DEIF

-power in control

DESIGNER'S REFERENCE HANDBOOK

Protection and Power Management, PPM-3

- Functional description
- Modes and sequences
- Application setup
- Power management functions
- Additional functions

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5. Application setup

6. Power management functions

7. Additional functions

8. Alarms

9. PID controller

10. Synchronisation

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.

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

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 terminals 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

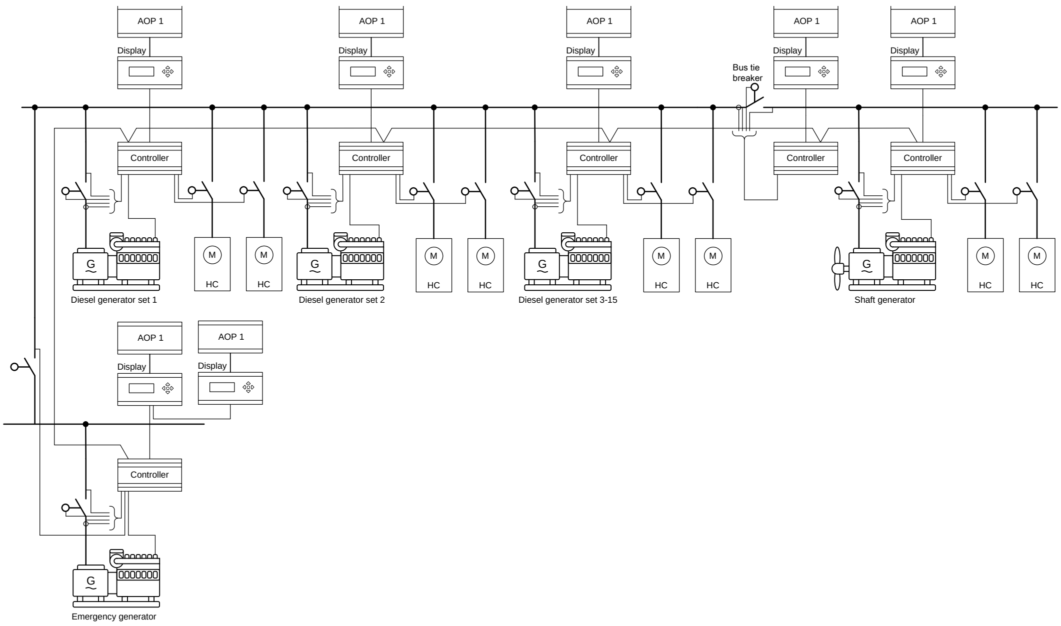
This document is divided into chapters, and in order to make the structure simple and easy to use, each chapter will begin from the top of a new page.

2. General product information

2.1 Protection and Power Management PPM-3

The *Protection and Power Management (PPM-3)* is a standard power management system for marine applications. The system carries out **generator control**, **supervision** and **protection** functions. The power management functions are calculated by all diesel generator units, making the system a true multi-master system. One of the diesel generator units is internally defined as the "Command unit". This unit is the one where start priority and other power management-related functions are calculated.

Should the command unit fail, the power management calculations will automatically be transferred to the next available unit.



The internal communication between the units is carried out via internal CAN bus. This CAN bus is intended for DEIF use only and cannot be connected to other external CAN bus systems.

External communication to an alarm and monitoring system can be performed via:

- RS-485 Modbus RTU
- Profibus DP
- Ethernet TCP/IP Modbus

The PPM-3 system can handle:

● **1-16 DG** (Diesel Generator) units	(1-15 with EDG unit)	CAN ID 1-16
● **0-1 EDG** (Emergency Diesel Generator) unit		CAN ID 1-16
● **0-2 SG** (Shaft Generator) units		CAN ID 17-20
● **0-2 SHORE** (Shore Connection) units		CAN ID 17-20
● **0-8 BTB** (Bus Tie Breaker) units		CAN ID 33-40

For further information about the possibilities in the applications, see the application notes.

3. Functional description

3.1 Standard functions

In the following, the standard functions are listed.

Operation
- Diesel generator
- Emergency diesel generator
- Shaft generator
- Bus tie breaker
- Load sharing between diesel generators
- Load transfer from/to shaft generator/shore connection
- Fixed power/base load for diesel generator and shaft generator (asymmetrical load sharing)
- Heavy consumer control (fixed load/variable load)
- Secured operation (reserving extra power)
- Temperature-dependent cool-down

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

Protections (ANSI)
- Over-current, 4 levels (51)
- Reverse power, 2 levels (32)
- Over- and under-voltage (27/59)
- Over- and under-frequency (81)
- Overload (32)
- Current unbalance (46)
- Voltage asymmetry (60)
- Loss of excitation/over-excitation (40)
- Multi-inputs (digital, 4 to 20 mA, 0 to 40 V DC, Pt100, Pt1000 or RMI)
- Digital inputs

Display
- Prepared for remote mounting
- Push-buttons for start and stop
- Push-buttons for breaker operations
- Status and information text messages

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

Power Management
Plant operation:
- Diesel generator supply (up to 16 generators)
- Shaft generator supply (up to two shaft generators)
- Shore connection supply
- Split busbar operation (up to eight tie breakers)

Power management functions:

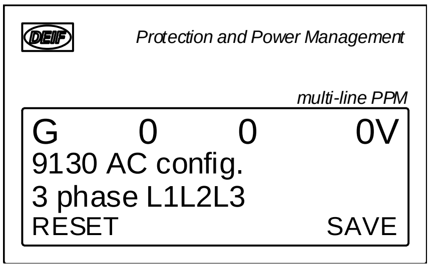
- Blackout handling
- Load-dependent start/stop
- Priority selection
    - Manual
    - Running hours
    - Fuel optimisation
- Safety stop (fail class = Safe stop)
- Secured mode (reserving extra power)
- Minimum amount of running DGs
- Maximum amount of running DGs
- Load-shedding (trip of non-essential load groups)
- Load reduction outputs (analogue and digital)
- Conditional connection of heavy consumers

3.2 Measurement systems

The PPM-3 is designed for measurement of voltages between 100 and 690 V AC. For further reference, the AC wiring diagrams are shown in the installation instructions. In menu 9130, the measurement principle can be changed between three-phase, single phase and split phase.

The settings can be changed by using the display. Press the JUMP push-button and go to the menu 9130 or use the USW.

The menu for adjusting the measurement principle looks like this:



Use the or push-button to choose between 1-phase, 2-phase or 3-phase. Press until SAVE is underscored, and then press to save the new setting.

Configure the PPM-3 to match the correct measuring system. When in doubt, contact the switchboard manufacturer for information about the required adjustment.

Three-phase
When the PPM-3 is delivered from the factory, the three-phase system is selected. When this principle is used, all three phases must be connected to the PPM-3.
The following adjustments must be made in order to make the system ready for the three-phase measuring (example 400/230 V AC):

Setting/adjustment		Description	Adjust to value
6004	G nom. voltage	Phase-phase voltage of the generator	400 V AC
6041	G transformer	Primary voltage of the voltage transformer (if installed)	U_{NOM}
6042	G transformer	Secondary voltage of the voltage transformer (if installed)	U_{NOM}
6051	BB transformer	Primary voltage of the BB voltage transformer (if installed)	U_{NOM}
6052	BB transformer	Secondary voltage of the BB voltage transformer (if installed)	U_{NOM}

Split phase
This is a special application where two phases and neutral are connected to the PPM-3. The PPM-3 shows phases L1 and L3 in the display. The phase angle between L1 and L3 is 180 degrees. Split phase is possible between L1-L2 or L1-L3.
The following adjustments must be made in order to make the system ready for the split phase measuring (example 240/120 V AC):

Setting/adjustment		Description	Adjust to value
6004	G nom. voltage	Phase-phase voltage of the generator	120
6041	G transformer	Primary voltage of the voltage transformer (if installed)	U_{NOM}
6042	G transformer	Secondary voltage of the voltage transformer (if installed)	U_{NOM}
6051	BB transformer	Primary voltage of the voltage transformer (if installed)	U_{NOM}
6052	BB transformer	Secondary voltage of the voltage transformer (if installed)	U_{NOM}

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

Single phase
The single phase system consists of one phase and the neutral.
The following adjustments must be made in order to make the system ready for the single phase measuring (example 230 V AC):

Setting/adjustment		Description	Adjust to value
6004	G nom. voltage	Phase-phase voltage of the generator	230
6041	G transformer	Primary voltage of the voltage transformer (if installed)	$U_{NOM} \times \sqrt{3}$
6042	G transformer	Secondary voltage of the voltage transformer (if installed)	$U_{NOM} \times \sqrt{3}$
6051	BB transformer	Primary voltage of the voltage transformer (if installed)	$U_{NOM} \times \sqrt{3}$
6052	BB transformer	Secondary voltage of the voltage transformer (if installed)	$U_{NOM} \times \sqrt{3}$

The voltage alarms refer to U_{NOM} (230 V AC).

4. Modes and sequences

4.1 Unit operational modes and corresponding sequences

4.1.1 Application types

This chapter describes the different unit operational modes in different applications and the corresponding sequences of each PPM-3 unit including flow chart descriptions.

The PPM-3 units can be used for the following application types listed in the table below.

Application	Comment
Multiple gensets, power management	Standard
Emergency-/harbour generator control	Standard
Fixed power/base load for diesel and shaft generator	Standard
Load transfer to/from shaft generator/shore supply	Standard
Split busbar operation	Standard

If a PPM-3 unit is under SWBD (switchboard) control, all the operation modes described below are not available, and the display of the unit in question will display the text "SWBD control".

4.2 Running mode description

4.2.1 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 commands are used

The standard PPM-3 is only equipped with a limited number of digital inputs, see "Digital inputs" in the installation instructions and the data sheet for additional information about availability.

When a genset is running in semi-auto mode, the unit will control the speed governor and the voltage regulator (AVR). For the AVR control, the option D1 must be 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.	Diesel generator unit only
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 without cooling-down time.	Diesel generator unit only
Close CB	The unit will synchronise and close the circuit breaker, if the main busbar is alive.	
Open CB	The unit will de-load and open the circuit breaker at the breaker open point, if the unit is dispensable regarding the actual power situation. The unit will not open the breaker instantly, if it will cause a blackout.	
Close TB	The unit will synchronise and close the tie breaker, when the emergency generator breaker is closed and the main busbar is alive.	Emergency generator only
Open TB	The unit will de-load and open the tie breaker at the breaker open point, if the emergency generator is online. The unit will not open the breaker instantly, if it will cause a blackout on the emergency busbar.	Emergency generator only

4.2.2 Auto mode

The unit will participate in the automatic control carried out by the power management system. No operator actions are needed.

The emergency generator unit does not participate in the load-dependent start/stop function or priority control. See the relevant function description.

4.3 Multiple gensets, power management

4.3.1 Multiple gensets, power management

Auto mode description

All available diesel generator units are controlled by the power management system and are started and stopped according to the start priority and the actual busbar load. Should a running generator develop an alarm, the system will start the next generator in line and synchronise its breaker before taking the failing generator out of service (safety stop alarm). If the failure results in a shutdown (immediate trip of the breaker and stop of the generator), the system will start and synchronise the next generator in line. At the same time, the system monitors that the generators are not overloaded. Should that be the case, the Non Essential Load (NEL) trip will activate to maintain power supply to the main busbar.

If a heavy consumer is requested, the system calculates the power needed and starts an additional generator if needed before allowing the heavy consumer to be connected. The load-dependent stop function can be blocked by either a binary input (configurable input) or in connection with a heavy consumer request (parameter 8025).

When any busbar alarm(s) is (are) present (BB over-/under-frequency and voltage), the system will start an additional generator and let it run with open generator breaker, so it is ready to connect immediately if a blackout occurs. When the busbar alarm(s) is (are) no longer active, the generator will stop after a defined time set in parameter 8140: Stop non-connected DG.

Semi-auto description
All available diesel generator units can be started/stopped/synchronised/de-loaded upon push-button commands on the front panels for each generator. The power management load-dependent start/stop function is disabled for the generator unit under semi-auto control.
The system monitors that the generators are not overloaded. Should that be the case, the Non Essential Load (NEL) trip will activate to maintain power supply to the main busbar.
If a heavy consumer is requested, the system calculates the power needed. If the available power is insufficient, the heavy consumer connection will not be allowed.

4.4 Multiple gensets, load sharing

4.4.1 Equal load sharing

Auto and semi-auto description
In both cases, load sharing (and var sharing, option D1) is carried out via the internal CAN bus line(s).
There are two CAN bus ports available for power management and load sharing. If both are chosen, the two CAN bus lines will be redundant for each other.

The load sharing is normally based on equal distribution of load in %. This means that generators of different size can load-share with each other.

4.4.2 Asymmetrical load sharing (base load)

Each DG unit can be selected as running with base load (2952). This can be done from the display unit, M-Logic or via a binary input. If the unit is selected to run with base load, the status message FIXED POWER will be indicated. The fixed power value can be adjusted with parameter 2951.

The unit selected for base load operation will automatically be set in SEMI-AUTO. Only one generator per independent busbar can run with base load.

If a generator runs in base load and the total load decreases to the point where it closes in on the fixed power value, the system will lower the fixed power set point. This is to prevent frequency control problems since the generator running base load does not participate in the frequency control.
When the generator breaker is closed, the generator power will be increased to the fixed power set point.
If AVR control (option D1) is selected, the set point will be the adjusted power factor.

4.5 Emergency generator control

4.5.1 Shutdown override

When the tie breaker between the emergency busbar and the main busbar is open (internal status), all alarms on the emergency generator unit are automatically switched to WARNINGS, except the fail class "Short circuit", the binary input "Overspeed" or the binary input "Emergency stop".
When the tie breaker is closed, the emergency generator is treated as a normal diesel generator and the shutdown override function is disabled.

4.5.2 Blackout function

Blackout is defined as:

- tie breaker position OFF (TB between emergency and main busbar)

AND
- dead busbar detection

AND
- generator breaker position OFF.

In case of blackout on the main busbar (MBB), the tie breaker will be tripped by an under-voltage coil, additionally the PPM-3 EDG will send the TB OFF command. After 15 s (factory setting, adjustable from 0 to 60 s), the emergency generator is started and the generator breaker closes on the dead bus as soon as voltage/frequency build-up is OK. This function is active both in SEMI-AUTO and AUTO mode. In case of TEST mode and blackout, the PPM-3 EDG will automatically disable the test mode function and proceed with the blackout start sequence.

Auto mode description
After return of MBB voltage, the TB will automatically be synchronised, followed by de-loading of the generator breaker, generator breaker open command, cooling down and stop of the engine.

Semi-auto description
After return of MBB voltage, the operator can synchronise the bus tie breaker by pressing the tie breaker ON push-button on the PPM-3 EDG display. Now, the operator can open (incl. de-load) the generator breaker by pressing the generator breaker OFF push-button. By pressing the STOP push-button, the cooling down timer starts, which can be interrupted by pressing the STOP push-button again.

4.5.3 Emergency generator as harbour generator

Harbour operation means that the emergency generator is allowed to supply the main switchboard with power. This function is used to save fuel while the ship is docked in the harbour, as the emergency generator is much smaller in size than a diesel generator.

There is a max. parallel running timer integrated in the system (parameter 1940). When the timer is running out (adjustable from 1 to 999.9 s, factory setting = 30 s), the tie breaker will be opened. The timer starts running when the EDG is connected AND any DG on MBB is connected AND the emergency generator is not selected as harbour generator (PPM-3 EDG input).

The harbour operation can be obtained in auto or in semi-auto mode.

Auto
When activating harbour mode in auto mode, the emergency generator will be started and the generator breaker will be synchronised. Diesel generators connected to the main busbar will be de-loaded and stopped.

Semi-auto
In semi-auto, the operator can start and synchronise the harbour generator to the diesel generators on the main busbar.

Selected as harbour generator, the max. parallel timer is not active, and the harbour generator will be treated as an ordinary diesel generator in the system.

The tie breaker position feedback signal decides if the protections are activated for harbour operation. If the tie breaker is in position ON, all the protections are equal to the other diesel generator units. If the tie breaker position is OFF (Shutdown override), the protections for busbar voltage, overload, over-current, and so on, are changed to warnings. The only protections that can trip the generator breaker are overspeed, short circuit and emergency stop.

4.5.4 Emergency generator TEST mode

All emergency generators have to be tested for operation at least one time a week by the operator. To make this user-friendly, a test mode has been implemented in the PPM-3 EDG unit.
The TEST mode can be activated by pressing the TEST push-button or by activating a binary input.

By adjusting the parameter 7040 (Test), the operator can adjust:
- set point (load set point)
- timer (engine runtime during test)
- return (when test is completed, the unit will return to the selected mode, semi-auto/auto)
- type (selection of the three types of test mode: simple, load or full test)

SIMPLE test:
The emergency generator will start and run at its nominal frequency but does not synchronise, and stops when timer for the test mode timer (adjustable from 1 to 180 min, default 15 min) runs out. The test mode will then be disabled automatically. The timer starts running, when test mode has been activated.

LOAD test:
The emergency generator will start and run at its nominal frequency, synchronise the generator breaker and produce the power typed in the set point in menu 7041. The test will run until the timer expires. When the timer has expired, the generator breaker will be de-loaded, and the emergency generator will be stopped (including cooling down).

FULL test:
The full test will start the emergency generator, synchronise the generator breaker and transfer the adjusted load to the emergency generator before opening the tie breaker. When the test timer expires, the tie breaker will be synchronised, and the load is transferred back to the main busbar before the generator breaker is opened and the generator is stopped.

Should there be a blackout situation during any test mode, the test mode will be interrupted immediately.

For further information regarding the possibilities with the emergency/harbour generator, see the application notes.

4.6 Shaft generator and shore control

4.6.1 Shaft generator/shore connection control

The shaft generator or shore connection unit do not have separate push-buttons for the mode selections. Each unit can be set under switchboard control. This signal is coming from the switchboard via a binary input. If the unit is not under switchboard control, it will automatically be set in Auto mode.

4.6.2 Going from diesel generator supply to shaft/shore supply

SG/SHORE can be selected simply by pressing the SG/SC breaker ON button. Alternatively, a binary input or an AOP button can be configured for the purpose.

When SG/SHORE supply is selected, the system will supervise whether the shaft generator/shore connection is ready and can handle the load. When this is true, the LED for SG/SHORE breaker ON will flash yellow to indicate that the sequence has been initiated. All connected DG units will synchronise the shaft generator/shore connection to the busbar. When the shaft generator/shore connection breaker is closed, the SG/SC breaker LED will turn green and the diesel generators will de-load and stop.

4.6.3 Going from shaft/shore supply to diesel generator supply

DG supply can be selected simply by pressing the SG/SC breaker OFF push-button. Alternatively, a binary input or an AOP push-button can be configured for the purpose.

When DG supply is selected, the power management system will supervise whether there are enough diesel generators available to handle the load situation and if the shaft generator/shore connection unit is not under switchboard control.

If this is true, the LED for SG/SC breaker OFF will light up yellow to indicate that the sequence has been initiated. The PMS will start the necessary amount of diesel generators (regarding the priority), close the breakers and de-load and open the shaft generator/shore connection breaker.

4.6.4 Diesel generator/shore connection overlap function

The purpose of the overlap function is to be able to define a very short paralleling time between a generator and a shore connection.

This function is typically used when shore converter requirements specify a low maximum allowed paralleling time and is available when DG units are in auto mode.

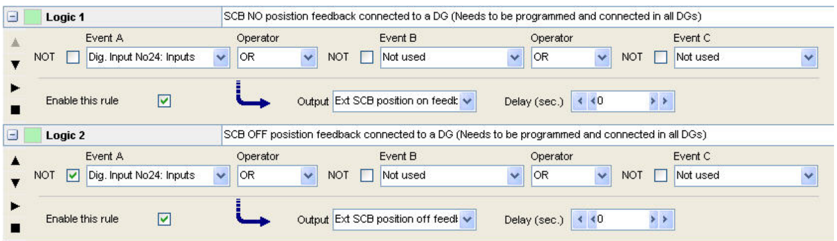
Due to the fact that the speed of the CAN bus communication between the units is limited, position feedback from the breakers must be applied to all units in order to ensure fast breaker open response.

Going from SC to DG supply
When DG breaker is synchronised, the shore connection breaker will be opened automatically after a time delay.

Going from DG to SC supply
When SC breaker is synchronised, and the generator breaker is opened after the time delay.

The GB's position feedbacks can be paralleled, so only one input on the shore connection is used. All DG units must have the shore connection feedback connected.

Breaker feedbacks for the overlap function are set up in M-Logic:



Parameters for the overlap function are set up in parameter 2760 (DG/SC Overlap):

2761 (Enable)
Setting the DG/SC Overlap function ON or OFF

2762 (Del.)
Timer delay setting for max. parallel time DG/SC
The same time delay should be used for both generator and shore breaker synchronisation.

2763 (Min. load) SC only
Minimum load on busbar allowing generator breaker to be synchronised.
This function is to prevent reverse power on the shore converter. Setting is set as a percentage of the nominal power setting of the SC.

4.6.5 Setting the shaft generator to PTH (Power Take Home) mode

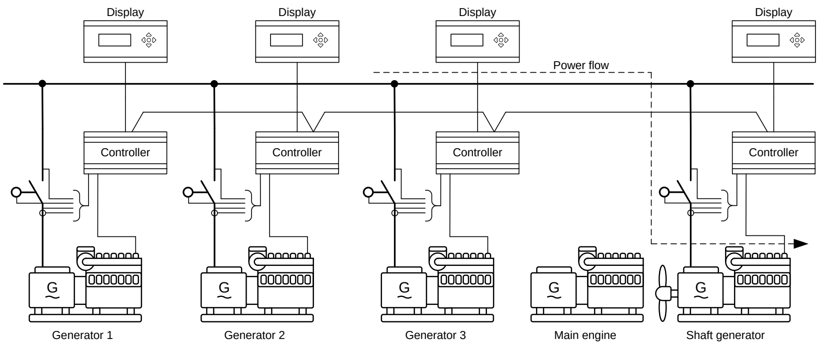
Power Take Home (PTH) provides limited propulsion capacity to a ship by using the shaft generator as a motor to drive the shaft propeller.

PTH can only be activated in a shaft generator controller, and only when the shaft is running at nominal frequency. When PTH is activated, the shaft generator consumes power because it functions as a motor to drive the shaft propeller.

The PTH mode is activated with a binary input on the SG PPM-3 unit. This input is one of the configurable inputs and has to be selected before the PTH mode is possible.

PTH operation is also possible from one SG to another SG (both SG breakers closed).

PTH mode: the diesel generators are supplying the ship's electrical load and run the shaft generator as electric motor to drive the propeller. The load-dependent start/stop function is active. The main engine is shut off.



The shaft generator has to be synchronised manually when PTH mode is selected. Since the main engine is shut off, the synchronisation has to take place using a pony motor or the like.

When the PTH input is set and the shaft generator breaker is closed, the parameters for reverse power and DG/SG max. parallel timer are ignored.

If the PTH input is removed with the SGB closed, the SG unit will trip the SGB.

Zero Pitch input

In order to prevent tripping, the SGB with high load applied, the "Zero pitch" input could be configured.

If Zero Pitch is configured, it is not possible to open the SG breaker unless the "Zero Pitch" input is set. The info text "PITCH NOT ZERO" is shown if breaker open command is issued without "Zero pitch" input active.

When synchronising the shaft generator in PTH mode, the parameters below are used:

2101 = Sync Df Max PTH - Default setting 0.0 Hz
(Max. allowable frequency difference for PTH synchronisation)

2102 = Sync Df MinPTH - Default setting -0.3 Hz
(Min. allowable frequency difference for PTH synchronisation)

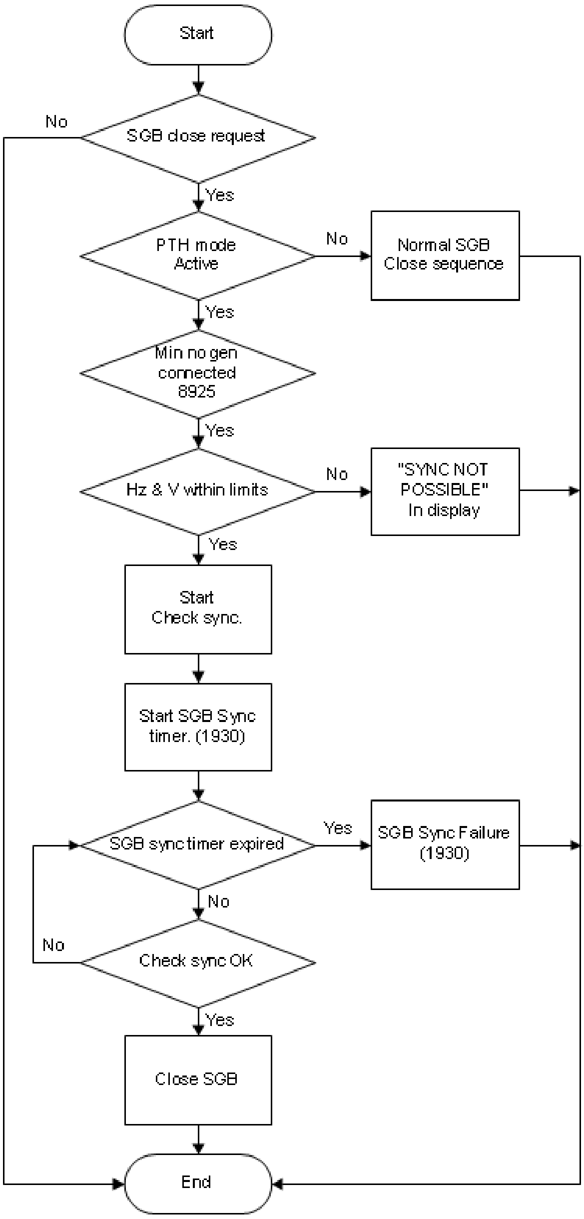
2103 = Sync DU Max PTH - Default setting 5 %

(Max. allowable voltage difference for PTH synchronisation)

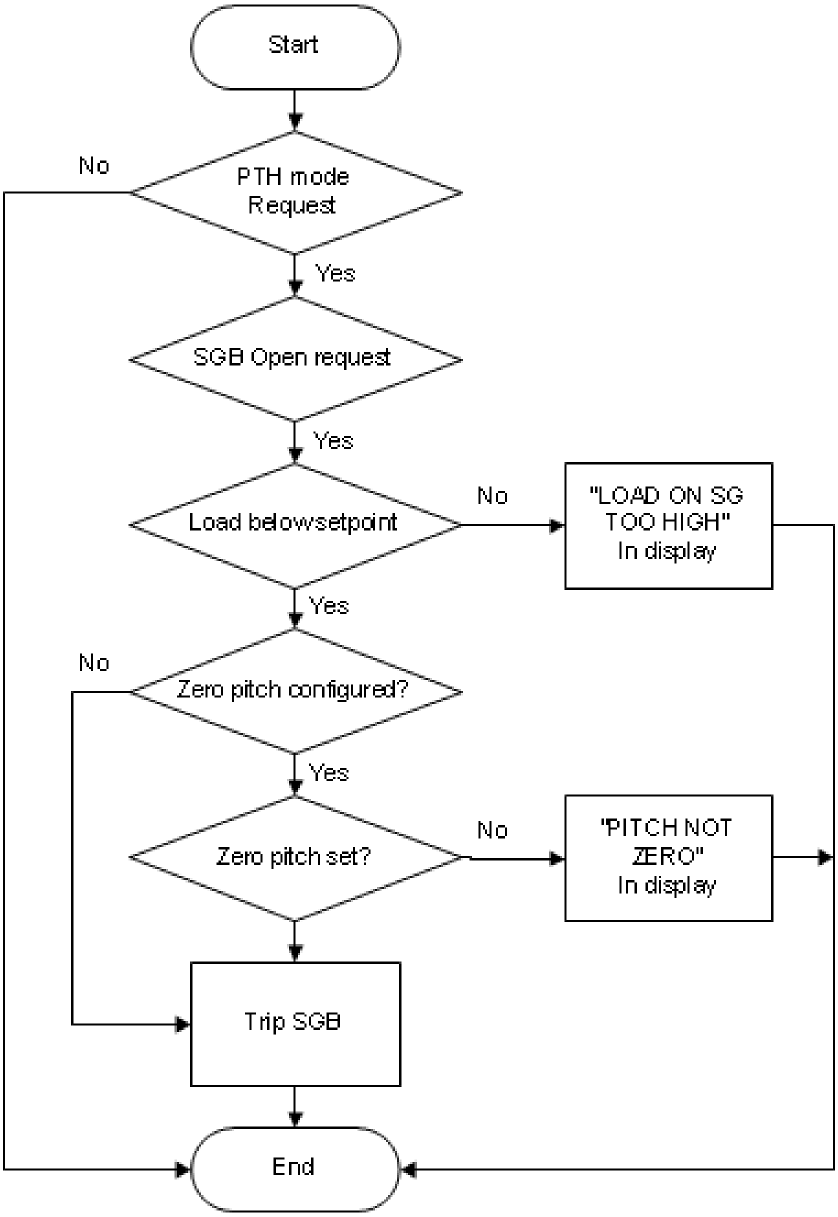
2104 = Power ramp down PTH - Default setting: 100 %
(Max. allowable power when opening the breaker). If set to 100 %, this parameter is disabled XXXX = PTH minimum number running

8926 = Min no. run. PTH
(Min. number of generators running when PTH mode is set)

PTH SGB ON sequence:



PTH SGB OFF sequence:



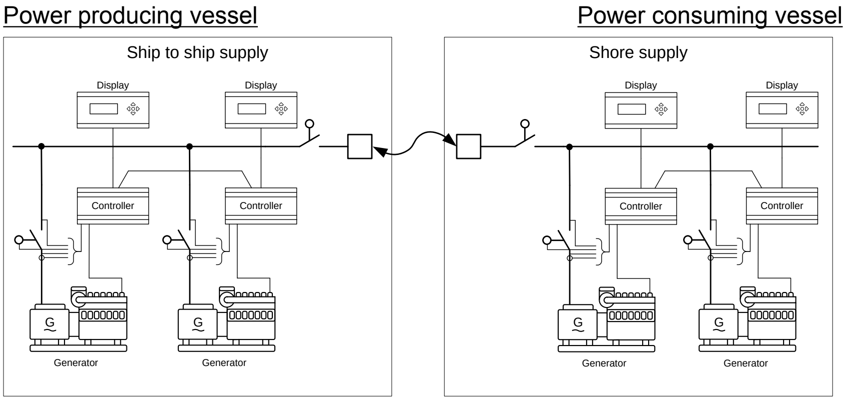
4.6.6 Parallel shore connection operation

In applications with two shore connections supplied from the same source, it is possible to allow both shore connection breakers to be closed at the same time.

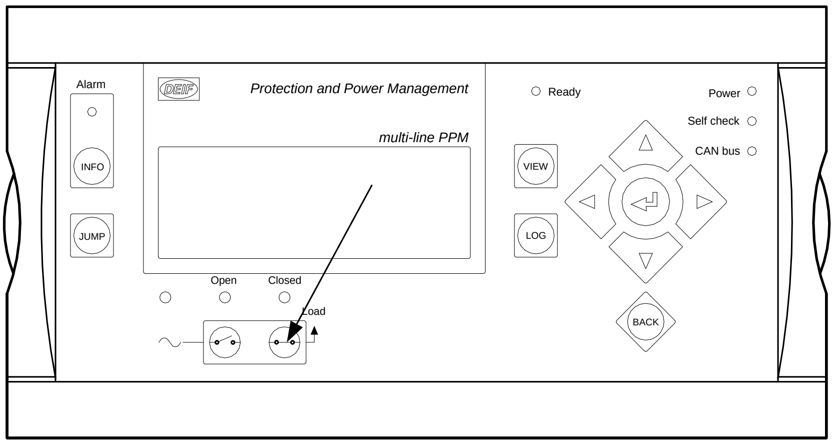
To enable this function, parameter 8980 "Parallel SCB" should be set ON.

4.7 Setting the shore connection breaker to “ship-to-ship” supply

The unique function "ship-to-ship" supply is used for applications, where one ship can supply power to another ship.
To use the function "ship-to-ship" supply, the binary input on the PPM-3 SC unit can be activated. This input is one of the configurable inputs and has to be selected before the "ship-to-ship" is possible.



As soon as "ship-to-ship" supply is selected for a PPM-3 SC unit, the display unit will indicate the status message: "SHIP TO SHIP ENABLED".
Now, the shore breaker can be connected directly (if there is a black busbar on the other ship) or synchronised to a "live" busbar. This is done by activating the breaker ON push-button on the display unit.



As soon as the shore breaker is closed, the status text "SHIP TO SHIP ACTIVE" is indicated at the display unit for the shore connection controller.

If the consuming vessel runs with higher frequency, the SC trips on 1070 P>ship to ship. Adjust parameter 2021/2022 Sync. dfMin/dfMax.

If the consuming vessel runs with higher or lower voltage than the set point of parameter 2023, the breaker will not close.

4.8 Split busbar control

4.8.1 Splitting a busbar into diesel generator busbar "A" and diesel generator busbar "B"

Split busbar can be selected simply by pressing the BT breaker OFF button. Alternatively, a binary input or an AOP push-button can be configured for the purpose.

The power management system will check the actual load condition on both sides of the breaker and start the necessary amount of diesel generators before opening the bus tie breaker. If the diesel generators are not able to handle the load situation, the info message "SPLIT NOT POSSIBLE" will be indicated and the BTB stays closed.

Once the split has taken place, the calculations for load-dependent start/stop will be carried out independently on each side of the bus tie breaker.

4.8.2 Splitting a busbar into diesel generator busbar and shaft generator busbar sections

Split busbar can be selected simply by pressing the BT breaker OFF button. Alternatively, a binary input or an AOP push-button can be configured for the purpose.

"SPLIT" can only be selected if the shaft generator/shore connection is connected. The power management system will de-load and open the bus tie breaker. If it is not possible to synchronise the shaft generator/shore connection breaker the info message "SPLIT NOT POSSIBLE" will be displayed on the BTB display. When the separation sequence is starting, the BT breaker OFF LED will be yellow. When the BT breaker opens, the sequence is ended.

4.9 Reconnection

4.9.1 Reconnecting diesel generator busbar and shaft generator busbar sections

Going to diesel generator supply:
To reconnect the two switchboards for DG supply, the operator has to activate the "DG" LED on the BTB unit and then press the BT breaker ON button.

The mode change can only be done if:

- the bus tie breaker unit is not in SWBD control
- the shaft generator unit is not in SWBD control
- enough diesel generator units are in Auto mode

If the actual load situation requires an additional DG, the power management will connect the necessary amount of diesel generators to handle the actual load situation and synchronise the bus tie breaker followed by de-loading and opening the shaft generator breaker. The "breaker closed" LED on the BTB unit is yellow until the bus tie breaker is closed and the shaft generator breaker is open.

Going to shaft generator mode:
To reconnect the two switchboards for SG supply, the operator has to activate the "SG" LED on the AOP of the BTB unit and press the BT breaker ON button.

The plant mode change can only be done if:

- the bus tie breaker unit is not in SWBD control
- the shaft generator unit is not in SWBD control
- the connected diesel generator(s) units are in Auto mode

When the above is true, the diesel generator(s) will synchronise the bus tie breaker followed by de-loading and stopping of the diesel generator(s). The "BTB Closed" LED is yellow until the bus tie breaker is closed and the shaft generator breaker is closed and the diesel generator breaker(s) are open.

4.9.2 Reconnecting split diesel generator busbars

To reconnect both sections for DG supply, the BT breaker ON button must be pressed. The bus tie breaker will be synchronised. The normal load-dependent start/stop functions will start and stop the diesel generators according to their priority.

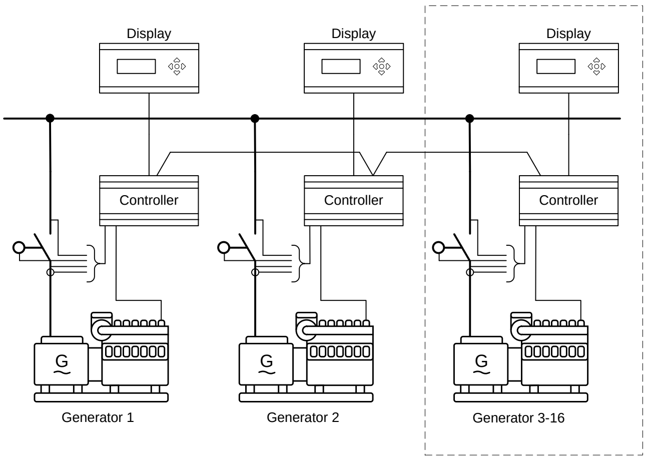
4.10 Single-line diagrams

4.10.1 Illustrations of applications

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

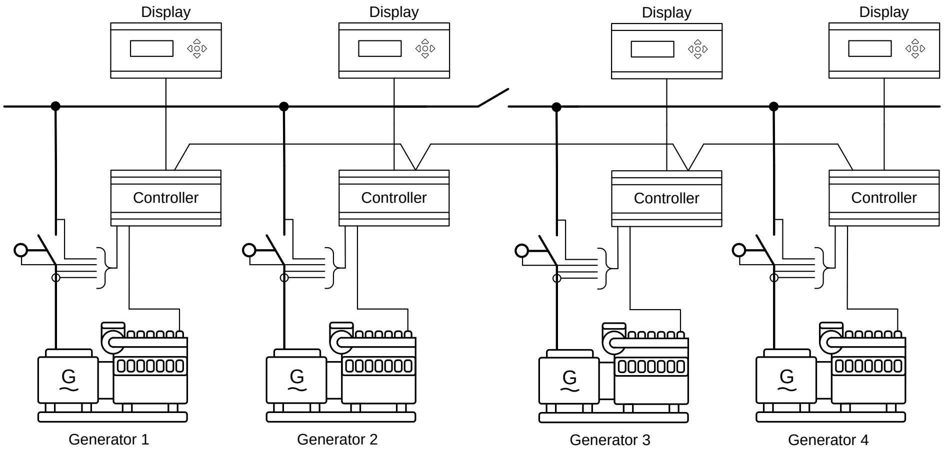
4.10.2 Multiple gensets, single busbar

This system can handle two to 16 diesel generators.



4.10.3 Multiple gensets, 2 busbars

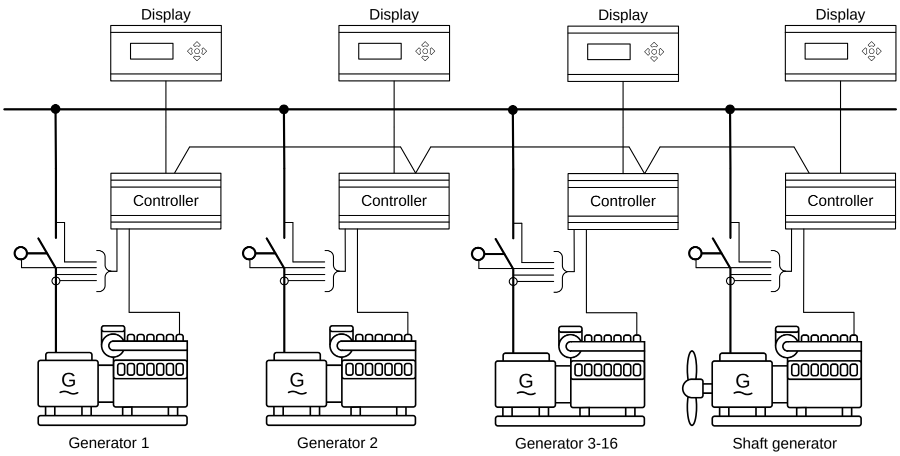
This system can handle two to 16 diesel generators.



Generators can be added on both sides of the bus tie breaker.

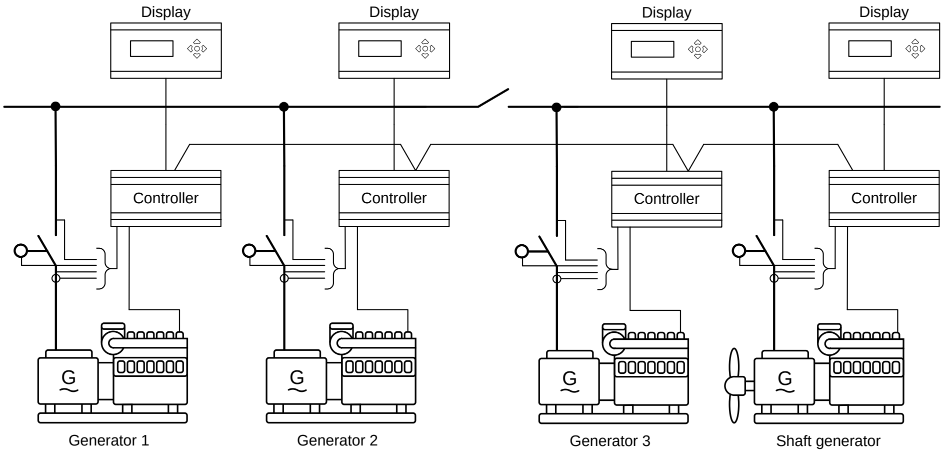
4.10.4 Multiple gensets, 1 shaft generator, single busbar

This system can handle two to 16 diesel generators and one shaft generator.



4.10.5 Multiple gensets, 1 shaft generator, 2 busbars

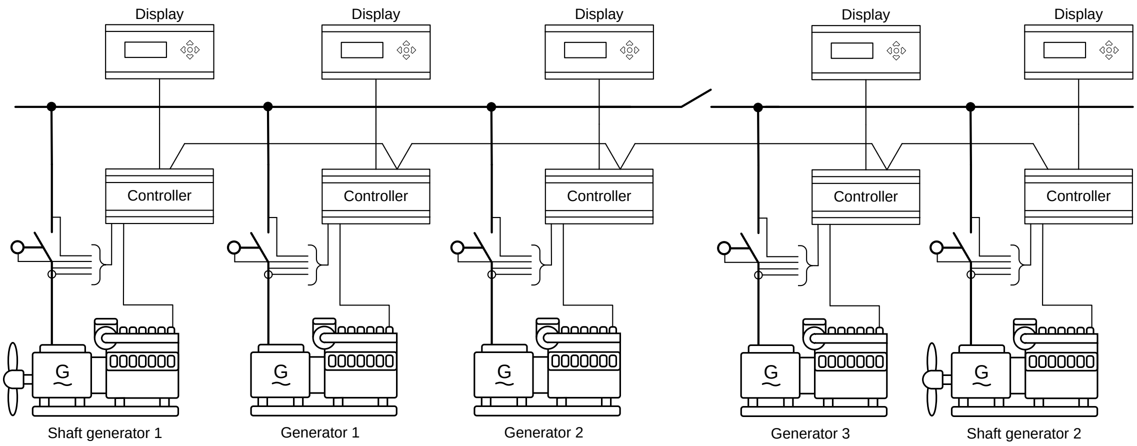
This system can handle two to 16 diesel generators and one shaft generator.



Diesel generators can be added on both sides of the bus tie breaker.

4.10.6 Multiple gensets, 2 shaft generators, 2 busbars

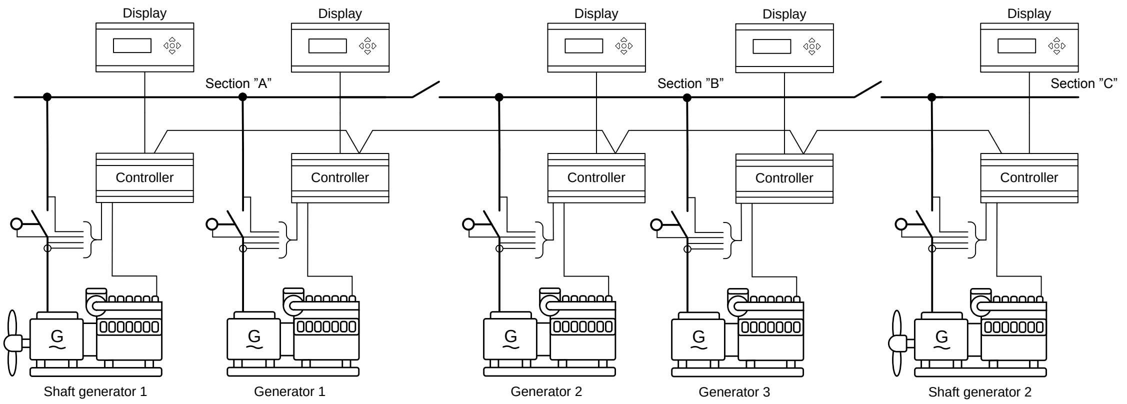
This system can handle two to 16 diesel generators and two shaft generators.



Diesel generators can be added on both sides of the bus tie breaker.

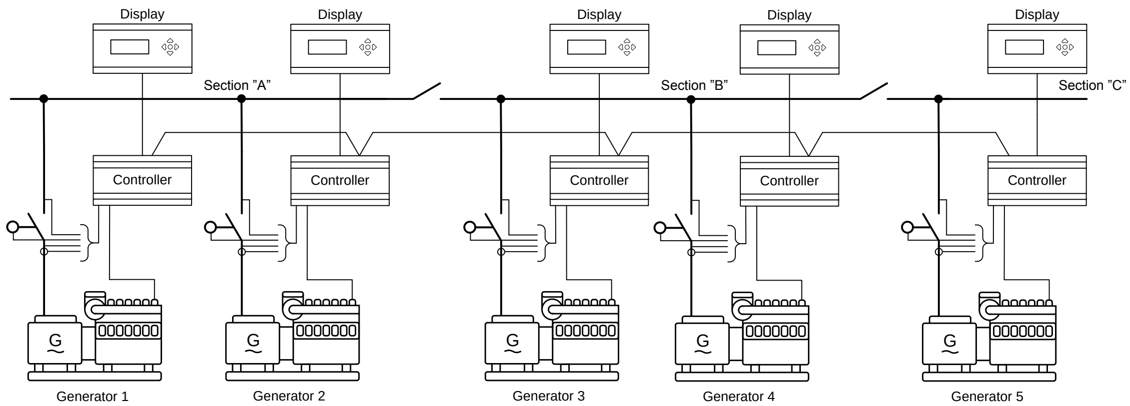
4.10.7 Multiple gensets, 2 shaft generators, 3 busbars

This system can handle two to 16 diesel generators and two shaft generators.



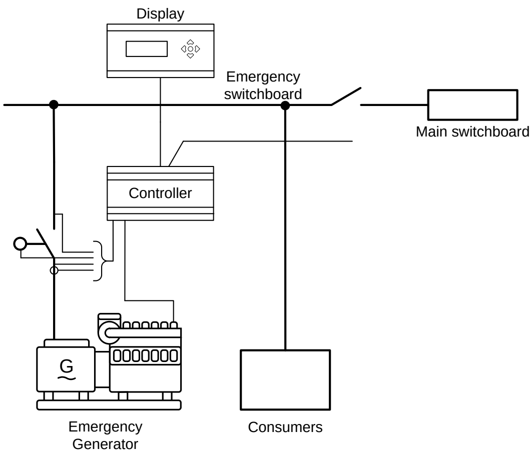
4.10.8 Multiple gensets, multiple busbars

This system can handle two to 16 diesel generators and up to eight bus tie breakers.



Diesel generators can be added to any section.

4.10.9 Emergency generator



With an emergency generator in the system, a maximum of 15 diesel generators can be controlled.

4.11 Flowcharts

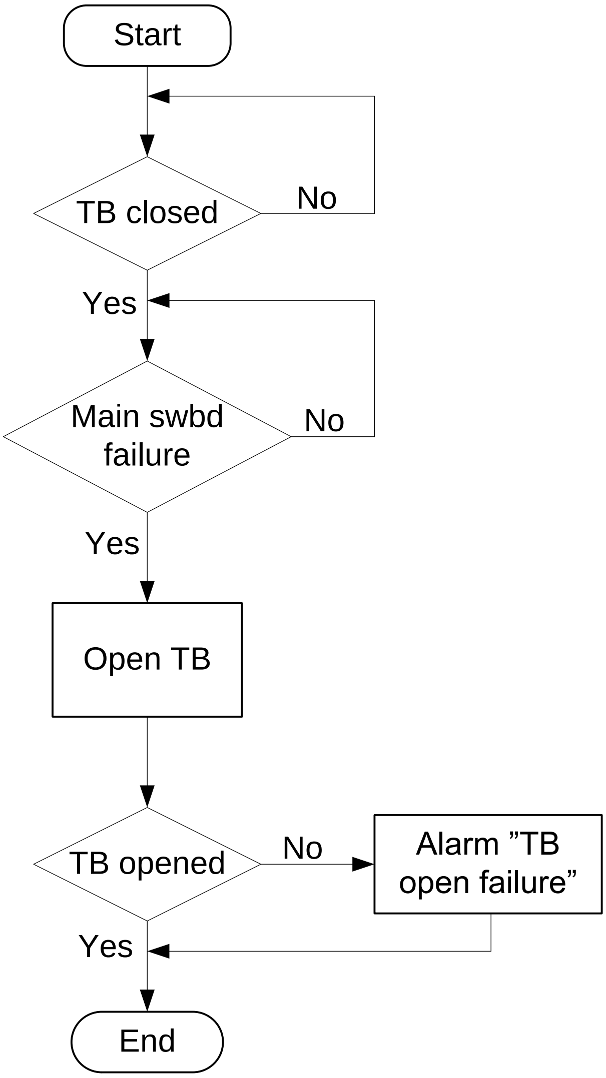
4.11.1 How to use flowcharts

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

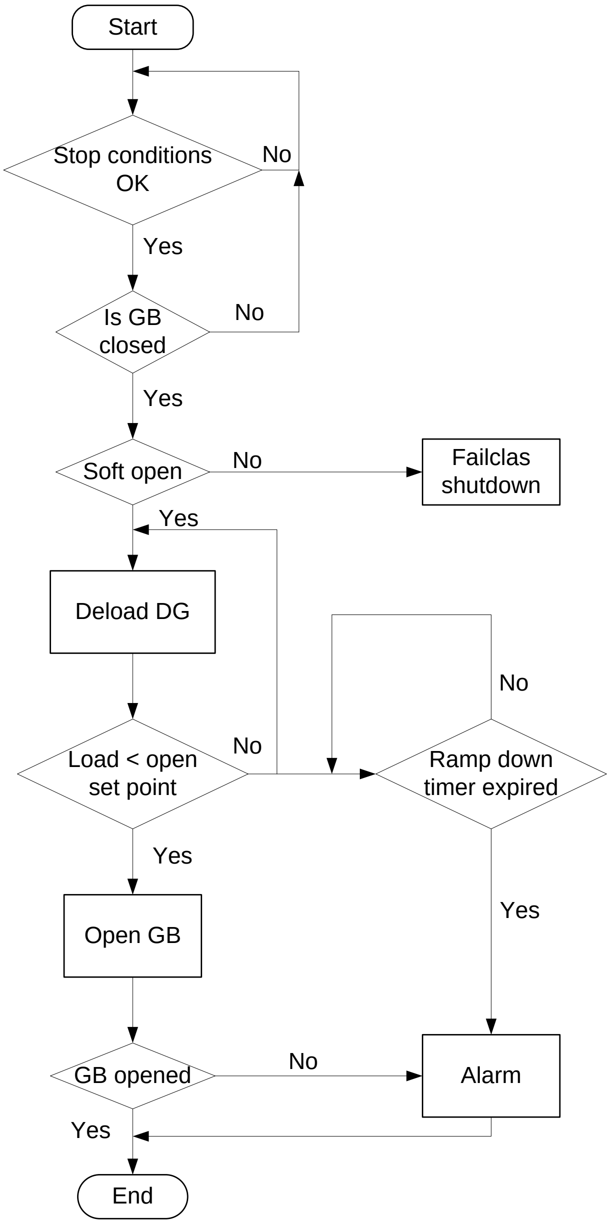
- TB open sequence (emergency generator)
- GB open sequence
- Stop sequence
- Start sequence
- TB close sequence (emergency generator)
- GB close sequence
- Base load
- Emergency generator running
- Emergency generator test sequence

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

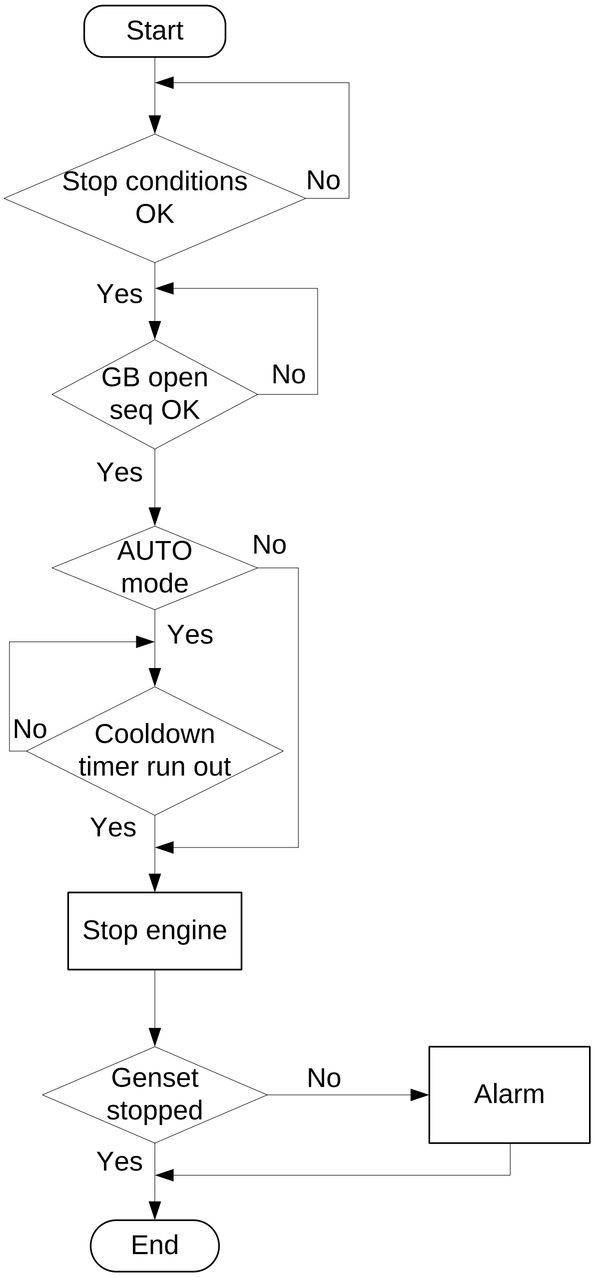
4.11.2 TB open sequence (emergency generator)



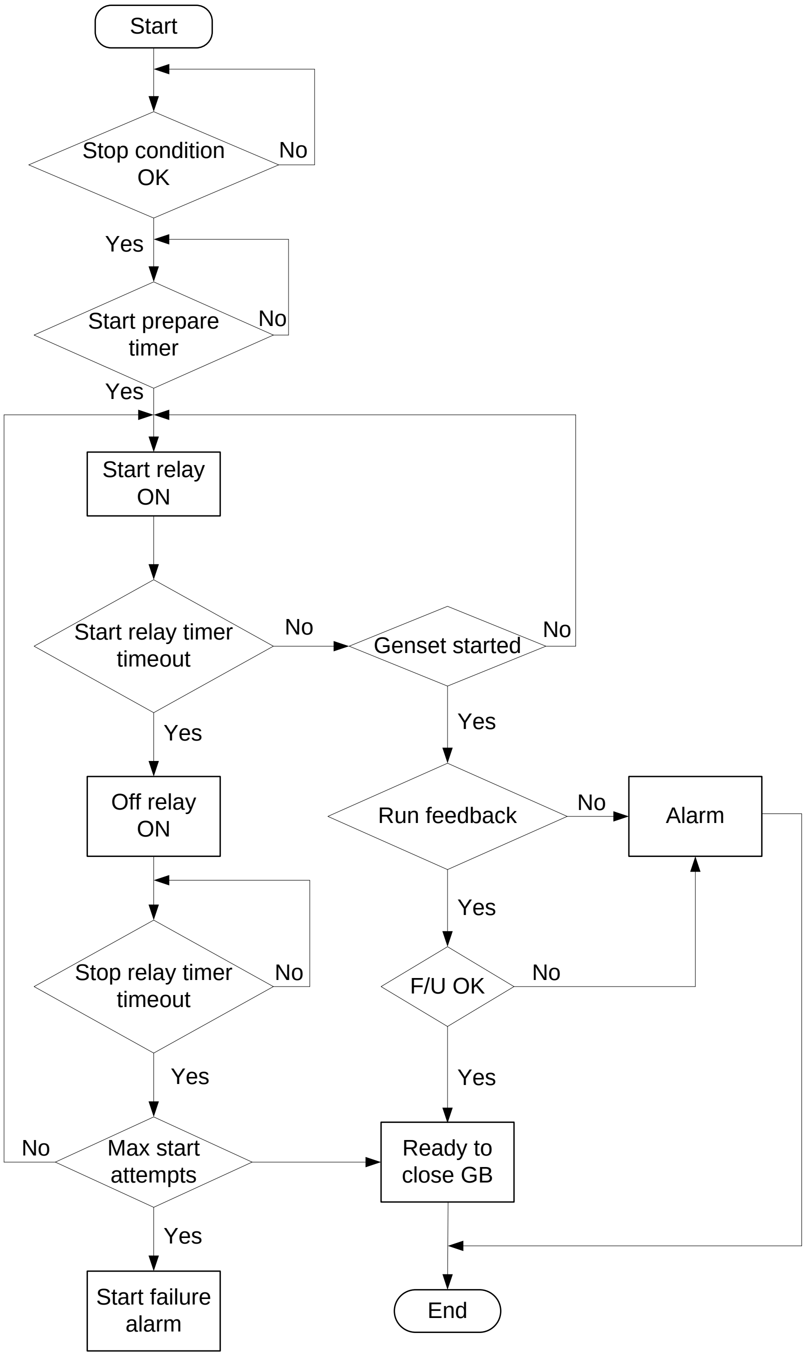
4.11.3 GB open sequence



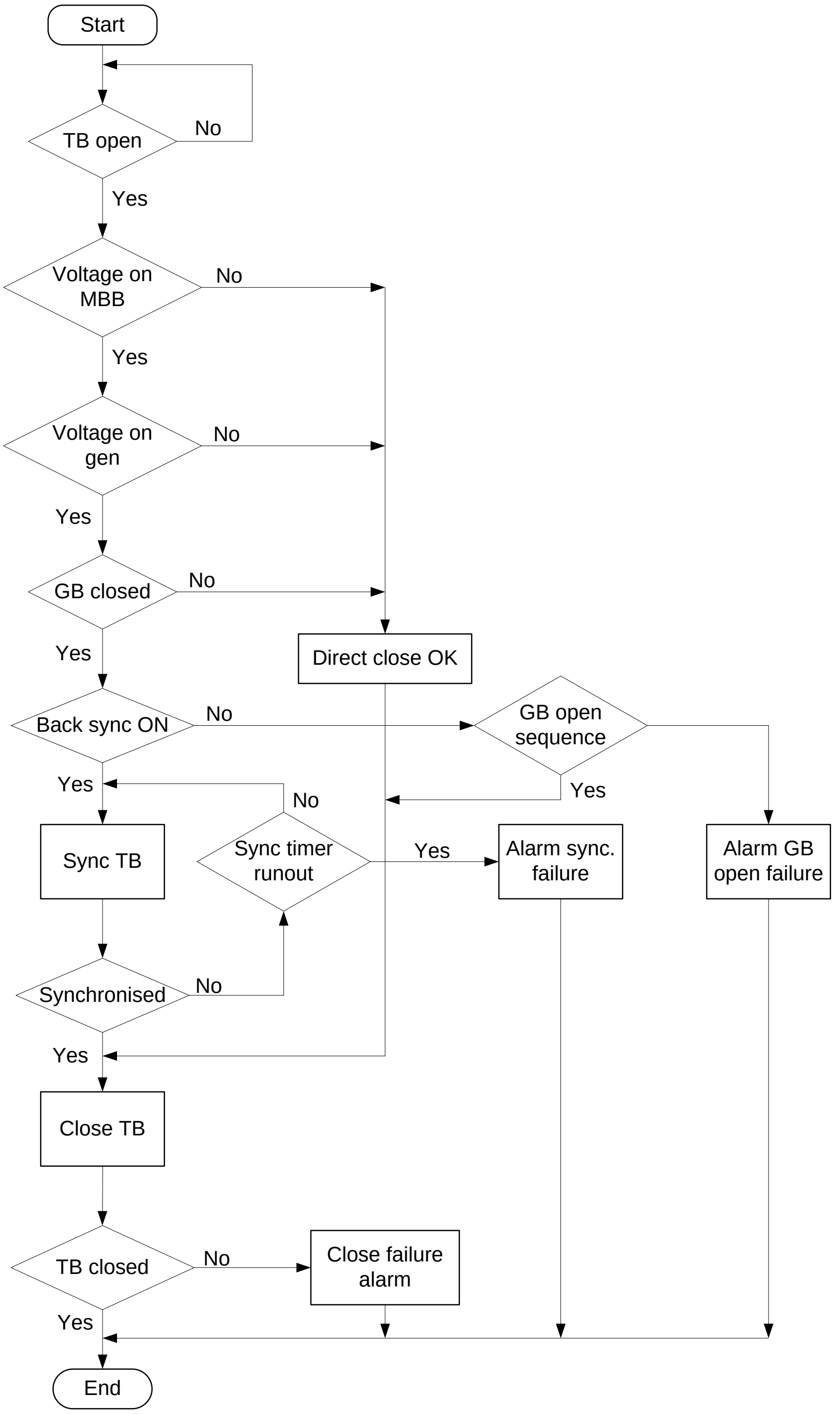
4.11.4 Stop sequence



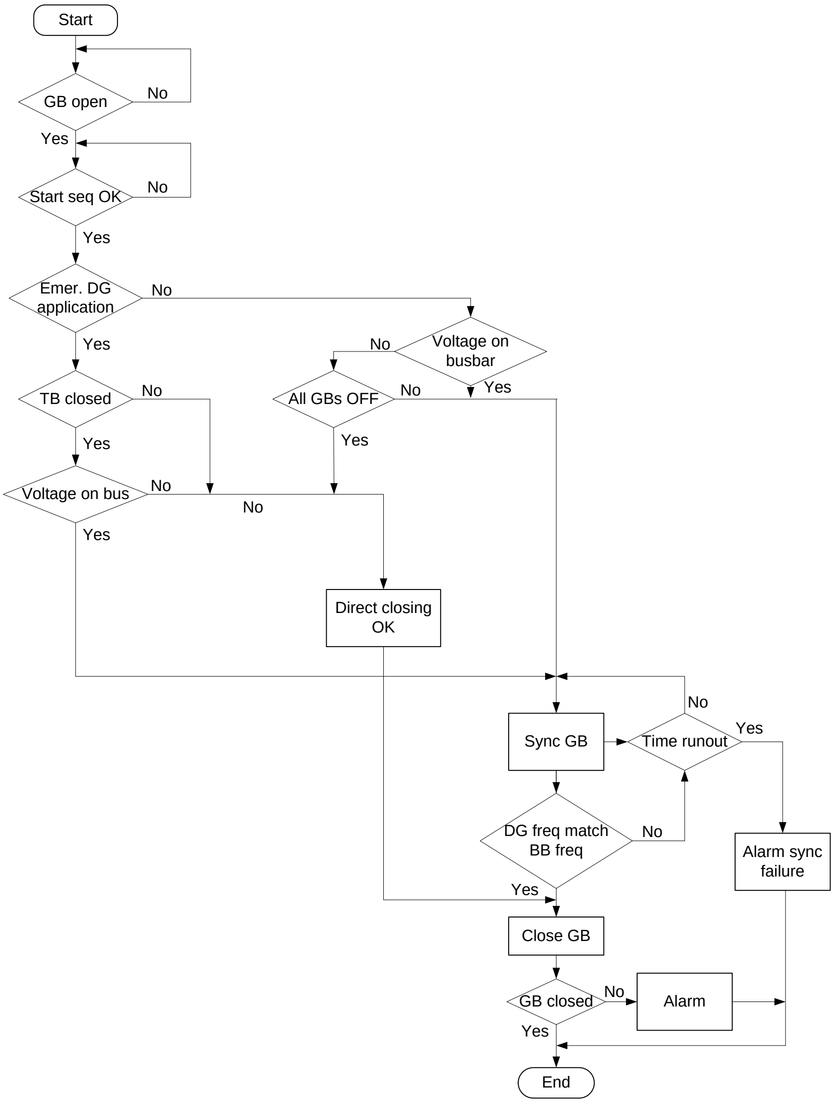
4.11.5 Start sequence



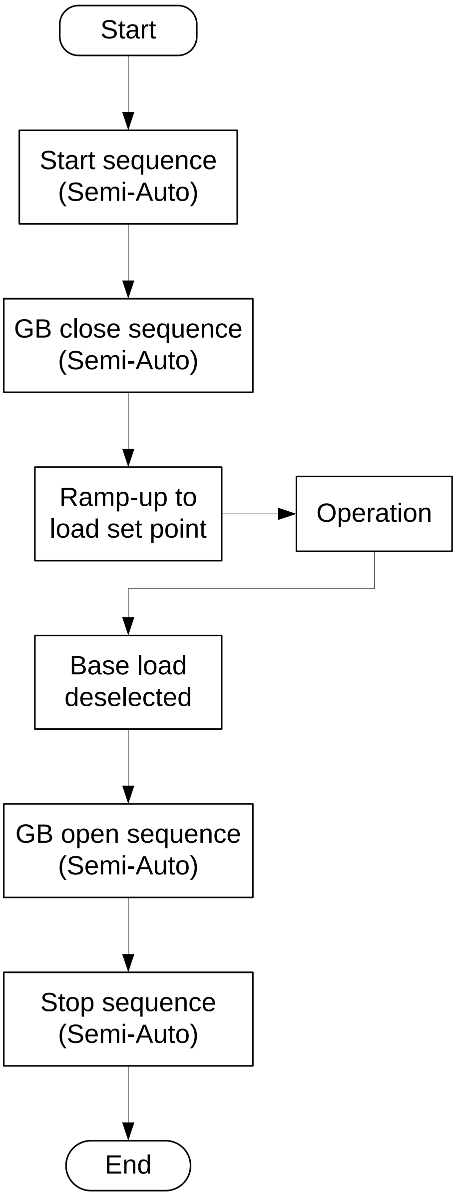
4.11.6 TB close sequence (emergency generator)



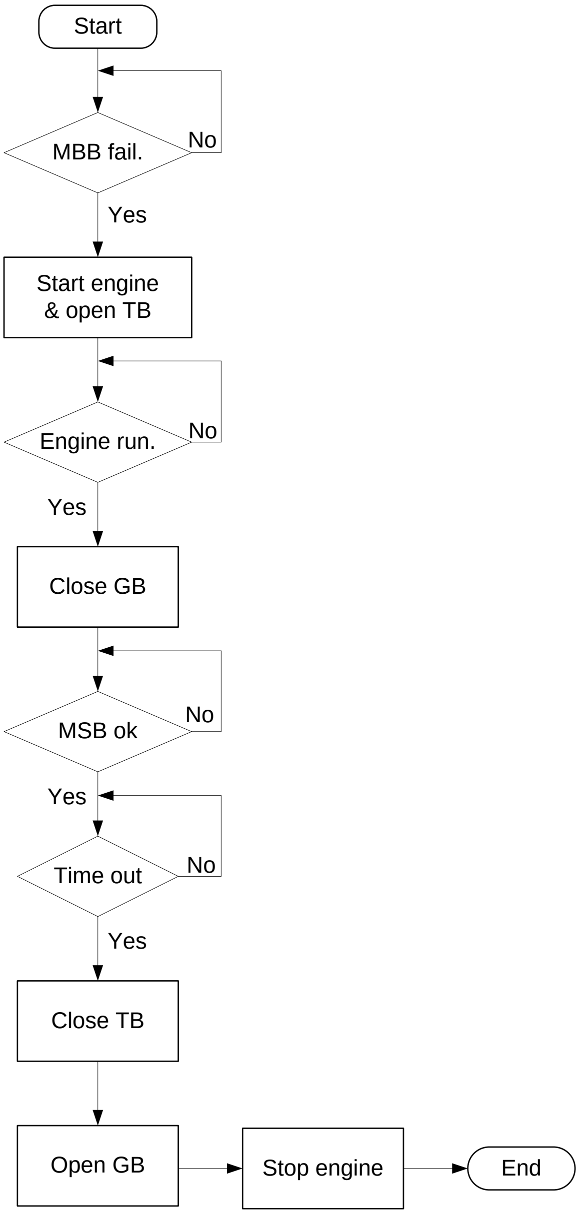
4.11.7 GB close sequence



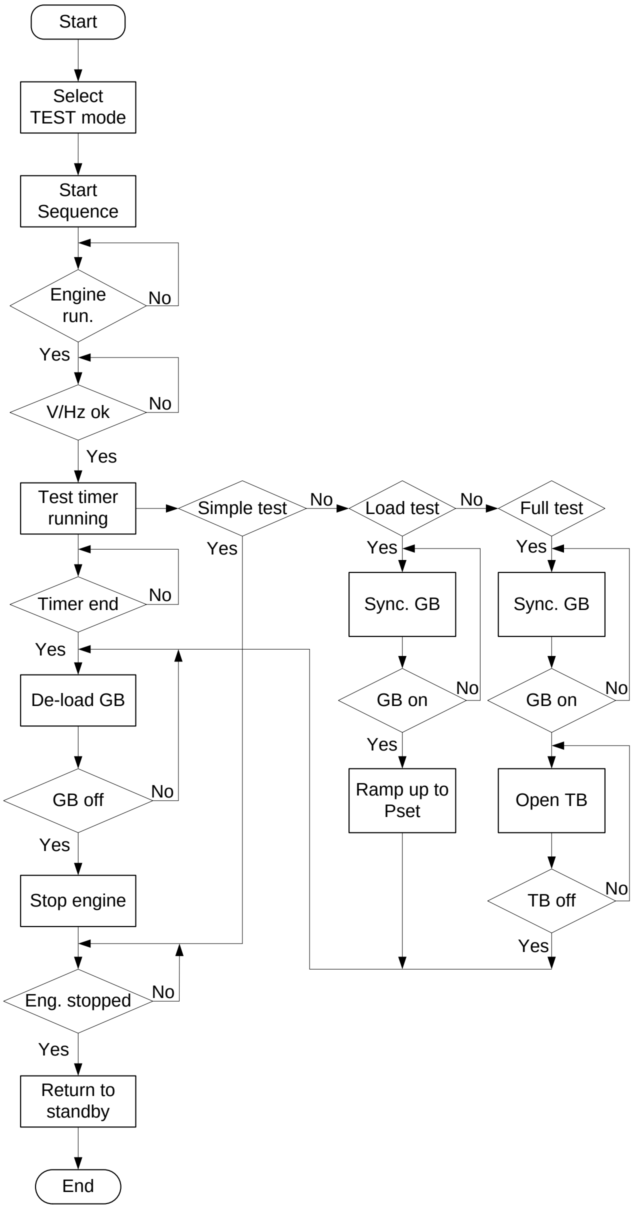
4.11.8 Base load



4.11.9 Emergency generator running



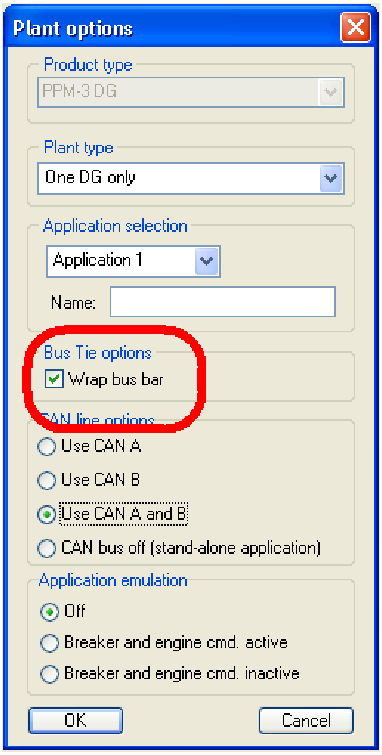
4.11.10 Emergency generator test sequence



4.12 Wrapped busbar

4.12.1 Wrapped busbar

The wrapped busbar selection is made in the application configuration tool in the USW.



To allow closed ring connection on the busbar, parameter 8990 (Closed Ring) is selected to ON.
When requesting BTB open with a closed ring connection, the BTB that is requested will trip the breaker. De-load will not be performed!

4.13 Sequences

4.13.1 Sequences

The following contains information about the sequences of the engine, the generator breaker and, if installed, the bus tie 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 (for example, press the START push-button: The engine will start, but no subsequent synchronising is initiated).

The following sequences will be illustrated below:

- START sequence
- STOP sequence

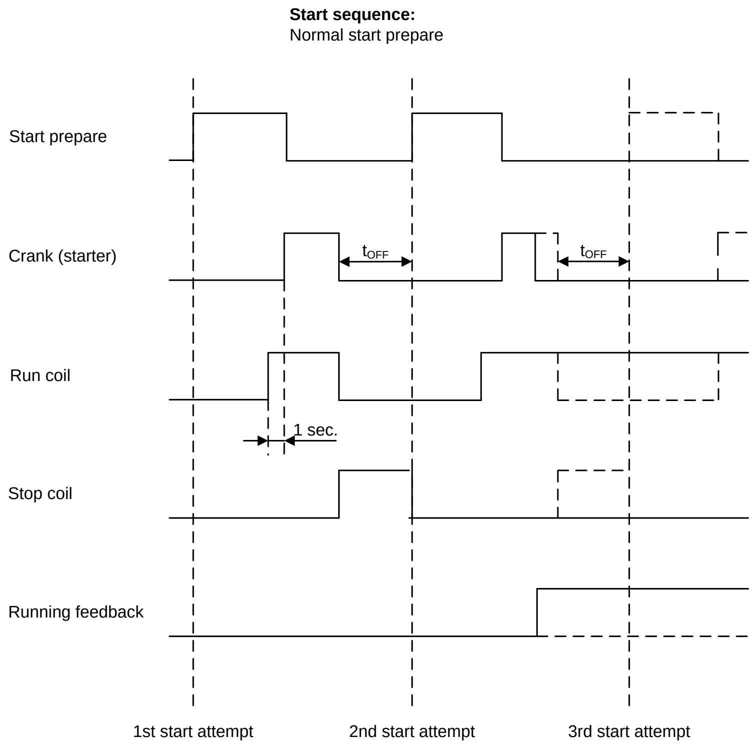
- Breaker sequences

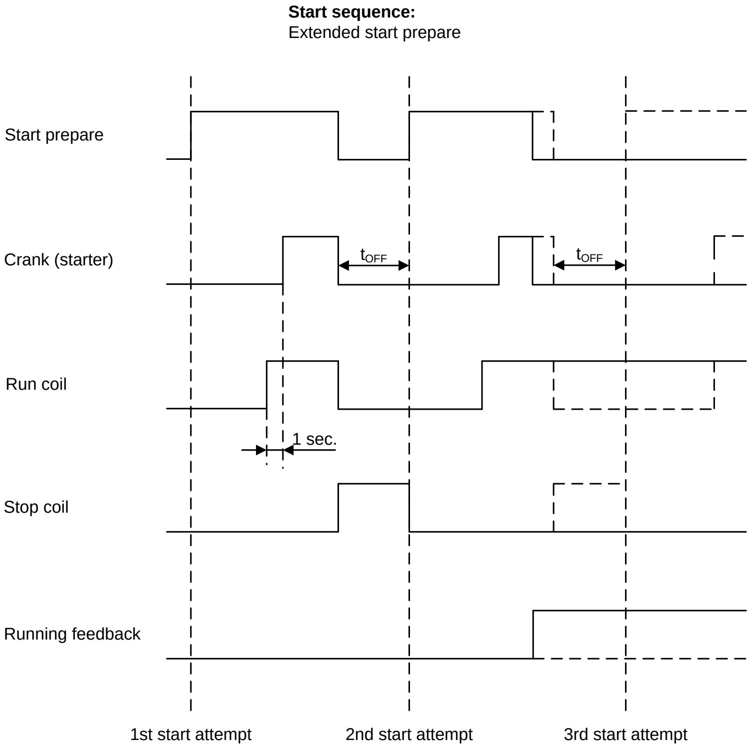
Refer to the installation instructions for information about the required breaker wiring.

4.13.2 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 the start prepare function; the running coil is activated 1 s before the start relay (starter).





4.13.3 Start sequence conditions

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

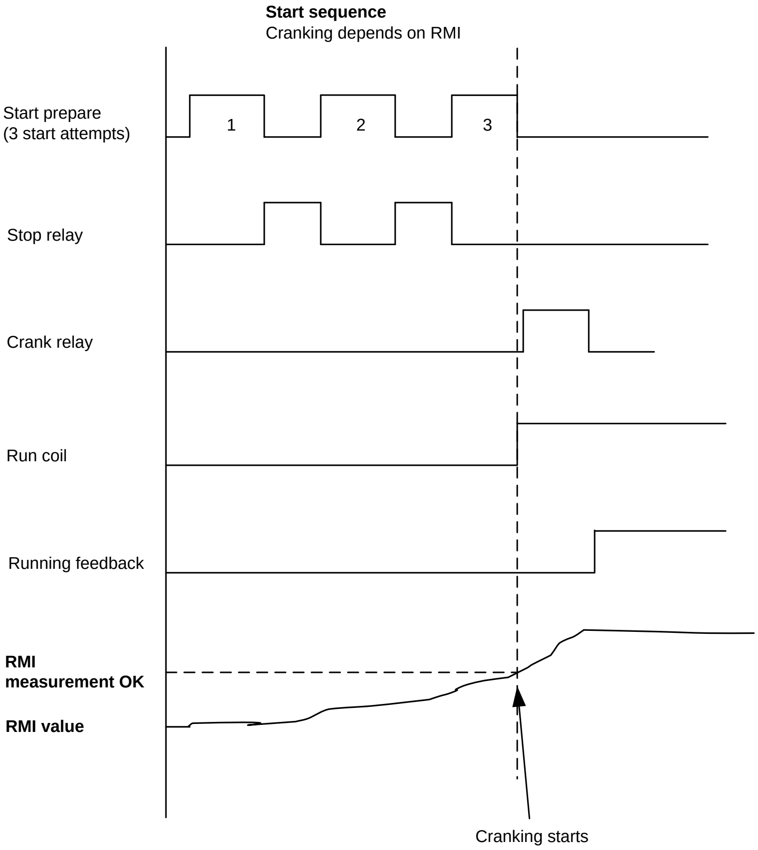
- RMI 22 (oil pressure)
- RMI 23 (fuel level)
- RMI 35 (water temperature)

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

The selection is made in setting 6185. For each of the RMI settings, the rule is that the value (oil press, fuel level or water temp) must exceed the setting 6186 selected value before the starting sequence is initiated.

If the value in 6186 is set to 0.0, the start sequence is initiated as soon as requested for.

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



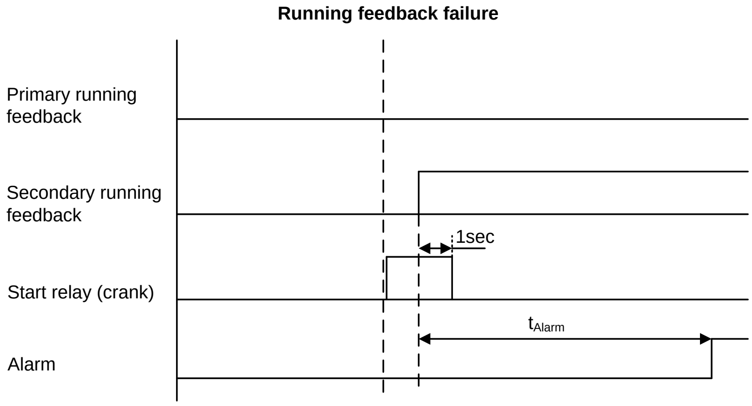
4.13.4 Running feedback

Different types of running feedback can be used to detect if the engine 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 one additional second. If a running feedback is detected based on one of the secondary choices, the genset will be considered running. 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.



4.13.5 Interruption of start sequence

The start sequence is interrupted in the following situations:

Event	Comment
Stop signal	
Start failure	
Remove starter feedback	Tacho set point.
Running feedback	Digital input.
Running feedback	Tacho set point.
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 set point (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.
Running mode	It is not possible to change the running mode to "block" as long as the gen-set is running.

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".

Set points 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, for example 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 **(4560 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, for example pre-lubrication or pre-glowing. The start prepare relay is activated when the start sequence is initiated and deactivated when the start relay is activated. If the timer is set to 0.0 s, the start prepare function is deactivated.

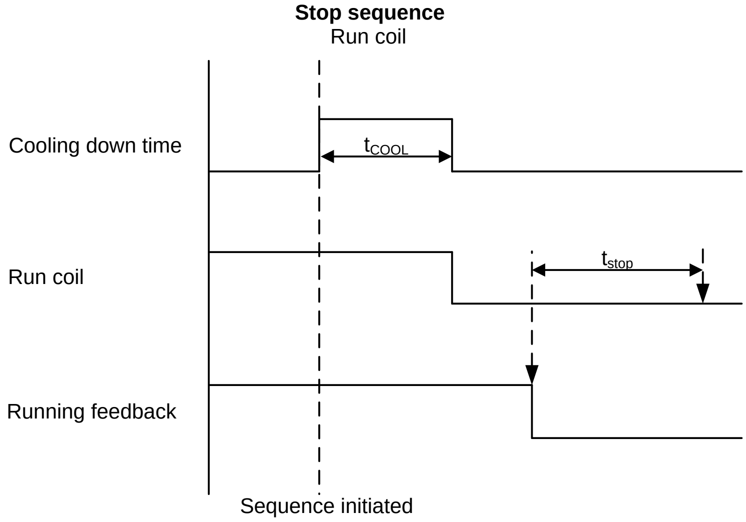
Extended prepare: The extended prepare will activate the start prepare relay when the start sequence is initiated and keep it activated when the start relay activates until the specified time has expired. If the extended prepare time exceeds the start ON time, the start prepare relay is deactivated when the start relay deactivates. If the timer is set to 0.0 s, the extended prepare function is deactivated.

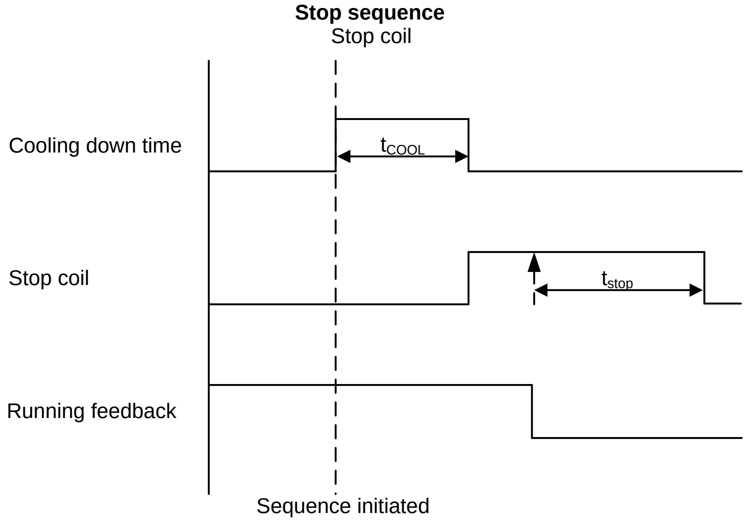
Start ON time: The starter will be activated for this period when cranking.

Start OFF time: The pause between two start attempts.

4.13.6 Stop sequence

The drawings illustrate the stop sequence.





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
PMS stop	X	X	Auto mode: The set point for load-dependent stop has been exceeded
Trip and stop alarm	X	X	Alarm sequence
Stop button on display		X	Semi-auto mode
Emergency stop		X	GB trips and engine shuts down

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

Event	Comment
Start button is pressed	Semi-auto mode: Engine will run in idle speed
PMS start	Auto mode: The set point for starting the next standby generator has been exceeded
GB close button is pressed	Semi-auto mode only
Main switchboard blackout	Active in semi-auto, auto or test mode

When the engine is stopped, the analogue speed governor output is reset to the offset value if option E1, E2, EF2 or EF4 is selected. See the mentioned option descriptions.

4.13.7 Set points 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.
Type: Input selection for the *temperature-dependent cool down* function. Available inputs are *multi-input, M-Logic* or *EIC.*
Set point: Temperature set point for the *temperature-dependent cool down* function.

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

4.13.8 Temperature-dependent cool down

This function allows the controller to skip the cool down time under the stop sequence if the measured temperature is at the set point or below. If engine communication (option H5/H7) is used, the engine temperature can be measured this way if you choose EIC in parameter 6213. Multi-inputs are also selectable in this parameter, as well as M-Logic.

4.13.9 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
SWBD	All	None
Block (fail class)	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.

4.13.10 7080 TB control (EDG only)

If a blackout of the main busbar appears, the system will initially start additional main generators to deal with the situation. If that is not possible, the following will take place (provided the EDG is in AUTO mode):

- The tie breaker is opened.
- The EDG is started.
- Once the generator voltage and frequency is within limits (2110 sync blackout), the EDG breaker will be closed.

On return of one or more main generators, these will be started. The first generator ready will make a blackout closing, the subsequent generators will synchronise.

When the main busbar is live, the emergency generator automatically goes offline when in auto mode:

- The tie breaker will be synchronised.
- The EDG will be de-loaded and the EDG breaker opened.
- The EDG will cool down and stop.

5. Application setup

5.1 Initial application setup

The PPM-3 application can be configured either by using the PPM-3 display or by using the DEIF utility software.

5.1.1 Unit type setup

Enter the menu 9100 using the JUMP push-button. Select the PPM-3 type to one of the following:

1. DG unit
2. SG unit
3. SC unit
4. BTB unit
5. EDG unit

This setting is normally already done in the factory before delivery. When this setting has been adjusted, the device returns to factory settings! Therefore, this must be changed prior to other adjustments.

Enter the menu 9170 using the JUMP push-button. Select "can protocol 2" unless the PPM-3 unit is to be an addition to a system based on SW 2.xx.x. In that case, select "can protocol 1".

An alarm appears if CAN protocol 2 is needed.

5.1.2 PC software setup

In the utility software, the communication ID must be adjusted for each of the PPM-3 units.
In the screen shot below, the internal communication ID is set to 1.

Category	Channel	Text	Address	Value
Comm	7531	Int. comm. ID	566	1
Comm	7533	Miss. all units	568	N/A
Comm	7534	Fatal CAN error	569	N/A
Comm	7535	Any DG missing	570	N/A
Comm	7536	Any mains miss.	571	N/A
Comm	7881	Any BTB miss.	1183	N/A

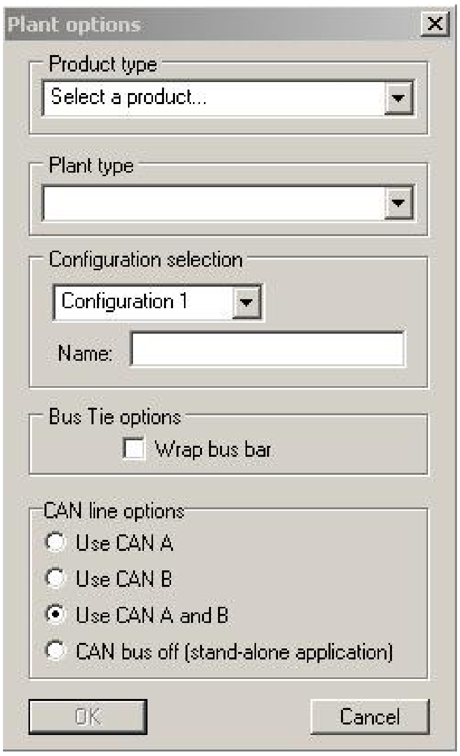
The numbering of the communication IDs must always start from the lowest number, so an application always includes a DG with ID1. The principle also follows the SG/SC units where the numbering starts from ID 17 and the BTB units where the numbering starts from ID 33.

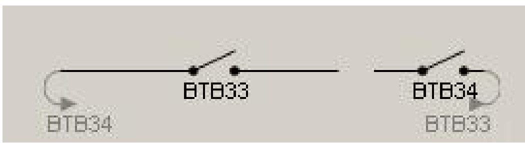
5.1.3 Application design

The application is designed through the utility software application configuration tool.

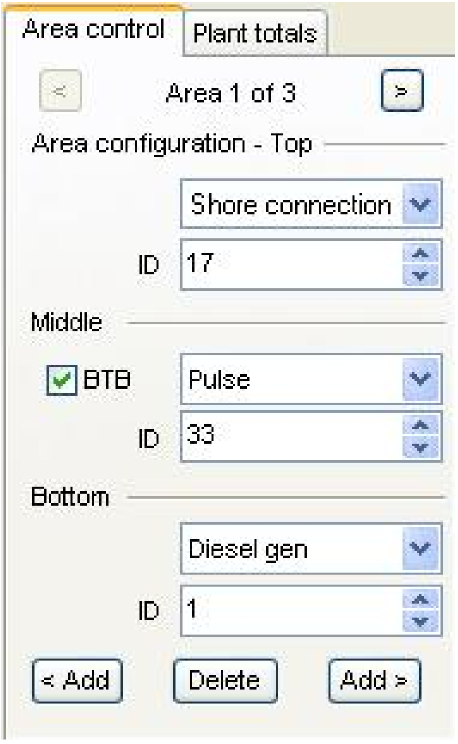
Select a new application.

Adjust the settings in this dialogue box.



	Description	Comments
Product type	Select PPM-3.	The other possible selection, AGC, is a power management system for land-based installations.
Plant type	Select standard.	Use "standard" if a power management application is needed.
Configuration selection	The PPM-3 is able to include four applications. One of these can be active. Write a proper name of your application.	Tick the "Active" field or adjust the selection in menu 9160.
Bus tie options	Select "Wrap busbar" if the BTBs are connected in a ring busbar connection.	
CAN line options	CAN line 1: connect A1 - A3. CAN line 2: connect B1 - B3.	

Now, the application can be designed using the section design panel.



For each section, it is defined whether a generator and a shaft generator and/or a shore connection is present, and the amount and type of breakers.

5.2 Remove a unit from the application

If one or more units have to be taken out of the power management system, the following possibilities exist, depending on the situation.

5.2.1 Auxiliary supply OFF

The auxiliary supply must be removed from the unit. This means that a CAN bus alarm occurs on the other PPM-3 units. The following alarms appear, that is in a 2 DG plant where ID2 is powered down:

Alarms	Functioning unit (ID1)
Communication alarm	CAN ID 2 MISSING
Menu 7533	Miss. all units
Menu 7535	Any DG missing

The alarms will be present at all times during the failure. A reconfiguration of the power plant is required to remove the alarms.

The operation mode changes according to the setting in CAN failure mode (menu 7532).

When the unit is reconnected, the ID will automatically be enabled again in the other units when the ID has been recognised. If the unit that is reconnected is a new unit with the factory settings set in the parameter file, a "Duplicate CAN ID" error message will appear. When an ID is chosen for the new unit, and the ID chosen is already active in another device, the error message "CAN ID not available" will appear, and the ID is reset to the start value.

5.2.2 Auxiliary supply ON

If a failure appears on the CAN bus lines of a unit, the following alarms appear in the example where a failure appears at ID2:

Alarms	Defective unit	Functioning unit
Communication alarm	CAN ID 1 MISSING	CAN ID 2 MISSING
Menu 7533	Miss. all units	Miss. all units
Menu 7535	Any DG missing	Any DG missing

If the auxiliary supply of the unit where the CAN bus is not functioning is connected, the unit can be adjusted to another operational mode than AUTO. In that case the genset will not take part in the power management routines.

Semi-automatic start or automatic start is possible if the mode is changed to SEMI or AUTO mode. The only exception to this is when SWBD mode is selected on a genset PPM unit. In this situation, the GB can be closed without being given allowance from the power management system but only manually by the operator from the switchboard.

5.3 CAN bus failure handling

5.3.1 CAN failure mode

In case of a CAN failure on the internal CAN controlling the power management, the system can be set up in different ways. In menu 7530, it is decided how the power management system will react in case of a CAN failure.

1. If "**SWBD**" is selected, all PPM-3 units will change mode to SWBD mode, and this way the regulators will have no reaction, and it will only be possible to close any breakers manually from the switchboard.

Example 1:

- A wire break on the CAN line is made between ID1 and ID2 shown below.
- Both gensets are running and all breakers are closed.

When a wire break occurs, the regulators will stop on both gensets, but they will stay online. As the gensets have no valid information about the other unit, over time a blackout can occur, as no load sharing is active between the units.

If for example six gensets are available in an island application, and the CAN failure happens between ID3 and ID4, the load sharing will still be disabled between all units, as the units are forced to be under switchboard control.

If the CAN error happens when no gensets are running, it will block the whole system and it will not be possible to start any gensets, before the CAN error has been fixed.

2. If "**SEMI-AUTO**" is selected, all PPM-3 units will change mode to semi-auto mode, and in this way, the regulators will continue to regulate the load on the gensets which are still "visible" on the internal CAN communication. This means that in the example with six gensets, the load sharing will continue between the units that are still connected (ID1-ID3 and ID4-ID6).

If the CAN bus error is present on both CAN bus lines and no generator breakers are closed, it will be possible to close two breakers on the same busbar at the same time, which may result in fatal damage to the whole system.

3. If "No mode change" is selected, all PPM-3 units will stay in the mode they were in before the failure appeared.

This setting makes it possible to keep the system in Auto mode in case of a CAN failure, however, the faulty unit will not be a part of the power management, since it cannot send or receive status and commands on the CAN bus.

If this selection is used, it is recommended to use the CAN bus fail class settings to disconnect the faulty units (see "CAN bus fail class" in this chapter).

If the CAN bus error is present on both CAN bus lines and no generator breakers are closed, it will be possible to close two breakers on the same busbar at the same time, which may result in fatal damage to the whole system.

5.3.2 Redundant CAN bus communication

It is possible to use two CAN bus communication lines; CAN I/F 1 (A1/A2/A3) and CAN I/F 2 (B1/B2/B3). This way, the communication will be redundant, and if one of the CAN bus communication lines is damaged, the application will still continue in Auto mode with full functionality.

5.3.3 CAN bus alarms

The following alarms can be displayed on a PPM-3 unit in case of CAN bus communication failures:

- CAN1 ID X MISSING
  The PPM-3 unit has lost CAN bus communication to one or more CAN IDs on CAN bus I/F 1.
- CAN1 SG X MISSING
  The PPM-3 unit has lost CAN bus communication to the PPM-3 SG unit on CAN bus I/F 1.
- CAN1 BTB X MISSING
  The PPM-3 unit has lost CAN bus communication to the PPM-3 BTB unit on CAN bus I/F 1.
- CAN2 ID X MISSING
  The PPM-3 unit has lost CAN bus communication to one or more CAN IDs on CAN bus I/F 2.
- CAN2 SG X MISSING
  The PPM-3 unit has lost CAN bus communication to the PPM-3 SG unit on CAN bus I/F 2.
- CAN2 BTB X MISSING
  The PPM-3 unit has lost CAN bus communication to the PPM-3 BTB unit on CAN bus I/F 2.

- MISSING ALL UNITS
  The PPM-3 unit has lost the CAN bus communication to all the other units. The fail class set in menu 7533 will be executed.

- FATAL CAN ERROR
  The PPM-3 unit has lost CAN bus communication to more than one CAN ID on the CAN bus line. The fail class set in menu 7534 will be executed.

- ANY DG MISSING
  The PPM-3 unit has lost CAN bus communication to one of the generator CAN IDs on the CAN bus line. The fail class set in menu 7535 will be executed.

- ANY SG MISSING
  The PPM-3 unit has lost CAN bus communication to one of the other shaft generator CAN IDs on the CAN bus line. The fail class set in menu 7536 will be executed.

- ANY BTB MISSING
  The PPM-3 unit has lost CAN bus communication to one of the BTB CAN IDs on the CAN bus line. The fail class set in menu 7536 will be executed.

5.3.4 CAN bus fail class

In menu 7530, it is possible to set a fail class of the following CAN bus alarms:

- Missing all units
- Fatal CAN error
- Any DG missing
- Any SG missing

By using these settings, it is possible to disconnect the faulty units and in this way keep the system running in Auto mode. (Depends on the setting 7532.)

5.4 Relay

5.4.1 Relay setup

The PPM-3 has several relay outputs available. Each of these relays can be given a special function depending on the required functionality. This is done in the I/O setup (menu 5000-5270).

Relay functions
There are six available functions:

Function	Description
Alarm relay NE	The relay is energised until the alarm occurs. From here, the relay stays deactivated until the alarm is acknowledged and gone. Based on the alarm, the relay will either send out a signal or not, depending on its physical setup (normally open or normally closed).
Limit relay	The relay will activate at the limit set point. No alarm will appear when both outputs (OA/OB) of the alarm are adjusted to the limit relay. After the condition activating this relay has returned to normal, the relay will deactivate when the "OFF delay" has expired. The OFF delay is adjustable.
Horn relay	The output activates on all alarms. For a detailed description, see the chapter "Horn output".
Siren relay	The output activates on all alarms, like "Horn output". If the relay is ON and another alarm is active, a short-time reset will be activated.
Alarm relay ND	The relay is de-energised until the alarm occurs. From here, the relay stays activated until the alarm is acknowledged and gone. Based on the alarm, the relay will either send out a signal or not, depending on its physical setup (normally open or normally closed).
Common alarm	The output activates all alarms, like "Horn output". If the relay is ON and another alarm is active, a short-time reset will be activated. The common alarm output will be activated as long as there is an active alarm - also if the alarm is acknowledged.

5.5 Self-check

5.5.1 Self-check

The PPM-3 has a self-check function and a status relay output that responds to this function. The status relay is prepared for 24 V DC/1 A, and it is normally energised.

The self-check is monitoring the programme execution. Should this fail, that is in the unlikely event of a microprocessor failure, then the self-check function deactivates the status relay.

Use the output from the status relay to perform a proper action for the genset application. Typically, this would mean a shutdown of the genset since it is now operating without protection and control.

The protections in the PPM-3 are not functioning when the self-check function deactivates the status relay.

There are two "Self-check ok" LEDs on the PPM-3. One is placed on the display and one on the main unit. The LEDs are lit when the unit is fully operational.

5.6 Password

5.6.1 Password

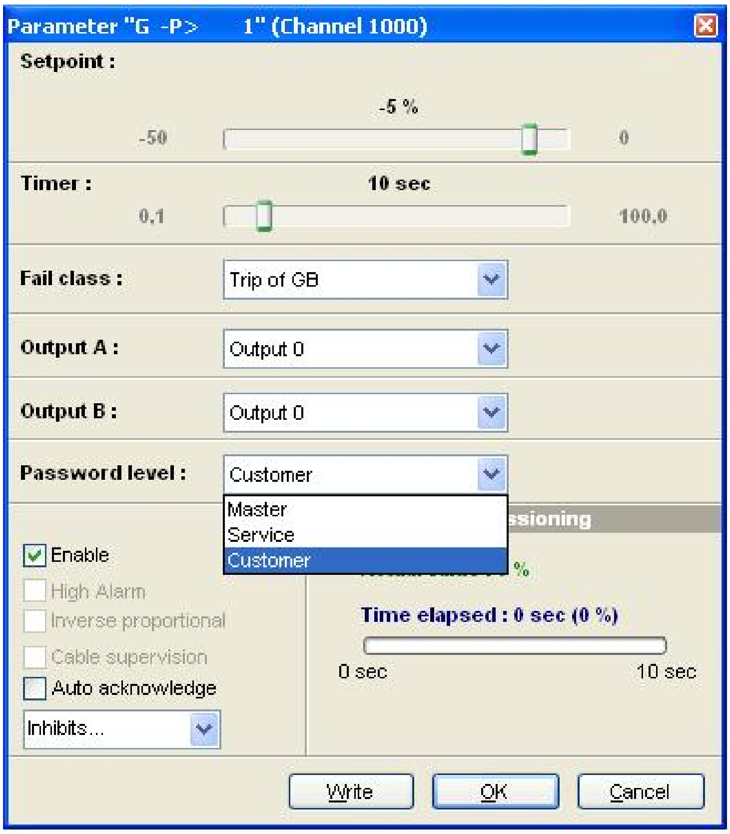
The unit includes three password levels. All levels can be adjusted in the PC software.

Available password levels:

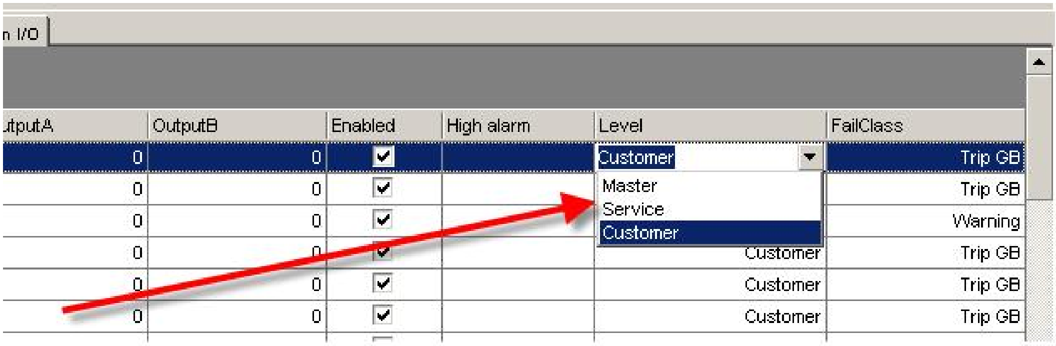
Password level	Factory setting	Access		
		Customer	Service	Master
Customer	2000	X		
Service	2001	X	X	
Master	2002	X	X	X

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

Each parameter can be protected by 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".



5.6.2 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.

The customer password can be changed in jump menu 9116. The service password can be changed in jump menu 9117. The master password can be changed in jump menu 9118.

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

It is not possible to change the password at a higher level than the password entered.

6. Power management functions

6.1 Multi-master system

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

6.1.1 Command unit

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

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

6.2 Load-dependent starting and stopping

6.2.1 Load-dependent start/stop function

The load-dependent start/stop function is active when the AUTO mode is selected. The start/stop function transmits a PMS start/stop command, which is based on a calculation of how many generator sets are needed in order to satisfy the actual power demand at the busbar.

The PMS start/stop command causes the individual generator sets to carry out the start/stop according to the programmed start priority. The calculation of the load-dependent PM start/stop command is based on a comparison of the programmed start/stop limit.

The load-dependent start/stop function can be selected as a power value or in percentage. The power value can be chosen in power (kW) or apparent power (kVA).

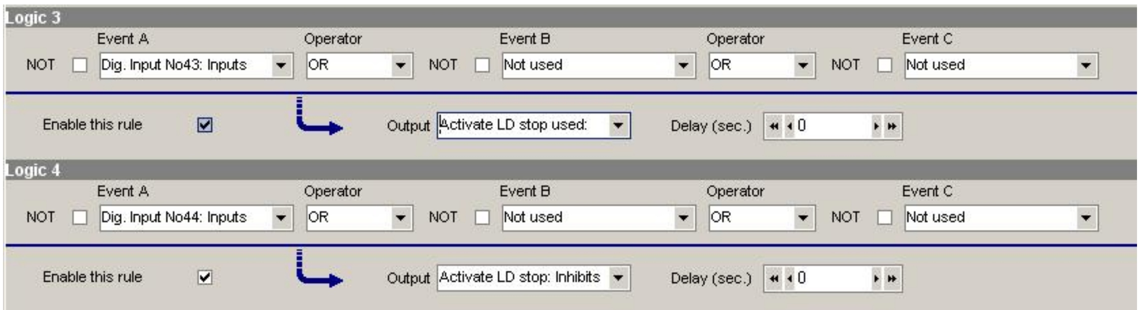
6.2.2 Terminology

The table shows the abbreviations used.

Short	Description	Comment
$P_{NOMINAL}$	Nominal power	The nominal power is the power rating of a generator.
$P_{CONNECTED}$	Connected power	Sum of the nominal power of all connected gensets.
$P_{CONSUMED}$	Consumed power	The amount of power consumed in a system by motors, pumps, and so on.
$P_{AVAILABLE}$	Available power	$P_{AVAILABLE} = P_{CONNECTED} - P_{CONSUMED}$. The power available for consumers.

Deactivate load-dependent stop
Through M-Logic, the load-dependent stop can be deactivated if this should be preferred. This can, for example, be used during harbour manoeuvring.

In the example below, the function is activated with terminal 43. Now the operator can switch the load-dependent stop ON or OFF with a switch connected to terminal 43.



6.2.3 The produced power method

This method is in effect if percentage is selected as basis for the start/stop calculation. If the load percentage of a generator exceeds the load-dependent start set point, the start sequence of the next generator in stand-by will be initiated. The generator is selected using the priority so the generator with the second highest priority will be started. For example, if a generator with priority 1 is running, then the next generator to start is the generator with priority 2. Only generators in AUTO mode and ready for operation will be started using load-dependent start.

If the load percentage of the system drops below the load-dependent stop set point, the stop sequence of the running generator with the lowest priority will be initiated. For example, if the generators with priority 1 (high priority) and priority 2 (low priority) are running and the load drops below the load-dependent stop limit, then the generator with priority 2 (lowest priority) will stop.

Note that the load-dependent stop limit is for the remaining running generator or generators. For example, if the load-dependent stop set point is 70 % and the last generator (lowest priority) is stopped, the load must not be higher than 70 % on the remaining generators.

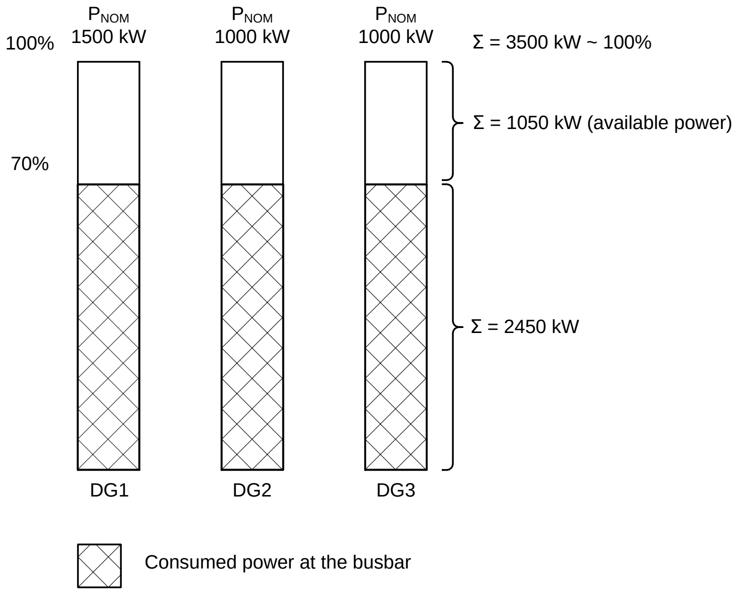
6.2.4 The available power method

This method is in effect if Value is selected as basis for the start/stop calculation.

Independent of choice (P [kW] or S [kVA]), the functionalities are basically identical; therefore the principle explanation of the functionality will be done for the load-dependent start function with selected rated power (P) value.

The apparent power set point is typically selected, if connected load has an inductive character and the power factor is below 0.7.

Description
This drawing illustrates the terms used.



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

Connected power
The connected power is the summation of the nominal power of each individual genset connected to the busbar. In the example above, the plant consists of three DGs:

DG1 = 1500 kW
DG2 = 1000 kW
DG3 = 1000 kW

The connected power is 3500 kW.

Consumed power
The consumed power is defined as the load on the busbar. In the example above, the consumed power is indicated as the hatched area and the total of all three gensets = 2450 kW.

Available power
The available power is the difference between the power of the connected gensets and the consumed power from the ship's consumers. When the consumed power increases, the available power decreases.

In the example above, the system consists of three gensets with a connected power of 3500 kW. The consumed power is 2450 kW. The available power is the consumed power subtracted from the connected power.

The available power = 3500 kW - 2450 KW = 1050 kW.

6.2.5 Available power principle

One genset is running and supplying the load. The load increases which means that the available power decreases. When the load has increased so much that the load-dependent start set point has been reached, the next priority genset will be started in order to increase the amount of available power.

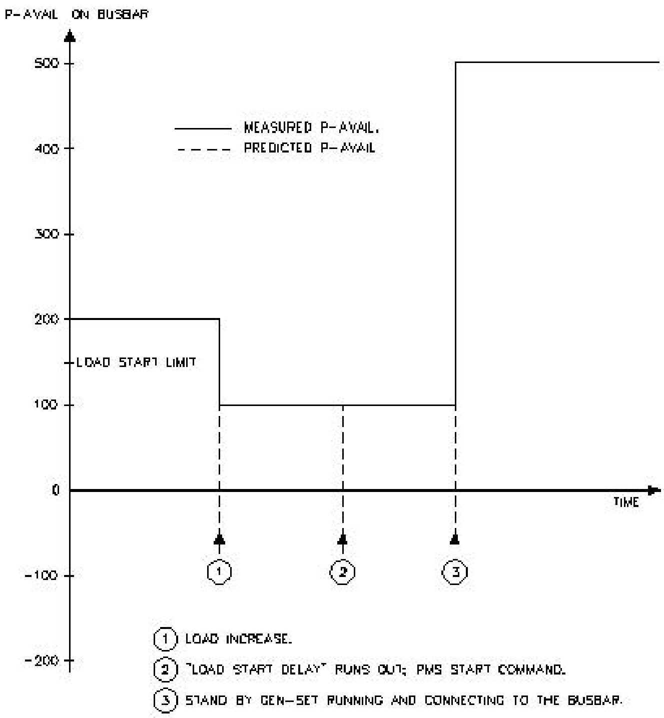
When the load drops, the available power will increase. When the available power has increased above the load-dependent stop set point plus the nominal power of the last priority genset, the last priority genset will be stopped.

Note that the nominal power of the genset to be stopped is added to the load-dependent stop set point. The reason is that otherwise the available power would immediately drop below the start level.

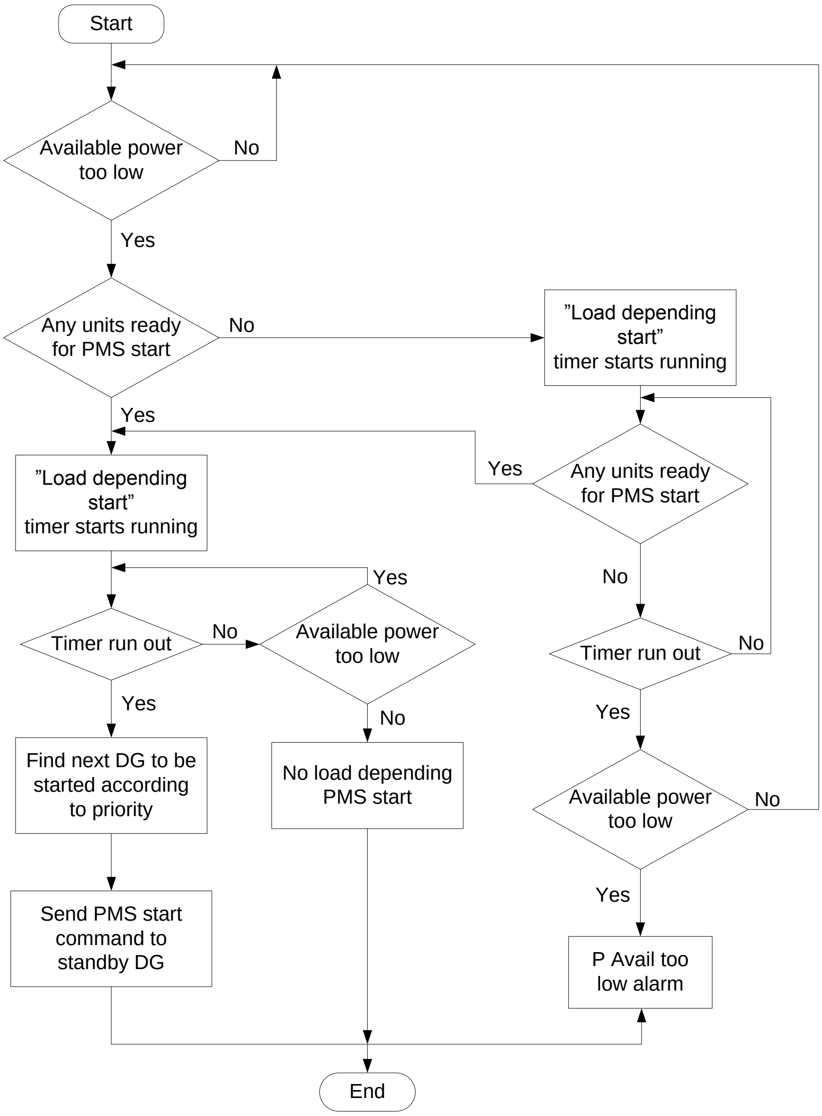
If the load-dependent stop set point is 200 kW and the genset with the last priority is 1000 kW, it is necessary that the available power reaches 1200 kW, because the available power will be reduced with 1000 kW immediately after the last priority genset is stopped.

6.2.6 Adjusting load-dependent start, available power method

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



6.2.7 Load-dependent start flowchart



6.2.8 Adjusting load-dependent stop, available power method

The load-dependent stop point is the highest acceptable available power value for the plant. If this value is reached or exceeded, a stop command will be sent to the running diesel generator, which is next in the stop order dependent on the start/stop priority.

The operator is able to adjust the following set points and timer, by which the transmission of the load-dependent PMS stop command is controlled.

The load-dependent stop function can be blocked by the following two functions:

- Via the set point (8035) whenever a heavy consumer is connected to the busbar,

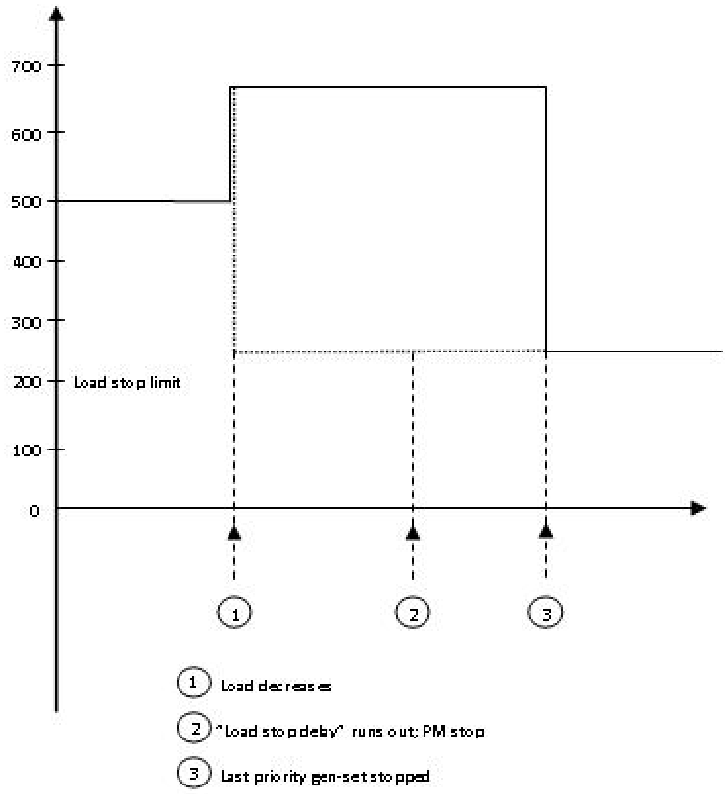
or

- whenever the binary input "load-dependent stop block" (term. 53 on DG 1) is set.

The load-dependent stop blocking function via the set point is automatically ignored, if there is **not** a heavy consumer (HC) connected to the busbar. The load-dependent stop blocking function via the binary input will be active as long as the input is set.
An active load-dependent stop timer is indicated as information message on the display.

In the example below, the available power is 500 kW. When the load decreases, the available power increases to 750 kW. The PPM-3 now calculates what happens, if the last priority genset is stopped. In the example below, the last priority genset is 400 kW which means that it can be stopped, because the available power will still be above the stop level.

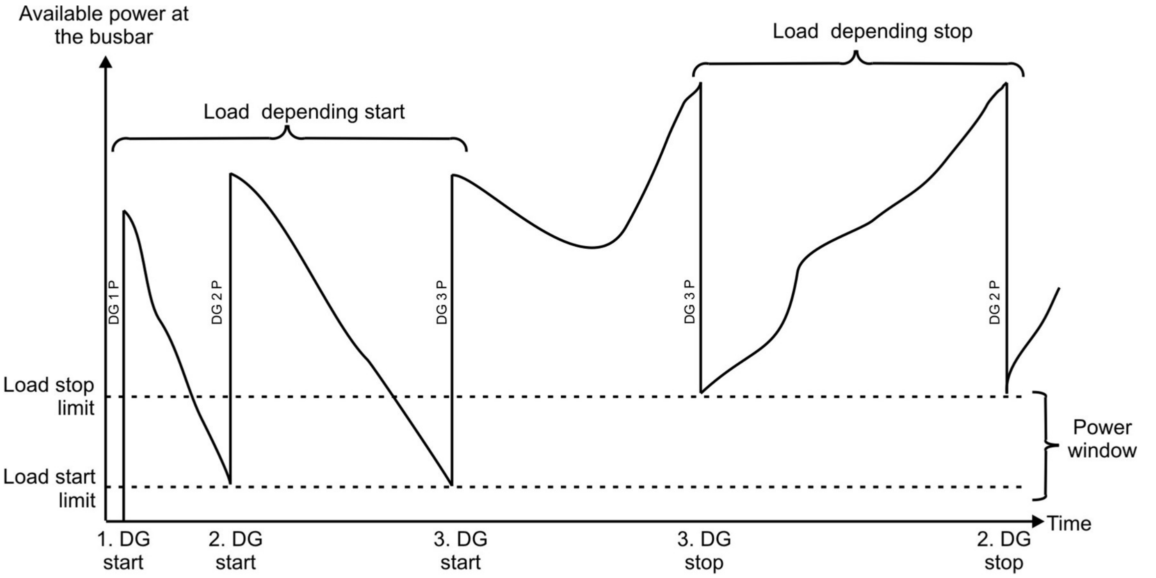
Now, the difference between the stop level and the available power is 50 kW. This means that only if the genset, which now has the last priority, is 50 kW, it can be stopped!



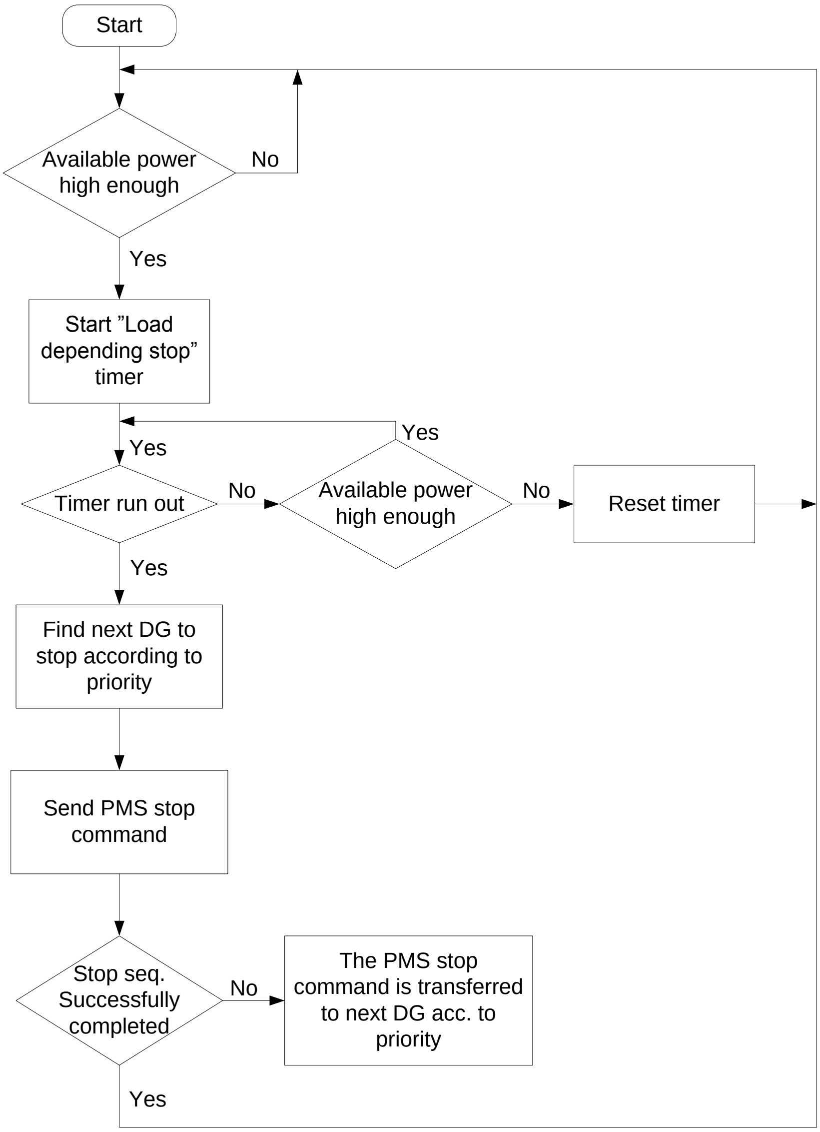
If the order of priority is changed, the following must be observed: if the priority does not seem to change as expected, it is because the load-dependent stop function would not be able to stop the lowest priority after having started the new first priority. That would cause two DGs to be running at low load instead of one DG.

6.2.9 Power window, available power method

The difference between the programmed load-dependent start and stop limits forms the power hysteresis between the start and stop. This is shown in the diagram below:



6.2.10 Load-dependent stop flowchart



6.3 Load sharing

When the power management communication is running, the load sharing between the gensets is done using the CAN bus communication between the PPM-3 units.

If both CAN bus connections are being used (A1-A3 and B1-B3), the communication automatically switches to the other port if, for example, A1-A3 is disconnected or faulty. (For further description of redundant CAN bus, see the paragraph "Redundant CAN bus communication").

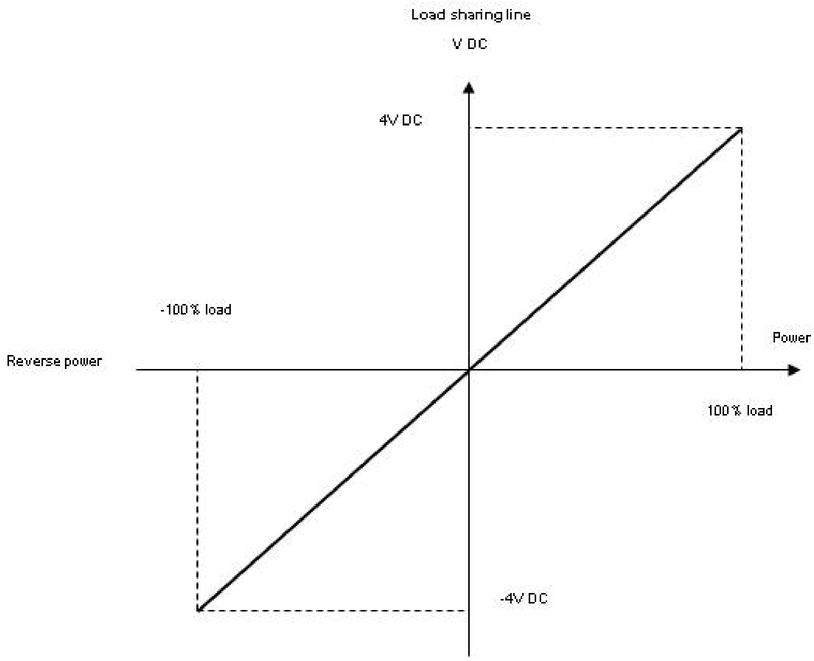
If both CAN bus lines are disconnected or faulty, the PPM-3 units switch over to analogue load sharing using the terminal 37/38/39. This means that the power management will be lost, but the gensets already running will stay stable.

The analogue load sharing line can be used as load share backup when connected. This function is standard in the PPM-3.

The analogue load sharing line enables the unit to share the active reactive load (option D1) equally in percentage of the nominal power. The analogue load sharing is active when both internal CAN bus lines are disconnected, the genset is running in island mode and the generator breaker is closed.

A voltage signal equal to the load produced by the genset is sent to the load sharing line. When the generator load is 0 %, 0 V DC is sent to the load sharing line. When the load is 100 %, the voltage will be 4 V DC.

This is illustrated in the drawing below.



The active load sharing line is illustrated above, and the characteristics of the reactive load sharing line are equivalent to it.

6.3.1 Working principle

The controller unit will supply a voltage on the load sharing line equal to the actual load. This voltage comes from an internal power transducer. At the same time, the actual voltage on the load sharing line will be measured.

If the measured voltage is higher than the voltage from the internal power transducer, the unit will increase its load in order to match the voltage on the load sharing line. If the measured voltage is lower than the voltage from the internal power transducer, the unit will decrease its load in order to match the voltage on the load sharing line.

The voltage on the load sharing line will only be different from the voltage from the internal power transducer, if two or more controller units are connected to the load share line.

To enable/disable the load share line by user command, use the M-Logic category Output/ Inhibits in the PC utility software.

To improve the handling of several generators in the same application, the analogue load share line is working as backup system for the power management. This means that if both the analogue load share line and power management are available in the same unit, the load sharing will be done by the CAN bus communication as the primary choice, but if a CAN bus error occurs, the load sharing will continue on the analogue load sharing line. The generators will stay stable even though the power management is lost.

Example 1:
Two generators are running in parallel. The loads of the generators are:

Generator	Actual load	Voltage on load sharing line
Generator 1	100 %	4 V DC
Generator 2	0 %	0 V DC

The voltage level on the load sharing line can be calculated to:

U_{LS}: (4 + 0) / 2 = 2.0 V DC

Now generator 1 will decrease the load in order to match the voltage on the load sharing line (in this example 2.0 V DC). Generator 2 will increase the load in order to match the 2.0 V DC.

The new load share situation will be:

Generator	Actual load	Voltage on load sharing line
Generator 1	50 %	2.0 V DC
Generator 2	50 %	2.0 V DC

Example 2:
If the size of the generators differs, the load sharing will still be carried out on the basis of a percentage of the nominal power.

Two generators supply the busbar. The total load is 550 kW.

Generator	Nominal power	Actual load	Voltage on load sharing line
Generator 1	1000 kW	500 kW	2.0 V DC
Generator 2	100 kW	50 kW	2.0 V DC

Both generators are supplying 50 % of their nominal power.

6.4 External analogue set points

The genset can be controlled from internal as well as from external set points. The external set points are activated with a digital input.

Five different inputs can be selected by using the Multi-line 2 (ML-2) PC utility software (USW):

Input	Ext. set point active condition	Comment
Ext. frequency ctrl	Stand-alone generator or GB opened	
Ext. power ctrl	Parallel to shaft generator/shore connection PPM-3	
Ext. voltage ctrl	Stand-alone generator or GB opened	Requires option D1
Ext. PF ctrl	Parallel to shaft generator/shore connection PPM-3	
Ext. var ctrl	Parallel to shaft generator/shore connection PPM-3	

The controller setpoints will be ignored if the running condition is not present. It is for instance not possible to use the frequency controller when paralleling to the busbar.

The table below shows the possible set points.

Controller	Input voltage	Description	Comment
Frequency	+/-10 V DC	f_{NOM} +/-10 %	
Power	+/-10 V DC	P_{NOM} +/-100 %	
Voltage	+/-10 V DC	U_{NOM} +/-10 %	
Reactive power	+/-10 V DC	Q_{NOM} +/-100 %	
Power factor	0 to 10 V DC	1.0 to 0.6	

The external set points can be used in all genset modes, when auto or semi-auto mode is selected.

Only a limited number of digital inputs are available in the standard unit. The unit should be installed with the sufficient number of options to get the desired digital inputs.

If the option H2 (Modbus RS-485 RTU) is available in the unit, the external set points can be controlled from the control registers in the Modbus protocol. See the description of option H2 for further information.

6.5 Parameters

This function has the following related parameters: 6380 Load share out and 6390 Load share type.
For further information, see the separate PPM-3 parameter list, document no. 4189340672.

6.6 Blackout start

6.6.1 Blackout start

If the power management system is working and the internal CAN communication between all the other units is without any failure, the blackout handling is controlled by the power management system.

The power management blackout sequence is started once the power management system receives an individual "dead busbar" signal over the internal CAN communication from all units in the system.

In case of no active CAN bus communication between the units and a blackout, a binary input named "blackout" can be configured to any generator unit. The signal for this input is coming from an external device (that is under-voltage relay). When this input is activated while the CAN communication is deactivated, the diesel generator in question will start up and connect to the busbar.

The operator is able to adjust the following parameters:

- Amount of diesel generator sets to start in case of blackout
- Automatic change of plant mode to either SEMI-AUTO or AUTO mode
- Start and connection attempts in case of short circuit and blackout

The individual "dead busbar" internal signal is transmitted, when a unit has continuously registered the following conditions during a one second delay:

- The largest measured busbar phase-phase voltage (U_{L-L}) is below 20 % of nominal value
- The corresponding generator breaker is in OFF position
- *No/one short circuit alarm* is active in the unit (selectable)

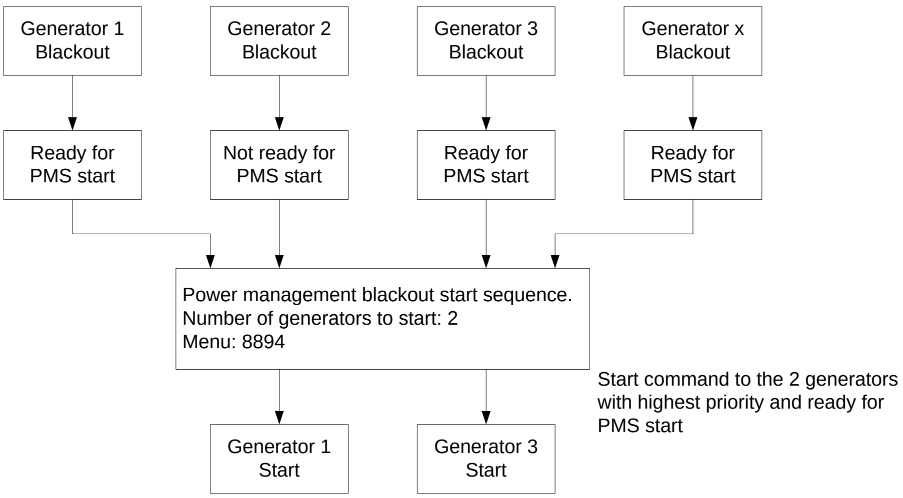
An unacknowledged short circuit alarm at any unit can block the entire blackout start sequence (depends on parameter selection).

In such cases, the operator must acknowledge the short circuit alarm in order to enable the blackout start sequence.

If one or several of the above-mentioned initiating conditions disappear, *the "dead busbar" detection is immediately disabled*.

When a blackout occurs, the blackout start sequence will begin.

Activation of the blackout start sequence is only possible, if at least one of the generators is in PMS control and "ready for PMS start" or a shaft generator/shore connection unit is selected for auto close ON (8891).



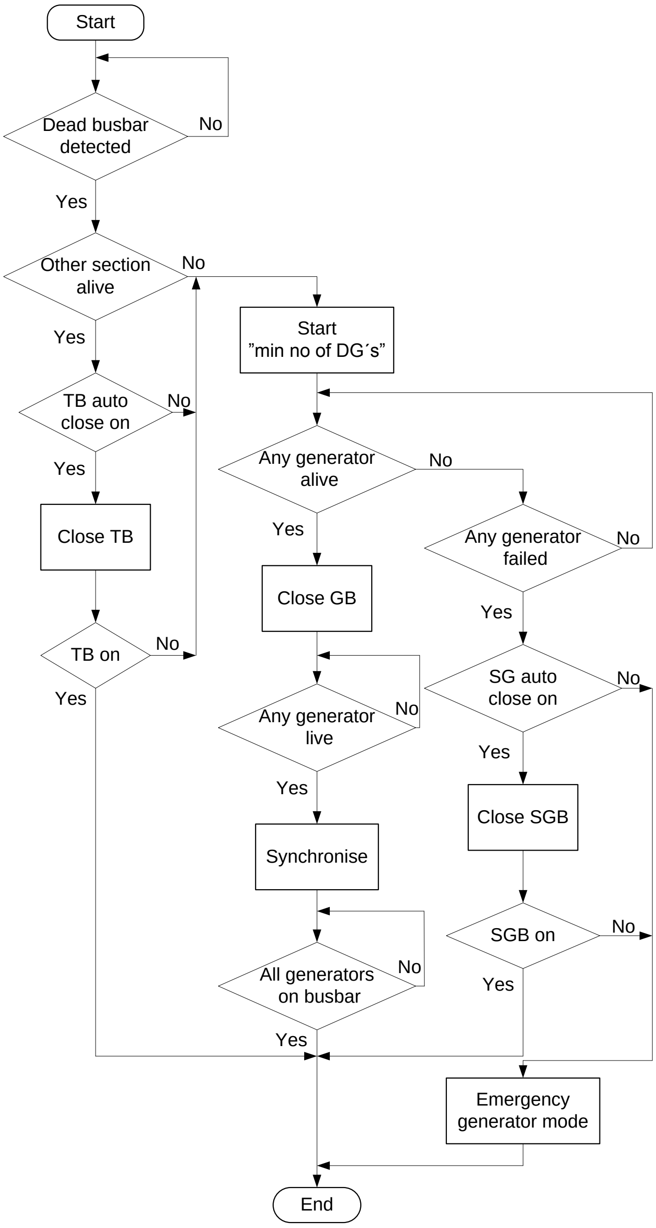
The blackout start sequence will activate the automatic start sequence, starting the generators with the highest priority and the second highest start priority (if selected), which at the same time are "ready for PMS start".

If two generators have been selected, the functionality is as follows:

1. The DG unit which first obtains normal running feedback and normal generator voltage/frequency will close the breaker immediately (after receiving an acknowledge signal from the power management unit).
    - If this does not result in closing of the generator breaker, the other blackout-started generator set will be requested to close this breaker without synchronisation.
2. The second blackout-started generator will initiate synchronisation of the generator breaker approximately 2 s after satisfactory voltage and frequency has been detected at the busbar.
3. *If any of the two chosen generator sets* fails during the start sequence, the power management start command is transferred to the next stand-by generator, as long as the blackout situation is present.
4. *When one generator set is successfully connected to the busbar*, the blackout function is considered to be completed, and the system will switch back to "normal" operation again.

If the power management system is unable to communicate with a unit (indicated by a communication alarm message), the signal from the defective unit is not required in order to initiate the blackout start sequence.

6.6.2 Blackout start flowchart



6.7 Priority selection

It is possible to use one of five types of priority selection. The type selection is made in menu 8031.

6.7.1 Manual

The manual selection gives a possibility to adjust the order of priority between the adjusted numbers of available DGs. This means that each genset always has a specific priority setting.

The adjustment is made in the menus 8080 (P1-P5), 8090 (P6-P11) and 8100 (P12-P16). In this example, the order of priority is DG3, DG1, DG2, DG4.

	Genset	DG1	DG2	DG3	DG4
Priority					
Menu 8081	**P1**			X	
Menu 8082	**P2**	X			
Menu 8083	**P3**		X		
Menu 8084	**P4**				X

These settings may be adjusted in one generator unit only. After the adjustment, the order of priority must be transmitted manually to the other gensets using the transmit function in menu 8086.

6.7.2 Using the 1st priority button on the display

The selection in setting 8031 must be "Manual". The start priority can be selected by pushing the 1st prior button on all generator units in a "reversed" manner.

Example:

A 3 generator system, with the requested start priority 2-3-1:
1: Push the 1st prior button on the display for generator 1. Wait for the LED to come ON.
2: Push the 1st prior button on the display for generator 3. Wait for the LED to come ON.
3: Push the 1st prior button on the display for generator 2. Wait for the LED to come ON.

You have now set the start priority 2-3-1.

It is recommended to set all generators in "Semi-Auto" mode during the procedure to prevent unwanted starting of generators.

6.7.3 Running hours

The purpose of the priority selection based on running hours is to let all the gensets have the same or nearly the same amount of running hours.

Every time the adjusted period in menu 8111 is reached, a new order of priority is determined, and the gensets with first priorities will be started (if not already running), and the gensets with the last priorities will stop.

There are two possibilities for operating the priority routine based on the running hours: absolute or relative. The selection between the absolute and relative routine defines whether the offset adjustment of the running hours is taken into consideration in the priority calculation. The offset adjustment is used, for example when the PPM-3 unit is installed on an old genset which already has many running hours, or if a PPM-3 unit is replaced.

Absolute running hours
All gensets participate in the priority routine based on the principle shown in the table below. This means that the gensets with the lowest number of running hours will be running. This can be a disadvantage for instance if the application consists of old gensets together with new gensets. In that situation, the new gensets will be the first priorities, until they have reached the same number of running hours as the old gensets. To avoid this, the priority routine called relative running hours can be used instead.

The actual number of running hours is adjusted in each genset PPM-3 in menus 6101 and 6102, typically at the commissioning. The purpose of the menu is to have the correct number of running hours displayed.

Relative running hours
When "relative" is selected, then all gensets will participate in the priority routine independently of the number of running hours adjusted in menus 6101 and 6102. This means that all gensets in AUTO mode participate in the priority routine.

The relative selection gives a possibility to reset the priority routine. When the reset is activated in menu 8113, the relative running hour counters in the PPM-3 units will be reset to 0 hours, and at the next priority selection, the calculation is based on the reset values.

Principle for priority routine
The principle for the priority routine is described in the following table where the running hours (menu 8111) are adjusted to 24 hours. In this example, only one genset is required by the load.

Day	Hours	DG1 (int. ID3)	DG2 (int. ID2)	DG3 (int. ID4)	DG4 (int. ID1)	Comment
Monday	0	1051 h	**1031 h**	1031 h	1079 h	DG2 will start due to the lowest internal ID number
Tuesday	24	1051 h	**1055 h**	**1031 h**	1079 h	DG 3 will be started, and DG2 will be stopped
Wednesday	48	**1051 h**	1055 h	**1055 h**	1079 h	DG1 will be started, and DG3 will be stopped
Thursday	72	**1075 h**	**1055 h**	1055 h	1079 h	DG2 will be started due to the lowest internal ID number, and DG1 will be stopped
Friday	96	1075 h	**1079 h**	**1055 h**	1079 h	DG3 will be started, and DG 2 will be stopped
Saturday	120	**1075 h**	1079 h	**1079 h**	1079 h	DG1 will be started, and DG3 will be stopped
Sunday	144	**1099 h**	1079 h	1079 h	**1079 h**	DG4 will be started due to the lowest internal ID number… and so on

The time adjusted in menu 8111 is the time between each priority calculation.

6.7.4 Fuel optimisation

The purpose of the fuel optimisation routine is to always let the gensets run in the best combination at any given load based on their actual nominal powers.

Description
The function is set up in the following menus:

Menu number	Menu text	Description	Comment
8171	Set point	Load with best fuel economy (% of P_{NOM})	The units will optimise around this genset load
8172	Swap set point	Initiate optimising	The improvement in nominal power must be better than this set point to initiate fuel optimising
8173	Delay	Time delay	Optimal combination must be present during this period, before optimising is initiated
8174	Hour	Running hours	Maximum allowed difference in running hours
8175	Enable	Activate running hours	Activates the dependency of the running hours

The function is best described with an example. An example with three DGs is shown below.

- DG1 = 1000 kW
- DG2 = 1000 kW
- DG3 = 500 kW

Settings used in the fuel optimising function in this example:

- 8011 Load-dependent stop = 200 kW (extended with 10 % in this function)
- 8881 Load-dependent start/stop = kW
- 8882 Load-dependent start/stop = Value
- 8171 Set point = 100 %
- 8172 Swap percentage = 200 kW

Situation 1:
The two 1000 kW gensets must operate. The load is too big for one 1000 kW and one 500 kW genset.

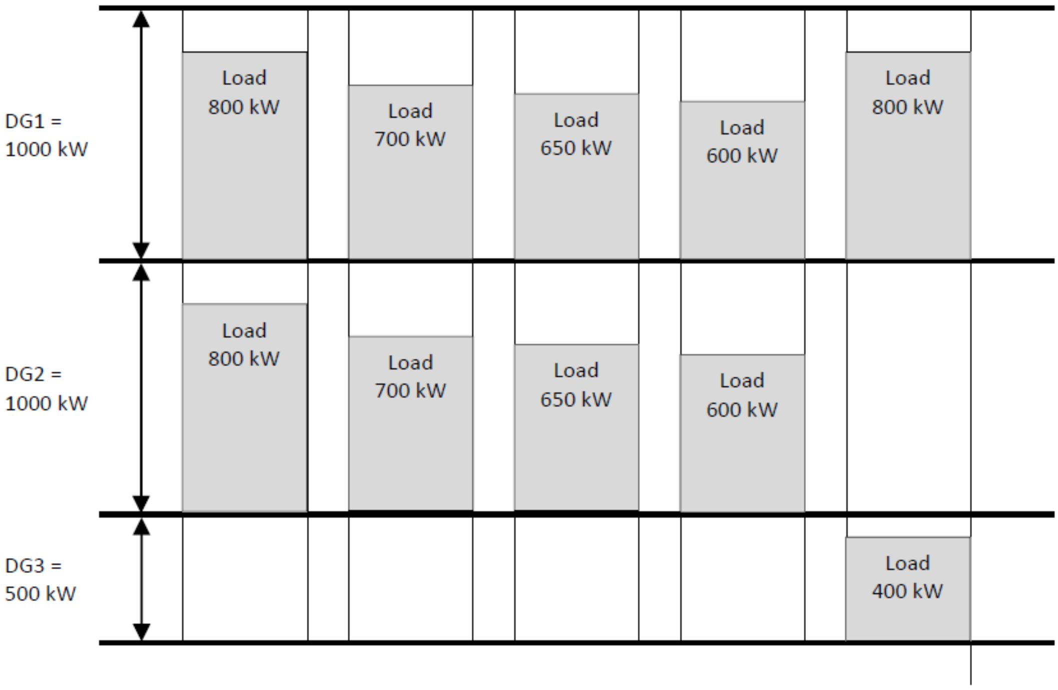
Situation 2:
Since the load has decreased to 1400 kW, it would be enough with one 1000 kW and one 500 kW genset. The improvement is 500 kW which is better than 200 kW (menu 7672). The problem is that only 100 kW would be available. The load-dependent stop requires 220 kW available, so no swapping can take place.

Situation 3:
Now the load has decreased to 1300 kW. It would be enough with one1000 kW and one 500 kW genset. The improvement is 500 kW which is better than 200 kW (menu 7672). The problem is that only 200 kW would be available. The load-dependent stop requires 220 kW available, so no swapping can take place.

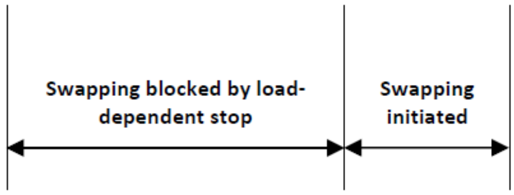
Situation 4:
Now the load has decreased to 1200 kW. It would be enough with one 1000 kW and one 500 kW genset. The improvement is 500 kW, which is better than 200 kW (menu 7672). This means that 300 kW would be available, so the load-dependent stop does not interfere with the fuel optimising.

Fuel optimising is initiated!

Situation 5:
Now DG3 has been started and is running in parallel with DG1. DG1 is running with 800 kW and DG3 is running with 400 kW.
This is the best combination at this time.



	Situation 1	Situation 2	Situation 3	Situation 4	Situation 5
P_{xxx}	800 kW	700 kW	650 kW	600 kW	800 kW
P_{xxx}	800 kW	700 kW	650 kW	600 kW	0 kW
P_{xxx}	0 kW	0 kW	0 kW	0 kW	400 kW
Present P_{AVAIL}	400 kW	600 kW	700 kW	800 kW	300 kW
New P_{AVAIL}	-100 kW	100 kW	200 kW	300 kW	800 kW
Improve kW	none	500 kW	500 kW	500 kW	none
Improvement	-	v	v	v	-



The set point (menu 8171) in percentage is typically set to 80 to 85 % for optimum fuel economy.

Running hours
It is possible to combine the fuel optimising with the running hours. This is enabled in menu 8175. If this setting is OFF, the fuel optimising will be active, but the running hours will not be included in the calculation.

If the function "running hours" is enabled, the principle is the following: If one genset reaches the adjusted amount of running hours, it will be given quarantine. This means that it will just rest until it has the lowest number of running hours. The only exception to this is if there is no alternative combination. Then it will be used but will still be in quarantine.

6.7.5 Delayed priority shift

"Delayed priority shift" is a manual priority selection and setup under parameter 8031. When priority is shifted, the new priority selection is not executed until a load-dependent start or stop is activated.

6.7.6 Dynamic

"Dynamic" priority selection will arrange the priority according to the sequence of connection and follows some simple rules.

- A generator will get the priority status according to the sequence it is connected to. For example, if a generator is connected as the third generator on the busbar, it will get third priority.
- If a breaker is tripped, the unit will get last priority.

During blackout recovery, the first priority will be given to the generator first online – second generator to connect will be assigned second priority.

If the function "Delayed priority shift" is requested in “Running hours” or “Dynamic”, parameter 8023 "Del. Prio shift" should be used.

6.8 Trip of Non Essential Load (NEL)

The trip of **N**on **E**ssential **L**oad (NEL) groups 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 trip of NEL groups function is implemented in each *DG/SG/SC/EDG* unit. This means each unit executes the trip of NEL groups according to individual settings. But it is *highly* recommended to programme all units with identical settings in order to obtain a uniform operation.

Each 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,
  and
- the measured frequency at the busbar.

The load groups are tripped as 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 sets.
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 will reduce the real power load at the busbar and thus reduce the load percentage on all the running generator sets. This can prevent a possible blackout at the busbar.

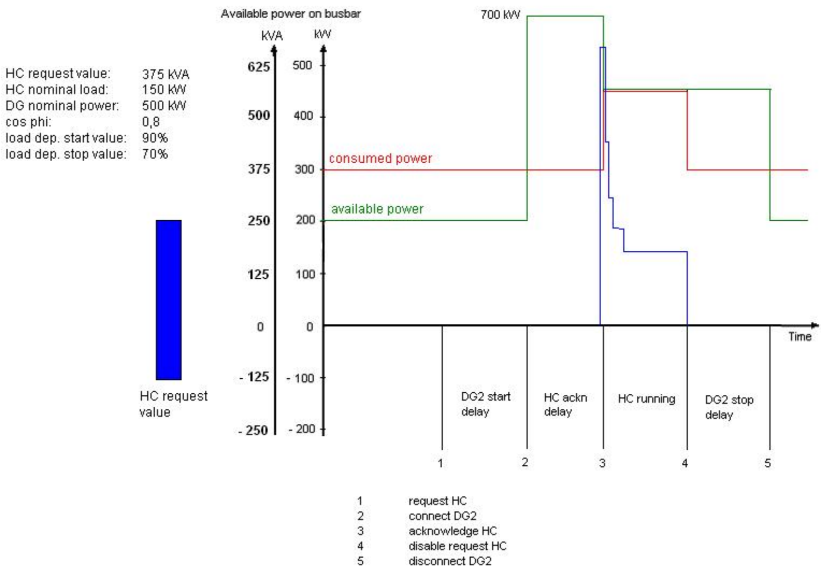
6.8.1 Non Essential Load common trip

If parameter 8970 is set ON, all NEL groups will be tripped if a GB trip occurs.

6.9 Heavy consumers

6.9.1 Conditional connection of heavy consumers

Each diesel generator, shaft generator and shore generator unit is able to handle four **H**eavy **C**onsumers (HC).
When a heavy consumer is requested, the function for conditional connection of heavy consumers reserves the programmed HC requested value (parameter 8201/8211/8320/8331) on the busbar and blocks for engagement of the heavy consumer, until sufficient predicted available power is present at the busbar.



After the available power is above the requested HC power, the heavy consumer is subsequently blocked until the programmed HC acknowledge delay runs out (fixed delay of 4 s).
The "DELAY ACK. HC" may be necessary in order to allow the recently started generator set to take load and thus actually increase the available power at the busbar before engagement of the HC.

The heavy consumers (HC) are connected according to their priority. This means that if two or more heavy consumers request start acknowledgement at the same time, the HC with the highest priority is handled first, subsequently HCs with lower priority, and so on.

HC 1.1 (1st HC in DG unit with CAN ID no.1) is designated the highest priority. This means that HC 1.1 is handled before HC 1.2, and HC 2.1 is handled before HC 2.2 if they are requested for start at the same time. If there are any preferential HCs, they must be connected to the hardware interface for 1st HC in order to ensure first priority handling.

The power management system carries out the following systematic sequence when a heavy consumer is requested for start:

1. The programmed "HC # REQ. VALUE" is reserved at the busbar (parameter 8201/8211/8321/8331). When a heavy consumer needs to start, a request is sent to the controller by turning on the *Heavy consumer # > Request* digital input.

2. The power management system uses the heavy consumer *Initial load* to calculate whether there is enough power for the heavy consumer to connect. The nominal HC power value is set in parameter 8202/8012/8321/8331.
3. If additional genset(s) are needed, the power management system starts the genset(s). That is, if the available power after connection of the heavy consumer is less than the load-dependent start limit, additional genset(s) must be started.
4. When enough power is available, the controller activates the HC ACK. DELAY (fixed delay timer of 2 s). If a longer delay is required, the HC connect timer can be used. This timer starts after the fixed timer of 2 s has expired (parameter 8204/8214/8324/8334).
5. Feedback:
   For a fixed load heavy consumer, when the heavy consumer connects, it must activate the *Heavy consumer # > Feedback*. As long as this feedback is not activated, the power management system will reserve the heavy consumer's full nominal power at the busbar. When this feedback is on, the heavy consumer will draw power as part of the system load. The power management system will not reserve any extra power for the heavy consumer.
   For a variable load heavy consumer, the power reserved at the busbar for the heavy consumer will change according to the heavy consumer load feedback. When the load feedback corresponds to 0 % of the nominal load, the power reserved at the busbar is 100 % of the nominal load. When the load feedback is 80 %, the power reserved at the busbar is 20 %.
6. When the heavy consumer is no longer required, the operator (or an external signal) must turn the *Heavy consumer # > Request* digital input off.

6.9.2 The power feedback from the heavy consumer

The Protection and Power Management system is able to handle two types of power feedback:

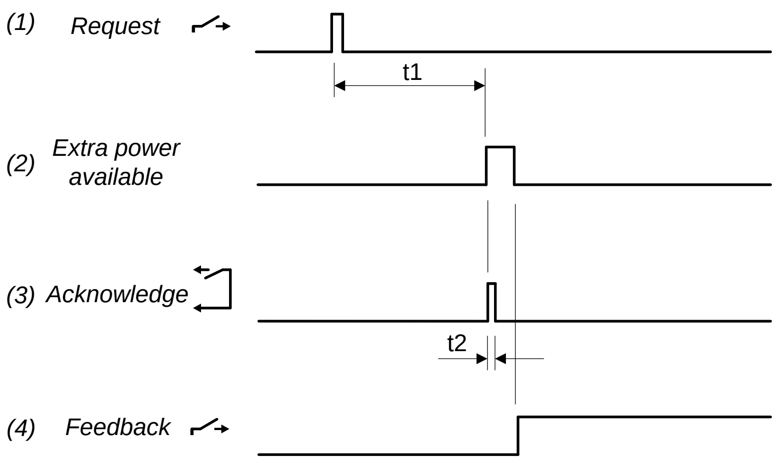
- Binary feedback (fixed feedback)
- Analogue feedback

The two types of power feedback signals are handled the same way by the conditional connection of heavy consumers function.

Changing the power feedback type is done by a parameter (8203/8213) in each generator unit.

Activating the corresponding start request binary input activates the HC engagement sequence. The PPM-3 system transmits a start acknowledge signal when sufficient predicted available power is present at the busbar.

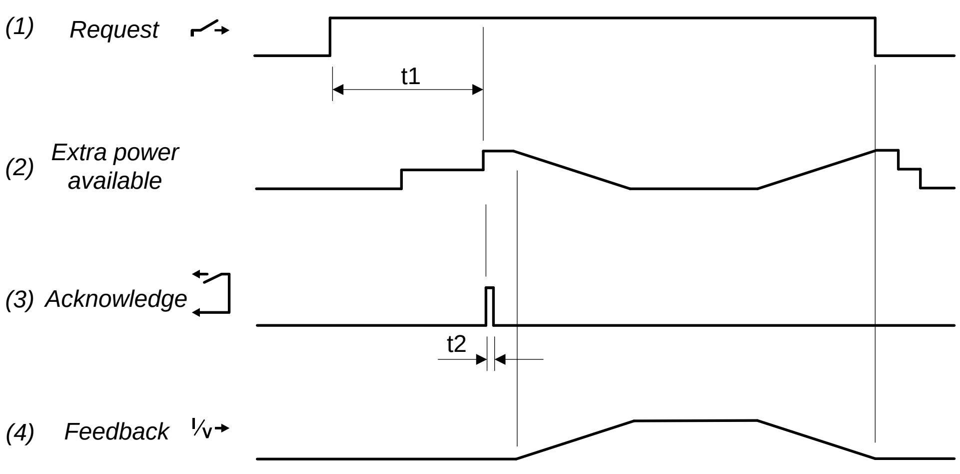
HC with binary power feedback signal:



6.9.3 The engagement sequence for HCs with fixed load

The power reservation by means of the feedback "HCx fixed load" input is enabled for as long as the **start request** signal is active. An OFF status (indicates that the HC is not operating) of the power feedback signal results in a 100 % power reservation at the busbar. An ON status (indicates that the HC is operating) at the power feedback signal results in a 0 % power reservation at the busbar.

HC with analogue power feedback signal:



The analogue power feedback for the heavy consumer is intended for a power transducer with a 4 to 20 mA output corresponding to 0 to 100 % load. If the heavy consumer is of 400 kW, then the power transducer has to be calibrated to 0 to 400 kW = 4 to 20 mA, and the setting has to be set for 400 kW.

7. Additional functions

7.1 Start functions for DG + EDG

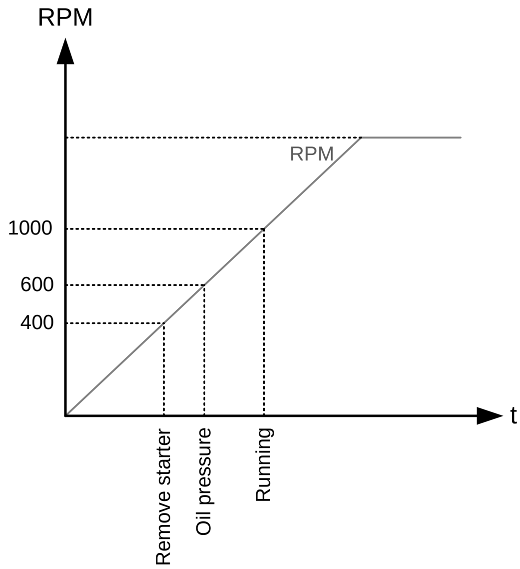
The unit will start the genset when the start command is given. The start sequence is deactivated when the remove starter event occurs or when the running feedback is present.

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

See chapter 4 for detailed information about start sequence.

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

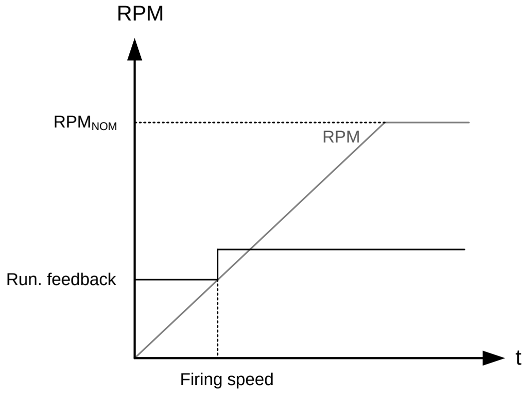
An example of a critical alarm is the oil pressure alarm. Normally, it is configured according to the shutdown fail class. But if the starter motor has to disengage at 400 RPM, and the oil pressure does not reach a level above the shutdown set point before 600 RPM, then, obviously, the genset would shut 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.



7.1.1 Digital feedbacks

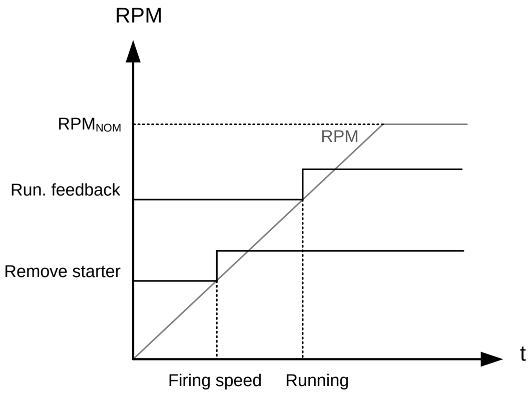
If an external running relay is installed, the digital control inputs for running detection or remove starter can be used.

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



The diagram 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.



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.

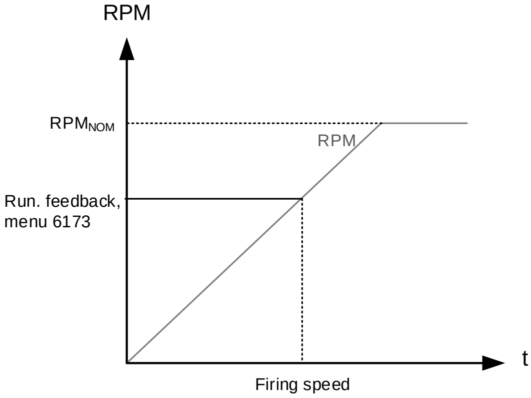
The remove starter input must be configured from a number of available digital inputs.

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

7.1.2 Analogue tacho feedback

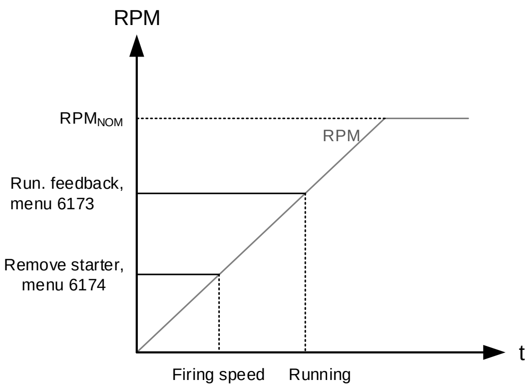
When a magnetic pickup (MPU) is being used, the specific level of revolutions for deactivation of the start relay can be adjusted.

Running feedback.
The diagram 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 to a lower value to avoid damage of the starter motor.

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



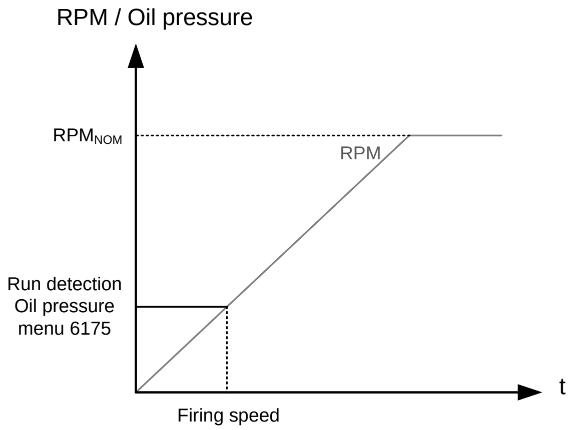
The number of teeth on the flywheel must be adjusted in menu 6170 when the MPU input is used.

7.1.3 Oil pressure

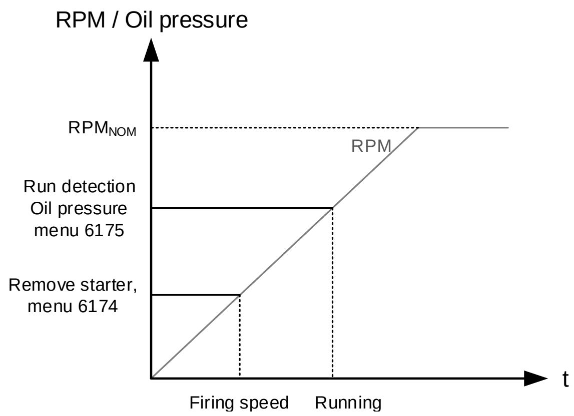
The multi-inputs on terminals 102, 105 and 108 can be used for the detection of running feedback. The terminal in question must be configured as an RMI input for oil pressure measurement.

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

Running feedback



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



The remove starter function can be using the MPU or a digital input.

7.2 Breaker

The breaker close signal is a pulse. The PPM-3 will use the close command and the open command relay. The close breaker relay will close for a short time for closure of the circuit breaker. The open breaker relay will close for a short time for opening of the breaker.

7.3 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 the breaker.
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 set point for the breaker 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 set point is found in menu 6230.

2. Digital input
A configurable input is to be used for feedbacks from the breaker: 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.

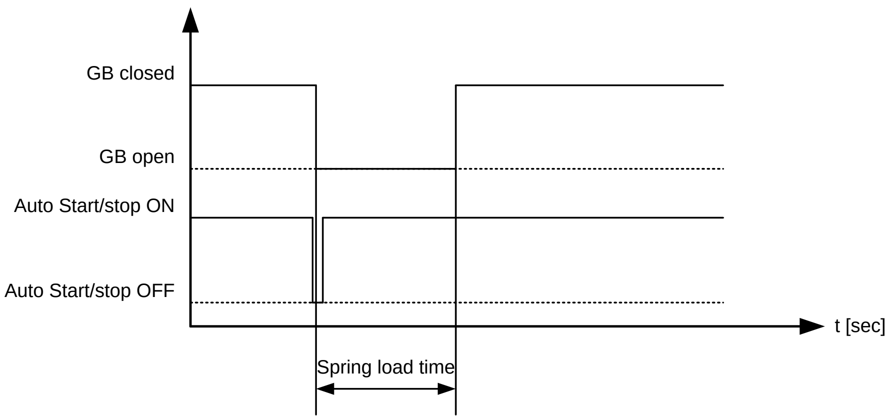
Breaker LED indication
To alert the user that the breaker close sequence has been initiated but is waiting for permission to give the close command, the LED indication for the breaker will be flashing yellow in this case.

If the breaker needs time to reload the spring after it has opened, the PPM-3 can take this delay into account. This can be controlled through timers in the PPM-3 or through digital feedbacks from the breaker, depending on the breaker type.

7.3.1 Principle

The diagram shows an example where a single PPM-3 in island mode is controlled by the AUTO start/stop input.

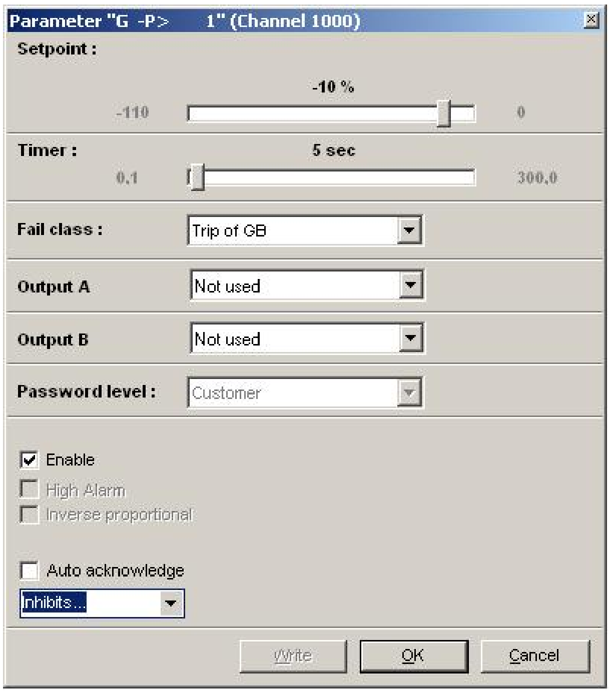
This is what happens: when the AUTO start/stop input deactivates, the GB opens. The AUTO start/stop is reactivated immediately after the GB has opened, for example by the operator through a switch in the switchboard. However, the PPM-3 waits a while before it issues the close signal again, because the spring load time must expire (or the digital input must be activated - not shown in this example). Then the PPM-3 issues the close signal.

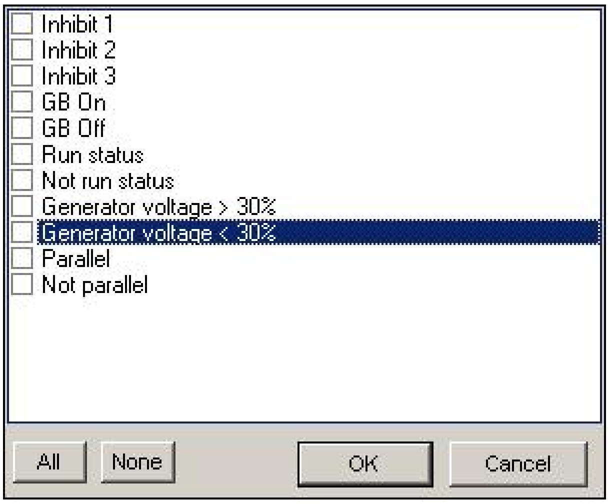


7.4 Alarm inhibit

7.4.1 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 have to be present in order to inhibit the alarm.



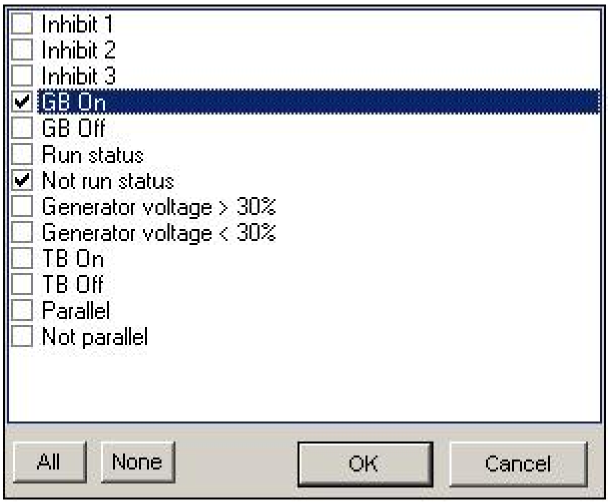


Selections for alarm inhibit:

Function	Description
Inhibit 1	M-Logic outputs: conditions are programmed in M-Logic
Inhibit 2	
Inhibit 3	
GB ON (BTB ON)	The generator (bus tie breaker) breaker is closed
GB OFF (BTB OFF)	The generator breaker (bus tie 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
TB ON	The tie breaker to main switchboard is closed (EDG only)
TB OFF	The tie breaker to main switchboard is open (EDG only)
Parallel	Both GB and TB are closed (EDG only)
Not parallel	Either GB or TB is closed, but not both (EDG only)

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.



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

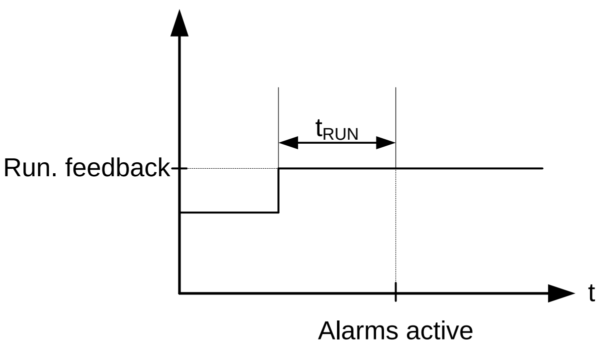
Function inputs such as running feedback, remote start or access lock are never inhibited. Only alarm inputs can be inhibited.

The bus tie breaker unit has no running detection that can be configured, so the only inhibit functions are the binary input and the BTB position.

7.4.2 Run status (6160)

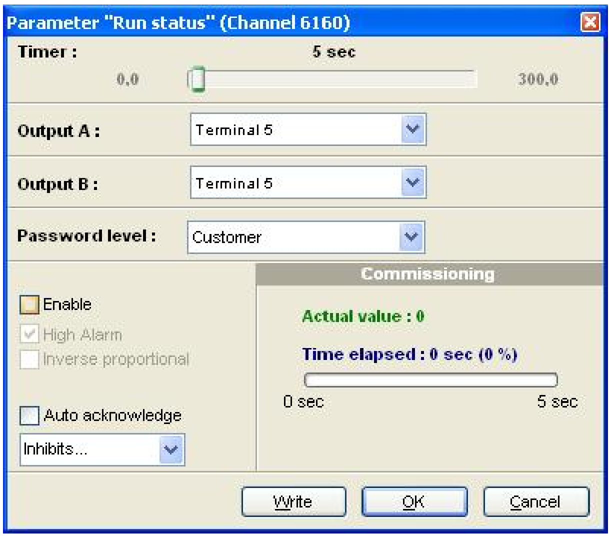
Alarms can be adjusted to activate only when the running feedback is active and a specific time delay has expired.

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.

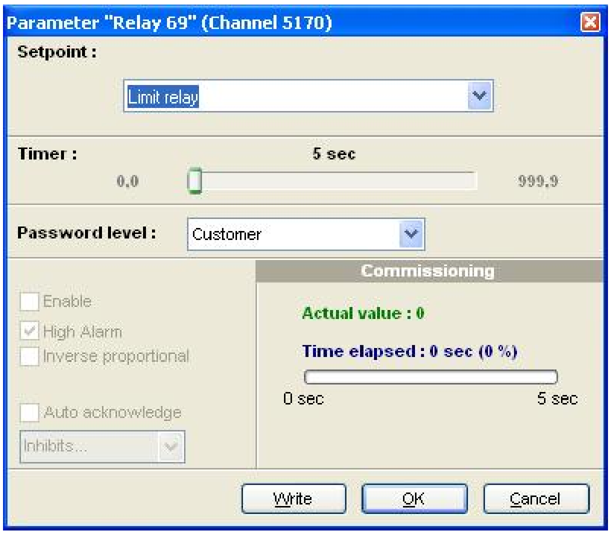


7.5 Running output

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.

7.6 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.

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

7.6.1 Engine running

Action / Fail class	Alarm horn relay	Alarm display	De-load	Trip of gen. breaker	Trip of bus tie breaker	Cooling-down gen-set	Stop genset
1 Block	X	X					
2 Warning	X	X					
3 Trip of GB	X	X		X			
4 Trip and stop	X	X	(X)	X		X	X
5 Shutdown	X	X		X			X
6 Trip of TB	X	X			X		
7 Safety stop	X	X	(X)	X		X	X

The table illustrates the action of the fail classes. If, for example, 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 de-load the genset before opening the breaker.

7.6.2 Engine stopped

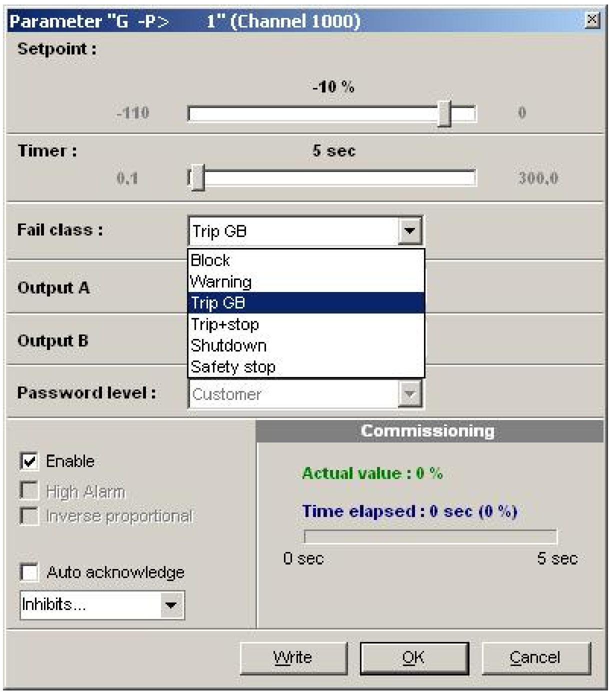
Action / Fail class	Block engine start	Block BTB sequence	Block GB sequence
1 Block	X		
2 Warning			
3 Trip of GB	X		X
4 Trip and stop	X		X
5 Shutdown	X		X
6 Trip of TB		X	
7 Safety stop	X		

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.

7.6.3 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.



7.6.4 Horn output

All configurable relays can be chosen to be a horn output. This means that the relay can be connected to an alarm annunciator, for example a horn. Every time a new alarm occurs, the horn output will activate.

The horn output will activate on all alarms. The output remains activated until:

- The alarm is acknowledged
- The horn relay timer runs out (automatic reset function)

When a relay is used as a horn relay, it cannot be used for other purposes.

The horn output will not activate on limit switch functions.

Automatic reset

The horn relay function has an automatic reset function. When the timer (menu 6130) differs from 0 seconds, the horn relay output resets itself when the delay has expired. This is also the situation when the alarm is STILL present.

The horn output resets when the alarm is still present. This is the function of the "Automatic reset".

Manual reset
If the time is set to 0.0 s, the automatic reset of the horn output is disabled. The horn will remain ON until the alarm is acknowledged by the operator. Now, the status of the alarm changes from unacknowledged (UN-ACK.) to acknowledged (ACK.).

If the alarm condition is gone when the alarm is acknowledged, the specific alarm message also disappears.

7.7 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 menu 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.

Set points available in menus 6110 and 6120:

Enable:	Enable/disable the alarm function.
Running hours:	The number of running hours to activate the alarm.
Day:	The number of days to activate the alarm - if the running hours are not reached before this number of days, the alarm will be raised.
Fail class:	The fail class of the alarm.
Output A:	Relay to be activated when the alarm is raised.
Reset:	Enabling this will reset the service timer to zero, this has to be done when the alarm is activated.

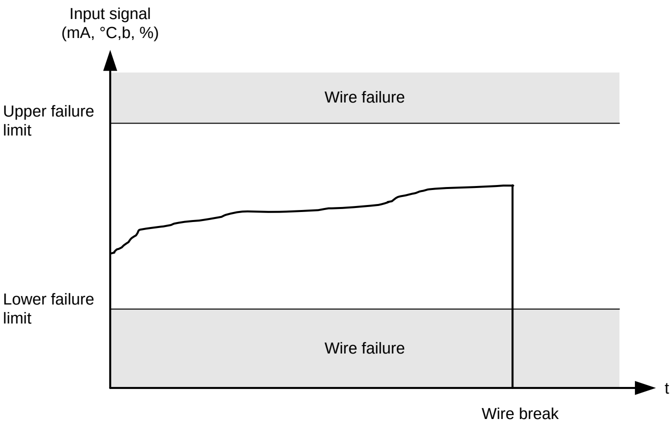
7.8 Wire fail detection

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 to 20 mA	< 3 mA	4-20 mA	> 21 mA
0 to 40 V DC	≤ 0 V DC	-	N/A
RMI Oil, type 1	< 10.0 Ohm	-	> 184.0 Ohm
RMI Oil, type 2	< 10.0 Ohm	-	> 184.0 Ohm
RMI Temp, type 1	< 22.4 Ohm	-	> 291.5 Ohm
RMI Temp, type 2	< 18.3 Ohm	-	> 480.7 Ohm
RMI Temp, type 3	< 7.4 Ohm	-	> 69.3 Ohm
RMI Fuel, type 1	< 1.6 Ohm	-	> 78.8 Ohm
RMI Fuel, type 2	< 3.0 Ohm	-	> 180.0 Ohm
RMI configurable	< lowest resistance	-	> highest resistance
Pt100	< 82.3 Ohm	-	> 194.1 Ohm
Pt1000	< 823 Ohm	-	> 1941 Ohm
Level switch	Only active if the switch is open		

7.8.1 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.



7.8.2 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 PPM-3 and MPU breaks.

7.8.3 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.

7.9 Digital inputs

The unit has a number of digital 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**

The table below illustrates all digital inputs used in the PPM-3 controllers and shows in which operation mode the described function will be activated.
X = function can be activated.
N/R = not relevant for the function.

	Input function	Auto	Semi	Test	SWBD	Configurable	Input type
1	Shore connection pos ON	X	X	X	N/R	Configurable	Constant
2	Manual GOV up	N/R	N/R	N/R	X	Configurable	Constant
3	Manual GOV down	N/R	N/R	N/R	X	Configurable	Constant
4	Manual AVR up	N/R	N/R	N/R	X	Configurable	Constant
5	Manual AVR down	N/R	N/R	N/R	X	Configurable	Constant
6	GB short circuit SGB short circuit SCB short circuit BTB short circuit TB short circuit	X	X	X	X	Configurable	Pulse
7	Alarm inhibit 1-3	X	X	X	X	Configurable	Constant
8	Secured mode ON	X	N/R	N/R	N/R	Configurable	Pulse
9	Secured mode OFF	X	N/R	N/R	N/R	Configurable	Pulse
10	Base load	N/R	X	N/R	N/R	Configurable	Pulse
11	Remote start and close	N/R	X	N/R	N/R	Configurable	Pulse
12	Remote open and stop	N/R	X	N/R	N/R	Configurable	Pulse
13	Remote start	N/R	X	N/R	N/R	Configurable	Pulse
14	Remote stop	N/R	X	N/R	N/R	Configurable	Pulse
15	Remote GB ON Remote SGB ON Remote SCB ON Remote BTB ON Remote TB ON	N/R	X	N/R	N/R	Configurable	Pulse
16	Remote GB OFF Remote SGB OFF Remote SCB OFF Remote BTB OFF Remote TB OFF	N/R	X	N/R	N/R	Configurable	Pulse
17	Binary running detection	X	X	X	X	Configurable	Constant
18	Semi-auto mode	X	N/R	X	N/R	Configurable	Pulse
19	Auto mode	N/R	X	X	N/R	Configurable	Pulse
20	GB spring loaded SGB spring loaded SCB spring loaded BTB spring loaded TB spring loaded	X	X	X	X	Configurable	Constant
21	Block for LD stop	X	N/R	N/R	N/R	Configurable	Constant
22	Force all units to SWBD control	X	X	X	N/R	Configurable	Constant
23	Force all DG units to semi-auto	X	N/R	X	N/R	Configurable	Pulse
24	Force all DG units to auto	N/R	X	X	N/R	Configurable	Pulse

	Input function	Auto	Semi	Test	SWBD	Configurable	Input type
25	Remote alarm acknowledge	X	X	X	X	Configurable	Pulse
26	Force all DG units in section to semi-auto	X	N/R	N/R	N/R	Configurable	Pulse
27	Force all DG units in section to auto	N/R	X	X	N/R	Configurable	Pulse
28	External f control	X	X	X	N/R	Configurable	Constant
29	External P control	X	X	X	N/R	Configurable	Constant
30	External U control	X	X	X	N/R	Configurable	Constant
31	External PF control	X	X	X	N/R	Configurable	Constant
32	External var control	X	X	X	N/R	Configurable	Constant
33	Force analogue LS	X	X	N/R	N/R	Configurable	Constant
34	Main supply on MBB	X	X	N/R	N/R	Configurable	Constant
35	Shutdown override	X	X	X	X	Configurable	Constant
36	1st priority	X	N/R	N/R	N/R	Configurable	Pulse
37	Blackout	X	X	N/R	N/R	Configurable	Constant
38	Overspeed	X	X	X	X	Configurable	Constant
39	Access lock	N/R	X	N/R	N/R	Configurable	Constant
40	Start enable	X	X	X	N/R	Configurable	Constant
41	HC 1 request	X	X	N/R	N/R	Configurable	Constant
42	HC 2 request	X	X	N/R	N/R	Configurable	Constant
43	HC 3 request	X	X	N/R	N/R	Configurable	Constant
44	HC 4 request	X	X	N/R	N/R	Configurable	Constant
45	HC 1 fixed load feedback	X	X	N/R	N/R	Configurable	Constant
46	HC 2 fixed load feedback	X	X	N/R	N/R	Configurable	Constant
47	HC 3 fixed load feedback	X	X	N/R	N/R	Configurable	Constant
48	HC 4 fixed load feedback	X	X	N/R	N/R	Configurable	Constant
49	PTH mode	X	X	N/R	N/R	Configurable	Constant
50	DG supply	X	N/R	N/R	N/R	Configurable	Pulse
51	SG/SC supply	X	N/R	N/R	N/R	Configurable	Pulse
52	Ship-to-ship supply	X	X	N/R	N/R	Configurable	Constant
53	Test	X	X	N/R	N/R	Configurable	Pulse

7.9.1 Functional description

1. Shore connection pos ON
The shore connection is closed. This will prevent any synchronising of generator breakers.

2. Manual GOV UP
Binary input for speed increase.

3. Manual GOV DOWN
Binary input for speed decrease.

4. Manual AVR UP
Binary input for voltage increase.

5. Manual AVR DOWN
Binary input for voltage decrease.

The manual governor and AVR increase and decrease inputs can only be used in manual mode (SWBD control). AVR control requires option D1.

6. GB/SGB/SCB/BTB/TB short circuit
Alarm input for an external short circuit trip of the breaker (all breaker types).

7. Alarm inhibit 1-3
Three separate alarm inhibit inputs can be used.

8. Secured mode ON
For DG running mode only: secured mode adds an extra generator to the system, that is one generator too will be running when comparing with the actual power requirement. This function is also called "harbour mode".

9. Secured mode OFF
Ends secured running mode (see 8).

10. 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 that the other generator(s) on line produces at least 10 % power.

11. Remote start and close
Semi-auto start and synchronise command.

12. Remote open and stop
Semi-auto de-load, open breaker and stop.

13. Remote start
Semi-auto start.

14. Remote stop
Semi-auto stop.

15. Remote GB/SGB/SCB/BTB/TB ON
The breaker ON sequence will be initiated and the breaker will synchronise, if the busbar is alive.

16. Remote GB/SGB/SCB/BTB/TB OFF
The breaker OFF sequence will be initiated, if the unit in question is not the last connected unit.

17. Binary running detection
Diesel/shaft generator: engine is running.

18. Semi-auto mode
Select semi-auto running mode.

19. Auto mode
Select auto running mode.

20. GB/SGB/SCB/BTB/TB spring loaded
Circuit breaker spring charged (loaded) feedback and the breaker is ready for closing.

21. Block for LD stop
DG only: load-dependent stop will not take place.

22. Force all units to SWBD control
All PPM-3 units will enter switchboard mode, that is all controls and commands will stop. Protections are still active.

23. Force all DG units to semi-auto
All diesel generator PPM-3 units will enter semi-auto mode.

24. Force all DG units to auto
All diesel generator PPM-3 units will enter auto mode.

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

26. Force all DG units in section to semi-auto
All diesel generator PPM-3 units in this section (split busbar running) will enter semi-auto mode.

27. Force all DG units in section to auto
All diesel generator PPM-3 units in this section (split busbar running) will enter auto mode.

28. External f control
The nominal frequency set point will be controlled from the analogue inputs terminal 40/41. The internal set point will not be used.

29. External P control
The power set point in fixed power will be controlled from the analogue inputs terminal 40/41. The internal set point will not be used.

30: External U control
The nominal voltage set point will be controlled from the analogue inputs terminal 41/42. The internal set point will not be used.

31. External PF control
The power factor set point will be controlled from the analogue inputs terminal 41/42. The internal set point will not be used.

32. External var control
The reactive power set point will be controlled from the analogue inputs terminal 41/42. The internal set point will not be used.

33. Force analogue LS
The analogue load share line is activated. Load sharing via CAN bus is disabled.

34. Main supply on MBB
The supply on the main busbar is not coming from the emergency generator, and the PPM-3 EDG is allowed to stop. Important input signal when the EDG controller is configured as stand-alone unit in harbour mode.

35. Shutdown override
All shutdown alarms (excl. overspeed, short circuit and emergency stop) are changed to fail class warning.

36. 1st priority
The diesel generator in question has the 1st start priority.

37. Blackout
A blackout has been detected on the main busbar. The PPM-3 DG unit in question will not wait on the CAN bus information and start immediately, when this input is activated.

38. Overspeed
The binary input overspeed is activated. The overspeed shutdown will be available, even though the shutdown override function is activated.

39. Access lock
The push-buttons on the display unit are disabled.

40. Start enable
The input must be activated to be able to start the engine. If not selected, the engine will start immediately.

When the genset is started, the input "start enable" can be removed.

41. HC 1 request
Request for heavy consumer 1 to start.

42. HC 2 request
Request for heavy consumer 2 to start.

43. HC 3 request
Request for heavy consumer 3 to start.

44. HC 4 request
Request for heavy consumer 4 to start.

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

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

47. HC 3 fixed load feedback
HC 3 is running and consuming 100 % power.

48. HC 4 fixed load feedback
HC 4 is running and consuming 100 % power.

49. PTH mode
SG only: the generator is running as drive motor for the propeller (Power Take Home).

50. DG supply
BTB unit only: selection of diesel generator running mode.

51. SG/SC supply
BTB unit only: selection of shaft generator/shore connection running mode.

52. Ship-to-ship supply
SC only: the shore connection breaker can be used to supply another ship with power.

53. Test
EDG only: test run command. Test can be simple (start, run for a certain time and stop), load (start and synchronise and run fixed load for a certain time, de-load the generator, open the generator breaker an stop) or full (start, synchronise, open tie breaker and let the emergency generator supply the emergency switchboard for a certain time, synchronise the tie breaker, de-load the generator, open the generator breaker and stop).

7.10 Multi-inputs

The PPM-3 unit has three multi-inputs which can be configured to be used as the following input types:

1. 4 to 20 mA
2. 0 to 40 V DC
3. Pt100
4. Pt1000
5. RMI oil
6. RMI water
7. RMI 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 to 20 mA	4120/4130	4250/4260	4380/4390
0 to 40 V DC	4140/4150	4270/4280	4400/4410
Pt100/Pt1000	4160/4170	4290/4300	4420/4430
RMI oil	4180/4190	4310/4320	4440/4450
RMI water	4200/4210	4330/4340	4460/4470
RMI fuel	4220/4230	4350/4360	4480/4490
Digital	3400	3410	3420

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

7.10.1 4 to 20 mA

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

7.10.2 0 to 40 V DC

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

7.10.3 Pt100/1000

This input type can be used for heat sensor, for example cooling water temperature. 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.

7.10.4 RMI inputs

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

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

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

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

7.10.5 RMI oil

This RMI input is used for measuring the lubricating oil pressure.

		RMI sensor type		
Pressure		**Type 1**	**Type 2**	**Type configurable**
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 to 480 Ω. The resistance as well as the pressure can be adjusted.

If the RMI 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 RMI inputs, then it will be damaged. See the application notes for further wiring information.

7.10.6 RMI water

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

		RMI sensor type			
Temperature		**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 to 480 Ω. The temperature as well as the resistance can be adjusted.

If the RMI 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 RMI inputs, then it will be damaged. See the application notes for further wiring information.

7.10.7 RMI fuel

This RMI input is used for the fuel level sensor.

	RMI sensor type
	Type 1
Value	**Resistance**
0 %	78.8 Ω
100 %	1.6 Ω

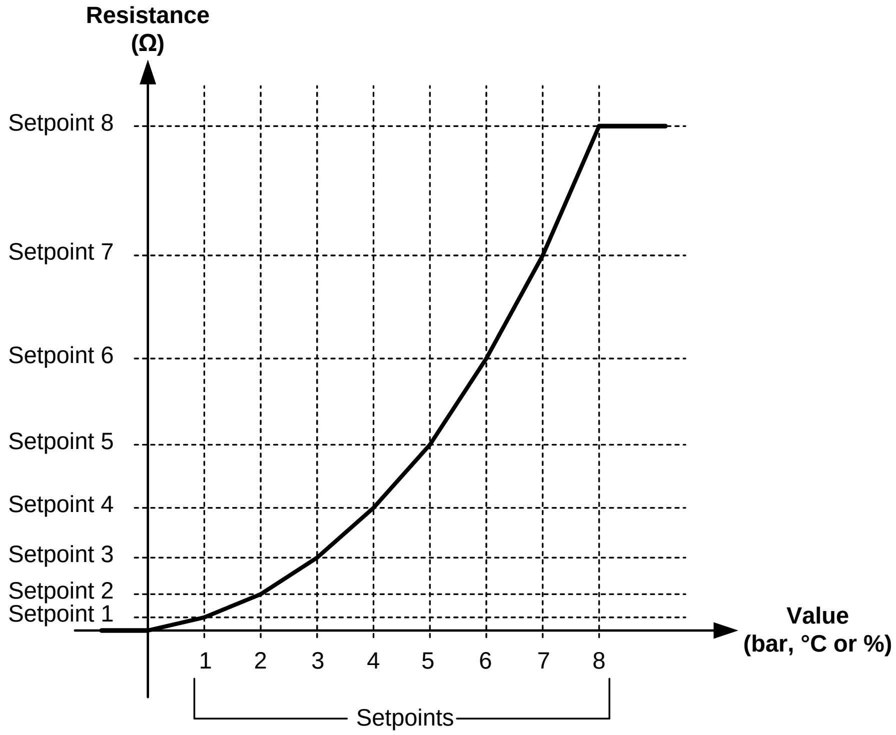
	RMI sensor type
	Type 2
Value	**Resistance**
0 %	3 Ω
100 %	180 Ω

If the RMI 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 RMI inputs, then it will be damaged. See the application notes for further wiring information.

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

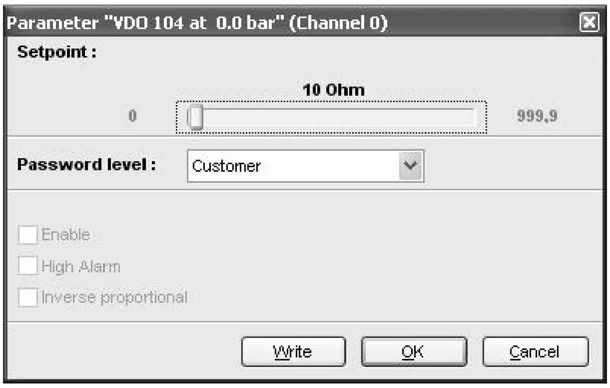
The configurable type is configurable with eight points in the range 0 to 480 Ω. The value as well as the resistance can be adjusted.

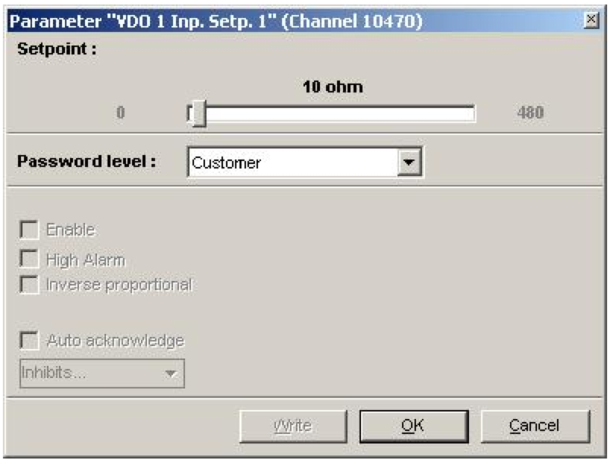
7.10.8 Illustration of configurable inputs



7.10.9 Configuration

The 8-curve settings for the configurable RMI 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:



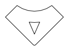


Adjust the resistance of the RMI sensor at the specific measuring value. In the example above, the adjustment is 10 Ω at 0.0 bar.

7.10.10 Digital

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

7.11 Governor and AVR output window

The governor and AVR output window can be activated by pressing  for more than two seconds. The intention of this window is to give the commissioning engineer a helpful tool for adjustment of the regulators.

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

AVR set point manipulation requires option D1.

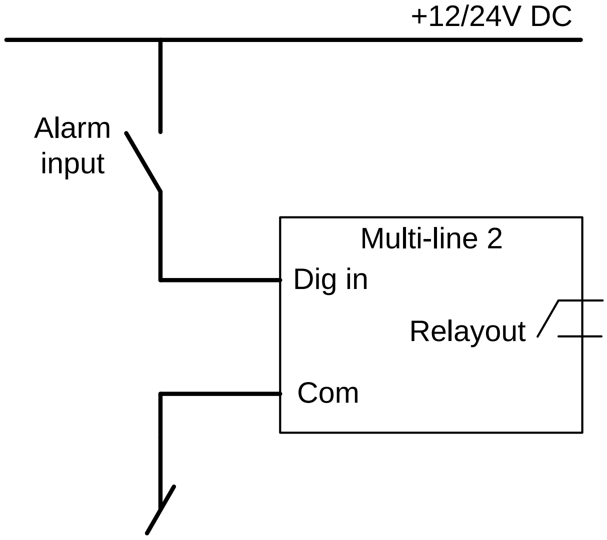
7.12 Input function selection

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.

The relay output function cannot be changed. This will always be a NO relay and will close when the alarm occurs, alarm = CC (closed contact).



7.13 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 "Translations" function.

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.

7.14 Counters

Counters for various values are included, and some of these can be adjusted if necessary, for example 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/BTB operations	Offset adjustment of the number of generator breaker operations.	Counting at each GB/BTB close command.
6104 TB operations	Offset adjustment of the number of tie breaker operations.	Emergency generator only. Counting at each TB 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.

7.15 kWh/kvarh counters

The PPM-3 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 one 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 to 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.

7.16 M-Logic

7.16.1 M-Logic

M-Logic functionality is included in the unit and is not an option-dependent function, however, selecting additional I/O options can increase the functionality.

M-Logic is used to execute different commands at pre-defined 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.

See the "M-Logic application note" for a description of this configuration tool.

7.17 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. Take precautions that it is safe to remote-operate the genset to avoid personal injury or death.

7.17.1 Application settings

See the PC utility software help file.

7.17.2 Safety

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

7.18 Nominal settings

The nominal settings can be changed to match different voltages and frequencies. The PPM-3 has two sets of nominal values, and they are adjusted in menus 6000 and 6010 (nominal settings 1 and 2).

The possibility to switch between the two sets of nominal set points is typically used on generators, where switching between 50 and 60 Hz is required.

7.18.1 Activation

The switching between the nominal set points 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

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

See the "Help" file in the PC utility software for details.

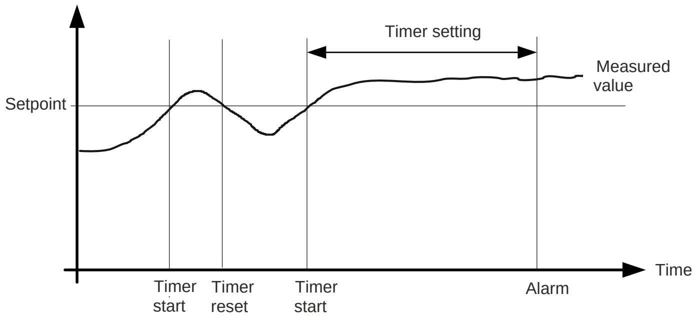
Menu settings
In menu 6006, the switching is made between settings 1 and 2 simply by choosing the desired nominal setting.

8. Alarms

8.1 General

With a few exceptions, alarms are set in % of nominal generator value. The delay settings are all of the definite time type, meaning that a set point and time is selected.

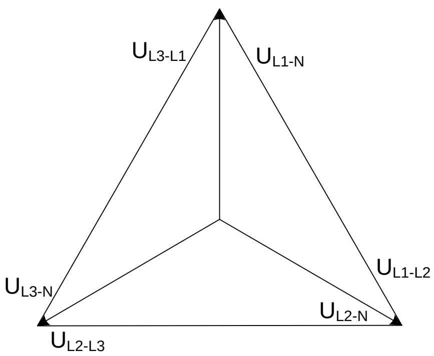
If the function is, for example, over-voltage, then the timer will be activated, if the set point is exceeded. If the voltage value goes below the set point value before the timer runs out, the timer will be stopped and reset.



When the timer runs out, the output is activated. The total delay will be the delay setting + the reaction time.

8.2 Voltage alarms

All voltage alarms in the PPM-3 system are based on phase-to-phase measurements:

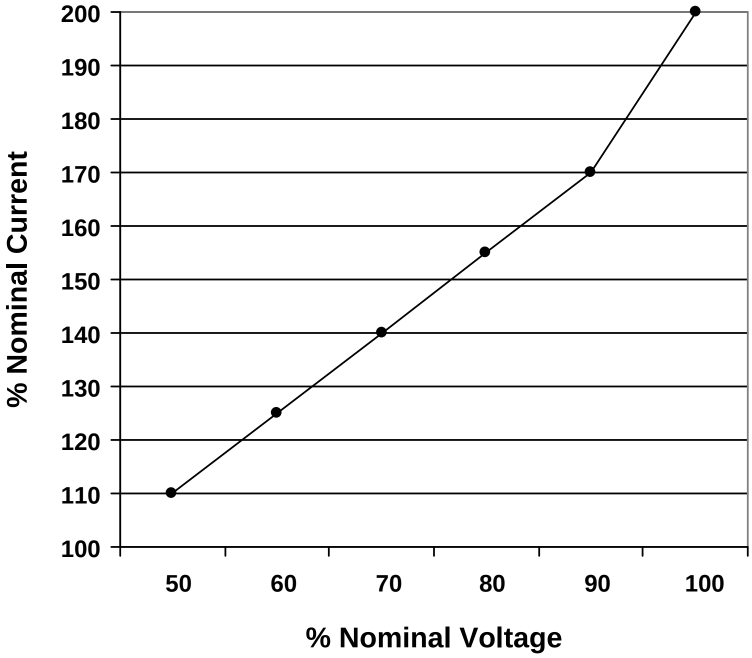


	Phase-to-phase
Nominal voltage	**400/230**
Low voltage, 10 % error	**360/185**

8.3 Voltage-dependent (restraint) over-current

The protection calculates the over-current set point as a function of the measured voltage on the generator voltage terminals.

The result can be expressed as a curve function:



This means that if the voltage drops, the over-current set point 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 to 200 %.

Voltage and current % values refer to the nominal settings.

Timer value can be adjusted in the range 0.1 to 10.0 s.

9. PID controller

9.1 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.

See "General Guidelines for Commissioning".

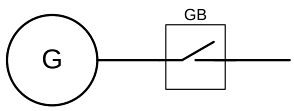
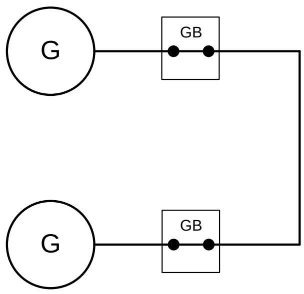
9.2 Controllers

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

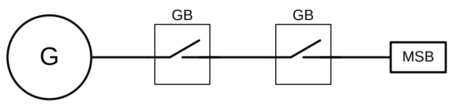
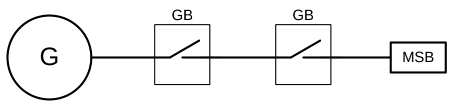
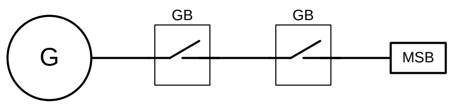
Controller	GOV	AVR	Comment
Frequency	X		Controls the frequency
Power	X		Controls the power
P load sharing	X		Controls the active power load sharing
Voltage (option D1)		X	Controls the voltage
var (option D1)		X	Controls the power factor
Q load sharing (option D1)	X	X	Controls the reactive power load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

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

For diesel generator:

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

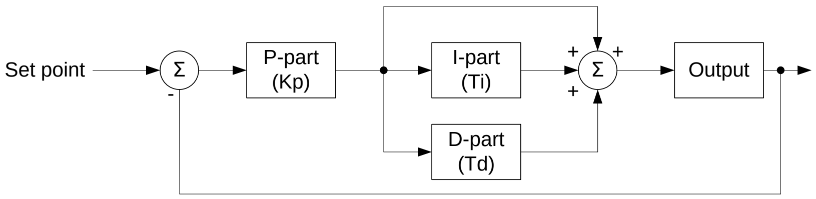
For emergency generator:

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

9.3 Principle drawing

9.3.1 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 PPM-3 unit are:

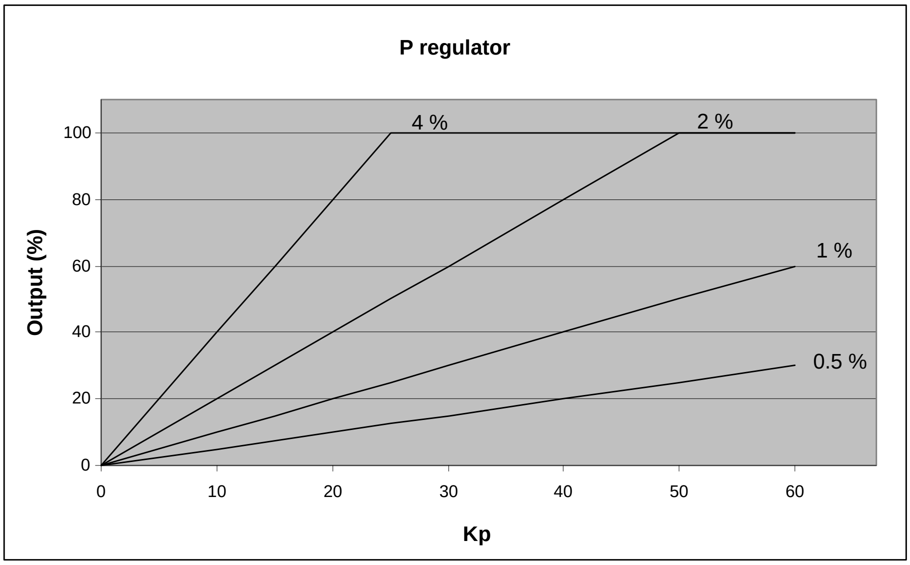
Kp: The gain for the proportional part.
Ti: The integral action time for the integral part.
Td: The differential action time for the differential part.

The function of each part is described in the following.

9.4 Proportional regulator

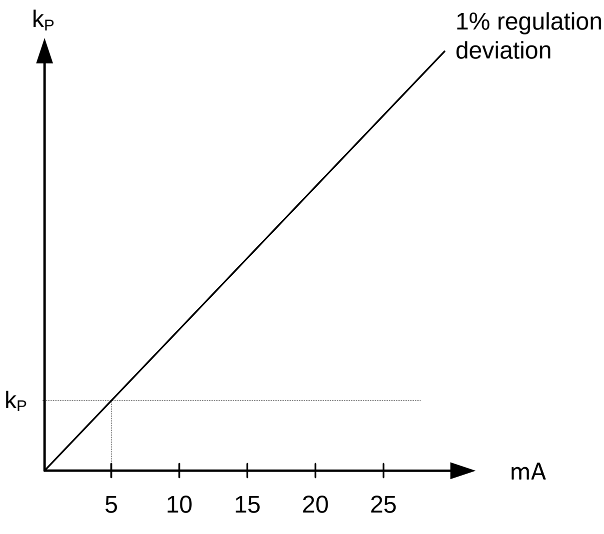
When the regulation deviation occurs, the proportional part will cause an immediate change of the output. The size of the change depends on the gain Kp.

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.



9.4.1 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.

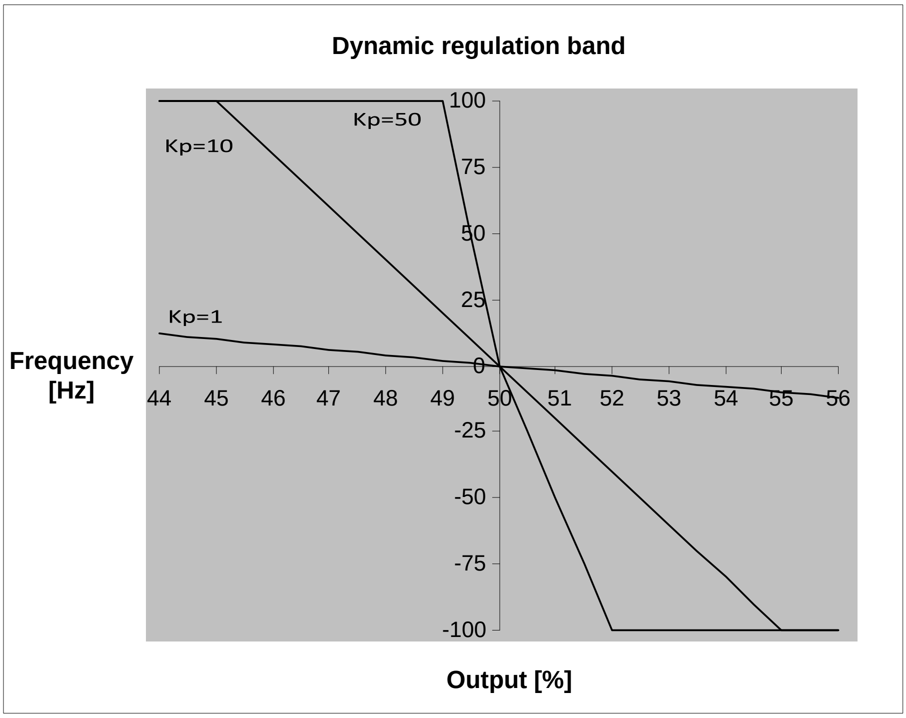


A 1 % regulation deviation occurs. With the Kp setting adjusted, the deviation causes the output to change 5 mA. The table shows that the output of the PPM-3 changes relatively much, if the maximum speed range is low.

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

9.4.2 Dynamic regulation area

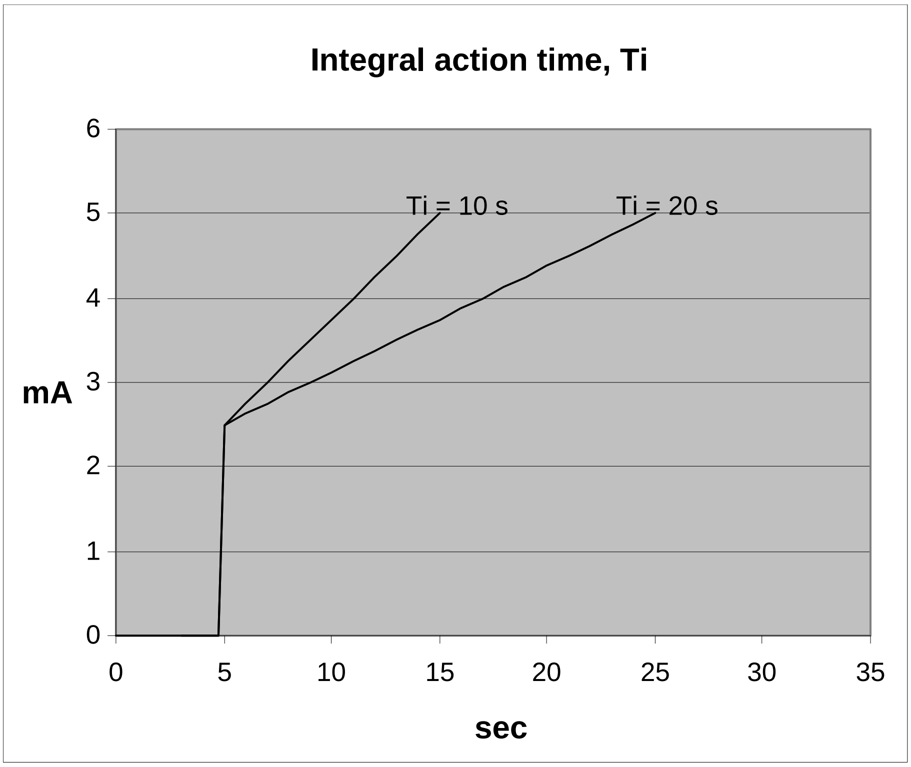
The drawing below shows the dynamic regulation area at given values of Kp. The dynamic area gets smaller, if the Kp is adjusted to a higher value.



9.4.3 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 × 2.5 mA = 5 mA.



As seen on 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.

9.4.4 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, for example static synchronisation, it can be very useful.

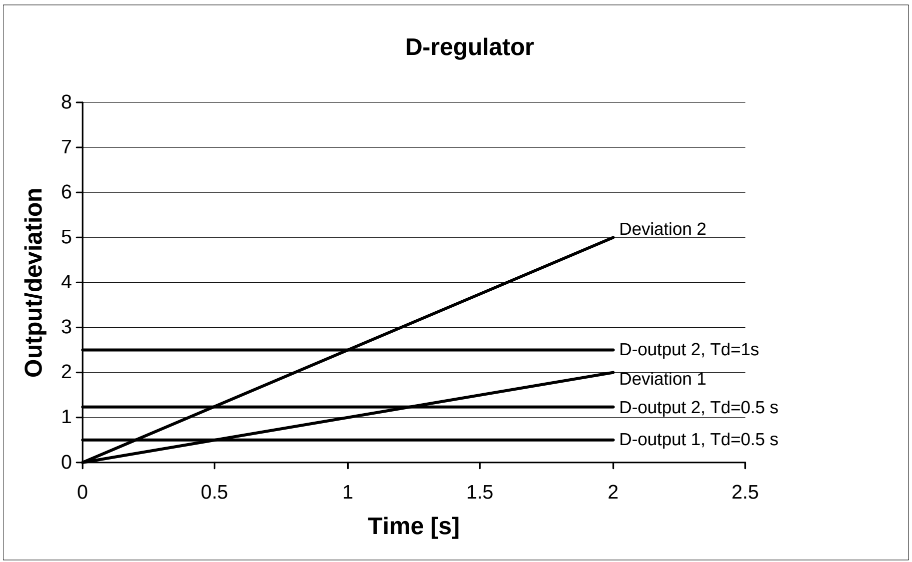
The output from the D-regulator can be explained with the equation: $D = Td \cdot Kp \cdot \frac{de}{dt}$

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.



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

The example shows that the bigger deviation and the higher Td setting, the bigger output from the D-regulator. 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.

When commissioning, keep in mind that the Kp setting has influence on the D-regulator output.

If the Td is adjusted to 0 s, the D-regulator is switched OFF.

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

9.5 Load share controller

The load share controller is used in the PPM-3 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 of how fast 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, hunting could be experienced. To avoid this, decrease either the weight factor or the parameters of the frequency regulator.

9.6 Synchronising controller

The synchronising controller is used in the PPM-3 whenever synchronising is activated. After a successful synchronisation, the frequency controller is deactivated and the relevant controller is activated. This could, for example, be the load sharing controller. The adjustments are made in menu 2050.

9.6.1 Dynamic synchronising

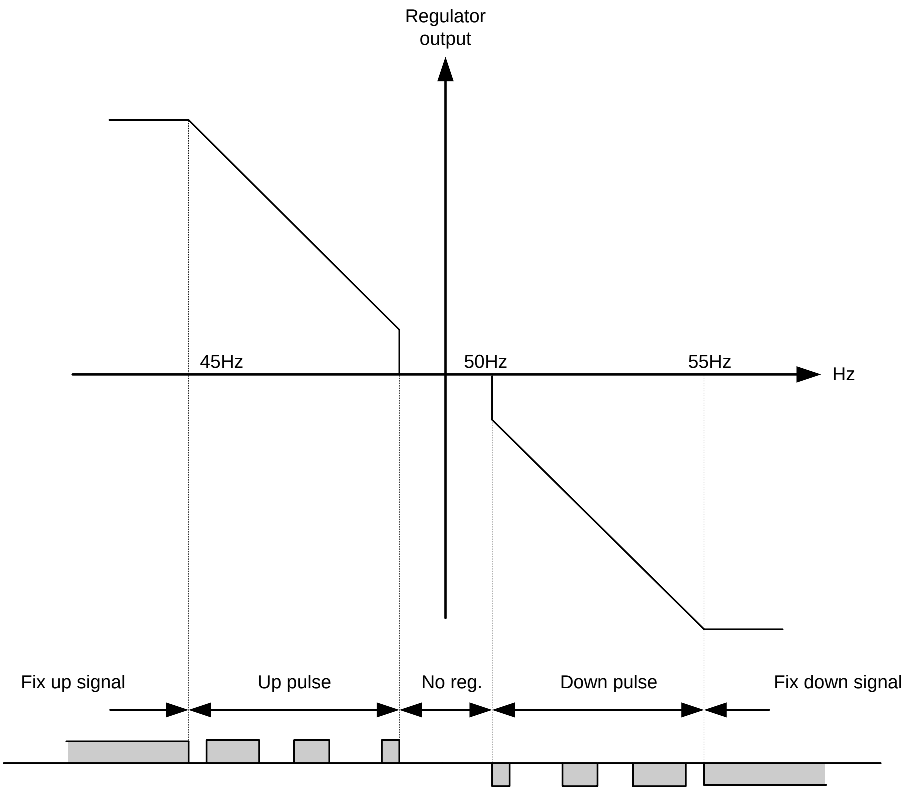
When dynamic synchronising is used, the controller "2050 f_{SYNC} controller" is used during the entire synchronising sequence. One of the advantages of dynamic synchronising is that it is relatively fast. In order to improve the speed of the synchronising further, the generator will be speeded up between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

9.6.2 Static synchronising

When synchronising is started, the synchronising controller "2050 f_{SYNC} controller" is activated and the generator frequency is controlled towards the busbar frequency. The phase controller takes over when the frequency deviation is so small that the phase angle can be controlled. The phase controller is adjusted in the menu 2070. ("2070 phase controller").

9.7 Relay control

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



The regulation with relays can be split into five steps.

#	Range	Description	Comment
1	Static range	Fix up signal	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	Deadband area	No reg.	In this particular range no regulation takes place. The regulation accepts a pre-defined deadband 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.

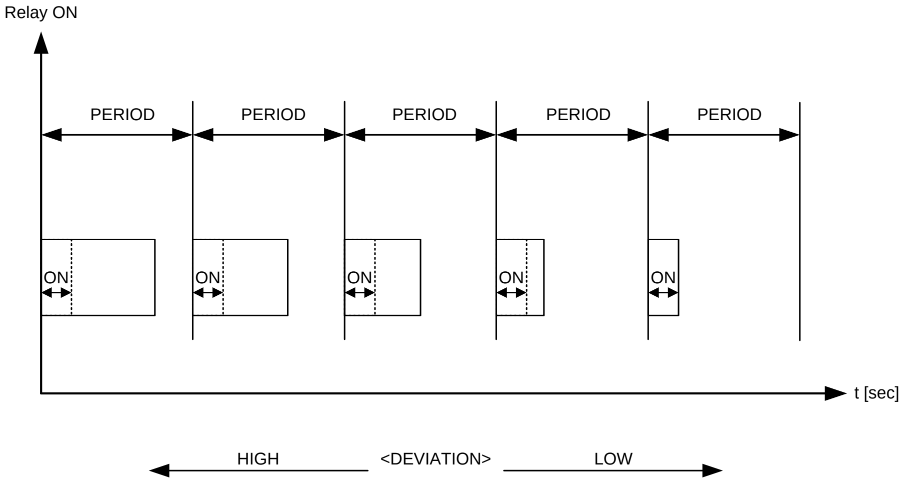
As the drawing indicates, the relays will be fixed ON if the regulation deviation is big, and they will be pulsing if it is closer to the set point. In the dynamic range, the pulses get shorter and shorter when the regulation deviation gets smaller. Just before the deadband area, the pulse is as short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

9.7.1 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.

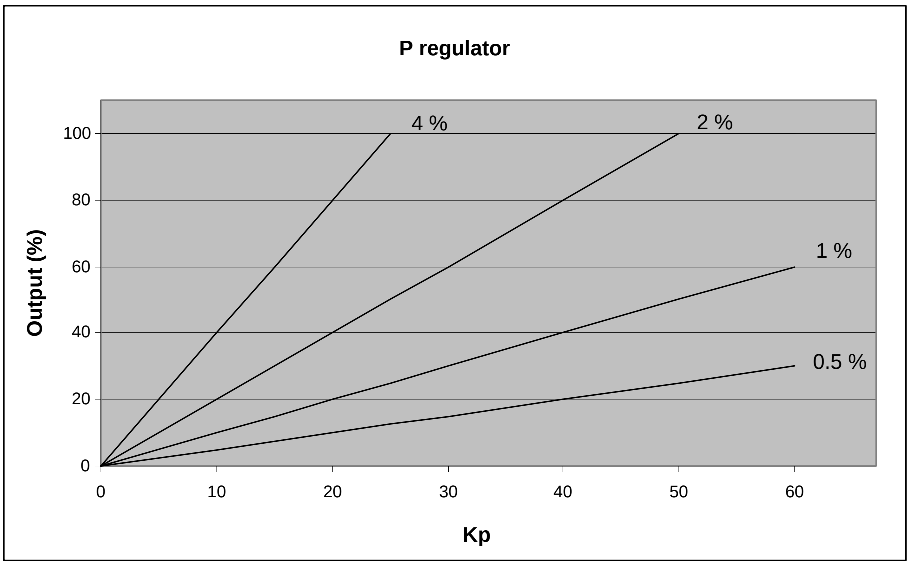
Adjustment	Description	Comment
Period time	Maximum relay time	The time between the beginnings of two subsequent relay pulses.
ON time	Minimum relay time	The minimum length of the relay pulse. The relays will never be activated for a shorter time than the ON time.

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, the pulses will be long (or a continued signal). If the deviation is small, the pulses will be short.



9.7.2 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.



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.

10. Synchronisation

10.1 Available synchronisation principles

10.1.1 Available synchronisation principles

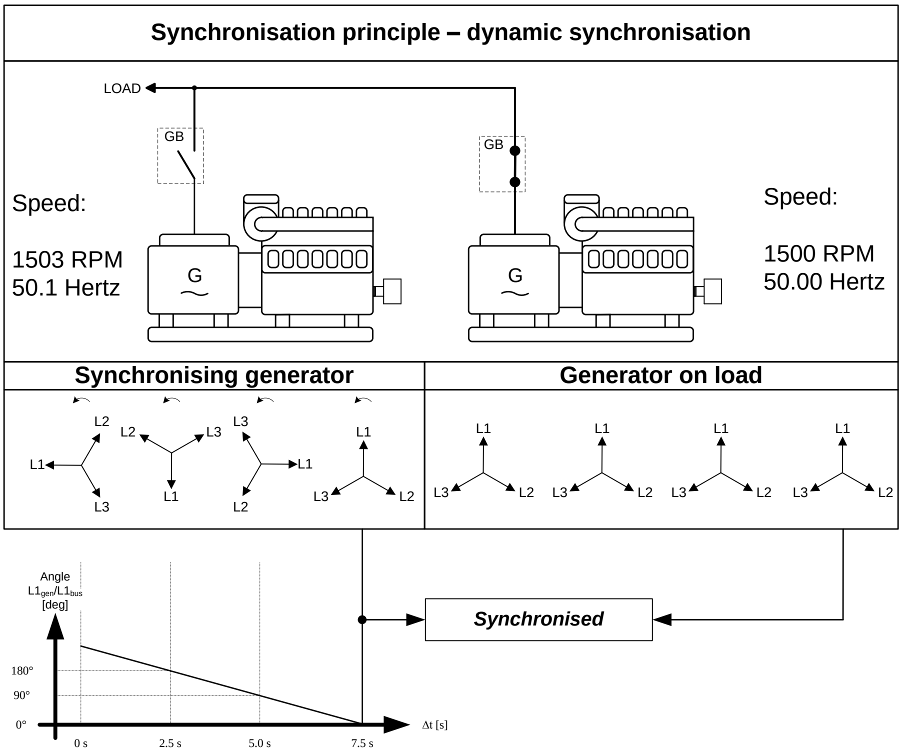
The unit can be used for synchronisation of generator breaker and tie breaker (tie breaker is only available on emergency generator unit). Two different synchronisation principles are available, namely static and dynamic synchronisation (dynamic is selected by default). This chapter describes the principles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

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

10.2 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.

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, the two systems will be synchronised every 10 seconds.

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

Observe the chapter regarding PID controllers and 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.

10.2.1 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):

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

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)**.

10.2.2 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.

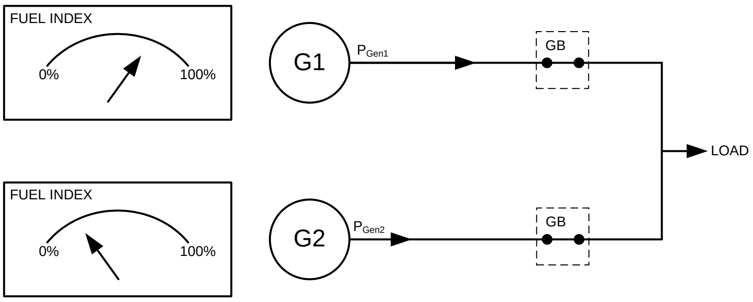


Illustration 1, POSITIVE slip frequency

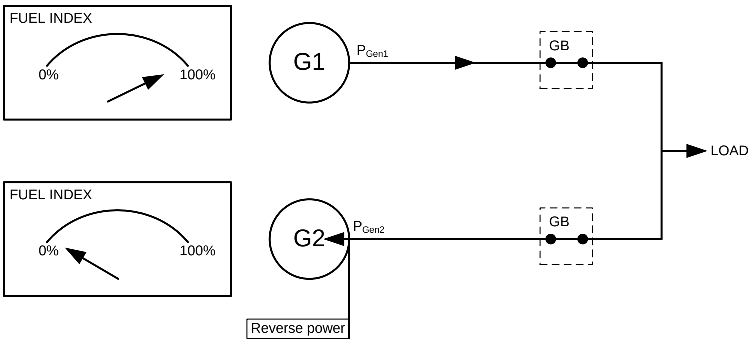


Illustration 2, NEGATIVE slip frequency

10.2.3 Adjustments

The dynamic synchroniser is selected 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 and the generator.
2024 t_{GB}	Generator breaker closing time.	Adjust the response time of the generator breaker.
2025 t_{TB}	Tie breaker closing time.	Adjust the response time of the tie 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 set point, then synchronising can still occur as long as the frequency is within the limits of the slip frequency adjustments.

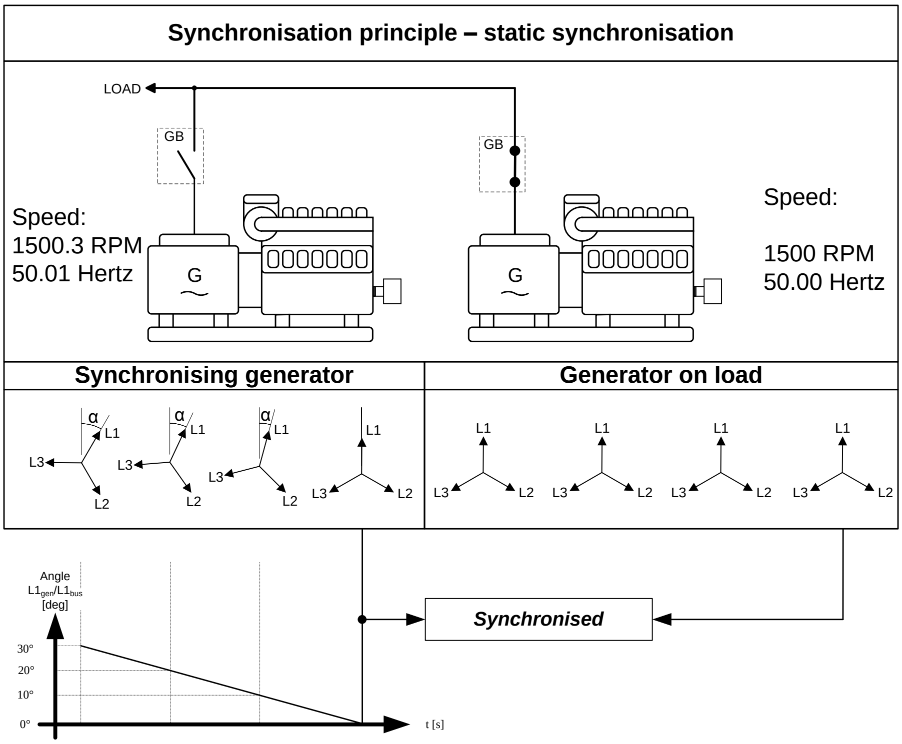
Dynamic synchronisation is recommended where fast synchronisation is required, and where the incoming gensets are able to take load just after the breaker has been closed.

10.3 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.



10.3.1 Phase controller

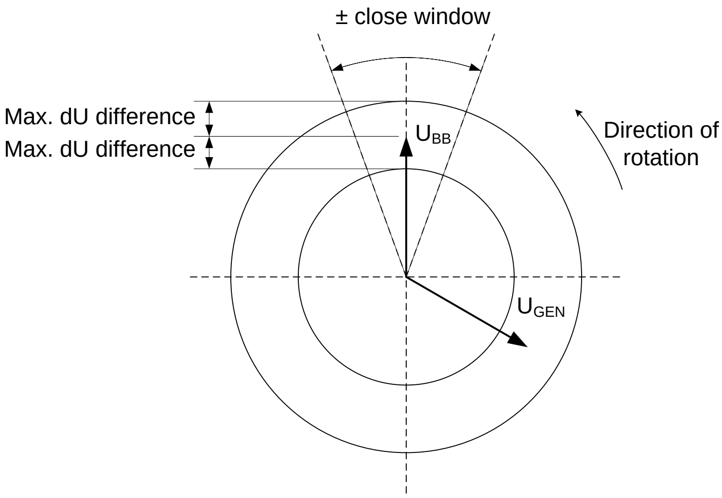
When the static synchronisation is used and the synchronising is activated, the frequency controller will bring the genset frequency towards the busbar frequency. When the genset frequency is within 50 mHz of the busbar frequency, the phase controller takes over. This controller uses the angle difference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

10.3.2 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 set point. The range is +/-0.1 to 20.0 deg. This is illustrated in the drawing below.



The synchronisation pulse is sent depending on the settings in **2020 Synchronisation**. It depends on whether it is the GB/SCB/BTB or the TB (EDG only) that is to be synchronised.

10.3.3 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, the observations in the section about "dynamic synchronisation" must be observed.

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

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

10.3.4 Settings

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

Setting	Description	Comment
Maximum df	The maximum allowed frequency difference between the busbar and the generator.	+/- value.
Maximum dU	The maximum allowed voltage difference between the busbar and the generator.	+/- value, related to the nominal generator voltage.
Close window	The size of the window where the synchronisation pulse can be released.	+/- value.
Phase K_P	Adjustment of the proportional factor of the PI phase controller.	Only used during static synchronisation.
Phase K_I	Adjustment of the integral factor of the PI phase controller.	