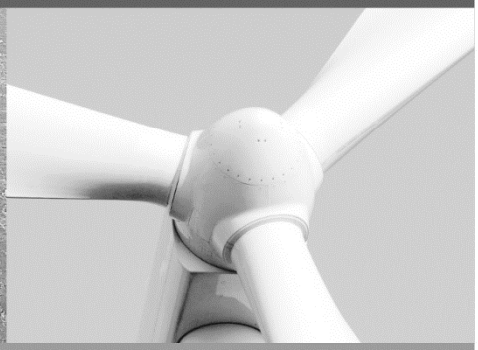
Delomatic 4





Generator Set Control
Part 2, chapter 17

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17. Generator set control

Distributed generator set control is handled by the DGUs according to a number of automatic sequences.

Altogether the automatic sequences form a complete cycle of operation for a generator set.

The Main PMS DGU is able to initiate a complete cycle of operation for a generator set by means of the PMS start/stop commands.

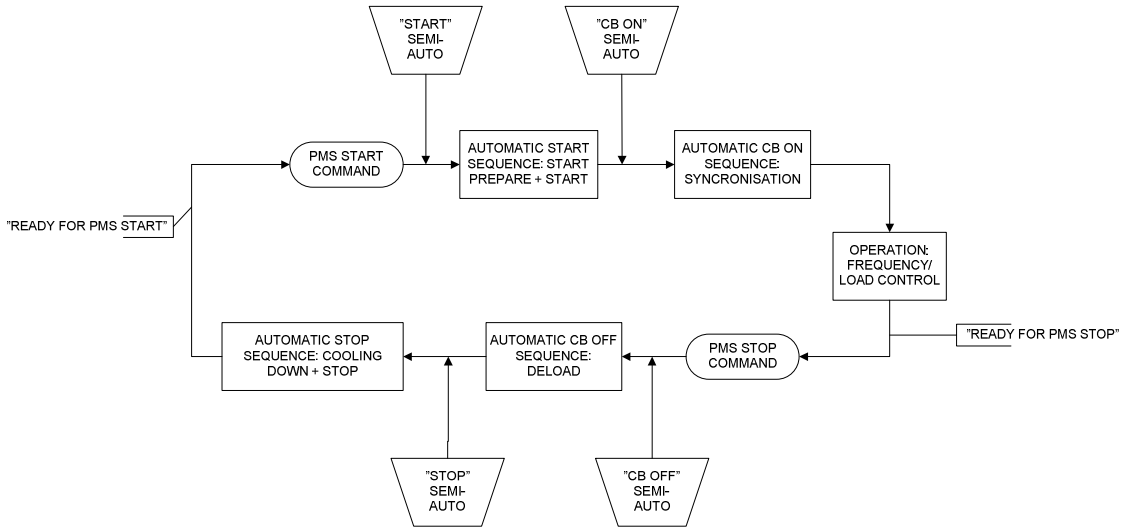
A DGU "ready for PMS start" will respond to the PMS start command by enabling:

- The automatic start sequence
- The automatic generator circuit breaker sync./close sequence

All generator sets in operation, which are "ready for PMS stop", respond to the PMS stop command by enabling:

- The automatic generator circuit breaker deload/open sequence
- The automatic stop sequence

During an active SEMI-AUTO plant mode, the initiations of the automatic sequences are carried out sequence by sequence according to the operator commands via the push-buttons at the Display Unit.



The automatic sequences contained in the cycle of operation for a generator set

All the above-mentioned automatic sequences are controlled according to a number of programmable setpoints and timers, which enable the operator to adjust the automatic operation of the generator set.

Fundamental AC settings

The fundamental AC setpoints make it possible for the operator to adapt each DGU in the Delomatic system to its surroundings. This is achieved by programming the fundamental AC setpoints individually at each DGU according to the characteristic values for the corresponding generator set.

Furthermore, the AC setpoints enable the operator to adapt generator sets with different characteristic values, e.g. different values of nominal power, into the common functions of the Delomatic system (e.g. the load-dependent start/stop function).

The fundamental AC settings are furthermore used for obtaining the correct scale of the basic AC measurements in the DGU.

At the same time this determines important system values, e.g. the nominal power for a generator set. The following adjustable setpoints are available:

ID	Channel △	Device	Text	Value	Unit	Timer	FailClass
190	4021	Diesel Gen 2	Volt	400	V	N/A	No alarm
191	4022	Diesel Gen 2	S power	1250	kVA	N/A	No alarm
192	4023	Diesel Gen 2	Power factor	80		N/A	No alarm
193	4031	Diesel Gen 2	VT primary	400	V	N/A	No alarm
194	4032	Diesel Gen 2	VT secondary	370	V	N/A	No alarm
195	4033	Diesel Gen 2	CT primary	800	A	N/A	No alarm
196	4034	Diesel Gen 2	CT secondary	1	A	N/A	No alarm

ID	Channel △	Device	Text	Value	Unit	Timer	FailClass
504	4011	BB 1 Main	Freq	50	Hz	N/A	No alarm
505	4012	BB 1 Main	Volt	400	V	N/A	No alarm

The VT (Voltage Transformer) ratio must be entered even though no voltage transformers are present in the system. E.g. nom. voltage = 440V AC, entered values VT primary SCM DG = 440V AC and VT secondary SCM DG= 440V AC set the VT's ratio to 1.

Derating of the generator set

The operator is able to derate the nominal power of a generator set manually. This is achieved simply by entering a smaller value of S-power, which causes the nominal power (P-power) for the generator set to be decreased according to:

S-power * Power factor = *P-power*

The calculated *P-power* value is used by the PMS common functions as a nominator for the maximum power a generator set may produce.

A decreasing of the P-power value results in a smaller load of the generator set. All related supervision and generator protective functions are working according to the new value of P-power.

AC values measured by an SCM module

The SCM module located in each DGU contains an integrated multi-transducer unit, which measures and calculates an extensive number of relevant AC values.

The integrated multi-transducer unit operates by means of the following hardware interface.

SIGNAL NAME	SIGNAL TYPE	LOCATION
• I_{GEN}	3-phase current input from the generator	(SCM – terminals 1, 2, 3, 4, 5, 6)
• U_{GEN}	3-phase voltage input from the generator	(SCM – terminals 7, 8, 9, 10)
• U_{BB}	3-phase voltage input from the busbar	(SCM – terminals 11, 12, 13,14)

The SCM module measures and calculates AC values such as:

- Generator frequency, f_{GEN}
- Generator voltages, U_{L1-L2}, U_{L1-L3} and U_{L2-L3}
- The generator voltage phase angles, $\_{L1-L2}$, $\_{L1-L3}$ and $\_{L2-L3}$
- Generator phase currents, I_{L1}, I_{L2} and I_{L3}
- The actual complex power produced by the generator, S_{GEN}
- The actual real power produced by the generator, P_{GEN}
- The actual reactive power produced by the generator, Q_{GEN}
- The actual generator power factor, PF
- Busbar frequency, f_{BUSBAR}
- The busbar voltages, U-BB_{L1-L2}, U-BB_{L1-L3} and U-BB_{L2-L3}
- The busbar voltage phase angles, _-BB_{L1-L2}, _-BB_{L1-L3} and _-BB_{L2-L3}

The measured and calculated values are transmitted to the control module PCM, to be included in the logic concerning load sharing, sophisticated protections etc. A large part of the values are available for read-out at the Display Unit and in the Modbus RTU serial communication.

DGU operational modes for the generator set

Each generator set is controlled according to the selected *DGU operational mode* for the controlling DGU.

Each generator set may be selected to be under *either*

- switchboard control (SWBD)

or

- power management system control (PMS)

Switchboard control (DGU operational mode)

Generator sets under switchboard control (SWBD control) are only to be operated manually; therefore a generator set under SWBD control is excluded from all automatic PMS functions.

SWBD control is strictly local operated. All other generator sets operating under selected PMS control will not be affected. However the supervision and protections are still enabled.

The synchronising unit in the SCM module turns into SWBD control, when SWBD control is selected on the DGU. SWBD control enables manual control of the speed governor via the synchronising unit in the SCM module. The speed governor may be manually decreased and increased by means of two binary inputs.

All supervision and protective functions regarding the generator set are still active for generator set(s) under SWBD control, e.g.:

- Generator protection
- Busbar supervision

PMS control (DGU operational mode)

Generator sets under PMS control are automatically controlled by the Delomatic system *according to the selected plant mode*.

Please refer to the chapter *POWER MANAGEMENT UNIT* for more information about automatic PMS control and plant modes.

Selection and indication of PMS/SWBD control

Selection of the DGU operational mode PMS/SWBD control is done via the following hardware interface.

SIGNAL NAME	SIGNAL TYPE	LOCATION
• PMS/SWBD CONTROL	Binary input	DGUs (SCM – terminal 26-29)

Selection of PMS control for a generator set is made by impressing a *closed contact* (CC) at the designated binary input at the SCM module in the DGU.

The selected control mode for a generator set is indicated at the corresponding Display Unit by means of the "PMS CONTROL" LED.

The selected control for a generator set is indicated at the corresponding Display Unit by

- a *green* "**PMS CONTROL**" LED

Indication that the DGU is forced into SWBD control

As a result of a Delomatic system alarm, a generator set may be *forced* into SWBD control. This is indicated by

- a *yellow* "**PMS CONTROL**" LED

Selection and indication of SWBD control

A generator set selected to be under SWBD control is indicated by

- a *dark (turned off)* "**PMS CONTROL**" LED

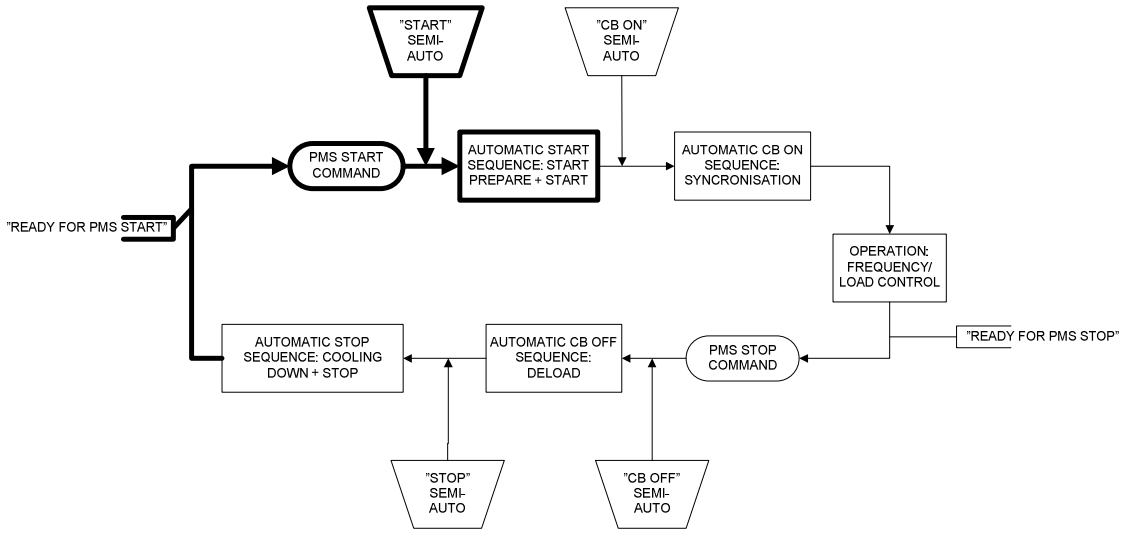
Selection of SWBD control for a generator set is made by impressing an *open contact* (OC) at the designated binary input at the SCM module in the DGU.

Automatic start sequence

The automatic start sequence starts the corresponding engine and detects, if the start is completed successfully. A successfully completed start sequence initiates the CB ON sequence.

The automatic start sequence is carried out, when a DGU receives a PMS start command. The PMS start command may be generated e.g. by the load-dependent start/stop or by the blackout function.

An operator dependent initiation (push-button) of the automatic start sequence may take place in SEMI-AUTO mode (this will *not* initiate the CB ON sequence).



Please refer to appendix 17.1 where the operating principle for the automatic start sequence is presented by a flow chart.

Each DGU in the Delomatic system is able to carry out the automatic start sequence, which includes:

- Continuous supervision of *"ready for PMS start"* status
- Programmable time for the "START PREPARE" output
- Programmable ON time for the "START" output
- Programmable OFF time for the "START" output
- Programmable activation of the stop output during OFF time
- Programmable number of start attempts
- Detection of start failure
- Supervision of generator voltage and frequency during idle run
- Transfer of the PMS start command to the next stand-by generator set in case of:
  - Start failure
  - Generator voltage or frequency failure

SEMI-AUTO start

Provided the SEMI-AUTO plant mode is selected, the operator may initiate a SEMI-AUTO start of the engine by

- pressing the "**START**" push-button at the corresponding Display Unit

A SEMI-AUTO stop command will interrupt an ongoing start sequence.

I/O interface for the automatic start

The automatic start sequence of the engine is controlled by the following I/O interface.

SIGNAL NAME	SIGNAL TYPE	LOCATION
• U_{GEN}	3-phase voltage input from generator	(SCM – terminals 7, 8, 9, 10)
• ENGINE RUNNING/ ENGINE RPM	Binary input Analogue input	(IOM 4.1 – terminals 1, 45)
• READY FOR OPERATION	Binary input	(IOM 4.1 – terminals 2, 46)
• START	Relay output	(IOM 4.1 – terminal 21, 22)
• STOP	Relay output	(IOM 4.1 – terminal 23, 24)
• START PREPARE (optional)	Relay output	(IOM 4.1 - terminal 25, 26)

U_{GEN} feedback

The 3-phase voltage AC input is used for measurement of the generator voltage and frequency, which, in combination with the engine running feedback, is used for a dual detection of running status at the engine.

Engine running/engine RPM feedback

The "ENGINE RUNNING/ENGINE RPM" feedback is used for indication of a running status on the engine.

The DGUs are prepared for both binary and analogue engine running feedback signals.

The ready for operation input

The "READY FOR OPERATION" input is used to enable the automatic start and synchronisation sequence. The input may be connected to e.g. a local/remote selector at a start box.

The start prepare output (optional)

The "START PREPARE" output may be used for e.g. prelubrication and/or preheating of the engine.

The start output

The "START" output is used for activation of the starter during the start sequence.

The stop output

The "STOP" output is used for stop of the auxiliary engine.

Ready for PMS start

The Main PMS DGU only transmits a PMS start command, if the receiving generator set is *"ready for PMS start"*.

A DGU is considered to be ready for PMS start, if the following conditions are fulfilled:

- PMS control is selected
- No active "SHUTDOWN" alarm sequences
- No active "SHORT CIRCUIT" alarm sequences
- No active "TRIP OF GB" alarm sequences
- No active "SAFETY STOP" alarm sequences
- No active "BLOCK" alarm sequences
- No active "RUNNING" status at the generator set
- No voltage or frequency is to be measured at the generator

A DGU *ready for a PMS start* is indicated at the corresponding Display Unit by

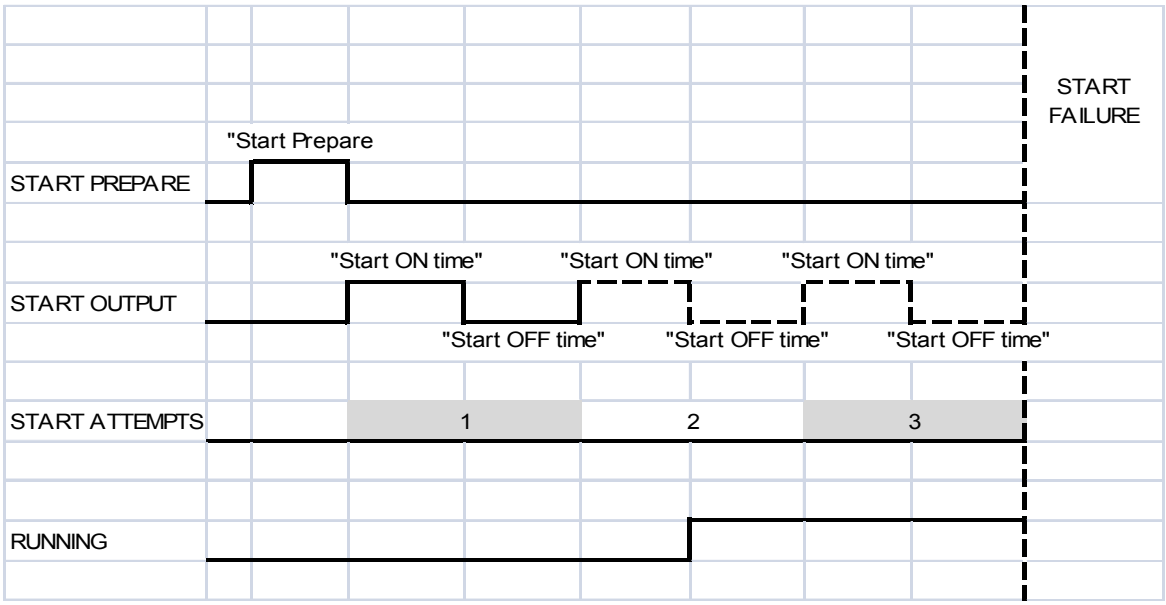
- a *green* "READY" LED
- a *green* "PMS CONTROL" LED

Programming the automatic start sequence

The operator is able to adjust the following Parameters regarding the automatic start sequence:

ID	Channel △	Device	Text	Value	Unit	Timer	FailClass
125	2194	Diesel Gen 2	Running	100		1	No alarm
126	2195	Diesel Gen 2	Tacho overspeed lim.	1800		0,1	DG shutdown
127	2201	Diesel Gen 2	Start prepare	N/A		0	No alarm
128	2202	Diesel Gen 2	Start on time	N/A		5	No alarm
129	2203	Diesel Gen 2	Start off time	N/A		5	No alarm
130	2204	Diesel Gen 2	Start attempts no.	3		N/A	No alarm
132	2211	Diesel Gen 2	Cooling down time	N/A		15	No alarm
133	2212	Diesel Gen 2	Extended stop	N/A		5	No alarm
135	2213	Diesel Gen 2	Stop fail	N/A		30	DG shutdown
134	2214	Diesel Gen 2	Pause stop select	0		N/A	No alarm
136	2230	Diesel Gen 2	Alarm inhibit	N/A		6	No alarm

Please refer to part 1, chapter 3 for a detailed description of the parameter.



The automatic start sequence, here programmed to max. 3 start attempts but the engine starts during the second attempt

Interruption of the start sequence

The start sequence is immediately interrupted (the "START" output deactivated) if *one* of the following events occurs during the automatic start sequence:

- An active running status at the generator set [1)]
- *Normal voltage* is measured at the generator [1)]
- A *PMS stop command* is received
- The *shutdown* alarm sequence is activated [2)]
- The *block* alarm sequence is activated [2)]
- The external start fail input is activated [2)]

[1)] Indicating that the start has succeeded.
[2)] The PMS start command is transferred to the next stand-by generator set, if the interruption is caused by an alarm sequence, or if the DGU is unable to complete the start sequence.

Normally completed start sequence

The automatic start sequence is considered to be normally completed, if *both* below-mentioned conditions are fulfilled:

- An active **"RUNNING"** status signal at the generator set
- Normal generator voltage is measured

A normally completed start sequence is indicated by

- the **"RUN"** LED turning *steady-green*

Detection of running status at the engine

The running status at the engines is generated by means of the "ENGINE RUNNING/ENGINE RPM" feedback signal.

Running status is indicated at the Display Unit corresponding to the DGU by

- a *green* **"RUN"** LED

Selection of running feedback type

Each DGU is able to handle the "ENGINE RUNNING/ENGINE RPM" feedback signal both as

- a binary feedback **"ENGINE RUNNING"** signal

or

- an analogue feedback **"ENGINE RPM"** signal

Changing of running feedback type is simply done by setting the jumpers (for designation as binary or analogue input channels) at the "ENGINE RUNNING/ENGINE RPM" input channel; see the chapter *SERVICE GUIDE* for details.

The running feedback type may be selected as

- binary feedback (CC)
- voltage feedback (0...10V DC, offset 2-10V DC is software-controlled)
- current feedback (0...20mA, offset (4...20 mA) is software-controlled)

Automatic activation of cable supervision

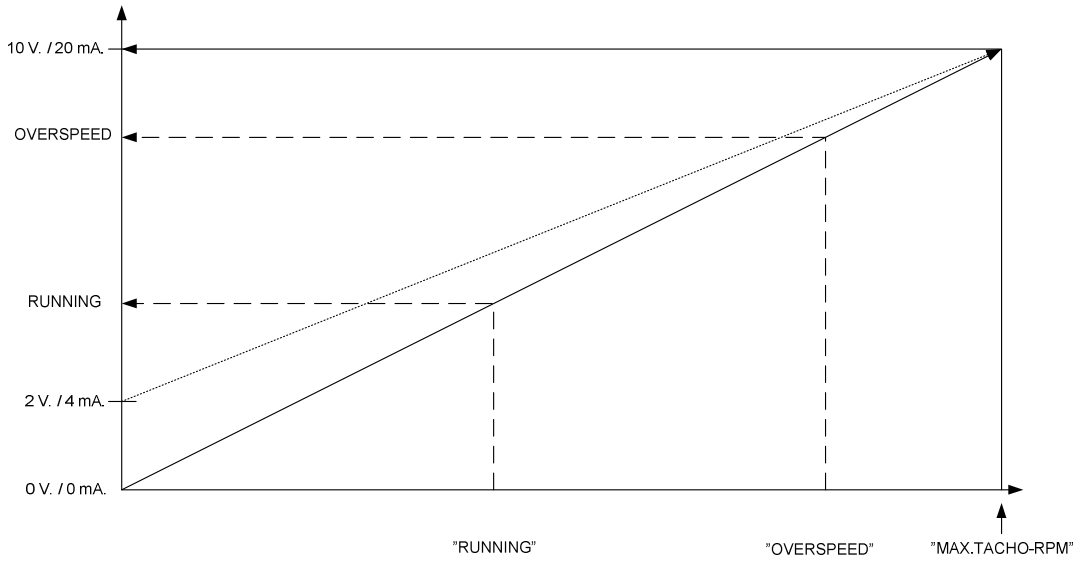
Cable supervision is automatically activated, when the running feedback signal is selected as analogue input and setup for 20% offset.

Adjusting the scale of the analogue running feedback signal

The operator is able to adjust the following parameter structures, by which the detection of running status at the engine with analogue running feedback signal is controlled:

ID	Channel △	Device	Text	Value	Unit	Timer	FailClass
123	2191	Diesel Gen 2	Offset select	1		N/A	No alarm
124	2192	Diesel Gen 2	Max scale	2000		N/A	No alarm
125	2194	Diesel Gen 2	Running	100		1	No alarm
126	2195	Diesel Gen 2	Tacho overspeed lim.	1800		0,1	DG shutdown

Please refer to part 1, chapter 3 for a detailed description of the parameter.



Significance of the adjustable setpoints for scaling of the analogue running feedback

Read-out of the measured RPMs at the auxiliary engine

The actual measured RPMs at the engine are furthermore available for read-out at the Display Unit (DGU DG).

Running hours counter

Each DGU is implemented with two counters, which accumulate the running hours of the generator set (auxiliary engine):

- The counter "RUNHOURS tot" accumulates the total running hours
- The counter "RUNHOURS step" accumulates the trip running hours

The accumulated values in the counters are individual values, which are recorded for each generator set.

Counting begins once the generator set has achieved running status. The counting stops, when the running status signal disappears.

The counters are furthermore available for read-out at Display Unit (DGU DG).

The counters have a resolution of:

Hours	Min.	Seconds
XXXXXX	60	60
	Not shown in display	

The "RUNHOURS tot" counter is displayed with a resolution of 10 hours, and the other counter, the "RUNHOURS step" counter, is shown with a resolution of 1 hour.

Edit/reset of counter

The operator may edit the values of the two counters by entering a new desired value via

ID	Channel △	Device	Text	Value	Unit	Timer	FailClass
141	2251	Diesel Gen 2	Runhours step	0		N/A	DG warning
142	2252	Diesel Gen 2	Runhours total	0		N/A	DG warning

Please refer to part 1, chapter 3 for a detailed description of the parameter.

Start failure

Each DGU supervises, if the engine responds successfully to the automatic start sequence. This is done by means of *both* internal and external start failure supervision.

A DGU carries out the following actions in case of an active start failure alarm (*both external and internal detected start failures*):

- the *automatic stop sequence* for the defective generator set is carried out

and

- the *PMS start command* is transferred to the next stand-by generator set

Internal detected start failure

The *internal* start failure alarm is generated, if one of the following two situations occurs:

1. If the DGU after the programmed number of start attempts is *unable* to detect *either*

   - an active running status signal

   or

   - a normal generator voltage (must be inside the busbar supervision limits)

2. If the DGU, after the automatic start sequence is considered to be completed successfully, is unable to detect *either*

   - an active running status signal

   or

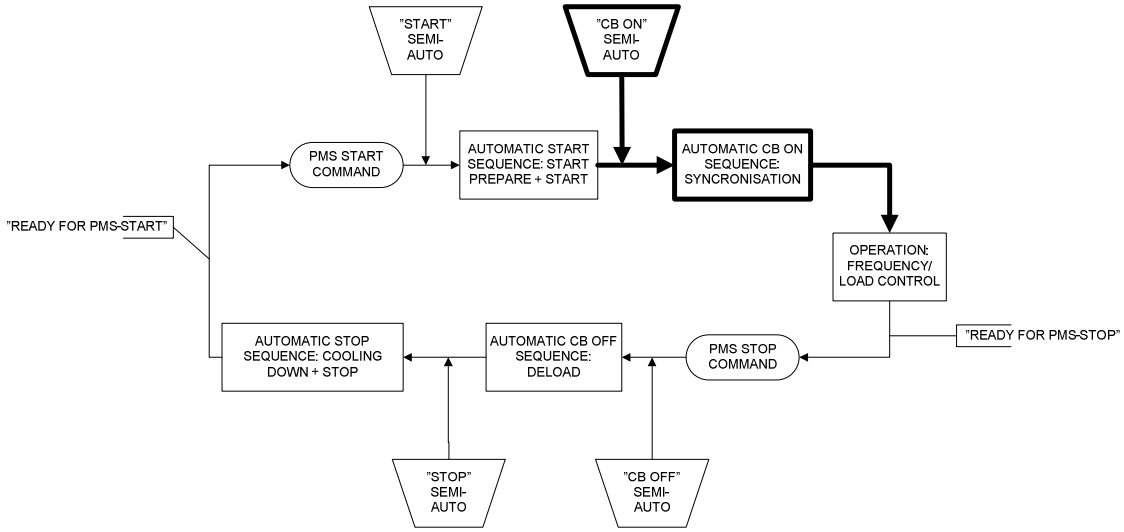
   - a normal generator voltage

If an *internal* start failure is detected, the following alarm message is displayed at the Display Unit (DGU DG):

- Alarm **"START FAIL"**

CB ON sequence

The CB ON sequence is automatically initiated (except during SEMI-AUTO mode), when the automatic start sequence has been completed successfully.



Please refer to appendix 17.2 where the operating principle of the CB ON sequence is presented by means of a flow chart.

The automatic CB ON sequence includes:

- Detection of *"ready for PMS synchronisation"* status for the generator set
- Programmable dynamical synchronisation
- Generator circuit breaker ON control
- Transfer of the PMS start command to the next stand-by generator set in case of
  - a failed synchronisation
  - a generator breaker ON failure

When the CB ON sequence is entered, it is indicated at the Display Unit (DGU DG) by

- a *yellow* **"ON"** LED

SEMI-AUTO control of the CB ON sequence

During SEMI-AUTO mode the operator may initiate the CB ON sequence by

- pressing the "**CB ON**" push-button

This will initiate closing of the generator breaker. A SEMI-AUTO stop or CB OFF command will interrupt an ongoing CB ON sequence.

Detection of "ready for synchronisation" status

The DGU will only initiate the automatic synchronisation, if the generator set is detected to be *"ready for synchronisation"*.

A positive detection of the "ready for synchronisation" status is accepted by the DGU, when the below-mentioned conditions are fulfilled:

- An active running status
- Generator voltage and frequency are acceptable
- No active "SAFETY STOP", "TRIP OF GB" or "SHUTDOWN" alarm sequences
- A positive sequential order of phases

If a positive sequential order of phases is *not* detected between the generator and the busbar, the following alarm message is displayed at the Display Unit (DGU DG):

- Alarm **"PHASE SEQ. FAIL"**

The supervision of positive phase sequence is only active when entering the CB ON sequence.

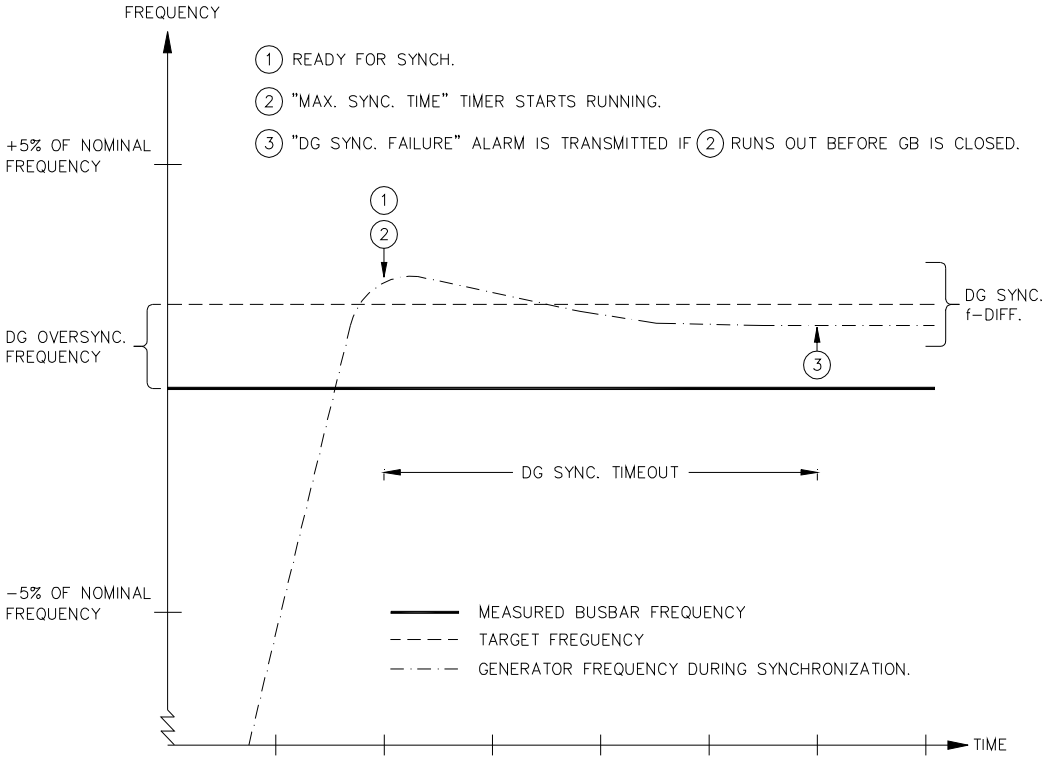
Programming the dynamical synchronisation

The dynamical synchronisation is initiated as soon as the auxiliary engine has obtained running status (except when started in SEMI-AUTO mode, then it waits for the CB ON command).

For the dynamical synchronisation the operator is able to program the following:

ID	Channel △	Device	Text	Value	Unit	Timer	FailClass
80	2011	Diesel Gen 2	Set Diff.	0,2	Hz	N/A	No alarm
81	2012	Diesel Gen 2	Min Diff.	0,05	Hz	N/A	No alarm
82	2013	Diesel Gen 2	Max Diff.	0,3	Hz	N/A	No alarm
83	2014	Diesel Gen 2	CB close time	60	ms	N/A	No alarm
84	2020	Diesel Gen 2	Sync volt diff fail	10	%	20	DG block
86	2040	Diesel Gen 2	Sync fail	N/A		90	DG block
48	2050	Diesel Gen 2	CB unavail. selected	0		N/A	DG block
88	2070	Diesel Gen 2	Volt freq ok	N/A		3	No alarm
90	2081	Diesel Gen 2	P deload	5	%	60	DG block
92	2083	Diesel Gen 2	P deload CB off	10	%	N/A	No alarm
93	2091	Diesel Gen 2	Q deload	5	%	60	DG block
95	2093	Diesel Gen 2	Q deload CB off	60	%	N/A	No alarm

Please refer to part 1, chapter 3 for a detailed description of the parameter.



Programmable delay and setpoints for control of the dynamical synchronisation

The target frequency for the dynamical synchronisation is the programmed desired over-synchronous frequency added to the measured busbar frequency. The frequency is calculated continuously during the synchronisation of the generator set.

- Parameter "**Setp. Diff. 0.2 Hz**"

The calculated target frequency forms references for the frequency controller.

The DGU will only transmit the CB ON signal, if the following conditions have been *continuously fulfilled for 6 periods*:

- The generator frequency is within the window between "**Min.diff.**" and "**Max.diff.**"
- The generator voltage is within the parameter "**SYNC VOLT DIFF. FAIL**"
- The measured difference in phase angle between the generator and the busbar (Δ_{GEN-BB}) must be < 30.0° el. with consideration to the delay in the generator breaker
- The measured difference in phase angle acceleration between the generator and the busbar (Δ_{GEN-BB}/dt) must be within 0.0° < (Δ_{GEN-BB}/dt) < 9.0° el.

The CB ON signal is transmitted with compensation for the closing time of the generator breaker (the time it takes for the generator breaker to switch from OFF position to ON position).

If the alarm timer delay for "**SYNC VOLT DIFF. FAIL**" voltage difference is running out during the synchronisation, meaning there is a large voltage difference between the two sides of the breaker, the following alarm message is displayed at the Display Unit (DGU DG):

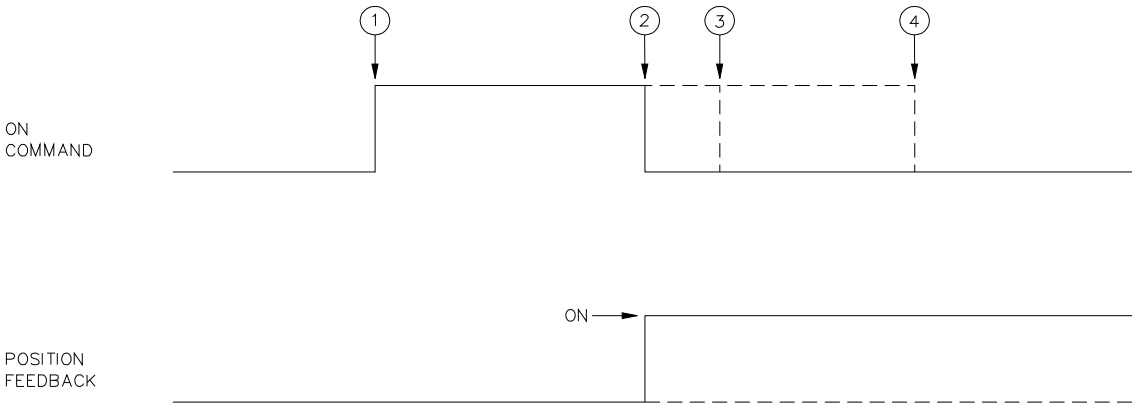
- Alarm **"SYNC.VOLT.DIFF.FAIL"**

If the generator breaker is not closed within the programmed delay for max. synchronisation time, the following alarm message is displayed at the Display Unit (DGU DG):

- Alarm **"SYNC. FAIL"**

Generator breaker ON control

The DGU supervises, if the generator breaker is turned into ON position when requested.



The generator breaker ON control

1) Synchronisation conditions are OK.
2) The ON signal is deactivated, when the ON position feedback signal is received.
3) Max. time for an active ON output. The time consists of two contributions: The closing time for the breaker and the max. timer.
4) Delay time for the "ON FAILURE" alarm runs out.

A generator breaker ON position is indicated at the Display Unit (DGU DG) corresponding to the DGU by

- a *green* "**CB ON**" LED

If the generator breaker is not in ON position a short delay after the "CB ON COMMAND" signal is transmitted by the SCM module, the following alarm message is displayed at the Display Unit (DGU DG):

- Alarm **"BREAKER ON FAIL"**

If alarm "BREAKER ON FAIL" occurs, a command to open the generator breaker is immediately transmitted by the SCM module!

Frequency control/active load control

Each DGU has two programmable controllers, which enable them to carry out both frequency control and load control.

- The frequency controller is active, when the DGU is designated with frequency control
- The load controller is active, when the DGU controls a generator running in parallel

During synchronisation only frequency control is active.

Frequency and load control is indicated at the Display Unit related to the DGU having activated the controllers by

- a *green* "**REGULATOR ON**" LED

If the optional voltage regulation is implemented in the software, the voltage regulator will be indicated on the same LED.

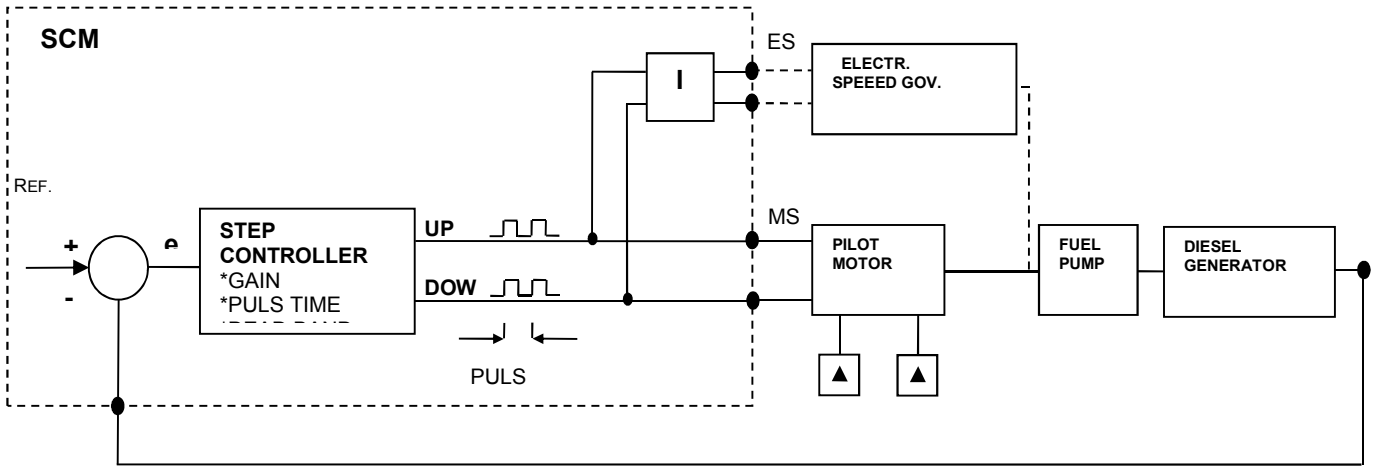
The programmable frequency/load controller

Frequency and load control are handled by the same hardware outputs in the SCM module.

SIGNAL NAME	SIGNAL TYPE	LOCATION
• ESG	Analogue outputs	(SCM – terminals 20-32)
• MSG	Relay outputs	(SCM – terminals 36-37 / 38-39)

MSG (relay outputs for mechanical speed governors) is only implemented in the SCM module if requested.

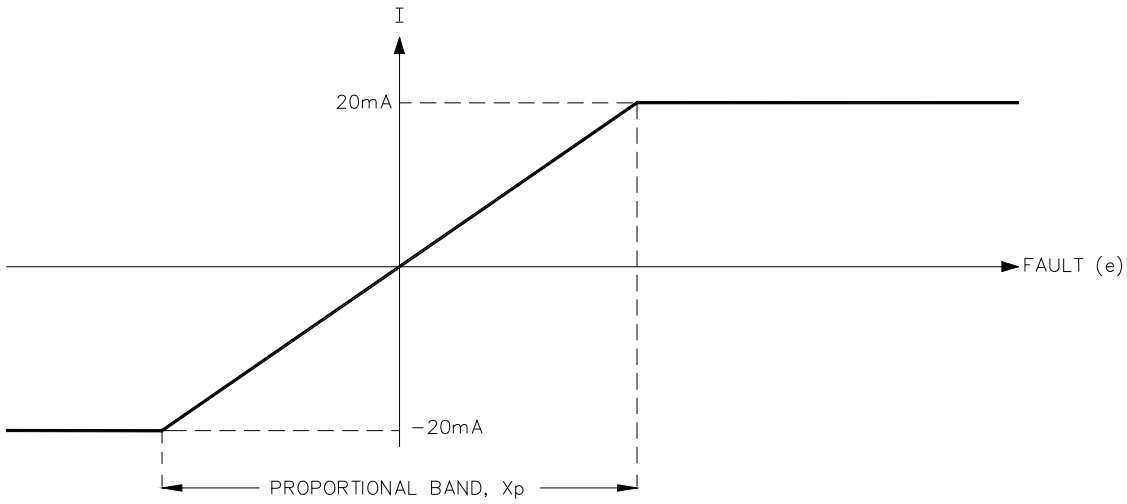
The controllers in the SCM module consist of a programmable Pulse Width Modulator controlled by a P controller. In case of an active ESG output, an integral circuit transforms the output from the PWM to the analogue value present at the ESG terminals.



Functional principle of the controllers

Output characteristic for the ESG output

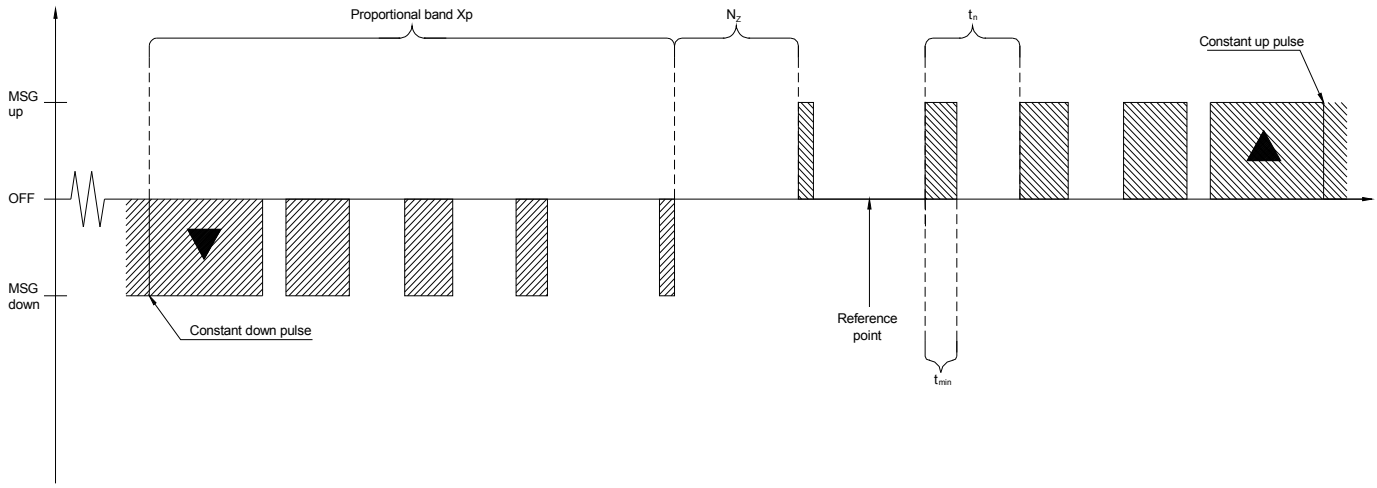
The ESG analogue output characteristic is directly dependent on the amplification (GAIN, Xp).



The output characteristic of the ESG (analogue) output for electronic speed governors

The pulse time duration for the step controller (PULS TIME, tn) has a direct influence on the response dynamics for the frequency/load control carried out by means of the ESG output, as it represents the updating interval for the analogue value presented at the ESG output. So the pulse time duration (PULS TIME, tn) has influence on the response characteristic of the control system.

Output characteristic for the MSG output



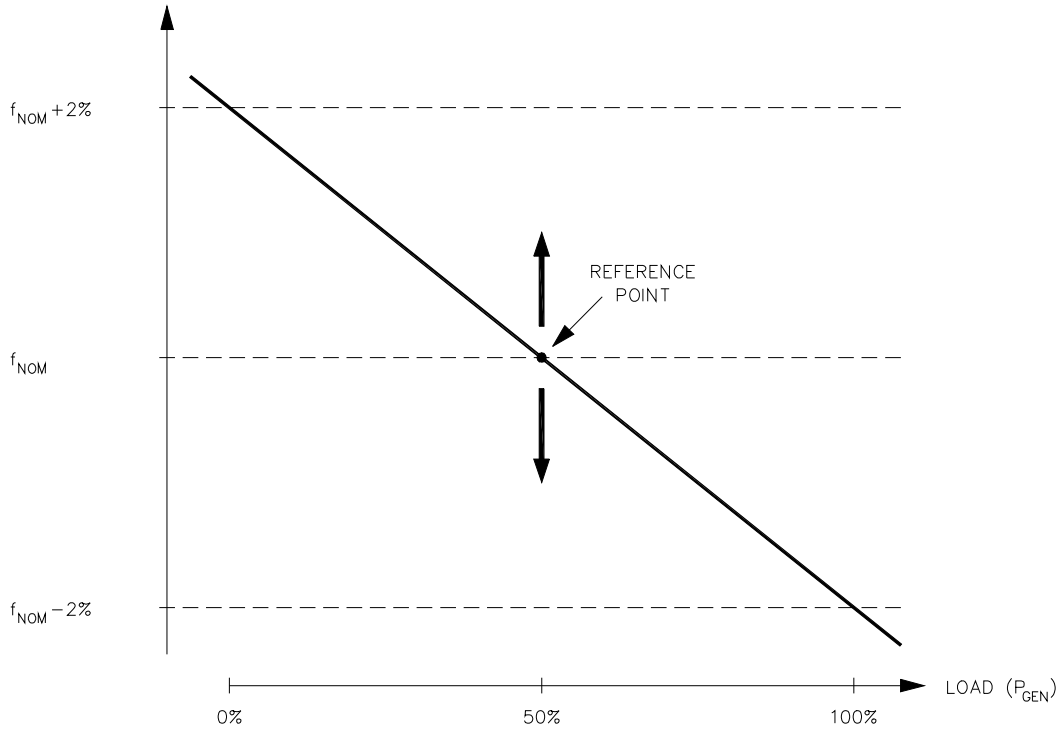
The output characteristic of the MSG (relay) output for mechanical speed governors

The pulse time duration for the step controller (PULS TIME, tn) has a very significant influence on the dynamics of the control response when using the MSG output, as it directly represents the interval of regulation at the mechanical speed governor.

Speed droop in the speed governors

The frequency as well as real power controllers are only able to operate, if their corresponding speed governors have an available *speed droop mode*.

The DGU controls the frequency and real power by changing the droop line in either upward or downward direction.



Recommended setting of the speed droop range in the speed governors

The speed droop range is recommended to be set to at least 4% of the nominal frequency (f_{NOM}).

A lower speed droop range than the recommended 4% may result in a fast (maybe too fast) dynamic control loop and thus an unstable power plant.

A higher speed droop range than the recommended 4% may result in a slow (maybe too slow) dynamic control loop.

Programming the frequency control

The DGU uses the following parameters in the frequency controller in idle mode (when the Generator Breaker is opened):

- Parameter **"Gain freq idle"**
- Parameter **"Puls time on+off"**
- Parameter **"Puls time on min"**
- Parameter **"Dead band freq"**

Please refer to part 1, chapter 3 for a detailed description of the parameters.

The frequency controller is active during idle and synchronisation of the generator set, during synchronisation the dead band is set to 0 Hz, meaning the dead band is minimised.

An increased "Gain freq idle" value gives a more quickly responding frequency control.

Programming the frequency/load sharing control

The DGU uses the following Parameters for the load controller:

- Parameter **"Gain freq connected"**
- Parameter **"Gain Power"**
- Parameter **"Puls time on+off"**
- Parameter **"Puls time on min"**
- Parameter **"Dead band freq"**
- Parameter **"Dead band power"**
- Parameter **"ESG time division" (only used with analogue interface)**

Please refer to part 1, chapter 3 for a detailed description of the parameters.

An increased "Gain freq connected" value gives a more quickly responding frequency control. An increased "Gain power" value gives a more quickly responding frequency and load control.

Supervision of active load share

Each DGU supervises how much the real power produced by the generator set deviates from the calculated real power reference point.

The operator is able to set up the parameters, by which the load share is supervised.

- Parameter **"Loadcontrol fail GOV"**

Please refer to part 1, chapter 3 for a detailed description of the parameter.

The load share supervision function does not distinguish between symmetrical or asymmetrical load share, but simply compares setpoint "Loadcontrol fail GOV" to the calculated real power reference.

If the DGU is unable to control the real power load on the generator set within the max. real power deviation limit, within the programmed delay, the following alarm message is displayed at the Display Unit (DGU DG):

- Alarm **"Loadcontrol fail GOV "**

SWBD control of frequency/load via the SCM module

Provided that SWBD control is *selected* on the DGU, the operator is able to manually control the speed of the engine in upwards or downwards direction respectively by the SCM module.

The manual speed control is handled by the following hardware interface.

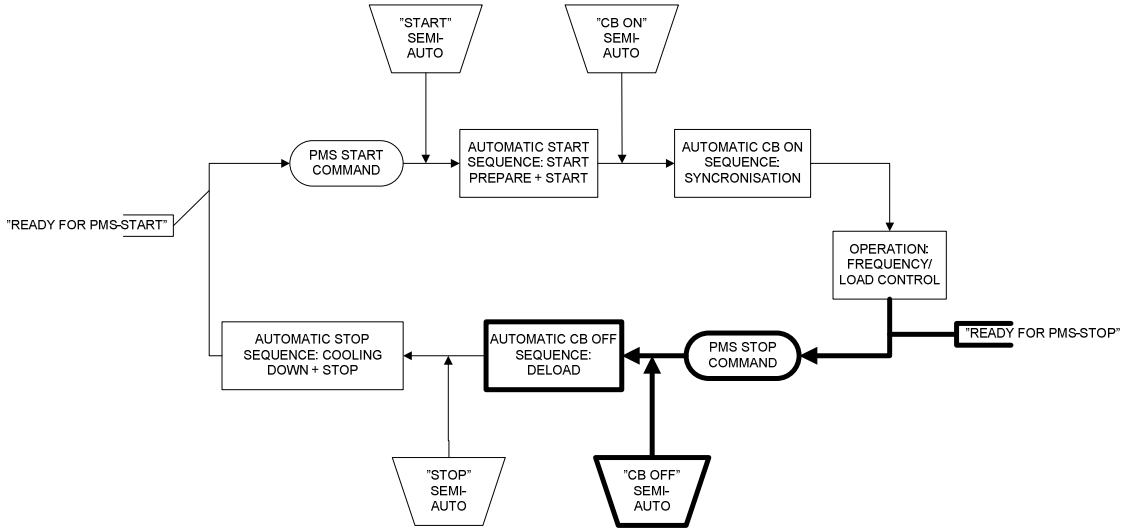
SIGNAL NAME	SIGNAL TYPE	LOCATION
• GOV. ⮝	Binary input	(SCM – terminals 22-29)
• GOV. ⮟	Binary input	(SCM – terminals 23-29)
• MSG/ ESG	Relay outputs/ Analogue outputs	(SCM – terminals 36-37 / 38-39) (SCM – terminals 30-32)

For the hardwired connection to the SCM module regarding manual speed control, please refer to the *INSTALLATION INSTRUCTIONS*.

The speed of the engine is manually *increased* by impressing a *closed contact* (CC) between terminals 22-29 at the SCM module, whereas the speed of the auxiliary engine is manually *decreased* by impressing a *closed contact* (CC) between terminals 23-29 at the SCM module.

CB OFF sequence

The CB OFF sequence is initiated, when the DGU receives a PMS stop command from the Main PMS DGU (or a SEMI-AUTO initiated CB OFF). The PMS stop command is *only* accepted by the DGU, if the generator set is "ready for PMS stop".



The CB OFF sequence deloads the generator set and opens the generator breaker.

Please refer to appendix 17.3, where the operating principle for the CB OFF sequence is presented by means of a flow chart.

SEMI-AUTO generator breaker OFF control

During SEMI-AUTO plant mode the operator may initiate the CB OFF sequence by

- pressing the "**CB OFF**" push-button on the Display Unit (DGU DG)

The DGU will only accept the SEMI-AUTO "CB OFF" command, if the generator set is expendable at the busbar (meaning it is not alone on the busbar, and the available power on the busbar exceeds the nominal power of the DG in question).

A SEMI-AUTO CB ON command will interrupt an ongoing CB Off sequence!

Ready for PMS stop

A PMS stop command is only accepted by a DGU, if the generator set is *ready for PMS stop*.

A DGU is only considered to be *"ready for PMS stop"*, if the following conditions are fulfilled:

- PMS control is selected
- The circuit breaker is closed (position ON)
- No "**Breaker off fail**" alarm
- No "**P deload"** alarm

Deloading of the generator set

The automatic CB OFF deloads the generator set before allowing the generator breaker to be opened. The DGU will reduce the generator load by changing the load reference for the load regulator.

When the measured generator load (real power) goes below the programmable limit, the generator breaker is opened.

The operator is able to configurate the parameters, by which the generator breaker is opened.

- parameter **"P deload CB Off" & "Q deload CB Off"**

Please refer to part 1, chapter 3 for a detailed description of the parameters.

If the DGU is unable to deload the generator below this limit within the allowed time, the alarm **"P deload"** is activated, and an alarm message is displayed at the Display Unit (DGU DG).

Programmable deloading, parameter ramp down

The deloading is done by changing the load reference for the generator with the purpose of reducing the load to be below the limit for opening the circuit breaker.

The deloading is done with reference to a programmable ramp-down rate of the generator load reference, where the load reference is decremented step by step (constant rate), until the breaker is opened. This will allow the operator to adjust the deloading rate of the generator. The DGU reduces the generator real power reference point step by step (each second) from the actual real power load to 0 kW.

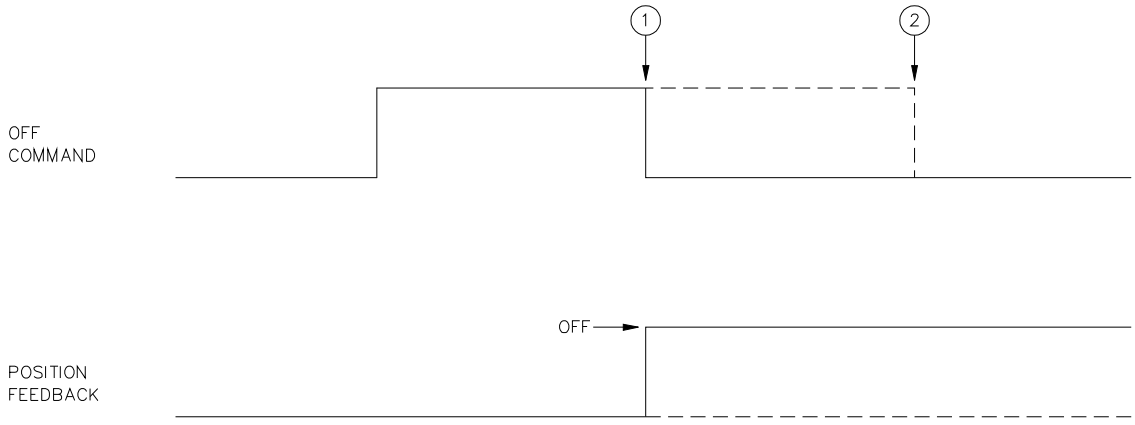
Please refer to part 1, chapter 3 for a detailed description of the parameters.

If the breaker is not opened (the generator deloaded) within time, the alarm **"P deload"** is displayed at the Display Unit (DGU DG).

If the "P deload" alarm becomes active, the generator set is included in the symmetrical load share again and (if possible) loaded according to this.

Generator circuit breaker OFF control

The DGU supervises, if the generator breaker is turned into OFF position when requested by the SCM module.



The generator circuit breaker OFF control

1) The off signal is deactivated, when the OFF position feedback is received.
2) Delay timer for the "OFF FAILURE" alarm times out.

A generator breaker OFF position is indicated at the corresponding Display Unit (DGU DG) by

- a *green* "**CB OFF**" LED

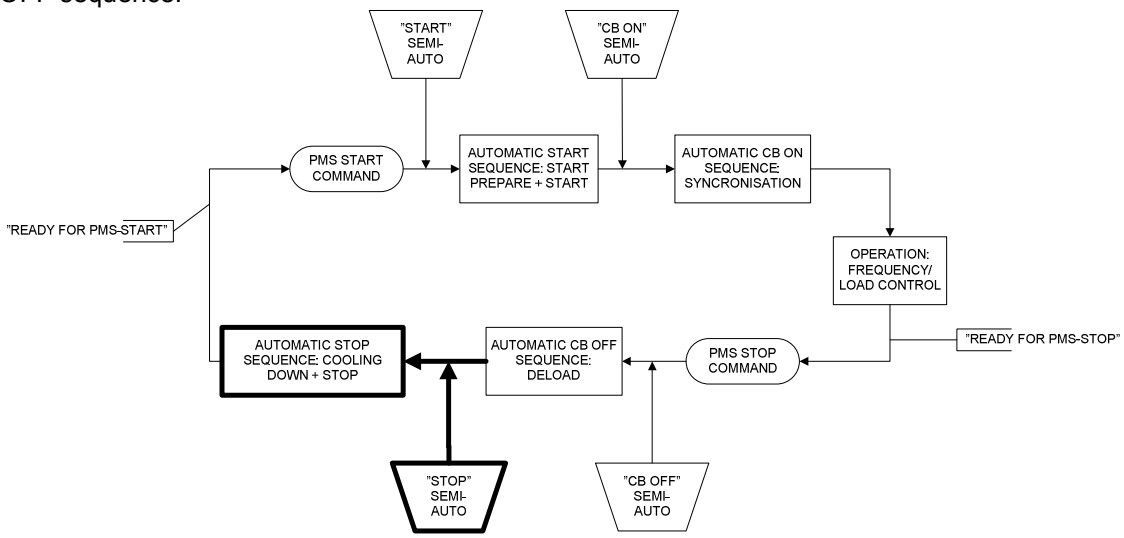
If the generator breaker is not in opened position 1.0 s after the "CB OFF COMMAND" signal is transmitted by the SCM module, the following alarm message is displayed at the Display Unit (DGU DG):

- Alarm **"Breaker off fail"**

The generator set is included in the load share again if the alarm is generated and will, if possible, be loaded according to that.

Automatic stop sequence

The automatic stop sequence is carried out, when the DGU has successfully completed the CB OFF sequence.



The stop sequence is automatically initiated, when the CB OFF sequence has been completed

Please refer to appendix 17.4, where the operating principle for the automatic stop sequence is presented by means of a flow chart.

The DGU in the Delomatic system is able to carry out the automatic stop sequence, which includes:

- Automatic stop sequence incl.:
  - Programmable cooling down time
  - "STOP" output with programmable extended ON time
- SEMI-AUTO stop of engine incl.:
  - Programmable cooling down time
  - "STOP" output with programmable extended ON time

SEMI-AUTO stop of engine

Provided that SEMI-AUTO plant mode is selected, the operator may initiate a SEMI-AUTO stop of the engine by

- pressing the "**STOP**" push-button at the Display Unit (DGU DG)

A SEMI-AUTO CB ON or Start command will interrupt an ongoing stop sequence!

I/O interface for the automatic stop sequence

The automatic sequence for stop of the auxiliary engine is controlled by the following I/O interface.

SIGNAL NAME	SIGNAL TYPE	LOCATION
• U_{GEN}	3-phase voltage input from generator	(SCM – terminals 7-8-9-10)
• ENGINE RUNNING/ ENGINE RPM	Binary input Analogue input	(IOM 4.1 – terminals 1-45)
• STOP	Relay output	(IOM 4.1 – terminals 23-24)

U_{GEN} feedback

The generator voltage and frequency measured via the 3-phase voltage AC inputs are in combination with the engine running feedback used for a dual detection of a stopped engine.

Engine running feedback

The disappearance of the "ENGINE RUNNING" feedback is used for detection of a stopped engine during the automatic stop sequence.

The stop output

The "STOP" output is activated (ON) after cooling down of the engine.

Programming the automatic stop sequence

The operator is able to adjust the following Parameters, by which the automatic stop sequence is controlled:

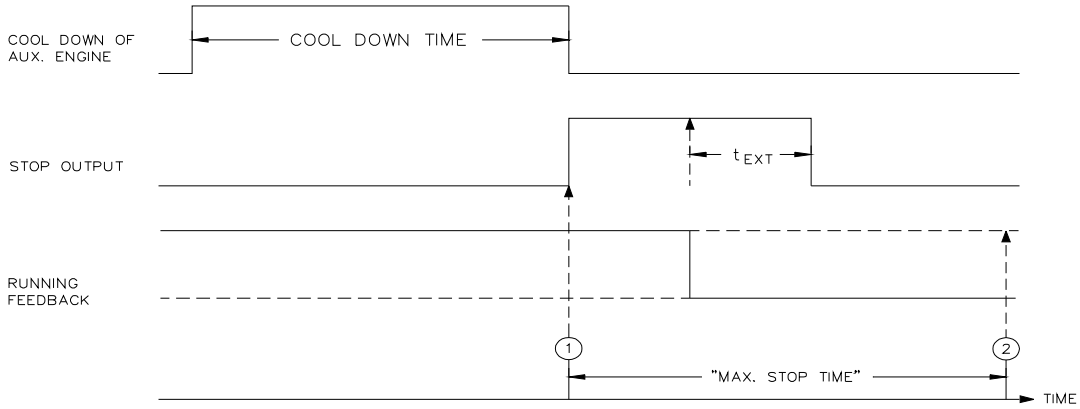
ID	Channel △	Device	Text	Value	Unit	Timer	FailClass
132	2211	Diesel Gen 2	Cooling down time	N/A		15	No alarm
133	2212	Diesel Gen 2	Extended stop	N/A		5	No alarm
135	2213	Diesel Gen 2	Stop fail	N/A		30	DG shutdown
134	2214	Diesel Gen 2	Pause stop select	0		N/A	No alarm

Please refer to part 1, chapter 3 for a detailed description of the parameters.

Stop failure

A stop failure alarm is displayed at the Display Unit (DGU DG), if the "ENGINE RUNNING/ENGINE RPM" feedback signal has not disappeared, or if normal voltage and frequency are still to be measured, when the "Stop fail" timer runs out.

- Alarm **"Stop fail"**



The automatic stop

1) Max. stop timer starts running.
2) DG stop fail. alarm is transmitted, if the running feedback is still present when timer runs out.

The cooling down sequence may be interrupted by the following events:

- **A shutdown alarm sequence is activated**
- **A new PMS start command is received by the DGU**

Stop of non-connected generator

A generator set may be left running idle, e.g. due to generator frequency or voltage failure during the automatic start sequence. Likewise, a generator set started during SEMI-AUTO mode may be left running idle, when an automatic plant mode is subsequently selected.

A running generator as described above will be stopped after a time (to preserve fuel, minimise attrition etc.), which is called "Non connected stop".

Any generator set, which has an active generator protective function ("Trip of GB" alarm sequence), is not stopped by the function for stop of non-connected generator sets.

The operator is able to program the following parameter, by which the function for stop of non-connected generator set is controlled. When the timer runs out, the automatic stop sequence is initiated as in a normal stop situation.

ID △	Channel	Device	Text	Value	Unit	Timer	FailClass
137	2240	Diesel Gen 2	Non connected stop	N/A		15	No alarm

If the operator wants to have a DG running idle, set it in SWBD control.

Additional functions

This chapter contains additional optional functions.

Programmable priming

Priming of the engine is controlled by the following I/O interface.

SIGNAL NAME	SIGNAL TYPE	LOCATION
• PRIMING	Relay output	(IOM 4.1 – terminals xx-xx)

The priming output becomes active, whenever the generator set has the "ready for PMS start" status, and once activated, the priming output will carry out a sequence with interval of OFF and ON. Priming stops when the DGU receives a PMS start command. The operator is able to activate the output priming ON/OFF and to program the ON and OFF time of the priming output.

ID	Channel	Device	Text	Value	Unit	Timer	FailClass
121	2181	Diesel GEN 1	Priming On	10		N/A	DG noalarm
122	2182	Diesel GEN 1	Priming Off	15		N/A	DG noalarm

Please refer to part 1, chapter 3 for a detailed description of the parameters.

Analogue outputs

On the IOM 4.1 module (2) analogue output channels are present.

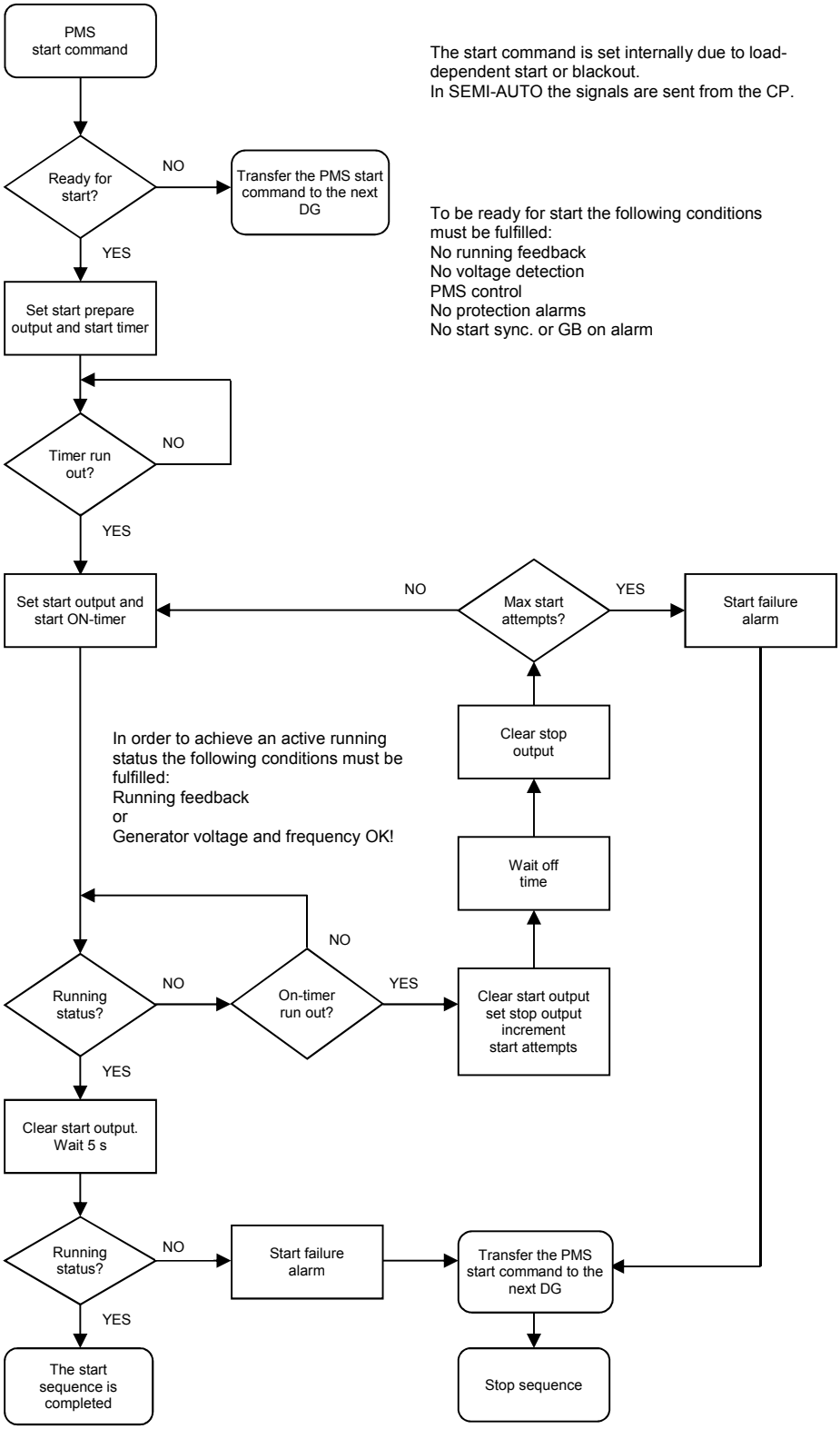
Adjusting the scale of the analogue output

The scale of the analogue output signals are defined as:

- "AO min scal ID:XCh:X". " AO min scal ID:XCh:X " corresponding to:
  - min… max ⇔ 20...100% output

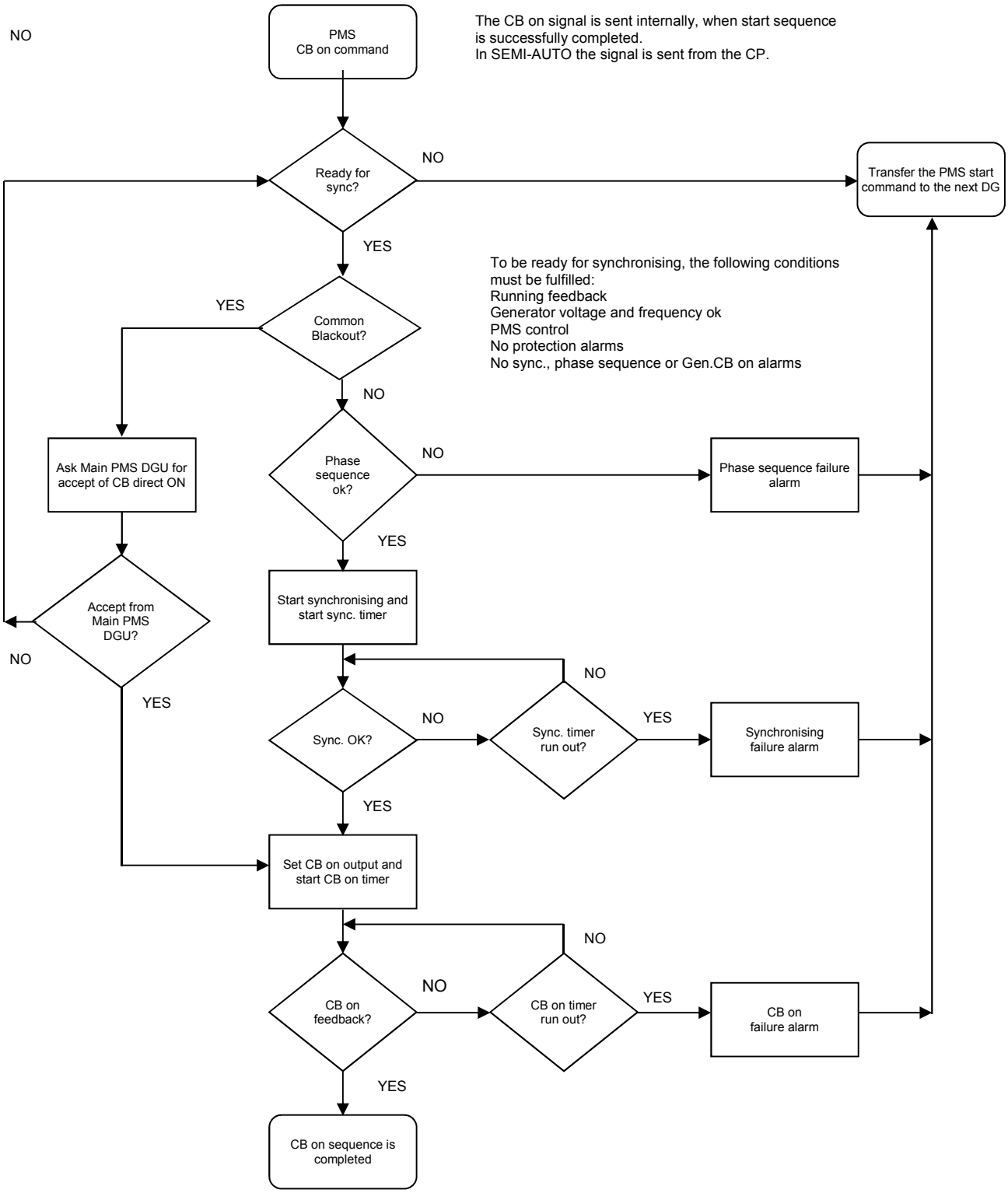
Appendix 17.1

Automatic start sequence flow chart



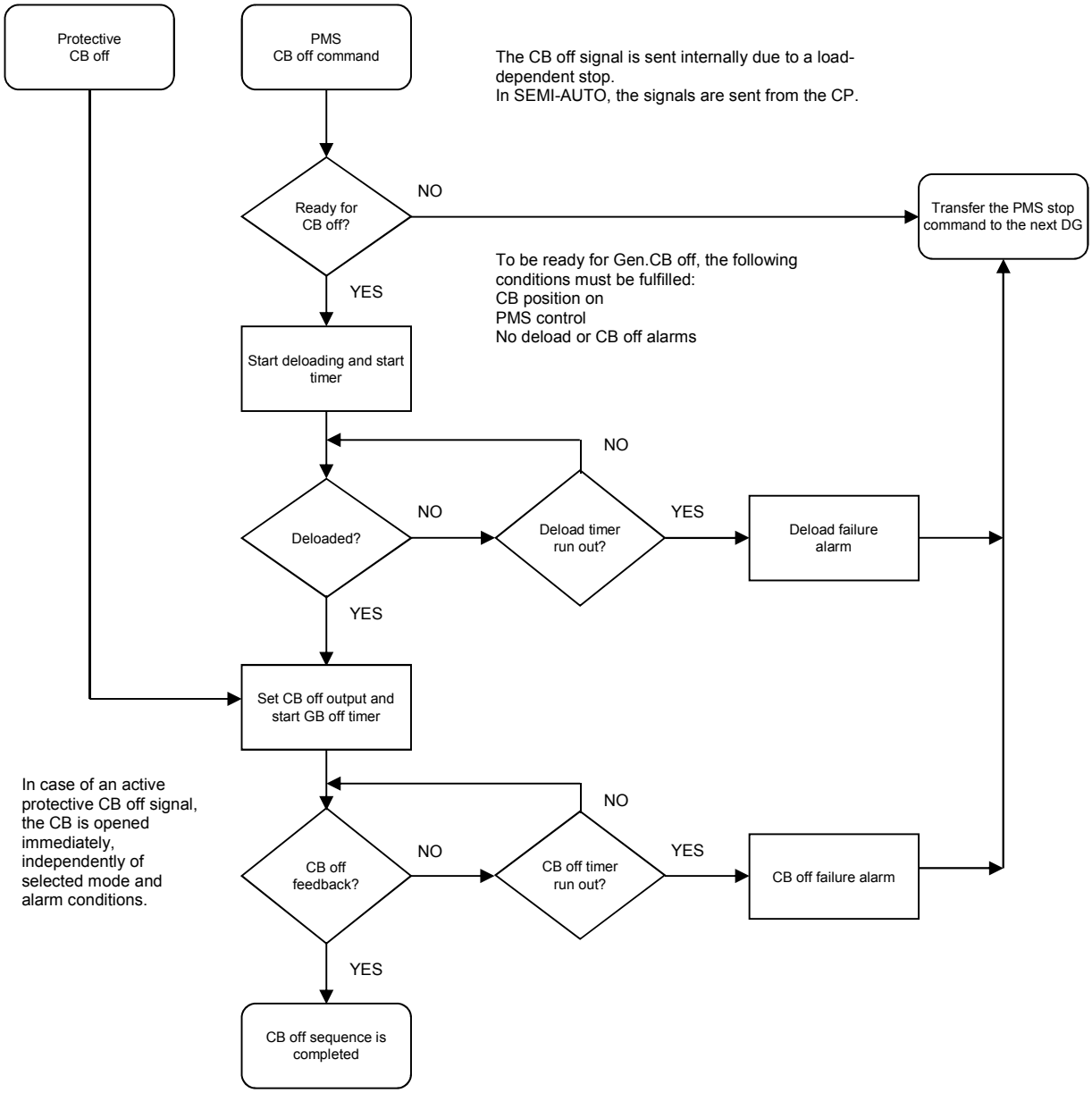
Appendix 17.2

CB ON sequence flow chart



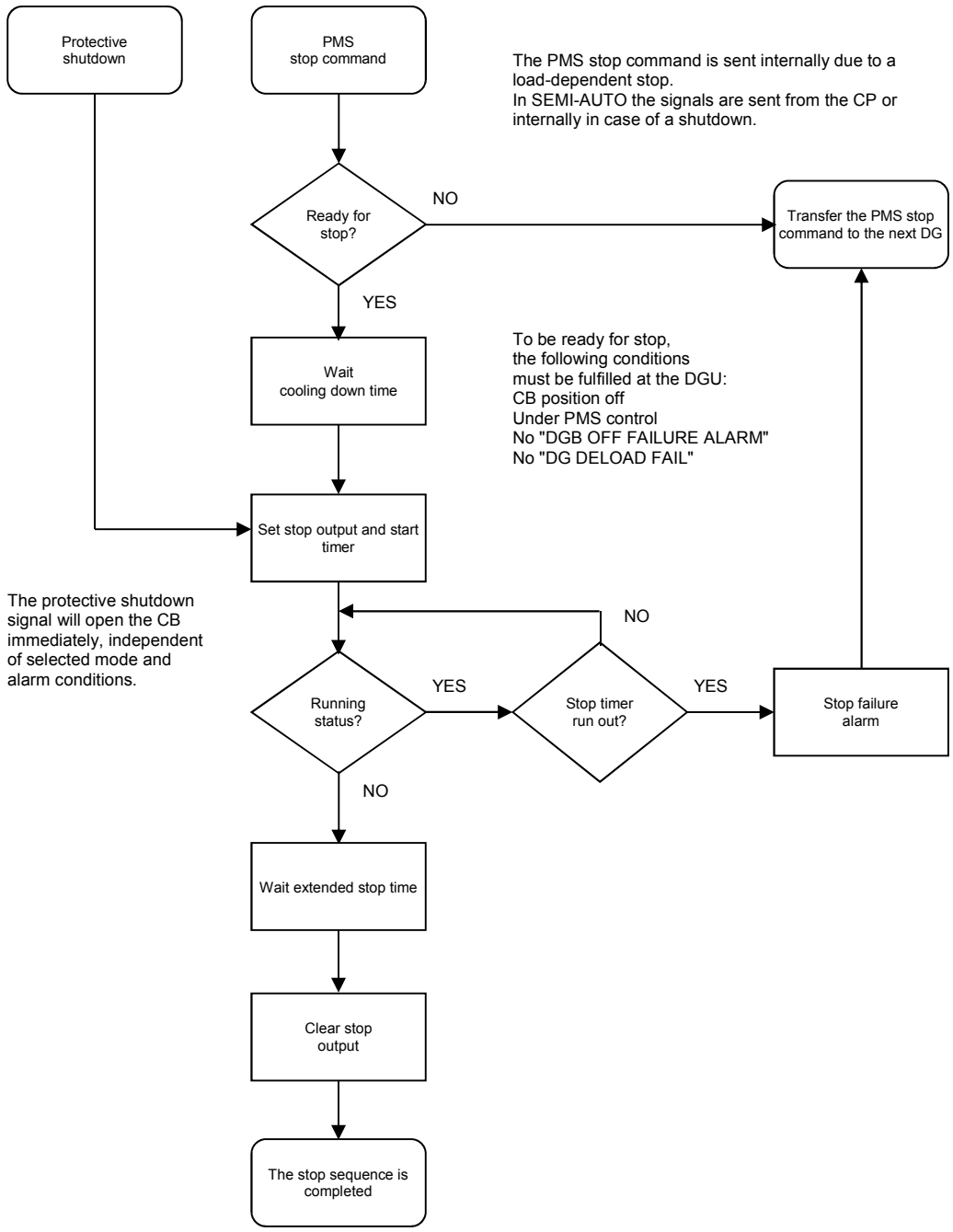
Appendix 17.3

CB OFF sequence flow chart



Appendix 17.4

Automatic stop sequence flow chart



DEIF A/S reserves the right to change any of the above.