DEIF

-power in control

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DESIGNER'S REFERENCE HANDBOOK

Automatic Genset Controller, AGC-3

- Functional description
- Display unit and menu structure
- PID-controller
- Procedure for parameter setup
- Parameter list

1. General information

2. General product information

3. Functional descriptions

1. General information

1.1 Warnings, legal information and safety

1.1.1 Warnings and notes

Throughout this document, a number of warnings and notes with helpful user information will be presented. To ensure that these are noticed, they will be highlighted as follows in order to separate them from the general text.

Warnings

⚠ **Warnings indicate a potentially dangerous situation, which could result in death, personal injury or damaged equipment, if certain guidelines are not followed.**

Notes

ⓘ **Notes provide general information, which will be helpful for the reader to bear in mind.**

1.1.2 Legal information and disclaimer

DEIF takes no responsibility for installation or operation of the generator set. If there is any doubt about how to install or operate the engine/generator controlled by the Multi-line 2 unit, the company responsible for the installation or the operation of the set must be contacted.

⚠ **The Multi-line 2 unit 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.

1.1.3 Safety issues

Installing and operating the Multi-line 2 unit may imply work with dangerous currents and voltages. Therefore, the installation should only be carried out by authorised personnel who understand the risks involved in working with live electrical equipment.

⚠ **Be aware of the hazardous live currents and voltages. Do not touch any AC measurement inputs as this could lead to injury or death.**

1.1.4 Electrostatic discharge awareness

Sufficient care must be taken to protect the terminal against static discharges during the installation. Once the unit is installed and connected, these precautions are no longer necessary.

1.1.5 Factory settings

The Multi-line 2 unit is delivered from factory with certain factory settings. These are based on average values and are not necessarily the correct settings for matching the engine/generator set in question. Precautions must be taken to check the settings before running the engine/generator set.

1.2 About the Designer's Reference Handbook

1.2.1 General purpose

This Designer's Reference Handbook mainly includes functional descriptions, presentation of display unit and menu structure, information about the PID controller, the procedure for parameter setup and reference to parameter lists.

The general purpose of this document is to provide useful overall information about the functionality of the unit and its applications. This document also offers the user the information he needs in order to successfully set up the parameters needed in his specific application.

⚠ **Please make sure to read this document before starting to work with the Multi-line 2 unit and the genset to be controlled. Failure to do this could result in human injury or damage to the equipment.**

1.2.2 Intended users

This Designer's Reference Handbook is mainly intended for the panel builder designer in charge. On the basis of this document, the panel builder designer will give the electrician the information he needs in order to install the Multi-line 2 unit, e.g. detailed electrical drawings. In some cases, the electrician may use these installation instructions himself.

1.2.3 Contents and overall structure

This document is divided into chapters, and in order to make the structure simple and easy to use, each chapter will begin from the top of a new page.

2. General product information

2.1 Introduction

This chapter will deal with the unit in general and its place in the DEIF product range.

The AGC is part of the DEIF Multi-line 2 product family. Multi-line 2 is a complete range of multi-function generator protection and control products integrating all the functions you need into one compact and attractive solution.

The concept of the AGC is to offer a cost-effective solution to genset builders, who need a flexible generator protection and control unit for medium to large genset applications. Being part of the Multi-line product family, the standard functions can be supplemented with a variety of optional functions.

2.2 Type of product

The Automatic Genset Controller is a micro-processor based control unit containing all necessary functions for protection and control of a genset.

It contains all necessary 3-phase measuring circuits, and all values and alarms are presented on the LCD display.

2.3 Options

The Multi-line 2 product range consists of different basic versions which can be supplemented with the flexible options needed to provide the optimum solution. The options cover e.g. various protections for generator, busbar and mains, voltage/VAr/PF control, various outputs, power management, serial communication, additional operator display, etc.

> **(i)** **A full options list is included in the data sheet, document no. 4921240396. Please see www.deif.com**

2.4 PC utility software warning

> **⚠** **It is possible to remote control the genset from the PC utility software or M-Vision by use of a modem. To avoid personal injury, make sure that it is safe to remote control the genset.**

3. Functional descriptions

3.1 Standard functions

This chapter includes functional descriptions of standard functions as well as illustrations of the relevant application types. Flowcharts and single-line diagrams will be used in order to simplify the information.

In the following paragraphs the standard functions are listed.

3.1.1 Operation modes
● Automatic Mains Failure
● Island operation
● Fixed power/base load
● Peak shaving
● Load takeover
● Mains power export
● Remote Maintenance

3.1.2 Engine control
● Start/stop sequences
● Run and stop coil
● Relay outputs for governor control

3.1.3 Generator protection (ANSI)
● 2 x reverse power (32)
● 5 x overload (32)
● 6 x overcurrent (50/51)
● 2 x overvoltage (59)
● 3 x undervoltage (27)
● 3 x over-/underfrequency (81)
● Voltage-dependent overcurrent (51V)
● Current/voltage unbalance (60)
● Loss of excitation/overexcitation (40/32RV)
● Non-essential load/load shedding, 3 levels (I, Hz, P>, P>>)
● Multi-inputs (digital, 4-20 mA, 0-40V DC, Pt100, Pt1000 or VDO)
● Digital inputs

3.1.4 Busbar protection (ANSI)
● 3 x overvoltage (59)
● 4 x undervoltage (27)
● 3 x overfrequency (81)
● 4 x underfrequency (81)
● Voltage unbalance (60)

3.1.5 Display
● Prepared for remote mounting
● Push-buttons for start and stop
● Push-buttons for breaker operations
● Status texts

3.1.6 M-logic

● Simple logic configuration tool
● Selectable input events
● Selectable output commands

3.2 Terminal strip overview

The terminal strip overview shows I/Os for selectable standard and optional hardware.

Refer to the data sheet for accurate information about possible configurations for the AGC.

Refer to the input/output lists in the installation instructions for detailed information about the I/Os of the specific options.

3.2.1 Slot #1, #2, #5 and #6

	36			97	
	35			96	
	34			95	
	33	Reserved for options.	Reserved for options.	94	
	32	*See datasheet*	*See datasheet*	93	
	31			92	
	30			91	
	29	Slot #2	Slot #6	90	

Common for 23-27 — 28 — Slot #1 / Slot #5

Label	Terminal
Common for 23-27	28
GB Closed	27
GB Open	26
MB Closed / configurable	25
MB Open / configurable	24
Configurable	23
Common for 20/21	22
kVArh pulse / Relay 21	21
kWh pulse / Relay 20	20
Close Generator Breaker (sync.)	19
	18
	17
	16
Open Generator Breaker	15
	14
Close Mains Breaker / configurable	13
	12	Relay 11
	11
Open Mains Breaker / configurable	10
	9	Relay 08
	8
	7
Alarm horn / configurable	6	Relay 05
	5
Status relay	4
	3	Status relay
DC power supply (÷)	2
8-36VDC (+)	1

Terminal	Label	
89	L3	
88	Neutral	
87	L2	BUSBAR VOLTAGE
86		
85	L1	
84	Neutral	
83	L3	
82		GENERATOR VOLTAGE
81	L2	
80		
79	L1	
78	S2 (l)	L3 AC current
77	S1 (k)	L3 AC current
76	S2 (l)	L2 AC current
75	S1 (k)	L2 AC current
74	S2 (l)	L1 AC current
73	S1 (k)	L1 AC current

3.2.2 Slot #3, #4, #7 and #8
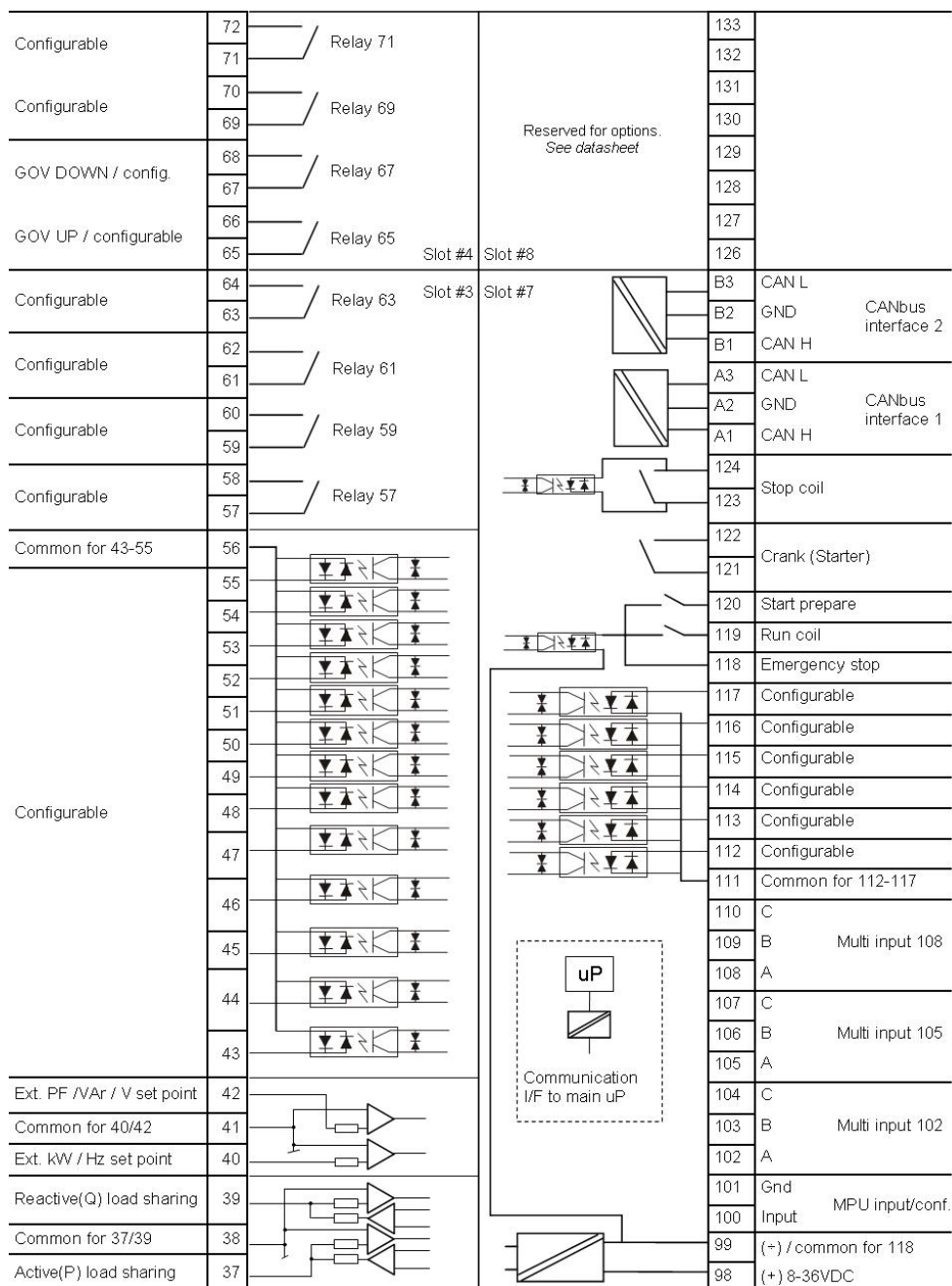
The hardware shown in slot #3 is option M12 and G3. For a detailed description of these options, please refer to the option descriptions.

3.3 Applications

3.3.1 Applications and genset modes

(i) **This section about applications is to be used for reference using the particular genset mode as starting point. It is not suitable for reading from beginning to end.**

The unit can be used for the applications listed in the table below.

Application	Comment
Automatic Mains Failure (no back sync.)	Standard
Automatic Mains Failure (with back sync.)	Standard
Island operation	Standard
Fixed power/base load	Standard
Peak shaving	Standard
Load takeover	Standard
Mains power export (fixed power to mains)	Standard
Multiple gensets, load sharing	Requires option G3
Multiple gensets, power management	Requires option G5
Remote maintenance	Requires option H8.x and a remote maintenance box from DEIF A/S

Genset mode	Running mode				
	Auto	Semi	Test	Man	Block
Automatic Mains Failure (no back sync.)	X	X	X	X	X
Automatic Mains Failure (with back sync.)	X	X	X	X	X
Island operation	X	X		X	X
Fixed power/base load	X	X	X	X	X
Peak shaving	X	X	X	X	X
Load takeover	X	X	X	X	X
Mains power export	X	X	X	X	X
Multiple gensets, load sharing	X	X		X	X
Multiple gensets, power management	X	X	(X)	X	X
Remote maintenance		X			X

(i) **Power Management (option G5): test mode is not available in an island application or with the plant mode set to "Island operation".**

(i) **For a general description of the available running modes, please refer to the chapter "Running mode description".**

3.3.2 AMF (no back synchronisation)

Auto mode description

The unit automatically starts the genset and switches to generator supply at a mains failure after an adjustable delay time. It is possible to adjust the unit to change to genset operation in two different ways.

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

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

When the mains returns, the unit will switch back to mains supply and cool down and stop the genset. The switching back to mains supply is done without back synchronisation when the adjusted "Mains OK delay" has expired.

Semi-auto mode description

When the generator breaker is closed, the unit will use the nominal frequency as the setpoint for the speed governor. If AVR control (option D1) is selected, then the nominal voltage is used as setpoint.

(i) **For a general description of the available running modes, please refer to the chapter "Running mode description".**

3.3.3 AMF (with back synchronisation)

Auto mode description

The unit automatically starts the genset and switches to generator supply at a mains failure after an adjustable delay time. It is possible to adjust the unit to change to genset operation in two different ways:

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

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

When the mains returns, the unit will synchronise the mains breaker to the busbar when the "Mains OK delay" has expired. Then the genset cools down and stops.

(i) **The automatic mains failure mode can be combined with the "Overlap" function. In that case, the generator breaker and the mains breaker will never be closed at the same time for a longer period than the adjusted "Overlap" time.**

Semi-auto mode description

When the generator breaker is closed and the mains breaker is opened, the unit will use the nominal frequency as the setpoint for the speed governor. If AVR control (option D1) is selected, the nominal voltage is used as the setpoint.

When the generator is paralleled to the mains, the governor regulation will no longer be active. If AVR control (option D1) is selected, then the setpoint will be the adjusted power factor **(7050 Fixed power set).**

(i) **For a general description of the available running modes, please refer to the chapter "Running mode description".**

3.3.4 Island operation

Auto mode description
The unit 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 will be 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 the *time-dependent start/stop* commands are to be used, then the auto mode must also be used.

Semi-auto mode description
When the generator breaker is closed, the unit will use the nominal frequency as setpoint for the speed governor. If AVR control (option D1) is selected, the nominal voltage is used as setpoint.

(i) **For a general description of the available running modes, please refer to the chapter "Running mode description".**

3.3.5 Fixed power/base load

Auto mode description
The unit automatically starts the genset and synchronises to the mains when the digital input "auto start/stop" is activated. After the generator breaker closure, the unit ramps up the load to the setpoint level. When the stop command is given, the genset is deloaded and stopped after the 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 the *time-dependent start/stop* commands are to be used, then the auto mode must also be used.
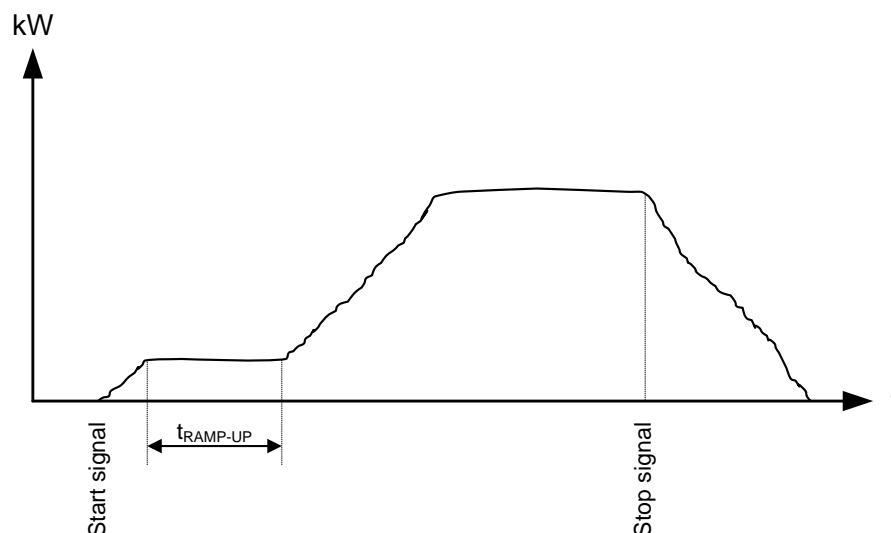
Diagram, fixed power - principle

Semi-auto mode description
When the generator breaker is closed and the mains breaker is opened, the unit will use the nominal frequency as the setpoint for the speed governor. If AVR control (option D1) is selected, the nominal voltage is used as setpoint.

When the generator is paralleled to the mains, the generator power will be increased to the fixed power setpoint. If AVR control (option D1) is selected, then the setpoint will be the adjusted power **(7050 Fixed power set).**

Setpoints related to fixed power

2610 Power ramp up

Ramp speed: Defines the slope of the ramp up.
Delay point: At this point, the ramp up is cancelled until the delay has expired.
Delay: When this delay has expired, the ramp up is continued from the delay point.
Enable: Enable load ramp steps.
Steps: Defines the number of steps related to the delay point setting.
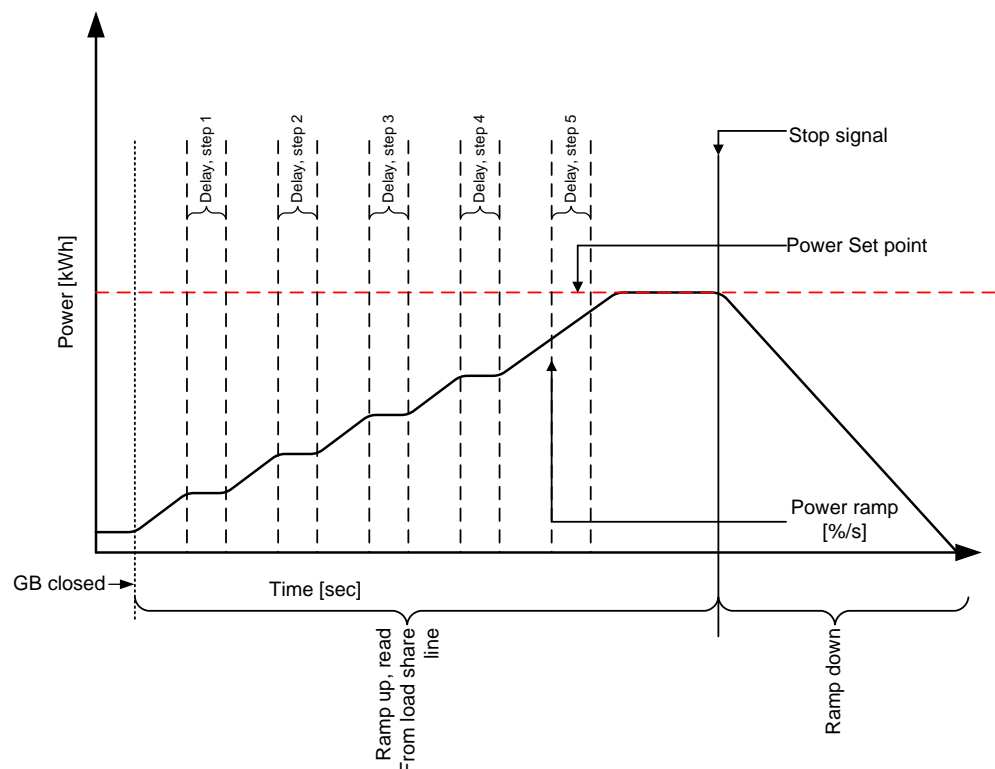
3.3.6 Ramp up with load steps

When the GB is closed, the power setpoint continues to rise in ramp up steps, determined by the number of steps in menu 2615. 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 present power setpoint.

3.3.7 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:

1. The power ramp will stop at any point of the power ramp, and this setpoint will be maintained as long as the function is active.
2. If the function is activated while ramping from one delay point to another, the ramp will be fixed until the function is deactivated again.
3. 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.

(i) **The delay starts running when the GB has been closed.**

2620 Power ramp down

Ramp speed: Defines the slope of the ramp down.
Breaker open: The amount of power accepted when opening the breaker.

7050 Fixed power set

Power set: The amount of power the genset will produce.

(i) **For a general description of the available running modes, please refer to the chapter "Running mode description".**

3.3.8 Peak shaving

Auto mode description

The genset will start at a predefined mains import level and run at a fixed minimum load, e.g. 10%. When the mains import increases above the maximum mains import setpoint, the genset will supply the extra load in order to maintain the mains import at the maximum import level.

When the load drops below the maximum mains import setpoint, the genset will run at min. load again. When the mains import and the generator load decrease below the stop setpoint, the genset will cool down and stop.

A 4-20 mA transducer is used for indication of the power imported from the mains.
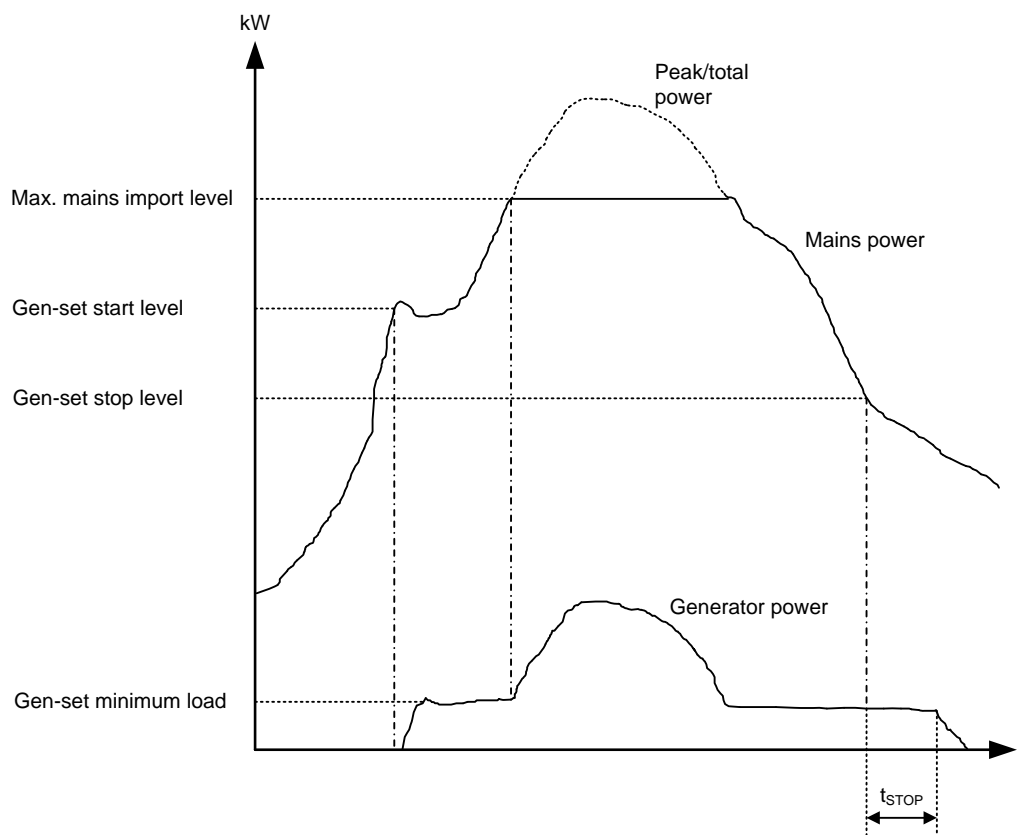
Diagram, peak shaving – example

Semi-auto mode description
When the generator breaker is closed and the mains breaker is opened, the unit will use the nominal frequency as setpoint for the speed governor. If AVR control (option D1) is selected, the nominal voltage is used as setpoint.

When the generator is paralleled to the mains, the generator will be controlled according to the peak shaving setpoint. So the maximum mains import will not be exceeded in spite of the semi- auto mode. If AVR control (option D1) is selected, the setpoint is the adjusted power factor **(7050 Fixed power set).**

Setpoints related to peak shaving

7000 Mains power
Day and night: The mains power import limits for the peak shaving.
Tmax and Tmin: The transducer range in kW which corresponds to the 4-20 mA transducer signal connected on multi-input 102.

7010 Daytime period
These settings define the daytime period. The hours outside the daytime period are considered to be the night-time period.

7020 Start generator
Start setpoint: The start setpoint is in percent of the day and night settings in menu 7000 Mains power.
Delay: The genset will start when the start setpoint has been exceeded and this delay has expired.
Load: The minimum load the genset will produce when parallel to mains.

7030 Stop generator
Stop setpoint: The stop setpoint is in percent of the day and night settings in menu 7000 Mains power.
Delay: The genset will stop when the stop setpoint has been exceeded and this delay has expired.

(i) **For a general description of the available running modes, please refer to the chapter "Running mode description".**

3.3.9 Load takeover

Auto mode description
- Back synchronising ON
The purpose of the load takeover mode is to transfer 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. Then 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 is used for indication of the power imported from the mains.
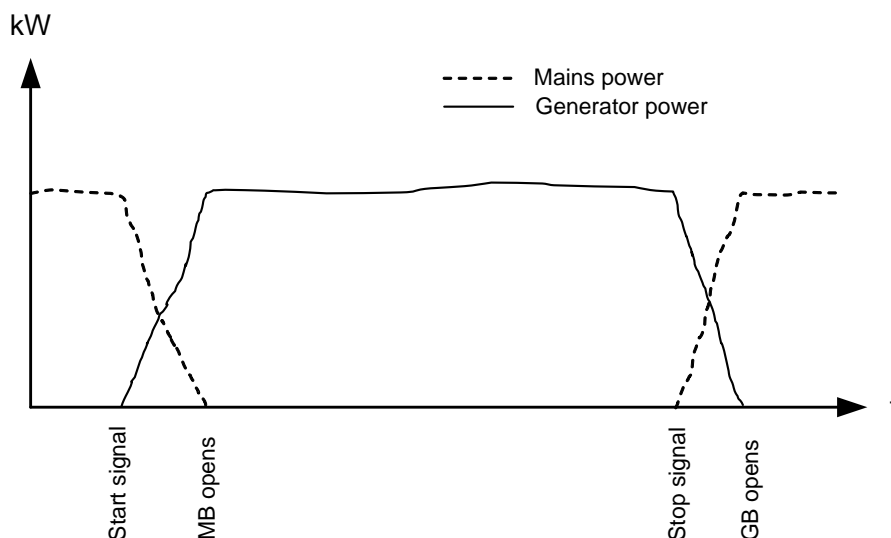
Diagram, load takeover - example

(i) **The load takeover mode can be combined with the overlap function. In that case, the generator and the mains breakers will never be closed at the same time for a longer period than the adjusted "overlap" time.**

(i) **If the imported load is higher than the nominal genset power, an alarm appears and the load takeover sequence is paused.**

- 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. Now, the generator supplies the load until the stop command is given. Then, the generator breaker opens and the mains breaker closes. The genset cools down and stops.

A 4-20 mA transducer is used for indication of the power imported from the mains.

(i) **If the imported load is higher than the nominal genset, an alarm appears and the load takeover sequence is paused.**

Semi-auto mode

When the generator breaker is closed and the mains breaker is opened, the unit will use the nominal frequency as setpoint for the speed governor. If AVR control (option D1) is selected, the nominal voltage is used as setpoint.

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 (option D1) is selected, the setpoint is the adjusted power factor **(7050 Fixed power set).**

(i) **For a general description of the available running modes, please refer to the chapter "Running mode description".**

3.3.10 Mains power export (fixed power to mains)

Auto mode description

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.

(i) **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 will start to export power to the mains. The amount of power exported will be kept at a fixed level regardless of the load on the busbar (the factory).

The stop command will cause the genset to deload and trip the generator breaker. Afterwards, it will cool down and stop.

A 4-20 mA transducer is used for indication of the power exported from the mains.
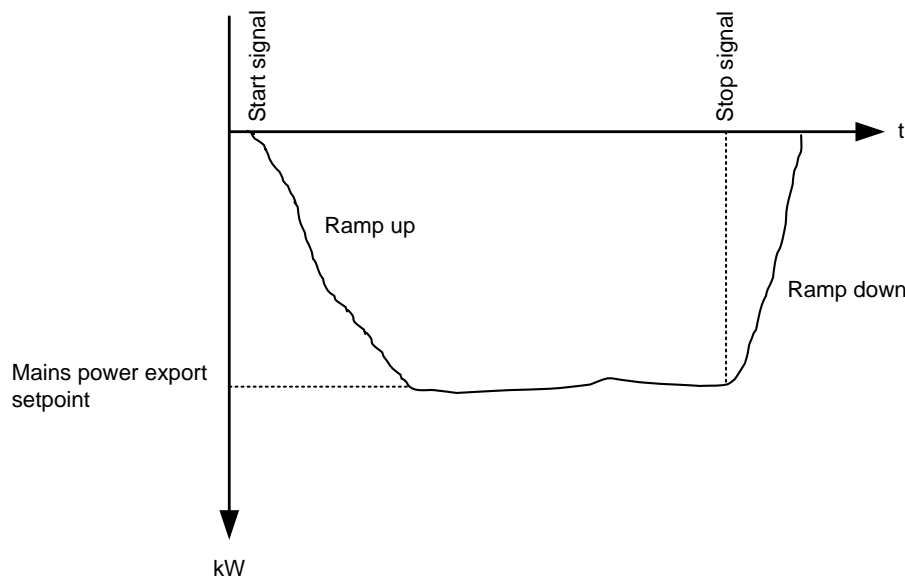
Diagram, mains power export - example

ⓘ **Please notice that the setpoint of the mains power export can be adjusted to 0 kW. This means that the genset will be parallel to the mains but no power import or export.**

Semi-auto mode description
When the generator breaker is closed and the mains breaker is opened, the unit will use the nominal frequency as setpoint for the speed governor. If AVR control (option D1) is selected, the nominal voltage is used as setpoint.

When the generator is paralleled to the mains, it will be controlled according to the mains power export setpoint. If AVR control (option D1) is selected, the setpoint is the adjusted power factor **(7050 Fixed power set).**

ⓘ **For a general description of the available running modes, please refer to the chapter "Running mode description".**

3.4 Running mode description

3.4.1 Semi-auto mode

The unit can be operated in semi-auto mode. Semi-auto means that the unit 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. Push-buttons on the display are used
2. Digital inputs are used
3. Modbus command

(i) **The standard AGC is only equipped with a limited number of digital inputs, please refer to "Digital inputs" in this document and the data sheet for additional information about availability.**

When the genset is running in semi-auto mode, the unit will control the speed governor and the AVR, if option D1 is selected.

The following sequences can be activated in semi-auto:

Command	Description	Comment
Start	The start sequence is initiated and continues until the genset starts or the maximum number of start attempts has been reached. The frequency (and voltage) will be regulated to make the GB ready to close.	
Stop	The genset will be stopped. After disappearance of the running signal, the stop sequence will continue 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 unit will close the generator breaker if the mains breaker is open, synchronise and close the generator breaker if the mains breaker is closed.	When AMF mode is selected, the unit will not regulate after breaker closure.
Open GB	The unit will ramp down and open the generator breaker at the breaker open point if the mains breaker is closed. The unit will open the generator breaker instantly if the mains breaker is open or the genset mode is island mode.	
Close MB	The unit will close the mains breaker if the generator breaker is open, synchronise and close the mains breaker if the generator breaker is closed.	
Open MB	The unit 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.	Option D1 is required.
Manual AVR DOWN	The regulator is deactivated and the governor output is activated as long as the AVR input is ON.	Option D1 is required.

3.4.2 Test mode

The test mode function is activated by selecting test with the MODE push-button on the display or by activating a digital input.

The settings for the test function are set up in menu

7040 Test

- Setpoint: Load setpoint when paralleling to mains.

- Timer: Engine run time during the test period.

- Return: When the test is completed, the unit will return to the selected mode (semi-auto or auto).

- Type: Selection of one of the three types of tests: Simple, Load or Full.

(i)   If the timer is set to 0.0 min., the test sequence will be infinite.

(i)   Test mode cannot be used if the genset is in island operation (genset mode selected to Island mode).

(i)   Power Management (option G5): test mode is not available in an island application or with the plant mode set to "Island operation".

(i)   If the DG unit is in the stop sequence in test mode and the mode is changed to semi-auto, the DG will continue to run.

3.4.3 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.

3.4.4 Load test
The load test will start the genset and run it at nominal frequency, synchronise the generator breaker and produce the power typed in the setpoint in menu 7041. The test will run until the timer expires.

(i)   To run the load test, it is required that "Sync to Mains" is enabled in menu 7084.

(i)   When running a load test sequence, the overlap function is ignored.

3.4.5 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.

(i)   To run the full test, it is required that "Sync to Mains" is enabled in menu 7084.

3.4.6 Manual mode

When manual mode is selected, the genset can be controlled from the display and with digital inputs. The following commands are possible:

Command	Description	Comment
Start	The start sequence is initiated and continues until the genset starts or the maximum number of start attempts has been reached.	No regulation.
Stop	The genset will be stopped. After disappearance of the running signal, the stop sequence will continue to be active in the "extended stop time" period. The genset is stopped with cooling down time.	
Close GB	The unit will close the generator breaker if the mains breaker is open, and synchronise and close the generator breaker if the mains breaker is closed.	No regulation. Sync. failure is deactivated.
Open GB	The unit will open the generator breaker instantly.	
Close MB	The unit will close the mains breaker if the generator breaker is open, and synchronise and close the mains breaker if the generator breaker is closed.	No regulation. Sync. failure is deactivated.
Open MB	The unit will open the mains breaker instantly.	
Manual GOV UP	The unit gives increase signal to the speed governor.	
Manual GOV DOWN	The unit gives decrease signal to the speed governor.	
Manual AVR UP	The unit gives increase signal to the AVR.	Option D1 is required.
Manual AVR DOWN	The unit gives decrease signal to the AVR.	Option D1 is required.

(i) **It is possible to open and close both the generator breaker and the mains breaker in manual mode.**

3.4.7 Block mode

When the block mode is selected, the unit is locked for certain actions. This means that it cannot start the genset or perform 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.

The purpose of the block mode is to make sure that the genset does not start for instance during maintenance work.

If the digital inputs are used to change the mode, then it is important to know that the input configured to block mode is a constant signal. So, when it is ON, the unit is in a blocked state, and when it is OFF, it returns to the mode it was in before block mode was selected.

(i) **If block mode is selected using the display after the digital block input is activated, the AGC 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.**

(!) **Before the running mode is changed, it is important to check that persons are clear of the genset and that the genset is ready for operation.**

(i) **Alarms are not influenced by block mode selection.**

(!) **The genset can be started from the local engine control panel, if such is installed. Therefore, DEIF recommends avoiding local cranking and starting of the genset.**

(!) **The genset will shut down if block mode is selected while the genset is running.**

3.5 Single-line diagrams

3.5.1 Application illustration
In the following, the various applications are illustrated in single-line diagrams.

3.5.2 Automatic Mains Failure
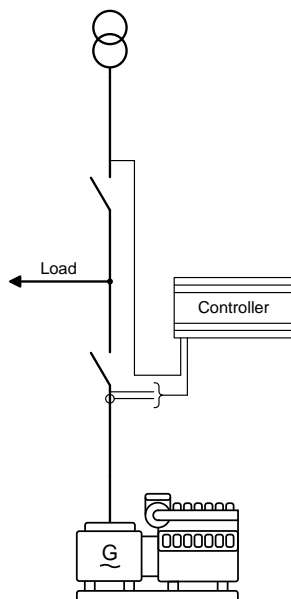
3.5.3 Island operation
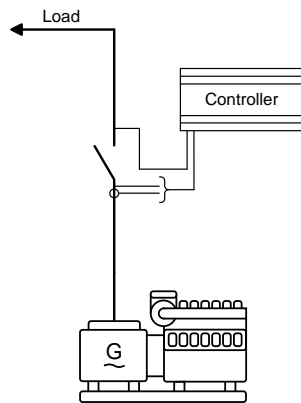
3.5.4 Fixed power/base load
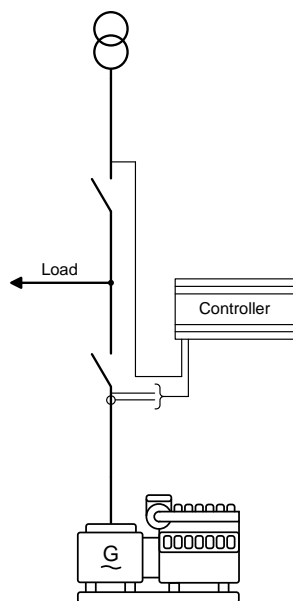
3.5.5 Peak shaving
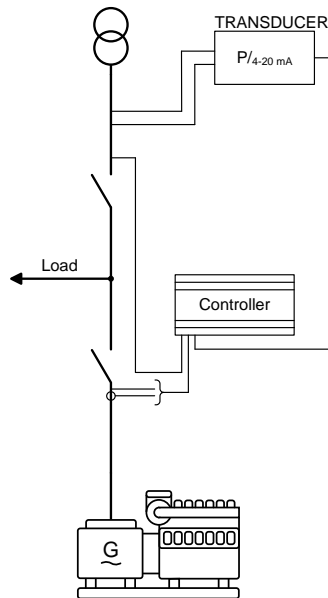
3.5.6 Load takeover
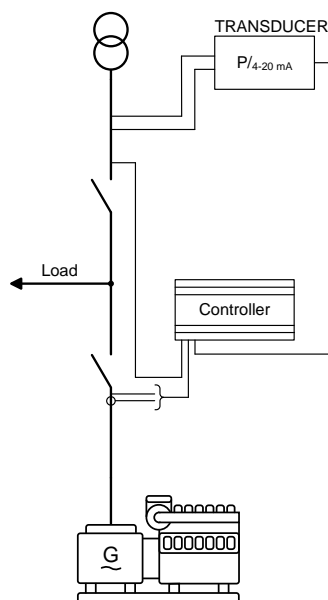
3.5.7 Mains power export
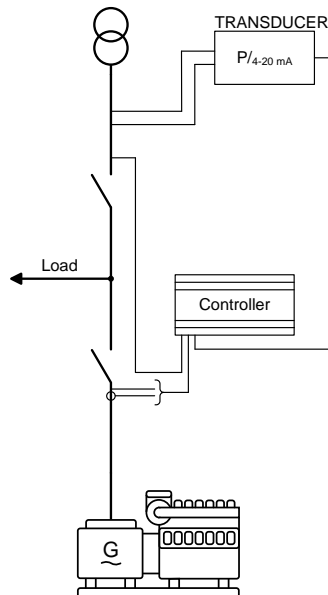
3.5.8 Multiple gensets, load sharing (option G3 required)
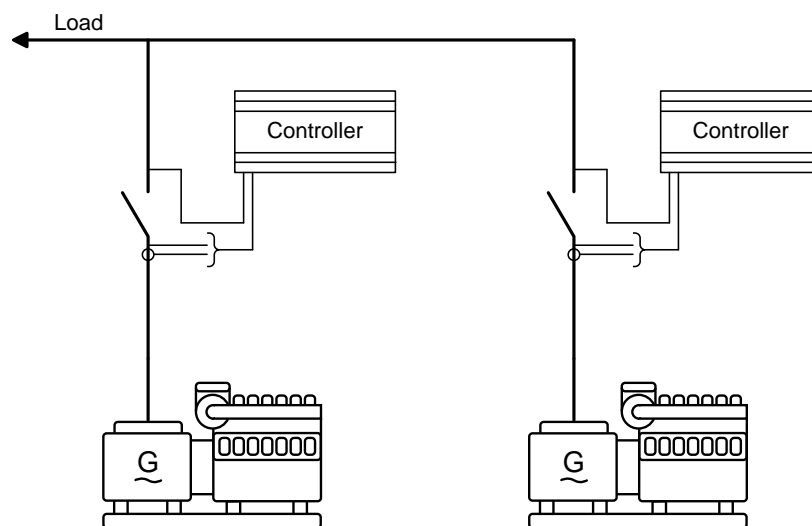
3.5.9 Multiple gensets, power management (option G5 required)

- Island mode application
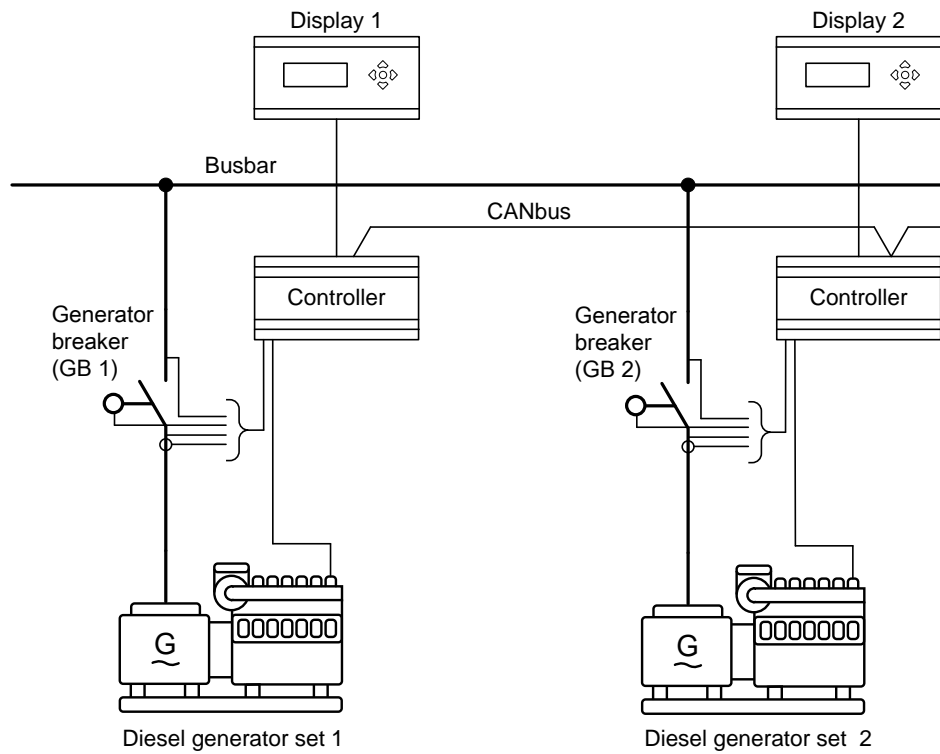
- Parallel to mains application
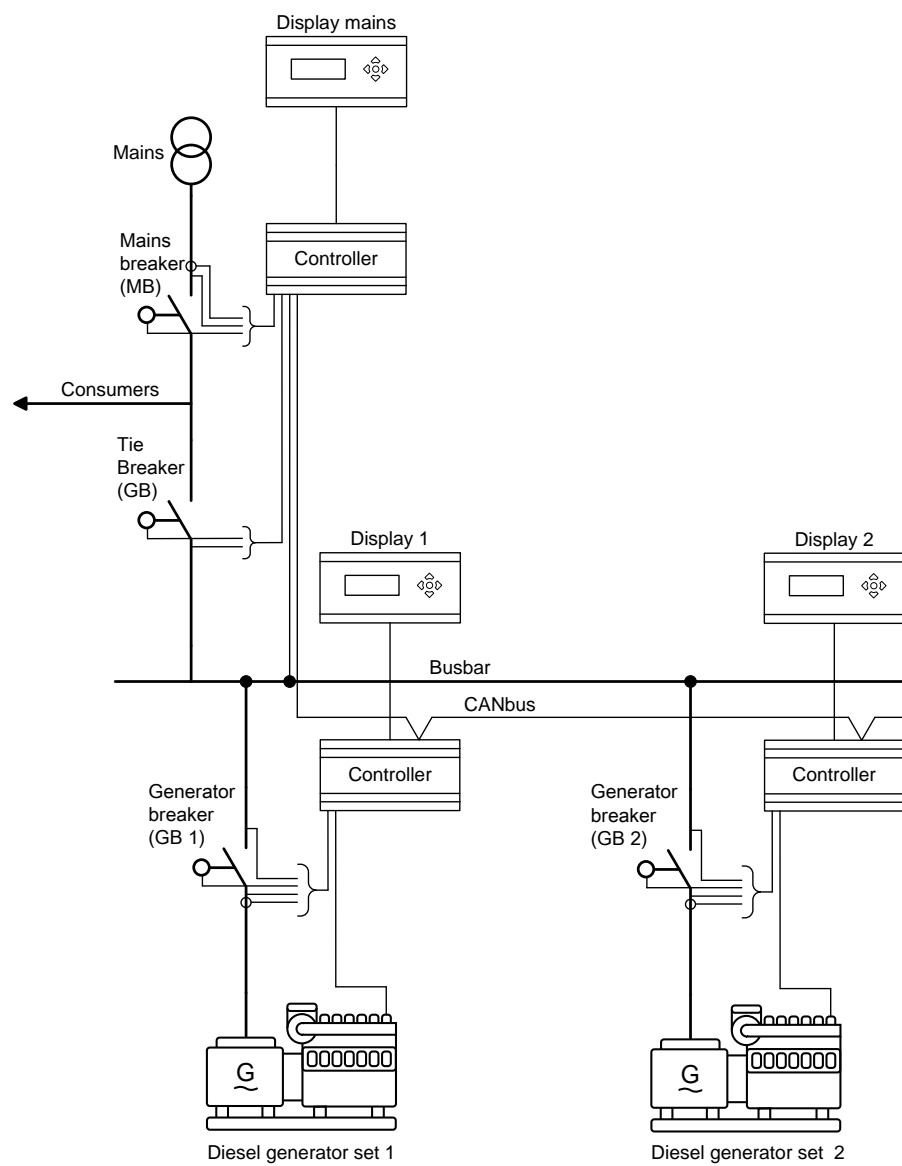
- Parallel with two mains with a tie breaker (the tie breaker is optional)
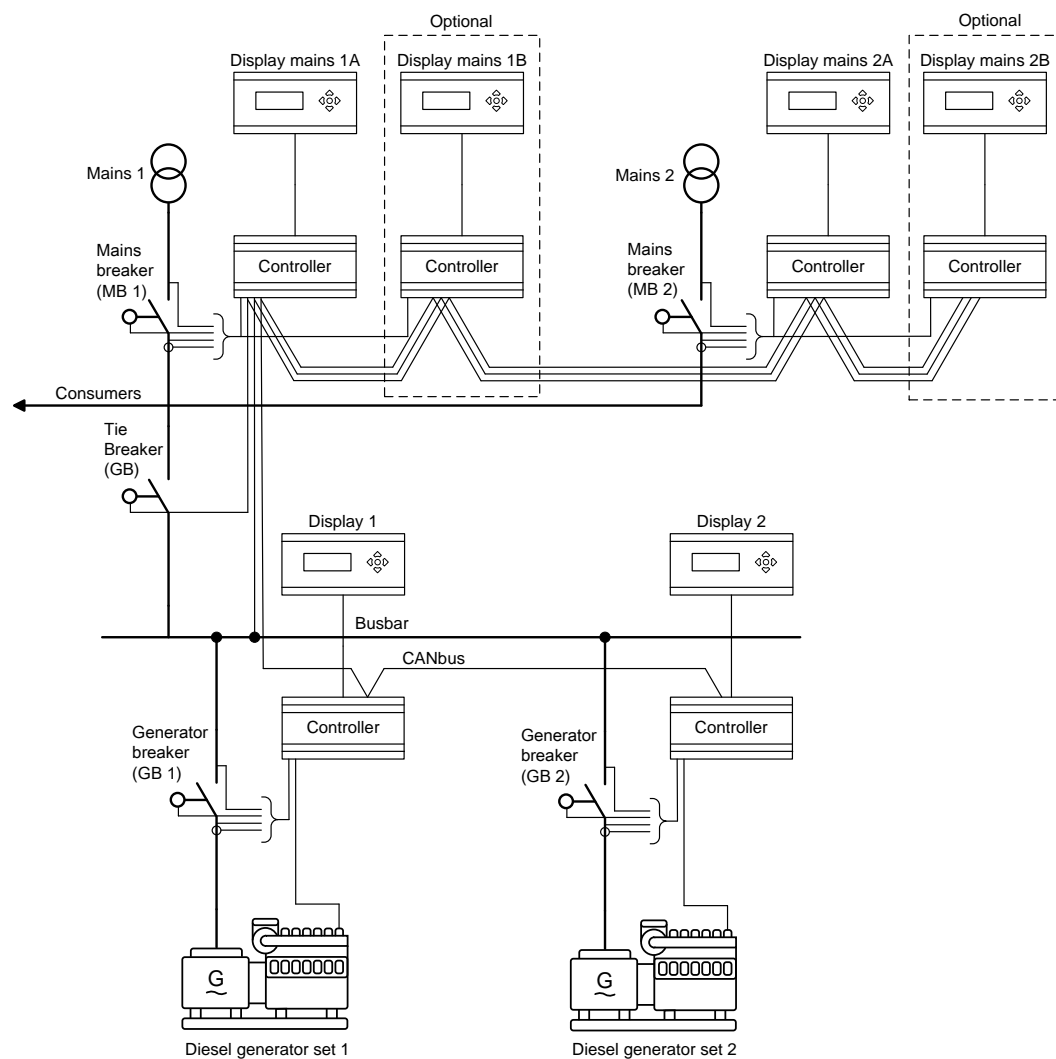
- Multi mains with two mains, two tie breakers, one bus tie breaker and four gensets
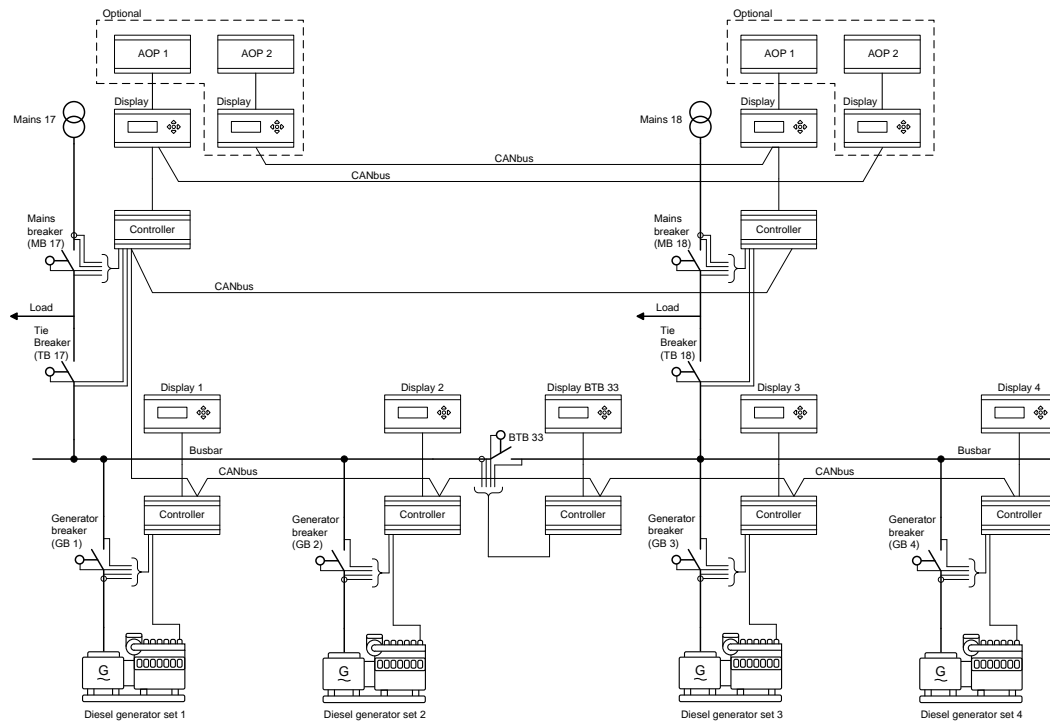
ⓘ **The diagram shows four generators, but the system supports up to 16 generators. Please refer to the option G5 manual for further description of multi mains.**

- ATS plant, mains unit
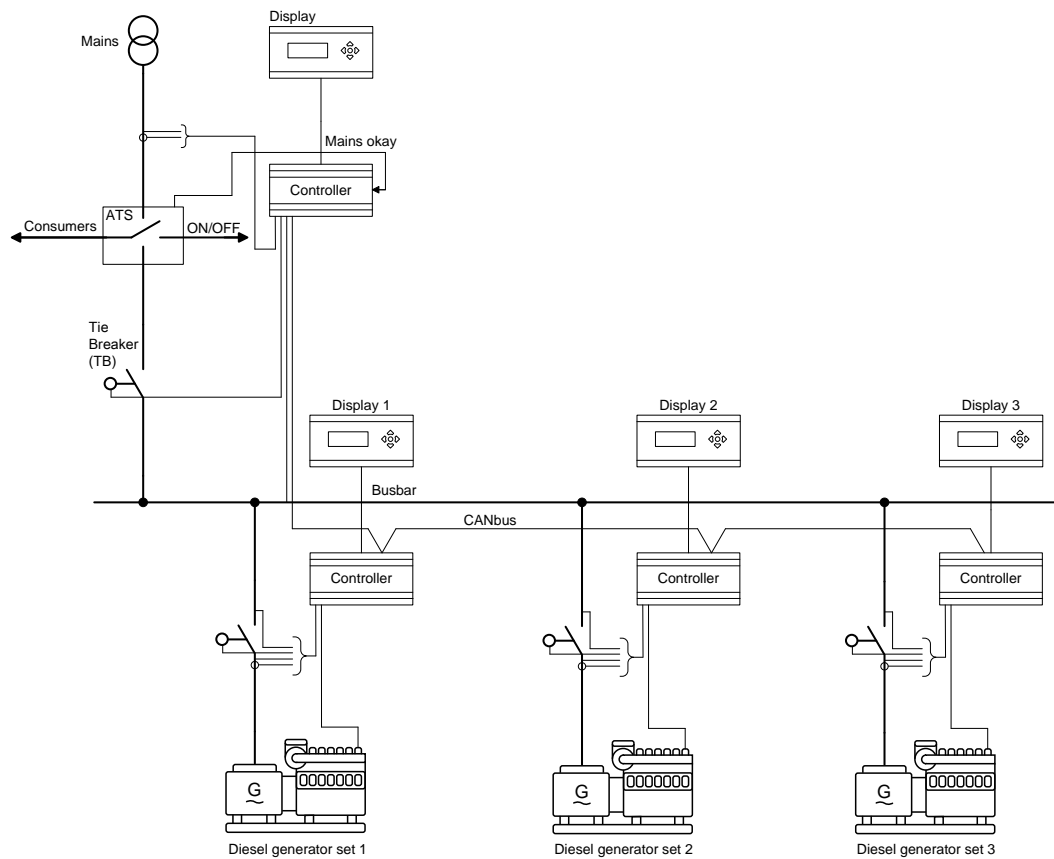
- Remote maintenance
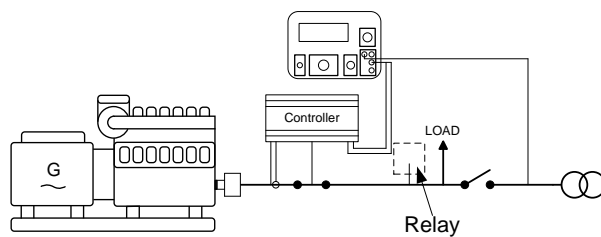
> ⓘ **The diagram shows a setup using the remote maintenance box. Please refer to the operator's manual of the remote maintenance box for further description.**

3.6 Flowcharts

Using flowcharts, the principles of the most important functions will be illustrated in the next sections. The functions included are:

- Mode shift
- MB open sequence
- GB open sequence
- Stop sequence
- Start sequence
- MB close sequence
- GB close sequence
- Fixed power
- Load takeover
- Island operation
- Peak shaving
- Mains power export
- Automatic Mains Failure
- Test sequence

The flowcharts on the following pages are for guidance only. For illustrative purposes, the flowcharts are simplified in some extent.

3.6.1 Mode shift

```
                    ┌─────────┐
                    │  Start  │
                    └─────────┘
                         │
                         ▼
                    ╱ Mode shift ╲      No
                   ╲  enabled   ╱ ──────────────────────┐
                         │                              │
                        Yes                             │
                         │                              │
                         ▼                              │
                  ╱ Plant mode not ╲     No             │
                 ╲ Island and AMF ╱ ──────────────┐     │
                         │                         │     │
                        Yes                        │     │
              ┌──────────┤                         │     │
              │          ▼                         │     │
            No│    ╱ Mains failure ╲               │     │
              └────╲              ╱                │     │
                         │                         │     │
                        Yes                        │     │
                         │                         │     │
                         ▼                         │     │
                  ┌──────────────┐                 │     │
                  │ Initiate AMF │                 │     │
                  │  sequence    │                 │     │
                  └──────────────┘                 │     │
              ┌──────────┤                         │     │
              │          ▼                         │     │
            No│   ╱ Mains OK timer ╲   Yes         │     │
              └───╲  timed out    ╱ ────┐          │     │
                         │               │          │     │
```

Initiate mains return sequence	MB close sequence	Continue in selected mode	

End

3.6.2 MB open sequence

```
                    ┌──────────┐
                    │  Start   │
                    └──────────┘
                         │
                         ▼
                    ╱─────────╲   No
                   ╱ MB closed ╲─────┐
                   ╲           ╱◄────┘
                    ╲─────────╱
                         │ Yes
                         ▼
                    ╱─────────╲   No      ┌──────────────┐
                   ╱ Load take  ╲────────►│ Mains failure│
                   ╲    over    ╱         └──────────────┘
                    ╲─────────╱
                         │ Yes
                         ▼
                 ┌──────────────┐
                 │  Deload MB   │
                 └──────────────┘
                         │
                         ▼
                    ╱─────────╲   No     ╱───────────╲  Yes   ┌────────┐
                   ╱  Load = 0  ╲───────►╱ Load too    ╲─────►│ Alarm  │
                   ╲           ╱         ╲    high     ╱      └────────┘
                    ╲─────────╱           ╲───────────╱
                         │ Yes
                         ▼
                 ┌──────────────┐
                 │   Open MB    │◄───
                 └──────────────┘
                         │
                         ▼
                    ╱─────────╲   No     ┌──────────────┐
                   ╱ MB opened  ╲───────►│  Alarm "MB   │
                   ╲           ╱         │ open failure"│
                    ╲─────────╱          └──────────────┘
                         │ Yes
                         ▼
                    ┌──────────┐
                    │   End    │
                    └──────────┘
```

3.6.3 GB open sequence

```
                    ┌─────────┐
                    │  Start  │
                    └────┬────┘
                         │  ┌──────────────┐
                         ▼  │              │
                    ╱────────────╲   No    │
                   ╱ Stop conditions ╲─────┘
                   ╲      OK       ╱
                    ╲────────────╱
                         │ Yes
                         ▼
                    ╱─────────╲   No
                   ╱  Is GB    ╲──────┐
                   ╲  closed   ╱      │
                    ╲─────────╱       │
                         │ Yes        │
                         ▼            │
                    ╱─────────╲   No    ┌──────────────┐
                   ╱ Soft open ╲───────▶│   Failclas   │
                   ╲           ╱        │   shutdown   │
                    ╲─────────╱         └──────────────┘
                         │ Yes
                         ▼
                   ┌───────────┐
                   │ Deload DG │
                   └─────┬─────┘
                         │
                         ▼
                   ╱──────────╲   No          ╱──────────────╲   No
                  ╱ Load < open ╲────────────▶╱  Ramp down     ╲──────┐
                  ╲  set point  ╱             ╲ timer expired  ╱      │
                   ╲──────────╱                ╲──────────────╱       │
                         │ Yes                       │ Yes
                         ▼                           │
                   ┌──────────┐                      │
                   │ Open GB  │                      │
                   └────┬─────┘                      │
                        │                            ▼
                        ▼                       ┌──────────┐
                  ╱──────────╲   No             │  Alarm   │
                 ╱ GB opened  ╲────────────────▶│          │
                 ╲           ╱                  └──────────┘
                  ╲─────────╱
                   │ Yes
                   ▼
               ┌─────────┐
               │   End   │
               └─────────┘
```

3.6.4 Stop sequence

```
                    ┌──────────┐
                    │  Start   │
                    └──────────┘
                         │
                         ▼
                   ╱──────────╲
                  ╱ Stop conditions╲  No
                  ╲    OK     ╱──────┐
                   ╲──────────╱      │
                         │ Yes       │
                         ▼           │
                   ╱──────────╲  No  │
                  ╱  GB open   ╲─────┐│
                  ╲  seq OK    ╱     ││
                   ╲──────────╱      ││
                         │ Yes       ││
                         ▼           ││
                   ╱──────────╲  No  ││
                  ╱   AUTO     ╲─────┐││
                  ╲   mode     ╱     │││
                   ╲──────────╱      │││
                         │ Yes       │││
                         ▼           │││
              No   ╱──────────╲      │││
              ┌───╱ Cooldown   ╲     │││
              │   ╲timer run out╱    │││
              │    ╲──────────╱      │││
              │         │ Yes        │││
              │         ▼            │││
              │   ╱──────────╲  No   ┌─────────┐
              │  ╱ Run coil   ╲──────│Stop relay│
              │  ╲            ╱      └─────────┘
              │   ╲──────────╱            │
              │         │ Yes             ▼
              │  ┌──────────┐      ┌──────────┐
              │  │Deactivate │      │Activate stop│
              │  │"stop" relay│     │   relay   │
              │  └──────────┘      └──────────┘
              │         │                 │
              │         ▼                 │
              │   ╱──────────╲  No   ┌─────────┐
              │  ╱  Genset    ╲──────│  Alarm  │
              │  ╲  stopped   ╱      └─────────┘
              │   ╲──────────╱
              │         │ Yes
              │         ▼
              │    ┌──────────┐
              │    │   End    │
              │    └──────────┘
```

3.6.5 Start sequence

```
                    ┌─────────┐
                    │  Start  │
                    └────┬────┘
                         │       ◄──────────────┐
                         ▼                       │
                    ╱─────────╲   No             │
                  ╱ Start condition ╲────────────┘
                   ╲     OK      ╱
                    ╲─────────╱
                         │ Yes    ◄──────────┐
                         ▼                   │
                    ╱─────────╲   No          │
                  ╱ Start prepare ╲───────────┘
                   ╲    timer    ╱
                    ╲─────────╱
                         │ Yes
       ┌─────────────────┤◄──────────────────────────────────────┐
       │                 ▼                                        │
       │           ┌──────────┐                                   │
       │           │ Start relay│                                 │
       │           │    ON     │                                  │
       │           └─────┬────┘                                   │
       │                 ▼                                        │
       │           ╱──────────╲  No    ╱──────────╲  No           │
       │         ╱ Start relay timer ╲────►╲ Genset started ╲──────┘
       │          ╲    timeout    ╱    ╲──────────╱
       │           ╲──────────╱             │ Yes
       │                │ Yes               ▼
       │                ▼            ╱──────────╲  No   ┌────────┐
       │           ┌──────────┐   ╱ Run feedback ╲──────►│ Alarm  │
       │           │ Off relay│    ╲  detected   ╱       └───┬────┘
       │           │    ON    │     ╲──────────╱            │
       │           └─────┬────┘          │ Yes              │
       │                 ▼◄──────┐        ▼                 │
       │           ╱──────────╲   │  ╱──────────╲  No        │
       │         ╱ Stop relay timer ╲─┘ ╱  F/U OK  ╲──────────┘
       │          ╲  timed out   ╱    ╲──────────╱
       │           ╲──────────╱          │ Yes
       │                │ Yes            ▼
       │                ▼         ┌──────────┐
       │ No      ╱──────────╲     │ Ready to │
       └────────╱ Max start  ╲────►│ close GB │
                 ╲ attempts  ╱     └─────┬────┘
                  ╲────────╱            │
                      │ Yes            ▼
                      ▼          ┌─────────┐
                ┌──────────┐     │   End   │
                │Start failure│  └─────────┘
                │   alarm   │
                └──────────┘
```

3.6.6 MB close sequence

```
                    ┌──────────┐
                    │  Start   │
                    └────┬─────┘
                         │ ◄─────────────┐
                    ◇ Is MB open ◇──No───┘
                         │
                        Yes
                         │
                  ◇ Voltage on ◇──No──────────►
                    mains/bus
                         │
                        Yes
                         │
                  ◇ Voltage on ◇──No──────────►
                      gen
                         │
                        Yes
                         │
                  ◇ GB closed ◇──No──────────►
                         │
                        Yes            ┌─────────────────┐
                         │             │ Direct close OK │
                         │             └─────────────────┘
                  ◇ Back sync ON ◇──No──────►◇ GB open ◇──No──┐
                         │                     sequence
                        Yes                       │
                         │◄────────No────┐       Yes
                  ┌──────────┐      ◇ Sync timer ◇──Yes──►┌───────────┐  ┌───────────┐
                  │ Sync MB  │        runout             │Alarm sync.│  │ Alarm GB  │
                  └────┬─────┘                           │ failure   │  │open failure│
                       │                                 └───────────┘  └───────────┘
                  ◇ Synchronised ◇──No──┘
                       │
                      Yes
                  ┌──────────┐
                  │ Close MB │
                  └────┬─────┘
                       │
                  ◇ MB closed ◇──No──►┌───────────┐
                       │              │  Close    │
                      Yes             │  failure  │
                       │              │  alarm    │
                       │              └───────────┘
                  ┌──────────┐
                  │   End    │
                  └──────────┘
```

3.6.7 GB close sequence

3.6.8 Fixed power

```
        ╭─────────╮
        │  Start  │
        ╰────┬────╯
             │
             ▼
      ┌──────────────┐
      │ Activate start│
      │    input      │
      └──────┬───────┘
             │
             ▼
      ┌──────────────┐
      │    Start      │
      │   sequence    │
      └──────┬───────┘
             │
             ▼
      ┌──────────────┐
      │   GB close    │
      │   sequence    │
      └──────┬───────┘
             │
             ▼
      ┌──────────────┐        ┌──────────────┐
      │  Ramp-up to   │───────▶│   Operation  │
      │ load set-point│        └──────┬───────┘
      └──────┬───────┘               │
             │◀─────────────────────┘
             ▼
      ┌──────────────┐
      │  Deactivate   │
      │  start input  │
      └──────┬───────┘
             │
             ▼
      ┌──────────────┐
      │   GB open     │
      │   sequence    │
      └──────┬───────┘
             │
             ▼
      ┌──────────────┐
      │    Stop       │
      │   sequence    │
      └──────┬───────┘
             │
             ▼
        ╭─────────╮
        │   End   │
        ╰─────────╯
```

3.6.9 Load takeover

```
                    ┌──────────────┐
                    │    Start     │
                    └──────┬───────┘
                           │
                    ┌──────▼───────┐
                    │ Activate start│
                    │    input      │
                    └──────┬───────┘
                           │
                    ┌──────▼───────┐
                    │    Start     │
                    │   sequence   │
                    └──────┬───────┘
                           │
                    ┌──────▼───────┐
                    │   GB close   │
                    │   sequence   │
                    └──────┬───────┘
                           │
```

Mains load = 0 kW   — No →   Ramp-up genset load

Yes

MB open sequence → Genset operation

Deactivate start input

MB close sequence → GB open sequence → Stop sequence → End

3.6.10 Island operation

```
        ┌─────────┐
        │  Start  │
        └─────────┘
             │
             ▼
     ┌───────────────┐
     │  Start input  │
     │    active     │
     └───────────────┘
             │
             ▼
     ┌───────────────┐
     │    Start      │
     │   sequence    │
     └───────────────┘
             │
             ▼
     ┌───────────────┐      ┌───────────────┐
     │   GB close    │─────▶│   Operation   │
     │   sequence    │      └───────────────┘
     └───────────────┘              │
             │◀─────────────────────┘
             ▼
     ┌───────────────┐
     │  Start input  │
     │  deactivated  │
     └───────────────┘
             │
             ▼
     ┌───────────────┐
     │   GB open     │
     │   sequence    │
     └───────────────┘
             │
             ▼
     ┌───────────────┐
     │     Stop      │
     │   sequence    │
     └───────────────┘
             │
             ▼
        ┌─────────┐
        │   End   │
        └─────────┘
```

3.6.11 Peak shaving

```
        ┌─────────┐
        │  Start  │
        └─────────┘
             │
             ▼
     ┌──────────────┐
     │ Mains power  │
     │ above start  │
     │  set point   │
     └──────────────┘
             │
             ▼
     ┌──────────────┐
     │    Start     │
     │   sequence   │
     └──────────────┘
             │
             ▼
     ┌──────────────┐        ┌──────────────┐
     │   GB close   │───────▶│  Operation:  │
     │   sequence   │        │ produce power │
     └──────────────┘        │ above set point│
                             └──────────────┘
             │                      │
             ▼
     ┌──────────────┐
     │ Mains power  │
     │ below stop   │
     │  set point   │
     └──────────────┘
             │
             ▼
     ┌──────────────┐
     │   GB open    │
     │   sequence   │
     └──────────────┘
             │
             ▼
     ┌──────────────┐
     │     Stop     │
     │   sequence   │
     └──────────────┘
             │
             ▼
        ┌─────────┐
        │   End   │
        └─────────┘
```

3.6.12 Mains power export

```
                  ┌─────────┐
                  │  Start  │
                  └────┬────┘
                       │
                       ▼
              ┌──────────────────┐
              │  Activate start  │
              │      input       │
              └────────┬─────────┘
                       │
                       ▼
              ┌──────────────────┐
              │      Start       │
              │     sequence     │
              └────────┬─────────┘
                       │
                       ▼
              ┌──────────────────┐
              │    Close GB      │
              │    sequence      │
              └────────┬─────────┘
                       │
                       ▼
              ┌──────────────────┐      ┌──────────────┐
              │   Ramp up to     │─────▶│  operation   │
              │  MPE set point   │      └──────┬───────┘
              └────────┬─────────┘             │
                       │◀────────────────────────┘
                       ▼
              ┌──────────────────┐
              │   Deactivate     │
              │   start input    │
              └────────┬─────────┘
                       │
                       ▼
              ┌──────────────────┐
              │    GB open       │
              │    sequence      │
              └────────┬─────────┘
                       │
                       ▼
              ┌──────────────────┐
              │      Stop        │
              │    sequence      │
              └────────┬─────────┘
                       │
                       ▼
                  ┌─────────┐
                  │   End   │
                  └─────────┘
```

3.6.13 Automatic Mains Failure

```
                    ┌──────────┐
                    │   Start  │
                    └────┬─────┘
                         │◄──────────┐
                         ▼           │
                      ╱─────────╲ No │
                     ╱  Mains    ╲───┘
                     ╲  failure  ╱
                      ╲─────────╱
                         │ Yes
                         ▼
                   ╱───────────╲  No
                  ╱ #7065: start ╲──────────────┐
                  ╲ eng + open MB ╱              │
                   ╲───────────╱                 │
                         │ Yes                    │
                         ▼                        ▼
                 ┌──────────────┐        ┌──────────────┐
                 │   Open MB    │        │Start sequence│
                 └──────┬───────┘        └──────┬───────┘
                        ▼                        ▼
                 ┌──────────────┐        ┌──────────────┐
                 │Start sequence│        │   Open MB    │
                 └──────┬───────┘        └──────┬───────┘
                        ▼                        ▼
                 ┌──────────────┐        ┌──────────────┐
                 │   GB close   │        │   GB close   │
                 │   sequence   │        │   sequence   │
                 └──────┬───────┘        └──────┬───────┘
                        │◄──────────────────────┘
                        ▼◄──────────┐
                     ╱─────────╲ No │
                    ╱ Mains ok  ╲───┘
                     ╲─────────╱
                        │ Yes
                        ▼
                 ┌──────────────┐     ┌──────────────┐     ╭──────────╮
                 │   Time out   │────►│   MB close   │────►│   End    │
                 │              │     │   sequence   │     ╰──────────╯
                 └──────────────┘     └──────────────┘
```

3.6.14 Test sequence

```
              ┌──────────┐
              │  Start   │
              └──────────┘
                   │
                   ▼
            ┌──────────────┐
            │ Select test  │
            │    mode      │
            └──────────────┘
                   │
                   ▼
            ┌──────────────┐
            │ Start sequnce│
            └──────────────┘
                   │
                   ▼
            ┌──────────────┐
            │  Test timer  │
            └──────────────┘
                   │
                   ▼
         ◇ Timer run out ◇──No──▶ ◇ Engine running ◇──No──┐
                   │                      │               │
                  Yes                    Yes              │
                   ▼                      ▼               │
            ┌──────────────┐       ◇ Freq/voltage OK ◇──No─┘
            │ Stop sequnce │              │
            └──────────────┘             Yes
                   │                      ▼
                   ▼              ◇ Sync of GB allowed ◇──No──┐
         ◇ Engine stopped ◇              │                   │
                   │                    Yes                  │
                  No                     ▼                   │
                   ▼              ┌──────────────┐           │
            ┌──────────────┐      │   Sync GB    │           │
            │ Return to    │      └──────────────┘           │
            │ running mode,│             │                   │
            │ menu 7043    │             ▼                   │
            └──────────────┘      ◇ Opening og MB allowed ◇──No──▶ ┌────────────┐
                   │                     │                          │ Ramp up to │
                   ▼                    Yes                         │ P set point│
              ┌──────────┐              │                           └────────────┘
              │   End    │              ▼                                │
              └──────────┘      ◇ P Mains = 0kW ◇──Yes──▶ ┌────────┐     │
                          No◀────        │                │ Open MB│─────┘
                                         │                └────────┘
```

3.7 Sequences

The following contains information about the sequences of the engine, the generator breaker and, if installed, the mains breaker. These sequences are automatically initiated if the auto mode is selected, or if the commands are selected in the semi-auto mode.

In the semi-auto mode, the selected sequence is the only sequence initiated (e.g. press the START pushbutton: The engine will start, but no subsequent synchronising is initiated).

The following sequences will be illustrated below:

- START sequence
- STOP sequence
- Breaker sequences

If island operation is selected, the digital input "MB closed" must NOT be activated with a 12/24 volt input signal. A "mains breaker failure" will occur if the wiring of the mains breaker feedback inputs is wrong.

(i) Refer to our application notes or installation instructions for information about the required breaker wiring.

(i) We recommend not using small relays for stop coil output. If small relays are used, a resistor must be mounted across the relay coil to prevent undesirable closing of the relay. This is caused by the wirebreak function.

3.7.1 Start sequence

The following drawings illustrate the start sequences of the genset with normal start prepare and extended start prepare.

No matter the choice of start prepare function, the running coil is activated 1 sec. before the start relay (starter).

Start sequence:
Normal start prepare

Start sequence:
Extended start prepare

Start prepare

Crank (starter) t_{OFF} t_{OFF}

Run coil

1 sec.

Stop coil

Running feedback

1st start attempt   2nd start attempt   3rd start attempt
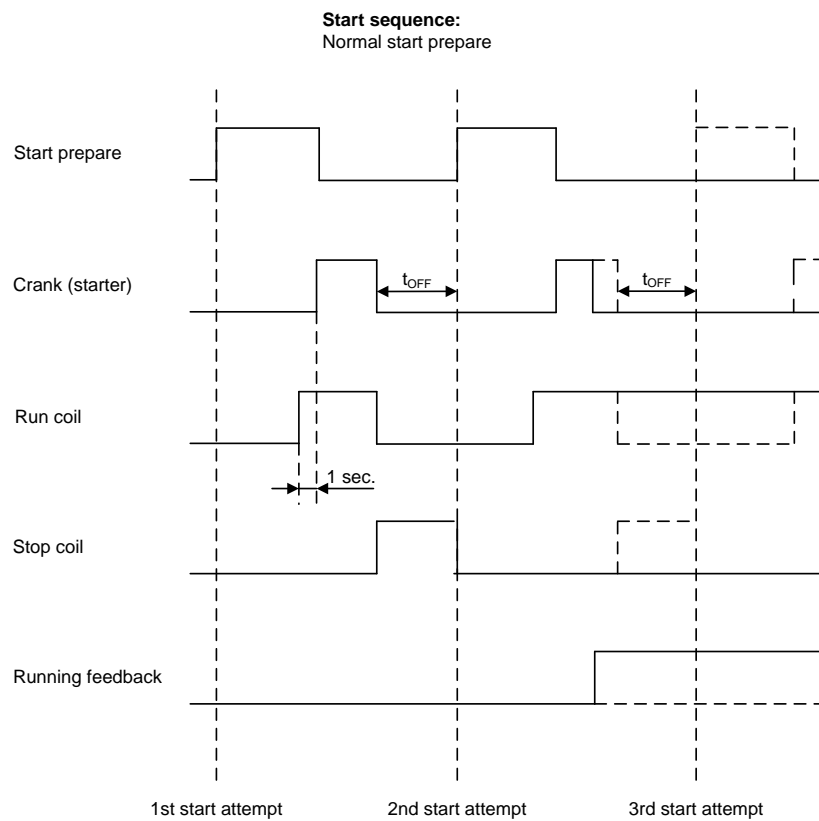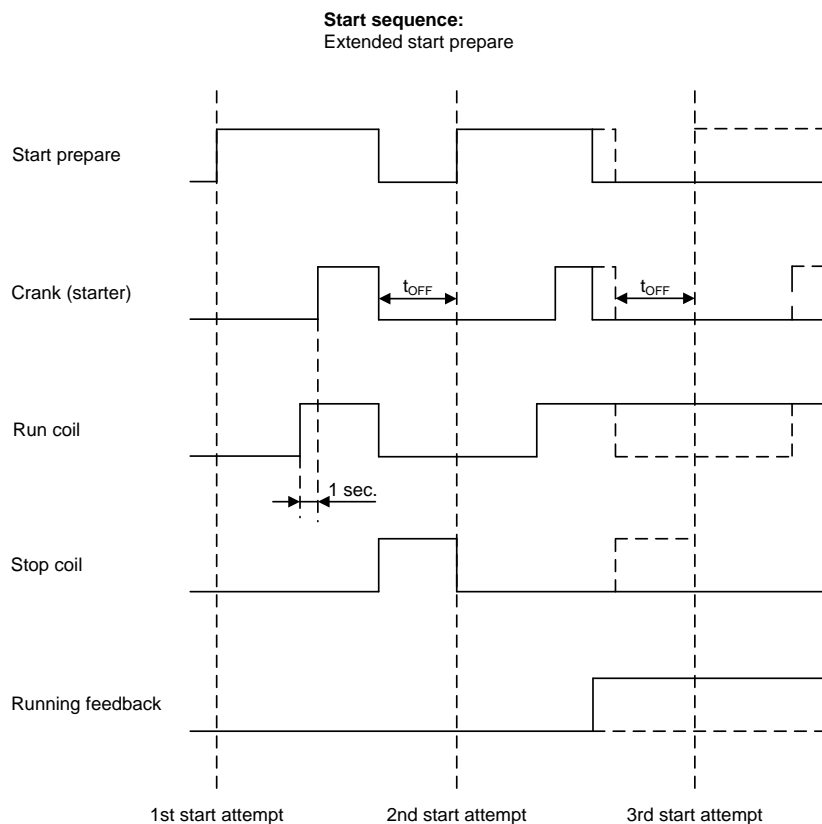
> ⓘ **Run coil can be activated from 1...600 sec. before crank (starter) will be executed. In the above example, the timer is set to 1 sec. (menu 6150).**

3.7.2 Start sequence conditions

The start sequence initiation can be controlled by the following conditions:

● VDO 102 (oil pressure)
● VDO 105 (water temperature)
● VDO 108 (fuel level)

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

The selection is made in setting 6185. For each of the VDO settings, the rule is that the value (oil pressure, fuel level or water temperature) must exceed the setpoint of setting 6186 before starting is initiated.

> ⓘ **If the value in 6186 is set to 0.0, the start sequence is initiated as soon as it is requested.**

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

Start sequence
Cranking depends on VDO

Start prepare
(3 start attempts) | 1 | | 2 | | 3 |

Stop relay

Crank relay

Run coil

Running feedback

**VDO
measurement OK**

VDO value

Cranking starts
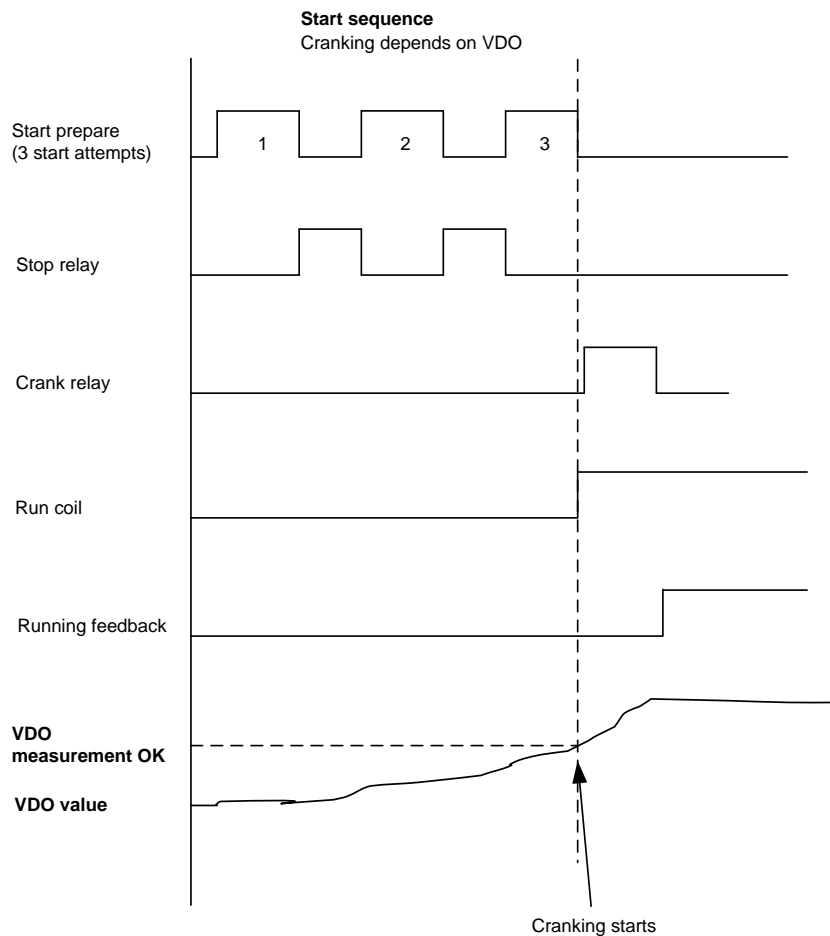
3.7.3 Running feedback

Different types of running feedback can be used to detect if the motor is running. Refer to menu 6170 for selection of the running feedback type.

The running detection is made with a built-in safety routine. The running feedback selected is the primary feedback. At all times all the types of running feedback is used for running detection. If, for some reason, the primary choice is not detecting any running feedback, the starter relay will stay activated for 1 additional second. If a running feedback is detected based on one of the secondary choices, the genset will start. This way, the genset will still be functional even though a tacho sensor is damaged or dirty.

As soon as the genset is running, no matter if the genset is started based on the primary or secondary feedback, the running detection will be made based on all available types.

The sequence is shown in the diagram below.

Running feedback failure
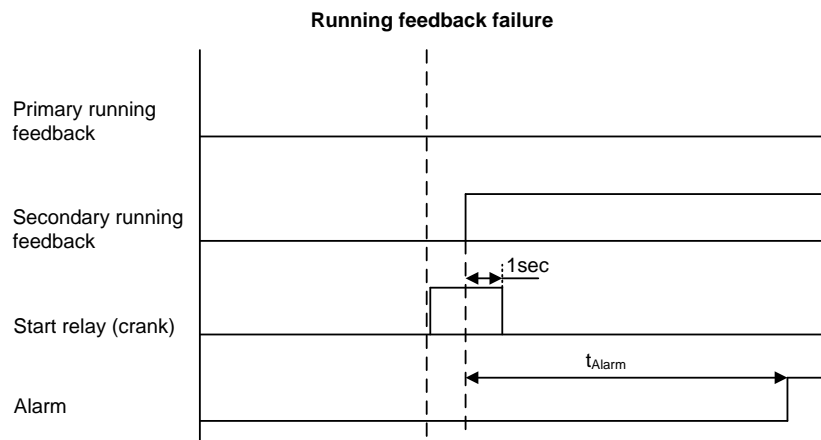
Interruption of start sequence
The start sequence is interrupted in the following situations:

Event	Comment
Stop signal	
Start failure	
Remove starter feedback	Tacho setpoint.
Running feedback	Digital input.
Running feedback	Tacho setpoint.
Running feedback	Frequency measurement above 32 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 setpoint (menu 6175).
Running feedback	EIC (engine communication) (option H5 or H7).
Emergency stop	
Alarm	Alarms with shutdown" or "trip and stop" fail class.
Stop push-button on display	Only in semi-auto or manual mode.
Modbus stop command	Semi-auto or manual mode.
Binary stop input	Semi-auto or manual mode.
Deactivate the "auto start/ stop"	Auto mode in the following genset modes: Island operation, fixed power, load takeover 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.

(i) **If the MPU input is to be used to remove the starter, it has to be set up in menu 6174.**

> **The only protections that can stop the genset/interrupt the start sequence when the "shutdown override" input is activated, are the digital input "emergency stop" and the alarm "overspeed 2". Both of these must have the fail class "shut down".**

Setpoints related to the start sequence
- Crank failure alarm **(4530 Crank failure)**
If MPU is chosen as the primary running feedback, this alarm will be raised if the specified rpm is not reached before the delay has expired.

- Run feedback failure **(4540 Run feedb. fail)**
If running is detected on the frequency (secondary), but the primary running feedback, e.g. digital input, has not detected running, this alarm will be raised. The delay to be set is the time from the secondary running detection and until the alarm is raised.

- Hz/V failure **(4550 Hz/V failure)**
If the frequency and voltage are not within the limits set in menu 2110 after the running feedback is received, this alarm is raised when the delay has expired.

- Start failure alarm **(4570 Start failure)**
The start failure alarm occurs, if the genset has not started after the number of start attempts set in menu 6190.

- Start prepare **(6180 Starter)**
Normal prepare: The start prepare timer can be used for start preparation purposes, e.g. prelubrication or preglowing. 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.

Extended prepare: The extended prepare will activate the start prepare relay when the start sequence is initiated and keep it activated when the start relay activates until the specified time has expired. If the ext. 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.

Start ON time: The starter will be activated for this period when cranking.

Start OFF time: The pause between two start attempts.

3.7.4 Stop sequence

The drawings illustrate the stop sequence.

Stop sequence
Run coil

Cooling down time t_{COOL}

Run coil   text

Running feedback

Sequence initiated

Stop sequence
Stop coil

Cooling down time t_{COOL}

Stop coil   text

Running feedback

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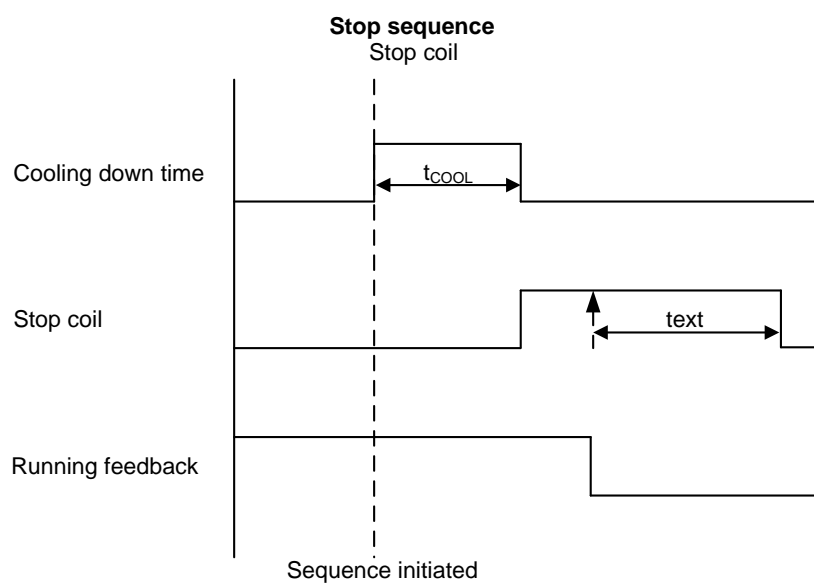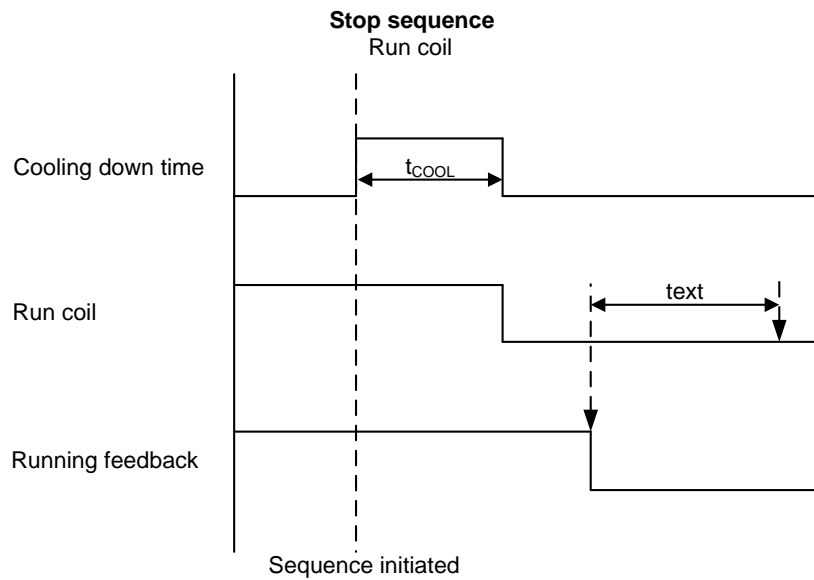
The stop sequence will be activated if a stop command is given. The stop sequence includes the cooling down time if the stop is a normal or controlled stop.

Description	Cooling down	Stop	Comment
Auto mode stop	X	X	
Trip and stop alarm	X	X	
Stop button on display	(X)	X	Semi-auto or manual. Cooling down is interrupted if the stop button is activated twice.
Remove "auto start/stop"	X	X	Auto mode: Island operation, fixed power, load takeover, mains power export.
Emergency stop		X	Engine shuts down and GB opens.

The stop sequence can only be interrupted during the cooling down period. Interruptions can occur in these situations:

Event	Comment
Mains failure	AMF mode selected (or mode shift selected ON) and auto mode selected.
Start button is pressed	Semi-auto mode: Engine will run in idle speed.
Binary start input	Auto mode: Island operation and fixed power, load takeover or mains power export.
Exceeding setpoint	Auto mode: Peak shaving.
GB close button is pressed	Semi-auto mode only.

(i) **The stop sequence can only be interrupted during the cooling down period.**

(i) **When the engine is stopped, the analogue speed governor output is reset to the offset value. Please refer to the mentioned option descriptions.**

Setpoints related to the stop sequence

- Stop failure **(4580 Stop failure)**
A stop failure alarm will appear if the primary running feedback or the generator voltage and frequency are still present after the delay in this menu has expired.

- Stop **(6210 Stop)**
Cooling down:
The length of the cooling down period.

Extended stop:
The delay after the running feedback has disappeared until a new start sequence is allowed. The extended stop sequence is activated any time the Stop button is pressed.

Cool down controlled by engine temperature:
The engine temperature-controlled cool down is to ensure that the engine is cooled down below the setpoint in menu 6214 "Cool down temperature" before the engine is stopped. This is particularly beneficial if the engine has been running for a short period of time and therefore not reached normal cooling water temperature, as the cool down period will be very short or none at all. If the engine has been running for a long period, it will have reached normal running temperature, and the cool down period will be the exact time it takes to get the temperature below the temperature setpoint in menu 6214.

If, for some reason, the engine cannot get the temperature below the temperature setpoint in 6214 within the time limit in parameter 6211, the engine will be shut down by this timer. The reason for this could be high ambient temperature.

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

ⓘ **If the cooling down temperature is set to 0 deg., the cooling down sequence will be entirely controlled by the timer.**

3.7.5 Breaker sequences
The breaker sequences will be activated depending on the selected mode:

Mode	Genset mode	Breaker control
Auto	All	Controlled by the unit
Semi-auto	All	Push-button
Manual	All	Push-button
Block	All	None

Before closing the breakers it must be checked that the voltage and frequency are OK. The limits are adjusted in menu 2110 Sync. blackout.

Setpoints related to MB control

7080 MB control

Mode shift: When enabled, the AGC will perform the AMF sequence in case of a mains failure regardless of the actual genset mode.

MB close delay: The time from GB OFF to MB ON when back synchronisation is OFF.

Back sync.:   Enables synchronisation from mains to generator.

Sync. to mains: Enables synchronisation from generator to mains.

Load time: After opening of the breaker, the MB ON sequence will not be initiated before this delay has expired. Please refer to the description of "Breaker spring load time".

ⓘ **If no MB is represented, then the relays and inputs normally used for MB control become configurable. The power plant constructor (USW) is used for configuration of the plant design if the application does not include an MB.**

ⓘ **AGC 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.**

ⓘ **AGC with back synchronisation: If the GB or MB push-button is activated, the AGC will start synchronising if the generator or mains voltage is present. The GB can close directly if the MB is open. The MB can close directly if the GB is open.**

- AMF MB opening **(7060 U mains failure)**

It is possible to select the functionality of the mains breaker closing function. This is necessary if the unit operates in Automatic Mains Failure (AMF).

The possibilities are:

Selection	Description
Start engine and open mains breaker	When a mains failure occurs, the mains breaker opens, and the engine starts at the same time.
Start engine	When a mains failure occurs, the engine starts. When the generator is running and the frequency and voltage are OK, the MB opens and the GB closes.

3.7.6 AMF timers

The time charts describe the functionality at a mains failure and at mains return. Back synchronisation is deactivated. The timers used by the AMF function are indicated in the table below:

Timer	Description	Menu number
t_{FD}	Mains failure delay	**7070 f mains failure** **7060 U mains failure**
t_{FU}	Frequency/voltage OK	**6220 Hz/V OK**
t_{FOD}	Mains failure OK delay	**7070 f mains failure** **7060 U mains failure**
t_{GBC}	GB ON delay	**6230 GB control**
t_{MBC}	MB ON delay	**7080 MB control**

The timer t_{MBC} is only active if back synchronisation is deactivated.

Example 1:
7065 Mains fail control: Start engine and open MB
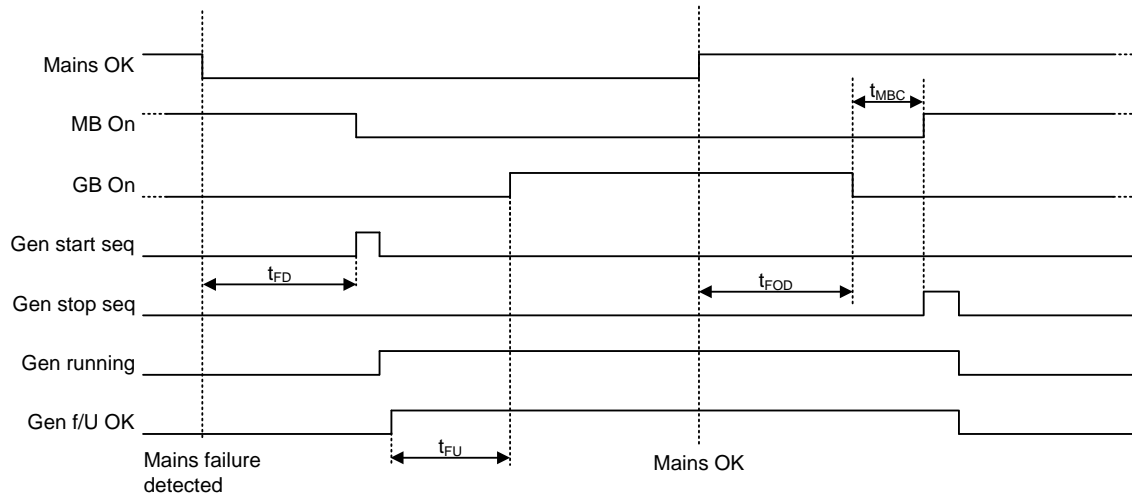
Example 2:
7065 Mains fail control: Start engine
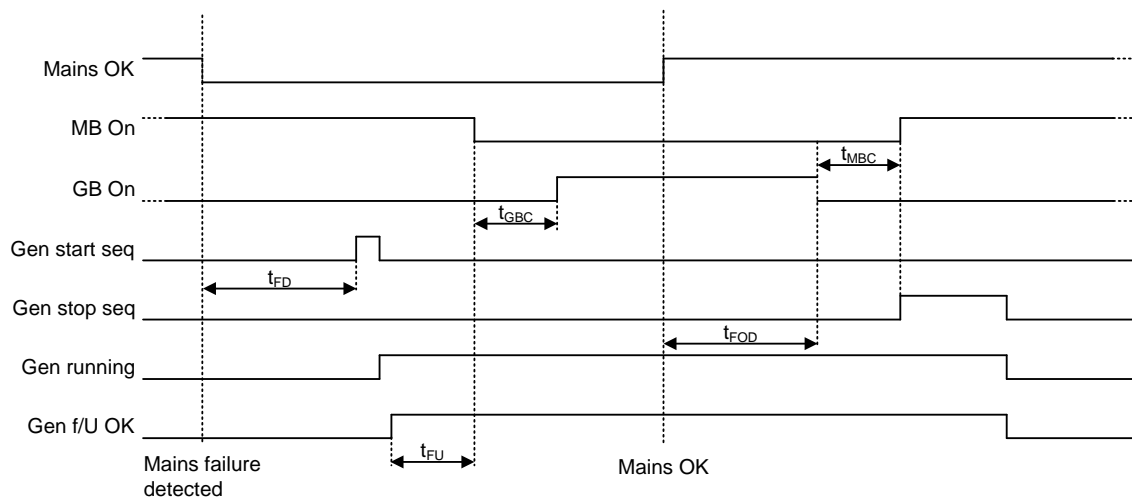
Conditions for breaker operations
The breaker sequences react depending on the breaker positions and the frequency/voltage measurements.

The conditions for the ON and OFF sequences are described in the table below:

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

4. Display unit and menu structure

4.1 Presentation

This chapter deals with the display unit including the push-button and LED functions. In addition, the unit menu structure will be presented.

4.2 Display unit (DU-2)

The display has four different lines, each with 20 characters, and holds a number of push-button functions.

ⓘ **Display dimensions are H x W = 115 x 220 mm (4.528" x 9.055").**

4.2.1 Push-button functions

The display unit holds a number of push-button functions which are described below:
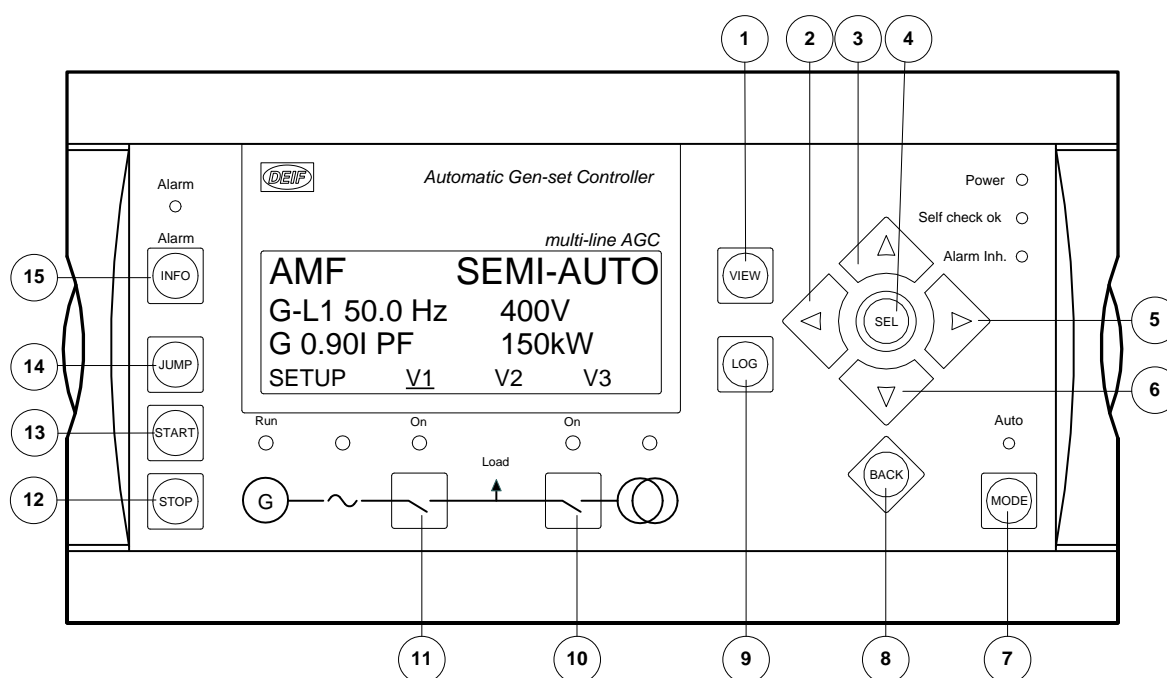
1. Shifts the first line displaying in the setup menus. Push 2 sec. to switch to master display in case more than one display is connected.
2. Moves the cursor left for manoeuvring in the menus.
3. Inreases the value of the selected setpoint (in the setup menu). In the daily use display, this button function is used for scrolling the View lines in V1 or the second line (in the setup menu) displaying of generator values.
4. Selects the underscored entry in the fourth line of the display.
5. Moves the cursor right for manoeuvring in the menus.

6. Decreases the value of the selected setpoint (in the setup menu). In the daily use display, this button function is used for scrolling the second line displaying of generator values.
7. Changes the menu line (line four) in the display to mode selection.
8. Jumps one step backwards in the menu (to previous display or to the entry window).
9. Displays the LOG SETUP window where you can choose between the Event, Alarm and Battery logs. The logs are not deleted when the auxiliary supply is switched off.
10. Manual activation of close breaker and open breaker sequence if "SEMI-AUTO" is selected.
11. Manual activation of close breaker and open breaker sequence if "SEMI-AUTO" is selected.
12. Stop of the genset if "SEMI-AUTO" or "MANUAL" is selected.
13. Start of the genset if "SEMI-AUTO" or "MANUAL" is selected.
14. Enters a specific menu number selection. All settings have a specific number attached to them. The JUMP button enables the user to select and display any setting without having to navigate through the menus (see later).
15. Shifts the display three lower lines to show the alarm list.

4.2.2 LED functions

The display unit holds 10 LED functions. The colour is green or red or a combination in different situations. The display LEDs are indicating as follows:
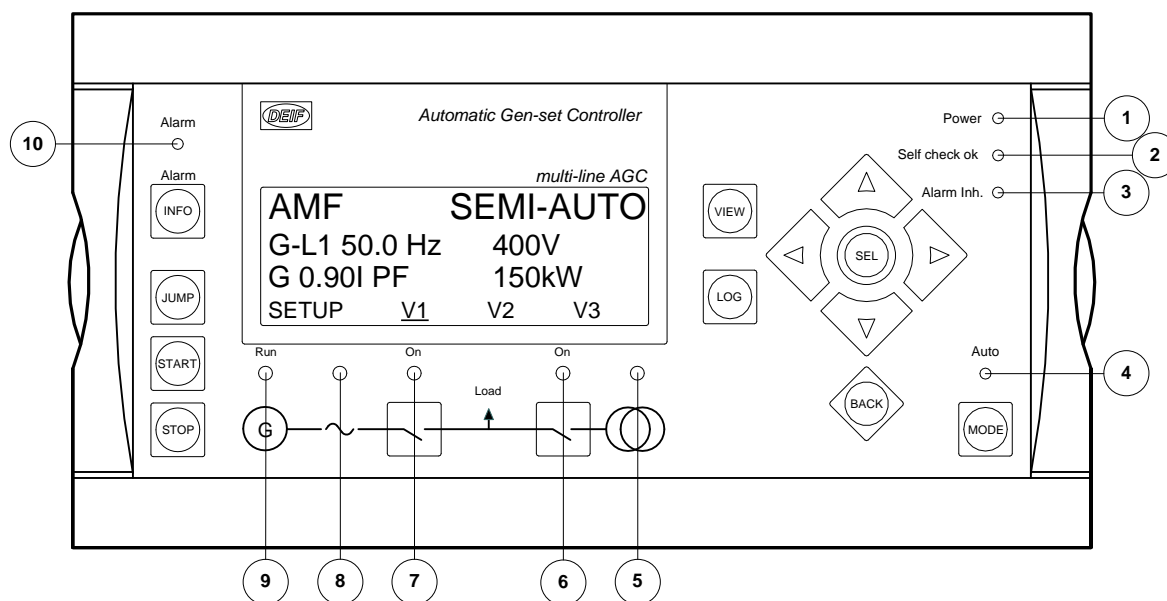
1. LED indicates that the auxiliary supply is switched on.
2. LED indicates that the unit is OK.
3. Please refer to "Alarm inhibit" in the chapter "Additional functions".
4. LED indicates that auto mode is selected.
5. LED is green if the mains is present and OK. LED is red at a measured mains failure. LED is flashing green when the mains returns during the "mains OK delay" time.
6. LED indicates that the mains breaker is closed. LED is flashing yellow if the "MB spring loaded" signal from the breaker is missing or the MB load time has not expired.

7. LED green light indicates that the generator breaker is closed. LED yellow light indicates that the genera-
    tor breaker has received a command to close on a black bus, but the breaker is not yet closed due to
    interlocking of the GB. LED is flashing yellow if the "Enable GB black close" or the "GB spring loaded"
    signal is missing or the GB load time has not expired.
8. LED green light indicates that the voltage/frequency is present and OK.
9. LED indicates that the generator is running.
10. LED flashing indicates that unacknowledged alarms are present. LED fixed light indicates that ALL alarms
    are acknowledged, but some are still present.

4.3 Menu structure

The display includes two menu systems which can be used without password entry:

> *View menu system*
> This is the commonly used menu system. 15 windows are configurable and can be entered by using
> the arrow push-buttons.

> *Setup menu system*
> This menu system is used for setting up the unit, and if the user needs detailed information that is not
> available in the view menu system. Changing of parameter settings is password protected.

4.3.1 Entry window

When the unit is powered up, an entry window appears. The entry window is the turning point in the menu
structure and as such the gateway to the other menus. It can always be reached by pressing the BACK push-
button three times.

ⓘ **The event and alarm list will appear at power up if an alarm is present.**

```
┌──────────────────────────────────────────────┐
│  ⬭DEIF        Automatic Gen-set Controller    │
│                                               │
│                                               │
│                              multi-line AGC   │
│  ┌──────────────────────────────────────────┐ │
│  │ AGC              V 3.00.0                 │ │
│  │ 2010-01-02         16:11:59               │ │
│  │ SETUP MENU                                │ │
│  │ SETUP    V3    V2    V1                   │ │
│  └──────────────────────────────────────────┘ │
│                                               │
└──────────────────────────────────────────────┘
```

```
┌─────────────────────────────────────────────┐
│  ┌───────┐                                    │
│  │ DEIF  │        Automatic Gen-set Controller│
│  └───────┘                                    │
│                                               │
│                              multi-line AGC   │
│  ┌─────────────────────────────────────────┐ │
│  │ AGC            V 3.00.0                  │ │
│  │ 2010-01-02        16:11:59               │ │
│  │ SETUP MENU                               │ │
│  │ SETUP     V3    V2    V1    P00          │ │
│  └─────────────────────────────────────────┘ │
│                                               │
└─────────────────────────────────────────────┘
```
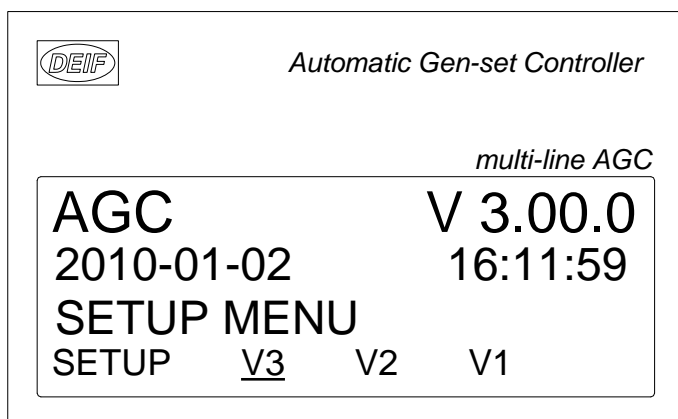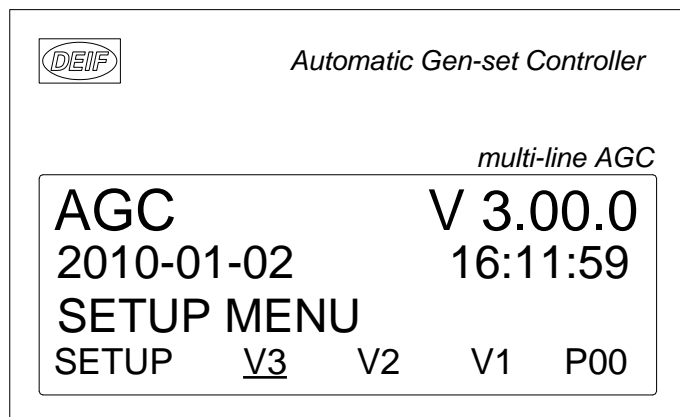
ⓘ **The priority "P00", shown in the lower right corner, is related to the power management option G4 and G5.**

4.3.2 View menu

The view menus (V1, V2 and V3) are the most commonly used menus of the unit.

```
              ┌─────────────────────────────────────────────┐
              │  ┌───────┐                                    │
              │  │ DEIF  │        Automatic Gen-set Controller│
              │  └───────┘                                    │
              │                              multi-line AGC   │
       ┌─┐    │  ┌─────────────────────────────────────────┐ │
       │1│────┼──│ G   400   400   400V                     │ │
       └─┘    │  │ G-L1 50 Hz        440V                   │ │
       ┌─┐    │  │ G-L1 50 Hz        440V                   │ │
       │2│────┼──│ SETUP     V3    V2    V1                 │ │
       └─┘    │  └─────────────────────────────────────────┘ │
       ┌─┐    │                                               │
       │3│────┤                                               │
       └─┘    └─────────────────────────────────────────────┘
       ┌─┐
       │4│
       └─┘
```
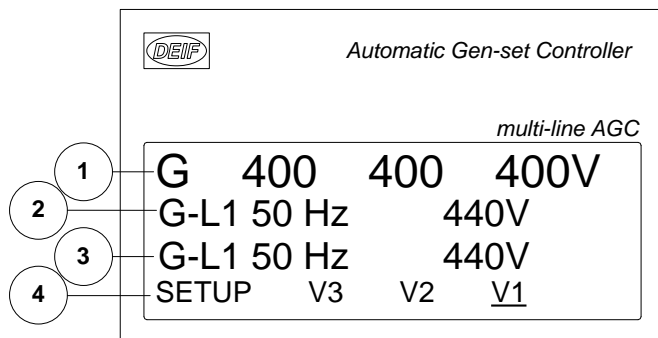
1. First display line: Operational status or measurements
2. Second display line: Measurements relating to operational status
3. Third display line: Measurements relating to operational status
4. Fourth display line: Selection of setup and view menus

In the view menus various measured values are on display.

The menu navigating starts from the fourth display line in the entry window and is carried out using the

△, ▽, ◁ and ▷ push-buttons.
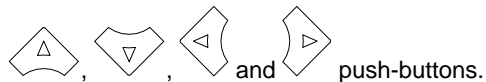
The entry window displays view 3 (in the illustration above the window where "manual" is displayed).

Moving the cursor left or right offers the following possibilities.

- Setup menu – access to the following sub-menus:
    - Protection setup
    - Control setup
    - I/O setup
    - System setup
- View 3 – window displays operational status and selectable measurements
- View 2 – window displays selectable measurements. The same as view 1
- View 1 – access to up to 15 selectable windows displaying selectable measurements

(i) **The factory settings for view 1 and view 2 are identical.**

4.3.3 Setup menu

The setup menu system is used for parameter setup of the unit, and if the user needs detailed information that is not available in the view menu system. So, this menu can be used for both daily use and setup purposes. The menu is entered from the entry window by selecting the entry SETUP in the fourth display line.
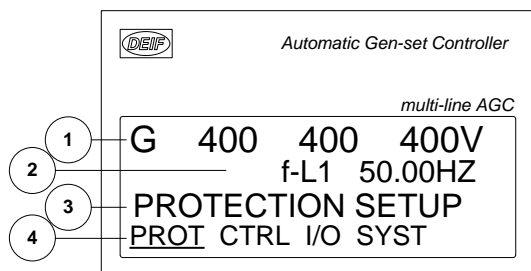
1. First display line
    (Daily use)   The first line is used to display generator and bus values

2. Second display line
    (Daily use)   Various values can be displayed
    (Menu system)   Information about the selected channel number
    (Alarm/event list)   The latest alarm/event is displayed

3. Third display line
    (Daily use)   Explanation for the fourth line cursor selection
    (Setup menu)   Presents setting of the selected function, and, if changes are made, the possible max.
                                 and min. values for the setting

4. Fourth display line
    (Daily use)   Entry selection for the setup menu. Press SEL to enter the underscored menu
    (Setup menu)   Sub-functions for the individual parameters, e.g. limit

Possible values in second display line

View line/second display line configuration	
For generator	**For bus/mains**
G f-L1 frequency L1 (Hz)	M f-L1 frequency L1 (Hz)
G f-L2 frequency L2 (Hz)	M f-L2 frequency L2 (Hz)
G f-L3 frequency L3 (Hz)	M f-L3 frequency L3 (Hz)
Gen. active power (kW)	Mains active power (kW)
Gen. reactive power (kVAr)	Mains reactive power (kVAr)
Gen. apparent power (kVA)	Mains apparent power (kVA)
Power factor	Power factor
Voltage angle between L1-L2 (deg.)	Voltage angle between L1-L2 (deg.)
Voltage angle between L2-L3 (deg.)	Voltage angle between L2-L3 (deg.)
Voltage angle between L3-L1 (deg.)	Voltage angle between L3-L1 (deg.)
BB U-L1N	BB U-L1N
BB U-L2N	BB U-L2N
BB U-L3N	BB U-L3N
BB U-L1L2	BB U-L1L2
BB U-L2L3	BB U-L2L3
BB U-L3L1	BB U-L3L1
BB U-MAX	BB U-MAX
BB U-Min	BB U-Min
BB f-L1	BB f-L1
BB AngL1L2-180.0deg	BB AngL1L2-180.0deg
BB-G Ang -180.0deg	BB-M Ang -180.0deg
U-Supply (power supply V DC)	U-Supply (power supply V DC)
Energy counter, total (kWh)	Energy counter, total (kWh)
Energy counter, daily (kWh)	Energy counter, daily (kWh)
Energy counter, weekly (kWh)	Energy counter, weekly (kWh)
Energy counter, monthly (kWh)	Energy counter, monthly (kWh)
G U-L1N (voltage L1-N)	M U-L1N (voltage L1-N)
G U-L2N (voltage L2-N)	M U-L2N (voltage L2-N)
G U-L3N (voltage L3-N)	M U-L3N (voltage L3-N)
G U-L1L2 (voltage L1-L2)	M U-L1L2 (voltage L1-L2)
G U-L2L3 (voltage L2-L3)	M U-L2L3 (voltage L2-L3)
G U-L3L1 (voltage L3-L1)	M U-L3L1 (voltage L3-L1)
G U-Max (voltage max.)	M U-Max (voltage max.)
G U-Min (voltage min.)	M U-Min (voltage min.)
G I-L1 (current L1)	M I-L1 (current L1)

View line/second display line configuration	
G I-L2 (current L2)	M I-L2 (current L2)
G I-L3 (current L3)	M I-L3 (current L3)
Run abs. (absolute run time)	
Run rel. (relative run time)	
Next prio (next priority shift)	
Run ShtD O (shutdown override run time)	
Mains power A102	P TB A105
Number of GB operations	Number of TB operations
Start attempts	
P available	P available
P mains	P mains
P DGs tot	P DGs tot
Number of MB operations	Number of MB operations
Service timer 1	
Service timer 2	
MPU	
Multi-input 1	Multi-input 1
Multi-input 2	Multi-input 2
Multi-input 3	Multi-input 3
Battery asym 1	Battery asym 1
Battery asym 2	Battery asym 2
Power factor	Power factor
Cos Phi	Cos Phi
Cos Phi reference (current)	Cos Phi reference (current)
Power reference (actual)	
Power reference (current)	Power reference (current)

Setup structure
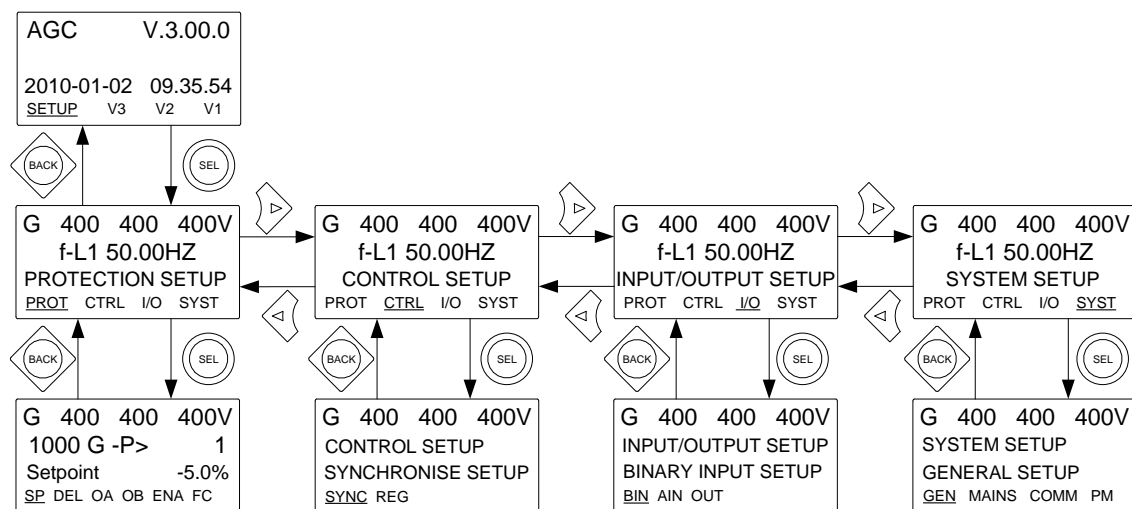
Setup example
The following example illustrates how a specific setting is changed in the setup menu. In this case **Reverse power** is the selected parameter.
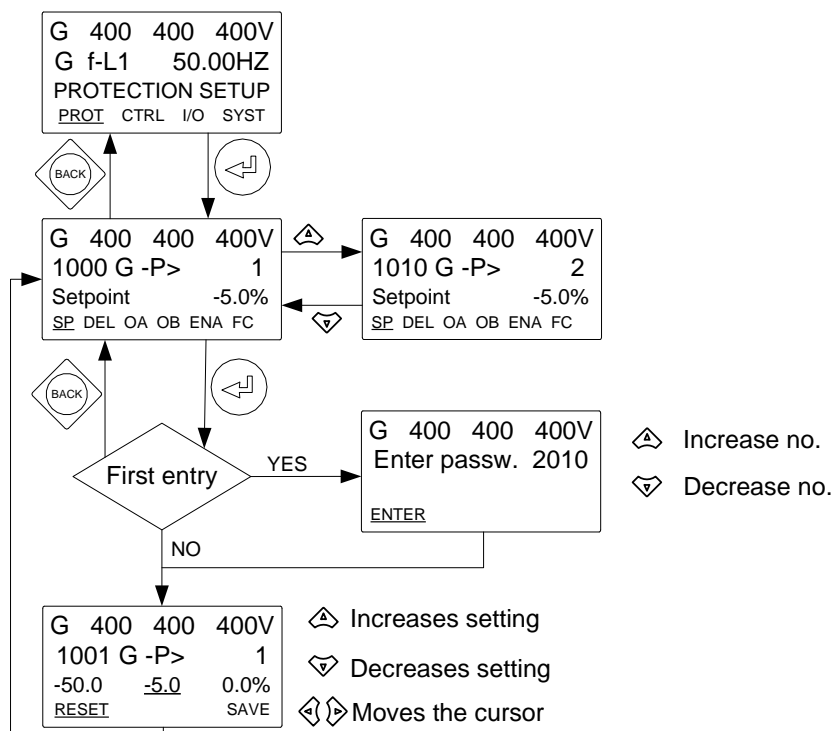
4.4 Mode overview

The unit has four different running modes and one block mode. For detailed information, see chapter "Applications".

Auto
In auto mode the unit will operate automatically, and the operator cannot initiate any sequences manually.

Semi-auto
In semi-auto mode the operator has to initiate all sequences. This can be done via the push-button functions, Modbus commands or digital inputs. When started in semi-automatic mode, the genset will run at nominal values.

Test
The test sequence will start when the test mode is selected.

Manual
When manual mode is selected, the binary increase/decrease inputs can be used (if they have been configured) as well as the start and stop push-buttons. When starting in manual mode, the genset will start without any subsequent regulation.

Block
When the block mode is selected, the unit is not able to initiate any sequences, e.g. the start sequence.

ⓘ **Block mode must be selected when maintenance work is carried out on the genset.**

⚠ **The genset will shut down if block mode is selected while the genset is running.**

4.5 Mode selection

The following drawings illustrate how the mode selection is carried out.

Pushing the MODE push-button will change the displayed text. After pushing "MODE", the fourth display line indicates the selectable modes. In the third display line, the underscored (fourth line) selection will be displayed.

Two possibilities are now available:

If "BACK" is pushed, the display returns to the original text without changing the mode.

1. push		2. push

```
AGC              V 3.00.0
2010-01-02        13:45:18
SETUP MENU
SETUP    V3    V2    V1
```
(MODE) →
```
AGC              V 3.00.0
2010-01-02        13:45:18
SEMI-AUTO MODE
SEMI   TST   AUT   MAN   BLK
```
(BACK)

or

```
G   0   0    0V
      F-L1   0.00HZ
PROTECTION SETUP
PROT  CTRL  I/O  SYST
```
(MODE) →
```
G   0   0    0V
      F-L1   0.00HZ
SEMI-AUTO MODE
SEMI   TST   AUT   MAN   BLK
```
(BACK)
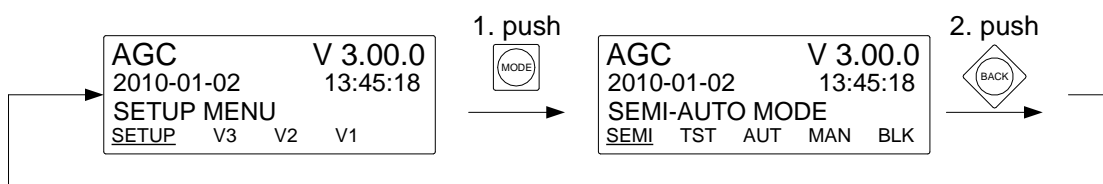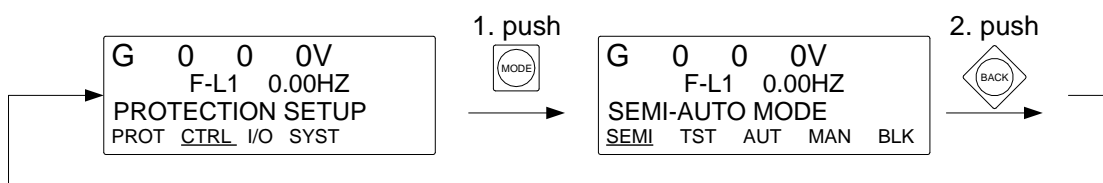
If "SEL" is pushed, the underlined mode is selected, and the display returns to the original text. In this example the SEMI-AUTO mode is selected.

3. push		4. push

```
AGC              V 3.00.0
2010-01-02        13:45:18
SETUP MENU
SETUP    V3    V2    V1
```
(MODE) →
```
AGC              V 3.00.0
2010-01-02        13:45:18
SEMI-AUTO MODE
SEMI   TST   AUT   MAN   BLK
```
(SEL)

or

```
G   0   0    0V
      F-L1   0.00HZ
PROTECTION SETUP
PROT  CTRL  I/O  SYST
```
(MODE) →
```
G   0   0    0V
      F-L1   0.00HZ
SEMI-AUTO MODE
SEMI   TST   AUT   MAN   BLK
```
(SEL)
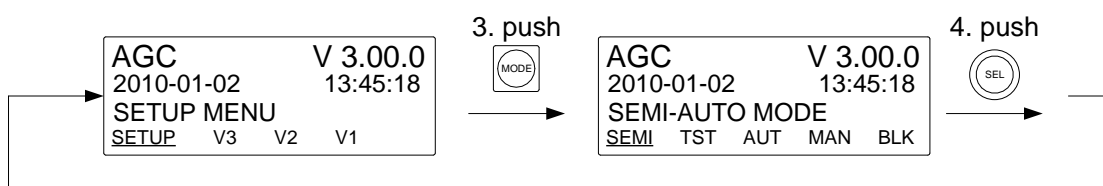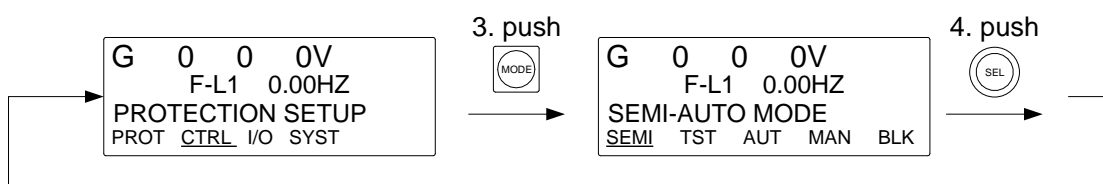
4.6 Password

The unit includes three password levels. All levels can be adjusted in the PC software.

Available password levels:

Password level	Factory setting	Access		
		Customer	Service	Master
Customer	2000	X		
Service	2001	X	X	
Master	2002	X	X	X

A parameter cannot be entered with a too low ranking password. But the settings can be displayed without password entry.

Each parameter can be protected at a specific password level. To do so, the PC utility software must be used. Enter the parameter to be configured and select the correct password level.
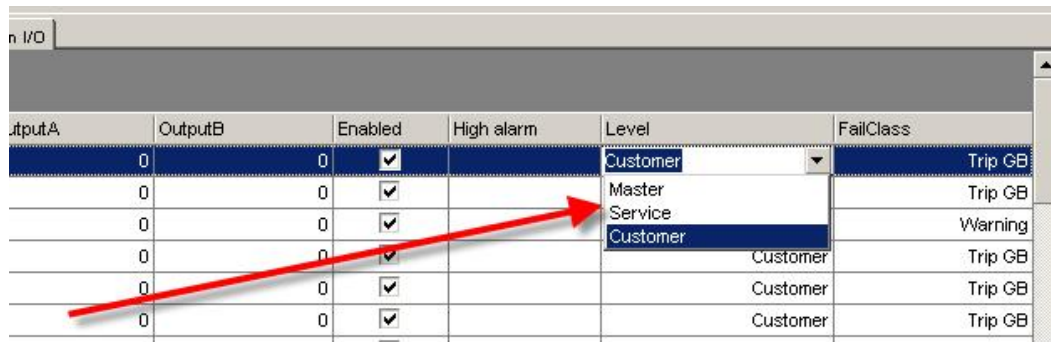
The password level can also be changed from the parameter view in the column Level.

4.6.1 Parameter access
To gain access to adjust the parameters, the password level must be entered:

If the password level is not entered, it is not possible to enter the parameters.

(i) **The customer password can be changed in menu 9116. The service password can be changed in menu 9117. The master password can be changed in menu 9118.**

(i) **The factory passwords must be changed if the operator of the genset is not allowed to change the parameters.**

(i) **It is not possible to change the password at a higher level than the password entered.**

5. Additional functions

5.1 Start functions

The unit will start the genset 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. But if the starter motor has to disengage at 400 RPM, and the oil pressure does not reach a level above the shutdown setpoint before 600 RPM, then, obviously, the genset would shut down if the specific alarm was activated at the preset 400 RPM. In that case, the running feedback must be activated at a higher number of revolutions than 600 RPM.
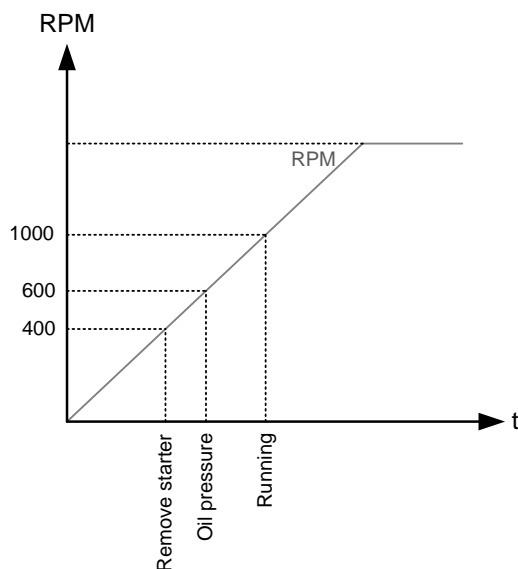
5.1.1 Digital feedbacks
If an external running relay is installed, then the digital control inputs for running detection or remove starter can be used.

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

RPM

RPM$_{NOM}$ -

RPM

Run. feedback

Firing speed

t
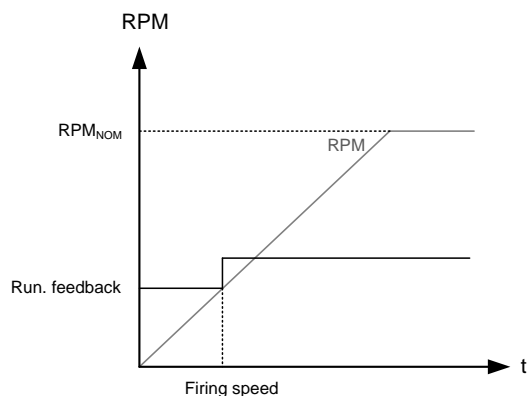
The diagram illustrates how the digital running feedback (terminal 117) is activated when the engine has reached its firing speed.

Remove starter

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

RPM

RPM$_{NOM}$ -

RPM

Run. feedback

Remove starter

Firing speed   Running

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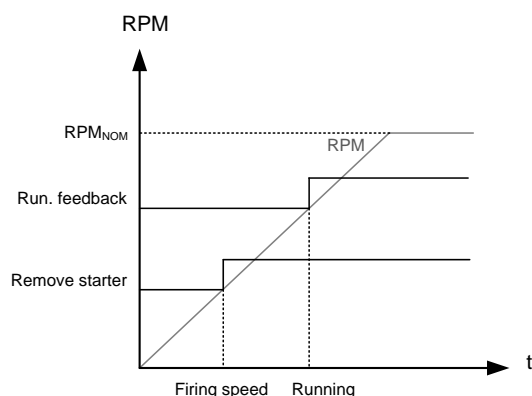
The diagram illustrates how the remove starter input is activated when the engine has reached its firing speed. At the running speed, the digital running feedback is activated.

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

The running feedback is detected by either the digital input (see diagram above), frequency measurement above 32 Hz, RPM measured by magnetic pick-up or EIC (option H5/H7).

5.1.2 Analogue tacho feedback

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

Running feedback
The diagram below shows how the running feedback is detected at the firing speed level. The factory setting is 1000 RPM **(6170 Running detect.).**
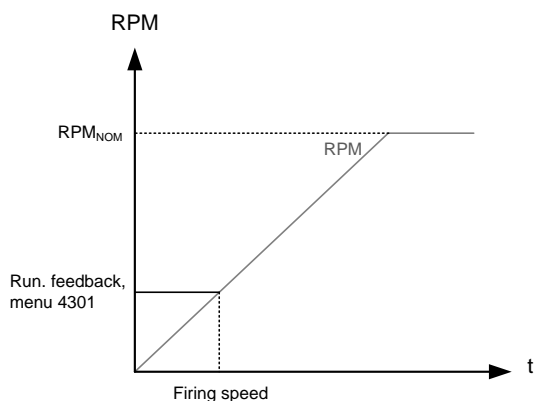
⚠️ **Notice that the factory setting of 1000 RPM is higher than the RPM level of starter motors of typical design. Adjust this value to a lower value to avoid damage of the starter motor.**

Remove starter input
The drawing below shows how the setpoint of the remove starter is detected at the firing speed level. The factory setting is 400 RPM **(6170 Running detect.).**
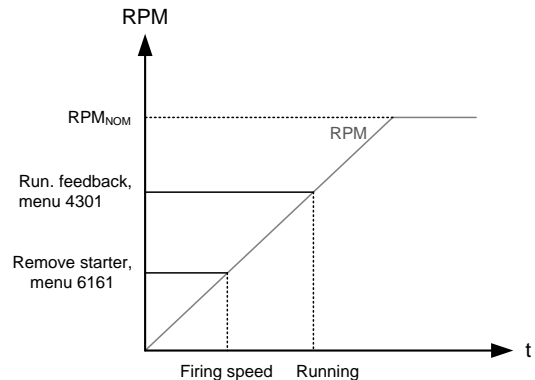
ⓘ **The number of teeth on the flywheel must be adjusted in menu 6170 when the MPU input is used.**

5.1.3 Oil pressure

The multi-inputs on terminals 102, 105 and 108 can be used for the detection of running feedback. The terminal in question must be configured as a VDO input for oil pressure measurement.

When the oil pressure increases above the adjusted value **(6175 Pressure level)** then the running feedback is detected and the start sequence is ended.

Running feedback
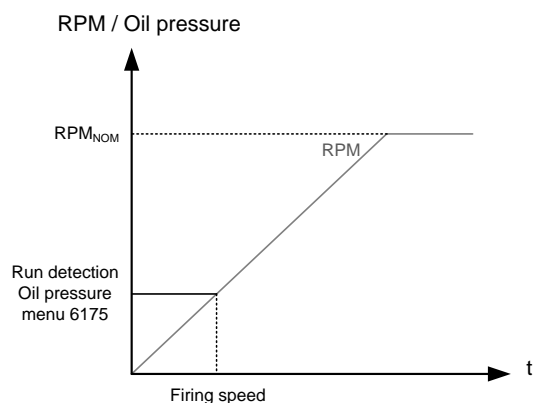
RPM / Oil pressure

RPM$_{NOM}$ .... RPM

Run detection
Oil pressure
menu 6175

Firing speed   t

Remove starter input
The drawing below shows how the setpoint of the "remove starter input" is detected at the firing speed level. The factory setting is 400 RPM **(6170 Running detect.).**

RPM / Oil pressure

RPM$_{NOM}$ .... RPM

Run detection
Oil pressure
menu 6175

Remove starter,
menu 6161

Firing speed   Running   t
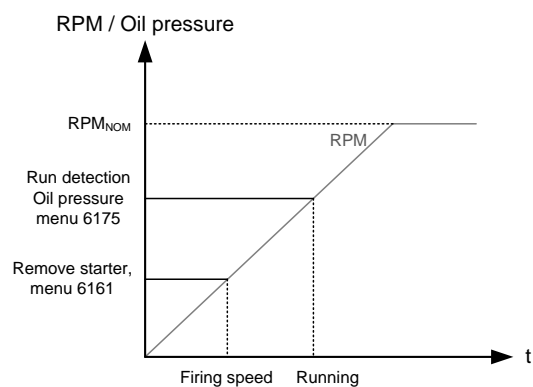
(i) **The remove starter function can use the MPU or a digital input.**

5.2 Breaker types

There are five possible selections for the setting of breaker type for both mains breaker and generator breaker.

Continuous NE and Continuous ND
This type of signal is most often used combined with a contactor. When using this type of signal, the AGC will only use the close breaker relays. The relay will be closed for closing of the contactor and will be opened for opening of the contactor. The open relay can be used for other purposes. Continuous NE is a normally energised signal, and Continuous ND is a normally deenergised signal.

Pulse
This type of signal is most often used combined with circuit breaker. With the setting pulse the AGC will use the close command and the open command relay. The close breaker relay will close for a short time for closing of the circuit breaker. The open breaker relay will close for a short time for opening of the breaker.

External/ATS no control
This type of signal is used to indicate the position of the breaker, but the breaker is not controlled by the AGC.

Compact
This type of signal will most often be used combined with a compact breaker, a direct controlled motor driven breaker. With the setting compact the AGC will use the close command and the open command relay. The close breaker relay will close for a short time for the compact breaker to close. The breaker off relay will close for the compact breaker to open and hold it closed long enough for the motor in the breaker to recharge the breaker. If the compact breaker is tripped externally, it is recharged automatically before next closing.

(i) **If compact breaker is selected, the length of breaker open signal can be adjusted. This can be done in menu 2160/2200.**

5.3 Breaker spring load time

To avoid breaker close failures in situations where breaker ON command is given before the breaker spring has been loaded, the spring load time can be adjusted for GB/TB and MB.

The following describes a situation where you risk getting a close failure:

1. The 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 GB will give a GB close failure as the GB needs time to load the spring before it is ready to close.

Different breaker types are used, and therefore there are two available solutions:

1. Timer-controlled
A load time setpoint 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. The setpoints are found in menus 6230, 7080 and 8190.

(i) **On the AGC mains unit (option G5), the spring load feedback from the tie breaker can be connected instead of the GB spring load feedback.**

2. Digital input
Two configurable inputs to be 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 will not be allowed to close again before the configured inputs are active. The inputs are configured in the ML-2 utility software. When the timers are counting, the remaining time is shown in the display.

If the two solutions are used together, both requirements are to be met before closing of the breaker is allowed.

Breaker LED indication
To alert the user that the breaker close sequence has been initiated but is waiting for permission to give the close command, the LED indication for the breaker will be flashing yellow in this case.

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

5.3.1 Principle

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

This is what happens: When the AUTO start/stop input deactivates, the GB opens. The AUTO start/stop is reactivated immediately after the GB has opened, e.g. by the operator through a switch in the switchboard. However, the AGC waits a while before it issues the close signal again, because the spring load time must expire (or the digital input must be activated - not shown in this example). Then the AGC issues the close signal.
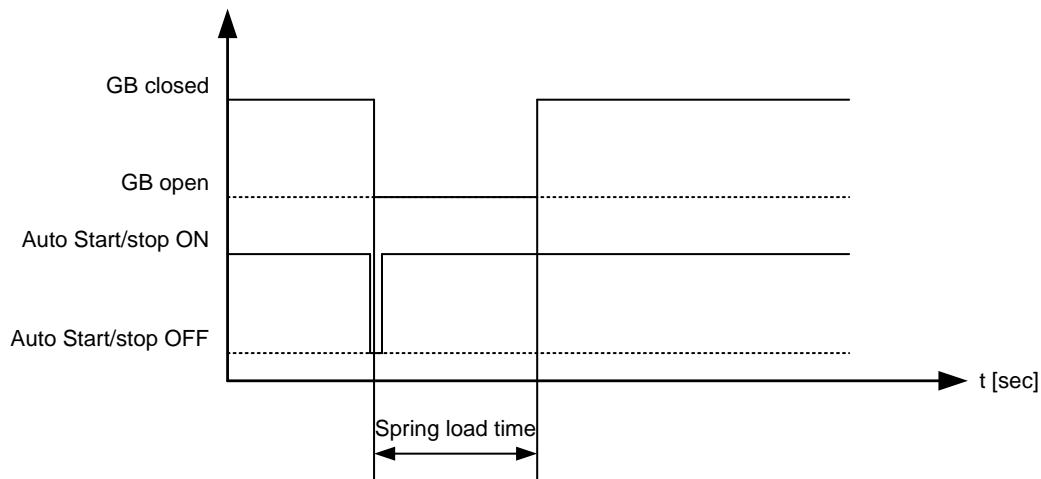
5.4 Alarm inhibit

In order to select when the alarms are to be active, a configurable inhibit setting for every alarm has been made. The inhibit functionality is only available via the PC utility software. For every alarm there is a drop-down window where it is possible to select which signals that have to be present in order to inhibit the alarm.

Selections for alarm inhibit:

Function	Description
Inhibit 1	M-logic outputs: Conditions are programmed in M-logic
Inhibit 2	
Inhibit 3	
GB ON (TB ON)	The generator breaker is closed
GB OFF (TB ON)	The generator breaker is open
Run status	Running detected and the timer in menu 6160 expired
Not run status	Running not detected or the timer in menu 6160 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	Both GB and MB are closed
Not parallel	Either GB or MB is closed, but not both

(i) **The timer in 6160 is not used if binary running feedback is used.**

Inhibit of the alarm is active as long as one of the selected inhibit functions is active.

In this example, inhibit is set to *Not run status* and *GB ON*. Here, the alarm will be active when the generator has started. When the generator has been synchronised to the busbar, the alarm will be disabled again.

(i) **The inhibit LED on the unit and on the display will activate when one of the inhibit functions is active.**

(i) **Function inputs such as running feedback, remote start or access lock are never inhibited. Only alarm inputs can be inhibited.**

(i) **The tie breaker unit has no running detection that can be configured, so the only inhibit functions are the binary input and the TB position.**

5.4.1 Run status (6160)

Alarms can be adjusted to activate only when the running feedback is active and a specific time delay has expired.

The diagram below illustrates that after activation of the running feedback, a run status delay will expire. When the delay expires, alarms with *Run status* will be activated.
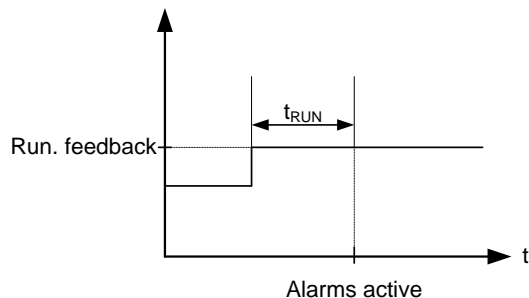
(i) **The timer is ignored if binary running feedback is used.**

5.5 Access lock

The purpose of access lock is to deny the operator the possibility to configure the unit parameters and change the running modes.

The input to be used for the access lock function is defined in the ML-2 PC utility software (USW).

Access lock will typically be activated from a key switch installed behind the door of the switchboard cabinet.

Button	Button status	Comment
INFO	Active	It is possible to read all alarms, but it is not possible to acknowledge any of them.
JUMP	Not active	
START	Not active	
STOP	Not active	
GB ON	Not active	
MB ON	Not active	
VIEW	Active	
LOG	Active	
LEFT ◁	Active	
UP △	Active	
SELECT	Not active	If the access lock is activated when the view menu system is displayed, then the button is not active.
SELECT	Active	If the access lock is activated when the setup menu system is displayed, then the button is active.
DOWN ▽	Active	
BACK	Active	
RIGHT ▷	Active	
MODE	Active	If the access lock is activated when the view menu system is displayed, the button is not active.
MODE	Active	If the access lock is activated when the setup menu system is displayed, then the button is active.

(i) **After three minutes, the display returns to the view menu system. The setup menu system can only be entered again if the access lock is deactivated.**

(i) **The stop push-button is not active in semi-auto mode when the access lock is activated. For safety reasons it is recommended to install an emergency stop switch.**

The following digital input functions are affected when access lock is activated:

Input name	Input status	Comment
Remote start	Not active	
Remote stop	Not active	
Semi-auto	Not active	
Test	Not active	
Auto	Not active	
Manual	Not active	
Block	Not active	
Remote GB ON	Not active	
Remote GB OFF	Not active	
Remote MB ON	Not active	
Remote MB OFF	Not active	
Remote TB ON	Not active	
Remote TB OFF	Not active	

(i)   AOP buttons are not locked when access lock is activated.

5.6 Overlap

The purpose of the *overlap* function is to be able to define a maximum paralleling time between the generator and the mains supply.

The function is typically used if there are local requirements to maximum allowed paralleling time.

(i)   The overlap function is only available in the automatic mains failure and load takeover genset modes.
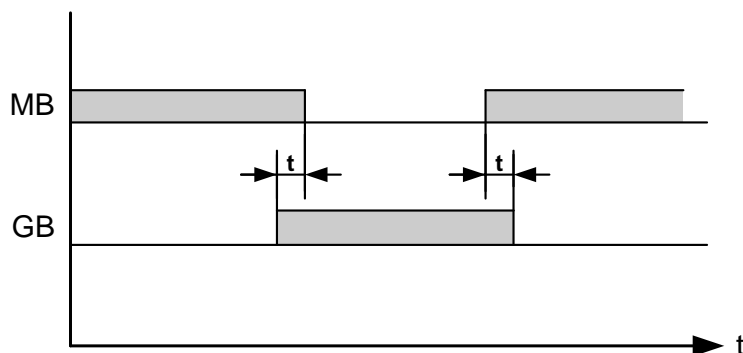
The diagram shows that when the generator breaker is synchronised, the mains breaker will be opened automatically after a time delay (t). Later the mains breaker is synchronised, and the generator breaker is opened after the time delay (t).

The time delay is measured in seconds and can be adjusted from 0.10 to 99.90 seconds.

ⓘ **The same time delay is used for both generator and mains breaker synchronisation.**

ⓘ **If the function is used in a Power Management (option G5) application, then the overlap will occur between the mains breaker and the tie breaker on the AGC mains.**

ⓘ **The time delay typed in the setpoint is a maximum time. This means that if 0.10 seconds are used, the two breakers will never be closed at the same time for a longer delay than the setpoint.**

The short time parallel function is set up in **2760 Overlap.**

5.7 Digital mains breaker control

The unit will normally execute the automatic mains failure sequence based on the settings adjusted in the system setup. Besides these settings it is possible to configure a digital input that can be used to control the mains return sequence. This input is the "mains OK" input. The purpose of this function is to let an external device or an operator control the mains return sequence. The external device can e.g. be a PLC.

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

The mains OK delay is not used at all when the "Mains OK" input is configured.

```
                        ┌─────────────┐
                        │  Mains OK   │
                        └─────────────┘
                               │
                               ▼
                    ╱──────────────────╲
              No   ╱     MB input        ╲   Yes
           ┌──────<     configured        >──────┐
           │       ╲                      ╱       │
           │        ╲────────────────────╱        │
           ▼                                       ▼
    ┌─────────────┐                        ┌─────────────┐
    │  Mains OK   │◄─┐                   ┌►│ MB control  │
    │   delay     │  │                   │ │   input     │
    └─────────────┘  │                   │ └─────────────┘
           │         │                   │        │
           ▼         │ No             No │        ▼
       ╱───────╲     │                   │    ╱───────╲
      ╱ Expired ╲────┘                   └───<   ON    >
       ╲───────╱                              ╲───────╱
           │                                      │
           │ Yes                              Yes │
           │         ┌─────────────┐              │
           └────────►│  MB and GB  │◄─────────────┘
                     │  operation  │
                     └─────────────┘
                            │
                            ▼
                     ┌─────────────┐
                     │  Sequence   │
                     └─────────────┘
```
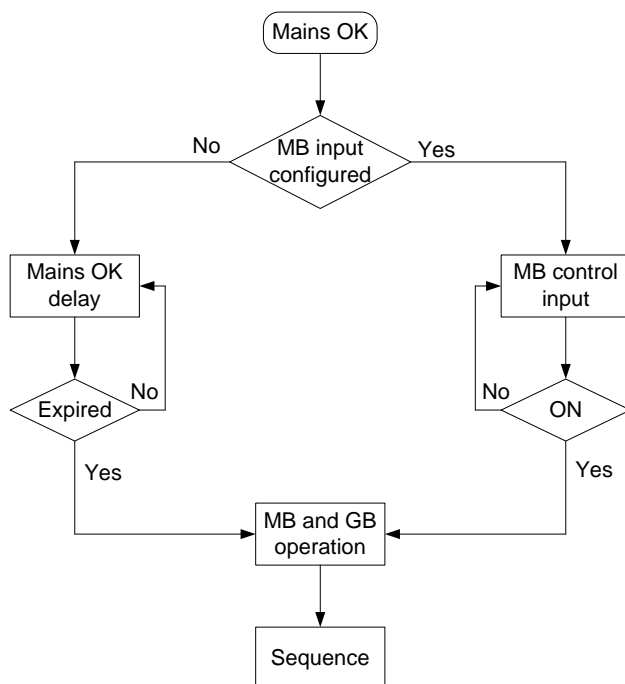
5.8 Command timers

The purpose of the command timers is to be able to e.g. start and stop the genset automatically at specific times each weekday or certain weekdays. If auto mode is activated, this function is available in island operation, load takeover, mains power export and fixed power operation. Up to four command timers can be used for e.g. start and stop. The command timers are available in M-logic and can be used for other purposes than starting and stopping the genset automatically. The settings are set up through the PC utility software. Each command 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

ⓘ **The "Auto start/stop" command is programmed in M-logic or in the input settings.**

ⓘ **The time-dependent commands are flags that are raised when the command timer is in the active period.**

ⓘ **It is necessary to use the PC utility software when setting up the command timers.**

5.9 Running output

6160 Run status can be adjusted to give a digital output when the genset is running.

Select the correct relay number in output A and output B and enable the function. Change the relay function to limit in the I/O menu. Then the relay will activate, but no alarm will appear.

ⓘ **If the relay function is not changed to "limit" function, an alarm will appear at every running situation.**

5.10 Frequency-dependent droop

This droop function can be used when the genset is parallel to the mains. In case the frequency drops or rises due to instability of the mains, the curve for frequency-dependent droop is made to compensate the power setpoint.

Example:
With a nominal frequency of 50 Hz and an actual frequency of 51.5 Hz, there is a deviation of 1.5 Hz which is equal to a 3% deviation from the nominal setting. The genset will then droop to 400 kW according to the below vector diagram.
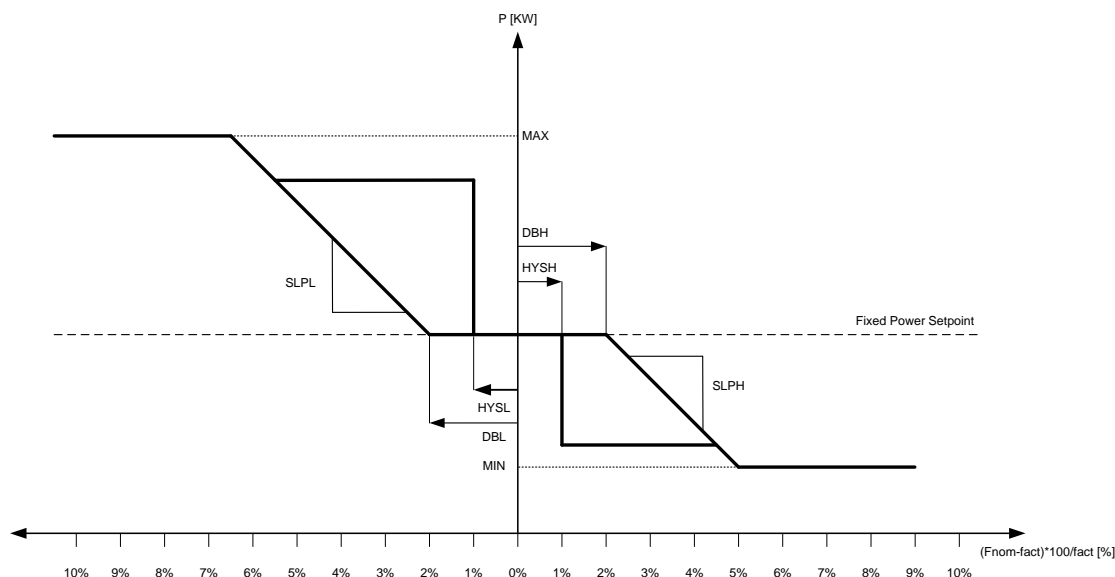
The above vector diagram is configured with the parameter settings as in the following table.

The curve can be designed inside MIN/MAX [kW] area.

Menu	Settings	Name	Description
7051	450	kW	Fixed power setpoint
7121	2	DBL[%]	Dead band low in percentages of nominal frequency.
7122	2	DBH[%]	Dead band high in percentages of nominal frequency.
7123	1	HYSL[%]	Hysterese low in percentages of nominal frequency. If HYSL is set above DBL, the hysteresis low is disabled.
7124	1	HYSH[%]	Hysterese high in percentages of nominal frequency. If HYSH is set above DBH, the hysteresis high is disabled.
7131	150	MIN[kW]	Minimum output of droop handling.
7132	900	MAX[kW]	Maximum output of droop handling.
7133	50	SLPL[kW/%]	Slope low. The setting determines the increase/decrease of power reference per percentage the actual frequency drops below nominal frequency.
7134	-50	SLPH[kW/%]	Slope high. The setting determines the increase/decrease of power reference per percentage the actual frequency rises above nominal frequency.
7143	ON	Enable	Enable droop curve function.

ⓘ **The frequency-dependent droop is only available in fixed power mode.**

5.11 Derate genset

The purpose of the derate function is to be able to reduce the maximum output power of the genset if specific conditions require this. An example of such a condition is the ambient temperature. If the ambient temperature increases to a level where the cooling water coolers decrease in cooling capacity, it will be necessary to reduce the power of the genset. If the genset is not derated, alarms and shutdown events will very likely occur.

(i) **The derate function is typically used when cooling problems are expected.**

5.11.1 Input selection
The derate function can be configured to one of the following inputs:

Input	Comment
Multi-input 102	0-40V DC
Multi-input 105	4-20 mA
Multi-input 108	Pt100/1000
	VDO
	Digital
EIC	
M-logic	

Select the needed input in **6260 Power derate.**

(i) **Refer to the type label for information about engine interface selection.**

5.11.2 Derate parameters
The parameters that define the derate characteristics are the following:

Start derate point (6260 Power derate)

> This is the setting where the derating must start. The setting can be in mA (max. 20 mA) or in centigrades ºC (max. 200ºC).

Slope (6260 Power derate)

> Adjust the derating speed. The adjustment is in percent per unit, i.e. if the 4-20 mA input is used, then the derating will be in %/mA, and if the Pt100/Pt1000/VDO input is used, then the derating will be in %/C.

(i) **Be aware that the 4-20 mA input can be configured with different minimum and maximum settings. In this case the settings "start derate point" and "slope" use these new settings.**

Derate limit (6260 Power derate)

This is the lowest derate level.
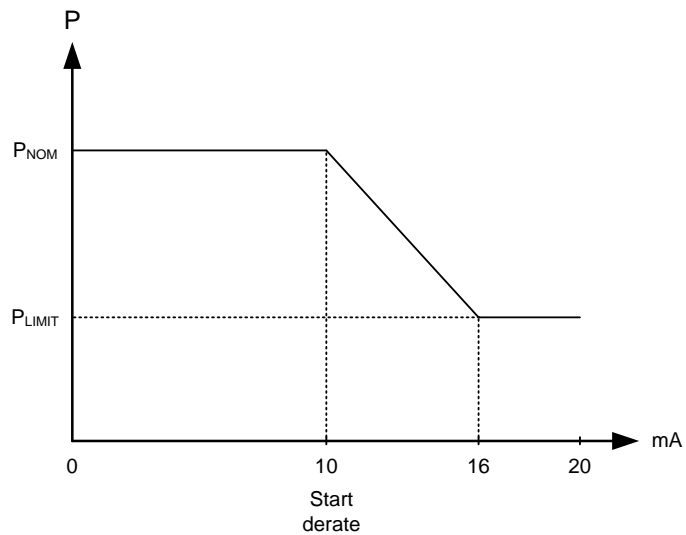
5.11.3 Derate characteristic

It can be selected whether the characteristic of the derating should be proportional or inverse proportional. The drawing above shows the inverse characteristic.

The proportional characteristic is illustrated below.
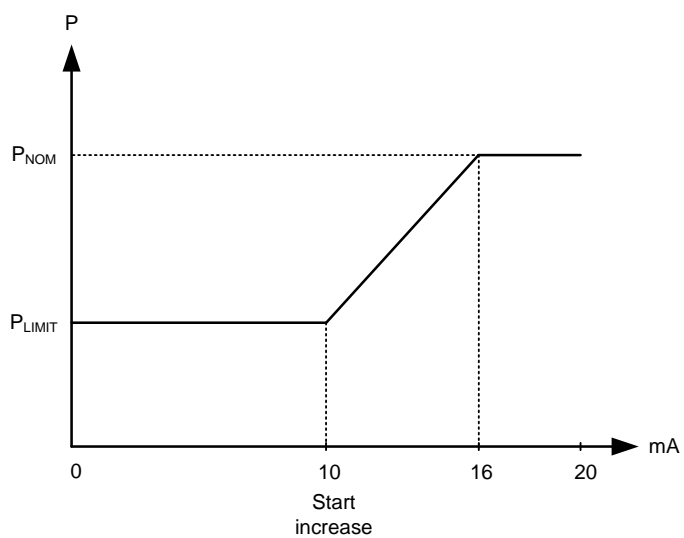
The genset is derated when the control value is lower than the setpoint (in the example above the control value is an mA signal).

The derate characteristic is selected in **6260** Power derate

        Setting OFF: Inverse characteristic
        Setting ON: Proportional characteristic

5.12 Idle running

The purpose of the idle run function is to change the start and stop sequences to allow the genset to operate under low temperature conditions.

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 main purpose of the function is to prevent the genset from stopping. The timers are available to make the function flexible.

ⓘ   **The speed governor must be prepared for the idle run function if this function is to be used.**

The function is typically used in installations where the genset is exposed to low temperatures which could generate starting problems or damage the genset.

5.12.1 Description

The function is enabled and configured in 6290 Idle running. It has to be noted that the governor itself must handle the idle speed based on a digital signal from the unit (see the principle diagram below).

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

No.	Input	Description
1	Low speed input	This input is used to change between idle speed and nominal speed. This input does not prevent the genset from stopping - it is only a selection between idle and nominal speed.
2	Temperature control input	When this input is activated, the genset will start. It will not be able to stop as long as this input is activated.

ⓘ   **If the idle run function is selected by means of timer, the low speed input is overruled.**

ⓘ   **The input must be configured through the PC software at commissioning.**

ⓘ   **One extra relay output must be available on the unit. Notice that this is option-dependent.**

ⓘ   **Turbo chargers not originally prepared for operating in the low speed area can be damaged if the genset is running in "idle run" for too long.**
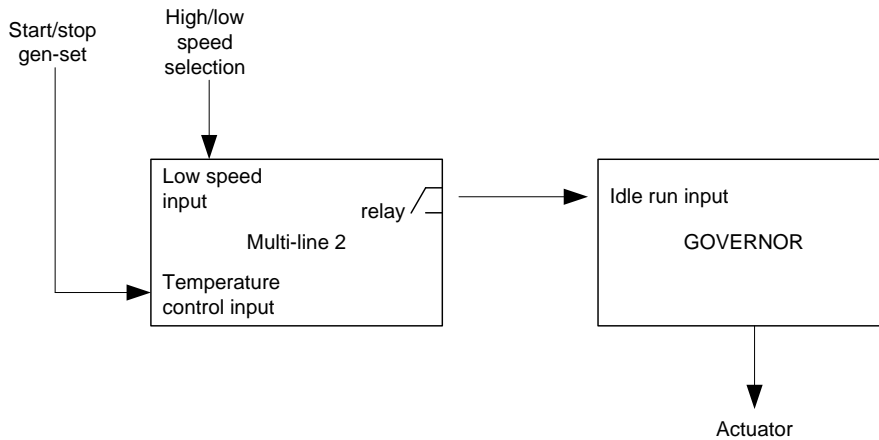
5.12.2 Examples

Idle speed during starting and stopping
In this example both the start and the stop timers are activated.

The start and stop sequences are changed in order to let the genset stay at the idle level before speeding up.
It also decreases the speed to the idle level for a specified delay time before stopping.
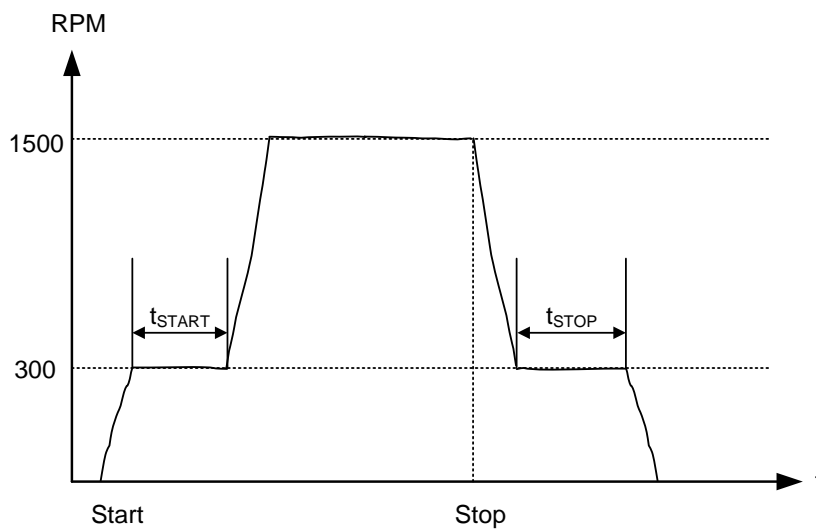
Idle speed, no stopping
In this example both timers are deactivated.

If the genset is to be prevented from stopping, then the digital input "temp control" must be left ON at all times. In that case the characteristic looks like this:
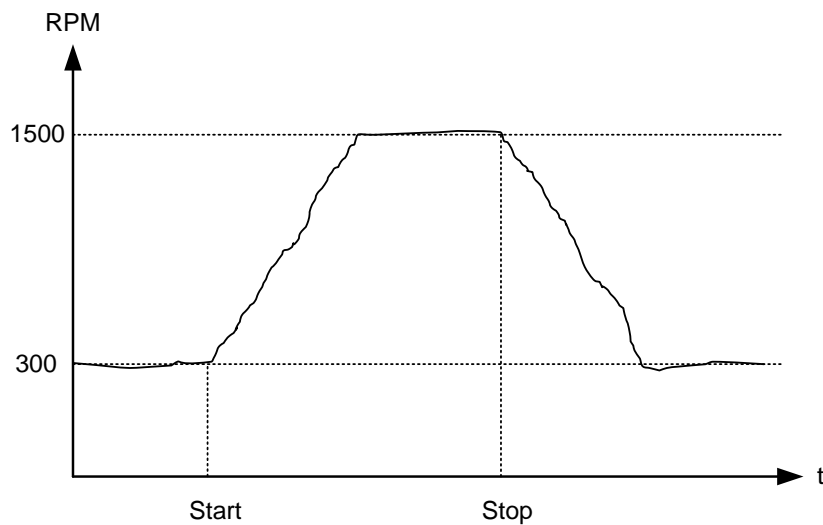
ⓘ **The oil pressure alarm (VDO oil) will be enabled during idle run if set to "ON".**

5.12.3 Configuration of digital input
The digital input is configured via the PC software.
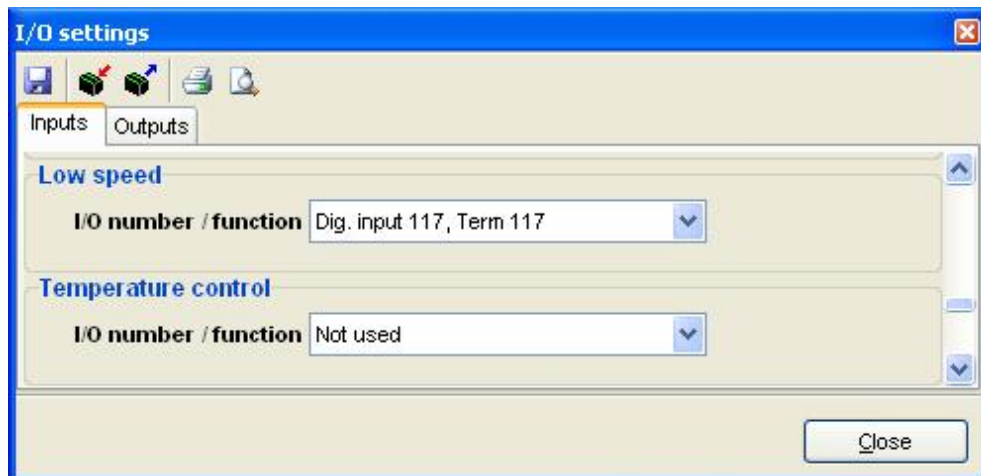
5.12.4 Inhibit
The alarms that are deactivated by the inhibit function are inhibited in the usual manner, except for the oil pressure alarms; VDO oil 102, 105 and 108 which are active during "idle run" as well.

5.12.5 Running signal
The running feedback must be activated when the genset is running in idle mode.

5.12.6 Idle speed flowcharts

The flowcharts illustrate the starting and stopping of the genset by use of the inputs "temp control" and "low speed".

5.12.7 Start

5.12.8 Stop

```
                              ┌─────────┐
                              │  Start  │
                              └─────────┘
```
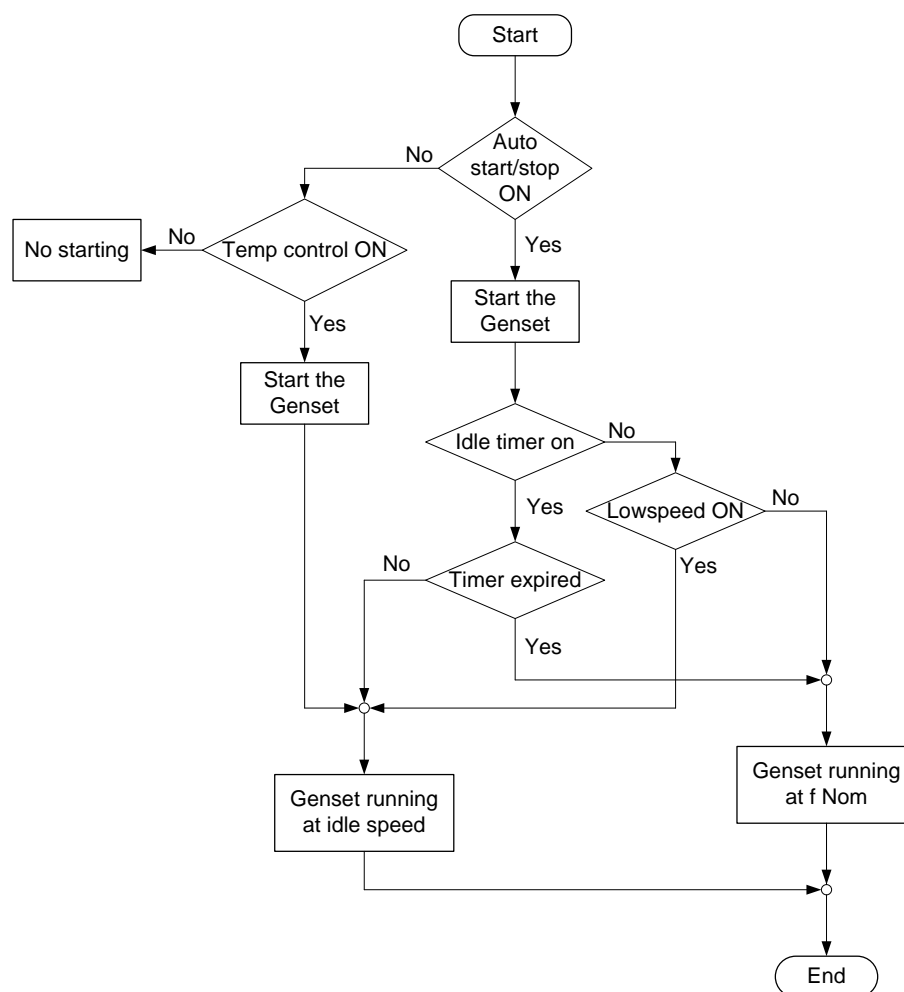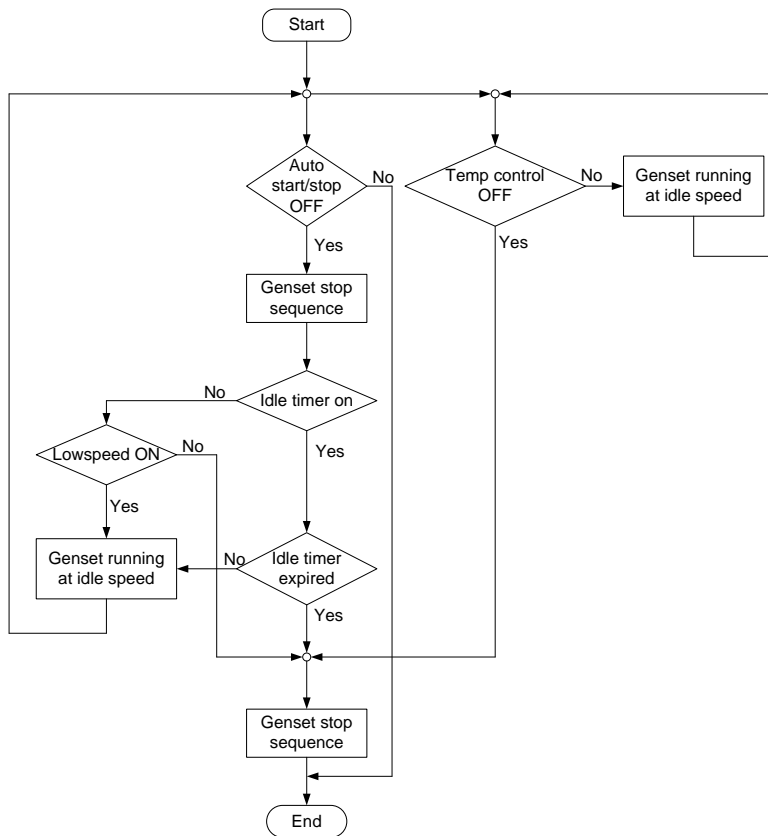

5.13 Engine heater

This function is used to control the temperature of the engine. A sensor measuring the cooling water tempera-ture is used to activate an external heating system to keep the engine at a minimum temperature.

The setpoints adjusted in menu 6320 are:

Setpoint: This setpoint +/- the hysteresis is the start and stop points for the engine heater.

Output A: The relay output for the engine heater.

Input type: Multi-input to be used for temperature measurement.

Hysteresis: This decides how big a deviation from the setpoint is needed to activate/deactivate the engine heater.

Enable: Enables the engine heater function.

Principle diagram:
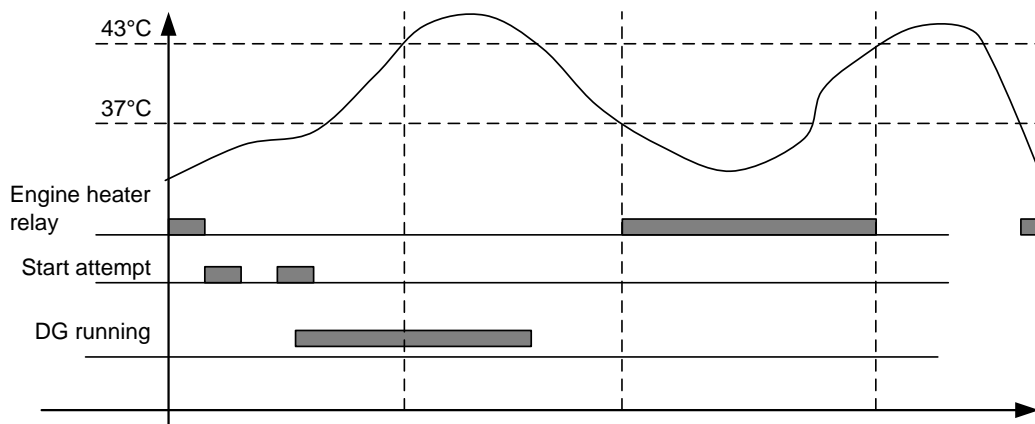
ℹ️ **The engine heater function is only active when the engine is stopped.**

5.13.1 Engine heater alarm

If the temperature keeps dropping after the start setpoint has been exceeded, an alarm will be raised if configured in menu 6330.

5.14 Master clock

The purpose of the master clock is to control the frequency of the genset in order to obtain the correct number of periods.

ℹ️ **This function can only be used if island operation is selected.**

In a 50 Hz system one period lasts 20 ms. If this changes, e.g. due to the dead band setting of the frequency controller, a difference will exist between the actual number of periods and the theoretical number of periods.

Equipment that works based on the zero crossings will be affected by the surplus or missing zero crossings. The most common example of such equipment is alarm clocks.

The unit's internal clock is a timekeeper which is included in the battery backed memory circuit. The timekeeper function works based on an oscillating crystal instead of zero crossings of the AC measurements. Due to the accuracy of the timekeeper, it is recommended to synchronise the clock on a regular basis, e.g. once every month.

Setting	Description	Comment
6401 Start	Start time.	The compensation period starts at the adjusted time.
6402 Stop	Stop time.	The compensation period stops at the adjusted time.
6403 Difference	The setpoint in seconds that initiates the compensation.	
6404 Compensation	Frequency difference when the compensation is initiated.	+/- value.
6405 Enable	Enables the function.	

If the power management option is selected (option G5), then the adjustment is made in the command unit.

The compensation frequency must be adjusted to a value higher than the dead band setting.

5.14.1 Compensation time

The time for the compensation can easily be calculated at a given adjustment of 6403 and 6404 (example):

- 6403 = 30 seconds
- 6404 = +/- 0.1 Hz

$$t_{TOTAL} = t_{SET} / (1 - f_{NOM} / f_{DIFF})$$
$$t_{TOTAL} = 30s / (1 - 50Hz / 50,1Hz)$$
$$t_{TOTAL} = 15030s \sim 4,1 hours$$

5.15 Battery test

This function gives the possibility to test the condition of the battery. The battery test can be initiated with a digital input and is available when the genset is in semi-auto and auto mode.

If a mains failure occurs during the battery test sequence, the test will automatically be interrupted, and the automatic mains failure start up sequence will be activated.

During the test, the battery voltage will decrease, and an alarm will occur if it drops to the setpoint.
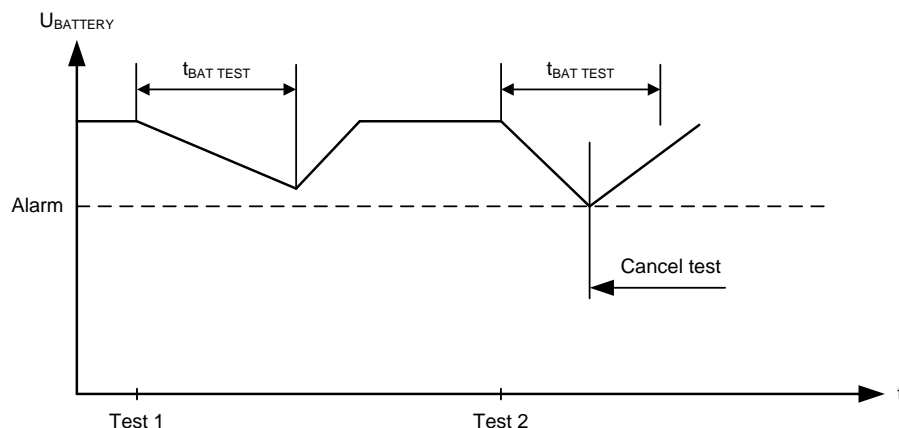
The drawing shows that test #1 is carried out without a large voltage drop of the battery voltage, whereas test #2 reaches the alarm setpoint.

As there is no reason to wear the battery down even more, the test stops when the battery test alarm occurs.

The test is typically used at periodical intervals, e.g. once every week. The engine must be at a standstill when the test is started. Otherwise, the test command will be ignored.

The stop relay will act depending on the coil type:

Stop coil: *The stop relay activates during the test.*
Run coil: *The stop relay stays deactivated during the test.*

The drawing below shows that when the test is started, the start relay activates making the engine turn.
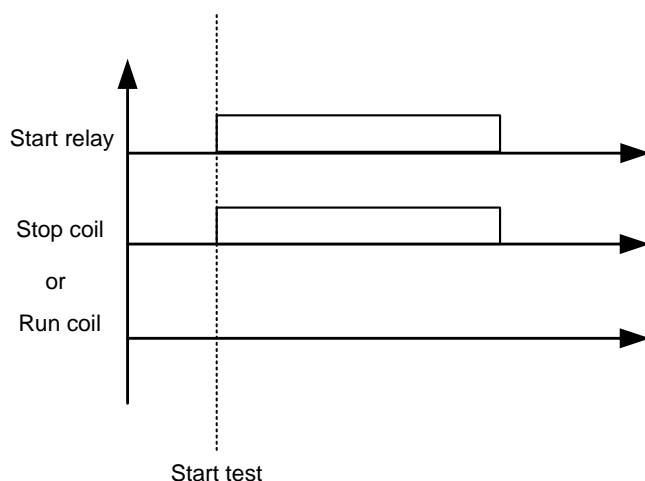
5.15.1 Input configuration
If this function is to be used, it is necessary to configure a digital input that initiates the function. This is done in the dialogue box below.
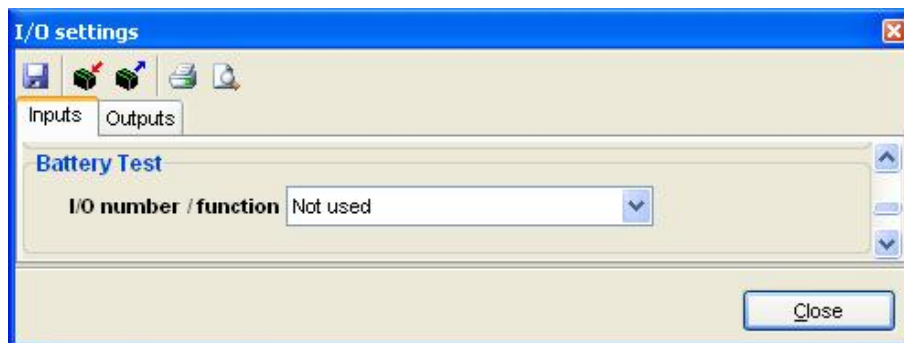
> **(i)** **If AUTO mode is selected, the mains failure sequence will be initiated if a mains failure occurs during the battery test.**

5.15.2 Auto configuration

If the automatic battery test is used, the function has to be enabled in menu 6420. When the function is enabled, the battery test will be carried out with a specified interval, e.g. once a week. Completed battery tests will be logged in a separate battery test log.

> **(i)** **The factory setting in menu 6424 is 52 weeks. This means that the automatic battery test will be executed once a year.**

> **(i)** **If application 3, 6 or 7 is used, it is expected that one of the multi-inputs is used for the battery test of the starter battery.**

> **(i)** **It is expected that the multi-inputs used for the battery test are configured to "0-40V DC".**

5.15.3 Battery asymmetry (6430 Batt. asymmetry)

The reason for making the battery asymmetry test is to determine if one of the batteries is getting weak. The battery asymmetry is a combination of measurements and calculations.

Setpoints available:

T1:   The input type to be used for calculation of battery asymmetry 1.
RF1:   Reference of asymmetry measurement no. 1.
T2:   The input type to be used for calculation of battery asymmetry 2.
RF2:   Reference of asymmetry measurement no. 2.

The following seven battery applications are supported. The shown applications are merely examples – the choice of multi-input (MI) or power supply input is configurable in menu 6410.

Application 1:

Start/Manoeuvre
battery

Application 2:

Start/Manoeuvre
battery

Application 3:

Manoeuvre battery   Start battery

Application 4:

Manoeuvre battery

Application 5:

Manoeuvre battery

Application 6:

Multi-line 2

MI 3
MI 2
MI 1
AUX

A   B C   E F D

- | + - | +
- | + - | +

- | + - | +
- | + - | +

Manoeuvre battery   Start battery

Application 7:

Multi-line 2

AUX
MI 2
MI 1   MI 3

A   E F   B C   D

- | +   - | +   - | + - | +
- | +   - | +   - | + - | +

Manoeuvre battery   Start battery
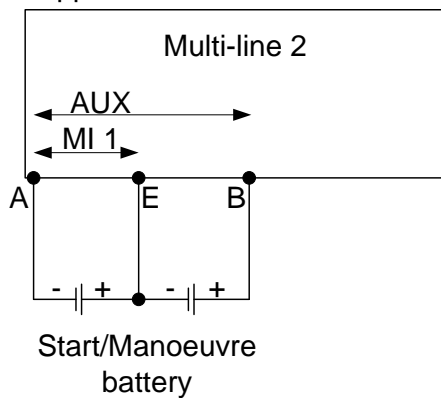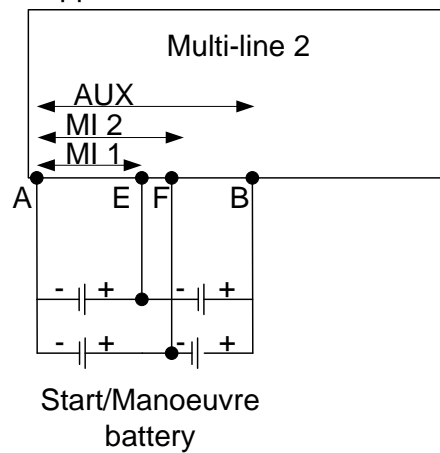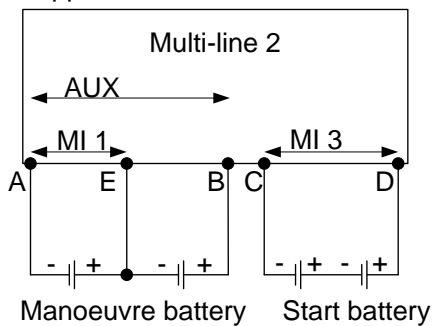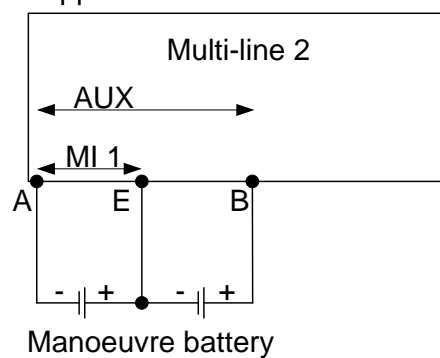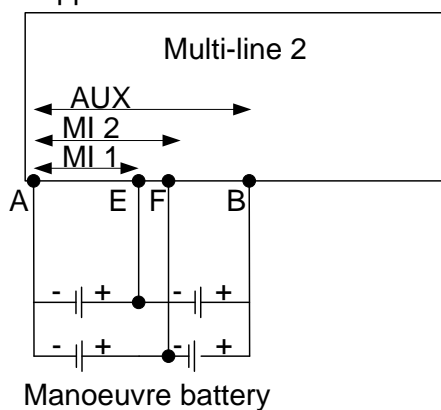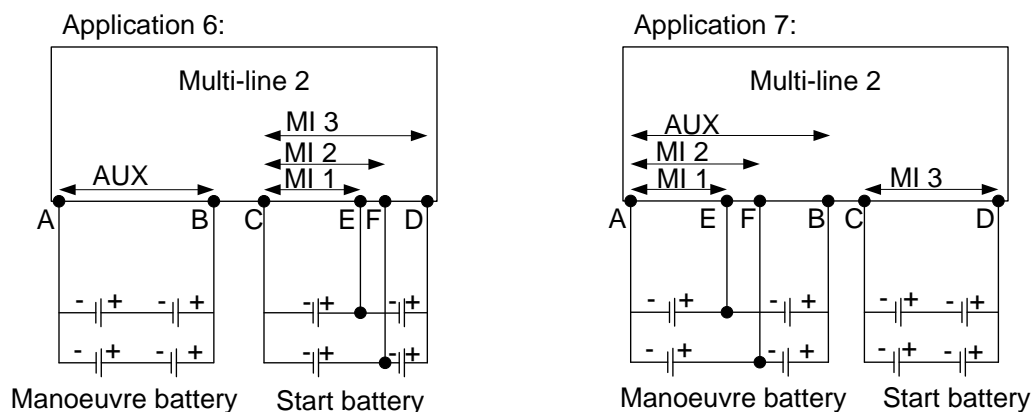
Looking at battery application 1 as an example:

Application 1:

Multi-line 2

AUX
MI 1

A   E   B

- | + - | +

Start/Manoeuvre
battery
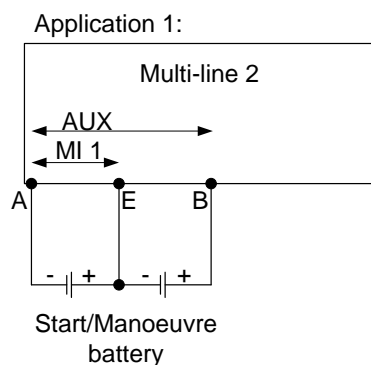
The power supply measurement is used as the reference RF1 (point A and B) in menu 6432 and multi-input 1 is used as the type T1 (point A and E) in menu 6431. By making these measurements it is possible to calculate the voltage between E and B. This gives a full picture of battery voltages, e.g.:

Measured value A/B (RF1) = 21V DC
Measured value A/E (T1) = 12V DC
Calculated value E/B (RF1 – T1) = 9V DC

Battery asymmetry = E/B – (RF1*1/2) = 9 – (21*1/2) = -1.5V DC

ⓘ **It is expected that the multi-inputs used for the battery asymmetry are configured to "0-40V DC".**

ⓘ **The selection power supply is referring to the supply on terminals 1 and 2.**

Battery asymmetry alarm
Alarms for battery asymmetry 1 and 2 are set up in menus 6440 and 6450.

(i) **The setpoint in menus 6440 and 6450 is only set in positive values, however, it will also trigger if the battery asymmetry calculation results in a negative value.**

5.16 Ventilation

This function can be used to control the cooling of the engine. The purpose is to use a multi-input for measuring the cooling water temperature and that way activate an external ventilation system to keep the engine below a maximum temperature. The functionality is shown in the below diagram.

Setpoints available **(6460 Max ventilation):**

Setpoint: The limit for activation of the relay set in OA.

Output A (OA):   The relay activated when the setpoint is exceeded.

Hysteresis: The number of degrees the temperature has to be below the setpoint in order to deactivate the relay set in OA.

Enable: Enable/disable the ventilation function.

(i) **The type of input to use for the temperature measurement is selected in menu 6323 Engine heater.**
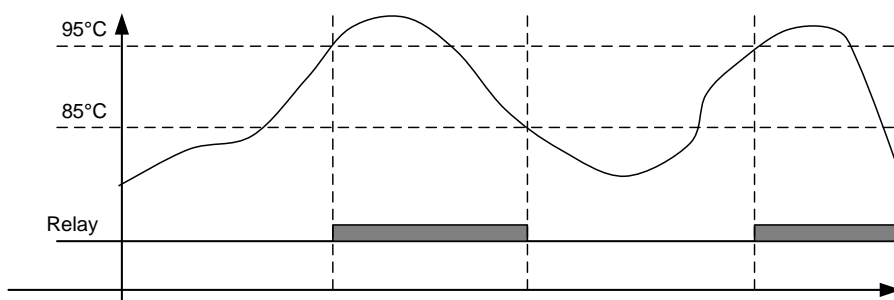
5.16.1 Max. ventilation alarm
Two alarms can be set up in menu 6470 and menu 6480 to activate if the temperature keeps rising after the start setpoint has been reached.

5.17 Summer/winter time

This function is used to make the AGC unit automatically adjust the clock in the unit according to summer and winter time. The function is enabled in menu 6490.

(i) **The function only supports the Danish rules.**

5.18 Switchboard error

The switchboard error function is handled in two different menus: 6500 "Block swbd error" and 6510 "Stop Swbd error". The functions are activated by using one configurable input (switchboard error) which is configured with the PC utility software

ⓘ **The functionality of the "switchboard error" input is active as soon as the input is configured. The "enable" in menus 6500 and 6510 only refers to the alarm function.**

5.18.1 Block swbd error (menu 6500)
When activated, this function will block the start sequence of the genset in case the genset is not running.

Setpoints available:

Delay: When the input is active, the alarm will be activated when this delay has expired.

Parallel: OFF: Only AMF start sequence is blocked when the input is active.
                ON: All start sequences, regardless of running mode, are blocked when the input is active.

Output A: Relay to activate when the delay has expired.

Output B: Relay to activate when the delay has expired.

Enable: Enable/disable the alarm function.

Fail class: The fail class of the alarm.

5.18.2 Stop swbd error (menu 6510)
When activated, this function will stop the genset if the genset is running in Auto mode.

Setpoints available:

Delay: When the input is active and the delay has expired, the genset will trip the breaker, cool
                down and stop. The function is active regardless of the "Enable" setting.

Output A: Relay to activate when the delay has expired.

Output B: Relay to activate when the delay has expired.

Enable: Enable/disable the alarm function.

Fail class: The fail class of the alarm.

5.19 Not in Auto

This function can be used for indication or to raise an alarm in case the system is not in Auto. The function is set up in menu 6540.

5.20 Fuel pump logic

The fuel pump logic is used to start and stop the fuel supply pump to maintain the fuel level in the service tank at predefined levels. The start and stop limits are detected from one of the three multi-inputs.

Setpoints available in menu 6550:

Setpoint 1:   Start level.

Setpoint 2:   Stop level.

Delay: If the fuel level has not increased by 2% within this delay, a *Fuel fill alarm* will be raised.

Output A (OA):   The relay to be used for control of the fuel pump. The selected relay activates below the start limit and deactivates above the stop level.

Type: The multi-input to be used for the fuel level sensor.

Fail class: The fail class of the *Fuel fill alarm*.

> (i) **The output relay should be configured as a limit relay, otherwise, an alarm will be raised whenever the output is activated.**

The below drawing shows how the fuel pump is activated when the level reaches 20% and stopped again when the level has reached 80%.

Fuel level

Fuel service tank level

80 %

20 %

Time

Fuel pump start level   Fuel pump stop level
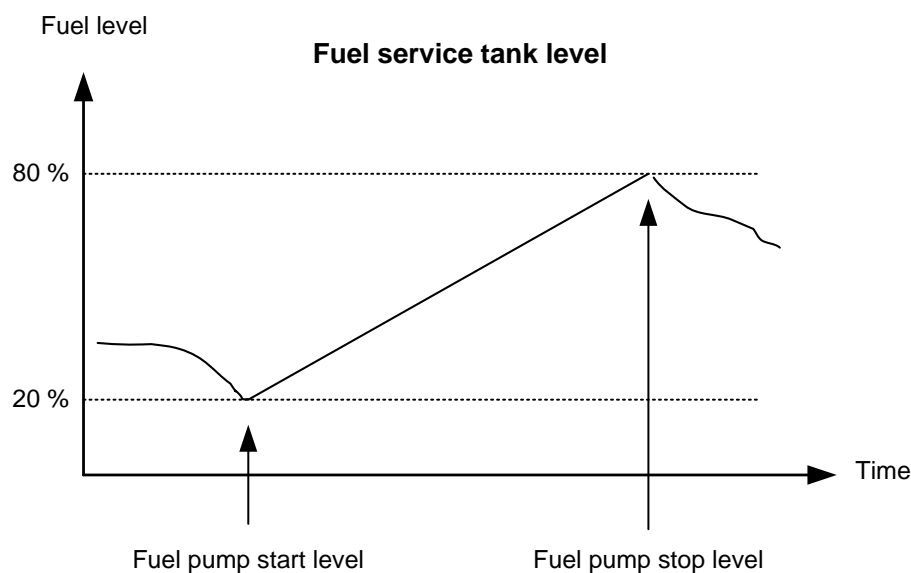
5.20.1 Fuel fill check
The fuel pump logic includes a *Fuel fill check* function.

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% within the adjusted delay time, then the fuel pump relay deactivates and a *Fuel fill alarm* occurs.
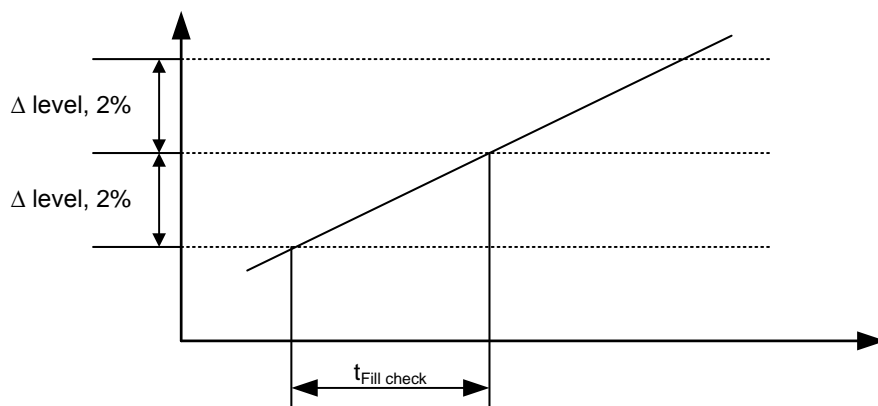
> ⓘ **The level of increase is fixed at 2% and cannot be changed.**

5.21 Fail class

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

Eight different fail classes can be used. The tables below illustrate the action of each fail class when the engine is running or stopped.

5.21.1 Engine running

Fail class	Action	Alarm horn re-lay	Alarm display	Deload	Trip of gen. breaker	Trip of mains breaker	Cooling-down genset	Stop genset
1 Block		X	X					
2 Warning		X	X					
3 Trip GB		X	X		X			
4 Trip + stop		X	X		X		X	X
5 Shutdown		X	X		X			X
6 Trip MB		X	X			X		
7 Safety stop		X	X	(X)	X		X	X
8 Trip MB/GB		X	X		(X)	X		

The table illustrates the action of the fail classes. If, for instance, an alarm has been configured with the "shut-down" fail class, the following actions occur.

- The alarm horn relay will activate
- The alarm will be displayed in the alarm info screen
- The generator breaker will open instantly
- The genset is stopped instantly
- The genset cannot be started from the unit (see next table)

ⓘ **The fail class "Safety stop" will only deload the genset before opening the breaker if option G4 or G5 (power management) is used. If power management is not active, the "Safety stop" will have the same function as "Trip and stop".**

ⓘ **The fail class "Trip MB/GB" will only trip the generator breaker if there is no mains breaker present.**

5.21.2 Engine stopped

Fail class	Action	Block engine start	Block MB sequence	Block GB sequence
1 Block		X		
2 Warning				
3 Trip GB		X		X
4 Trip + stop		X		X
5 Shutdown		X		X
6 Trip MB			X	
7 Safety stop		X		
8 Trip MB/GB		(X)	X	(X)

ⓘ **In addition to the actions defined by the fail classes, it is possible to activate one or two relay outputs if additional relays are available in the unit.**

ⓘ **The fail class "Trip MB/GB" will only block engine start and GB sequence if there is no mains breaker present.**

5.21.3 Fail class configuration
The fail class can be selected for each alarm function either via the display or the PC software.

To change the fail class via the PC software, the alarm function to be configured must be selected. Select the desired fail class in the fail class roll-down panel.
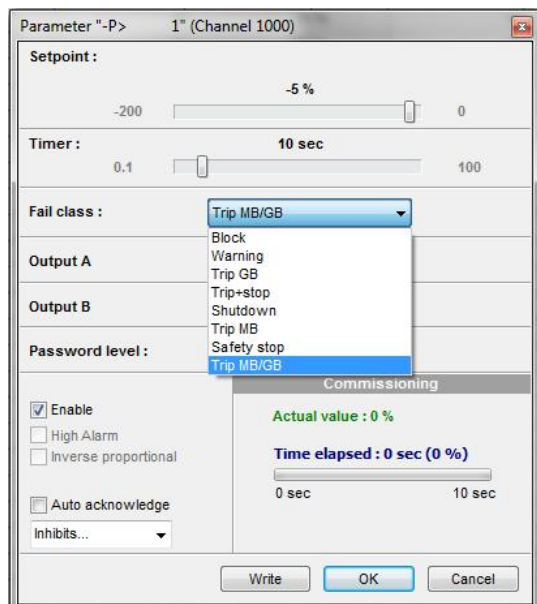
5.22 Trip of non-essential load (NEL)

ⓘ **The two terms "trip of non-essential load" and "load shedding" describe the same functionality.**

The trip of **N**on **E**ssential **L**oad (NEL) groups (load shedding) is carried out in order to protect the busbar against an imminent blackout situation due to either a high load/current or overload on a generator set or a low busbar frequency.

The unit is able to trip three NEL groups due to:

● the measured load of the generator set (high load and overload)
● the measured current of the generator set
● the measured frequency at the busbar

The load groups are tripped as three individual load groups. This means that the trip of load group no. 1 has no direct influence on the trip of load group no. 2. Only the measurement of either the busbar frequency or the load/current on the generator set is able to trip the load groups.

Trip of the NEL groups due to the load of a running generator set will reduce the load on the busbar and thus reduce the load percentage on the running generator set. This may prevent a possible blackout at the busbar caused by an overload on the running generator set. The current trip will be selected in case of inductive loads and unstable power factor (PF <0.7) where the current is increased.

Trip of the NEL groups due to a low busbar frequency will reduce the real power load at the busbar and thus reduce the load percentage on the generator set. This may prevent a possible blackout at the busbar.

(i) **For output setup, please refer to the description of outputs.**

5.23 Service timers

The unit is able to monitor the maintenance intervals. Two service timers are available to cover different intervals. The service timers are set up in menus 6110 and 6120.

The function is based on running hours. When the adjusted time expires, the unit will display an alarm. The running hours is counting when the running feedback is present.

Setpoints available in menus 6110 and 6120:

Enable:	Enable/disable the alarm function.
Running hours:	The number of running hours to activate the alarm. The service timer alarm will be activated as soon as the running hours have been reached.
Day:	The number of days to activate the alarm – if the running hours are not reached before this number of days, the alarm will still be activated. The service timer alarm will be activated at 8:00 AM on the day the alarm expires.
Fail class:	The fail class of the alarm.
Output A:	Relay to be activated when the alarm is activated.
Reset:	Enabling this will reset the service timer to zero. This must be done when the alarm is activated.

5.24 Wire fail detection

If it is necessary to supervise the sensors/wires connected to the multi-inputs and analogue inputs, then it is possible to 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 will be detected as if the wire has made a short circuit or a break. An alarm with a configurable fail class will be activated.

Input	Wire failure area	Normal range	Wire failure area
4-20 mA	< 3mA	4-20 mA	> 21 mA
0-40V DC	≤ 0V DC	-	N/A
VDO Oil, type 1	< 1.0 ohm	-	> 195.0 ohm
VDO Oil, type 2	< 1.0 ohm	-	> 195.0 ohm
VDO Temp, type 1	< 4.0 ohm	-	> 488.0 ohm
VDO Temp, type 2	< 4.0 ohm	-	> 488.0 ohm
VDO Temp, type 3	< 0.6 ohm	-	> 97.0 ohm
VDO Fuel, type 1	< 0.6 ohm	-	> 97.0 ohm
VDO Fuel, type 2	< 1.0 ohm	-	> 195.0 ohm
VDO configurable	< lowest resistance	-	> highest resistance
P100	< 82.3 ohm	-	> 194.1 ohm
P1000	< 823 ohm	-	> 1941 ohm
Level switch	Only active if the switch is open		

Principle
The illustration below shows that when the wire of the input breaks, the measured value will drop to zero. Then the alarm will occur.
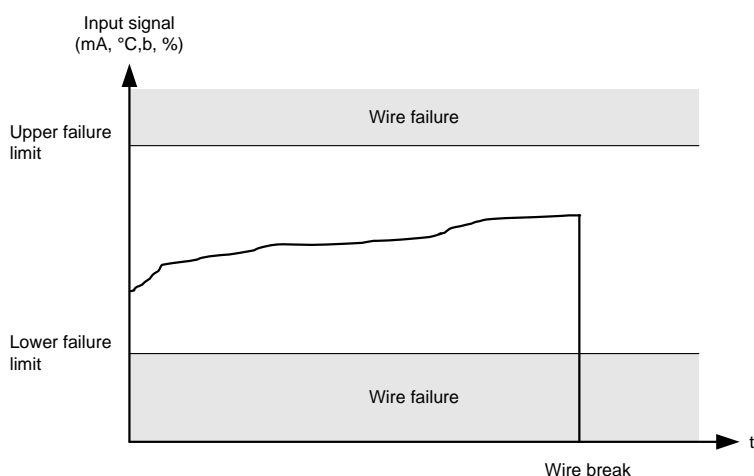
MPU wire break (menu 4550)
The MPU wire break function is only active when the genset is not running. In this case an alarm will be raised if the wire connection between the AGC and MPU breaks.

Stop coil wire break (menu 6270)
The alarm will occur when the stop coil is not activated (generator is running) and the input is de-energised.

5.25 Digital inputs

The unit has a number of binary inputs some of which are configurable and some are not.

Engine interface card	Available digital inputs – not configurable	Available digital inputs– configurable
M4 (standard)	1	6

	Input function	Auto	Semi	Test	Man	Block	Configurable	Input type
1	Shutdown override	X	X	X	X	X	Configurable	Constant
2	Access lock	X	X	X	X	X	Configurable	Constant
3	Running feedback	X	X	X	X	X	Configurable	Constant
4	Remote start		X		X		Configurable	Pulse
5	Remote stop		X		X		Configurable	Pulse
6	Semi-auto	X		X	X	X	Configurable	Pulse
7	Test	X	X		X	X	Configurable	Pulse
8	Auto		X	X	X	X	Configurable	Pulse
9	Manual		X	X		X	Configurable	Pulse
10	Block	X	X	X	X		Configurable	Constant
11	Remote GB ON		X				Configurable	Pulse
12	Remote GB OFF		X				Configurable	Pulse
13	Remote MB ON		X				Configurable	Pulse
14	Remote MB OFF		X				Configurable	Pulse
15	Remote alarm acknowledge	X	X	X	X	X	Configurable	Constant
16	Auto start/stop	X					Configurable	Constant
17	Remove starter	X	X	X	X		Configurable	Constant
18	Reset analogue GOV/AVR outputs	X	X	X	X	X	Configurable	Pulse
19	Manual GOV up	X	X	X	X		Configurable	Constant
20	Manual GOV down	X	X	X	X		Configurable	Constant
21	Manual AVR up	X	X	X	X		Configurable	Constant
22	Manual AVR down	X	X	X	X		Configurable	Constant
23	GB position ON	X	X	X	X	X	Not configurable	Constant
24	GB position OFF	X	X	X	X	X	Not configurable	Constant
25	MB position ON	X	X	X	X	X	Not configurable	Constant
26	MB position OFF	X	X	X	X	X	Not configurable	Constant
27	Emergency stop	X	X	X	X	X	Not configurable	Constant
28	Low speed	X	X	X			Configurable	Constant
29	Temperature control	X	X	X			Configurable	Constant
30	Battery test	X	X				Configurable	Pulse

	Input function	Auto	Semi	Test	Man	Block	Configurable	Input type
31	Mains OK	X	X	X	X	X	Configurable	Pulse
32	External f control	X	X	X			Configurable	Constant
33	External P control	X	X	X			Configurable	Constant
34	External PF control	X	X	X			Configurable	Constant
35	External U control	X	X	X			Configurable	Constant
36	External Q power	X	X	X			Configurable	Constant
37	Print status	X	X	X	X	X	Configurable	Pulse
38	Print event log	X	X	X	X	X	Configurable	Pulse
39	MB close inhibit	X	X	X	X	X	Configurable	Constant
40	Enable mode shift	X	X	X	X	X	Configurable	Constant
41	Enable GB black close	X	X	X	X	X	Configurable	Constant
42	Enable sep. sync.	X	X	X	X	X	Configurable	Constant
43	Start enable	X	X	X	X		Configurable	Constant
44	Alternative start	X	X	X	X	X	Configurable	Constant
45	Switchboard error	X	X	X	X	X	Configurable	Constant
46	Total test	X	X	X	X	X	Configurable	Constant
47	GB spring loaded	X	X	X	X	X	Configurable	Constant
48	MB spring loaded	X	X	X	X	X	Configurable	Constant
49	1st priority mains	X	X	X	X	X	Configurable	Constant
50	Ext. MB pos. OFF	X	X	X	X	X	Configurable	Constant
51	Heavy consumer 1 request	X	X	X	X	X	Configurable	Constant
52	Heavy consumer 2 request	X	X	X	X	X	Configurable	Constant
53	Deload	X					Configurable	Constant
54	GB OFF and BLOCK		X				Configurable	Pulse
55	HC 1 fixed load feedback	X	X	X	X	X	Configurable	Constant
56	HC 2 fixed load feedback	X	X	X	X	X	Configurable	Constant
57	Secured ON	X	X	X	X	X	Configurable	Pulse
58	Secured OFF	X	X	X	X	X	Configurable	Pulse
59	Base load		X				Configurable	Constant

5.25.1 Functional description

1. Shutdown override

This input deactivates all protections except the overspeed protection and the emergency stop input. The number of start attempts is seven by default, but it can be configured in **6180 Start**. Also a special cool down timer is used in the stop sequence after an activation of this input.

2. Access lock

Activating the access lock input deactivates the control display push-buttons. It will only be possible to view measurements, alarms and the log.

3. Running feedback
The input is used as a running indication of the engine. When the input is activated, the start relay is deactivated.

4. Remote start
This input initiates the start sequence of the genset when semi-auto or manual mode is selected.

5. Remote stop
This input initiates the stop sequence of the genset when semi-auto or manual mode is selected. The genset will stop without cooling down.

6. Semi-auto
Changes the present running mode to semi-auto.

7. Test
Changes the present running mode to test.

8. Auto
Changes the present running mode to auto.

9. Manual
Changes the present running mode to manual.

10. Block
Changes the present running mode to block.

(i) **When block mode is selected, the running mode cannot be changed by activating the digital inputs.**

11. Remote GB ON
The generator breaker ON sequence will be initiated and the breaker will synchronise if the mains breaker is closed, or close without synchronising if the mains breaker is opened.

12. Remote GB OFF
The generator breaker OFF sequence will be initiated. If the mains breaker is opened, then the generator breaker will open instantly. If the mains breaker is closed, the generator load will be deloaded to the breaker open limit followed by a breaker opening.

13. Remote MB ON
The mains breaker ON sequence will be initiated and the breaker will synchronise if the generator breaker is closed, or close without synchronising if the generator breaker is opened.

14. Remote MB OFF
The mains breaker OFF sequence will be initiated, and the breaker will open instantly.

15. Remote alarm acknowledge
Acknowledges all present alarms, and the alarm LED on the display stops flashing.

16. Auto start/stop
The genset will start when this input is activated. The genset will be stopped if the input is deactivated. The input can be used when the unit is in island operation, fixed power, load takeover or mains power export and the AUTO running mode is selected.

17. Remove starter
The start sequence is deactivated. This means the start relay deactivates, and the starter motor will disengage.

18. Reset analogue GOV/AVR outputs
The analogue +/-20 mA controller outputs will be reset to 0 mA.

(i) **All analogue controller outputs are reset. That is the governor output and the AVR output if option D1 is selected.**

If an offset has been adjusted in the control setup, then the reset position will be the specific adjustment.

19. Manual GOV up
If manual mode is selected, then the governor output will be increased.

20. Manual GOV down
If manual mode is selected, then the governor output will be decreased.

21. Manual AVR up
If manual mode is selected, then the AVR output will be increased.

22. Manual AVR down
If manual mode is selected, then the AVR output will be decreased.

(i) **The manual governor and AVR increase and decrease inputs can only be used in manual mode.**

23. Generator breaker closed feedback (GB position ON)
The input function is used as an indication of the generator breaker position. The unit requires this feedback when the breaker is closed or a position failure alarm occurs.

24. Generator breaker open feedback (GB position OFF)
The input function is used as an indication of the generator breaker position. The unit requires this feedback when the breaker is opened or a position failure alarm occurs.

25. Mains breaker closed feedback (MB position ON)
The input function is used as an indication of the mains breaker position. The unit requires this feedback when the breaker is closed or a position failure alarm occurs.

26. Mains breaker open feedback (MB position OFF)
The input function is used as an indication of the mains breaker position. The unit requires this feedback when the breaker is opened or a position failure alarm occurs.

27. Emergency stop
The input shuts down the engine immediately. At the same time it opens the generator breaker.

(i) **The shutdown fail class must be selected.**

28. Low speed
Disables the regulators and keeps the genset running at a low RPM.

ⓘ **The governor must be prepared for this function.**

29. Temperature control
This input is part of the idle mode function. When the input is high, then the genset starts. It starts at high or low speed, depending on the activation of the low speed input. When the input is deactivated, then the genset goes to idle mode (low speed = ON), or it stops (low speed = OFF).

30. Battery test
Activates the starter without starting the genset. If the battery is weak, the test will cause the battery voltage to drop more than acceptable, and an alarm will occur.

31. Mains OK
Disables the "mains OK delay" timer. The synchronisation of the mains breaker will happen when the input is activated.

32. External frequency control
The nominal frequency setpoint will be controlled from the analogue inputs terminal 40/41. The internal setpoint will not be used.

33. External power control
The power setpoint in fixed power will be controlled from the analogue inputs terminal 40/41. The internal setpoint will not be used.

34. External power factor control
The power factor setpoint will be controlled from the analogue inputs terminal 41/42. The internal setpoint will not be used.

35. External voltage control
The nominal voltage setpoint will be controlled from the analogue inputs terminal 41/42. The internal setpoint will not be used.

36. External reactive power
The reactive power setpoint will be controlled from the analogue inputs terminal 41/42. The internal setpoint will not be used.

37. Print status
When this input is activated, the current running status of the system will be printed.

ⓘ **Please refer to the description of option P1.**

38. Print event log
When this input is activated, the latest events will be printed. The number of events and possible additional data can be selected in the system setup.

ⓘ **Please refer to the description of option P1.**

39. MB close inhibit
When this input is activated, then the mains breaker cannot close.

40. Enable mode shift
The input activates the mode shift function, and the AGC will perform the AMF sequence in case of a mains failure. When the input is configured, the setting in menu 7081 (mode shift ON/OFF) is disregarded.

41. Enable GB black close
When the input is activated, the AGC is allowed to close the generator on a black busbar, providing that the frequency and voltage are inside the limits set up in menu 2110.

42. Enable separate sync.
Activating this input will split the breaker close and breaker synchronisation functions into two different relays. The breaker close function will remain on the relays dedicated for breaker control. The synchronisation function will be moved to a configurable relay dependent on the options configuration.

(i)   This function is option-dependent. Option M12 or M14.x is required.

43. Start enable
The input must be activated to be able to start the engine.

(i)   When the genset is started, the input can be removed.

44. 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.

45. Switchboard error
The input will stop or block the genset depending on running status.

46. Total test
This input will be logged in the event log to indicate that a planned mains failure has been made.

47. GB spring loaded
The AGC will not send a close signal before this feedback is present.

48. MB spring loaded
The AGC will not send a close signal before this feedback is present.

49. 1st priority mains
This input is used in G5 applications with two mains connections to select which mains connection has 1st priority.

50. Ext. MB pos. OFF
This input is used in G5 applications with two mains connections to tell the AGC mains units that the mains breaker not controlled by them has been tripped.

51. Heavy consumer 1 request
This input is used in G5 applications with two generators or more to request heavy consumer 1 to start.

52. Heavy consumer 2 request
This input is used in G5 applications with two generators or more to request heavy consumer 2 to start.

53. Deload
A running genset will start to ramp down the power.

54. GB OFF and BLOCK
The generator breaker will open, the genset will activate the stop sequence and when the genset is stopped, it will be blocked for start.

55. HC 1 fixed load feedback
HC 1 is running and consuming 100% power.

56. HC 2 fixed load feedback
HC 2 is running and consuming 100% power.

57. Secured mode ON
Secured mode adds an extra generator to the system, i.e. one generator too many will be running when comparing with the actual power requirement.

58. Secured mode OFF
Ends secured running mode (see 57).

59. Base load
The generator set will run base load (fixed power) and not participate in frequency control. Should the plant power requirement drop, the base load will be lowered so the other generator(s) on line produces at least 10% power.

ⓘ   **The input functions are set up with the PC utility software, please refer to "Help" in this.**

5.26 Outputs

The unit has a number of output functions which can be configured to any available relay.

	Output function	Auto	Semi	Test	Man	Block	Configurable	Output type
1	HC 1 ack.	X					Configurable	Pulse
2	HC 2 ack.	X					Configurable	Pulse
3	Trip NEL 1	X	X	X	X	X	Configurable	Pulse
4	Trip NEL 2	X	X	X	X	X	Configurable	Pulse
5	Trip NEL 3	X	X	X	X	X	Configurable	Pulse

5.26.1 Functional description
1. HC 1 ack.
This output is used in G5 applications with two or more generators to acknowledge the heavy consumer requested.

2. HC 2 ack.
This output is used in G5 applications with two or more generators to acknowledge the heavy consumer requested.

ⓘ   **Please refer to the option G4/G5/G8 manual for reference.**

3. Trip NEL 1
This output is used to trip load groups.

4. Trip NEL 2
This output is used to trip load groups.

5. Trip NEL 3
This output is used to trip load groups.

ⓘ   **Please refer to the description of NEL.**

5.27 Multi-inputs

The AGC unit has three multi-inputs which can be configured to be used as the following input types:

1. 4-20 mA
2. 0-40V DC
3. Pt100
4. Pt1000
5. VDO oil
6. VDO water
7. VDO fuel
8. Digital

ⓘ   **The function of the multi-inputs can only be configured in the PC utility software.**

For each input two alarm levels are available, the menu numbers of the alarm settings for each multi-input is controlled by the configured input type as seen in the following table.

Input type	Multi-input 102	Multi-input 105	Multi-input 108
4-20 mA	4120/4130	4250/4260	4380/4390
0-40V DC	4140/4150	4270/4280	4400/4410
Pt100/Pt1000	4160/4170	4290/4300	4420/4430
VDO oil	4180/4190	4310/4320	4440/4450
VDO water	4200/4210	4330/4340	4460/4470
VDO fuel	4220/4230	4350/4360	4480/4490
Digital	3400	3410	3420

ⓘ   **Only one alarm level is available for the digital input type.**

5.27.1 4-20 mA

If one of the multi-inputs has been configured as 4-20 mA, the unit and range of the measured value corresponding to 4-20 mA can be changed in the PC utility software in order to get the correct reading in the display.

5.27.2 0-40V DC

The 0-40V DC input has primarily been designed to handle the battery asymmetry test.

5.27.3 Pt100/1000

This input type can be used for heat sensor, e.g. cooling water temp. The unit of the measured value can be changed from Celsius to Fahrenheit in the PC utility software in order to get the desired reading in the display.

5.27.4 VDO inputs

The unit can contain up to three VDO inputs. The inputs have different functions, as the hardware design allows for several VDO types.

These various types of VDO inputs are available for all multi-inputs:

VDO oil:	Oil pressure
VDO water:	Cooling water temperature
VDO fuel:	Fuel level sensor

For each type of VDO input it is possible to select between different characteristics including a configurable.

5.27.5 VDO oil
This VDO input is used for measuring the lubricating oil pressure.

Pressure		VDO sensor type		
		Type 1	Type 2	Type 3
Bar	psi	Ω	Ω	Ω
0	0	10.0	10.0	
0.5	7	27.2		
1.0	15	44.9	31.3	
1.5	22	62.9		
2.0	29	81.0	51.5	
2.5	36	99.2		
3.0	44	117.1	71.0	
3.5	51	134.7		
4.0	58	151.9	89.6	
4.5	65	168.3		
5.0	73	184.0	107.3	
6.0	87		124.3	
7.0	102		140.4	
8.0	116		155.7	
9.0	131		170.2	
10.0	145		184.0	

The configurable type is configurable with eight points in the range 0-480 Ω. The resistance as well as the pressure can be adjusted.

If the VDO input is used as a level switch, then be aware that no voltage must be connected to the input. If any voltage is applied to the VDO inputs, it will be damaged. Please refer to the Application Notes for further wiring information.

5.27.6 VDO water

This VDO input is used for measuring the cooling water temperature.

| Temperature | | VDO sensor type | | | |
| | | Type 1 | Type 2 | Type 3 | Type 4 |
°C	°F	Ω	Ω	Ω	Ω
40	104	291.5	480.7	69.3	
50	122	197.3	323.6		
60	140	134.0	222.5	36.0	
70	158	97.1	157.1		
80	176	70.1	113.2	19.8	
90	194	51.2	83.2		
100	212	38.5	62.4	11.7	
110	230	29.1	47.6		
120	248	22.4	36.8	7.4	
130	266		28.9		
140	284		22.8		
150	302		18.2		

ⓘ **The configurable type is configurable with eight points in the range 0-480 Ω. The temperature as well as the resistance can be adjusted.**

ⓘ **If the VDO input is used as a level switch, then be aware that no voltage must be connected to the input. If any voltage is applied to the VDO inputs, it will be damaged. Please refer to the Application Notes for further wiring information.**

5.27.7 VDO fuel

This VDO input is used for the fuel level sensor.

| VDO sensor type | |
| Type 1 | |
Value	Resistance
0%	78.8 Ω
100%	1.6 Ω

| VDO sensor type | |
| Type 2 | |
Value	Resistance
0%	3 Ω
100%	180 Ω

ⓘ **If the VDO input is used as a level switch, then be aware that no voltage must be connected to the input. If any voltage is applied to the VDO inputs, it will be damaged. Please refer to the Application Notes for further wiring information.**

	VDO sensor type	
Value	**Type configurable**	
%	**Resistance**	
0		
10		
20		
30		
40		
50		
60		
70		
80		
90		
100		

ⓘ **The configurable type is configurable with eight points in the range 0-480 Ω. The value as well as the resistance can be adjusted.**

5.27.8 Illustration of configurable inputs
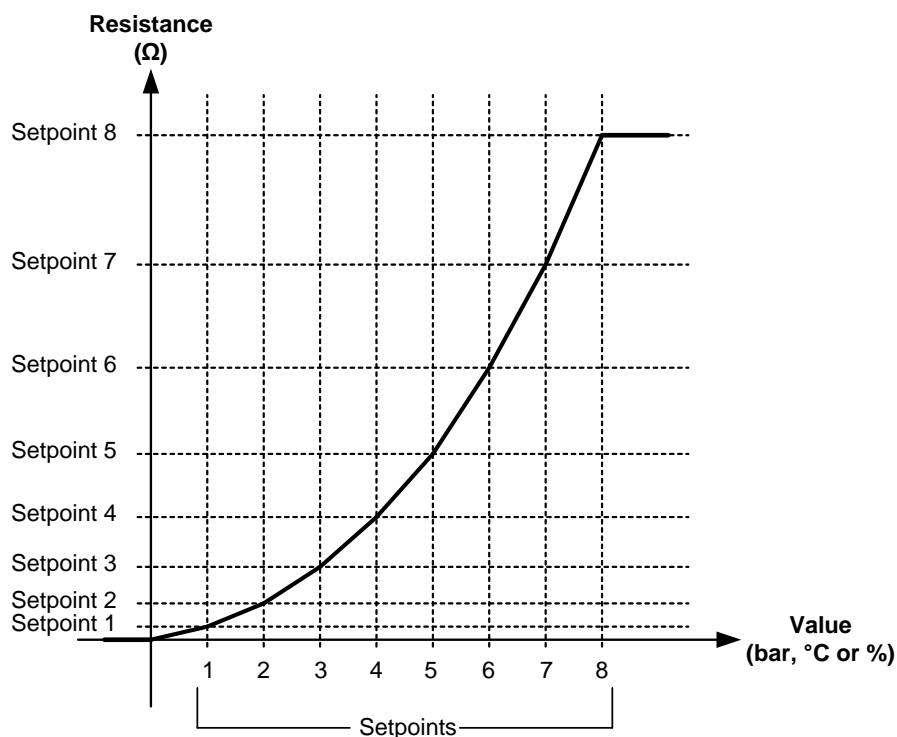
5.27.9 Configuration
The eight curve settings for the configurable VDO inputs cannot be changed in the display, but **only** in the PC utility software. The alarm settings can be changed both in the display and in the PC utility software. In the PC utility software the configurable inputs are adjusted in this dialogue box:

Adjust the resistance of the VDO sensor at the specific measuring value. In the example above the adjustment is 10 Ω at 0.0 bar.

5.27.10 Digital

If the multi-inputs are configured to "Digital", they become available as a configurable input.

5.28 Manual governor and AVR control

This function can be activated by pressing ▽ more than two seconds, or by activating the digital inputs or AOP buttons for governor or AVR control in semi-auto mode. The intention of this function is to give the commissioning engineer a helpful tool for adjustment of the regulation.

The function of the regulation window depends on the selected mode:

```
G         0         0         0V
P-Q Setp      100%      100%
P-Q Reg.       50%       60%
                   GOV        AVR
```

5.28.1 Manual mode

In manual mode the regulation is deactivated. When activating the up or down arrows, the output value to GOV or AVR is changed, this is the Reg. value in the display. The up and down arrows have the same function as the digital inputs or AOP buttons for governor and AVR control when the window is open. To exit the regulation window press "back".

5.28.2 Semi-auto mode

As in manual mode, the up and down arrows have the same function as the digital inputs or AOP buttons for governor or AVR control when the window is open.

The value Setp can be changed by pressing the arrow up or down. When GOV is underlined, the governor setpoint will be changed, and vice versa when the AVR is underlined. When changing the Setp value, an offset will be added to or subtracted from the nominal value. The Reg. value is the output value from the regulator. If the genset is running in parallel, the active or reactive nominal power setpoint value will be changed. If it is a stand-alone genset not parallel to the mains, the nominal frequency or voltage setpoint will be changed and also displayed. When the "back" button is activated, the regulation setpoint returns to nominal.

(i)   If the digital inputs or AOP buttons are activated in semi-auto, the regulation window is automatically opened.

5.28.3 Auto and test mode

Like semi-auto, except from the fact that activating the digital inputs or AOP buttons for governor or AVR control will change the regulation setpoint but not open the regulation window. When the digital inputs or AOP buttons are deactivated, the regulation setpoint returns to nominal.

(i)   AVR setpoint manipulation requires option D1.

(i)   Regarding AOP setup, please refer to "Help" in the PC utility software.

5.29 Input function selection

Digital input alarms can be configured with a possibility to select when the alarms are to be activated. The possible selections of the input function are normally open or normally closed.

The drawing below illustrates a digital input used as an alarm input.

1. Digital input alarm configured to NC, normally closed
   This will initiate an alarm when the signal on the digital input disappears.
2. Digital input alarm configured to NO, normally open
   This will initiate an alarm when the signal on the digital input appears.

(i)   The relay output function can be selected to be ND (Normally Deenergised), NE (Normally Energised), Limit or Horn.
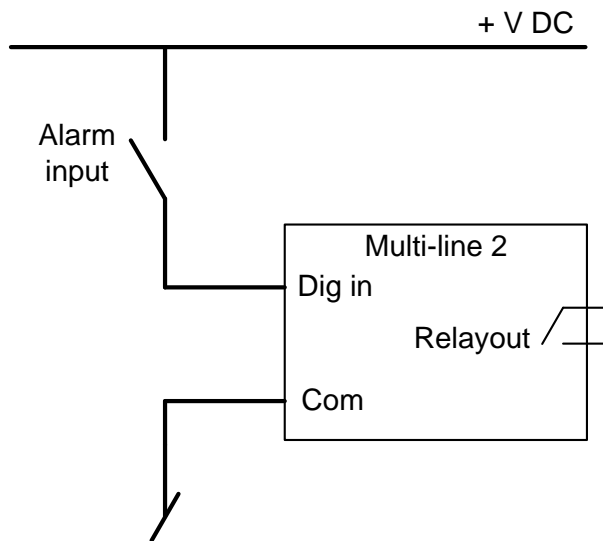
5.30 Language selection

The unit has the possibility to display different languages. It is delivered with one master language which is English. This is the default language, and it cannot be changed. In addition to the master language 11 different languages can be configured. This is done via the PC utility software.

The languages are selected in the system setup **menu 6080**. The language can be changed when connected to the PC utility software. It is not possible to make language configuration from the display, but the already configured languages can be selected.

5.31 Texts in status line

The status texts must be self-explanatory. If the operator does something wrong, then the status line must indicate it. The table below indicates the texts in the status line.

5.31.1 Standard texts

Status text	Condition	Comment
BLOCK	Block mode is activated	
SIMPLE TEST	Test mode is activated	
LOAD TEST		
FULL TEST		
SIMPLE TEST ###.#min	Test mode activated and test timer counting down	
LOAD TEST ###.#min		
FULL TEST ###.#min		
ISLAND MAN	Genset stopped or running and no other action taking place	
ISLAND SEMI		
READY ISLAND AUTO	Genset stopped in Auto	
ISLAND ACTIVE	Genset running in Auto	
AMF MAN	Genset stopped or running and no other action taking place	
AMF SEMI		
READY AMF AUTO	Genset stopped in Auto	
AMF ACTIVE	Genset running in Auto	
FIXED POWER MAN	Genset stopped or running and no other action taking place	
FIXED POWER SEMI		
READY FIXED P AUTO	Genset stopped in Auto	
FIXED POWER ACTIVE	Genset running in Auto	
PEAK SHAVING MAN	Genset stopped or running and no other action taking place	
PEAK SHAVING SEMI		
READY PEAK SHAV AUTO	Genset stopped in Auto	
PEAK SHAVING ACTIVE	Genset running in Auto	
LOAD TAKEOVER MAN	Genset stopped or running and no other action taking place	
LOAD TAKEOVER SEMI		
READY LTO AUTO	Genset stopped in Auto	
LTO ACTIVE	Genset running in Auto	
MAINS P EXPORT MAN	Genset stopped or running and no other action taking place	
MAINS P EXPORT SEMI		
READY MPE AUTO	Genset stopped in Auto	
MPE ACTIVE	Genset running in Mains power export mode	
DG BLOCKED FOR START	Generator stopped and active alarm(s) on the generator	
GB ON BLOCKED	Generator running, GB open and an active "Trip GB" alarm	
SHUTDOWN OVERRIDE	The configurable input is active	

Status text	Condition	Comment
ACCESS LOCK	The configurable input is activated, and the operator tries to activate one of the blocked keys	
GB TRIP EXTERNALLY	Some external equipment has tripped the breaker	An external trip is logged in the event log
MB TRIP EXTERNALLY	Some external equipment has tripped the breaker	An external trip is logged in the event log
IDLE RUN	The "Idle run" function is active. The genset will not stop until a timer has expired	
IDLE RUN ###.#min	The timer in the "Idle run"' function is active	
COMPENSATION FREQ.	Compensation is active	The frequency is not at the nominal setting
Aux. test ##.#V ####s	Battery test activated	
DELOAD	Decreasing the load of the genset in order to open the breaker	
START DG(s) IN ###s	The start genset setpoint is exceeded	
STOP DG(s) IN ###s	The stop genset setpoint is exceeded	
START PREPARE	The start prepare relay is activated	
START RELAY ON	The start relay is activated	
START RELAY OFF	The start relay is deactivated during the start sequence	
MAINS FAILURE	Mains failure and mains failure timer expired	
MAINS FAILURE IN ###s	Frequency or voltage measurement is outside the limits	The timer shown is the Mains failure delay.Text in mains units
MIANS U OK DEL ####s	Mains voltage is OK after a mains failure	The timer shown is the Mains OK delay
MAINS f OK DEL ####s	Mains frequency is OK after a mains failure	The timer shown is the Mains OK delay
Hz/V OK IN ###s	The voltage and frequency on the genset is OK	When the timer runs out it is allowed to operate the generator breaker
COOLING DOWN ###s	Cooling down period is activated	
COOLING DOWN	Cooling down period is activated and infinite	Cooling down timer is set to 0.0 s

Status text	Condition	Comment
GENSET STOPPING	This info is shown when cooling down has finished	
EXT. STOP TIME ###s		
PROGRAMMING LAN-GUAGE	This info is shown if the language file is downloaded from the PC utility software	
TOO SLOW 00<------------	Generator running too slow during synchronising	
----------> 00 TOO FAST	Generator running too fast during synchronising	
EXT. START ORDER	A planned AMF sequence is activated	There is no failure on the mains during this sequence
QUICK SETUP ERROR	Quick setup of the application failed	
MOUNT CAN CONNECTOR	Connect the power management CAN line	
ADAPT IN PROGRESS	The AGC is receiving the application that it has just been connected to	
SETUP IN PROGRESS	The new AGC is being added to the existing application	
SETUP COMPLETED	Successful update of the application in all AGC units	
REMOVE CAN CONNEC-TOR	Remove the power management CAN lines	
RAMP TO #####kW	The power ramp is ramping in steps, and the next step that will be reached after the timer has expired will be displayed	
DERATED TO #####kW	Displays the ramp down setpoint	

5.31.2 Texts only related to power management (option G5)

Status text	Condition	Comment
DG unit		
BLACKOUT ENABLE	This info is shown if a CAN failure is present in a power management application.	
UNIT STANDBY	If redundant mains units are present, this message is shown on the redundant unit.	
DELOADING BTB XX	DG units are load sharing asymmetrically to deload BTB XX dividing two sections in an island application.	
BTB XX DIVIDING SEC.	BTB XX is dividing two sections in an island application.	
SYNCHRONISING TB XX	TB XX is synchronising.	
SYNCHRONISING MB XX	MB XX is synchronising.	
SYNCHRONISING BTB XX	BTB XX is synchronising.	
Mains unit		
UNIT STANDBY	If redundant mains units are present this message is shown on the redundant unit.	
TB TRIP EXTERNALLY	Some external equipment has tripped the breaker.	An external trip is logged in the event log.
BTB unit		
DIVIDING SECTION	A BTB unit is dividing two sections in an island application.	
READY AUTO OPERATION	BTB unit in Auto and ready for breaker operation (no active BTB trip" alarm).	
SEMI OPERATION	BTB unit in Semi.	
AUTO OPERATION	BTB unit in Auto, but not ready for breaker operation (active "BTB trip" alarm).	
BLOCKED FOR CLOSING	Last open BTB in a ring bus.	
BTB TRIP EXTERNALLY	Some external equipment has tripped the breaker.	An external trip is logged in the event log.
All units		
BROADCASTING APPL. #	Broadcast an application through the CAN line.	Broadcasts one of the four applications from one unit to the rest of the AGCs in the power management system.
RECEIVING APPL. #	AGC receiving an application.	

Status text	Condition	Comment
BROADCAST COMPLE-TED	Successful broadcast of an application.	
RECEIVE COMPLETED	Application received successfully.	
BROADCAST ABORTED	Broadcast terminated.	
RECEIVE ERROR	Application is not received correctly.	

5.32 Service menu

The purpose of the service menu is to give information about the present operating condition of the genset. The service menu is entered using the "JUMP" push-button **(9120 Service menu).**

Use the service menu for easy troubleshooting in connection with the event log.

Entry window
The entry shows the possible selections in the service menu.

```
G  400  400  400V
9120 Service menu
ALARM
ALARM    IN OUT MISC
```

Available selections:

Alarm
Shows the alarm timer and the remaining time. The indicated remaining time is minimum remaining time. The timer will count downwards when the setpoint has been exceeded.

```
G  400  400  400V
1010 Reverse power
Remaining time  10.0s
UP DOWN
```

IN (digital input)
Shows the status of the digital inputs.
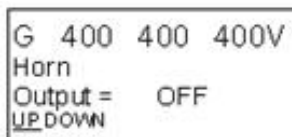
```
G  400  400  400V
Running
Input =     ON
UP DOWN
```

OUT (digital output)
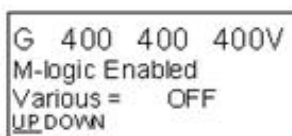
Shows the status of the digital outputs.

```
G  400  400  400V
Horn
Output =    OFF
UP DOWN
```

MISC (miscellaneous)

Shows miscellaneous messages.

```
G  400  400  400V
M-logic Enabled
Various =    OFF
UP DOWN
```

5.33 Event log
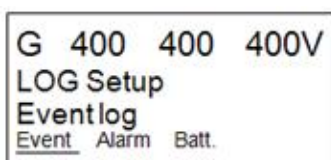
The logging of data is divided in three different groups:

● Event log containing 150 loggings.
● Alarm log containing 30 loggings.
● Battery test log containing 52 loggings.

The logs can be viewed in the display or in the PC utility software. When the individual logs are full, each new event will overwrite the oldest event following the "first in - first out" principle.

5.33.1 Display
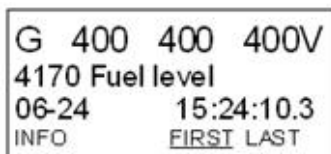
In the display it looks like this when the "LOG" push-button is pressed:

```
G  400  400  400V
LOG Setup
Event log
Event  Alarm  Batt.
```

Now it is possible to select one of the three logs.

If the "Event" is selected, the log could look like this:

```
G  400  400  400V
4170 Fuel level
06-24      15:24:10.3
INFO      FIRST LAST
```

The specific alarm or event is shown in the second line. In the example above the fuel level alarm has occurred. The third line shows the time stamp.

If the cursor is moved to "INFO", the actual value can be read when pressing "SEL":

```
G  400   400   400V
4170 Fuel level
VALUE        8 %
INFO      FIRST LAST
```
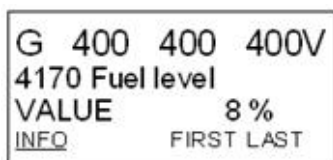
The first event in the list will be displayed if the cursor is placed below "FIRST" and "SEL" is pressed.

The last event in the list will be displayed if the cursor is placed below "LAST" and "SEL" is pressed.

The keyUP and keyDOWN push-buttons are used for navigating in the list.

5.34 Counters

Counters for various values are included, and some of these can be adjusted if necessary, for instance if the unit is installed on an existing genset or a new circuit breaker has been installed.

The table shows the adjustable values and their function in menu 6100:

Description	Function	Comment
6101 Running time	Offset adjustment of the total running hours counter.	Counting when the running feedback is present.
6102 Running time	Offset adjustment of the total running thousand hours counter.	Counting when the running feedback is present.
6103 GB operations	Offset adjustment of the number of generator breaker operations.	Counting at each GB close command.
6104 MB operations	Offset adjustment of the number of mains breaker operations.	Counting at each MB close command.
6105 kWh reset	Resets the kWh counter.	Automatically resets to OFF after the reset. The reset function cannot be left active.
6106 Start attempts	Offset adjustment of the number of start attempts.	Counting at each start attempt.

5.35 Quick setup

Both the PC utility software and the quick setup menu can be used to set up a plant.

The quick setup menu is made to provide easy setup of a plant. Entering the quick setup menu 9180 via the DU-2 display gives the possibility to add or remove e.g. mains and MB without using the utility software. It is only possible to do the same basic setup as via the application configuration in the utility software.

Menu 9180 Quick setup

9181:   Mode.

OFF: When the mode menu is set to "OFF", the existing application of the genset will not be
               changed.

Setup plant: The setup plant mode is used in G5 applications.

(i)   **Please refer to the option G5 manual.**

Setup stand-   When the mode menu is set to "Setup stand-alone", the AGC will change the application
alone: configuration. The settings in menu 9182-9185 are used for the new configuration.
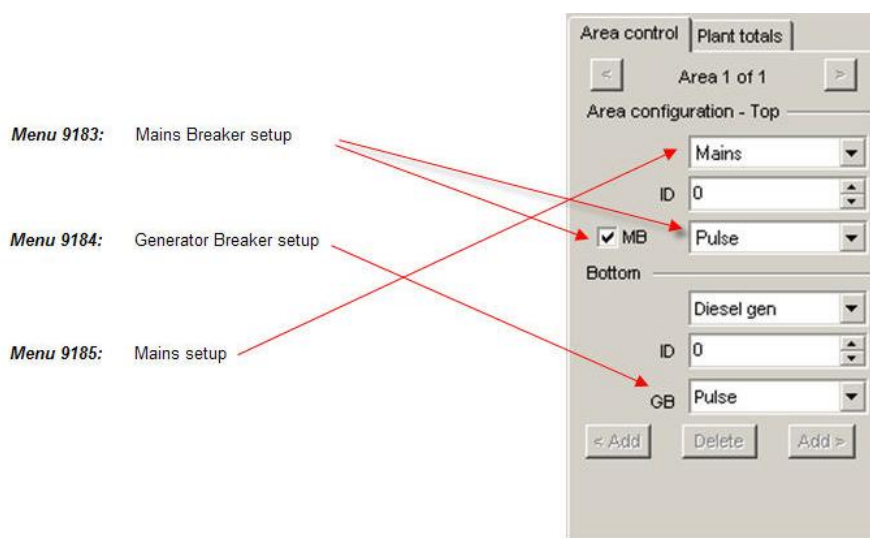
(i)   **If "Setup stand-alone" is activated while the genset is running, an info text, "Quick setup er-
       ror", will appear.**

5.36 kWh/kVArh counters

The AGC has two transistor outputs, each representing a value for the power production. The outputs are
pulse outputs, and the pulse length for each of the activations is 1 second.

Term. number	Output
20	kWh
21	kVArh
22	Common terminal

The number of pulses depends on the actual adjusted setting of the nominal power:

Generator power	Value	Number of pulses (kWh)	Number of pulses (kVArh)
P_{NOM}	<100 kW	1 pulse/kWh	1 pulse/kVArh
P_{NOM}	100-1000 kW	1 pulse/10 kWh	1 pulse/10 kVArh
P_{NOM}	>1000 kW	1 pulse/100 kWh	1 pulse/100 kVArh

The kWh measurement is shown in the display as well, but the kVArh measurement is only available through the transistor output.

Be careful - the maximum burden for the transistor outputs is 10 mA.

5.37 M-logic

M-logic functionality is included in the unit and is not an option-dependent function, however selecting additional options, such as option M12 which offers additional digital inputs and outputs, can increase the functionality.

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 genset modes and change of running modes.

The M-logic is part of the PC utility software, and as such it can only be configured in the PC utility software and not via the display.

The main purpose of M-logic is to give the operator/designer more flexible possibilities of operating the generator control system.

Please refer to the "Help" function in the PC utility software for a full description of this configuration tool.

5.38 GSM communication

The GSM modem communication is used to send a GSM message to up to five cellular telephones when an alarm appears on the display.

System single-line diagram
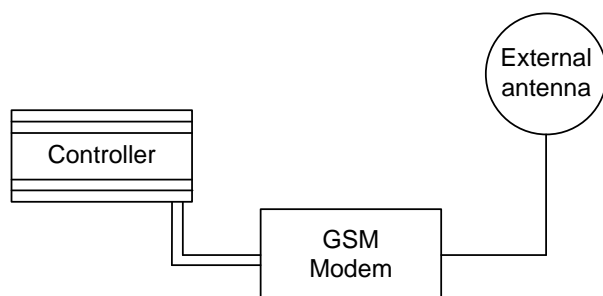
ⓘ **DEIF recommends using a MOXA OnCell G2150I, Wavecom WMOD2 or Westermo GDW-11 terminal, as the application has been tested with these terminals.**

Serial connection
The serial connection to the GSM modem is done via the null-modem cable (option J3).

Basic parameter settings

Setting no.	Name	Function	Set to
GSM	GSM PIN code	Set PIN code for GSM modem	None
GSM	12345678901	Set phone no. for SMS to cellular phone 1	None
GSM	12345678901	Set phone no. for SMS to cellular phone 2	None
GSM	12345678901	Set phone no. for SMS to cellular phone 3	None
GSM	12345678901	Set phone no. for SMS to cellular phone 4	None
GSM	12345678901	Set phone no. for SMS to cellular phone 5	None

ⓘ **For calling a foreign number type "+" and country code instead of "00", for example dial +45 99999999 for a Danish number.**

ⓘ **The phone number can only be dialed using the PC utility software.**

ⓘ **The SIM card used in the cellular telephone must support data transfer.**

PIN code configuration
After each auxiliary supply power up, the unit will send the required PIN code to the modem if this is necessary. The PIN code is adjusted in the PC utility software.

5.39 USW communication

It is possible to communicate with the unit via the PC utility software. The purpose is to be able to remote monitor and control the genset application.

⚠ **It is possible to remote control the genset from the PC utility software if a modem is used. Take precautions that it is safe to remote operate the genset to avoid personal injury or death.**

Serial connection
The serial connection to the GSM modem is via the null-modem cable (option J3).

ⓘ **Because of the RS232 communication the GSM function is only available with option H11.**

Setup
The Modbus protocol type can be changed from RTU to ASCII **(9020 Service port).** This menu can only be reached using the JUMP push-button. When set to 1, the ASCII protocol type is used, and the unit will allow for the slower modem communication.

9020 Service port

No.	Setting		Min. setting	Max. setting	Factory setting
9021	Service port	Setpoint	0 (normal USW)	1 (modem USW)	0 (normal USW)

ⓘ **If setting 9020 is set to 1, the PC utility software cannot communicate with the unit when it is connected directly to the PC and a modem is not used.**

Application settings
Please refer to the PC utility software help file.

Safety
If communication fails, the unit will operate according to the received data. If e.g. only half of the parameter file has been downloaded when the communication is interrupted, the unit will use this actual data.

5.40 Nominal settings

The nominal settings can be changed to match different voltages and frequencies. The AGC has four sets of nominal values, and they are adjusted in menus 6000 to 6030 (Nominal settings 1 to 4).

ⓘ **The possibility to switch between the four sets of nominal setpoints is typically used on rental gensets, where switching between 50 and 60 Hz is required.**

Activation
The switching between the nominal setpoints can be done in three ways; digital input, AOP or menu 6006.

Digital input
M-logic is used when a digital input is needed for switching between the four sets of nominal settings. Select the required input among the input events, and select the nominal settings in the outputs.

Example:

Event A		Event B		Event C	Output
Dig. input no. 115	or	Not used	or	Not used	Set nom. parameter settings 1
Not Dig. input no. 115	or	Not used	or	Not used	Set nom. parameter settings 2

(i) **See the "Help" file in the PC utility software for details.**

AOP

M-logic is used when the AOP is used for switching between the four sets of nominal settings. Select the required AOP push-button among the input events, and select the nominal settings in the outputs.

Example:

Event A		Event B		Event C	Output
Button07	or	Not used	or	Not used	Set nom. parameter settings 1
Button08	or	Not used	or	Not used	Set nom. parameter settings 2

(i) **See the "Help" file in the PC utility software for details.**

Menu settings

In menu 6006 the switching is made between settings 1 to 4 simply by choosing the desired nominal setting.

6. Protections

6.1 General

The protections are all of the definite time type, i.e. a setpoint and time is selected.

If the function is e.g. overvoltage, the timer will be activated if the setpoint is exceeded. If the voltage value falls below the setpoint value before the timer runs out, then the timer will be stopped and reset.
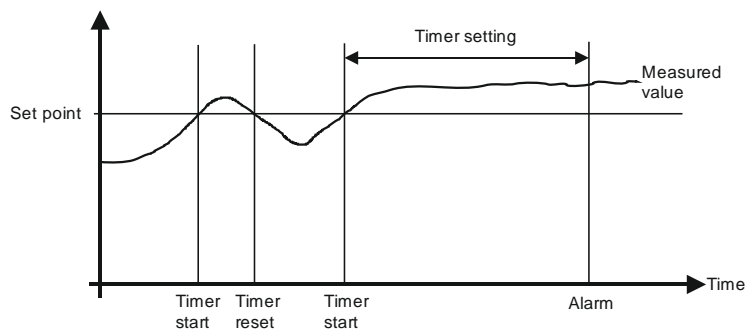
When the timer runs out, the output is activated. The total delay will be the delay setting + the reaction time.

Phase-neutral voltage trip
If the voltage alarms are to work based on phase-neutral measurements, please adjust menus 1200 and 1340 accordingly. Depending on the selections, either phase-phase voltages or phase-neutral voltages will be used for the alarm monitoring.
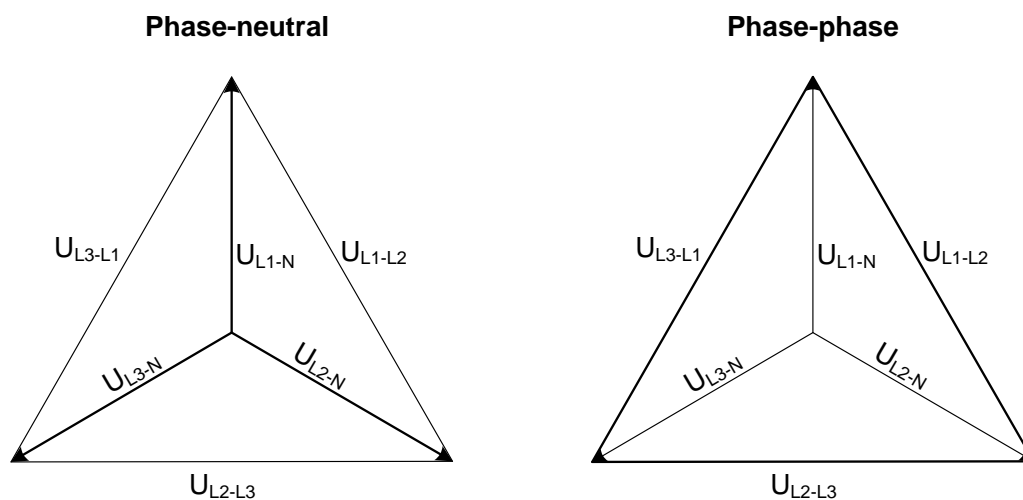
As indicated in the vector diagram, there is a difference in voltage values at an error situation for the phase-neutral voltage and the phase-phase voltage.

The table shows the actual measurements at a 10% undervoltage 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 setpoint is 10% in both cases.

Example
The below 400V AC system shows that the phase-neutral voltage must change 20%, when the phase-phase voltage changes 40 volts (10%).

Example:
U_{NOM} = 400/230V AC

Error situation:
U_{L1L2} = 360V AC
U_{L3L1} = 360V AC

U_{L1-N} = 185V AC

ΔU_{PH-N} = 20%
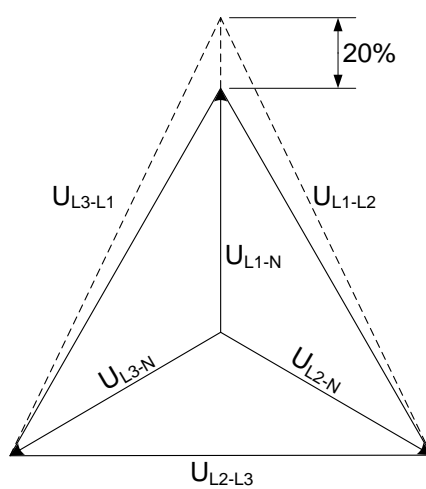
(i) **Phase-neutral or phase-phase: both the generator protections and the busbar/mains protections use the selected voltage.**

6.2 Voltage-dependent (restraint) overcurrent

This protection is used when the generator must be tripped due to a fault situation that creates a reduced generator voltage, e.g. a voltage collapse. During the voltage collapse, the generator can only produce part of its usual rating. A short-circuit current during a voltage collapse can even be lower than the nominal current rating.

The protection will be activated based on the overcurrent setpoint as a function of the measured voltage on the generator voltage terminals.

The result can be expressed as a curve function where the voltage setpoints are fixed values and the current setpoints can be adjusted (menu 1100). This means that if the voltage drops, the overcurrent setpoint will also drop.
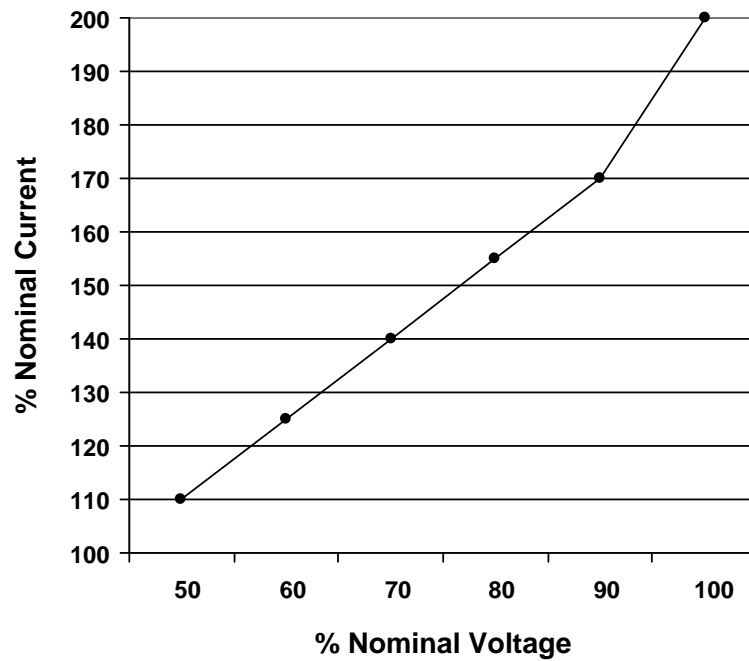
ⓘ The voltage values for the six points on the curve are fixed; the current values can be adjusted in the range 50-200%.

ⓘ Voltage and current % values refer to the nominal settings.

ⓘ Timer value can be adjusted in the range 0.1- 60.0 sec.

7. PID controller

7.1 Description of PID controller

The unit controller is 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.
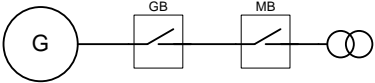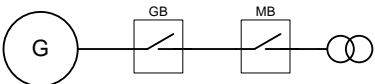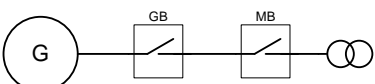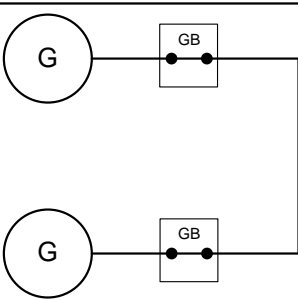
(i) **See "General Guidelines for Commissioning".**

7.2 Controllers

There are three controllers for the governor control and, if option D1 is selected, also three controllers for the AVR control.

Controller	GOV	AVR	Comment
Frequency	X		Controls the frequency
Power	X		Controls the power
P load sharing	X		Controls the active power load sharing
Voltage (option D1)		X	Controls the voltage
VAr (option D1)		X	Controls the power factor
Q load sharing (option D1)	X	X	Controls the reactive power load sharing

The table below indicates when each of the controllers is active. This means that the controllers can be tuned in when the shown running situations are present.

Governor			AVR (option-dependent)			Schematic
Frequency	**Power**	**P LS**	**Voltage**	**VAr**	**Q LS**	
X			X			
X			X			
	X			X		
		X			X	

ℹ **Load sharing mode is option-dependent (option G3/G5).**

7.3 Principle drawing

The drawing below shows the basic principle of the PID controller.
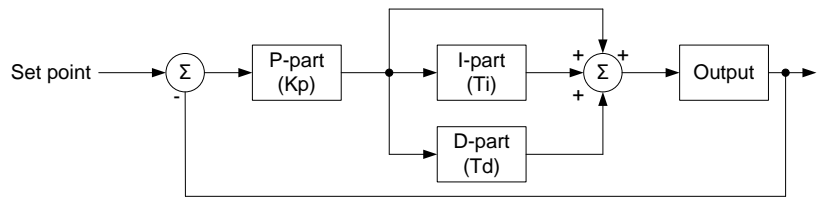
$$\mathrm{PID}(s) = Kp \cdot \left(1 + \frac{1}{Ti \cdot s} + Td \cdot s \right)$$

As illustrated in the above drawing and equation, each regulator (P, I and D) gives an output which is summarised to the total controller output.

The adjustable settings for the PID controllers in the AGC unit 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.

The function of each part is described in the following.

7.4 Proportional regulator

When the regulation deviation occurs, the proportional part will cause 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 will be doubled if the regulation deviation doubles.
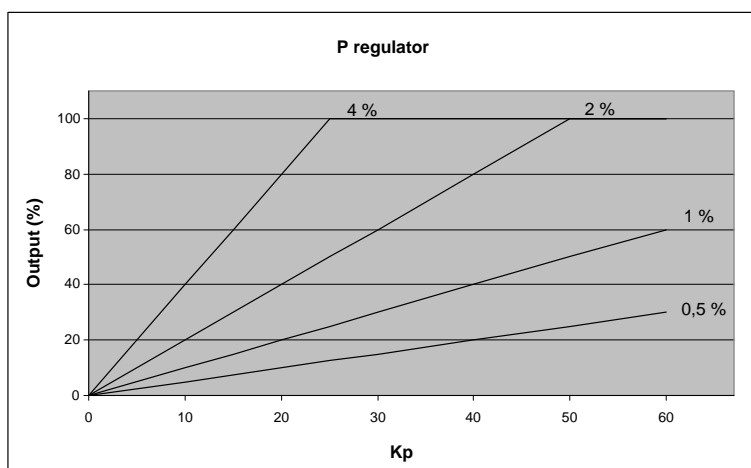
7.4.1 Speed range
Because of the characteristic above it is recommended to use the full range of the output to avoid an unstable regulation. If the output range used is too small, a small regulation deviation will cause a rather big output change. This is shown in the drawing below.
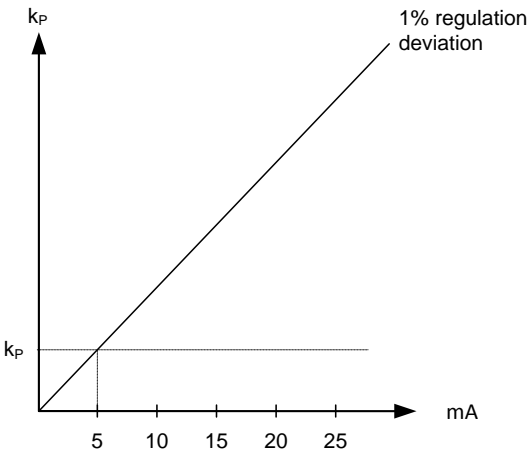
A 1% regulation deviation occurs. With the Kp setting adjusted, the deviation causes the output to change 5 mA. The table shows that the output of the AGC changes relatively much if the maximum speed range is low.

| Max. speed range	Output change		Output change in % of max. speed range
10 mA	5 mA	5/10*100%	50
20 mA	5 mA	5/20*100%	25

7.4.2 Dynamic regulation area

The drawing 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.
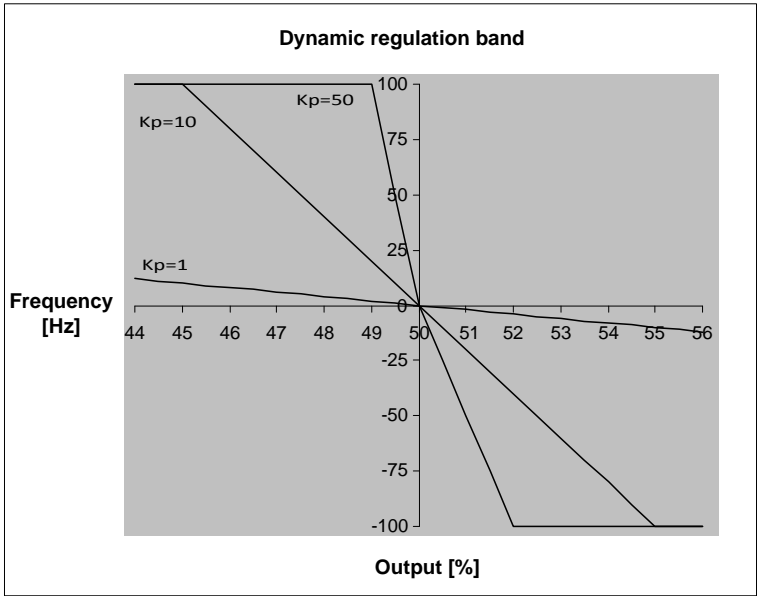
7.4.3 Integral regulator

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

In the drawing below the proportional regulator causes an immediate change of 2.5 mA. The integral action time is then measured when the output reaches 2 x 2.5 mA = 5 mA.

Integral action time, Ti
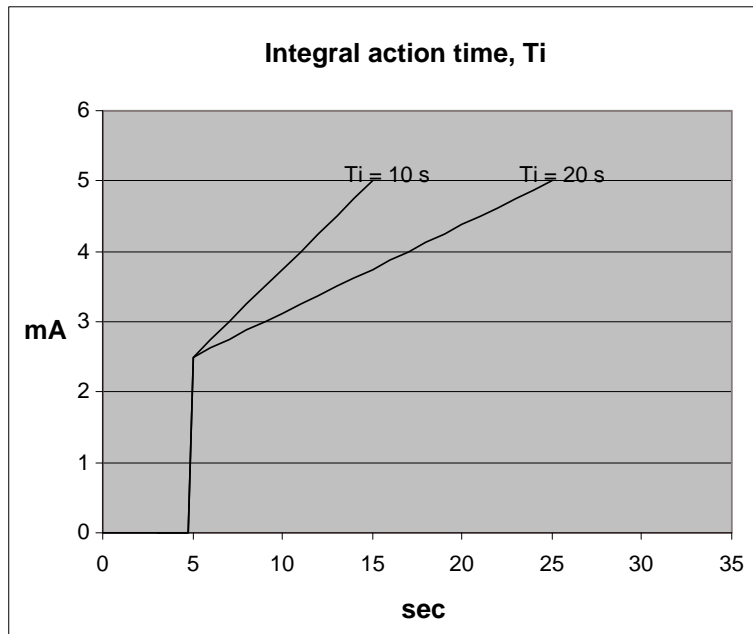
As shown in the drawing, the output reaches 5 mA twice as fast at a Ti setting of 10 s than with a setting of 20 s.

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.

ⓘ **If the Ti is adjusted to 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.**

7.4.4 Differential regulator

The main purpose of the differential regulator (D-regulator) 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 is not needed; however, in case of very precise regulation situations, e.g. static synchronisation, it can be very useful.

The output from the D-regulator can be explained with the equation: $D = Td \cdot Kp \cdot \dfrac{de}{dt}$
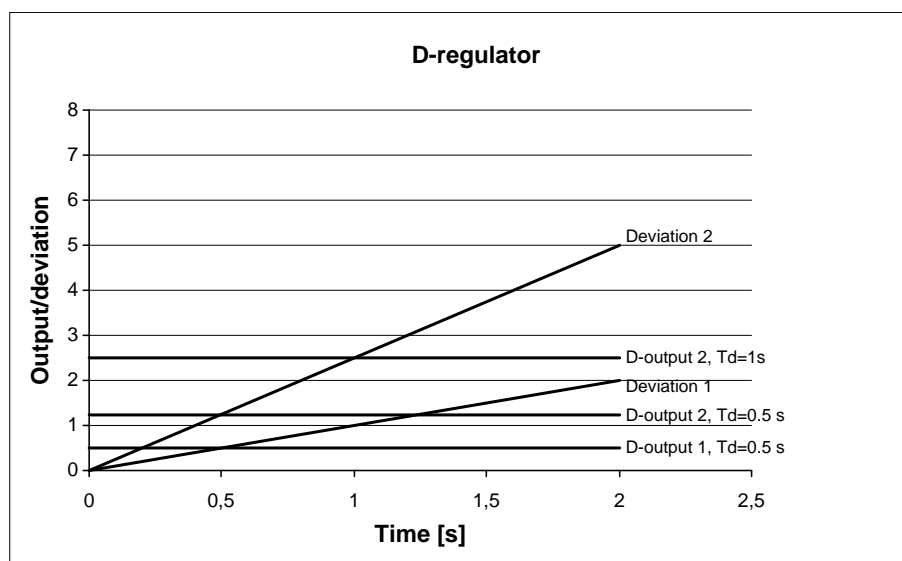
D = Regulator output
Kp = Gain
de/dt = Slope of the deviation (how fast does the deviation occur)

This means that the D-regulator output depends on the slope of the deviation, the Kp and the Td setting.

Example:
In the following example it is assumed that Kp = 1.

D-regulator

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 D-regulator when Td=0.5 s and the deviation is according to De-
                           viation 1.
D-output 2, Td=0.5 s: Output from the D-regulator when Td=0.5 s and the deviation is according to De-
                           viation 2.
D-output 2, Td=1 s: Output from the D-regulator when Td=1 s and the deviation is according to Devi-
                           ation 2.

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

(i) **When commissioning, please keep in mind that the Kp setting has influence on the D-regulator output.**

(i) **If the Td is adjusted to 0 s, the D-regulator is switched OFF.**

(i) **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.**

7.5 Load share controller

The load share controller is used in the AGC whenever load sharing mode is activated. The load share controller is a PID controller similar to the other controllers in the system and it takes care of frequency control as well as power control.

Adjustment of the load share controller is done in menu 2540 (analogue control) or 2590 (relay control).

The primary purpose of the PID controller is always frequency control because frequency is variable in a load sharing system as well as the power on the individual generator. Since the load sharing system requires power regulation as well, the PID controller can be affected by the power regulator. For this purpose a so-called weight factor is used (P_{WEIGHT}).

The regulation deviation from the power regulator can therefore have great or less influence on the PID controller. An adjustment of 0% means that the power control is switched off. An adjustment of 100% means that the power regulation is not limited by the weight factor. Any adjustment in between is possible.

The difference between adjusting the weight value to a high or low value is the speed at which the power regulation deviation is eliminated. So if a firm load sharing is needed, the weight factor must be adjusted to a higher value than if an easy load sharing is required.

An expected disadvantage of a high weight factor is that when a frequency deviation and a power deviation exist, then hunting could be experienced. The solution to this is to decrease either the weight factor or the parameters of the frequency regulator.

7.6 Synchronising controller

The synchronising controller is used in the AGC whenever synchronising is activated. After a successful synchronisation the frequency controller is deactivated and the relevant controller is activated. This could e.g. be the load sharing controller. The adjustments are made in the menu 2050.

Dynamic synchronising
When dynamic synchronising is used, the controller "2050 f_{SYNC} controller" is used during the entire synchronising sequence. One of the advantages of dynamic synchronising is that it is relatively fast. In order to improve the speed of the synchronising further, the generator will be 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.

Static synchronising
When synchronising is started, the synchronising controller "2050 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. The phase controller is adjusted in the menu 2070 ("2070 phase controller").

7.7 Relay control

When the relay outputs are used for control purposes, the regulation works like this:
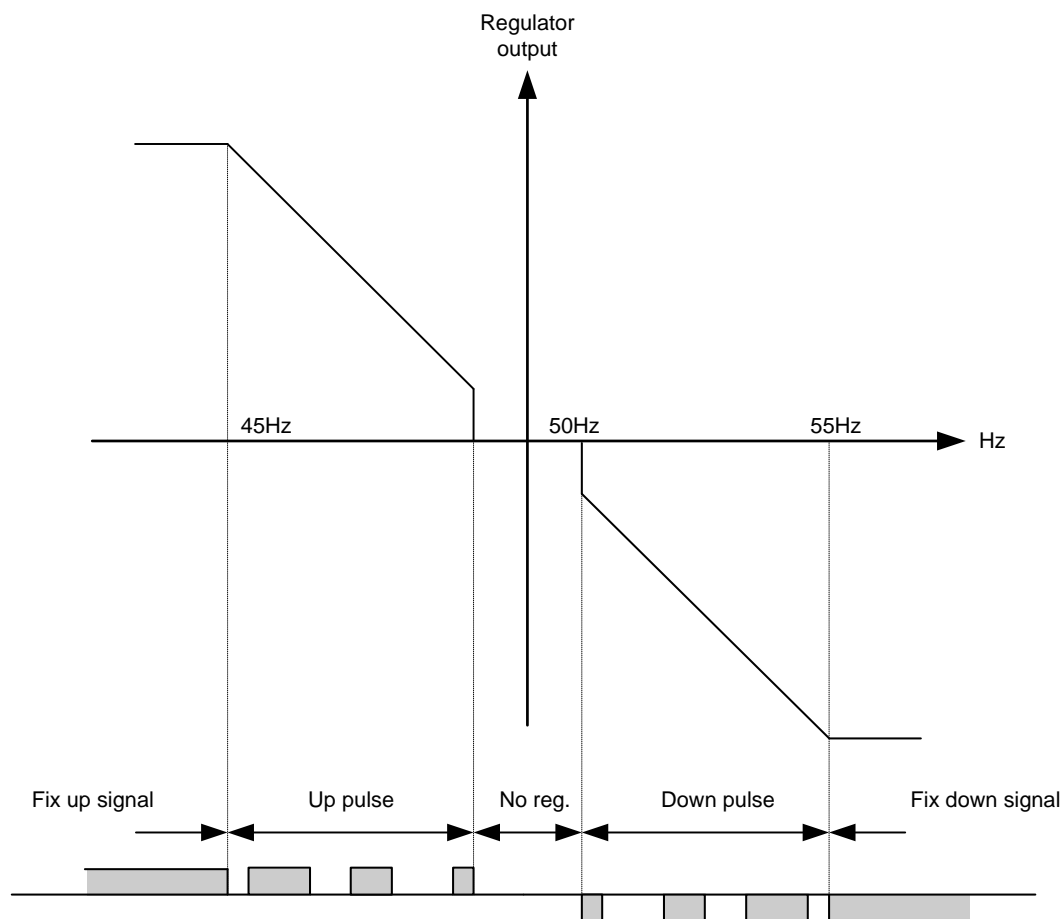
The regulation with relays can be split up into five steps.

| #	Range	Description	Comment
1	Static range	Fix up sig-nal	The regulation is active, but the increase relay will be constantly activated because of the size of the regulation deviation.
2	Dynamic range	Up pulse	The regulation is active, and the increase relay will be pulsing in order to eliminate the regulation deviation.
3	Dead band area	No reg.	In this particular range no regulation takes place. The regulation accepts a predefined dead band area in order to increase the lifetime of the relays.
4	Dynamic range	Down pulse	The regulation is active, and the decrease relay will be pulsing in order to eliminate the regulation deviation.
5	Static range	Fix down signal	The regulation is active, but the decrease relay will be constantly activated because of the size of the regulation deviation.

As the drawing indicates, the relays will be fixed ON if the regulation deviation is big, and they will be pulsing if it is closer to the setpoint. In the dynamic range the pulses get shorter and shorter when the regulation deviation gets smaller. Just before the dead band area the pulse is as short as it can get. This is the adjusted time "GOV ON time"/("AVR ON time"). The longest pulse will appear at the end of the dynamic range (45 Hz in the example above).

7.7.1 Relay adjustments

The time settings for the regulation relays can be adjusted in the control setup. It is possible to adjust the "period" time and the "ON time". They are shown in the drawing below.

Adjustment	Description	Comment
Period time	Maximum relay time	The time between the beginnings of two subsequent relay pulses.
ON time	Minimum relay time	The minimum length of the relay pulse. The relays will never be activated for a shorter time than the ON time.

As it is indicated in the drawing below, the length of the relay pulse will depend on the actual regulation deviation. If the deviation is big, then the pulses will be long (or a continued signal). If the deviation is small, then the pulses will be short.
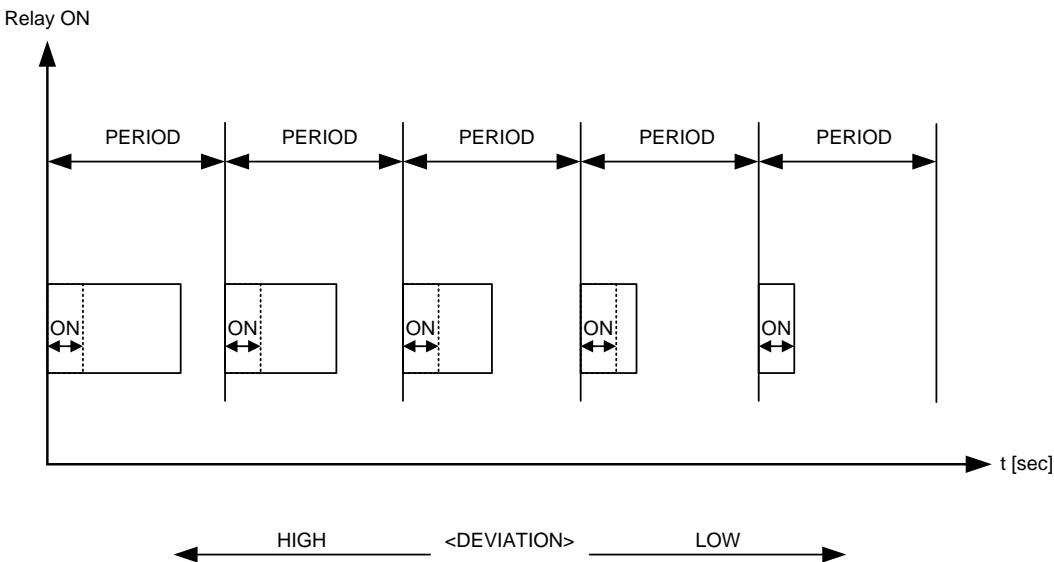
7.7.2 Signal length

The signal length is calculated compared to the adjusted period time. In the drawing below the effect of the proportional regulator is indicated.
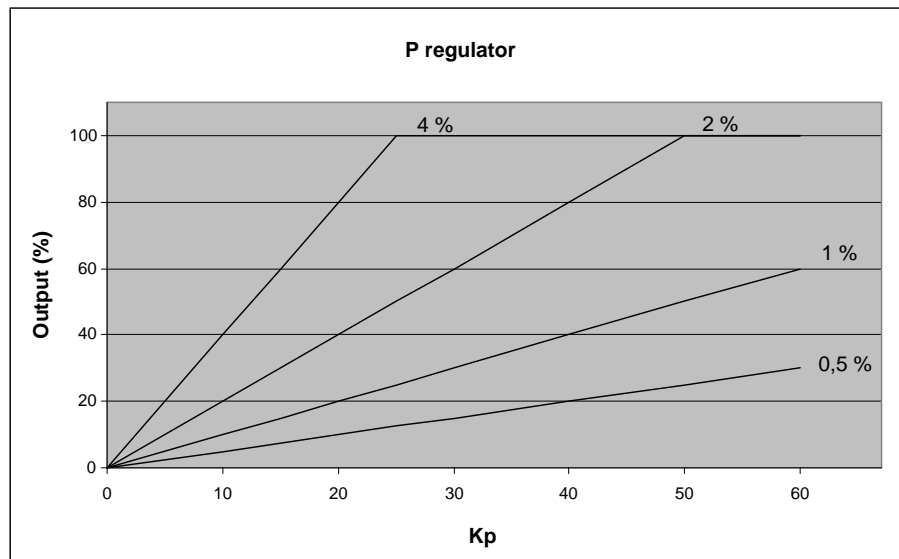
P regulator

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

$$e_{DEVIATION}/100 * t_{PERIOD}$$

$$40/100 * 2500 = 1000 ms$$

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

8. Synchronisation

8.1 Synchronisation principles

The unit can be used for synchronisation of generator and mains breaker (if installed). Two different synchronisation principles are available, namely static and dynamic synchronisation (dynamic is selected by default). This chapter describes the principles of the synchronisation functions and the adjustment of them.

> (i) **In the following, the term "synchronisation" means "*synchronising and closing of the synchronised breaker*".**

8.2 Dynamic synchronisation

In 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 is running with a positive slip frequency. This means that it is running with a higher speed than the generator on the busbar. The objective is to avoid a reverse power trip after the synchronisation.

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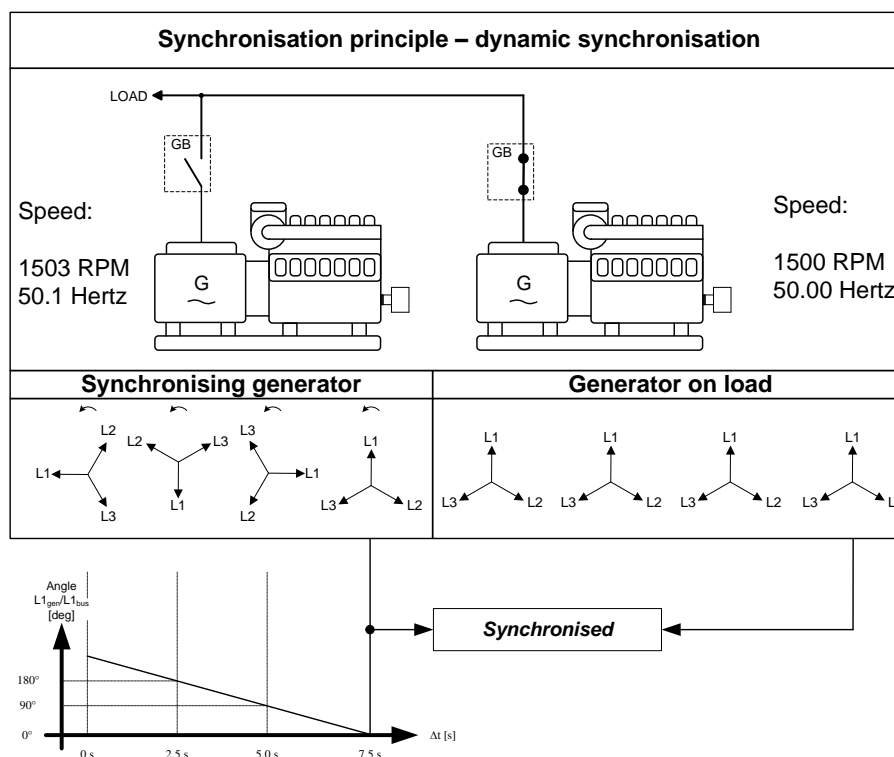
In the example above, the synchronising genset is running at 1503 RPM ~ 50.1 Hz. The generator on load is running at 1500 RPM ~ 50.0 Hz. This gives the synchronising genset a positive slip frequency of 0.1 Hz.

The intention of the synchronising is to decrease the phase angle difference between the two rotating systems. These two systems are the three-phase system of the generator and the three-phase system of the busbar. In the illustration 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.

> **(i) Of course both three-phase systems are rotating, but for illustrative purposes the vectors for the generator on load are not shown to be rotating. This is because we are only interested in the slip frequency for calculating when to release the synchronisation pulse.**

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

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

> **(i) Please observe the chapter regarding PID controllers and the synchronising controllers regarding the time between synchronism.**

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

8.2.1 Close signal

The unit always 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):

$$deg_{close} = 360 * t_{CB} * f_{slip}$$
$$deg_{close} = 360 * 0.250 * 0.1$$
$$deg_{close} = 9\,deg$$

> **(i) The synchronisation pulse is always issued, so the closing of the breaker will occur at the 12 o'clock position.**

The length of the synchronisation pulse is the response time + 20 ms **(2020 Synchronisation).**

8.2.2 Load picture after synchronising

When the incoming genset has closed its breaker, it will take a portion of the load depending on the actual position of the fuel rack. Illustration 1 below indicates that at a given *positive* slip frequency, the incoming genset will *export* power to the load. Illustration 2 below shows that at a given *negative* slip frequency, the incoming genset will *receive* power from the original genset. This phenomenon is called *reverse power*.

ⓘ **To avoid nuisance trips caused by reverse power, the synchronising settings can be set up with a positive slip frequency.**
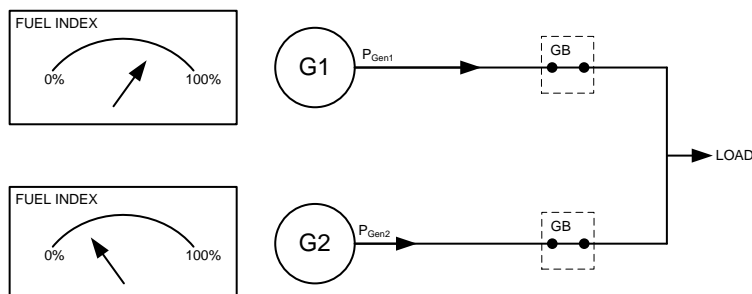

Illustration 1, POSITIVE slip frequency

_____
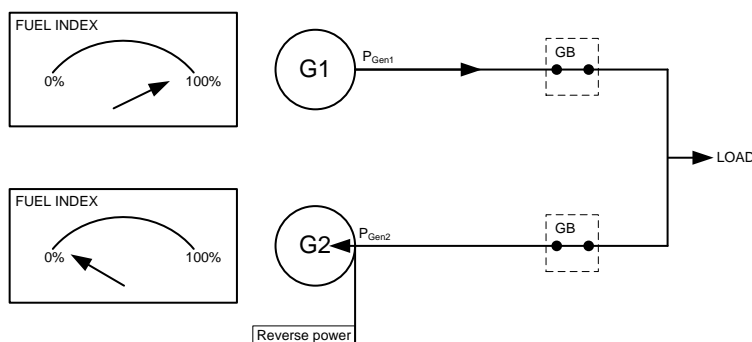
Illustration 2, NEGATIVE slip frequency

8.2.3 Adjustments

The dynamic synchroniser is selected in **2000 Sync. type** in the control setup and is adjusted in **2020 Synchronisation**.

Setting	Description	Comment
2021 f_{MAX}	Maximum slip frequency	Adjust the maximum positive slip frequency where synchronising is allowed.
2022 f_{MIN}	Minimum slip frequency	Adjust the maximum negative slip frequency where synchronising is allowed.
2023 U_{MAX}	Maximum voltage difference (+/- value)	The maximum allowed voltage difference between the busbar/mains and the generator.
2024 t_{GB}	Generator breaker closing time	Adjust the response time of the generator breaker.
2025 t_{MB}	Mains breaker closing time	Adjust the response time of the mains breaker.

It is obvious that this type of synchronisation is able to synchronise relatively fast because of the adjusted minimum and maximum slip frequencies. This actually means that when the unit is aiming to control the frequency towards its setpoint, then synchronising can still occur as long as the frequency is within the limits of the slip frequency adjustments.

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.

Static and dynamic synchronisation can be switched by using M-logic.

8.3 Static synchronisation

In static synchronisation, the synchronising genset is running very close to the same speed as the generator on the busbar. The aim is to let them run at exactly the same speed and with the phase angles between the three-phase system of the generator and the three-phase system of the busbar matching exactly.

It is not recommended to use the static synchronisation principle when relay regulation outputs are used. This is due to the slower nature of the regulation with relay outputs.

The static principle is illustrated below.
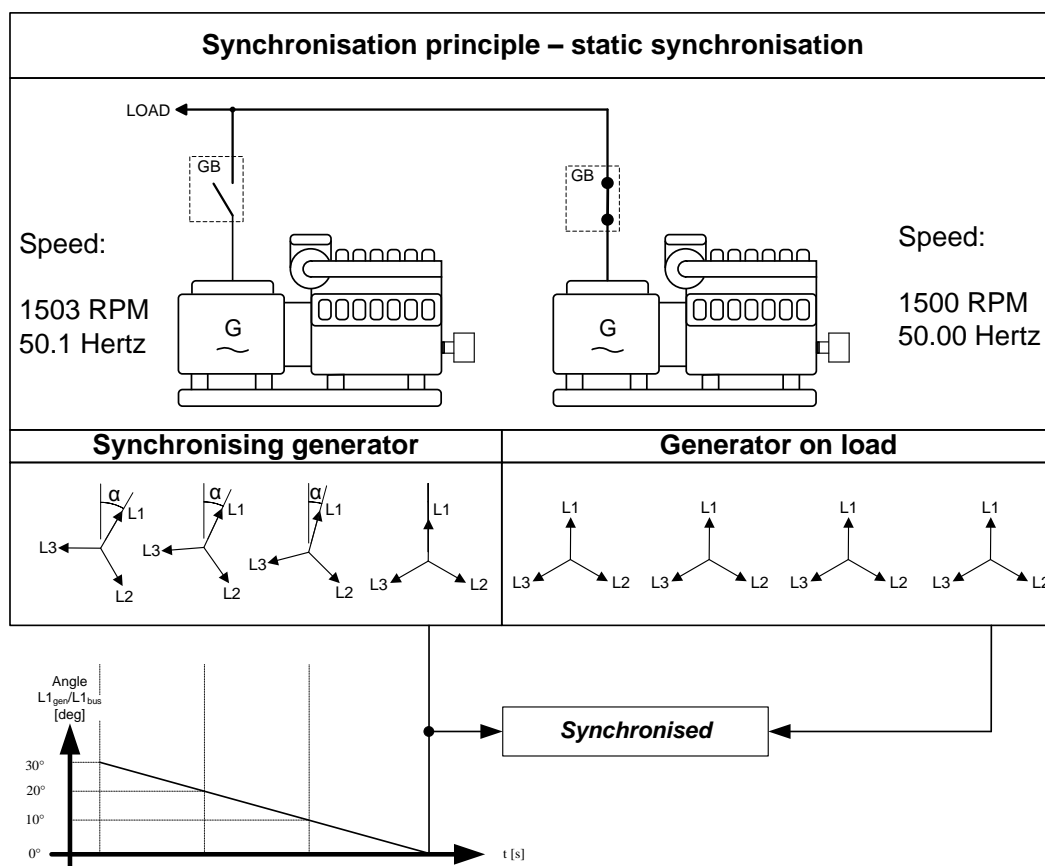
8.3.1 Phase controller

When the static synchronisation is used and the synchronising is activated, the frequency controller will bring the genset frequency towards the busbar frequency. When the genset frequency is within 50 mHz of the busbar frequency, then the phase controller takes over. This controller uses the angle difference between the generator system and the busbar system as the controlling parameter.

This is illustrated in the example above where the phase controller brings the phase angle from 30 deg. to 0 deg.

8.3.2 Close signal

The close signal will be issued when phase L1 of the synchronising generator is close to the 12 o'clock position compared 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 either very small or non-existing.

To be able to get a faster synchronisation, a "close window" can be adjusted. The close signal can be issued when the phase angle U_{GENL1}-U_{BBL1} is within the adjusted setpoint. The range is +/-0.1-20.0 deg. This is illustrated in the drawing below.
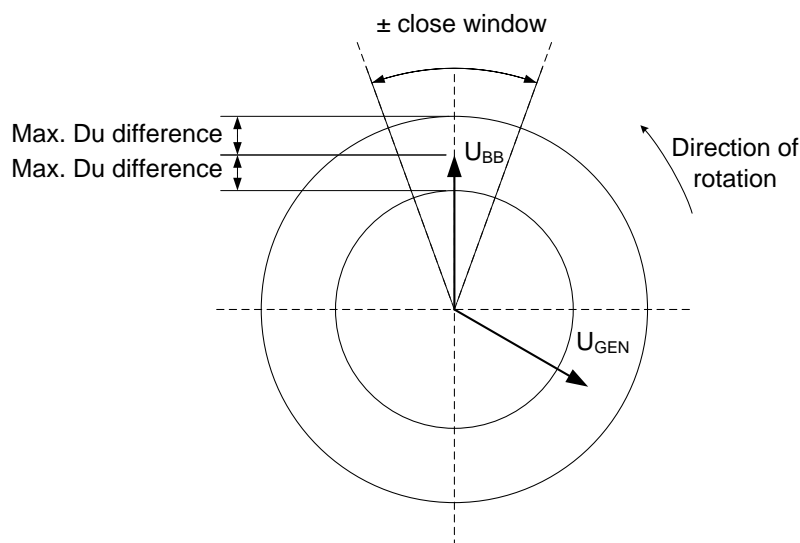
The synchronisation pulse is sent dependent on the settings in menu 2030. It depends on whether it is the GB or the MB that is to be synchronised.

8.3.3 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 adjusted to a low value. Since the fuel rack position almost exactly equals what is required to run at the busbar frequency, no load jump will occur.

If the maximum df setting is adjusted to a high value, then the observations in the section about "dynamic synchronisation" must be observed.

After the synchronising, the unit will change the controller setpoint 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 using M-logic.

8.3.4 Adjustments

The following settings must be adjusted if the static synchroniser is selected in menu 2000:

Setting	Description	Comment
2031 Maximum df	The maximum allowed frequency difference be-tween the busbar/mains and the generator.	+/- value.
2032 Maximum dU	The maximum allowed voltage difference be-tween the busbar/mains and the generator.	+/- value related to the nominal gener-ator voltage.
2033 Closing window	The size of the window where the synchronisa-tion pulse can be released.	+/- value.
2034 Static sync	Minimum time inside the phase window before sending a close command.	
2035 Static type GB	"Breaker" or "Infinite sync" can be chosen.	"Infinite sync" will close the MB to the busbar and run the generator in sync with the mains. The GB is not allowed to close.
2036 Static type MB	"Breaker" or "Infinite sync" can be chosen.	"Infinite sync" will close the GB to the busbar and run the generator in sync with the mains. The MB is not allowed to close.
2061 Phase K_P	Adjustment of the proportional factor of the PI phase controller.	Only used during analogue regulation output.
2062 Phase K_I	Adjustment of the integral factor of the PI phase controller.	
2070 Phase K_P	Adjustment of the proportional factor of the PI phase controller.	Only used during relay regulation out-put.

8.4 GB closing before excitation

It is possible to adjust the AGC to start up the genset with the excitation switched off. When the gensets are started up, the breakers will be closed and the excitation started. It is also possible to close the breaker be-fore the engine is started. This function is called "close before excitation".

The purpose of the "close before excitation" is that the gensets are able to be ready for the load very quickly. All of the gensets will be connected to the busbar as soon as they are started, and as soon as the excitation is switched on, the gensets are ready for operation. This is faster than the normal synchronising, because in that case the breakers will not be closed until the generator voltage is in the synchronised position, and it takes some time to achieve that 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 eventu-ally run in a synchronised system. When the excitation is activated, then the regulators of the AGC will be switched on after an adjustable delay.

The function can be used in the single AGC but also the AGC with option G4 or G5.

(i)   **The excitation must be increased slowly when this function is used.**

(i)   **This function can only be used when a magnetic pick-up is used.**

(i)   **This function is not available in units with option G3.**

The principle is described in the flowcharts below.

Flowchart abbreviations

Delay 1	=	Menu 2252
Delay 2	=	Menu 2262
Delay 3	=	Menu 2271

| SP1 | = | Menu 2251 |
| SP2 | = | Menu 2263 |

8.4.1 Flowchart 1, GB handling

Start → Start DG(s) → RPM > SP1

RPM > SP1 — No → Delay 1 expired — No → (back to Start DG(s))
RPM > SP1 — Yes → Close GB

Delay 1 expired — Yes → Start excitation

Close GB → RPM > SP2
RPM > SP2 — No → Delay 1 expired — No (loop)
Delay 1 expired — Yes → Trip GB → Start excitation
RPM > SP2 — Yes → Delay 1 expired on all DG(s)

Delay 1 expired on all DG(s) — No (loop)
Delay 1 expired on all DG(s) — Yes → Start excitation

Start excitation → Delay 2 expired
Delay 2 expired — No (loop)
Delay 2 expired — Yes → Activate regulators → U_{BUS} OK

U_{BUS} OK — No → Delay 3 expired
Delay 3 expired — No (loop)
Delay 3 expired — Yes → "Close before excitation" failure
U_{BUS} OK — Yes → End

Start excitation (right) → Delay 2 expired
Delay 2 expired — No (loop)
Delay 2 expired — Yes → Activate regulators → U_{BUS} OK

U_{BUS} OK — No → Delay 3 expired
Delay 3 expired — No (loop)
Delay 3 expired — Yes → "Close before excitation" failure
U_{BUS} OK — Yes → Sync GB → End

8.4.2 Flowchart 2, TB handling (option G5)

```
                    ┌──────────┐
                    │  Start   │
                    └────┬─────┘
                         │
         No         ◇ TB Open ◇
    ◄───────────────
                        Yes
                         │
                    ◇ Any GB closed ◇ ──► No
                        Yes
                         │
                    ◇ P_AVAIL > P_CAP ◇ ──► No
                        Yes
                         │
                    ◇ "GB + TB" ◇ ──► No
                        Yes
                         │
                    ◇ MB OFF ◇ ──► No
                        Yes
                         │
                  ┌──────────┐      ┌──────────┐
                  │ Close TB │      │ Sync TB  │
                  └────┬─────┘      └────┬─────┘
                       │                 │
                    ┌──────────┐
                    │   End    │
                    └──────────┘
```
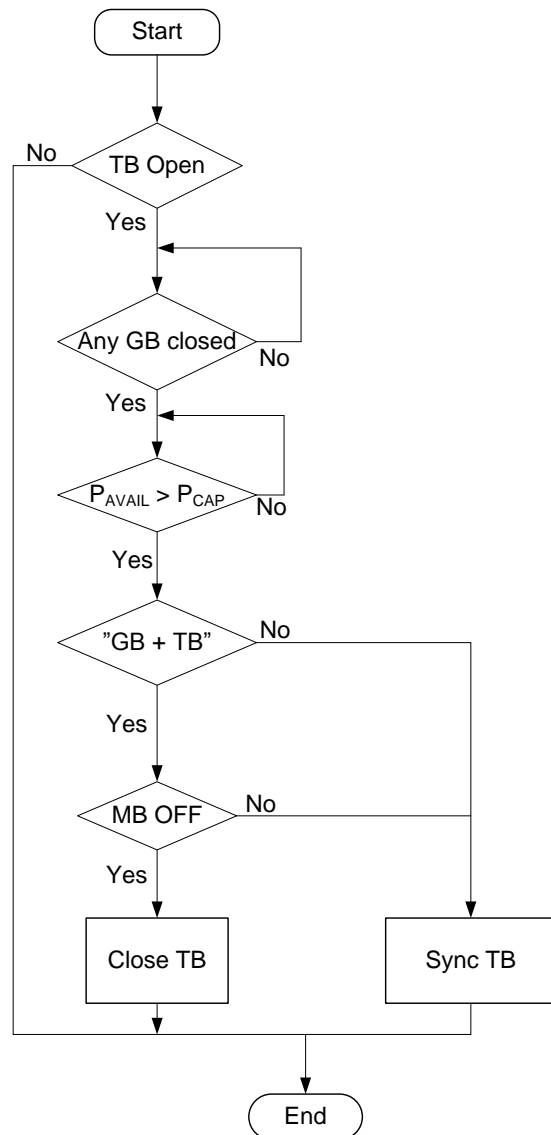
8.4.3 Genset start actions

The start sequence of the AGC is changed in order to achieve the function "close before excitation". The following parameters must be adjusted:

Menu	Description	Comment
2251	RPM setpoint for breaker closing	The generator breaker will close at the adjusted level. The range is from 0-400 RPM. If it is adjusted to 0, then the breaker will be closed when the start command is given. In the example below the setting is adjusted to 400.
2252	RPM timer	The genset must reach the setpoint (menu 2263) within the adjusted delay. When the delay expires and the RPM is above the setpoint, then the excitation will be started. If the RPM is below the setpoint, then 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 setup.
2255	Enable	Enable the function "close before excitation".
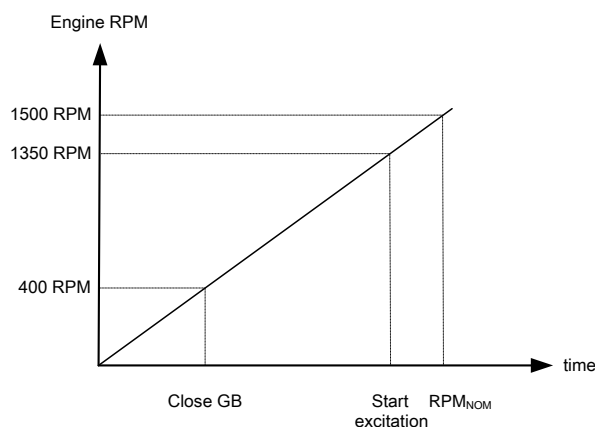
The diagram above shows that the GB will be closed at 400 RPM. When the engine RPM has reached the setpoint (menu 2263) (1450 RPM), then the excitation is switched on.

8.4.4 Breaker sequence

The "GB close before start" function can be used in three applications:

1. AGC single genset plant
2. AGC power management plant - no tie breaker present
3. AGC power management plant - tie breaker present

In one of the applications a tie breaker is present, and it must be adjusted in the menu 2261 whether only the generator breaker must be closed or both the generator breaker and also the tie breaker.

The breaker sequence adjustments are the following:

Menu	Description	Comment
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" will be activated after this timer has expired.
2263	Excitation start level	The setting defines at what level of RPM the excitation is started.

8.4.5 "Close before excitation" failure

If the starting of the genset does not succeed, then the alarm menu 2270 "Cl.bef.exc.fail" will occur, and the selected fail class will be executed.

8.5 Separate synchronising relay

When the AGC gives the synchronising command, then the relays on terminal 17/18/19 (generator breaker) and terminal 11/12/13 (mains breaker) will activate, and the breaker must close when this relay output is activated.

This default function can be modified using a digital input and extra relay outputs depending on the required function. The relay selection is made in the menu 2240, and the input is selected in the input settings in the utility software.

The table below describes the possibilities.

In-put	Re-lay	Relay selected Two relays used	Relay not selected One relay used
Not used		**Synchronising:** The breaker ON relay and the sync. relay activate at the same time when synchronising is OK. **Blackout closing:** The breaker ON relay and the sync. relay activate at the same time when the voltage and frequency are OK.	**Synchronising:** The breaker ON relay activates when synchronising is OK. **Blackout closing:** The breaker ON relay activates when the voltage and frequency are OK. **DEFAULT selection**
Low		**Synchronising:** Not possible. **Blackout closing:** The breaker ON relay and the sync. relay activate at the same time when the voltage and frequency are OK.	**Synchronising:** Not possible. **Blackout closing:** The breaker ON relay activates when the voltage and frequency are OK.
High		**Synchronising:** The relays will activate in two steps when the synchronising is selected: 1. Breaker ON relay activates. 2. When synchronised the sync. relay activates. **See note below!** **Blackout closing:** The breaker ON relay and the sync. relay activate at the same time when the voltage and frequency are OK.	**Synchronising:** Not possible. **Blackout closing:** The breaker ON relay activates when the voltage and frequency are OK.

When two relays are used together with the separate sync. input, then please notice that the breaker ON relay will be activated as soon as the GB ON/synchronising sequence is activated.

Care must be taken that the GB ON relay cannot close the breaker, before the sync. signal is issued by the sync. relay.

The selected relay for this function must have the "limit" function. This is adjusted in the I/O setup.

9. Parameter list

9.1 Related parameters

The Designer's Reference Handbook relates to the parameters 1000-1980, 2000-2780, 3000-3490, 4120-4990, 5000-5270, 6000-6900 and 7000-7120.

For further information, please see the separate Parameter List, AGC document number 4189340705.