	ON
2185	Fail class	Fail classes	Warning

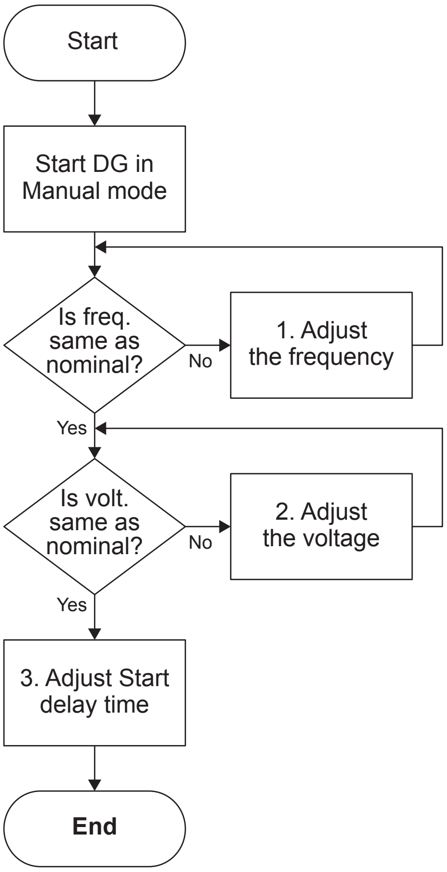
7.5 Governor and AVR configuration

7.5.1 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 Manual mode

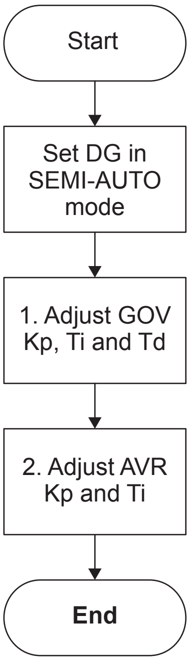


1. Adjust the frequency:
`Engine > Speed control > Offset for control signal` (2551).

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 SEMI-AUTO mode



1. Adjust GOV Kp, Ti and Td:

- Island settings: `Engine > Speed control > Speed PID > Island` (2511, 2512 and 2513).
- Mains parallel settings: `Engine > Speed control > Speed PID > Mains 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:

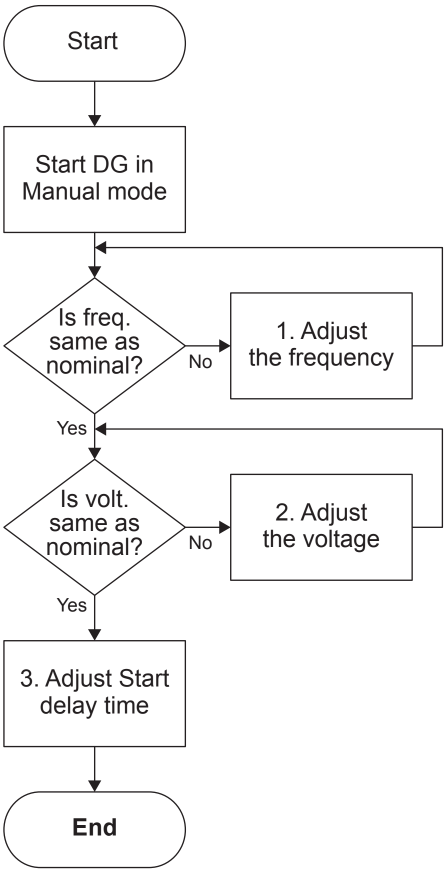
- Island settings: `Settings > Generator > AVR > Voltage PID > Island` (2641 and 2642).
- Mains parallel settings: `Generator > AVR > Voltage PID > Mains parallel` (2651 and 2652).
- Load share settings: `Generator > AVR > Voltage PID > Load share` (2661 and 2662).

7.5.2 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 Manual mode

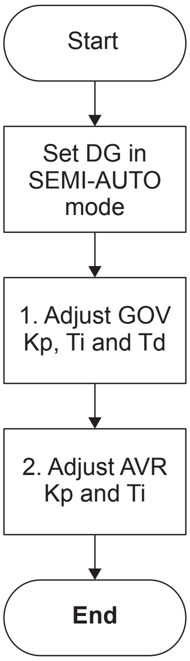


1. Adjust the frequency:
`Engine > Speed control > Offset for control signal` (2551).

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 SEMI-AUTO mode



1. Adjust GOV Kp, Ti and Td:
- Island settings: `Engine > Speed control > Speed PID > Island` (2511, 2512 and 2513).
- Mains parallel settings: `Engine > Speed control > Speed PID > Mains 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).

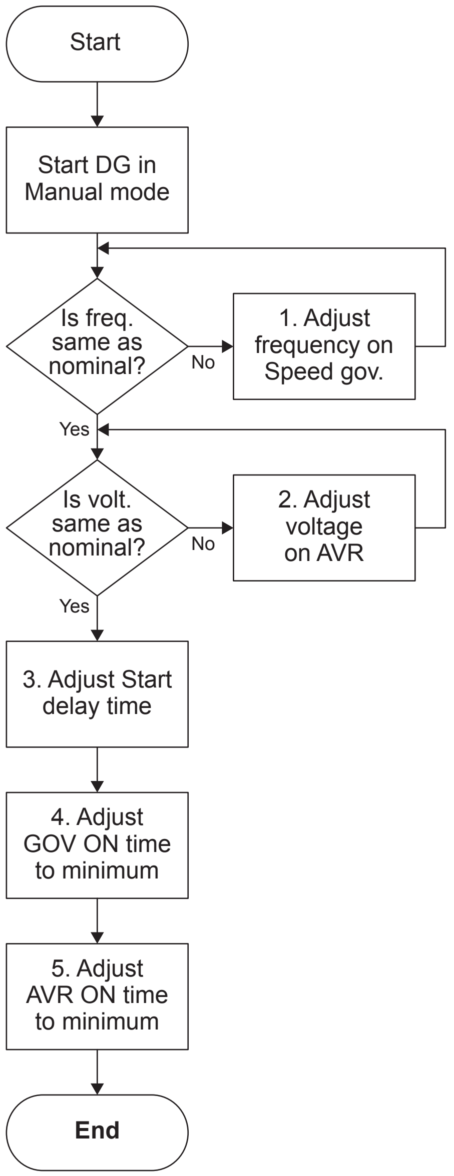
2. Adjust AVR Kp and Ti:
- Island settings: `Generator > AVR > Voltage PID > Island` (2641 and 2642).
- Mains parallel settings: `Generator > AVR > Voltage PID > Mains parallel` (2651 and 2652).
- Load share settings: `Generator > AVR > Voltage PID > Load share` (2661 and 2662).

7.5.3 Configuration of controller with relay governor and relay AVR

Initial settings

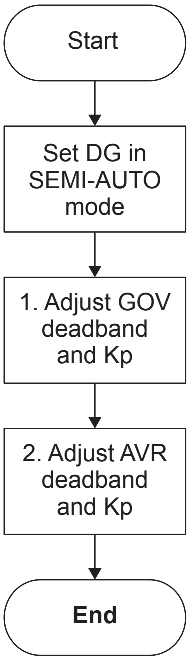
No.	Setting	Path	Parameter
1	Set the GOV type to Relay	`Engine > Speed control > General configuration`	2781
2	Set the AVR type to Relay	`Generator > AVR > General configuration`	2782
3	Select the Increase relay for AVR	`Generator > AVR > Relay configuration > Output and period`	2723
4	Select the Decrease 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 Manual 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 SEMI-AUTO mode



1. Adjust GOV deadband and Kp:

- Island settings: `Engine > Speed control > Speed PID > Island` (2571 and 2572).
- Mains parallel settings: `Engine > Speed control > Speed PID > Mains 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).
- Mains parallel settings: `Generator > AVR > Voltage PID > Mains parallel` (2701 and 2702).
- Load share settings: `Generator > AVR > Voltage PID > Load share` (2711, 2712, 2713 and 2714).

7.5.4 Manual governor and AVR control

This function can be activated in MANUAL/SEMI-AUTO 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	GOV type	Relay Analogue EIC	EIC

`Engine > Speed control > Manual step`

Parameter	Text	Range	Default
2783	Manual GOV ON	0.1 to 10.0 s	5.0 s

`Engine > Speed control > Offset for control signal`

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

AVR settings

`Generator > AVR > General configuration`

Parameter	Text	Range	Default
2782	AVR type	Relay Analogue EIC	Analogue

`Generator > AVR > Manuel step`

Parameter	Text	Range	Default
2784	Manual AVR ON	0.1 to 10.0 s	5.0 s

7.5.5 External set points

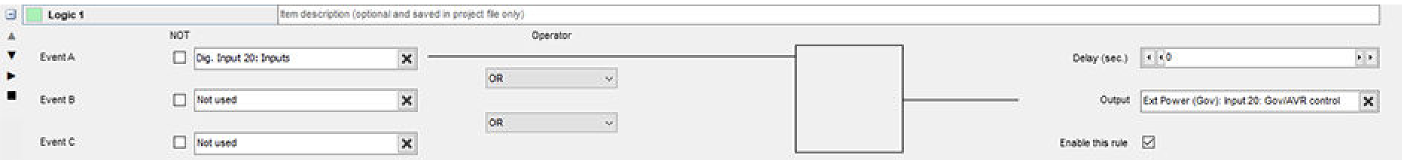
It is possible to control the governor and the AVR externally. A multi-input can be configured to receive a signal with the desired set point. The external control is enabled through M-Logic. The internal set point is discarded when the external control is enabled.

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	External power set point	OFF	OFF

Parameter	Text	Range	Default
		ON	
7502	External frequency set point	OFF ON	OFF
7503	External voltage set point	OFF ON	OFF
7504	External cos phi set point	OFF ON	OFF
7505	External reactive power set point	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 MB 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.

7.5.6 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
2561	Deadband	1.0 to 100.0 %	30.0 %
2562	Timer	10.0 to 300.0 s	60.0 s
2563	Output A	Relays and M-Logic	Not used
2564	Output B	Relays and M-Logic	Not used
2565	Fail class	Fail classes	Warning

`Generator > AVR > Regulation failure > AVR reg. fail`

Parameter	Text	Range	Default
2681	Deadband	1.0 to 100.0 %	30.0 %
2682	Timer	10.0 to 300.0 s	60.0 s

Parameter	Text	Range	Default
2683	Output A	Relays and M-Logic	Not used
2684	Output B	Relays and M-Logic	Not used
2685	Fail class	Fail classes	Warning

7.5.7 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.

7.6 Synchronisation principles

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

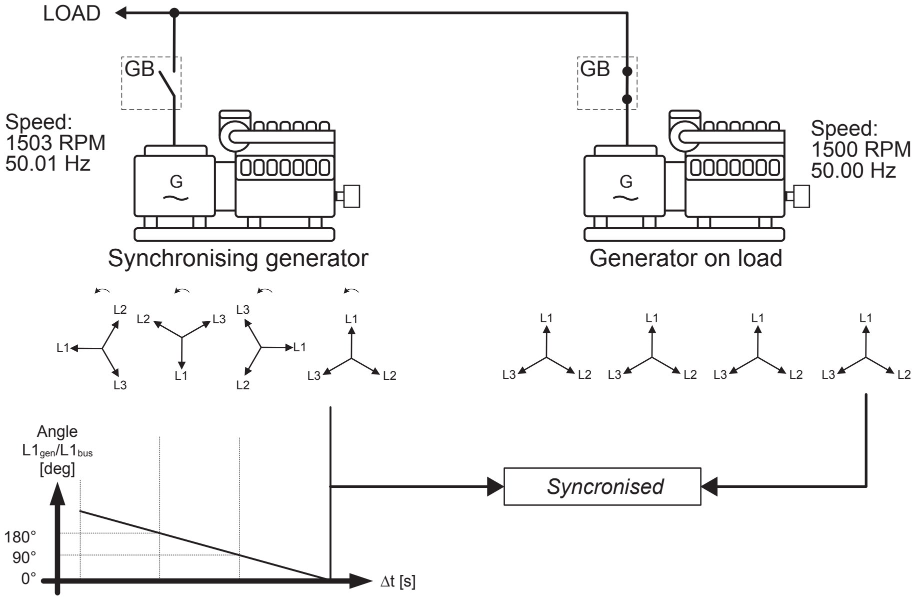
Two different synchronisation principles are available: static and dynamic synchronisation. Dynamic synchronisation is the default setting. You can change to static synchronisation: `Synchronisation > Sync. type`

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

7.7 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.

7.7.1 Settings for dynamic synchronisation

`Synchronisation > Dynamic sync.`

Parameter	Text	Range	Default
2021	Maximum slip frequency, dfMax	0.0 to 0.5 Hz	0.3 Hz
2022	Minimum slip frequency, dfMin	-0.5 to 0.3 Hz	0.0 Hz
2023	Maximum voltage difference, dUMax	2 to 10 %	5 %
2024	Minimum voltage difference, dUMin	-10 to 0 %	-5 %
2025	GB response time	40 to 300 ms	50 ms
2026	MB response time	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.

7.7.2 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):

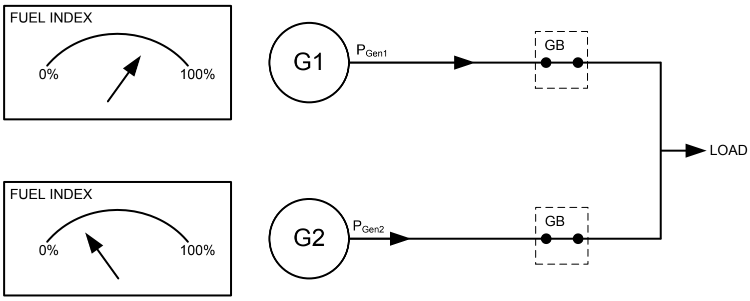
- deg close = 360*tCB*fSLIP
- deg close = 360*0.250*0.1
- deg close = 9 deg

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.

7.7.3 Load picture after synchronising

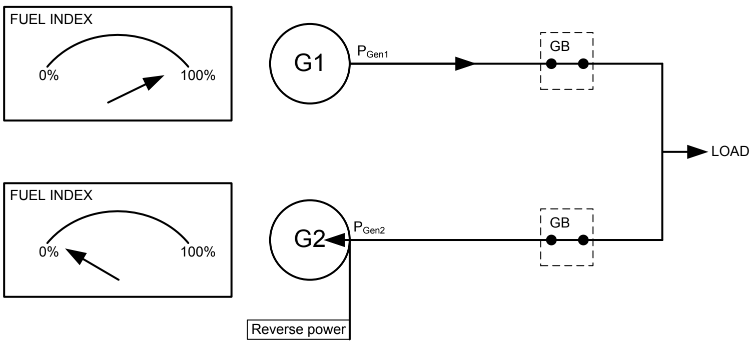
When the incoming genset has closed its breaker, it will take a portion off the load depending on the actual position of the fuel rack.

Positive slip frequency



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

Negative slip frequency



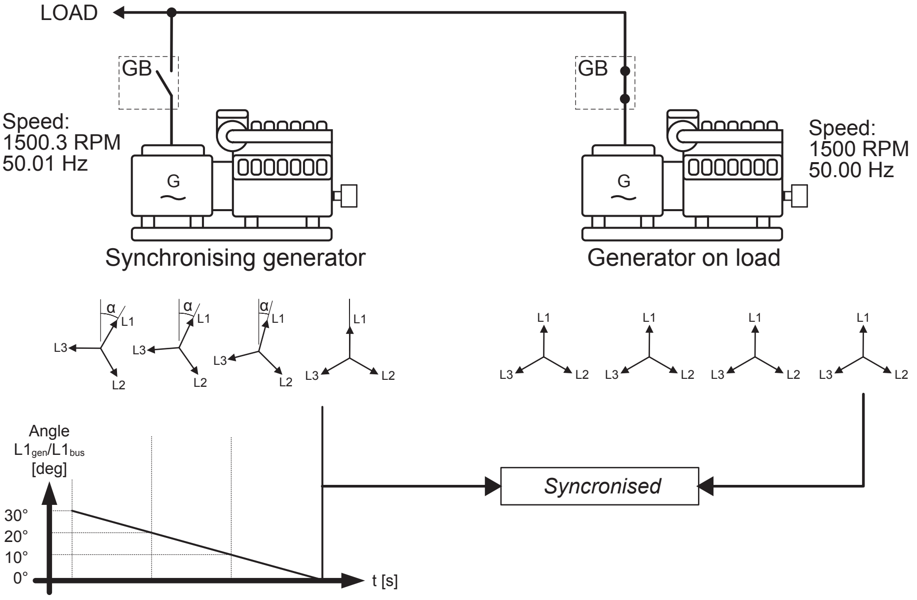
The diagram shows that at a given negative slip frequency, the incoming genset *receives* power from the original genset (reverse power).

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

7.8 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 °.

7.8.1 Settings for static synchronisation

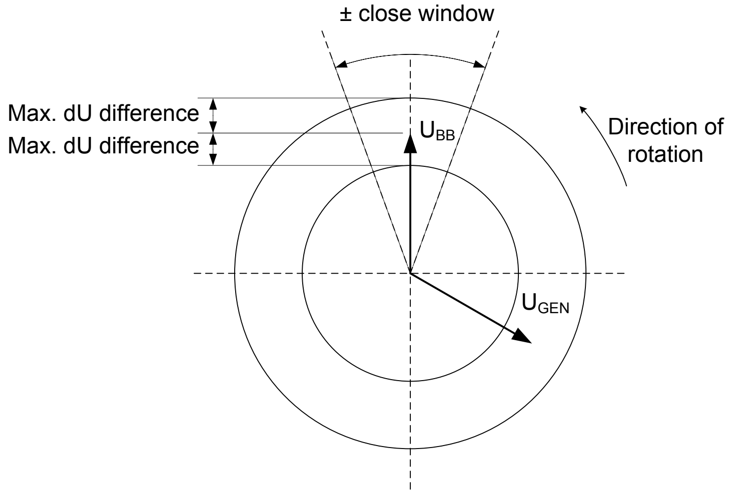
`Synchronisation > Static sync > Static sync`

Parameter	Text	Range	Default
2031	Maximum df	0.00 to 0.50 Hz	0.10 Hz
2032	Maximum dU	1 to 10 %	5 %
2033	Close window	0.1 to 20.0 °	10°
2034	Static sync timer	0.1 to 99.0 s	1.0 s
2035	GB breaker sync	Breaker sync Infinite sync	Breaker sync
2036	MB breaker sync	Breaker sync Infinite sync	Breaker sync

7.8.2 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 MB is to be synchronised.

7.8.3 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.

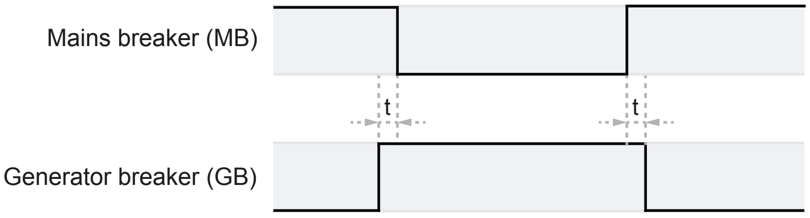
After synchronising, the controller will change the controller set point according to the requirements of the selected genset mode.

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.

7.9 Short-time parallel

If *Overlap* (menu 2760) is *On*, the controller enforces a maximum paralleling time for the generator and mains supply. This is used to meet local requirements for short-time parallel. The overlap function is only available in automatic mains failure and load takeover modes.



When the generator breaker is closed, the mains breaker is opened automatically before the timer runs out (t). Similarly, when the mains breaker is closed, the generator breaker is opened before the timer runs out (t). The timer is configurable (0.10 to 99.90 seconds).

NOTE The timer is a maximum time. The two breakers are never both closed for longer than the set point.

7.10 Generator PID controller

7.10.1 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.

7.10.2 Regulators

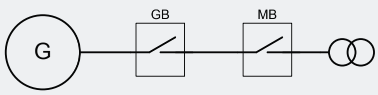
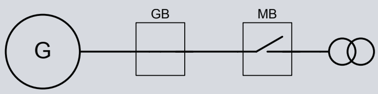
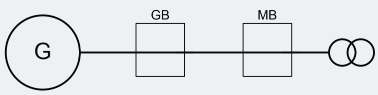
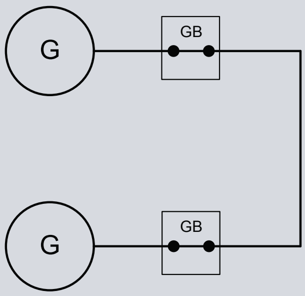
There are three regulators for the governor regulation and also three regulators for the AVR regulation.

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	
●			●			
●			●			
	●			●		
		●			●	

7.10.3 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

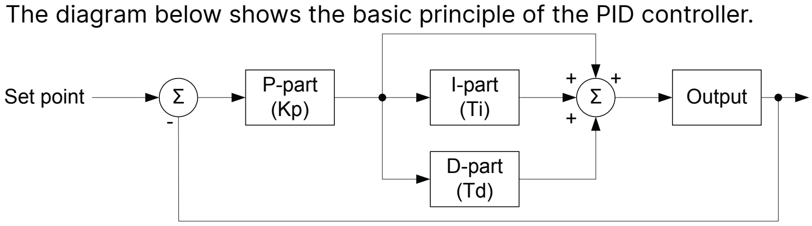
	Generator breaker open Island	Generator breaker closed but not parallel to grid Load share	Generator parallel to grid Mains parallel
Fixed frequency (f-controller)	●		
kW sharing with fixed frequency (P LS-controller)		●	
Fixed kW (P-controller)			●

AVR

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

7.10.4 Principle diagram

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



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

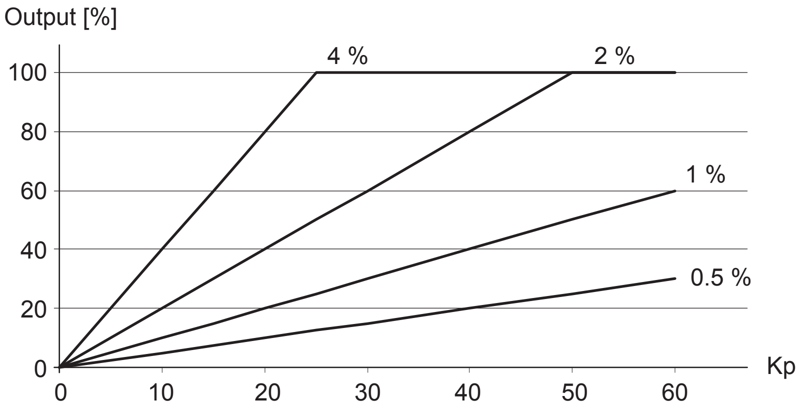
Each regulator (P, I and D) gives an output which is summarised to the total controller output. The adjustable settings for the PID controllers are:

- 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.

7.10.5 Proportional part of the regulator

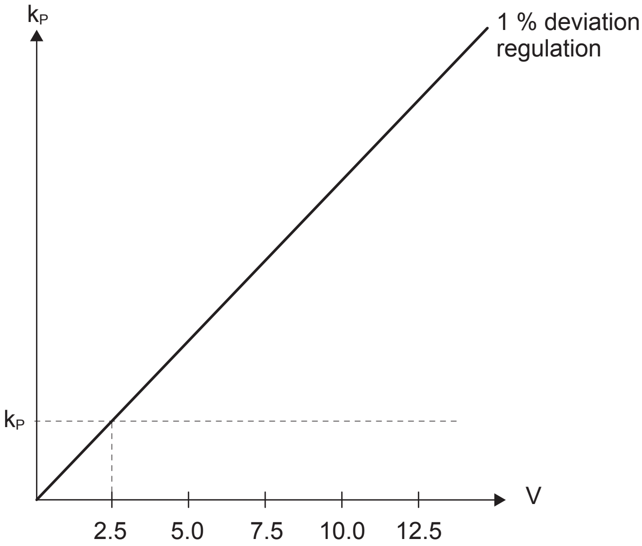
When the regulation deviation occurs, the proportional part causes an immediate change of the output. The size of the change depends on the gain Kp.

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.



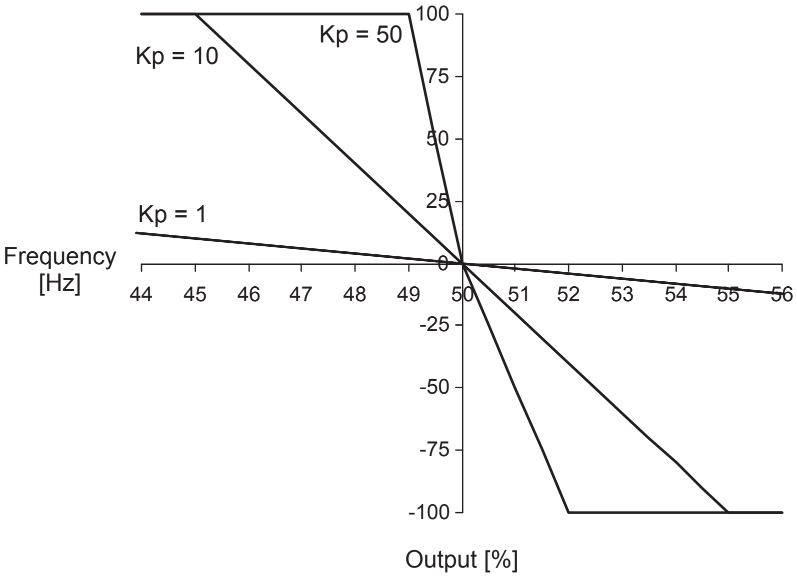
A 1 % regulation deviation occurs. With the Kp setting adjusted, the deviation causes the output to change 2.5 V. The table shows that the change in the output of the controller is relatively high if the maximum speed range is low.

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

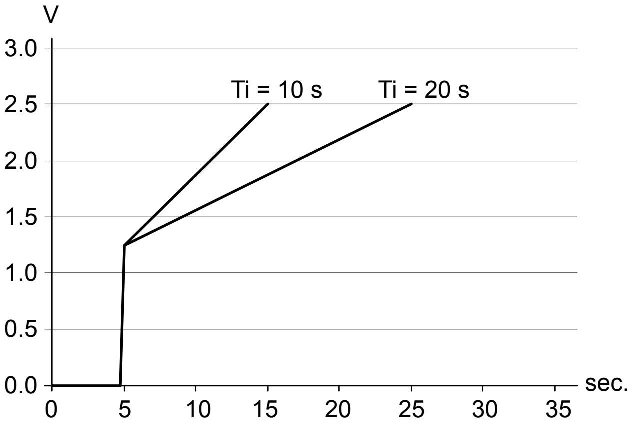
The diagram below shows the dynamic regulation area at given values of Kp. The dynamic area gets smaller if the Kp is adjusted to a higher value.



7.10.6 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.

7.10.7 Differential part of the regulator

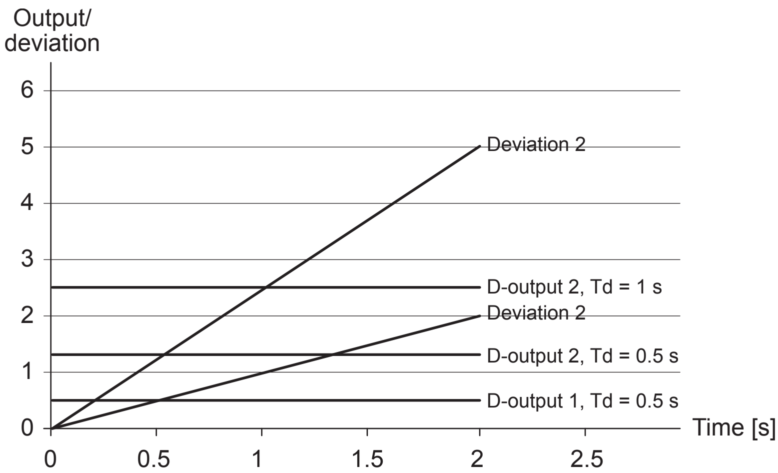
The main purpose of the differential regulator part is to stabilise the regulation, thus making it possible to set a higher gain and a lower integral action time Ti. This will make the overall regulation eliminate deviations much faster.

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.

7.10.8 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	Frequency controller Kp	0.00 to 60.00	2.50
2512	Frequency controller Ti	0.00 to 60.00 s	1.50 s
2513	Frequency controller Td	0.00 to 2.00 s	0.00 s
2514	Droop	0.0 to 10.0 %	4 %

Generator > AVR > Voltage PID > Island

Parameter	Text	Range	Default
2641	Voltage controller Kp	0.00 to 60.00	2.50
2642	Voltage controller Ti	0.00 to 60.00 s	1.50 s
2643	Voltage controller Td	0.00 to 2.00 s	0.00 s
2644	Droop	0.0 to 10.0 %	4 %

Engine > Speed control > Speed PID > Island

Parameter	Text	Range	Default
2571	Frequency controller - Relay regulation - deadband	0.2 to 10.0 %	1.0 %
2572	Frequency controller - Relay regulation - Kp	0 to 100	10
2573	Droop	0.0 to 10.0 %	4.0 %

Engine > Speed control > Speed PID > Island

Parameter	Text	Range	Default
2691	Voltage controller - Relay regulation - deadband	0.0 to 10.0 %	2.0 %
2692	Voltage controller - Relay regulation - Kp	0 to 100	10
2693	Droop	0.0 to 10.0 %	4.0 %

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

Parameter	Text	Range	Default
2741	Delay timer	0 to 9900 s	3 s
2742	Output A	Relays and M-Logic	Not used
2743	Output B	Relays and M-Logic	Not used
2744	Enable	OFF ON	OFF

7.10.9 Parallel to grid controllers

When the controller is parallel to the grid, it switches to using the parallel controllers. When the genset is parallel to the grid, the controller does not share the load like normal, but instead receives the power and cos phi set point from the mains controller, or instead uses the set points located in the genset controller.

When the mains breaker has just been closed, by default the controller uses power ramps when tuning up the power. So the regulators use this ramp when increasing in power towards the power set point. When the controller has ramped up the power of the genset to the set point, the regulator is used for keeping it at the set point. So it is possible to have aggressive regulators for parallel controllers, but it ramps up the power slowly. If the regulators have been tuned aggressively, the controller is able to follow the power ramp when ramping up or down, even though the grid frequency or voltage is fluctuating.

Engine > GOV > Speed PID > Mains parallel

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

Generator > AVR > Voltage PID > Mains parallel

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

7.10.10 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
2001	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	Frequency sync. controller Kp	0.00 to 60.00	2.50
2042	Frequency sync. controller Ti	0.00 to 60.00 s	1.50 s
2043	Frequency sync. controller Td	0.00 to 2.00 s	0.00 s
2050	Frequency sync. controller –Relay f Kp	0 to 100	10

Static synchronisation

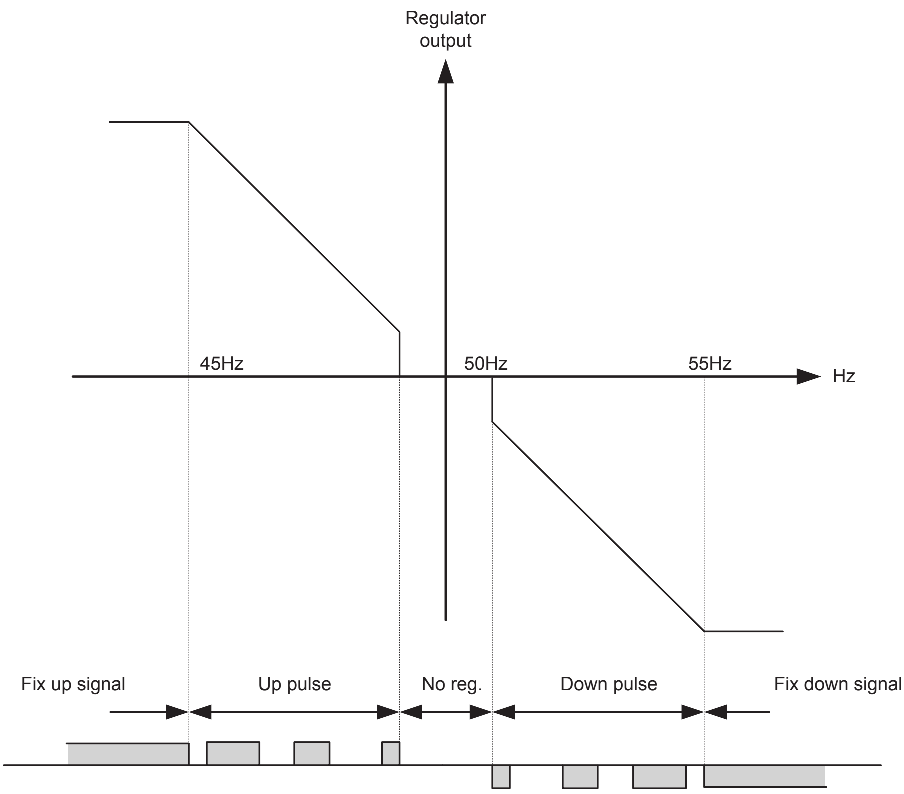
When synchronising is started, the synchronising controller f_{SYNC} controller is activated and the generator frequency is controlled towards the busbar/mains frequency. The phase controller takes over when the frequency deviation is so small that the phase angle can be controlled.

`Synchronisation > Static sync > Sync. regulator`

Parameter	Text	Range	Default
2061	Static phase Kp	0.00 to 60.00	0.50
2062	Static phase Ti	0.00 to 60.00 s	3.00 s
2063	Static phase Td	0.00 to 2.00 s	0.00 s
2070	Static phase –Relay phase Kp	0 to 100	10

7.10.11 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.

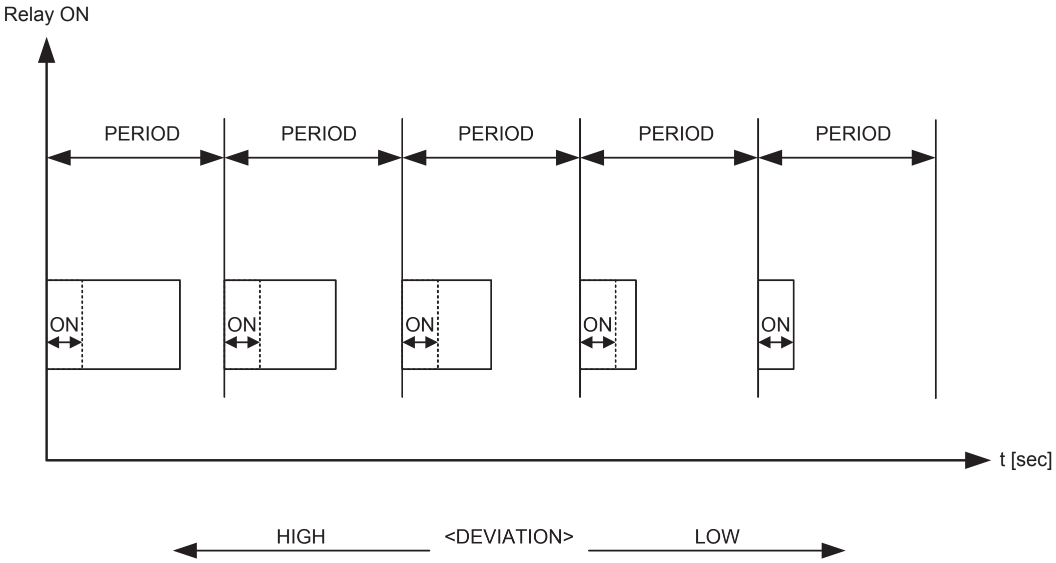
As the diagram shows, the relays are fixed ON if the regulation deviation is big, and they pulse if it is closer to the set point. In the dynamic range, the pulses get shorter and shorter when the regulation deviation gets smaller. Just before the deadband area, the pulse is as short as it can get. This 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.

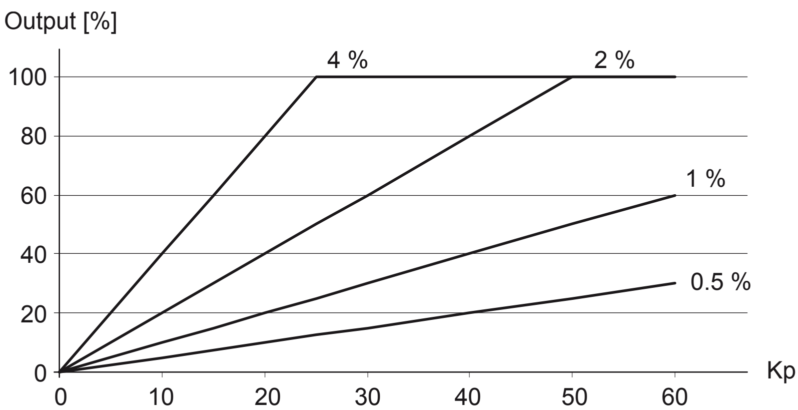
Adjustment	Description	Note
Period time	Maximum relay time	The time between the start of two subsequent relay pulses.
ON time	Minimum relay time	The minimum length of the relay pulse. The relays are never activated for a shorter time than the ON time.

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.

7.11 Power ramp

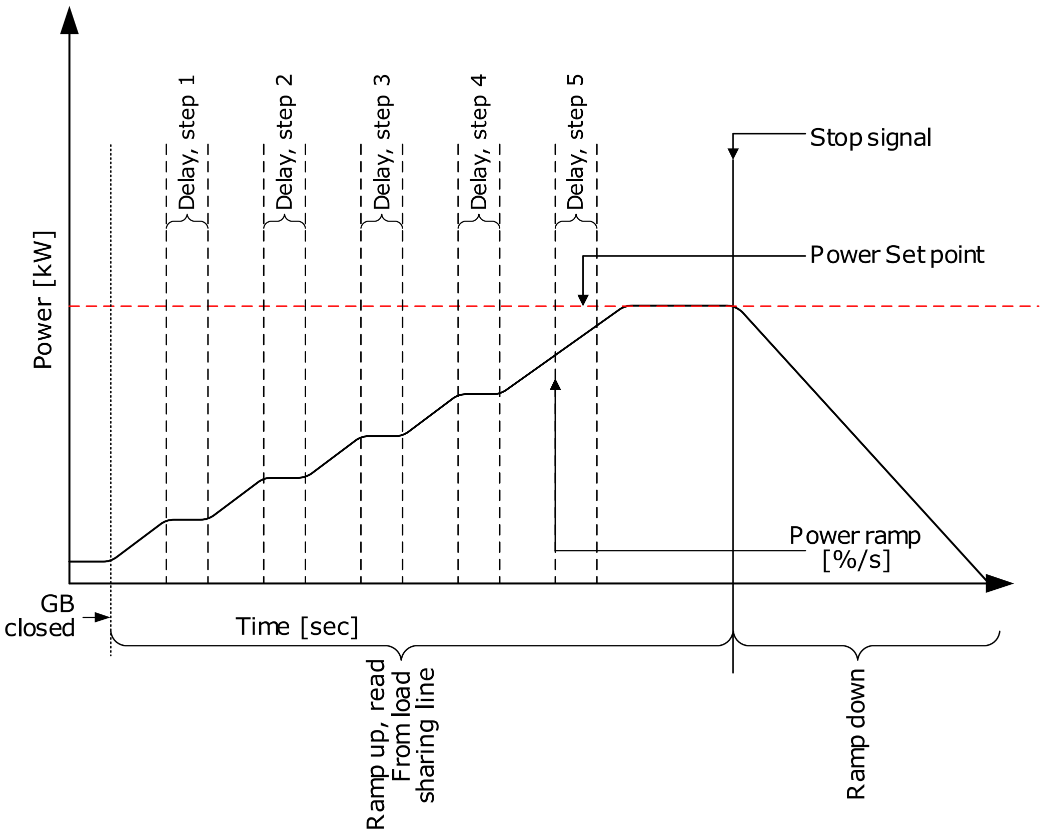
The power ramp function is used to ramp up or down towards the set points. For example, when a breaker has just been closed, and a genset is parallel to the grid. The power ramp then ramps up towards the power set point.

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	Power ramp up island ramp	OFF	OFF

Parameter	Text	Range	Default
		ON	
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.

7.12 Droop mode

7.12.1 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.

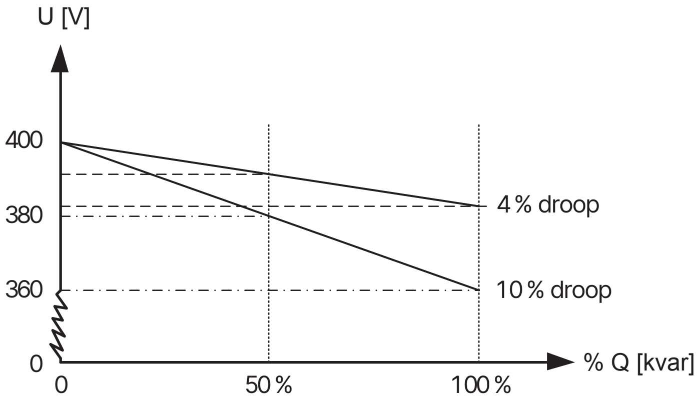
Application configuration

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.

7.12.2 Voltage droop example

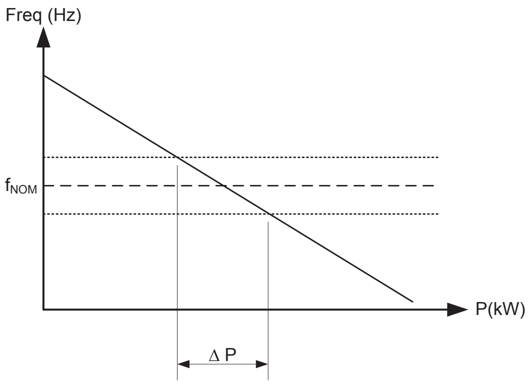
The diagram below shows an example for one generator where the voltage droop setting is 4 % and 10 % in proportion to the reactive power, Q (kvar). As it is shown in the example, the voltage drops as the load increases. The principle is the same with generators in parallel where the generators will use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



7.12.3 Droop settings

High droop setting

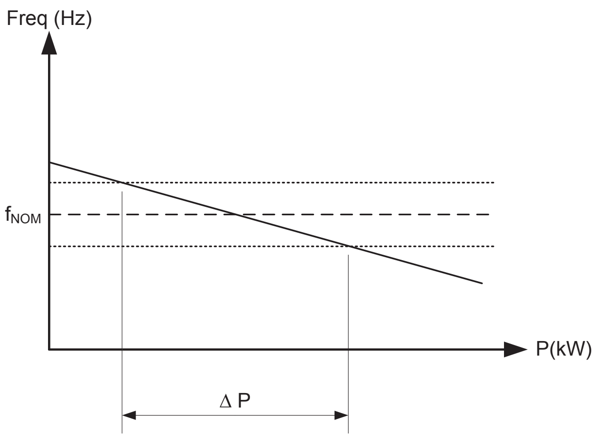
The diagram below shows how a frequency variation gives a change in the load. The principle is the same with voltage regulation. The load change is marked as ΔP.



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.

7.12.4 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.

7.13 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	30 to 100 %	80 %
6383	Load shedding trip timer	1 to 100 s	5 s
6384	Load adding return	30 to 100 %	70 %
6385	Load adding return timer	1 to 100 s	5 s
6386	Enable load shedding/adding	OFF ON	OFF

7.14 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.

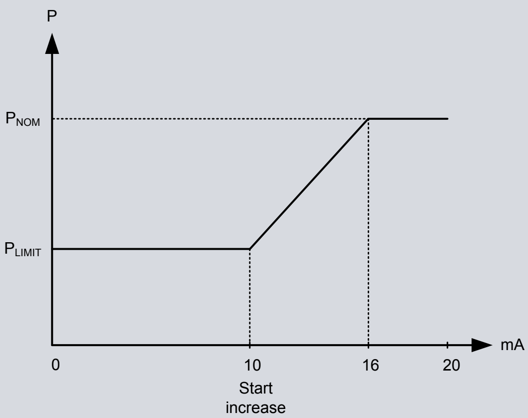
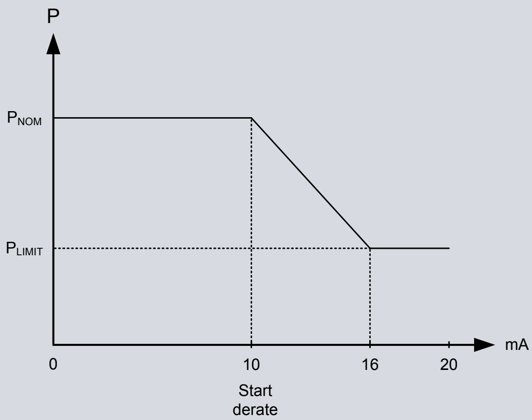
Up to three power derate curves and two reactive power curves can be made to derate the genset. The first active curve will derate the genset to the adjusted set point.

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

7.14.1 Power derate parameters (P-derate)

The parameters that define the power derate characteristics are:

<table>
<tr><th>Parameter name</th><th colspan="2">Description</th></tr>
<tr><td>Start derate point</td><td colspan="2">Starting point for the derate. Depending on the input, the unit can be 4-20 mA or °C (max. 200 °C).</td></tr>
<tr><td>Derate slope</td><td colspan="2">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 %/°C.
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.</td></tr>
<tr><td rowspan="2">Derate limit</td><td colspan="2">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).</td></tr>
<tr><td>Proportional

</td><td>Inverse proportional

</td></tr>
</table>

`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

Parameter	Text	Range	Default
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 %

7.15 GB close before excitation

The controller can be configured to start the genset with the excitation switched off. When the gensets are started, the breakers will be closed and the excitation started.

With the *Close before excitation* function, it is possible to close the breaker before the engine is started, which make the gensets ready for the load very quickly. All gensets will be connected to the busbar, as soon as they are started, and when the excitation is switched on, the gensets are ready for operation.

This function makes the synchronisation faster, because the breakers will not be closed until the generator voltage is in the synchronised position.

The *Close before start* function can also be used, if the load requires a "soft" start. This can be the case, when the gensets connect to a transformer.

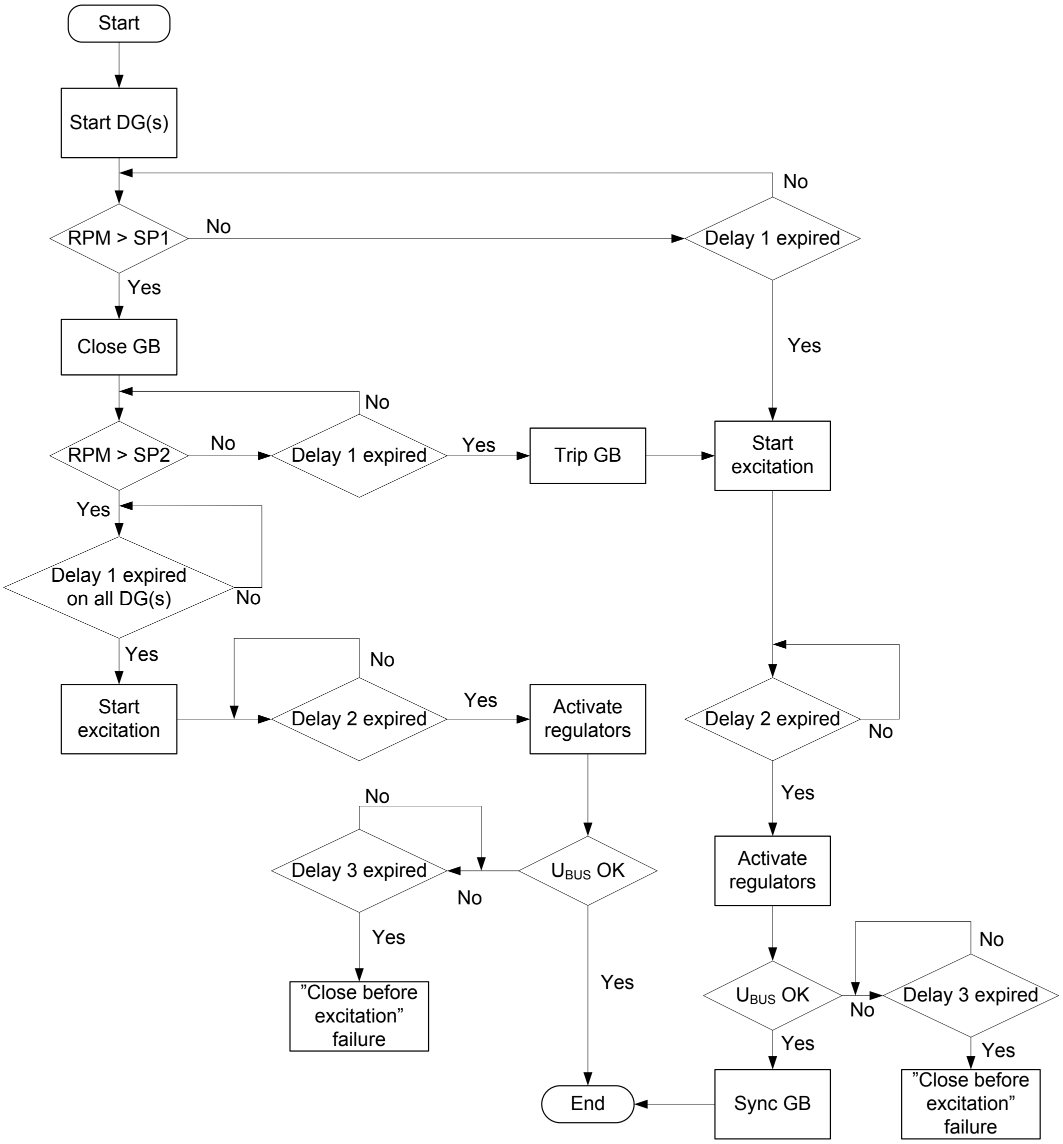
As soon as the excitation is activated, the generators will equalise the voltage and frequency, and will eventually run in a synchronised system. When the excitation is activated, the regulators of the controller will be switched on after an adjustable delay.

The excitation must be increased slowly when this function is used, and it can only be used with a magnetic pick-up or J1939 speed signal.

The principle is described in the following flowcharts.

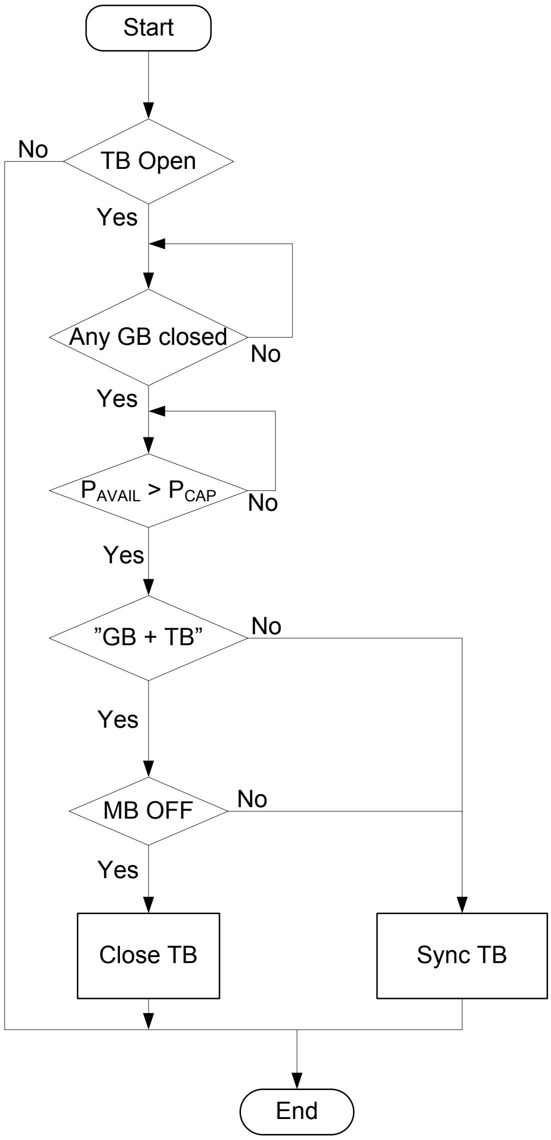
Abbreviations:
- Delay 1 = Menu 2252
- Delay 2 = Menu 2262
- Delay 3 = Menu 2271
- SP1 = Menu 2251
- SP2 = Menu 2263

GB handling



Start
Start DG(s)
RPM > SP1
No
Delay 1 expired
No
Yes
Yes
Close GB
RPM > SP2
No
Delay 1 expired
No
Yes
Trip GB
Start excitation
Yes
Delay 1 expired on all DG(s)
No
Yes
Start excitation
Delay 2 expired
No
Yes
Activate regulators
Delay 2 expired
No
Yes
Activate regulators
Delay 3 expired
No
No
U_{BUS} OK
Yes
Yes
"Close before excitation" failure
U_{BUS} OK
No
Delay 3 expired
No
Yes
Yes
End
Sync GB
"Close before excitation" failure

TB handling

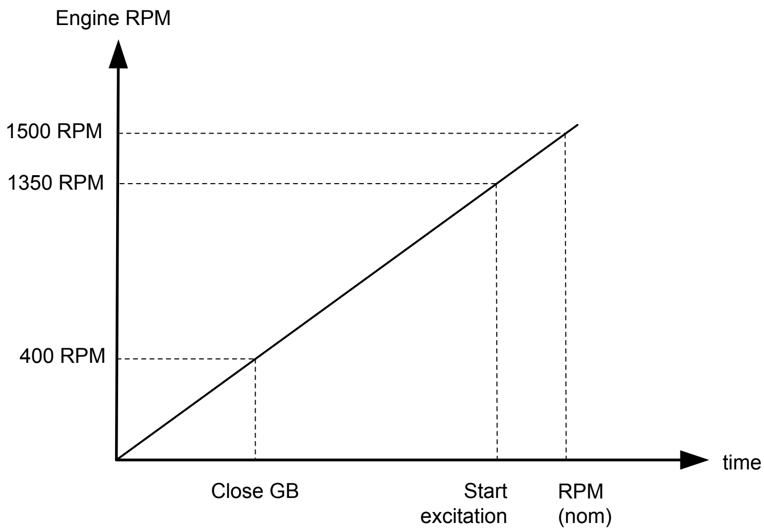


7.15.1 Genset start actions

The start sequence of the controller is changed for *Close before excitation*.

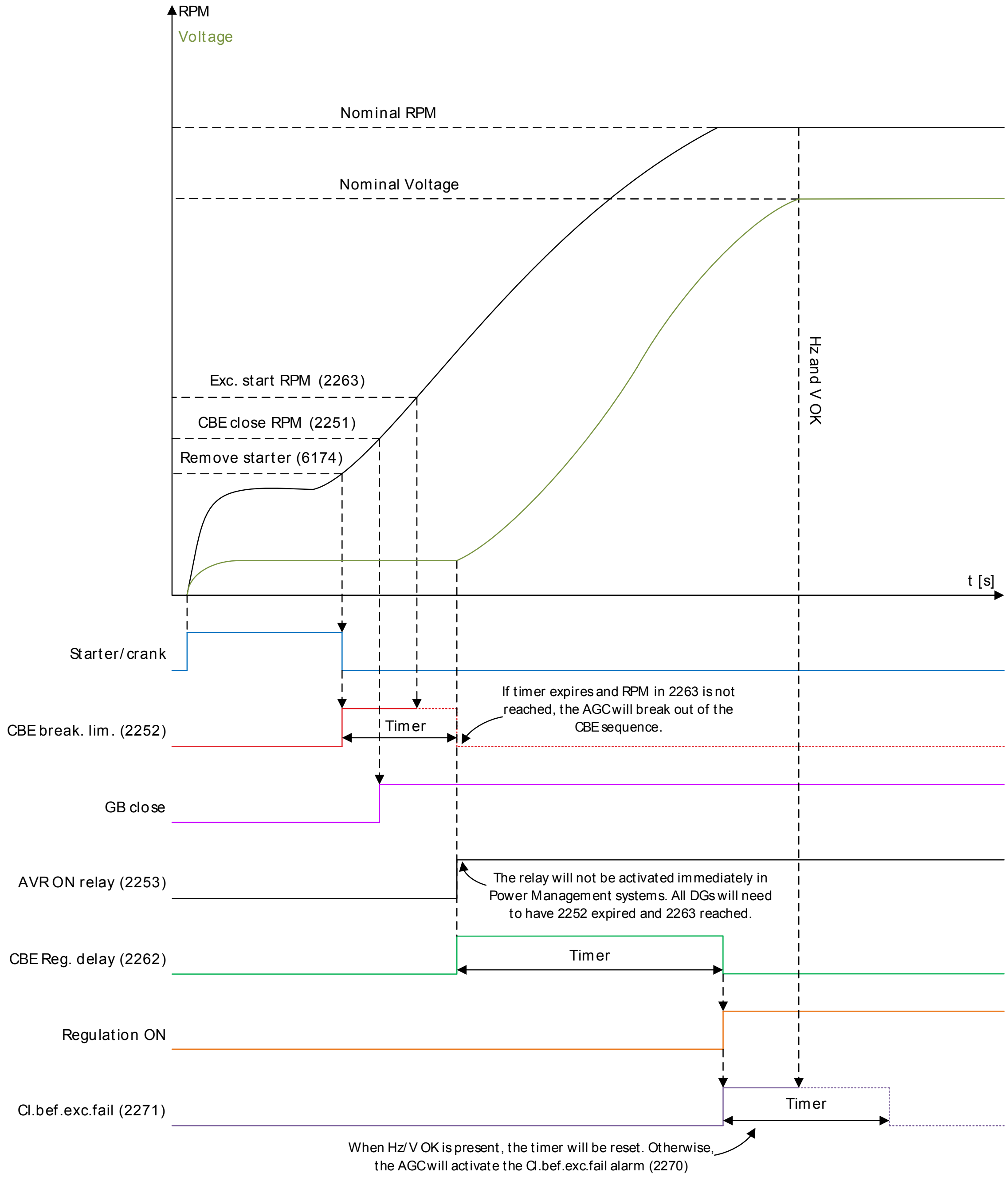
Genset start sequence settings

Parameter	Text	Description
2251	RPM set point	The generator breaker will close at the adjusted level. The range is from 0-4000 RPM. If adjusted to 0, the breaker closes when the start command is given. In the example below, the setting is adjusted to 400.
2252	RPM timer	The genset must reach the set point within the adjusted delay. When the delay expires and the RPM is above the set point, the excitation will be started. If the RPM is below the set point, the GB will be tripped.
2253	Output A	Select the relay output that must be used to start the excitation. Configure the relay to be a limit relay in the I/O & Hardware setup.



The diagram above shows that the GB will be closed at 400 RPM. When the engine RPM has reached the set point (1350 RPM), the excitation is switched on.

The different parameters and timers will be activated and deactivated at different levels and times. This gives the possibility to make the *Close before excitation* sequence so it matches the application. An overview of the *Close before excitation* sequence is shown below:



Settings > Synchronisation > CBE

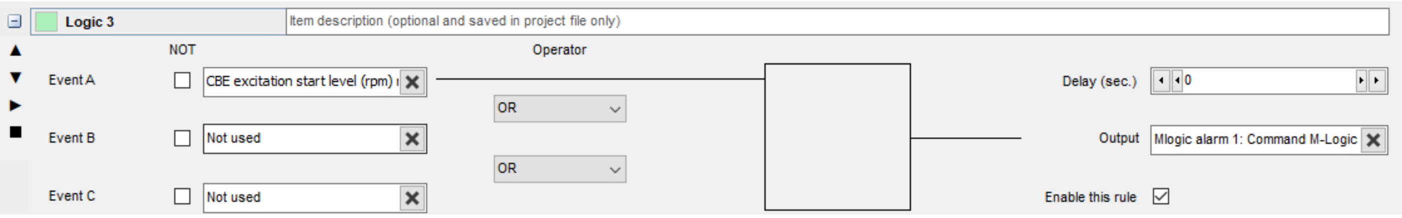
Parameter	Text	Range	Default
2251	Close breaker RPM	0 to 4000 rpm	400 rpm
2252	CBE release	0.1 to 999.0 s	5.0 s
2253	Output A	Relays and M-Logic	Not used
2254	Enable	OFF ON	OFF
2261	Close GB sequence	Close GB Close GB+TB	Close GB
2262	CBE regulation delay	0.0 to 999.0 s	5.0 s
2263	CBE excitation start relay	0 to 4000 rpm	1450 rpm
2264	Voltage discharge	1.0 to 20.0 s	5.0 s

Parameter	Text	Range	Default
2265	Voltage re-run level	30 to 100 %	30 %
2266	Excitation control cooldown	Exc. follow busbar voltage Exc. constant ON	Exc. follow busbar voltage

CBE excitation event (M-Logic)

Use the *CBE excitation start level (rpm) reached* event in M-Logic to activate an alarm when the excitation is started. This is when the genset has reached the RPM set point (2263) within the adjusted delay (2252).

M-Logic CBE event example



7.15.2 Breaker sequence

The GB close before start function can be used in different applications, such as:

1. Stand-alone applications.
2. Power management application without tie breaker.
3. Power management application with tie breaker.

Breaker sequence settings

Parameter	Text	Description
2261	Breaker selection	Select breakers to close: GB or GB + TB.
2262	Timer	The timer defines the period from the excitation is started and until the regulation is activated. The alarms with inhibit set to *Not run status* are activated after this timer has expired.
2263	Excitation start level	The setting defines at what level of RPM the excitation is started.
2264	Voltage discharge	This timer delays the closing of the GB after removing excitation. The intention of this delay is to let the voltage of the generator discharge, so that only residual voltage is present when the GB is closed.

7.15.3 Close before excitation – additional control parameters

If the application has been configured to use Close Before Excitation (CBE) during the genset start, the controller can do additional things to handle the sequence correctly.

If, for example, the application is backup power (AMF), you can select what the controller should do during cooldown. For example, if a new start request comes during cooldown (rerun), the genset(s) can do the CBE sequence again without stopping the genset(s).

Excitation control during cooldown

In parameter 2266 (ExcCtrl cooldwn), you can select how the controller should react during cooldown:

- **Excitation follow U busbar** (default): If there is voltage on the busbar during the genset cooldown, the excitation is ON. If the voltage on the busbar disappears, the excitation is shut OFF.
- **Excitation constant ON**: The excitation is ON until the genset stops or a new start request comes. This can be useful if the genset voltage drives the genset fans.

- **Excitation constant OFF**: The excitation is switched OFF as soon as the GB is open during cooldown. This can be useful if the genset mechanically pulls the genset fans. Then the genset can rerun faster.

NOTE The parameter is not shared between the gensets.

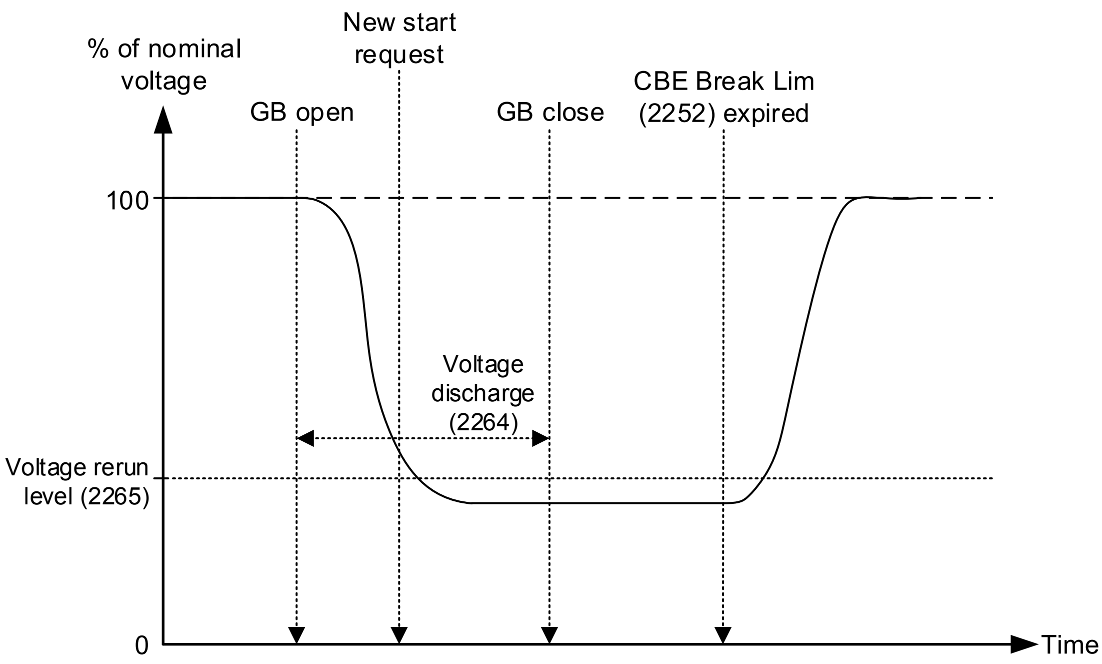
Voltage rerun level

In parameter 2265 (Volt. rerun levl), select how low the voltage must be, before the controller can close the breaker during the rerun. If the voltage is not below the voltage rerun level before the voltage discharge timer (parameter 2264) has expired, the genset is excluded from the CBE rerun sequence.

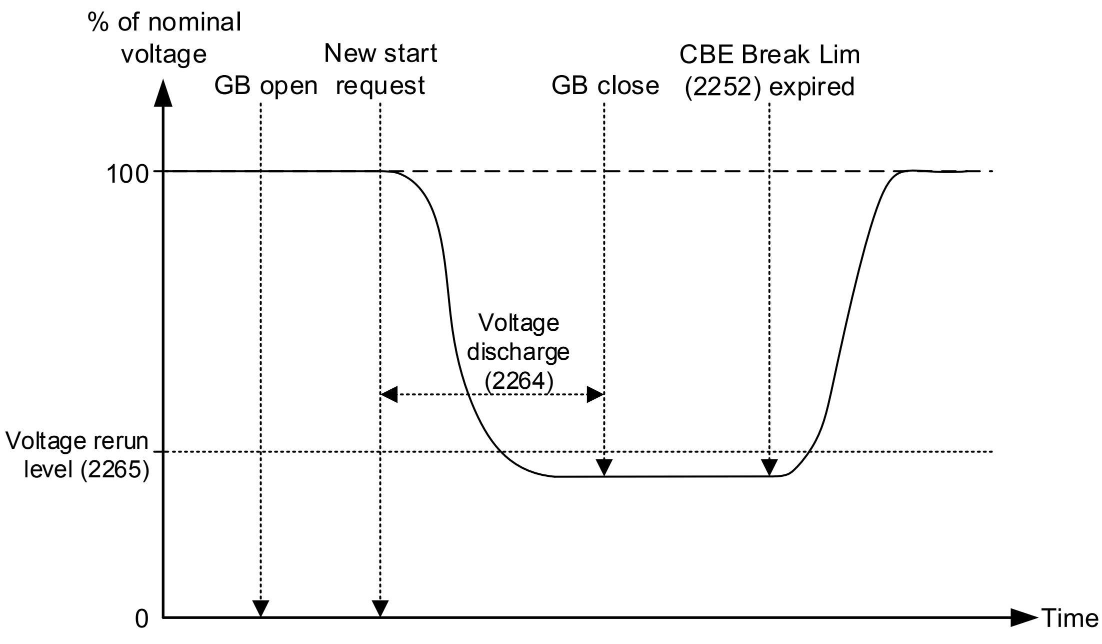
Parameter	Name	Range	Default	Note
2265	Voltage rerun level	30 to 100 %	30 %	The parameter is not shared between gensets.

Voltage discharge timer

The voltage discharge timer (parameter 2264) determines how much time is required from when the excitation is removed until the voltage is below the voltage rerun level. The voltage discharge timer can be started by a new start request or when the generator breaker opens. The reactions depend on the selection for excitation control during cooldown. The two rerun sequence examples are shown below.



In the diagram above, the excitation is shut off as soon as the breaker is opened. Soon after the breaker is opened, a new start request appears. The controller delays closing the GB until the voltage discharge timer has expired.



In the diagram above, the excitation is ON during cooldown. When a new start request is made, the excitation is shut off. When the excitation is shut off, the voltage discharge timer starts.

The first example is the fastest, because the excitation is already off when the start request appears. If the new start request appeared a little later, the voltage discharge timer could already have expired. This means that the generator breaker could close very shortly after the new start request.

Parameter	Name	Range	Default	Note
2264	Volt. discharge	1.0 to 20.0 s	5.0 s	The parameter is not shared between gensets.

7.15.4 Close before excitation failure

If start up of the genset does not succeed, an alarm will occur, and the selected fail class will be executed.

`Synchronisation > CBE > CBE fail`

Parameter	Text	Range	Default
2271	CBE Timer	0.0 to 999.0 s	5.0 s
2272	Output A	Relays and M-Logic	Not used
2273	Output B	Relays and M-Logic	Not used
2274	CBE Enable	OFF ON	OFF
2275	Fail class	Fail classes	Warning

Close before excitation re-run failure

If the re-run does not succeed within the configured time, the controller activates the *CBE Re-run fail* alarm (menu 2230).

Frequency or voltage failure

If there is no excitation, the controller will not activate the *Hz/V failure* alarm (menu 4560) during a CBE cooldown.

7.16 4th current transformer input

The 4th current transformer input (terminals 60-61) can be used for one of these functions:

- **Mains power measurement**: Place the CT on L1 of the mains connection.

> **More information**
> See **Single generator with mains power measurement**.

- **Neutral line over-current protection**: Place the CT on the N line from the genset. The 4th current transformer input is used for this function when this protection is enabled. See Neutral inverse time over-current (ANSI 51N).
- **Generator earth current (ground fault)**: Place the CT on the generator star point ground connection. The function includes third harmonics filtering of the signal. The 4th current transformer input is used for this function when this protection is enabled. See Earth fault inverse time over-current (ANSI 51G).

`Basic settings > Measurement setup > Current transformer > 4th CT`

Parameter	Text	Range	Default
6045	I primary E/N/M	5 to 9000 A	1000 A
6046	I secondary E/N/M	1 A 5 A	1 A

7.17 Inputs and outputs

7.17.1 Digital input functions

Default

Function	Details	AUTO mode	SEMI-AUTO mode	Test mode	Man. mode	Block mode	Type *
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	SEMI-AUTO mode	Test mode	Man. 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
Auto start/stop	The genset starts when this input is activated. The genset stops if the input is deactivated. The input can be used when the controller is in Island operation, Fixed power, Load take-over, or Mains power export and the Auto running mode is selected.	●					C
Remote start	This input initiates the start sequence of the genset when SEMI-AUTO or Manual mode is selected.		●		●		C
Remote stop	This input initiates the stop sequence of the genset when SEMI-AUTO or Manual mode is selected. The genset stops without cooling down.		●		●		C

Function	Details	AUTO mode	SEMI-AUTO mode	Test mode	Man. mode	Block mode	Type *
Alternative start	This input is used to simulate an AMF failure and this way run a full AMF sequence without a mains failure actually being present	●	●	●	●	●	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
Remote GB ON	The generator breaker close sequence is initiated and the breaker synchronises if the mains breaker is closed, or close without synchronising if the mains breaker is open.		●				P
Remote GB OFF	The generator breaker open sequence is initiated. If the mains breaker is open, then the generator breaker opens instantly. If the mains breaker is closed, the generator load is deloaded to the breaker open limit followed by a breaker opening.		●				P
Remote MB ON	The mains breaker close sequence is initiated and the breaker synchronises if the generator breaker is closed, or close without synchronising if the generator breaker is open.		●				P
Remote MB OFF	The mains breaker open sequence is initiated, and the breaker opens instantly.		●				P
GB close inhibit	When this input is activated, the generator breaker cannot close.	●	●	●	●	●	C
MB close inhibit	When this input is activated, the mains 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
MB 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
MB 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
Enable sep. sync	Activate to split the breaker close and the breaker synchronisation functions in two different relays. The breaker close function remains on the relays dedicated for breaker control. The synchronisation function is moved to a configurable relay.	●	●	●	●	●	C

Function	Details	AUTO mode	SEMI-AUTO mode	Test mode	Man. mode	Block mode	Type *
SEMI-AUTO mode	Changes the running mode to SEMI-AUTO.	●		●	●	●	P
Test mode	Changes the running mode to test.	●	●		x	x	P
AUTO mode	Changes the running mode to AUTO.		●	●	●	●	P
Manual mode	Changes the running mode to Manual.		●	●		●	P
Block mode	Changes the running mode to Block.	●	●	●	●		C
Total test	This input is logged in the event log to show that there was a planned mains failure.	●	●	●	●	●	C
Enable mode shift	If there is a mains failure, the input activates the mode shift function, and the controller follows the AMF sequence. When the input is configured, the setting in parameter 7081 (Mode shift) is disregarded.	●	●	●	●	●	C
Deload	A running genset starts to ramp down the power.	●					C
Mains OK	Disables the Mains OK delay timer. The mains breaker can only close if the input is activated.	●	●	●	●	●	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
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
Switchboard error	The input stops or blocks the genset, depending on running status.	●	●	●	●	●	C

Function	Details	AUTO mode	SEMI-AUTO mode	Test mode	Man. mode	Block mode	Type *
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
Base load	The genset runs base load (fixed power) and does not participate in frequency control. Should the plant power requirement drop, the base load is lowered so the other connected generator(s) produce at least 10 % power.		●				C
Ground breaker ON	Feedback from ground breaker when this is active.	●	●	●	●	●	C
Ground breaker OFF	Feedback from ground breaker when this is inactive.	●	●	●	●	●	C
Allow safe regeneration	Refer to the EIC manual for more information.	●	●	●	●		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
Simulate MB close button push	This input is used to simulate the close breaker (mains) button being pushed.		●	●	●		P
Simulate MB open button push	This input is used to simulate the open breaker (mains) 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

7.17.2 Relay output functions

Function	Activated when
Not used	The digital output is not used.
Status ok	The controller status is okay.
Horn	An alarm is activated and not silenced.
Start prepare	The start sequence activates the start prepare.
Starter (Crank)	The start sequence activates the crank.
Run coil	The start sequence activates the run coil.
Stop coil	The stop sequence activates the stop coil.
Double starter	The start sequence activates the double starter.
Siren	An alarm is activated and not silenced.
Load group [1 to 5]	There is enough power available for the load group.
Keyswitch	The AGC has had power for 5 seconds, and the extended stop timer is not running.

7.17.3 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.
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.

Measurement	Notes
DEIF DVC 550 PT100_[1 to 5]	The temperature read by the Pt100 thermocouple in the DVC 550.
EIC Speed (SPN 190)	The EIC engine speed.
MPU speed	The engine speed measured by the MPU connected to the controller.

7.18 Demand of peak currents

It is possible to have two different readings shown in the display:

1. **I thermal demand** shows the average maximum peak current over a time interval.
2. **I max. demand** shows the latest maximum peak current value.

I thermal demand

This measurement is used to simulate a bimetallic system, which is specifically suited for indication of thermal loads in conjunction with for example cables and transformers.

The calculated average is **not** the same as the average current over time. The I thermal demand value is an average of the maximum peak current in the adjustable time interval.

The measured peak currents are sampled once every second, and every six seconds an average peak value is calculated. If the peak value is higher than the previous maximum peak value, it is used to calculate a new average. The thermal demand period will provide an exponential thermal characteristic.

The time interval in which the average maximum peak current is calculated can be adjusted or reset. If the value is reset, it will be logged in the event log and the reading on the display is reset to 0*.

`Generator > Current protections > Peak and Mean values`

Parameter	Text	Range	Default
6841	Timer	0.0 to 20.0 min.	8.0 min.
6842	Reset	OFF ON	OFF

I max demand

When a new maximum peak current is detected, the value is shown on the display, and updated every six seconds. If the value is reset, it will be logged in the event log.

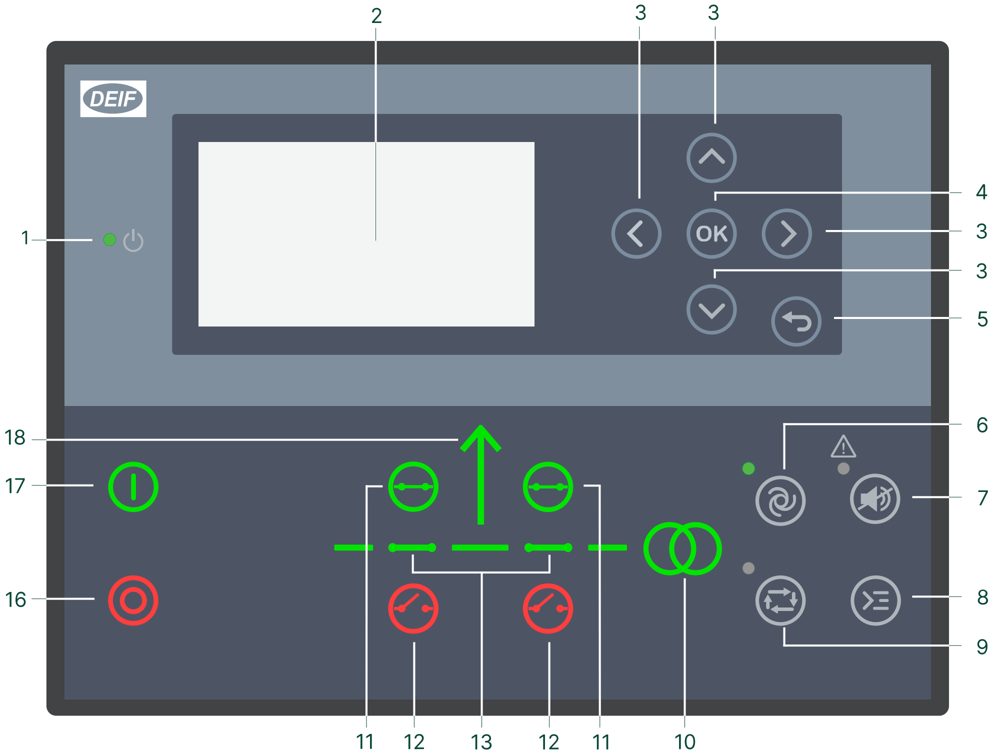
`Generator > Current protections > Peak and Mean values`

Parameter	Text	Range	Default
6843	Reset	OFF ON	OFF

NOTE Both reset functions are also available as commands through M-Logic.

8. Mains functions

8.1 Display, buttons and LEDs



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	Move the selector up, down, left and right on the screen.
4	OK	Go to the Menu system. Confirm the selection on the screen.
5	Back	Go to the previous page.
6	AUTO mode	For mains controllers, the controller automatically connects and disconnects the mains. No operator actions are needed. The controllers use the power management configuration to automatically select the power management action.
7	Silence horn	Stops an alarm horn (if configured) and enters the Alarm menu.
8	Shortcut menu	Access the Jump menu, Mode selection, Test, Lamp test.
9	SEMI-AUTO mode	The operator or an external signal can connect or disconnect the mains. The mains controller cannot automatically connect or disconnect the mains. The controller automatically synchronises before closing a breaker, and automatically deloads before opening a breaker.
10	Mains symbol	Green: Mains voltage and frequency are OK. The controller can synchronise and close the breaker. Red: Mains failure.
11	Close breaker	Push to close the breaker.
12	Open breaker	Push to open the breaker.

No.	Name	Function
13	Breaker symbols	Green: Breaker is closed. Green flashing: Synchronising or deloading. Red: Breaker failure.
16	Stop	Stops the plant.
17	Start	Starts the plant.
18	Load symbol	OFF: Power management application. Green: The supply voltage and frequency are OK. Red: Supply voltage/frequency failure.

8.2 Mains alarms

8.2.1 Fail classes

Fail class/Action	Alarm horn relay	Alarm display	Trip MB	Trip TB
Block	●	●		
Warning	●	●		
Trip TB	●	●		●
Trip MB	●	●	●	
Trip MB/TB*	●	●	●	(●)

NOTE * *Trip MB/TB* only trips the tie breaker if the mains controller is in an application, in which there is no mains breaker. So the fail class does **not** trip both the MB and the TB. If there is a mains breaker configured in the application configuration, the mains controller always only trips the MB if the *Trip MB/TB* fail class is used.

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 MB sequence	Block TB sequence
Block		●
Warning		
Trip TB		●
Trip MB	●	
Trip MB/TB*	●	(●)

NOTE * *Trip MB/TB* only blocks the TB sequence if there is no mains breaker for the present controller.

8.2.2 Inhibits

Function	Notes
Inhibit 1	M-Logic outputs: Conditions are programmed in M-Logic.
Inhibit 2	
Inhibit 3	
TB ON	The tie breaker is closed.
TB OFF	The tie breaker is open.
Mains voltage > 30 %	Mains voltage is above 30 % of nominal.
Mains voltage < 30 %	Mains voltage is below 30 % of nominal.

Function	Notes
MB ON	The mains breaker is closed.
MB OFF	The mains breaker is open.
Parallel	Genset(s) are parallel to grid/utility.
Not parallel	Genset(s) are not parallel to grid/utility.

8.3 Mains breaker

8.3.1 Breaker settings

`Synchronisation > Dynamic sync.`

Parameter	Text	Range	Default
2026	Synchronisation time MB	40 to 300 ms	50 ms

`Breakers > Mains breaker > Breaker configuration`

Parameter	Text	Range	Default
7082	MB close delay	0.0 to 30.0 s	0.5 s
7085	Load time	0.0 to 30.0 s	0.0 s

8.3.2 Breaker sequences

Set points for MB control

Parameter	Text	Description
7081	Mode shift	When enabled, regardless of the actual plant running mode, if there is a mains failure, the controller follows the AMF sequence.
7082	MB close delay	The time from GB/TB OFF to MB ON, when back synchronisation is OFF (only stand-alone or mains controller with MB and TB).
7083	Back Sync.	Enables synchronisation from mains to generator. **With back synchronisation**: When the *GB* or *MB* button is activated, the controller starts synchronising if the generator or mains voltage is present. The GB can close directly if the MB is open, and the MB can close directly if the GB is open. **Without back synchronisation**: The GB can only be closed if the mains breaker is open. The MB can only be closed if the generator breaker is open.
7084	Sync. to mains	Enables synchronisation from generator to mains.
7085	Load time	After opening the breaker, the MB ON sequence is not initiated before this delay has expired.

If there is no MB in the application drawing (see *Application configuration* in the utility software), then the relays for opening/closing and inputs for feedbacks normally used for MB control/supervision become configurable.

`Mains > AMF functions > AMF timers`

Parameter	Text	Range	Default
7081	Mode shift	Mode shift OFF Mode shift ON	Mode shift OFF

`Breakers > Mains breaker > Breaker configuration`

Parameter	Text	Range	Default
7082	MB close delay	0.0 to 30.0 s	0.5 s
7085	Spring load time	0.0 to 30.0 s	0.0 s

`Synchronisation > Mains parallel settings`

Parameter	Text	Range	Default
7083	Back synchronisation	OFF ON	OFF
7084	Synchronisation to mains	OFF ON	ON

AMF MB opening

If the controller operates in Automatic Mains Failure (AMF), it is necessary to select the functionality of the mains breaker opening function. This can be helpful, when the MB can only be operated with voltage on the mains or on the busbar.

`Mains > AMF functions > Start seq. in AMF mode`

Parameter	Text	Range	Default
7065	Start-up fail control	Start engine + open MB Start engine Open MB when eng ready	Start engine + open MB

Mains failure control sequences (parameter 7065)

Setting	Sequence with no failure	Sequence with start failure
Start engine + open MB	1. Mains failure delay timer is running. 2. Mains breaker opens. 3. Engine starts. 4. Volt/Hz OK timer is running. 5. Generator breaker closes.	1. Mains failure delay timer is running. 2. Mains breaker opens. 3. Engine tries to start. 4. Generator start failure.
Start engine	1. Mains failure delay timer is running. 2. Engine starts. 3. Volt/Hz OK timer is running. 4. Mains breaker opens. 5. Generator breaker closes.	1. Mains failure delay timer is running. 2. Engine tries to start. 3. Generator start failure. 4. Mains breaker opens.
Open MB when eng ready (only in genset controller)	1. Mains failure delay timer is running. 2. Engine starts. 3. Volt/Hz OK timer is running. 4. Mains breaker opens. 5. Generator breaker closes.	1. Mains failure delay timer is running. 2. Engine tries to start. 3. Generator start failure. 4. Mains breaker stays closed.

`Mains > AMF functions > AMF timers`

Parameter	Text	Range	Default
7061	U mains failure timer	0.5 to 990.0 s	5.0 s
7062	Mains OK Delay U	2 to 9900 s	60 s
7071	f mains failure timer	0.5 to 990.0 s	5.0 s
7072	Mains OK Delay f	2 to 9900 s	60 s
7081	Mode shift	OFF	OFF

Parameter	Text	Range	Default
		ON	

Mains > Voltage and freq. limits > Voltage settings

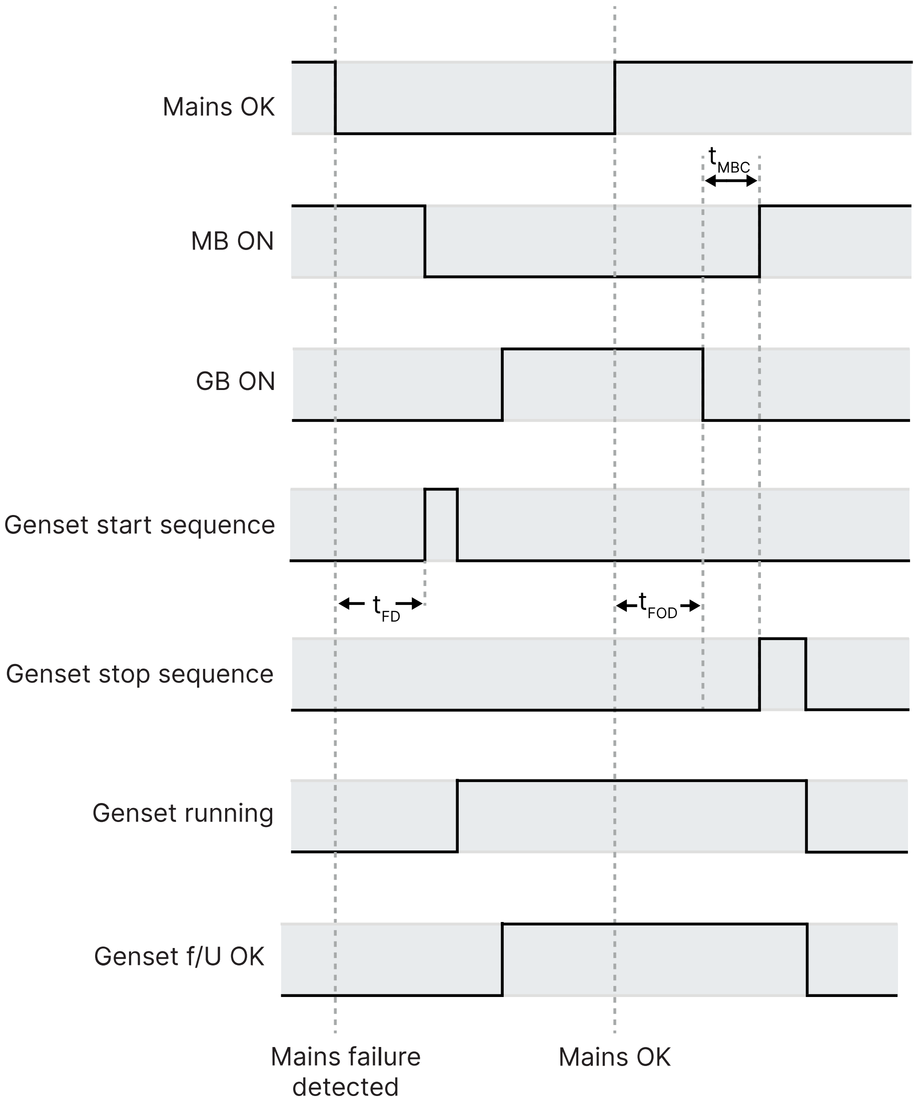
Parameter	Text	Range	Default
7066	U unbalance	2 to 100 %	100 %

Breakers > Mains breaker > Breaker configuration

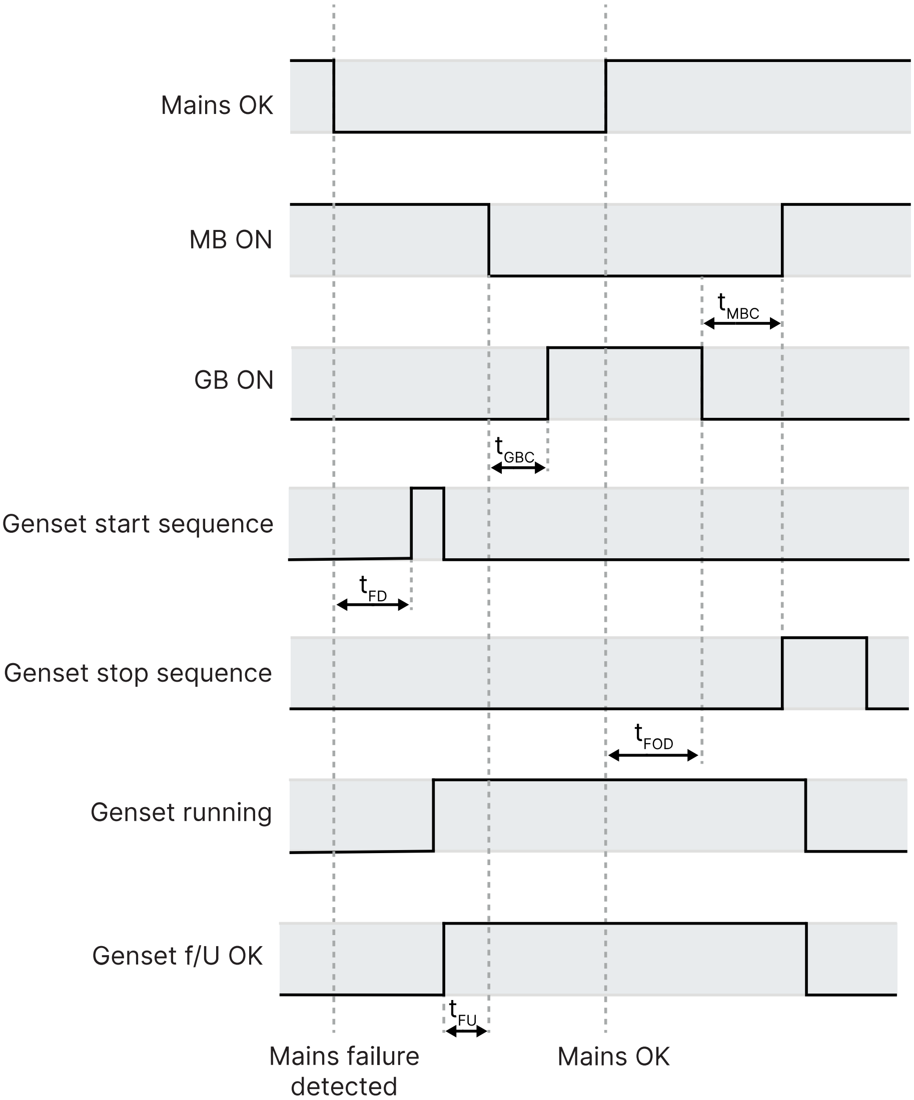
Parameter	Text	Range	Default
7082	MB close delay	0.0 to 30.0 s	0.5 s
7085	Load time*	0.0 to 30.0 s	0.0 s

NOTE * The *Load time* timer is only active if back synchronisation is deactivated.

Example 1: Mains fail control (Start engine and open MB)



Example 2: Mains fail control (Start engine)



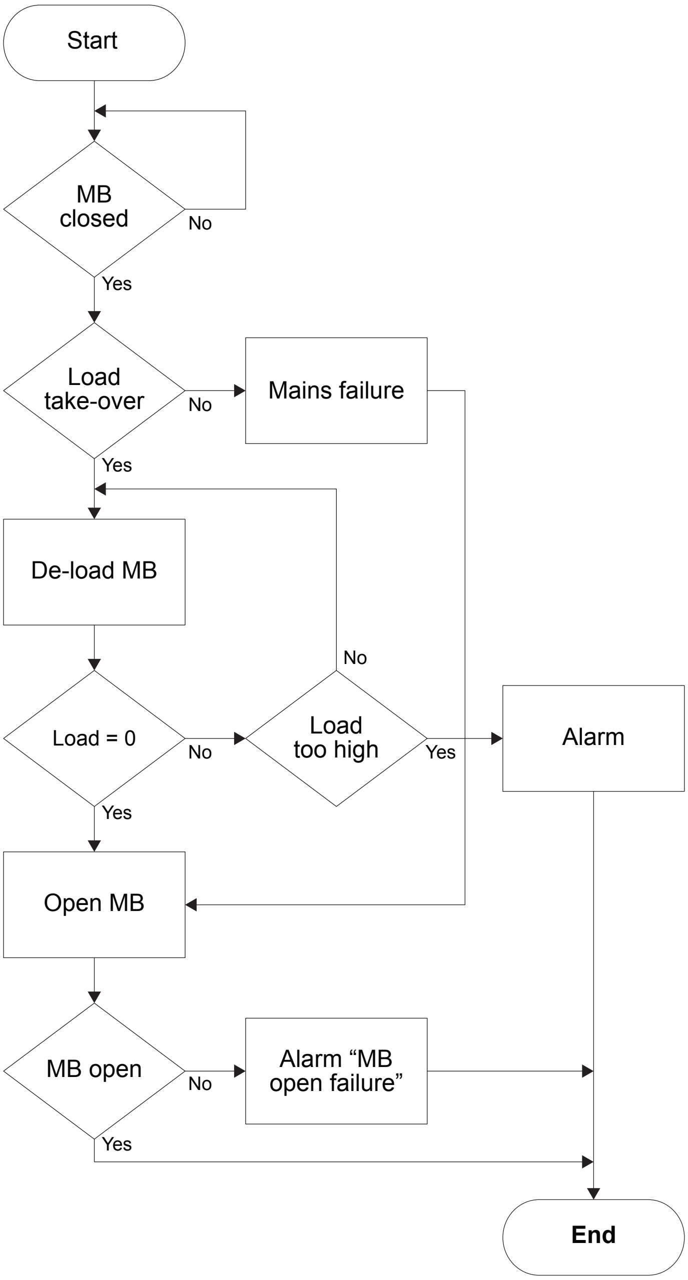
Conditions for breaker operations

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

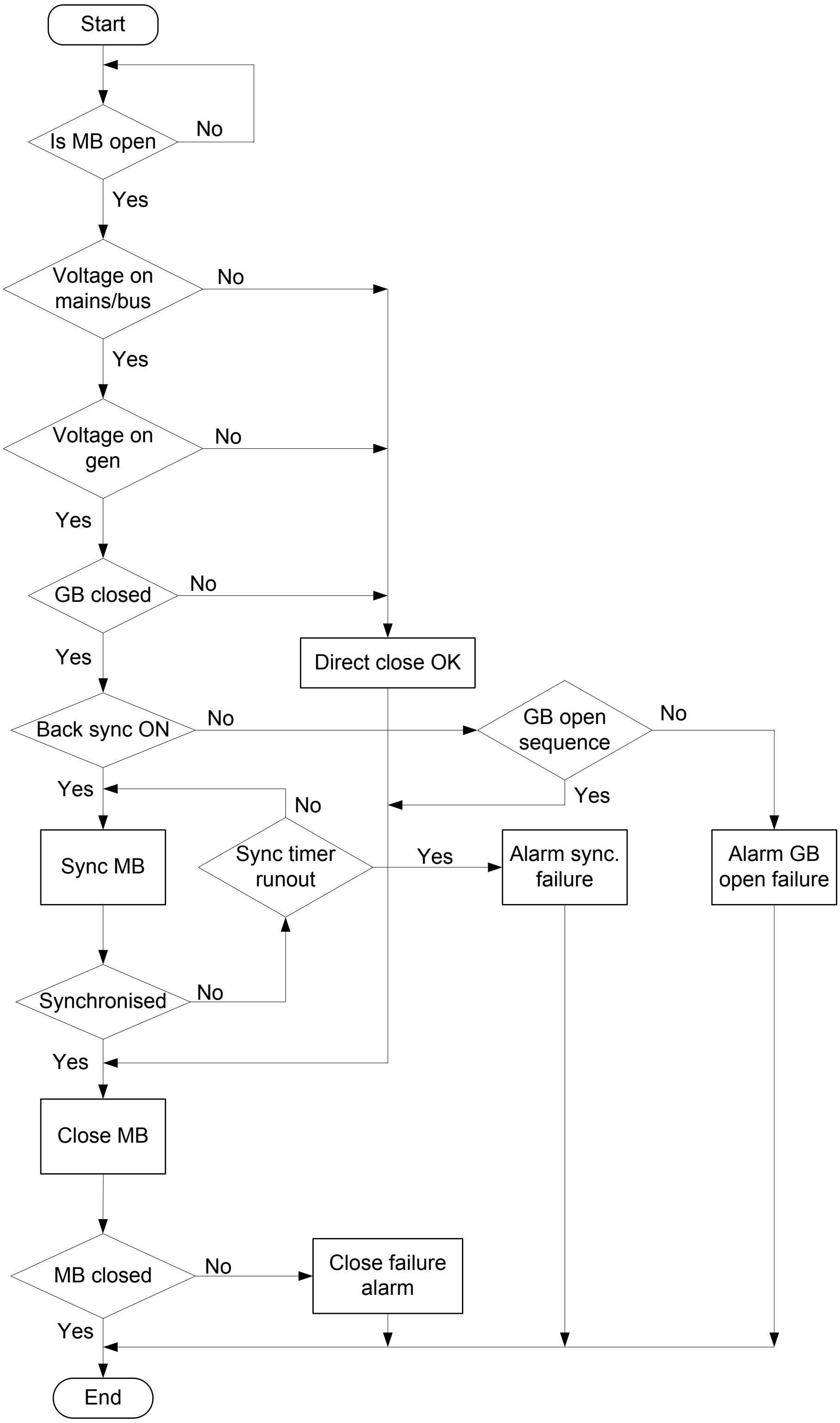
Sequence	Condition
MB ON, direct closing	Mains frequency/voltage OK GB open
MB ON, synchronising	Mains frequency/voltage OK GB closed No generator failure alarms
MB OFF, direct opening	Alarms with fail classes: Shut down or Trip MB alarms
MB OFF, deloading	Alarms with fail class: Trip and stop

8.3.3 Flowcharts

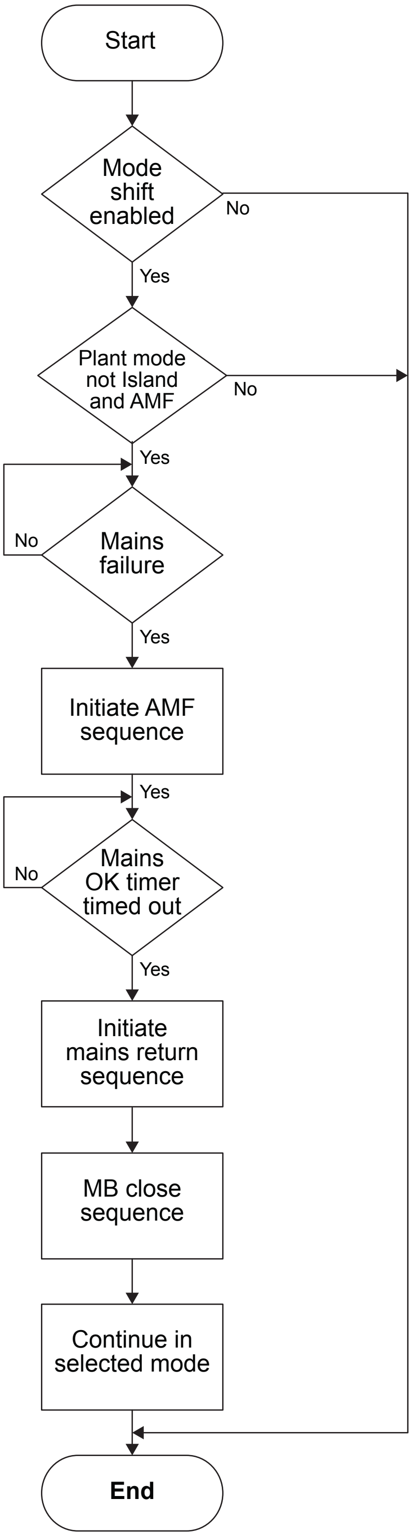
MB open sequence flowchart



MB close sequence flowchart

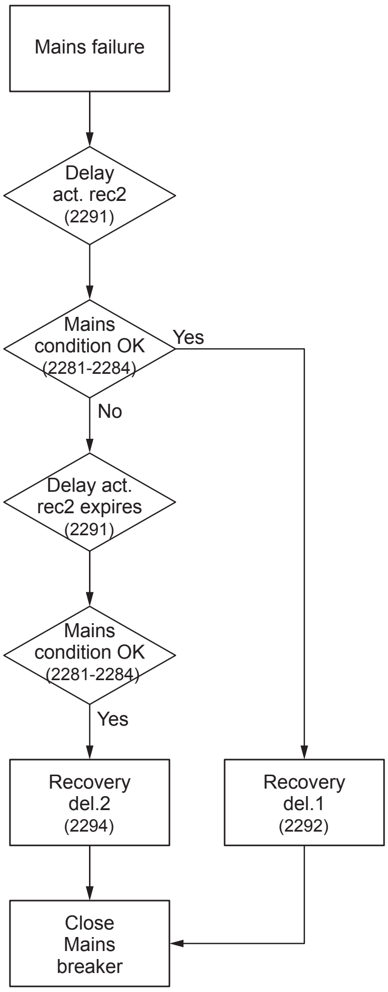


Mode shift flowchart



8.3.4 Inhibit conditions before synchronising mains breaker

This function is used to inhibit the synchronising of the mains breaker after blackout. After blackout a timer will start to run, and if the mains voltage and frequency are inside the limits before the timer runs out, the short interruption timer will be started. When the timer has run out, the synchronising of the MB will start.



`Synchronisation > Mains sync inhibits`

Parameter	Text	Range	Default
2281	Min. voltage, U<	80 to 100 %	85 %
2282	Max. voltage, U>	100 to 120 %	110 %
2283	Min. frequency, f<	90.0 to 100.0 %	95.0 %
2284	Max. frequency, f>	100.0 to 110.0 %	101.0 %
2285	Enable	OFF ON	OFF
2286	Fail class	-	Trip GB

If the Delay activate recovery 2 timer runs out, the long interruption timer will start to run.

`Synchronisation > Mains sync inhibits`

Parameter	Text	Range	Default
2291	Delay activate recovery 2 timer	0.0 to 20.0 s	3.0 s
2292	Recovery delay 1 timer	0.0 to 60.0 s	5.0 s
2294	Recovery delay 2 timer	0.0 to 900.0 s	60.0 s

Example 1: Recovery timer 1 (short interruption timer)

- Delay activate recovery 2 timer = 3 s
- Recovery delay 1 timer = 5 s

- If the short interruption timer is set to ≤ 3 s, and the grid is back and voltage and frequency are inside the acceptable range, then after 5 s the MB can be closed.

Example 2: Recovery timer 2 (long interruption timer)

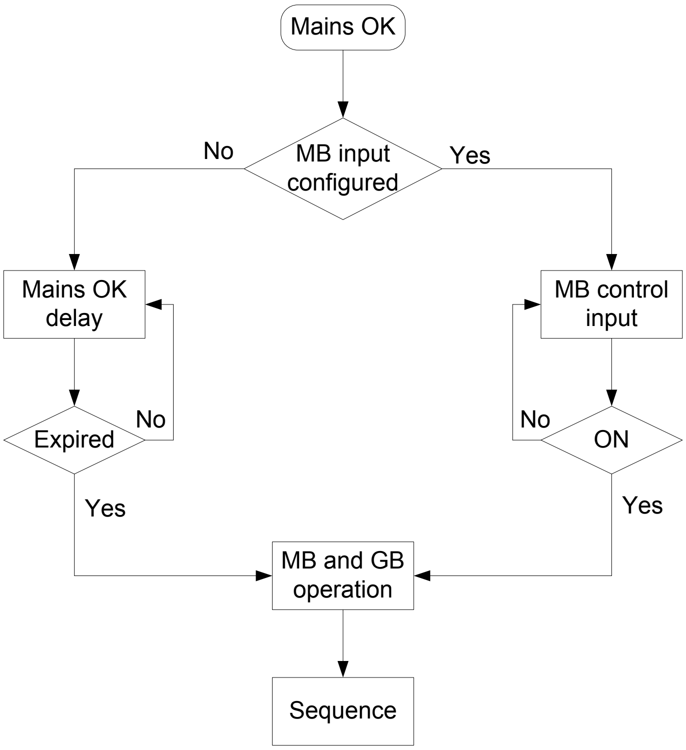
- Delay activate recovery 2 timer = 3 s
- Recovery delay 2 timer = 60 s
- The long interruption timer will allow the MB to reconnect as soon as the mains voltage and frequency have been uninterrupted within the timer setting in Recovery delay 2 timer. Then the MB can be closed.

8.3.5 Digital mains breaker control

The controller normally executes the Automatic Mains Failure sequence based on the parameters in the system setup. Besides these parameters, it is possible to configure the *Mains OK* digital to be used to control the mains return sequence. The purpose of this function is to let an external device (for example, a PLC) or an operator control the mains return sequence.

The flowchart below shows that if the input is configured, it needs to be activated (by a pulse) to start the mains return sequence. The load continues on generator supply if the input is not activated.

The mains OK delay is not used when the *Mains OK* input is configured.



8.3.6 Breaker failures

`Breakers > Mains breaker > Breaker monitoring > MB Open fail`

Parameter	Text	Range	Default
2201	Timer	1.0 to 10.0 s	2.0 s
2202	Output A	Relays and M-Logic	Not used
2203	Output B	Relays and M-Logic	Not used
2204	Enable	ON	ON
2205	Fail class	Fail classes	Warning

`Breakers > Mains breaker > Breaker monitoring > MB Close fail`

Parameter	Text	Range	Default
2211	Timer	1.0 to 5.0 s	2.0 s
2212	Output A	Relays and M-Logic	Not used
2213	Output B	Relays and M-Logic	Not used
2214	Enable	ON	ON
2215	Fail class	Fail classes	Warning

`Breakers > Mains breaker > Breaker monitoring > MB Pos fail`

Parameter	Text	Range	Default
2221	Timer	1.0 to 5.0 s	1.0 s
2222	Output A	Relays and M-Logic	Not used
2223	Output B	Relays and M-Logic	Not used
2224	Enable	ON	ON
2225	Fail class	Fail classes	Warning

8.4 Tie breaker

8.4.1 Breaker settings

`Synchronisation > Dynamic sync.`

Parameter	Text	Range	Default
2025	Synchronisation time TB	40 to 300 ms	50 ms

`Breakers > Tie breaker > Breaker configuration`

Parameter	Text	Range	Default
8191	TB open point	0 kW to 20000 kW	50 kW
8195	Load time	0.0 to 30.0 s	0.0 s

8.4.2 Tie power measurement

If a tie breaker is used, the controller needs the tie power measurement to deload the tie breaker.

Tie power measurement from a transducer

Select *Multi input 20 (transducer)* in parameter 8273. Configure the transducer range in parameters 8271 and 8272.

Configure the input from the transducer under *I/O & Hardware setup, MI 20*.

More information
See **Analogue inputs** in the **Installation instructions** for wiring a transducer as the tie power measurement.

Tie power measurement from the 4th CT

The controller can use the current measurement from the 4th CT to calculate the tie power. Select *4th CT power meas (internal)* in parameter 8273.

More information
See **I4 current** in the **Installation instructions** for wiring of the 4th CT for the tie current measurement.

`Basic settings > Nominal settings > Power > 4th CT nominal [1 or 2]`

Parameter	Text	Range	Default
6055/6064	4th CT Power	10 to 9000 kW	480/230 kW

8.4.3 Tie breaker configuration

In the *Application configuration*, a mains controller can be configured with a tie breaker between the gensets and the load bus. The tie breaker can be configured as normally closed or normally open.

The tie breaker can be open or closed when the generators are stopped, depending on the application and the auxiliaries:

- If auxiliary load is connected to the generator busbar, the tie breaker must be closed.
- If no load is connected to the generator busbar, an open tie breaker is often preferred when the generators are stopped.

`Breakers > Tie breaker > Breaker configuration`

Parameter	Text	Range	Default
8191	TB open point	0 to 20,000 kW	50 kW
8195	TB Load time	0.0 to 30.0 s	0.0 s

`Breakers > Tie breaker > Power capacity`

Parameter	Text	Range	Default
8192	Power capacity	1 to 20,000 kW	50 kW
8193	Power cap. overrule timer	0.0 to 999.9 s	30.0 s
8194	Enable power cap. overrule	OFF ON	OFF

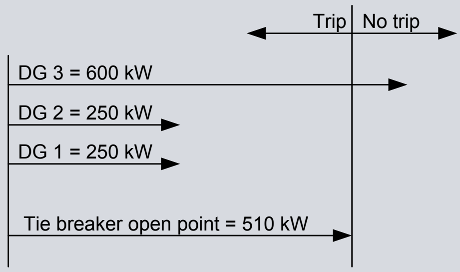
Tie breaker open point

If the gensets are running parallel to mains and the mains breaker trips it can be necessary to also trip the tie breaker. This depends on the total nominal power of the running gensets. If the gensets cannot supply the load in *TB open point*, then the tie breaker opens. It closes again when the power capacity is reached.

The delay in *TB Load time* can be used to trip non-essential load groups.

TB open point example

In the diagram below, the nominal powers of the gensets in the application are shown. The tie breaker trips if DG1 or DG2 is connected to the load, because they are smaller than 510 kW. If DG1 and DG2 are running together, the tie breaker also trips, because the total nominal power is still below 510 kW. If, however, DG3 is running alone or together with one of the two smaller DGs, then the tie breaker does not trip, because the total nominal power is higher than 510 kW.



NOTE It is possible to deload the tie breaker in SEMI-AUTO mode with *M-Logic, Output, Command Breakers, Act TB deload*.

8.4.4 Breaker failures

`Breakers > Tie breaker > Breaker monitoring > TB Open fail`

Parameter	Text	Range	Default
2161	Timer	1.0 to 10.0 s	2.0 s
2162	Output A	Relays and M-Logic	Not used
2163	Output B	Relays and M-Logic	Not used
2164	Enable	ON	ON
2165	Fail class	Fail classes	Warning

`Breakers > Tie breaker > Breaker monitoring > TB Close fail`

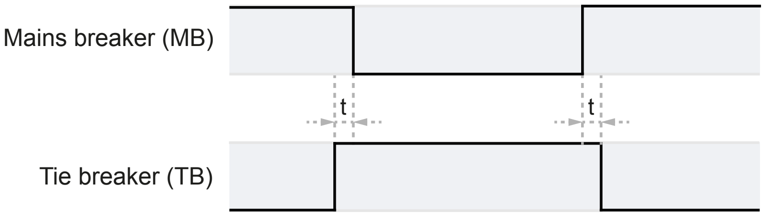
Parameter	Text	Range	Default
2161	Timer	1.0 to 900.0 s	2.0 s
2162	Output A	Relays and M-Logic	Not used
2163	Output B	Relays and M-Logic	Not used
2164	Enable	ON	ON
2165	Fail class	Fail classes	Warning

`Breakers > Tie breaker > Breaker monitoring > TB Pos fail`

Parameter	Text	Range	Default
2181	Timer	1.0 to 5.0 s	1.0 s
2182	Output A	Relays and M-Logic	Not used
2183	Output B	Relays and M-Logic	Not used
2184	Enable	ON	ON
2185	Fail class	Fail classes	Warning

8.5 Short-time parallel

If *Overlap* (menu 2760) is *On*, the controller enforces a maximum paralleling time for the generator and mains supply. This is used to meet local requirements for short-time parallel. The overlap function is only available in automatic mains failure and load takeover modes.



When the tie breaker is closed, the mains breaker is opened automatically before the timer runs out (t). Similarly, when the mains breaker is closed, the tie breaker is opened before the timer runs out (t). The timer is configurable (0.10 to 99.90 seconds).

NOTE The timer is a maximum time. The two breakers are never both closed for longer than the set point.

8.6 Input and output functions

8.6.1 Digital input functions

Function	Details	AUTO mode	SEMI-AUTO mode	Test mode	Man. mode	Block mode	Type *
Auto start/ stop	The genset starts when this input is activated. The genset stops if the input is deactivated. The input can be used when the controller is in Island operation, Fixed power, Load take-over, or Mains power export and the Auto running mode is selected.	●					C
Alternative start	This input is used to simulate an AMF failure, to run a full AMF sequence without a mains failure being present.	●	●	●	●	●	C
Remote TB On	The tie breaker close sequence is initiated and the breaker synchronises if the mains breaker is closed, or closes without synchronising if the mains breaker is opened.		●				P
Remote TB Off	The tie breaker open sequence is initiated. If the mains breaker is open, then the tie breaker opens instantly. If the mains breaker is closed, the generator load will be deloaded to the tie breaker open limit followed by the tie breaker opening.		●				P
Remote MB On	The mains 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 MB Off	The mains breaker open sequence is initiated, and the breaker opens instantly.		●				P
TB close inhibit	When this input is activated, the tie breaker cannot close.	●	●	●	●	●	C
MB close inhibit	When this input is activated, the mains breaker cannot close.	●	●	●	●	●	C
TB racked out	The breaker is considered as racked out when the pre-requisites are met and this input is activated.		●		●		C
MB racked out	The breaker will be considered as racked out when the pre-requisites are met and this input is activated.		●		●		C
TB spring loaded	The controller does not send a close signal before this feedback is present.	●	●	●	●	●	C
MB spring loaded	The controller does not send a close signal before this feedback is present.	●	●	●	●	●	C
Ext. MB open	Choose the terminal used for ext. MB open.						
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
Semi auto mode	Changes the running mode to SEMI-AUTO.	●		●	●	●	P
Test mode	Changes the running mode to test.	●	●		●	●	P
Auto mode	Changes the running mode to AUTO.		●	●	●	●	P
Block mode	Changes the running mode to Block.	●	●	●	●		P

Function	Details	AUTO mode	SEMI-AUTO mode	Test mode	Man. mode	Block mode	Type *
Total test	This input is logged in the event log to show that there has been a planned mains failure.	●	●	●	●	●	C
Enable mode shift	The input activates the mode shift function. If there is a mains failure, the controller follows the AMF sequence. When the input is configured, the setting in parameter 7081 (Mode shift) is disregarded.	●	●	●	●	●	C
Mains Okay	Disables the Mains OK delay timer. The synchronisation of the mains breaker only happens when the input is activated.	●	●	●	●	●	C
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
1st priority Mains	Changes this controller's mains to first priority	●	●	●			P
Switchboard error	The input stop or blocks the genset, depending on running status.	●	●	●	●	●	C

NOTE * C = Continuous, P = Pulse

8.6.2 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.

8.7 Power management

8.7.1 Plant mode

For power management to work in mains controllers, the controller must be in AUTO mode, and you must select the required plant mode.

- Applications without BTBs: Set the plant mode in one mains controller.
- Applications with BTBs: Set the plant mode in a mains controller in each section.

`Basic settings > Application type > Plant type > Plant mode`

Parameter	Text	Range	Default
6071	Type	Island operation Auto Mains Failure Peak shaving Fixed power Mains power export Load take over	Auto Mains Failure

8.7.2 Test mode

For a mains controller, the test mode does not depend on the plant mode. The test mode determines if the mains breaker and/or tie breaker closes.

`Power set points > Test`

Parameter	Text	Range	Default
7041	Test set point	1 to 20,000 kW	500 kW
7042	Test timer	0.0 to 999.0 min.	0 min.
7043	Return mode	SEMI-AUTO mode AUTO mode No mode change	AUTO mode
7044	Test type	Simple test Load test Full test	Simple test

The load-dependent start-stop settings and the multi-start settings are also used in the test. During the test, only the gensets required to supply the test load will start.

8.7.3 Synchronisation of MB, GB and TB

The mains controller parameters and breaker positions determine whether the power management system will synchronise across a breaker.

`Synchronisation > Mains parallel settings`

Parameter	Text	Range	Default
7083	Back Sync	OFF ON	OFF
7084	Sync. to mains	OFF ON	ON

NOTE These parameters are also present in genset controllers. When there is a mains controller, the power management system ignores the genset controller settings.

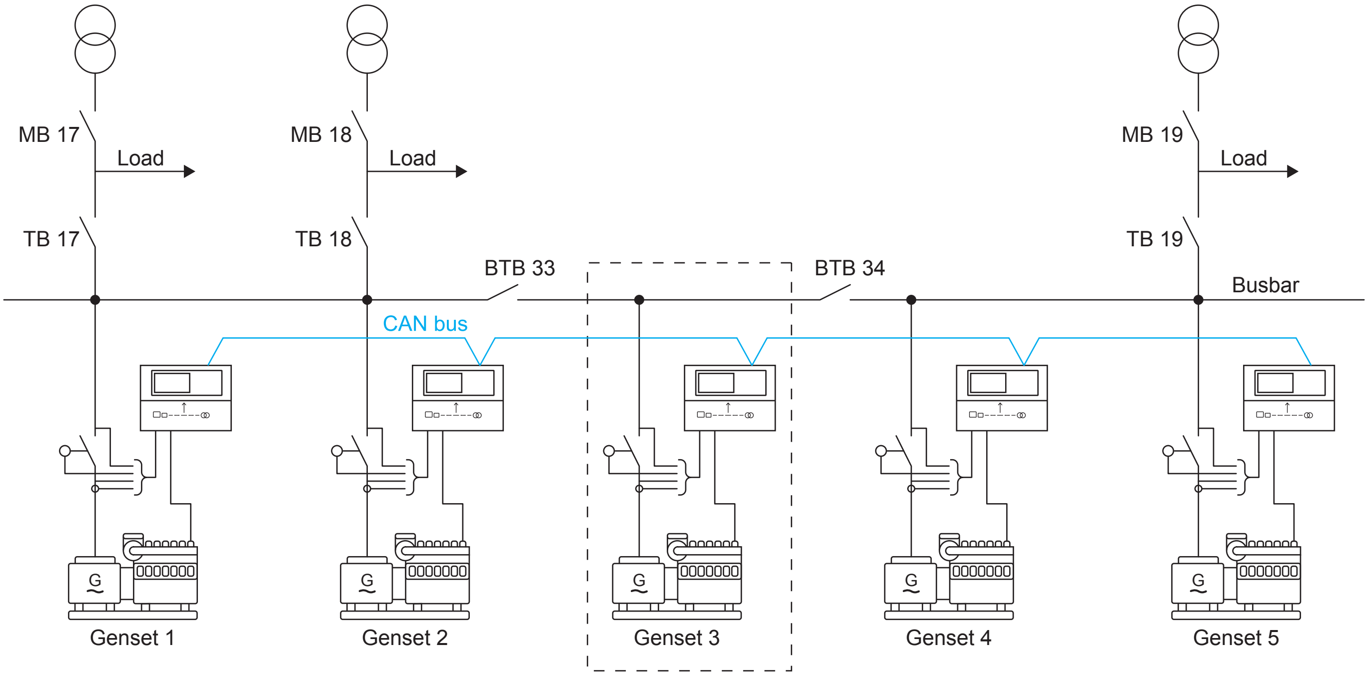
8.7.4 Multiple mains applications

The controller can be used in applications with multiple mains incomers. A multiple mains application has more than one mains connection. It can include feeders and generators, as well as GBs, TBs, BTBs and MBs.

Each application can handle:

- 0 to 32 mains controllers in the same application
- 0 to 32 genset controllers in the same application
- 0 to 8 bus tie breaker controllers

Example of a multiple mains application

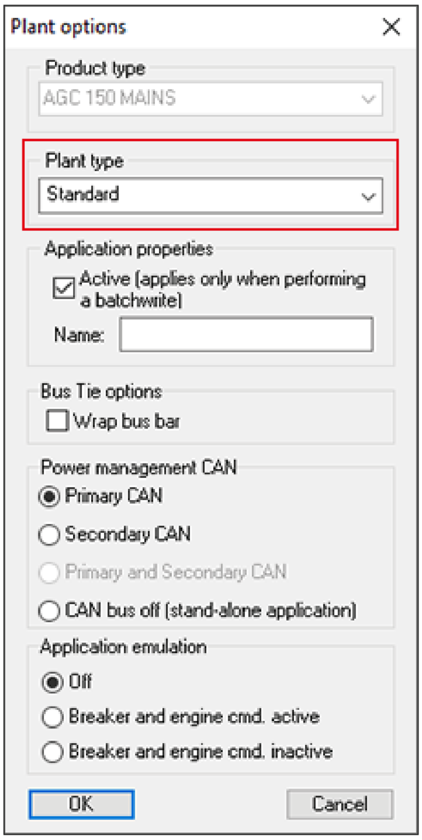


NOTE The multiple mains functionality covers a wide variety of applications. Contact DEIF support (support@deif.com) if you have questions.

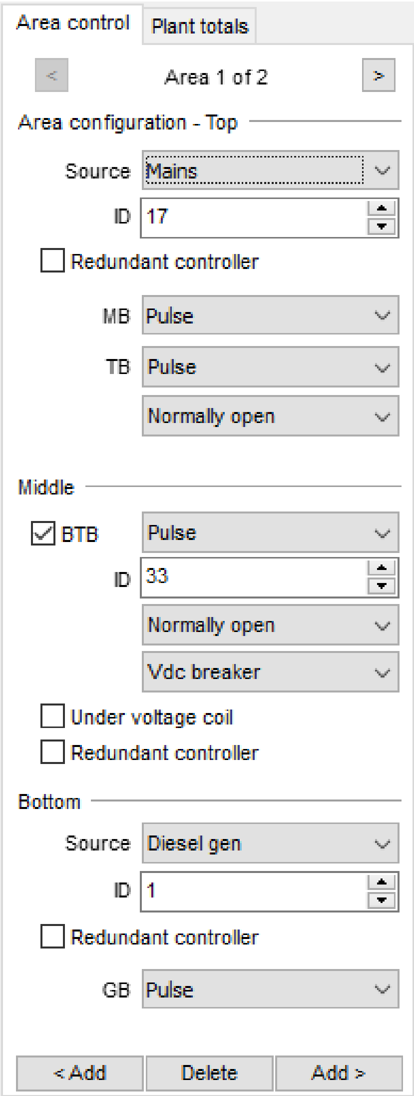
Configuration

In the utility software:

1. Select *Application configuration*.
2. Select *New plant configuration* 
3. In the *Plant options* window, select *Standard* from the *Plant type* list.



4. Configure the application in the *Area control* panel.



8.7.5 Plant mode handling

Mains breaker failure start

The MB failure start determines whether DGs should start if an MB close failure occurs. If MB failure start is activated, the mode shift function is automatically enabled.

`Mains > AMF functions > Start seq. in AMF mode`

Parameter	Text	Range	Default
8181	MB fail. start	OFF ON	OFF

MB parallel operation

The MB parallel determines whether the mains connections (MBs) can run in parallel. The setting of MB parallel affects the function of the auto switch setting.

`Power management > Plant operating set`

Parameter	Text	Range	Default
8182	Parallel	OFF ON	OFF

No break transfer

No break transfer determines whether switching between the mains connections (MBs) is a black coupling or a synchronised coupling. If MB parallel is activated, no break transfer is automatically enabled.

If the TBs in a section are normally closed and MB parallel is disabled, then only one of the TBs can be closed at the time. The system tries to keep the ID selected in parameter 8186 (Run type) to keep its TB closed. If, however, the selected ID does not have a TB configured as a normally closed breaker, or if it fails to close it, then the mains controller with the lowest ID without TB failures present will close. If parameter 8186 (Run type) is changed during operation, then the MB parallel setting decides whether there is a black or a synchronised change-over.

`Power management > Plant operating set`

Parameter	Text	Range	Default
8183	No break trans.	OFF ON	OFF

Auto switch

The Auto switch determines whether a mains controller detecting a mains failure tries to get the connected load supplied by another mains or by the available DGs. If no BTBs are installed, then the settings will have the same auto switch function.

`Power management > Plant operating set`

Parameter	Text	Range	Default
8184	Auto switch	OFF Static section Dynamic section All sections	OFF

NOTICE

Overloading a mains connection

If *Dynamic section* is selected, one mains controller is requested to carry all load from the dynamic section without any help from the gensets. Therefore the remaining mains feeders must be able to carry the load from the entire section.

Run type

The run type determines how the system in a dynamic section reacts in all the plant modes, except island and AMF.

`Power management > Plant operating set`

Parameter	Text	Range	Default
8185	Run type	Run one mains Run all mains	Run one mains

Alternatively, you can set up run type with *M-Logic, Output, Command Power management* in a mains controller:

Command	Effect when activated
Run my ID - constant	Close the mains breaker and (if possible) keep it closed.
Run my ID - activate	Close the mains breaker.
Run one mains	Close only one mains breaker at a time in the application.
Run all mains	Close all the mains breakers (if possible).

Use *M-Logic, Events, Events Power management* in a mains controller to see the status:

Command	Effect when activated
My ID to run selected	The mains controller selected to close its breaker.
Run one mains selected	Only one mains breaker is allowed to be closed at a time.
Run all mains selected	All mains breakers are allowed to be closed simultaneously.

8.7.6 ATS (Automatic Transfer Switch)

External ATS with a mains controller

The external ATS switches between the generator supply and the mains supply. If ATS is selected in the application configuration (MB: Ext/ATS no control), then the mains controller has no control over the ATS/mains breaker.

Normally the controller detects a mains failure based on the voltage and frequency measurement on the mains. However, when ATS is selected, you need a digital input (Alternative start) and the position feedbacks from the ATS (Remote MB On and Remote MB Off). Thus, the mains failure is not detected by the controller measurements but by:

1. Alternative start ON.
2. ATS (MB) feedback OFF.

For this function, the mains controller can control a tie breaker. This is useful if more gensets must start before supplying the load, since the tie breaker does not close until the required gensets are available.

External ATS without a mains controller (island mode)

If ATS island mode is needed, the gensets can be started by activating the *Auto start/stop* input. The gensets start and stop according to the power demand. That is, they will operate in load-dependent start-stop mode.

Since no tie breaker is installed, it is important that the first genset to close on the busbar can carry the load. If the load is too high, the genset is overloaded. This application can be combined with the multi-start function.

8.7.7 Mains controller acting as ATS

The mains controller has a built-in automatic transfer switch (ATS) function. An external ATS is therefore not required. To use the mains controller ATS function, select *Application configuration, MB, Pulse/Continuous NE/Compact/Continuous ND*.

This function is intended as a backup function if the power management CAN bus has a failure where a CAN bus ID is missing. So if the application has redundant CAN bus, the same ID is missing on both of them. The ATS function can also be used if the controller is placed in a configuration with only the specific mains controller.

Common for these two situations is that all breaker operations on the specific controller will be an open transition. The function can only be used in applications where the mains controller controls both an MB and a TB.

When the mains controller is placed in an application with other controllers, it must have an alarm with either *Any DG missing*, *Any mains missing*, *Any BTB missing*, *Any PV missing* or *Any ALC missing*.

In stand-alone - mains applications, the controller does not need any CAN bus alarm before the function becomes active. It is controlled from the parameter or the M-Logic command.

The ATS function settings are **not** broadcast between the controllers, so it is possible to activate ATS in only one mains controller.

To check if the ATS functionality is active in a specific situation, you can use *M-Logic, Event, Mains ATS active*. The event can be used, for example, as an AOP LED or to give an M-Logic alarm. Furthermore, when activation of the Mains ATS function is shown in the event log.

Mains > ATS

Parameter	Text	Range	Default
7251	Enable Mains ATS	OFF ON	OFF
7252	ATS transfer delay	0 to 30 s	0.5 s
7253	ATS configuration	Prioritize mains Prioritize busbar Shift at blackout	Prioritize mains

ATS can also be activated with M-Logic. If *M-Logic, Command, Output, Mains ATS commands, Activate mains ATS functionality* is configured, the controller ignores the selection in parameter 7251 Mains ATS.

8.7.8 Operation at CAN bus fail

The controller has three settings for when the ATS function is active:

- Prioritise mains
- Prioritise busbar
- Shift at blackout

Prioritise mains: The controller tries to power the load from the mains, when possible.

- If the mains fails and there is voltage on the busbar, the load is switched to the busbar.
- If the mains returns, the controller runs the *Mains OK* timer. When this expires, the load is switched back to mains using an open transition.

Prioritise busbar: The controller tries to power the load from the busbar, when possible.

- The controller does not check whether the busbar is powered from another mains feeder or from gensets. The only criterion is that the busbar is live. If then there is a blackout on the busbar and the mains is OK, it shifts to this source.
- If the busbar returns, the controller shifts with the open transition back to the busbar.

Shift at blackout: Almost the same as if the prioritisation changes dynamically according to the situation. The purpose is to minimise the transitions/blackouts and stay on the source as long as it is alive and the ATS function is active.

- If a CAN bus fail occurs, the generator starts up and closes the breaker. If the mains then fails, the load is shifted to the busbar. If the mains returns, the load stays on the busbar.
- If the busbar should fail and the mains is OK, the load is shifted to the mains.
- If both the mains and the busbar have a blackout at the same time, the first one that is OK again is the source that has first priority. If both sources are down, the ATS function skips the OK timer when the first one returns.

If these selections are not sufficient for the present application, it is possible to change them through M-Logic. By this, the parameter can be changed using an input or by using an AOP button.

The ATS function respects if the mains controllers parameter 7065 *Mains fail control* has been set to *Start engine* instead of *Start engine + open MB*. This means that if the mains fails, and there is no busbar voltage, the controller does not try to open the MB. It waits until the busbar comes live. This also works in another way: as if the TB is closed and the load is powered by the busbar. If this source should fail, the TB is not operated until there is a source present again.

It is important to notice that this feature does not check which source is on the busbar, but only that the busbar is alive. Furthermore, it does not check if there is sufficient rotating power on the busbar before closing.

The genset does not start automatically in this feature. The ATS function is only placed in the mains controller. So if the genset is to start due to a CAN bus failure, it must be started in SEMI-AUTO mode. This programming must be done by the user and can be done using M-Logic.

If there is no CAN bus failure, the ATS function is OFF. This means that the mains controllers return to normal state again. This can cause an open transition – even though the controllers are not in ATS mode anymore. If, for example, the application is made so the genset starts in SEMI-AUTO mode and closes the breaker, the busbar is live. If the mains then fails, the load is shifted to the busbar. The mains then returns, but the load stays on the busbar due to the Shift at blackout setting. When the CAN bus fail is cleared, the ATS function is stopped and the mains controller returns to normal state, which could be MB closed and TB open. If the load is at the genset in SEMI-AUTO mode, the mains controller cannot find any genset in AUTO mode to request to back-synchronise. So it will make an open transition at this point. If the genset instead was switched to AUTO mode when the CAN bus fail was cleared, the genset would have been able to back-synchronise.

Parameter	Text	Range	Default
7253	ATS configuration	Prioritize mains Prioritize busbar Shift at blackout	Prioritize mains

8.7.9 Stand-alone mains ATS

If the mains controller is configured to be in an application with only the present controller, the ATS functionality only needs to be enabled. It does not need any CAN bus alarms before it can become active. The selections for the prioritisation still work, and they work in the same way as described earlier.

Parameter	Text	Range	Default
7253	ATS configuration	Prioritize mains Prioritize busbar Shift at blackout	Prioritize mains

8.7.10 ATS changeover time

This can be helpful if, for example, there are some big rotating loads. The timer is a minimum blackout time that the load sees at changeover. This function is active in power management and stand-alone applications.

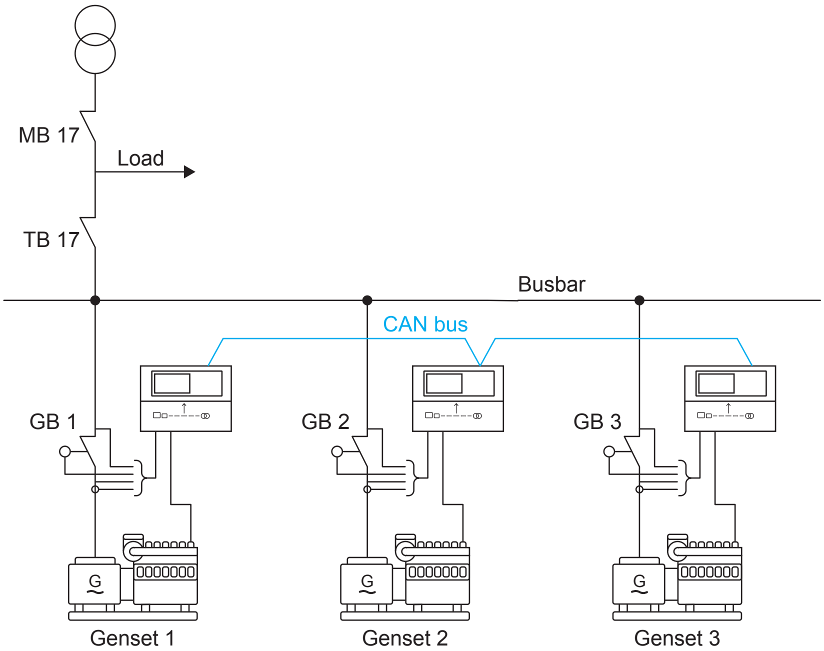
Parameter	Item	Range	Default
7252	ATS transfer delay	0 to 30 s	0.5 s

8.7.11 Deload sequence

The following examples explain how a deload sequence in a power management system functions when changing from generator to grid connection as power supply.

This could be relevant when reconnecting to the mains after an AMF situation, or when an auto start/stop signal has been removed from a peak shaving setup, fixed power setup, and so on.

The following diagram is used to show the two different ways of deloading where either the GB or the TB opens first.



GB deload sequence (standard)

The GBs open when the Power ramp down set point is reached while deloading. When all the GBs are opened, the TB opens.

1. Auto start/stop signal has been removed/leaving AMF sequence.
2. Diesel generator set 1, 2 and 3 deload.
3. GB 1, 2 and 3 open when Power ramp down set point is reached.
4. TB 17 opens.

Controller type	Parameter	Name	Comment
Genset	2622	Power ramp down	Maximum load on GB before open

TB deload sequence

When *Deload TB back sync.* is enabled, the generators deload. When TB open point is reached, the TB opens before the GB. This prevents the available power from decreasing on the busbar until the TB is opened.

1. Auto start/stop signal has been removed/leaving AMF sequence.
2. Diesel generator set 1, 2 and 3 deload.
3. TB 17 opens when TB open point is reached.
4. GB 1, 2 and 3 open.

Controller type	Parameter	Name	Comment
Mains	8273	Deload TB back sync.	Enable/disable
Mains	8191	TB open point	Maximum load on TB before open

NOTICE

Configure the tie power measurement

If the tie power measurement is not configured, the TB opens without deloading.

8.7.12 Power capacity

Power capacity is used in AMF applications to determine how much power must be available, before the tie breaker can close. When the gensets are started, the generator breakers will close, and when sufficient power is available, then the tie breaker will be closed.

If there is more than one tie breaker in the power management system, the tie breaker with the lowest power capacity is closed first.

`Breakers > Tie breaker > Power capacity`

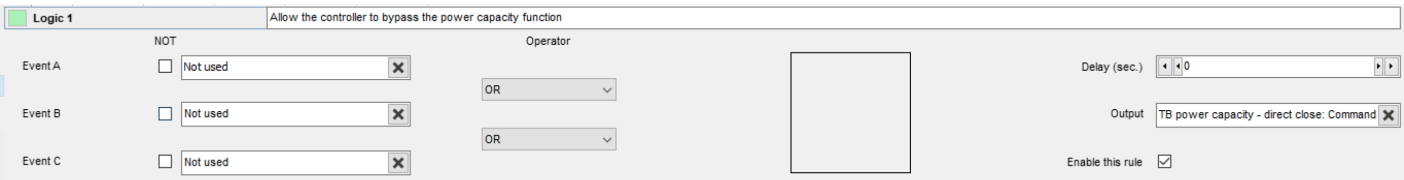
Parameter	Text	Range	Default
8192	Power capacity	1 to 20,000 kW	50 kW
8193	Power capacity overrule, Timer	0.0 to 999.9 s	30.0 s
8194	Power capacity overrule, Enable	OFF ON	OFF

Power capacity overrule

If some of the gensets fail to start and the power capacity set point is not reached, the tie breaker will never be closed. Because of this, it is possible to overrule the power capacity set point after a period of time set in parameter 8193. The power capacity overrule timer starts after one of the gensets has a fault with a fail class that will stop the genset from connecting to the busbar. Power capacity overrule is enabled in parameter 8194.

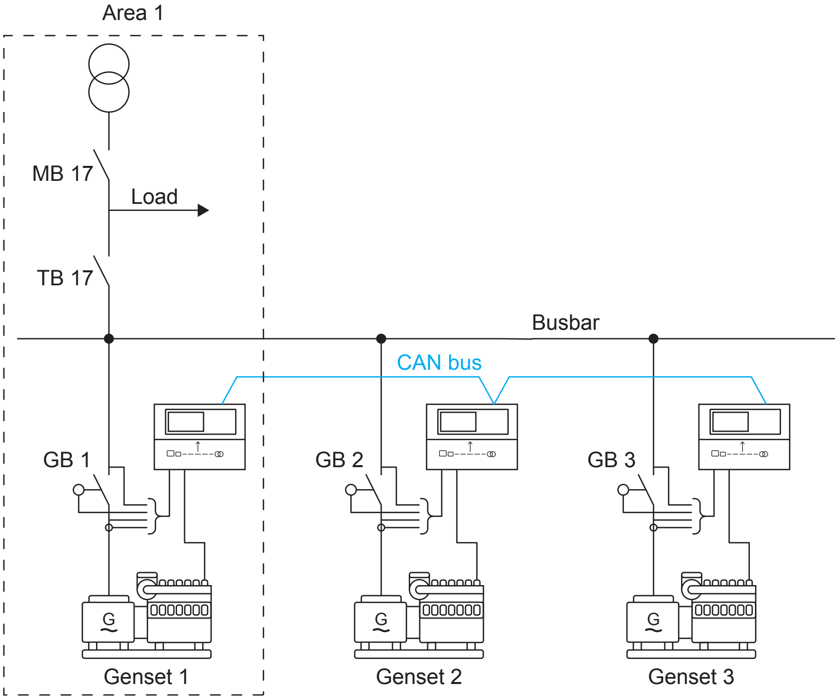
Tie breaker power capacity - direct close

Sometimes it is necessary to bypass the power capacity function completely. The direct close function allows the tie breaker to close after the busbar Hz/V timer runs out (and not wait for any additional timers). Note that this function only allows the controller to bypass the power capacity function, and therefore it is not a close command signal. Enable *M-Logic, Output, Command Power management, Tie breaker power capacity - direct close* in the mains controller.



NOTE Use this function with great caution, since it can affect the load and stability of the generators.

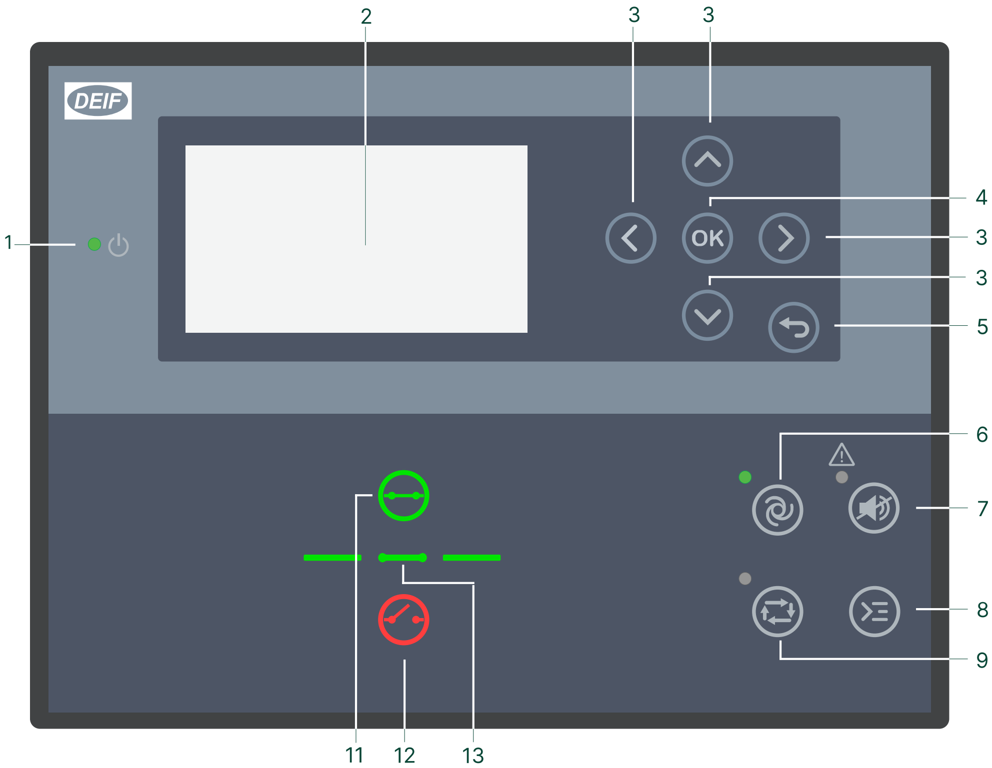
8.7.13 Island application with TB



A tie breaker in the mains controller can be operated in an island application. The *Power capacity* set point (parameter 8192) is used to ensure that the generators produce enough power to take the load. This protects the generators from going into overload.

9. Bus tie breaker functions

9.1 Display, buttons and LEDs



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	Move the selector up, down, left and right on the screen.
4	OK	Go to the Menu system. Confirm the selection on the screen.
5	Back	Go to the previous page.
6	AUTO mode	For BTB controllers, 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.
7	Silence horn	Stops an alarm horn (if configured) and enters the Alarm menu.
8	Shortcut menu	Access the Jump menu, Lamp test.
9	SEMI-AUTO mode	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.
11	Close breaker	Push to close the breaker.
12	Open breaker	Push to open the breaker.
13	Breaker symbols	Green: Breaker is closed. Green flashing: Synchronising or deloading. Red: Breaker failure.

9.2 BTB alarms

9.2.1 Fail classes

Fail class/Action	Alarm horn relay	Alarm display	Trip BTB
Block	●	●	
Warning	●	●	
Trip BTB	●	●	●

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	●

9.2.2 Inhibits

Function	Notes
Inhibit 1	M-Logic outputs: Conditions are programmed in M-Logic.
Inhibit 2	
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.

9.3 Inputs and outputs

9.3.1 Digital input functions

Function	Details	AUTO mode	SEMI-AUTO mode	Test mode	Man. 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

Function	Details	AUTO mode	SEMI-AUTO mode	Test mode	Man. mode	Block mode	Type *
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
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
Semi auto mode	Changes the running mode to SEMI-AUTO.	●		●	●	●	P
Auto mode	Changes the running mode to AUTO.		●	●	●	●	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

9.3.2 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.

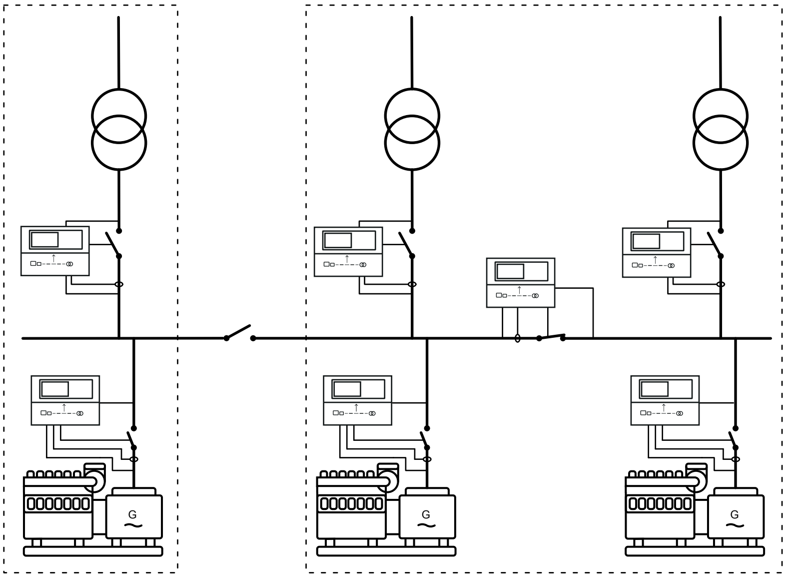
9.4 BTB power management

9.4.1 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

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.

9.4.2 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.

9.4.3 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 mains 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.
- You can use *M-Logic, Output, Command Power management, Store common settings* to force the power management system to store the dynamic system's common settings in each controller.
- 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

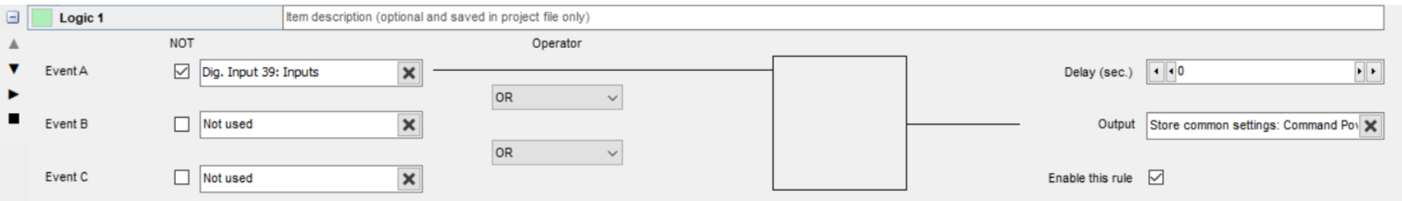
The power management system ensures that all the controllers have the same common settings. For example, if the BTB between a section with Run all mains closes to join a section with Run one mains, the new dynamic section must have one setting.

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.

You can use *M-Logic, Output, Command Power management, Store common settings* to force the power management system to store the dynamic system's common settings in each controller.

Example of M-Logic to store section settings



NOTE When the settings are stored, the input must be activated for at least one second.

9.4.4 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.

9.4.5 Plant mode

For a bus tie breaker controller, the plant mode defines when a mains controller can request help. That is, a mains controller can request that the BTB close if the plant mode is:

- Automatic mains failure
- Load take over
- Island operation

For these plant modes, a BTB does not close automatically, even if more power is needed:

- Fixed power
- Peak shaving
- Mains power export

9.4.6 Test mode

For a BTB controller, the BTB test response depends on the mains controller test mode. The BTB controller does not have a test mode.

For a bus tie breaker controller, a mains controller can request that the BTB close if the test mode is:
- Full test

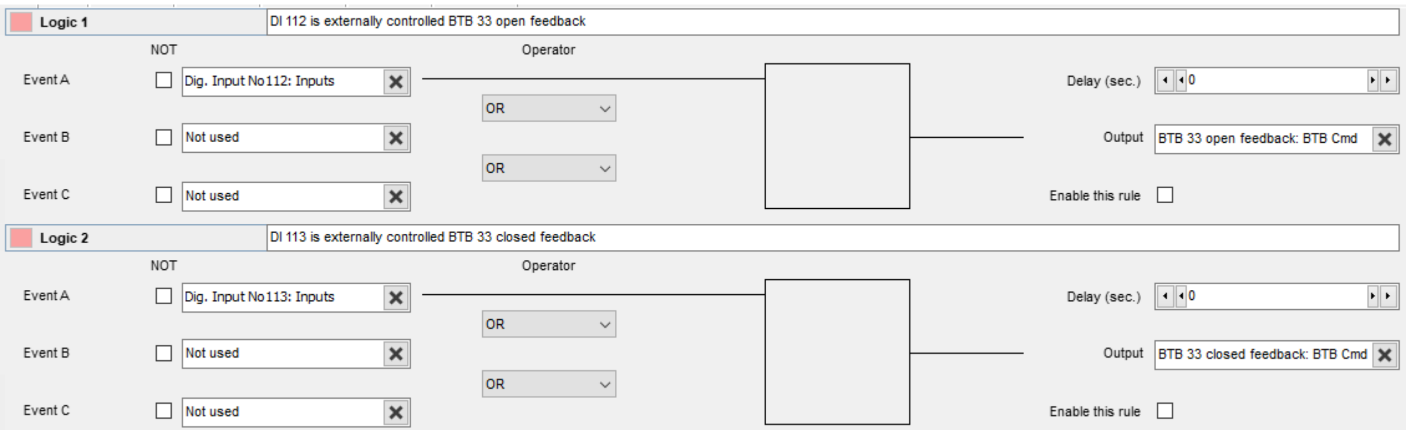
For these mains controller test modes, a BTB will not close automatically, even if more power is needed:
- Simple test
- Load test

9.4.7 Externally controlled BTB

The application can include externally controlled BTBs. These BTBs are assigned an ID number in the application configuration (without an AGC BTB controller). In total, there can only be 8 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.

10. AC protections

10.1 About protections

10.1.1 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	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
Output B	
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.

10.1.2 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.

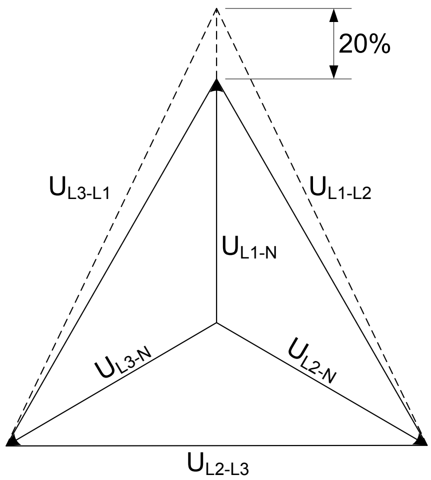
Example: Actual measurements at a 10 % under-voltage situation in a 400/230 volt system

	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

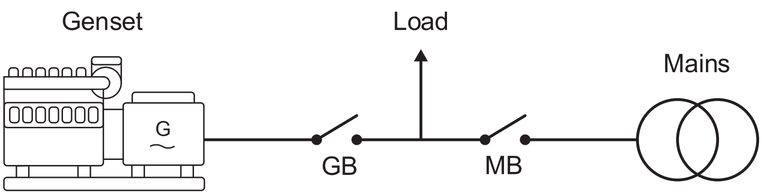
- U_{L1L2} = 360 V AC
- U_{L3L1} = 360 V AC
- U_{L1-N} = 185 V AC
- ΔU_{PH-N} = 20 %

10.1.3 Phase sequence error and phase rotation

The controller monitors the rotation of the voltage, and activates an alarm if the voltage is rotating in the wrong direction. The controller can monitor the rotation in both directions.

Stand-alone applications

A stand-alone application is able to handle up to one genset, one generator breaker and one mains breaker.



When the controller is wired correctly, the genset's voltage measurements are connected between the generator breaker (GB) and the genset. The other voltage measurements are connected between the mains breaker (MB) and the incoming grid connection.

Voltage terminals

- A-side voltage terminals: 62 to 65
- B-side 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

Example: Parameters for a stand-alone application with GB and MB

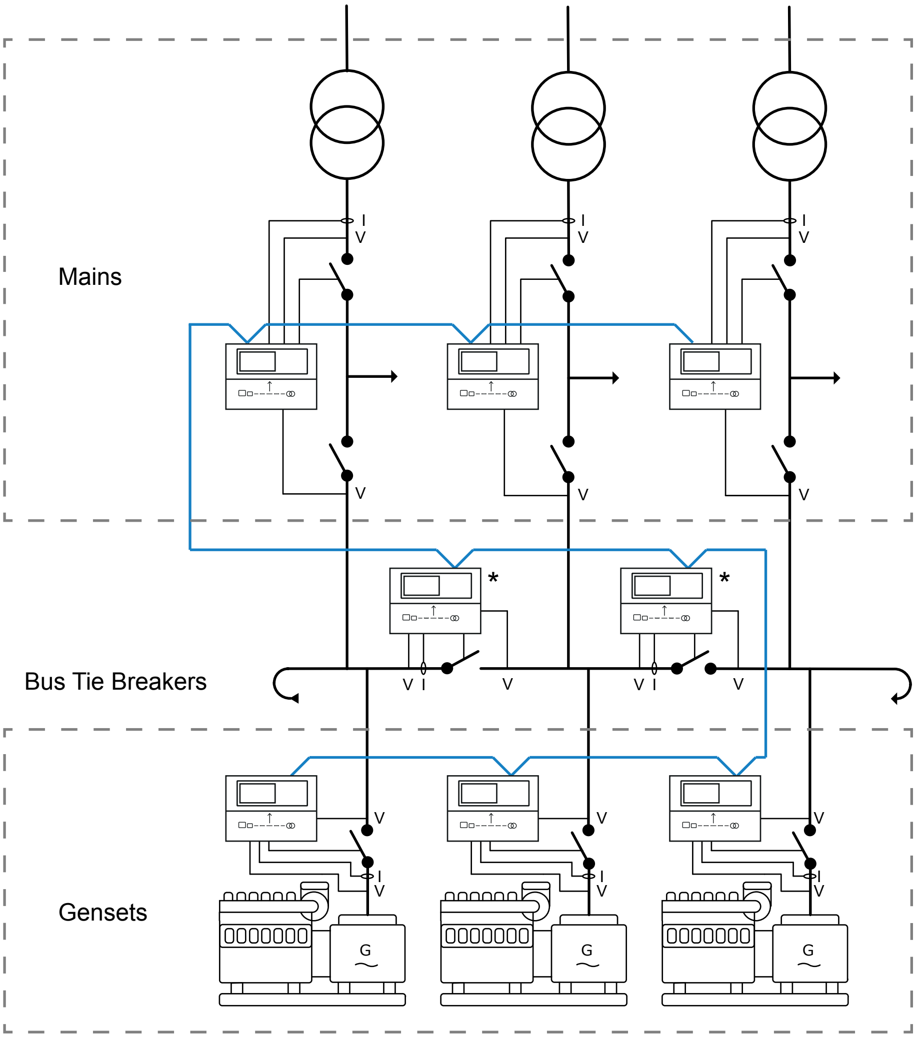
Parameter	Text	Setting
2153	Fail class	Trip+Stop
2154	Rotation	L1L2L3
2156	Fail class	Trip MB

If the controller is set to Load Take-over (LTO) and the start signal is given, the genset starts up. If there has been an alternator service, and two of the phases were switched when the alternator was assembled, the controller detects a phase sequence fail. Since this is on the genset voltage terminals, the fail class in parameter 2153 is used. The fail class is *Trip +Stop*, which trips the breaker (if the breaker is not closed, the controller will not send a trip signal), and then executes the stop sequence. If the alarm is acknowledged, the genset starts up again, if the start signal is still present.

In this plant there could be grid changes. If the grid company is coupling in the grid, and the phase sequence in changed on the grid connection, and the mains fail timer does not react to the small blackout, the fail class in parameter 2156 is used. At the moment there is a phase sequence error on the mains voltage terminals, and the fail class is *Trip MB*. When the MB is tripped, the genset is started, since there is a trip alarm MB, and load does not have any power at the moment.

To test the Automatic Mains Failure (AMF) sequence, the technician removes the fuses. The controller discovers the voltage is not present and afterwards start up the genset and take the load. When the technician is reassembling the transformer, he accidentally switches two phases. When the fuses are put into place again, the controller detects a phase sequence error on the mains voltages. The controller therefore keeps running until the phase sequence is fixed.

Power management controller applications



When setting up the phase sequence alarms, it can be helpful to activate *MB fail start* in some of the mains controllers.

Example

- If there is a *Phase sequence error* for mains voltage, and the fail class is *Trip MB*, the gensets can start.
- If *Auto switch* is then enabled the other grid connection act as a backup supply, before the gensets start.
- If the other mains do not have a phase sequence error, the mains continues to supply the load, and the gensets do not start.

More information
See **Plant mode handling** for the MB failure start explanation.

10.2 Generator protections

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.

Generator protections

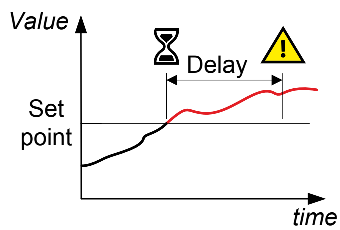
Protection	IEC symbol (IEC 60617)	ANSI (IEEE C37.2)	Operate time	Alarms
Over-voltage	U>, U>>	59	< 200 ms	2
Under-voltage	U<, U<<	27	< 200 ms	3
Voltage unbalance	UUB>	47	< 200 ms*	1
Negative sequence voltage		47	< 200 ms*	1
Zero sequence voltage		59Uo	< 200 ms*	1
Over-current	3I>, 3I>>	50TD	< 100 ms	4
Fast over-current (short circuit)	3I>>>	50/50TD	< 50 ms	2
Unbalance current	IUB>	46	< 200 ms*	2
Directional over-current		67	< 100 ms	2
Inverse time over-current	It>	51	-	1
Neutral inverse time over-current		51N	-	1
Earth fault inverse time-over current		51G	-	1
Negative sequence current		46	< 200 ms*	1
Zero sequence current		51Io	< 200 ms*	1
Over-frequency	f>, f>>	81O	< 200 ms	3
Under-frequency	f<, f<<	81U	< 200 ms	3
Overload	P>, P>>	32	< 200 ms	4
Low power	-	-	< 100 ms	1
Reverse power	P<, P<<	32R	< 200 ms	2
Reactive power export (Over-excitation)	Q>, Q>>	40O	< 200 ms	1
Reactive power import/loss of excitation (under-excitation)	Q<, Q<<	40U	< 200 ms	1

NOTE * These operate times include the minimum user-defined delay of 100 ms.

10.2.1 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]`

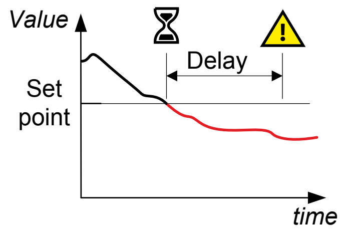
Parameter	Text	Range	G U> 1	G U> 2
1151 or 1161	Set point	100 to 130 %	103 %	105 %
1152 or 1162	Timer	0.1 to 100 s	10 s	5 s

Parameter	Text	Range	G U> 1	G U> 2
1155 or 1165	Enable	OFF ON	OFF	OFF
1156 or 1166	Fail class	Fail classes	Warning	Warning

10.2.2 Under-voltage (ANSI 27)

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

The alarm response is based on the lowest phase-to-phase voltage, or the lowest phase-to-neutral voltage, from the 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
1171, 1181 or 1191	Set point	40 to 100 %	97 %	95 %	95 %
1172, 1182 or 1192	Timer	0.1 to 100 s	10 s	5 s	5 s
1175, 1185 or 1195	Enable	OFF ON	OFF	OFF	OFF
1176, 1186 or 1196	Fail class	Fail classes	Warning	Warning	Warning

NOTE Under-voltage protection is inhibited, when the controller is in idle mode.

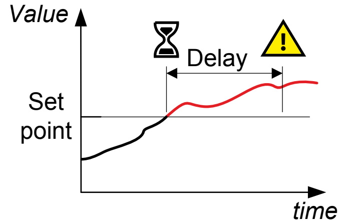
10.2.3 Voltage unbalance (ANSI 47)

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
1511	Set point	0 to 50 %	10 %
1512	Timer	0.1 to 100 s	10 s

Parameter	Text	Range	Default
1515	Enable	OFF ON	OFF
1516	Fail class	Fail classes	Trip GB

10.2.4 Negative sequence voltage (ANSI 47)

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

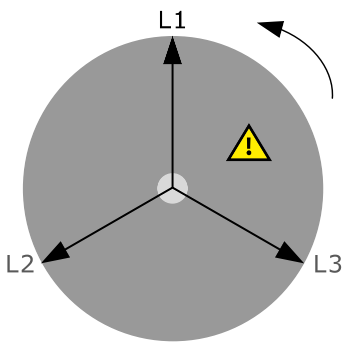
NOTE * The operate time includes the minimum user-defined delay of 100 ms.

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
1551	Set point	1 to 100 %	5 %
1552	Timer	0.2 to 100 s	0.5 s
1555	Enable	OFF ON	OFF
1556	Fail class	Fail classes	Trip MB

Generator > Voltage protections > Negative seq. voltage > Neg. seq select

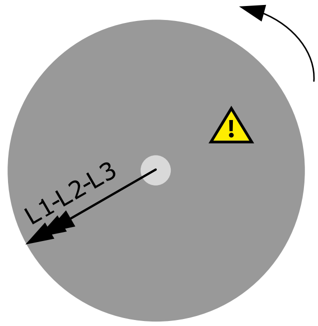
Parameter	Text	Range	Default
1561	Type	G measurement BB measurement	G measurement

10.2.5 Zero sequence voltage (ANSI 59Uo)

Protection	IEC symbol (IEC60617)	ANSI (IEEE C37.2)	Operate time
Zero sequence voltage		59Uo	< 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
1581	Set point	0 to 100 %	5 %
1582	Timer	0.2 to 100 s	0.5 s
1585	Enable	OFF ON	OFF
1586	Fail class	Fail classes	Trip MB

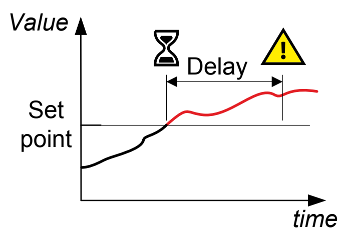
Generator > Voltage protections > Zero sequence voltage > Zero seq select

Parameter	Text	Range	Default
1591	Type	G measurement BB measurement	G measurement

10.2.6 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]

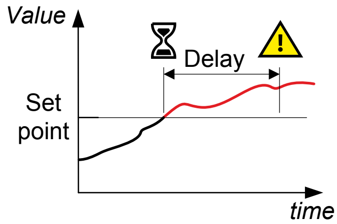
Parameter	Text	Range	I> 1	I> 2	I> 3	I> 4
1031, 1041, 1051 or 1061	Set point	50 to 200 %	115 %	120 %	115 %	120 %
1032, 1042, 1052 or 1062	Timer	0.1 to 3200 s	10 s	5 s	10 s	5 s
1035, 1045, 1055 or 1065	Enable	OFF ON	ON	ON	ON	ON
1036, 1046, 1056 or 1066	Fail class	Fail classes	Warning	Trip GB	Trip GB	Trip GB

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

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

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

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



`Generator > Current protections > Fast over-current > I>> [1 or 2]`

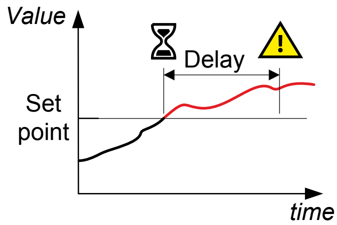
Parameter	Text	Range	I>> 1	I>> 2
1131 or 1141	Set point	150 to 300 %	150 %	200 %
1132 or 1142	Timer	0 to 3200 s	2 s	0.5 s
1135 or 1145	Enable	OFF ON	OFF	OFF
1136 or 1146	Fail class	Fail classes	Trip GB	Trip GB

10.2.8 Unbalance current (ANSI 46)

Protection	IEC symbol (IEC60617)	ANSI (IEEE C37.2)	Operate time
Unbalance current	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
1501 or 1711	Set point	0 to 100 %	30 %	40 %
1502 or 1712	Timer	0.1 to 100 s	10 s	10 s
1505 or 1715	Enable	OFF ON	OFF	OFF
1506 or 1716	Fail class	Fail classes	Trip GB	Trip GB

Generator > Current protections > Unbalance current > Type

Parameter	Text	Range	Default
1203	Type	Nominal Average	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 %.

10.2.9 Voltage-dependent over-current (ANSI 51V)

Protection	IEC symbol (IEC60617)	ANSI (IEEE C37.2)	Operate time
Voltage-dependent over-current	Iv>	51V	-

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 %

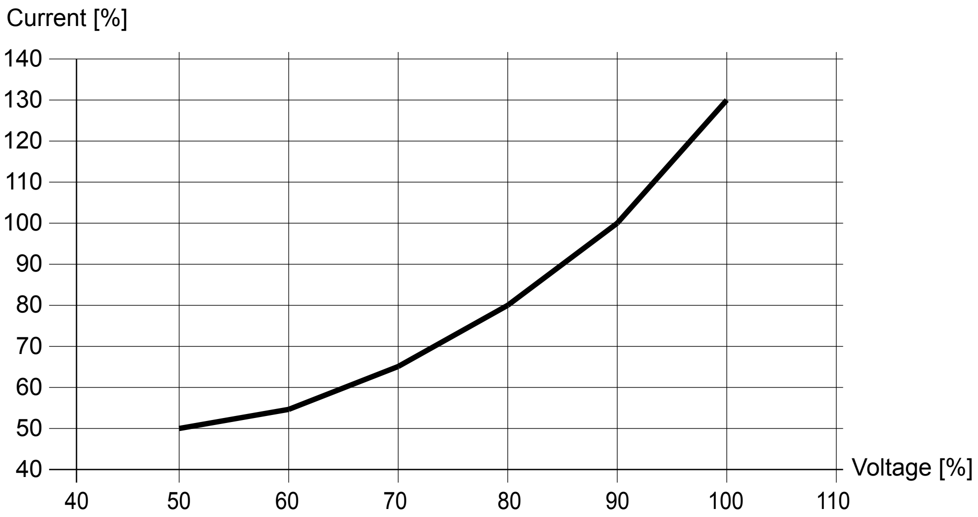
Parameter	Text	Range	Default
1106	G Iv> (100 %)	50 to 200 %	200 %
1110	Fail class	Fail classes	Trip GB

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:

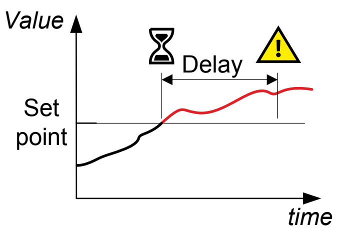


When the operating values are above the curve, the breaker is tripped. The generator breaker also trips when the generator voltage is below 50 % of rated, and the current is above 50 % of rated.

10.2.10 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
1601 or 1611	Set point	-200 to 200 %	120 %	130 %
1602 or 1612	Timer	0 to 3200 s	0.1 s	0.1 s
1605 or 1615	Enable	OFF ON	OFF	OFF
1606 or 1616	Fail class	Fail classes	Trip MB	Trip MB

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*.

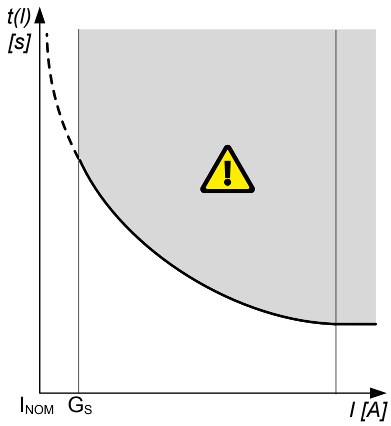
10.2.11 Inverse time over-current (ANSI 51)

Protection	IEC symbol (IEC60617)	ANSI (IEEE C37.2)	Operate time
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 ($G_S = I_{nom}$ • LIM / 100 %)
- TMS = Time multiplier setting

`Generator > Current protections > Inv. time over-current`

Parameter	Text	Range	Default
1081	Type	IEC Inverse IEC Very Inverse IEC Extremely inverse IEEE Moderately Inv. IEEE Very Inverse	IEC Inverse

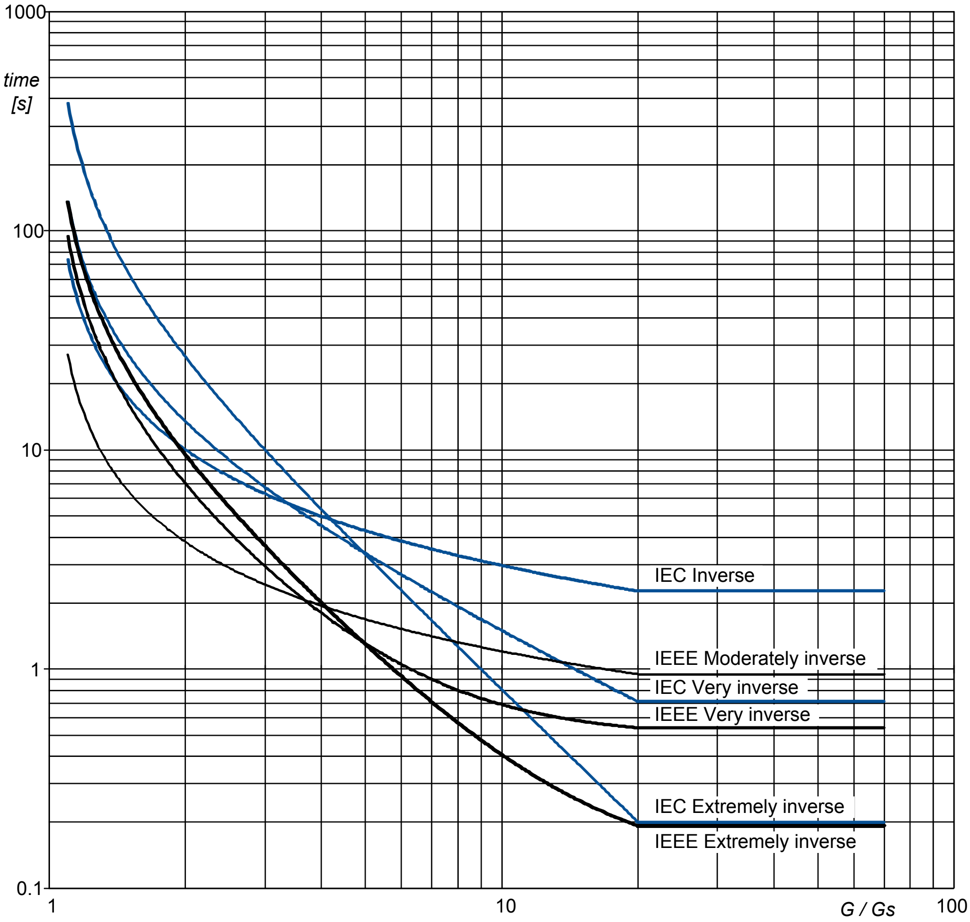
Parameter	Text	Range	Default
		IEEE Extremely Inv. Custom	
1082	Set point LIM	50 to 200 %	110 %
1083	Set point TMS	0.01 to 100.00	1.00
1084	Set point k	0.001 to 32.000 s	0.140 s
1085	Set point c	0.000 to 32.000 s	0.000 s
1086	Set point a	0.001 to 32.000 s	0.020 s

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

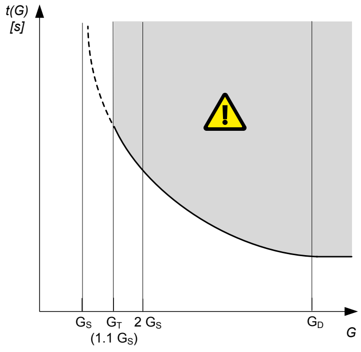
Standard curve shapes for inverse time over-current, with time multiplier setting (TMS) = 1



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).

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

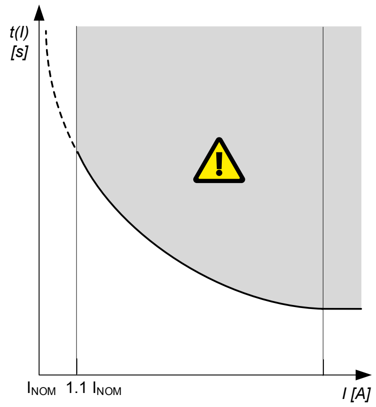
Protection	IEC symbol (IEC60617)	ANSI (IEEE C37.2)	Operate time
Neutral inverse time over-current		51N	-

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

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

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

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



`Generator > Current protections > Neut. inv. t. o-curr.`

Parameter	Text	Range	Default
1721	Type	IEC Inverse	IEC Inverse

Parameter	Text	Range	Default
		IEC Very Inverse IEC Extremely inverse IEEE Moderately Inv. IEEE Very Inverse IEEE Extremely Inv. Custom	
1722	Set point	2. to 120 %	30 %
1723	Set point TMS	0.01 to 100.00	1.00
1724	Set point k	0.001 to 32.000 s	0.140 s
1725	Set point c	0.000 to 32.000 s	0.000 s
1726	Set point a	0.001 to 32.000 s	0.020 s
1728	Enable	OFF ON	OFF
1729	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.

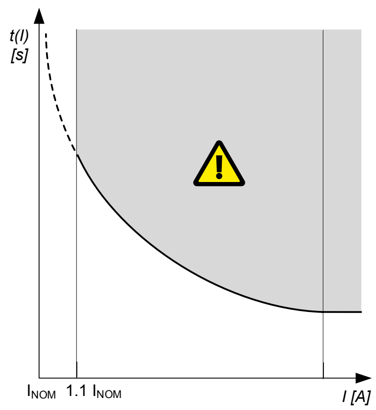
10.2.13 Earth fault inverse time over-current (ANSI 51G)

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

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

The alarm response is based on the ground current, as measured by the 4th current measurement filtered to attenuate the third harmonic (at least 18 dB).

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 > Earth f. inv t. o-curr.

Parameter	Text	Range	Default
1731	Type	IEC Inverse IEC Very Inverse IEC Extremely inverse IEEE Moderately Inv. IEEE Very Inverse IEEE Extremely Inv. Custom	-
1732	Set point	2 to 120 %	10 %
1733	Set point TMS	0.01 to 100.00	1.00
1734	Set point k	0.001 to 32.000 s	0.140 s

Parameter	Text	Range	Default
1735	Set point c	0.000 to 32.000 s	0.000 s
1736	Set point a	0.001 to 32.000 s	0.020 s
1738	Enable	OFF ON	OFF
1739	Fail class	Fail classes	Trip GB

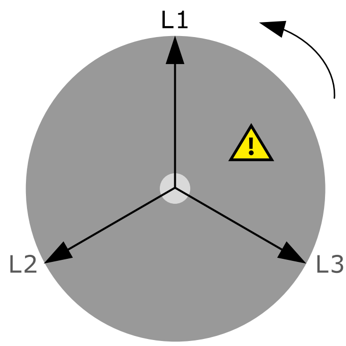
More information
See **Inverse time over-current (ANSI 51)** for the calculation method, the standard curves, and information about the definite time characteristic.

10.2.14 Negative sequence current (ANSI 46)

Protection	IEC symbol (IEC60617)	ANSI (IEEE C37.2)	Operate time
Negative sequence current		46	< 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
1541	Set point	1 to 100 %	20 %
1542	Timer	0.2 to 100 s	0.5 s
1545	Enable	OFF ON	OFF
1546	Fail class	Fail classes	Trip MB

10.2.15 Zero sequence current (ANSI 51Io)

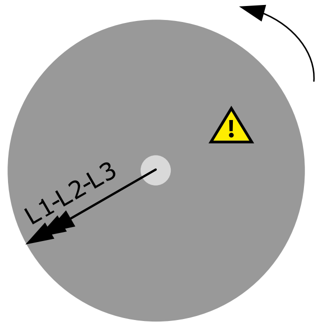
Protection	IEC symbol (IEC60617)	ANSI (IEEE C37.2)	Operate time
Zero sequence current		51Io	< 200 ms*

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.



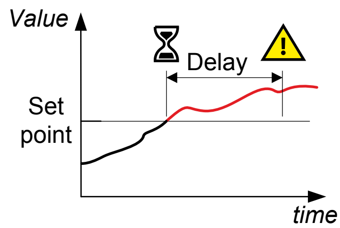
Generator > Current protections > Zero sequence current > Zero seq. I

Parameter	Text	Range	Default
1571	Set point	0 to 100 %	20 %
1572	Timer	0.2 to 100 s	0.5 s
1575	Enable	OFF ON	OFF
1576	Fail class	Fail classes	Trip MB

10.2.16 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
1211, 1221 or 1231	Set point	100 to 120 %	103 %	105 %	105 %
1212, 1222 or 1232	Timer	0.2 to 100 s	10 s	5 s	5 s
1215, 1225 or 1235	Enable	OFF ON	OFF	OFF	OFF
1216, 1226 or 1236	Fail class	Fail classes	Warning	Warning	Warning

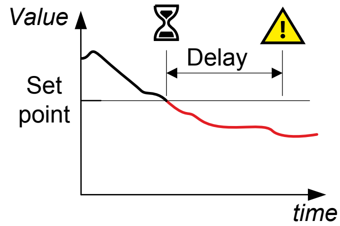
Generator > Frequency protections > Frequency detect. type

Parameter	Text	Range	Default
1204	Type	L1 L2 L3 L1 or L2 or L3 L1 and L2 and L3	L1 or L2 or L3

10.2.17 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]

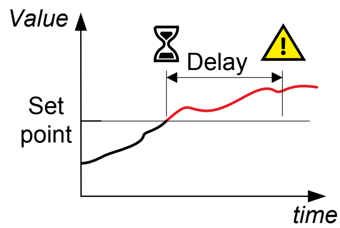
Parameter	Text	Range	G f< 1	G f< 2	G f< 3
1241, 1251 or 1261	Set point	80 to 100 %	97 %	95 %	95 %
1242, 1252 or 1262	Timer	0.2 to 100 s	10 s	5 s	5 s
1245, 1255 or 1265	Enable	OFF ON	OFF	OFF	OFF
1246, 1256 or 1266	Fail class	Fail classes	Warning	Warning	Warning

NOTE Under-frequency protection is inhibited, when the controller is in idle mode.

10.2.18 Overload (ANSI 32)

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

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



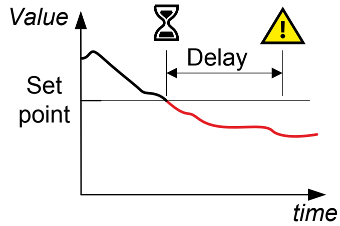
Generator > Power protections > Overload > P> [1 to 4]

Parameter	Text	Range	P> 1	P> 2	P> 3	P> 4	P> 5
1451, 1461, 1471 or 1481	Set point	-200 to 200 %	100 %	110 %	100 %	110 %	100 %
1452, 1462, 1472 or 1482	Timer	0.1 to 3200 s	10 s	5 s	10 s	5 s	10 s
1455, 1465, 1475 or 1485	Enable	OFF ON	OFF	OFF	OFF	OFF	OFF
1456, 1466, 1476 or 1486	Fail class	Fail classes	Warning	Trip GB	Trip GB	Trip GB	Trip GB

10.2.19 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.



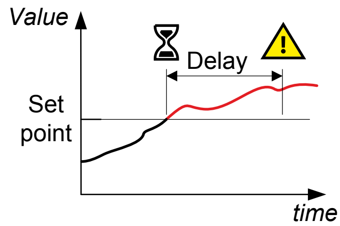
AC configuration and protections > Power protections > Overload > P<

Parameter	Text	Range	P<
1491	Set point	-200 to 200 %	30 %
1492	Timer	0.1 to 3200 s	3200 s
1495	Enable	OFF ON	OFF
1496	Fail class	Fail classes	Trip PVB

10.2.2 Reverse power (ANSI 32R)
0

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.



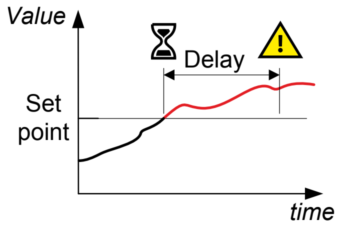
Generator > Power protections > Reverse power > -P> [1 to 3]

Parameter	Text	Range	-P> 1	-P> 2	-P > 3
1001, 1011 or 1071	Set point	-200 to 0 %	-5 %	-5 %	-5 %
1002, 1012 or 1072	Timer	0.1 to 100 s	10 s	10 s	10 s
1005, 1015 or 1075	Enable	OFF ON	ON	ON	OFF
1006, 1016 or 1076	Fail class	Fail classes	Trip GB	Trip GB	Trip GB

10.2.21 Reactive power export (ANSI 40O)

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



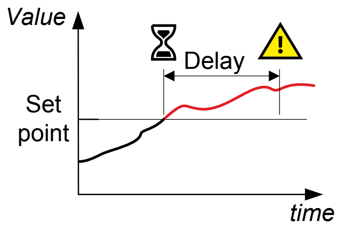
Generator > Reactive power protect. > Overexcitation > Q>

Parameter	Text	Range	Default
1531	Set point	0 to 100 %	60 %
1532	Timer	0.1 to 100 s	10 s
1535	Enable	OFF ON	OFF
1536	Fail class	Fail classes	Warning

10.2.22 Reactive power import (ANSI 40U)

Protection	IEC symbol (IEC60617)	ANSI (IEEE C37.2)	Operate time
Reactive power import (loss of excitation/under-excitation)	Q<, Q<<	40U	< 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
1521	Set point	0 to 150 %	50 %
1522	Timer	0.1 to 100 s	10 s
1525	Enable	OFF ON	OFF
1526	Fail class	Fail classes	Warning

10.3 Busbar standard protections

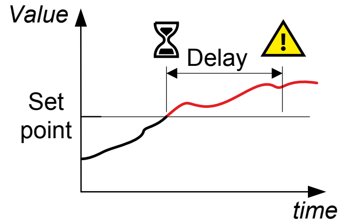
Protection	IEC symbol (IEC 60617)	ANSI (IEEE C37.2)	Operate time	Alarms
Over-voltage	U>, U>>	59	< 50 ms	3
Under-voltage	U<, U<<	27	< 50 ms	4
Voltage unbalance	UUB>	47	< 200 ms*	1
Positive sequence under-voltage	U_1<	27D	< 40 ms	1
Over-frequency	f>, f>>	81O	< 50 ms	3
Under-frequency	f<, f<<	81U	< 50 ms	4
Vector shift	dφ/dt	78	< 40 ms	1
Rate of change of frequency ROCOF (df/dt)	(df/dt)	81R	< 120 ms	1

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

10.3.1 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
1271, 1281 or 1291	Set point	100 to 120 %	103 %	105 %	105 %
1272, 1282 or 1292	Timer	0.04 to 99.99 s	10 s	5 s	5 s
1275, 1285 or 1295	Enable	OFF ON	OFF	OFF	OFF
1276, 1286 or 1296	Fail class	Fail classes	Warning	Warning	Warning

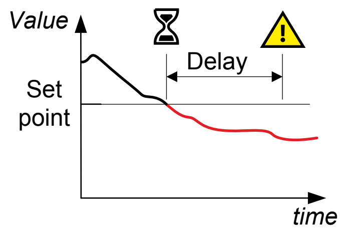
Busbar > Voltage protections > Voltage detect. type

Parameter	Text	Range	Default
1202	Type	Phase-Phase Phase-Neutral	Phase-Phase

10.3.2 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
1301, 1311, 1321 or 1331	Set point	40 to 100 %	97 %	95 %	97 %	95 %
1302, 1312, 1322 or 1332	Timer	0.04 to 99.99 s	10 s	5 s	10 s	5 s
1305, 1315, 1325 or 1335	Enable	OFF ON	OFF	OFF	OFF	OFF
1306, 1316, 1326 or 1336	Fail class	Fail classes	Warning	Warning	Warning	Warning

Busbar > Voltage protections > Voltage detect. type

Parameter	Text	Range	Default
1202	Type	Phase-Phase Phase-Neutral	Phase-Phase

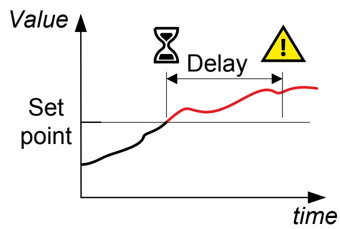
10.3.3 Busbar voltage unbalance (ANSI 47)

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
1621	Set point	0 to 50 %	6 %
1622	Timer	0.1 to 100 s	10 s
1625	Enable	OFF ON	OFF
1626	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 %

10.3.4 Positive sequence under-voltage (ANSI 27d)

Protection	IEC symbol (IEC60617)	ANSI (IEEE C37.2)	Operate time
Positive sequence under-voltage	U_2<	27d	< 40 ms

As a result of the generator's power production to the consumers, the positive sequence system represents the fault-free part of the voltages.

The controller measures the voltage state on the positive sequence voltage part of the voltage phasors of the busbar or mains. The alarm response is based on the lowest positive voltage value measured at the zero crossing point of each phase.

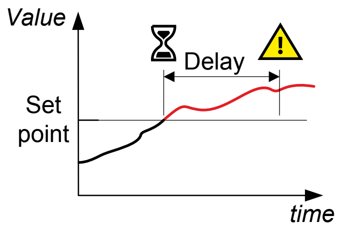
`Busbar > Voltage protections > Pos. seq. under-volt. > BB Pos seq volt`

Parameter	Text	Range	Default
1441	Set point	10 to 110 %	70 %
1442	Timer	1 to 9 Periods	2 Periods
1445	Enable	OFF ON	OFF
1446	Fail class	Fail classes	Trip MB

10.3.5 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
1351, 1361, 1371 or 1921	Set point	100 to 120 %	103 %	105 %	105 %	102 %
1352, 1362, 1372 or 1922	Timer	0.04 to 99.99 s	10 s	5 s	5 s	5600 s*
1355, 1365, 1375 or 1925	Enable	OFF	OFF	OFF	OFF	OFF

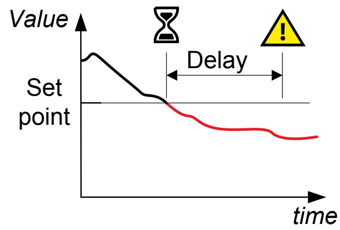
Parameter	Text	Range	BB f> 1	BB f> 2	BB f> 3	BB f> 4
		ON				
1356, 1366, 1376 or 1926	Fail class	Fail classes	Warning	Warning	Warning	Warning

NOTE * The range for this alarm is 1500 to 6000 s.

10.3.6 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
1381, 1391, 1401, 1411 or 1931	Set point	80 to 100 %	97 %	95 %	97 %	95 %	95 %
1382, 1392, 1402, 1412 or 1932	Timer	0.04 to 99.99 s	10 s	5 s	10 s	5 s	5600 s*
1385, 1395, 1405, 1415 or 1935	Enable	OFF ON	OFF	OFF	OFF	OFF	OFF
1386, 1396, 1406, 1416 or 1936	Fail class	Fail classes	Warning	Warning	Warning	Warning	Warning

NOTE * The range for this alarm is 1500 to 6000 s.

10.3.7 Vector shift (ANSI 78)

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

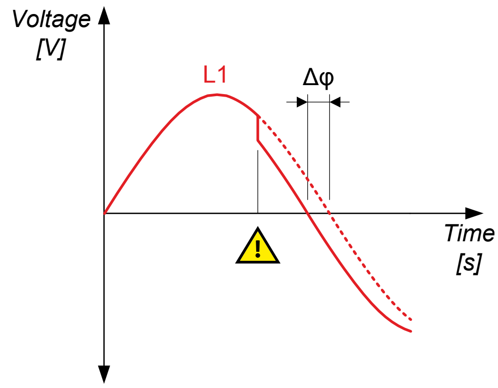
Vector shifts can arise when a mains failure occurs while a generator is running parallel with the mains.

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

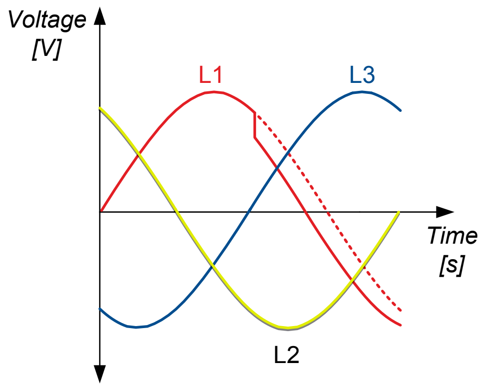
The alarm response is based on the change in the phase angle that occurred due to the mains failure. The alarm response can be based on the change in an individual phase, or on the change in all the phases.

In grids where fast automatic reconnection attempts are expected, this protection opens the breaker to prevent damaging failures. Fast changes in frequency can also activate this alarm. Too sensitive configuration can lead to too many unwanted detections of vector shift.

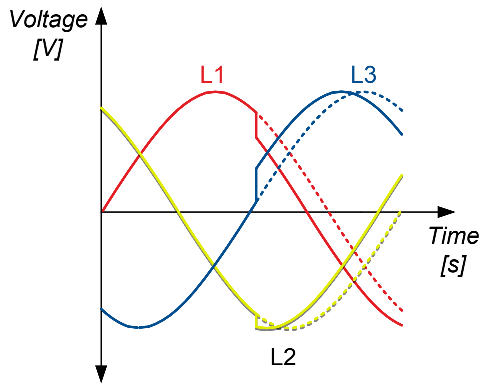
Vector shift causes the instantaneous phase angle change (Δφ)



Vector shift in phase L1 only



Vector shift in all phases



Busbar > Additional protections > Vector shift

Parameter	Text	Range	Default
1431	Set point	1 to 90 °	10 °
1434	Enable	OFF ON	OFF
1435	Fail class	Fail classes	Trip MB
1436	Type	Individual phases All phases	All phases

10.3.8 Rate of change of frequency (ANSI 81R)

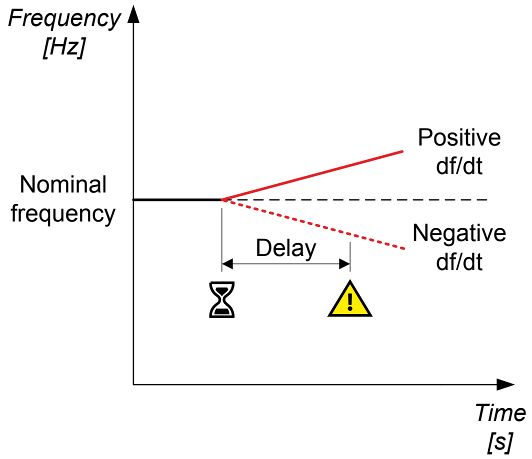
Protection	IEC symbol (IEC60617)	ANSI (IEEE C37.2)	Operate time
ROCOF (df/dt)	df/dt	ANSI 81R	Standard: < 120 ms

When a mains failure occurs, the measured frequency might change within a short period of time, if the generators are either instantly overloaded or instantly deloaded.

If the generator overloads instantly, it slows down, and the generator frequency might decrease shortly. Similarly, if the generator deloads instantly, it speeds up, and the generator frequency might increase shortly.

The alarm response is based on the rate of change of the measured frequency, within a specified time period.

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



`Busbar > Additional protections > df/dt (ROCOF)`

Parameter	Text	Range	Default
1421	Set point	0.200 to 10.000 Hz/s	5.000 Hz/s
1422	Periods	3 to 20 Periods	6 Periods
1423	Timer	0.00 to 3.00 s	0.00 s
1426	Enable	OFF ON	OFF
1427	Fail class	Fail classes	Trip MB

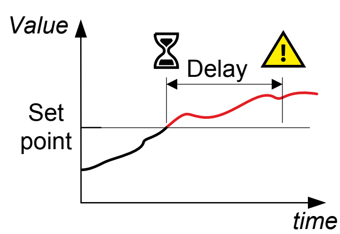
10.4 Mains protections

Protection	IEC symbol (IEC 60617)	ANSI (IEEE C37.2)	Operate time	Alarms
Over-current (4th CT)	3I>, 3I>>	-	-	2
Reverse power (4th CT)	P<, P<<	-	-	2
Overload (4th CT)	P>, P>>	-	-	2

10.4.1 Over-current (4th CT)

Protection	IEC symbol (IEC60617)	ANSI (IEEE C37.2)	Operate time
Over-current for 4th CT measurement	3I>, 3I>>	-	-

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



`Mains > Protections > Current protections (4th CT) [1 to 2]`

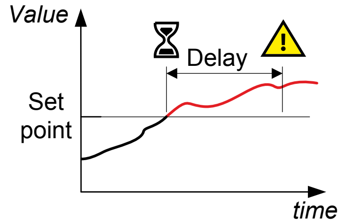
Parameter	Text	Range	I> 1	I> 2
7421, 7431	Set point	50 to 200 %	115 %	120 %
7422, 7432	Timer	0.1 to 3200 s	10 s	10 s

Parameter	Text	Range	I> 1	I> 2
7425, 7435	Enable	OFF ON	OFF	OFF
7426, 7436	Fail class	Fail classes	Warning	Warning

10.4.2 Overload (4th CT)

Protection	IEC symbol (IEC60617)	ANSI (IEEE C37.2)	Operate time
Overload	P>, P>>	-	-

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



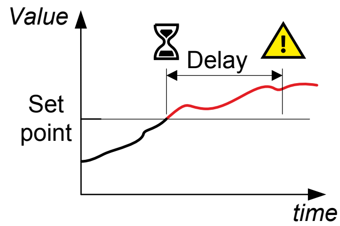
Mains > Protections > Power protections (4th CT) [1 to 2]

Parameter	Text	Range	P> 1	P> 2
7461, 7471	Set point	-200 to 200 %	100 %	110 %
7462, 7472	Timer	0.1 to 3200 s	10 s	5 s
7465, 7475	Enable	OFF ON	OFF	OFF
7466, 7476	Fail class	Fail classes	Warning	Warning

10.4.3 Reverse power (4th CT)

Protection	IEC symbol (IEC60617)	ANSI (IEEE C37.2)	Operate time
Reverse power	P<, P<<	-	-

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



Mains > Protections > Power protections (4th CT) [1 to 2]

Parameter	Text	Range	-P> 1	-P> 2
7441, 7451	Set point	-200 to 0 %	-5 %	-5 %
7442, 7452	Timer	0.1 to 100 s	10 s	10 s
7445, 7455	Enable	OFF ON	OFF	OFF
7446, 7456	Fail class	Fail classes	Warning	Warning

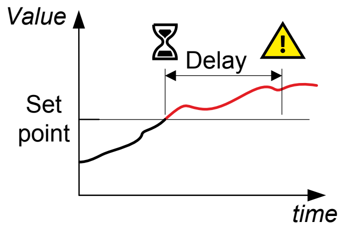
10.5 Additional protections

Protection	IEC symbol (IEC 60617)	ANSI (IEEE C37.2)	Operate time	Alarms
Average over-voltage	-	59AVG	-	2
AC average	-	-	-	2

10.5.1 Average over-voltage (ANSI 59AVG)

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

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



The average voltage calculation is based on the power quality approach in EN 61000-4.30. The root mean squared (RMS) voltage is measured and aggregated for 10 periods at 50 Hz nominal frequency (12 periods at 60 Hz). This result is then aggregated 15 times (that is, for a 3-second average). Finally, the 3-second averages are aggregated over the aggregate time.

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

`Mains > Protections > Voltage protections > Avg. U over-voltage BB > Avg U BB [1 or 2]`

Parameter	Text	Range	Avg U BB> 1	Avg U BB> 2
7481 or 7491	Set point	100 to 120 %	110 %	110 %
7482 or 7492	Timer	0.1 to 3200 s	10 s	10 s
7484 or 7494	Enable	OFF ON	OFF	OFF
7485 or 7495	Fail class	Fail classes	Warning	Warning
7486 or 7496	Timer	30 to 900 s	600 s	600 s

10.5.2 AC average

This function is intended for giving an alarm if the average of a specific measurement exceeds a set point in a certain time frame.

The AC average is calculated based on the RMS value of the three phases. For example, every time the main voltage measurement updates.

The parameters for AC average can only be configured from the utility software.

NOTE When the controller is in idle mode, AC average protection is inhibited.

`Generator > Average protections > Average L-L AC RMS voltage high [1 or 2]`

Parameter	Text	Range	Avg. G U> L-L 1	Avg. G U> L-L 2
14001 or 14011	Set point	100.0 to 120.0 %	103.0 %	105.0 %
14002 or 14012	Timer	0.1 to 100.0 s	10.0 s	10.0 s

Parameter	Text	Range	Avg. G U> L-L 1	Avg. G U> L-L 2
14005 or 14015	Enable	OFF ON	OFF	OFF
14006 Or 14016	Fail class	Fail classes	Warning	Warning

Generator > Average protections > Average L-L AC RMS voltage low [1 or 2]

Parameter	Text	Range	Avg. G U< L-L 1	Avg. G U< L-L 2
14021 or 14031	Set point	100.0 to 120.0 %	97.0 %	95.0 %
14022 or 14032	Timer	0.1 to 100.0 s	10.0 s	5.0 s
14025 or 14035	Enable	OFF ON	OFF	OFF
14026 or 14036	Fail class	Fail classes	Warning	Warning

Generator > Average protections > Average L-N AC RMS voltage high [1 or 2]

Parameter	Text	Range	Avg. G U> L-N 1	Avg. G U> L-N 2
14041 or 14051	Set point	100.0 to 120.0 %	103.0 %	105.0 %
14042 or 14052	Timer	0.1 to 100.0 s	10.0 s	5.0 s
14045 or 14055	Enable	OFF ON	OFF	OFF
14046 or 14056	Fail class	Fail classes	Warning	Warning

Generator > Average protections > Average L-N AC RMS voltage low [1 or 2]

Parameter	Text	Range	Avg. G U< L-N 1	Avg. G U< L-N 2
14061 or 1471	Set point	100.0 to 120.0 %	97.0 %	95.0 %
14062 or 1472	Timer	0.1 to 100.0 s	10.0 s	5.0 s
14065 or 1475	Enable	OFF ON	OFF	OFF
14066 or 1476	Fail class	Fail classes	Warning	Warning

Generator > Average protections > Average AC frequency high [1 or 2]

Parameter	Text	Range	Avg. G f> 1	Avg. G f> 2
14081 or 14091	Set point	100.0 to 120.0 %	103.0 %	105.0 %
14082 or 14092	Timer	0.1 to 100.0 s	10.0 s	5.0 s
14085 or 14095	Enable	OFF ON	OFF	OFF
14086 or 14096	Fail class	Fail classes	Warning	Warning

Generator > Average protections > Average AC frequency low [1 or 2]

Parameter	Text	Range	Avg. G f< 1	Avg. G f< 2
14101 or 14111	Set point	100.0 to 120.0 %	97.0 %	95.0 %
14102 or 14112	Timer	0.1 to 100.0 s	10.0 s	5.0 s
14105 or 14115	Enable	OFF ON	OFF	OFF
14106 or 14116	Fail class	Fail classes	Warning	Warning

Generator > Average protections > Average AC current high [1 or 2]

Parameter	Text	Range	Avg. I> 1	Avg. I> 2
14121 or 14131	Set point	50.0 to 200.0 %	115.0 %	120.0 %
14122 or 141312	Timer	0.1 to 3200.0 s	10.0 s	5.0 s
14125 or 14135	Enable	OFF ON	OFF	OFF
14126 or 14136	Fail class	Fail classes	Warning	Warning

11. General purpose PID

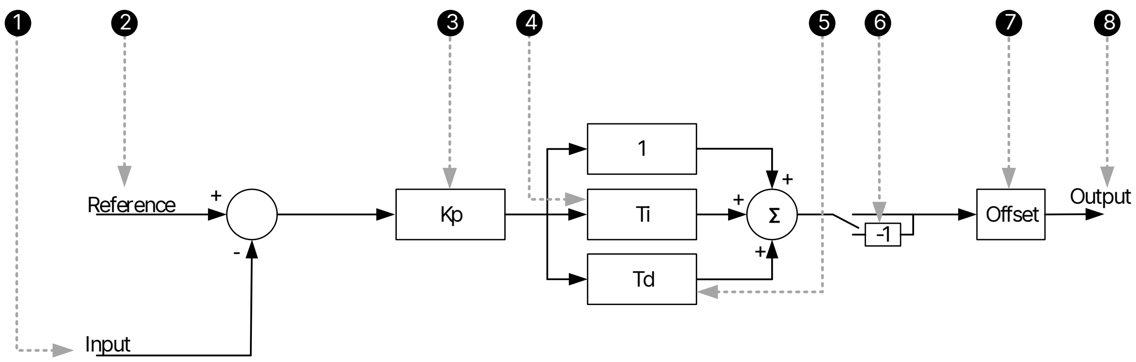
11.1 Introduction

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.

11.1.1 General purpose PID analogue loop

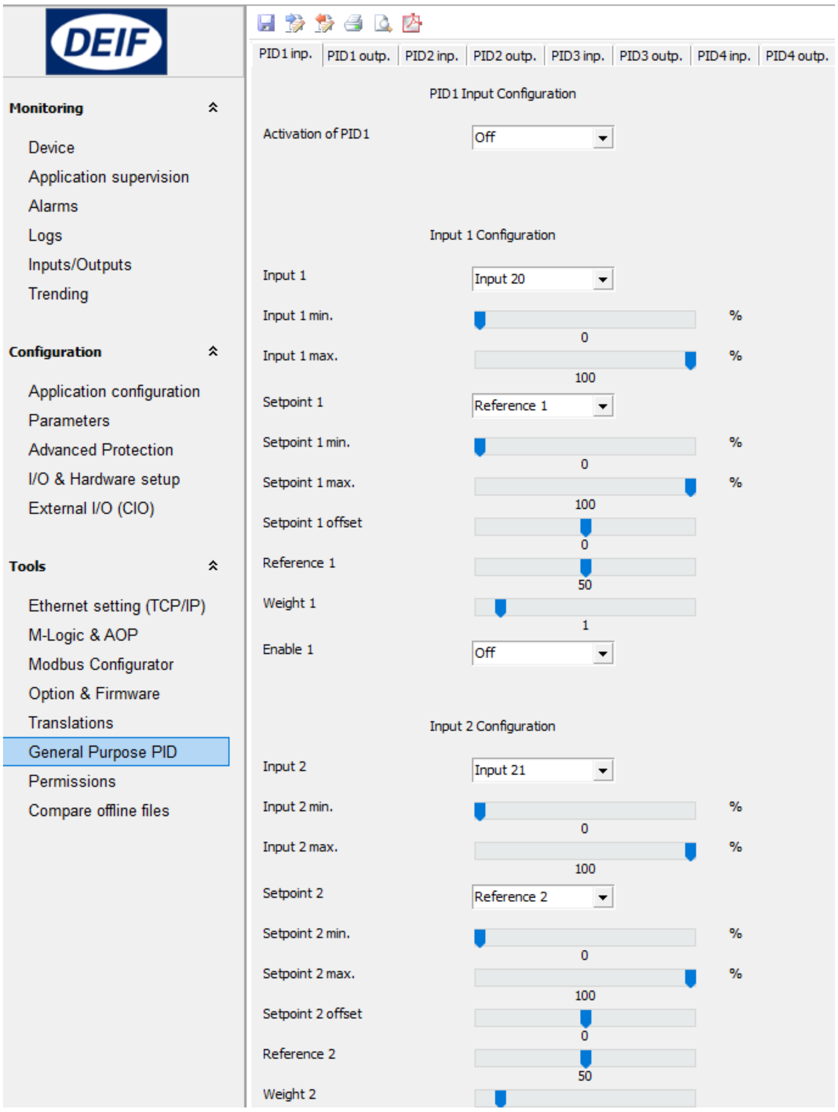
The analogue regulation in the general purpose PIDs is handled by a PID loop. The diagram below shows which elements the PID loop consists of.



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.

11.1.2 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 it cannot be done from the controller.



11.2 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.

11.2.1 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.

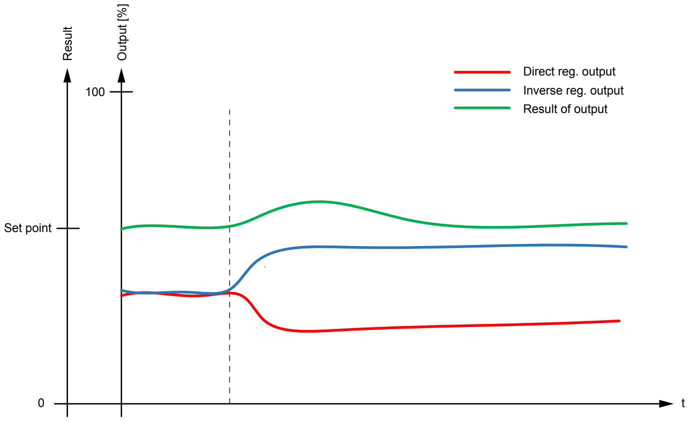
Weight factor applies to dynamic input selection as well. In the event that different weight factors have been configured for any of the three inputs, maximum deviation cannot be equated to maximum output. If two inputs with similar deviation to their respective set points are configured with weight factors of 1 and 2 respectively, the latter will result in twice the output as the first.

11.3 Outputs

11.3.1 Explanation of output settings

Explanation of general purpose PID settings

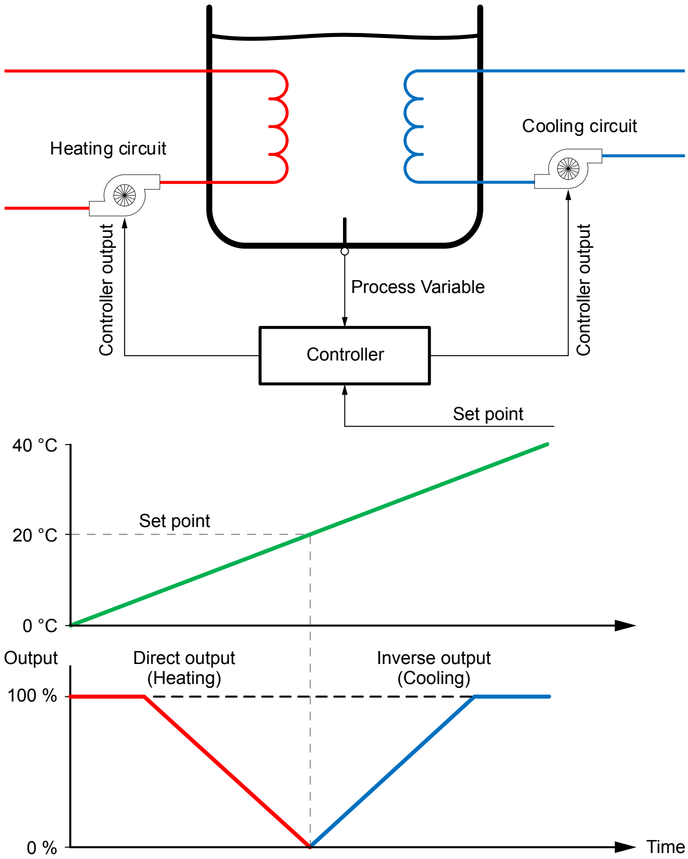
1. **Priority**: This setting determines whether the min. or max. output that is prioritised. This setting is used for the dynamic input selection feature. Maximum output results in selection of the input that gives the greatest output. Minimum output results in selection of the input that gives the 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

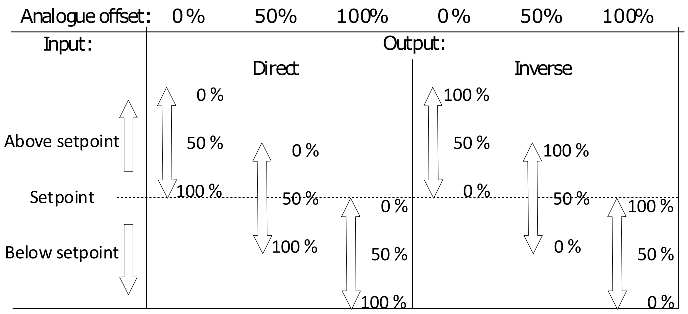


Typically, heating applications use direct output and cooling applications use inverse output. Imagine a container of water, which must be kept at a set point of 20 °C at all times. The container can be exposed to temperatures between 0 and 40 °C, hence it is fitted with both a heating coil and a cooling 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.



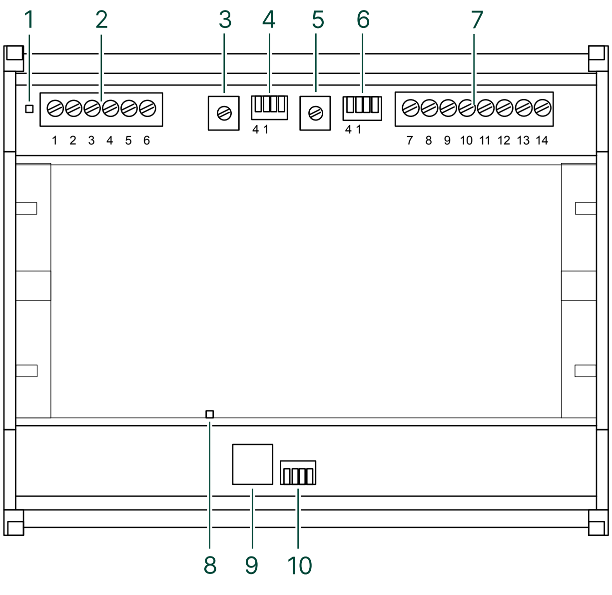
100 % offset is commonly used with inverse output, like in the previous cooling example.

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.

11.3.2 Additional analogue outputs with IOM 230

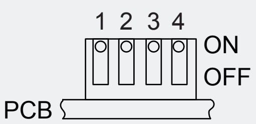
The controller includes two built-in analogue outputs. The controller also supports up to two IOM 230 analogue interface modules, which can provide four additional analogue outputs.

IOM 230 overview



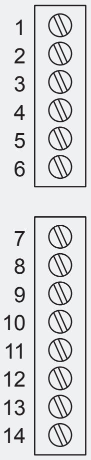
1. IOM 230 status LED (green = system OK, red = system failure)
2. Terminals 1 to 6
3. GOV adjustment
4. GOV output selector
5. AVR adjustment
6. AVR output selector
7. Terminal 7 to 14
8. CAN status LED (green = system OK, red = system failure)
9. PC port
10. IOM 230 CAN ID selector

GOV and AVR output selector settings

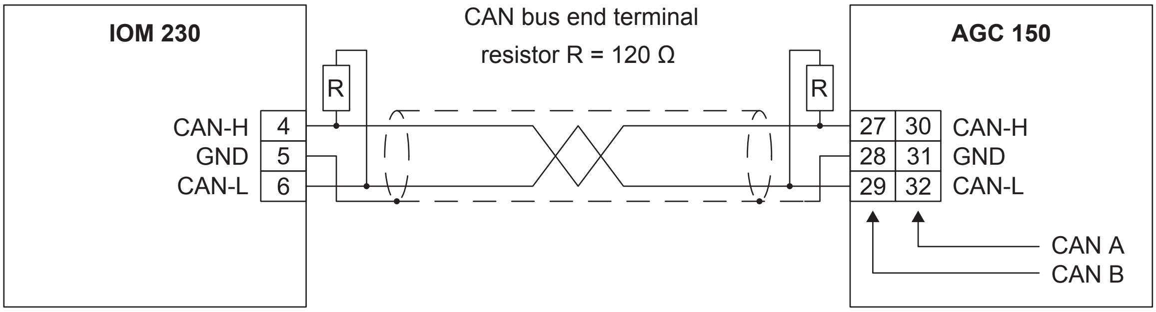
	Output	Switch 1	Switch 2	Switch 3	Switch 4
	+/-25 mA	ON	OFF	Not used	OFF
	0 to 20 mA	OFF	ON		OFF
	+/-12 V DC	ON	OFF		ON
	0 to 10 V DC	OFF	ON		ON

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	

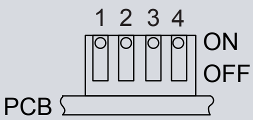
CAN bus connections



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.

11.4 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:

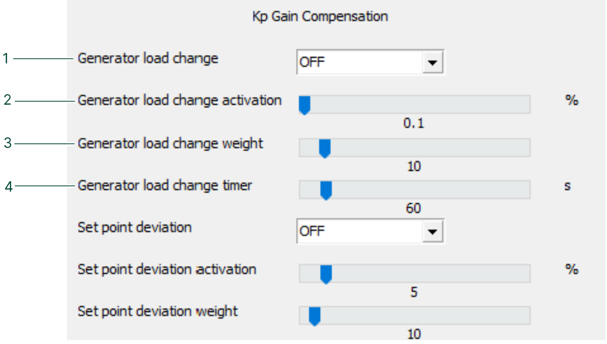
1. The load change gain compensation.
2. Set point deviation compensation.

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.

11.4.1 Load change gain compensation

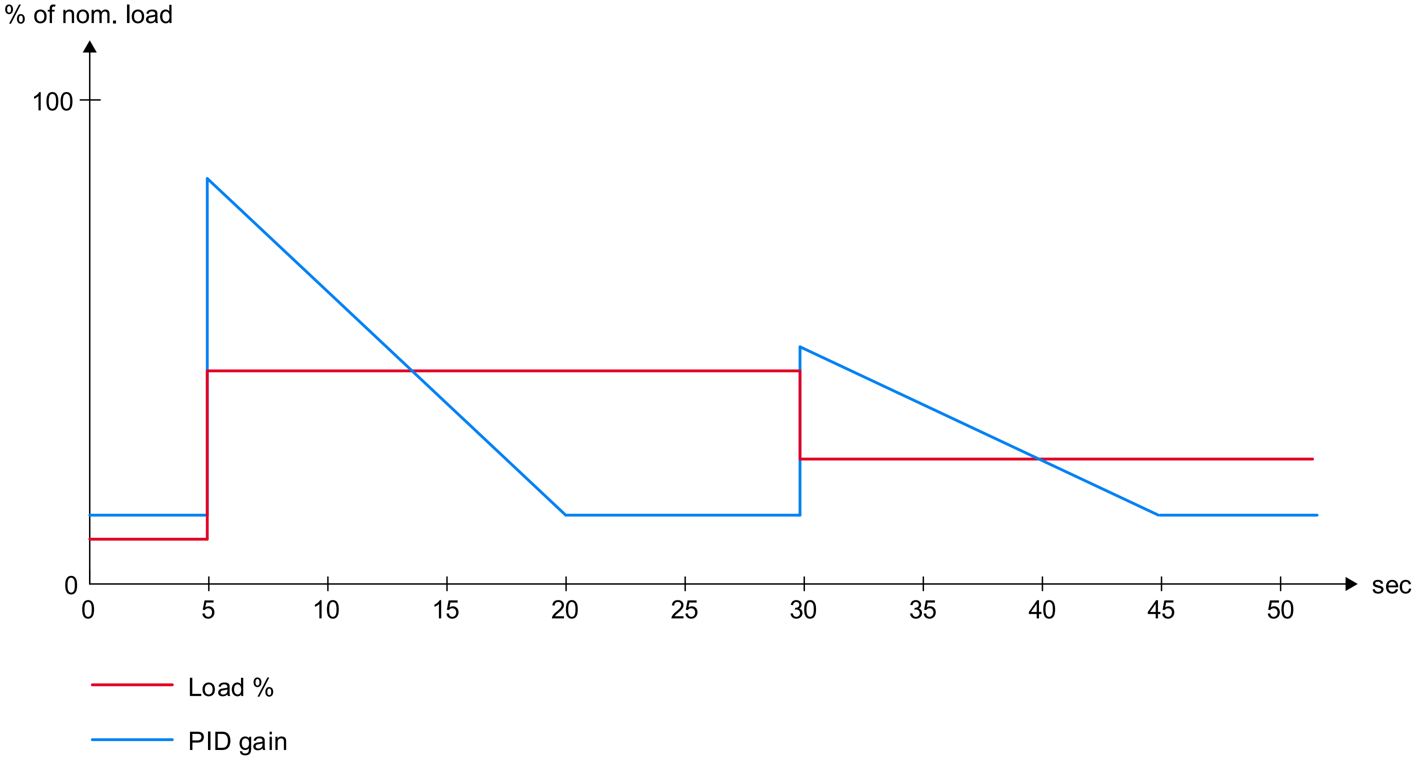
In case of large load impacts or rejections, it can create large deviation in the need of cooling, and thereby create some instability in the cooling system. To alleviate some of this instability, the load change gain compensation will instantaneously increase the gain in relation to the load gain. Larger 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.

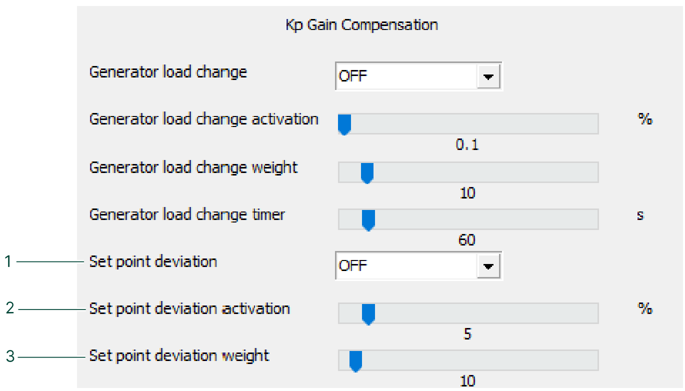
In the first situation, there is a large load impact that triggers the load change gain compensation and increases the gain instantaneously. This increase will decrease, in this case over 15 seconds, and bring the gain back to nominal.

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.

11.4.2 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.

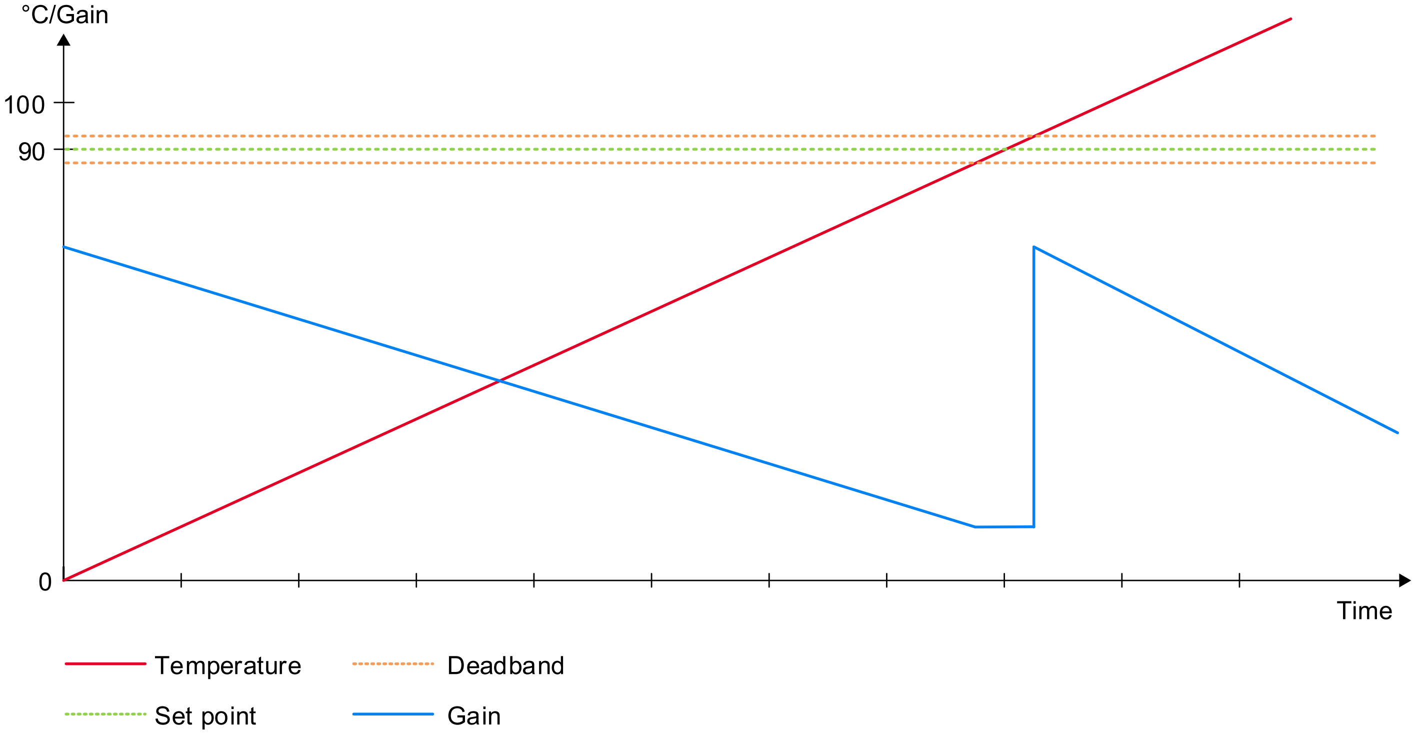
Explanation of settings



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.

11.5 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.

Events

- **PID active**: This event is active when the related PID is activated.
- **PID at min output**: This event is active when the output is below the output parameter M-Logic min event set point.
- **PID at max output**: This event is active when the output is above the output parameter M-Logic max event set point.
- **PID using input 1**: This event is active when dynamic input selection has selected input 1 for output calculation.
- **PID using input 2**: This event is active when dynamic input selection has selected input 2 for output calculation.
- **PID using input 3**: This event is active when dynamic input selection has selected input 3 for output calculation.
- **PID Modbus control**: This event is active when remote Modbus control of this PID is requested.

Commands

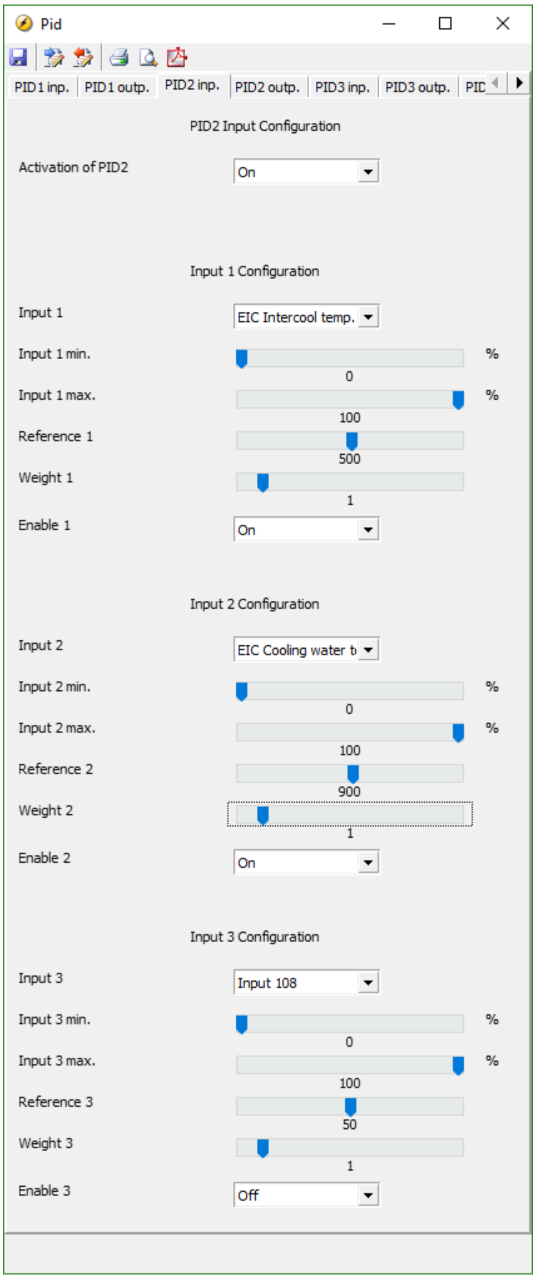
- **PID activate**: This command activates the PID controller.
- **PID force min. outp.**: This command forces the output to the value set in the output parameter Analogue min outp.
- **PID force max. outp.**: This command forces the output to the value set in the output parameter Analogue max outp. (for example, for post-cooling purposes).

- **PID reset**: This command forces the output to the value set in the output parameter Analogue offset.
- **PID Freeze**: This command freezes the output at the current value.

11.6 Example: Use of a general purpose PID

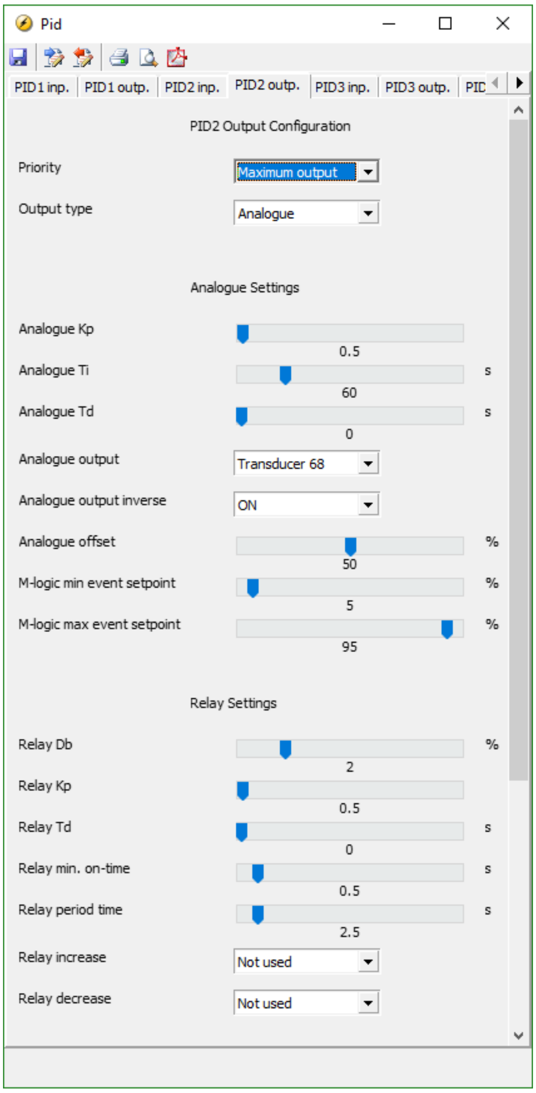
In this example a general purpose PID is used for analogue fan control.

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).

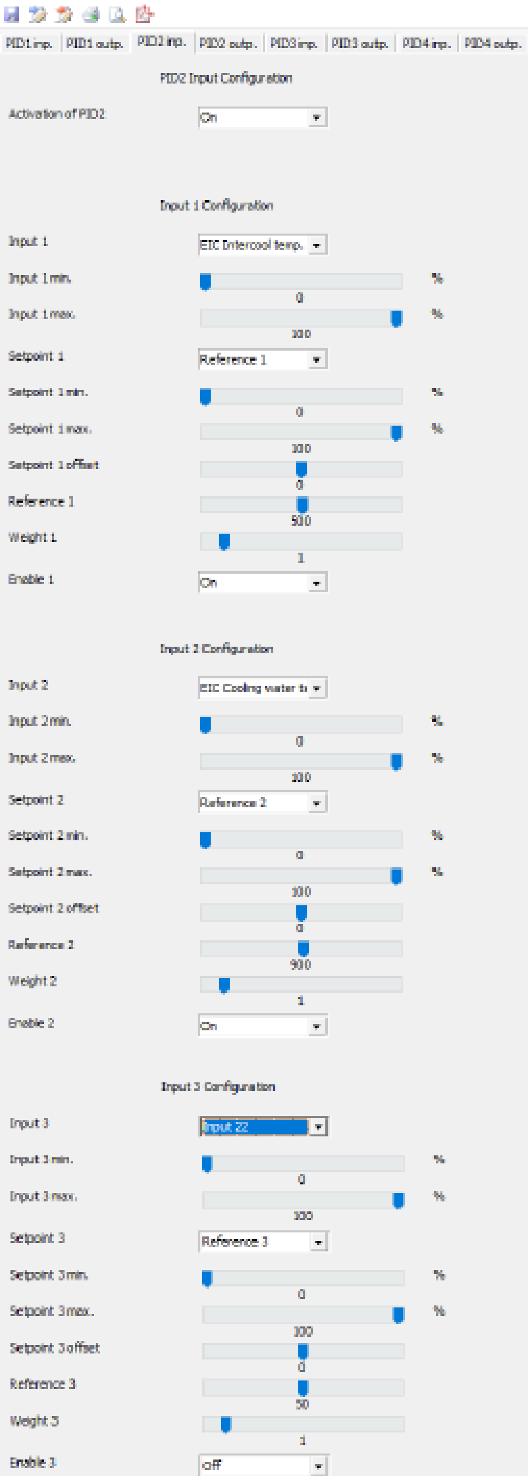
EIC Intercool temp. is selected as input 1, and EIC Cooling water temp. as input 2. Min. and max. values are configured for full range. Input 1 reference set point is set at 500 to achieve a temperature set point of 50.0 °C for intercooler coolant. Input 2 has a reference set point set at 900 to achieve 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:

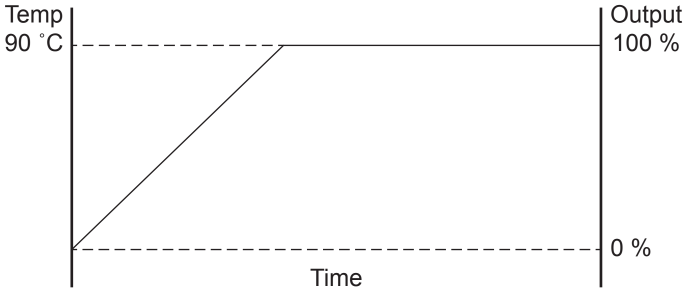
- Analogue is selected as output type, and the physical output is selected to be transducer 68.
- Inverse output is activated to obtain a rise in analogue output to the fan when the temperature rises.
- An offset of 100 % is chosen to achieve 100 % output at the set point.
- Full range of output is selected. 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

12. Inputs and outputs

12.1 Digital inputs

12.1.1 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	Function	Technical data
39	In	Auto start/stop	Negative switching only, < 100 Ω
40	In	Configurable	Negative switching only, < 100 Ω
41	In	Configurable	Negative switching only, < 100 Ω
42	In	Configurable	Negative switching only, < 100 Ω
43	In	Configurable	Negative switching only, < 100 Ω
44	In	Configurable	Negative switching only, < 100 Ω
45	In	Configurable	Negative switching only, < 100 Ω
46	In	Configurable	Negative switching only, < 100 Ω
47	MB on	Configurable (application dependent)	Negative switching only, < 100 Ω
48	MB off	Configurable (application dependent)	Negative switching only, < 100 Ω
49	GB/TB on	Configurable (application dependent), also used for BTB on	Negative switching only, < 100 Ω
50	GB/TB off	Configurable (application dependent), also used for BTB off	Negative switching only, < 100 Ω

12.1.2 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).

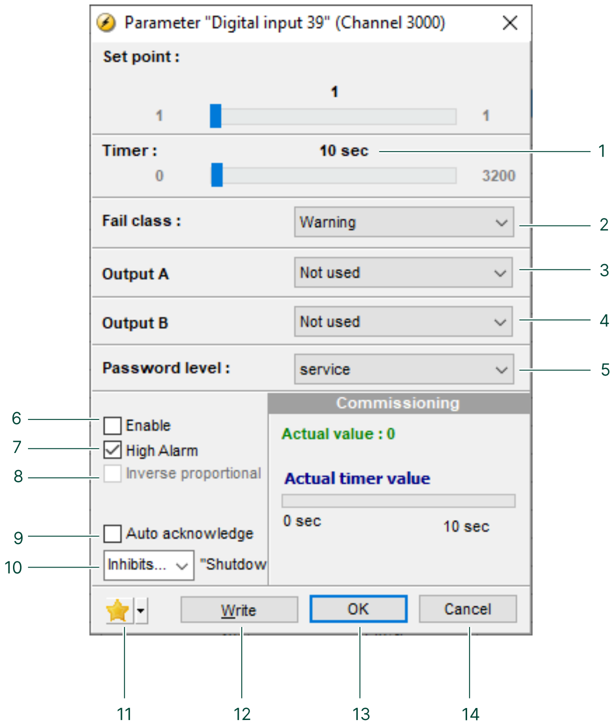
`I/O settings > Inputs > Digital input > Digital input [39 to 50]`

Parameter	Text	Range	Default
3001, 3011, 3021, 3031, 3041, 3051, 3061, 3071, 3081, 3091, 3101 or 3111	Delay	0.0 to 3200 s	10.0 s
3002, 3012, 3022, 3032, 3042, 3052, 3062, 3072, 3082, 3092, 3102 or 3112	Output A	Relays and M-Logic	Not used
3003, 3013, 3023, 3033, 3043, 3053, 3063, 3073, 3083, 3093, 3103 or 3113	Output B	Relays and M-Logic	Not used
3004, 3014, 3024, 3034, 3044, 3054, 3064, 3074, 3084, 3094, 3104 or 3114	Alarm	Disable Enable	Disable
3005, 3015, 3025, 3035, 3045, 3055, 3065, 3075, 3085, 3095, 3105 or 3115	Fail class	Fail classes	Warning
3006, 3016, 3026, 3036, 3046, 3056, 3066, 3076, 3086, 3096, 3106 or 3116	Type	High Low	High

Configure a digital input with the utility software

In the utility software, in *Parameters*, select the digital input to configure.

A window opens with the following parameter settings:



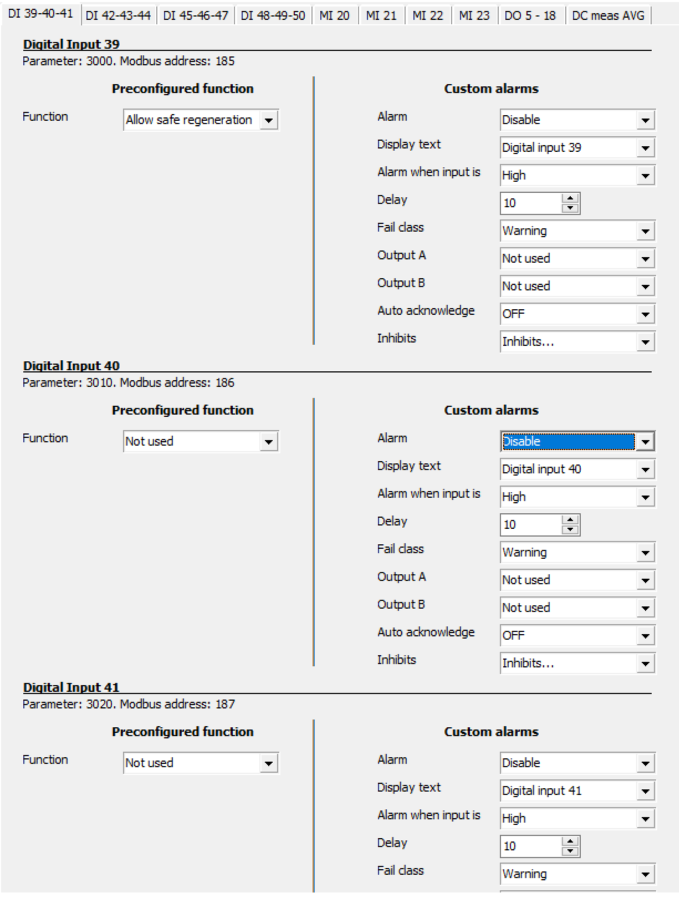
No.	Text	Description
1	Timer	The timer setting is the time from the alarm level is reached until the alarm occurs.
2	Fail class	Select the required fail class from the list. When the alarm occurs, the controller reacts according to the selected fail class.
3	Output A	Select the terminal (or the limit option) to be activated by an alarm. Limit makes the alarm useable as an input event in M-Logic.
4	Output B	Select the terminal (or the limit option) to be activated by an alarm. Limit makes the alarm useable as an input event in M-Logic.
5	Password level	Select the password level that is needed to modify this parameter (cannot be edited by a user with lower privileges).
6	Enable	Activates/deactivates the alarm function.
7	High alarm	The alarm is activated when the signal is high.
8	Inverse proportional	Not used for digital inputs.
9	Auto acknowledge	If this option is set, the alarm is automatically acknowledged if the signal related to the alarm disappears.
10	Inhibits	Select the exceptions to when an alarm must be activated. To select when the alarms are to be active, each alarm has a configurable inhibit setting.
11	Favourite	Mark the parameter as a favourite parameter. You can choose to view only favourite parameters.
12	Write	Select to write the changes to the controller.
13	OK	Select to confirm after each writing to the controller.
14	Cancel	Quit without writing to the controller.

12.1.3 Custom alarms

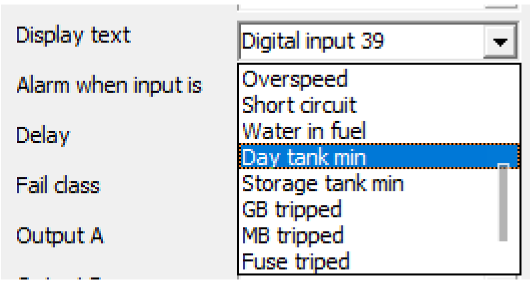
You can configure custom alarms for the digital inputs using the utility software or on the controller.

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:

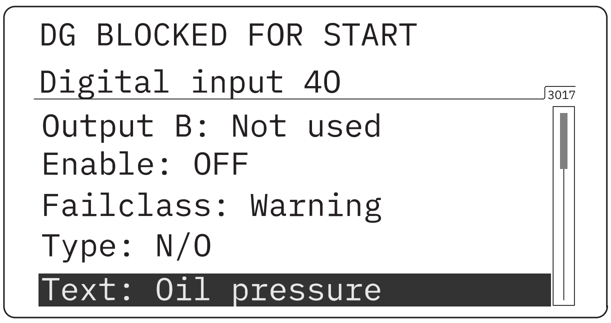


4. Pre-defined display text options are available for the custom alarms:



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.



12.2 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 other stated.

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	Mains default setting	BTB default setting
Relay 05	Run coil	No default	No default
Relay 06	Crank	No default	No default

Relay outputs, group 2

Electrical characteristics

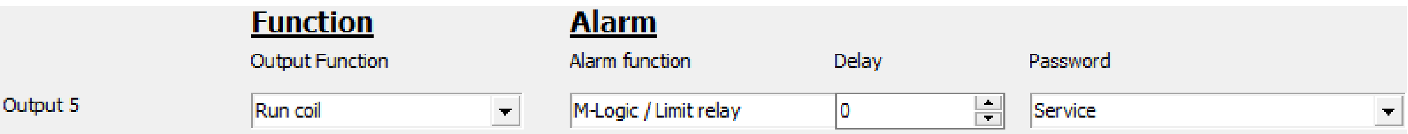
- Voltage: 4.5 to 36 V DC
- Current: 2 A DC inrush, 0.5 A DC continuous

Relay	Genset default setting	Mains default setting	BTB default setting
Relay 09	Start prepare	No default	No default
Relay 10	Stop coil	No default	No default
Relay 11	Status OK	Status OK	Status OK
Relay 12	Horn	Horn	Horn
Relay 13	No default	No default	No default
Relay 14	No default	No default	No default
Relay 15	No default	MB ON relay*	No default
Relay 16	No default	MB OFF relay*	No default
Relay 17	GB ON relay*	TB ON relay*	BTB ON relay*
Relay 18	GB OFF relay*	TB OFF relay*	BTB OFF relay*

NOTE * Not configurable.

12.2.1 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

Setting	Description
	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).

12.3 Analogue inputs

12.3.1 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.

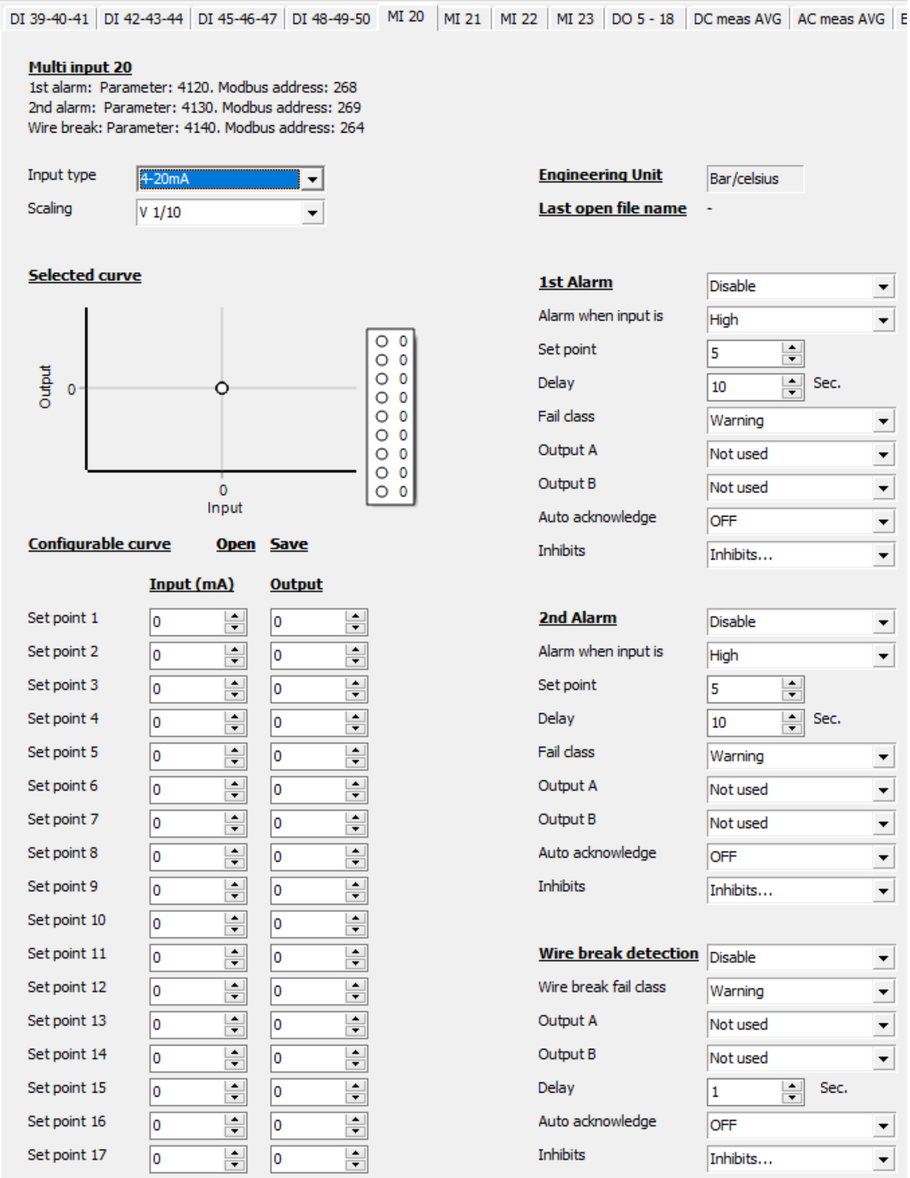
12.3.2 Application description

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.

12.3.3 Configuring multi-inputs

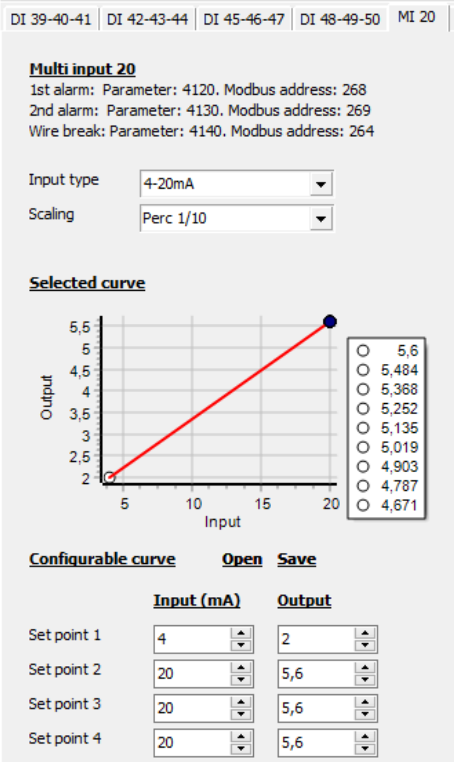
Configure each multi-input to match the connected sensor.

1. In the utility software, select *I/O & Hardware setup*, then select *MI 20 / 21 / 22 / 23*.

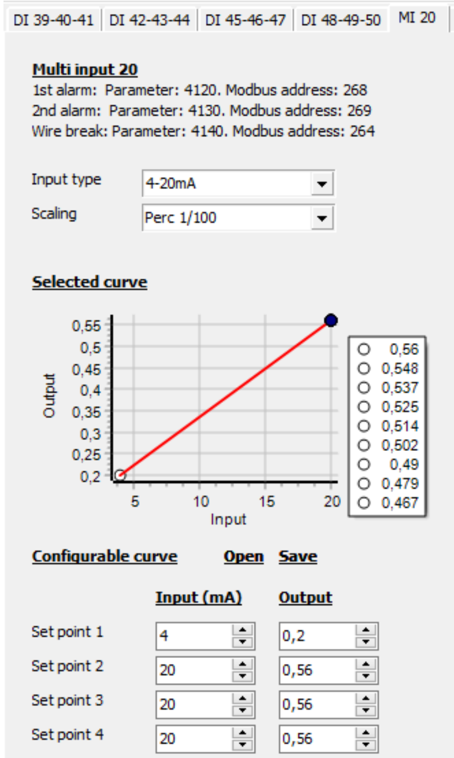


2. Select the appropriate *Scaling*.

Examples



Scaling 1/10

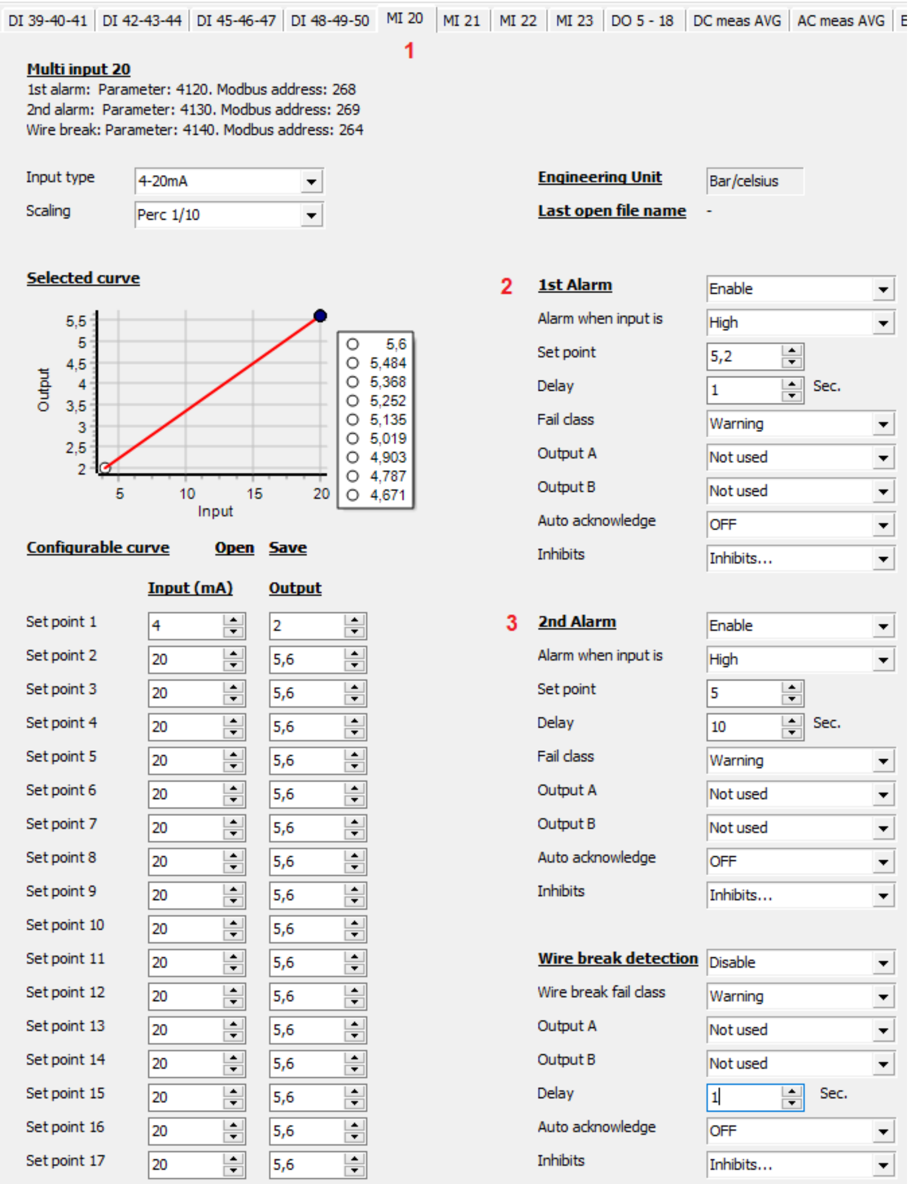


Scaling 1/100

12.3.4 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`

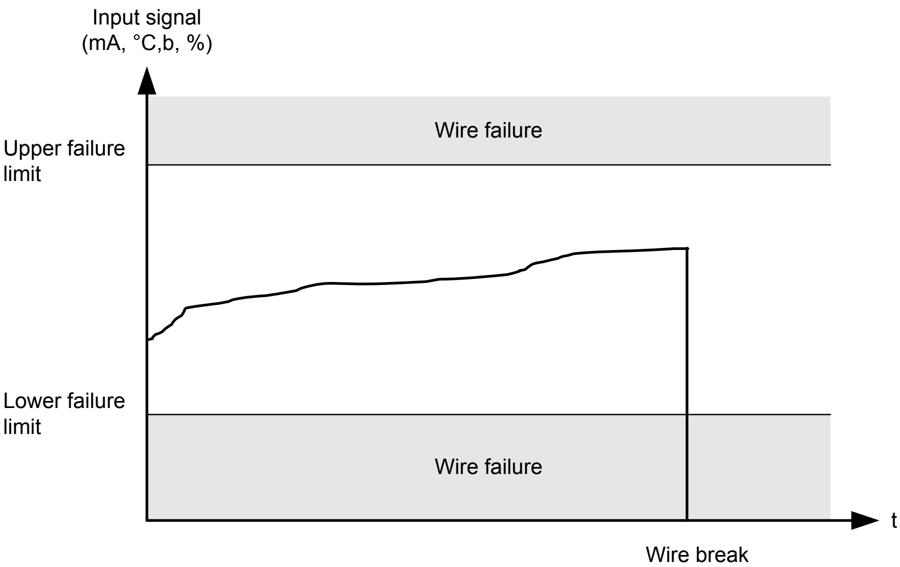
12.3.5 Wire break

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]`

12.3.6 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.

12.3.7 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		

12.4 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

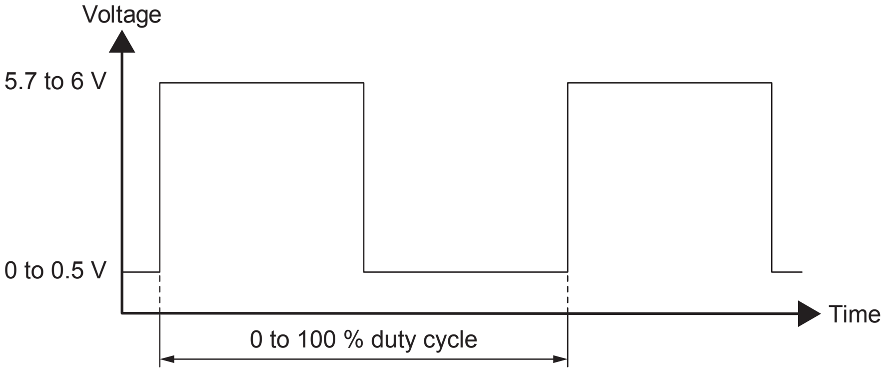
Duty cycle

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.

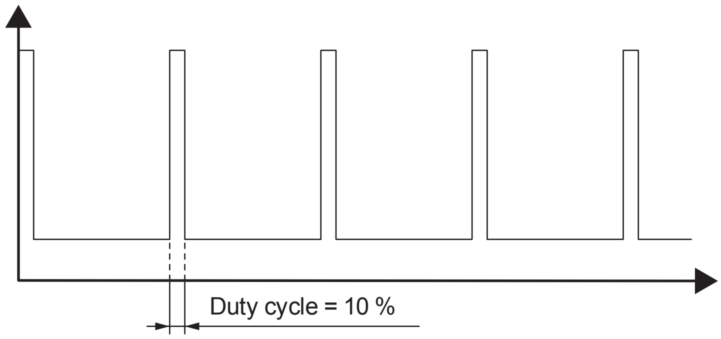
`Engine > Speed control > Analogue configuration > PWM 52 setup`

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

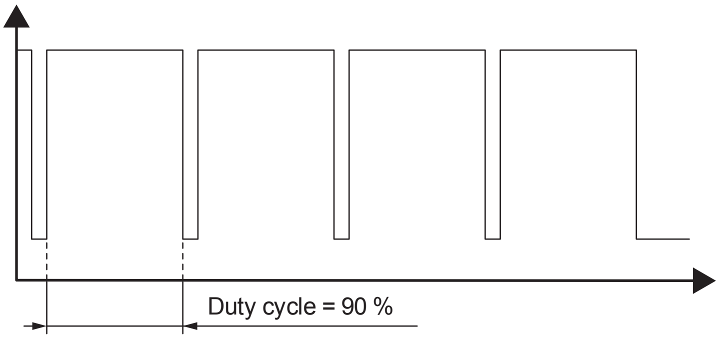
Duty cycle (min. level 0 to 0.05 V, max. level 5.7 to 6.0 V)



Example: 10 % duty cycle



Example: 90 % duty cycle



12.4.1 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**.

12.4.2 TEM controller configuration

The AGC 150 controller can be used to control a TEM controller.

Configure the TEM controller parameters

As a default, transducer output 52 is used to control the governor, however the output is needed to control the TEM controller.

1. Go to parameter 5981 and disable the *Governor output*.
2. To use the transducer output for the TEM controller, go to parameter 5753 and select **-10 to 10V** as the *set point* and for Transducer A, select **Transducer 52**.
3. Go to parameter 5755, *Contr. settings P*, to configure the power reference set point for when the genset breaker is open. The set point must be 30 % or more for the genset to start.
4. Configure the maximum power set point with parameter 5754.

Parameters for the TEM controller

Parameter	Value	Detail
5753	P ref perc Out type	The power set point.
5754	P ref perc Out max	The maximum value for the power set point.
5755	Control. settings P	The power set point with an open breaker.