Delomatic 4
DM-4 Land/DM-4 Marine

Power Management Unit
Part 2, chapter 16

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Document no.: 4189232116E

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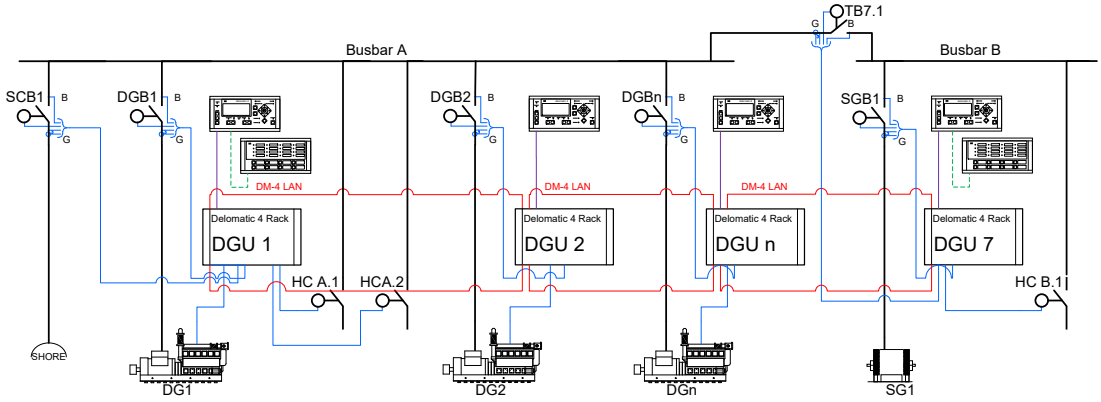
16. Power Management unit

The Power Management system is based on several Delomatic racks. Each rack is operated by means of several software modules.



The PMS in the DM-4 system operates as an **integrated unit in the PMS DGUs.**

The PMS interface in each DGU carries out distributed control of the generator sets according to the received PMS commands and PMS status feedback signals.

Only generator sets (DGUs) selected to be under PMS control are included in the automatic PMS functions.

Protection functions are not a PMS-function, and are enabled unaffected by the selection between PMS control/switchboard control.

Load-dependent start/stop function

The load-dependent start/stop function is active, when the plant mode AUTO *or* SECURED is selected. The start/stop function transmits PMS start and stop commands, which are based on a calculation of how many generator sets are needed in order to meet the actual power demand at the busbar. The PMS start/stop commands causes the individual generator sets to carry out start and stop sequences respectively according to the programmed start/stop priority.

In plant mode SEMI-AUTO, the operator-initiated operations as start diesel engine, sync. and close generator breaker, deload and open generator breaker, and cool down and stop engine functions will only allow the command to be effectuated, if the generator set as example is dispensable from the busbar (the predicted available power > the nominal power of the generator set). Calculation of the load-depending PMS start/stop commands are based on a comparison of the programmed start and stop limits and a special DM-4-calculated value called the **predicted available power.**

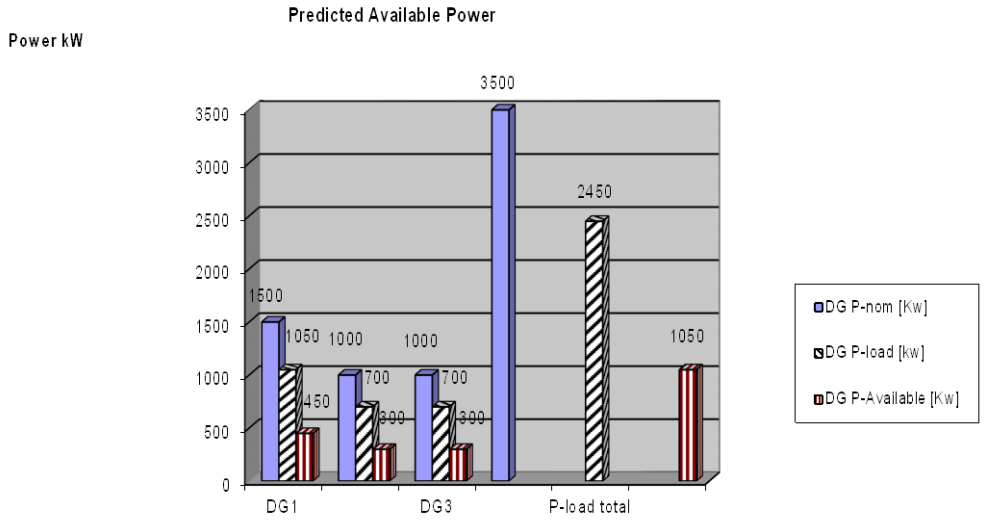
Predicted available power

In order to ensure sufficient available power at the busbar **at all times**, the DM-4 system uses a value called **the predicted available power**. Calculation of the predicted available power is based on a summation of the available power at each running and connected generator set (see the illustration below).

If a generator set is set in switchboard/manual control and is thus no longer available for PMS control, the nominal power of the generator set is not included in the predicted power available calculation, regardless of whether the generator breaker is connected or not.
The predicted power available calculation is also subject to subtraction of power reservation, for example in case there is one or more active start request signals for heavy consumers or thrusters.

The result of the summation is the total **measured available power** at the busbar.

	DG P-nom [Kw]	DG Load [%]	DG P-load [kw]	DG P-Available [Kw]
DG1	1500	70	1050	450
DG2	1000	70	700	300
DG3	1000	70	700	300
P-nom total	**3500**			
P-load total			**2450**	
P-available total				**1050**



The calculated **predicted available power** is compared with the programmed load-depending start/stop limits in order to generate the PMS start/stop commands.

Programming of the load-dependent start and stop limits

The parameters for load-dependent start/stop are:

ID	Channel △	Device	Text	Value	Unit	Timer	FailClass
382	4231	PMS	kW(0) %(1) LD S/S	1		N/A	No alarm
392	4232	PMS	Min NBR DGS con set1	1		N/A	No alarm
383	4233	PMS	NBRS black start	2		N/A	No alarm
384	4250	PMS	LD start delay	100	kW	5	No alarm
386	4250	PMS	LD stop delay	200	kW	30	No alarm
385	4270	PMS	Load dependent start	90	%	5	No alarm
387	4270	PMS	Load dependent stop	80	%	30	No alarm

ID 382 channel 4231: selection between start/stop to be performed according to kW or % calculated values.
If kW is selected the parameters ID 384 channel 4250 and ID 386 are enabled.
If % is selected the parameters ID 385 channel 4270and 387 are enabled.

Load depending start/stop limitation calculation principles

LDP Start/Stop in %

- Start:
  When the consumed busbar power in percentage exceeds the set point [xx %] during the time delay, then the next standby genset is started and connected.

- Stop:
  When subtracting the nominal power of the genset to be disconnected according to priority, the consumed busbar power in percentage must not exceed the set point [xx %].
  If this remains true during the time delay, one genset will be disconnected according to priority.

LDP Start/Stop in kW

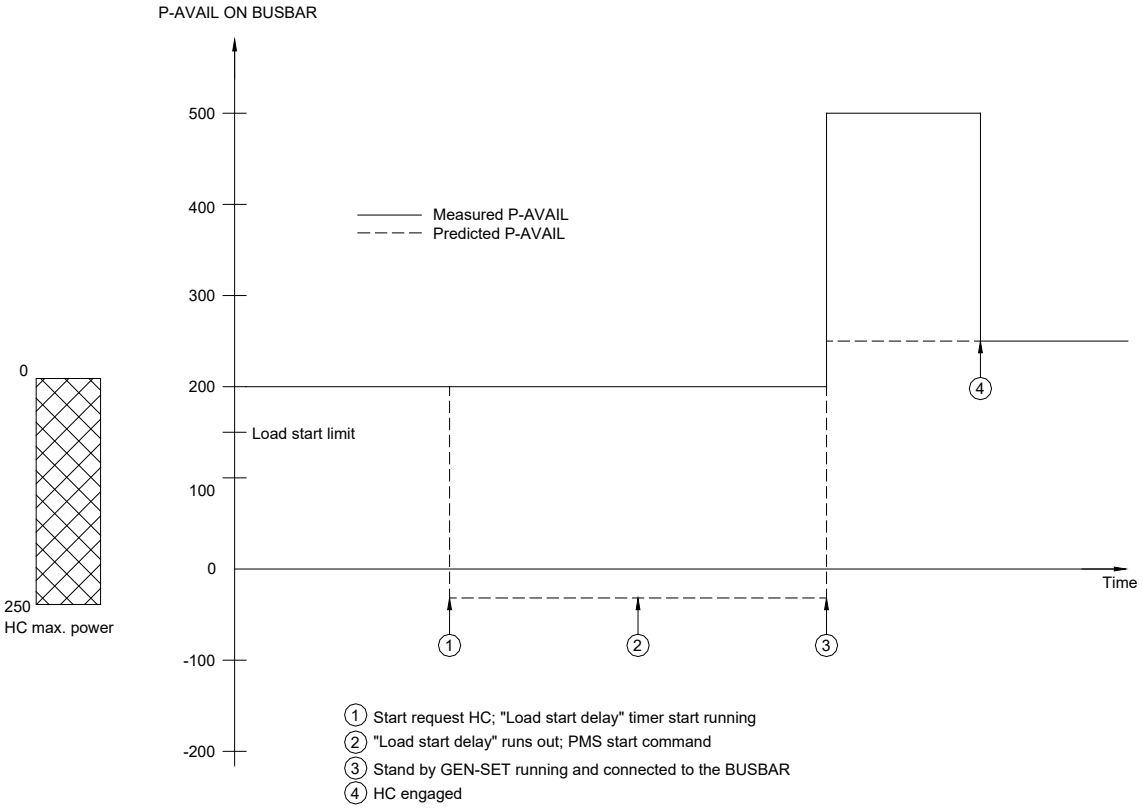
- Start:
  When the available busbar power drops below the set point [xx kW] during the time delay, then the next standby genset is started and connected.

- Stop:
  When subtracting the nominal power of the genset to be disconnected according to priority, and subtracting the set point for LDP STOP (kW), the available busbar power in kW must be positive.
  If this remains true during the time delay, one genset will be disconnected according to priority.

Programming of the load-dependent start limit

Generation of **the load-dependent PMS start command** is based on a comparison of the predicted available power at the busbar and the programmed start limit value.

Please refer to **Appendix A.16.1** where the operating principle for generation of the load-dependent start command is presented by means of a flow chart.

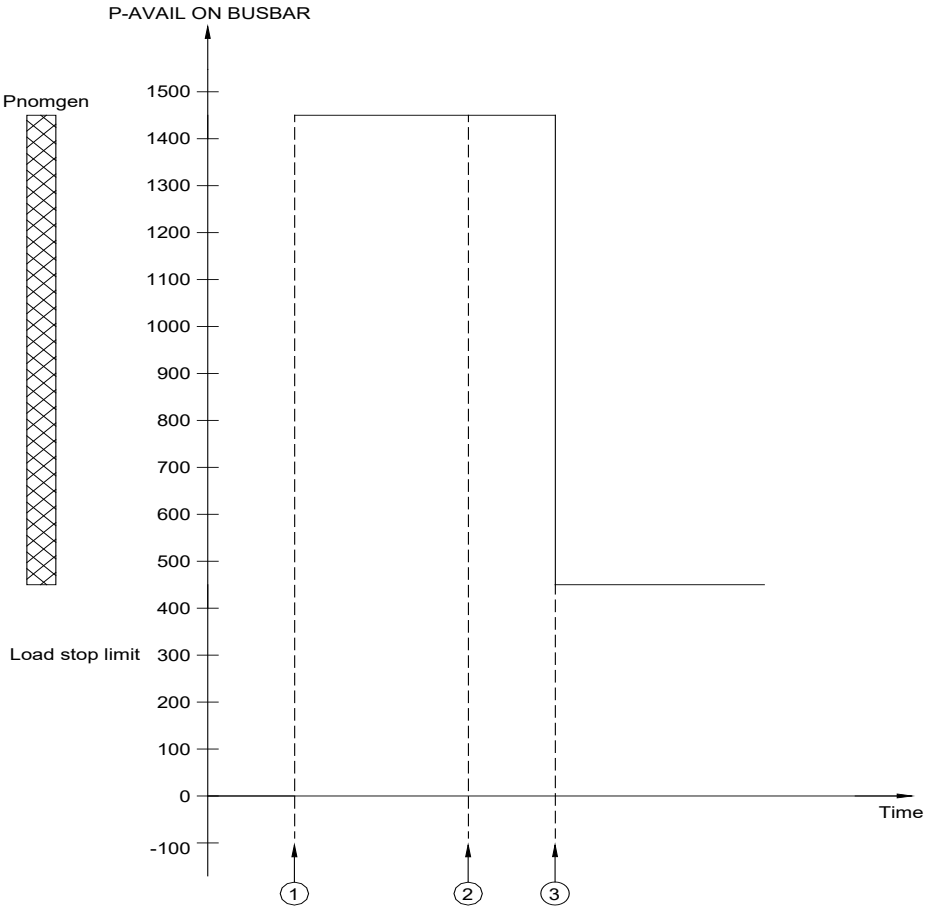


Load-dependent start

The load-dependent PMS start command is transmitted time-delayed in order to avoid un-necessary start of stand-by generator sets due to brief load variations.

The operator is able to adjust the above indicated parameters, by which the transmission of the load-dependent PMS start command is controlled.

Programming the load-dependent stop limit
The PMS stop command is generated by comparing the programmed stop limit value with the result of the following calculation: **The predicted available power deducted from the nominal load of the generator set designated with the highest stop priority.**



Load-dependent stop

The programmable stop limit represents the desired remaining available power at the busbar, **after** the load-dependent PMS stop of the generator set has been carried out.

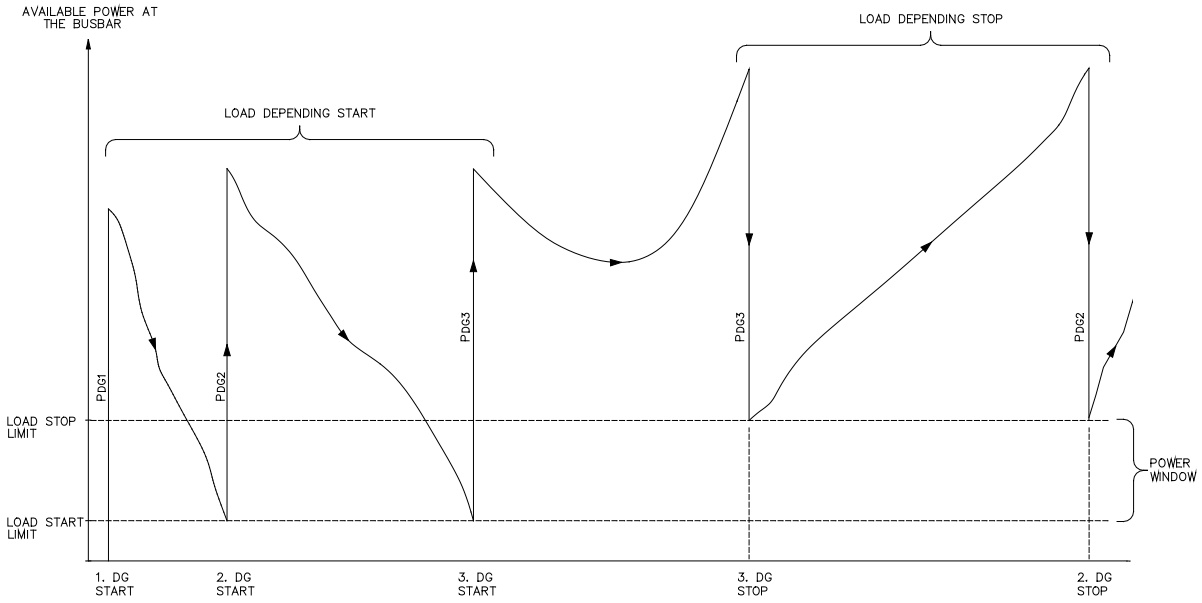
Please refer to **Appendix A.16.2** where the operating principle for generation of the load-dependent stop command is presented by means of a flow chart.

The PMS command for load-dependent stop is transmitted time-delayed to avoid unnecessary stop of running generator sets due to brief load variations.

The operator is able to adjust the above indicated parameters, by which the transmission of the load-dependent PMS stop command is controlled.

The power window

The difference between the programmed values "LD START" and "LD STOP" forms the power hysteresis between start and stop (the power window).



A load-dependent start/stop example stated with 3 generator sets

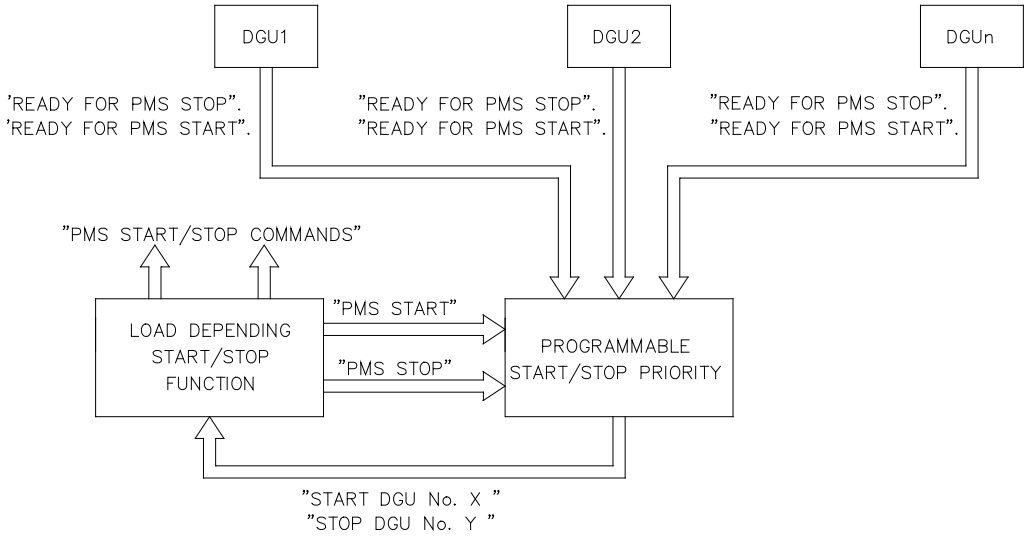
Transfer of the PMS start command

A PMS start command is automatically transmitted to the next stand-by generator set, if the below-mentioned alarm sequence becomes active at a running generator set:

- The **"SAFETY STOP"** alarm sequences

Selection of start/stop priority

Depending on the programmed priority sequence and the operational status of the generator sets, the start/stop priority function continuously designates each generator set with a **PMS start priority** and a **PMS stop priority** respectively. The load-dependent start/stop function uses this information when the PMS start/stop commands are to be transmitted.



Operating principle for determination of the start/stop priority

The start/stop priority function keeps track of which generator sets are "ready for PMS start", and which generator sets are "ready for PMS stop". Any running generator set, which during operation becomes not "ready for PMS stop", is not accepted as the next generator to be stopped.

Programming of the start/stop priority sequence

Programming and read-out of the start/stop priority sequence are carried out for all generator sets through the display unit (PMS DGU).

(Please refer to the menu SETUP – SYST – “Start priority 1-5” or jump menu 4200)

The DM-4 system will not accept the start/stop priority sequence if:

- Two or more generator sets are programmed to the same start/stop priority number, or a generator set is programmed to have several start/stop priority numbers

The example below shows a start/stop priority sequence for a four-generator set power plant, programmed to start priority 2-3-1-4.

```
CH 4200 PMS
Start priority 1-5
1st priority DG:  2
Exe 1 2 3 4
```

```
CH 4200 PMS
Start priority 1-5
2nd priority DG:  3
Exe 1 2 3 4
```

```
CH 4200 PMS
Start priority 1-5
3rd priority DG:  1
Exe 1 2 3 4
```

```
CH 4200 PMS
Start priority 1-5
4th priority DG:  4
Exe 1 2 3 4
```

After having selected the new priority list, also select to execute the list to be new valid start priority.

When the operator changes the priority sequence, the generator sets automatically rearrange according to the new start/stop priority

Any stand-by generator sets, which have been designated with a higher start priority than any running generator sets, will automatically substitute these.

Determination of the start/stop priority

The PMS DGU continuously designates each generator set with a PMS start/stop priority number according to the programmed priority sequence.

The priority sequence 2 - 3 - 1 - 4 designates

- DG no. 2 with **start/stop** priority no. 1 (to be started first)
- DG no. 3 with **start/stop** priority no. 2
- DG no. 1 with **start/stop** priority no. 3
- DG no. 4 with **start/stop** priority no. 4 (to be started last)

The DGU designated with *start* priority no. 1 is indicated by

- a green **"1st Prior."** LED

A priority sequence 2 - 3 - 1 - 4 designates

- DG no. 4 with **stop** priority no. 1 (to be stopped first)
- DG no. 1 with **stop** priority no. 2
- DG no. 3 with **stop** priority no. 3
- DG no. 2 with **stop** priority no. 4

"1st PRIOR" push-button

The operator is able to designate the highest start priority to any generator set via the corresponding display unit by pressing the

- **"1st PRIOR"** push-button

The example below shows how the start priority changes, if the operator presses the "1st PRIOR" push-button at the display unit (DGU no. 4).

The start priority sequence **before** the “1st PRIOR" push-button is activated on the display unit (DGU no 4):

2 - 3 - 1 - 4 meaning

- DG no. 2 is designated with **start** priority no. 1 (to be started first)
- DG no. 3 is designated with **start** priority no. 2
- DG no. 1 is designated with **start** priority no. 3
- DG no. 4 is designated with **start** priority no. 4 (to be started last)

The start priority sequence **after** the “1st PRIOR" push-button is activated on the display unit (DGU no 4):

4 - 2 - 3 - 1 meaning

- DG no. 4 is designated with *start* priority no. 1 (to be started first)
- DG no. 2 is designated with *start* priority no. 2
- DG no. 3 is designated with *start* priority no. 3
- DG no. 1 is designated with *start* priority no. 4 (to be started last)

The load-dependent start/stop function will subsequently rearrange the running generator sets according to the new start priority.

Plant frequency control

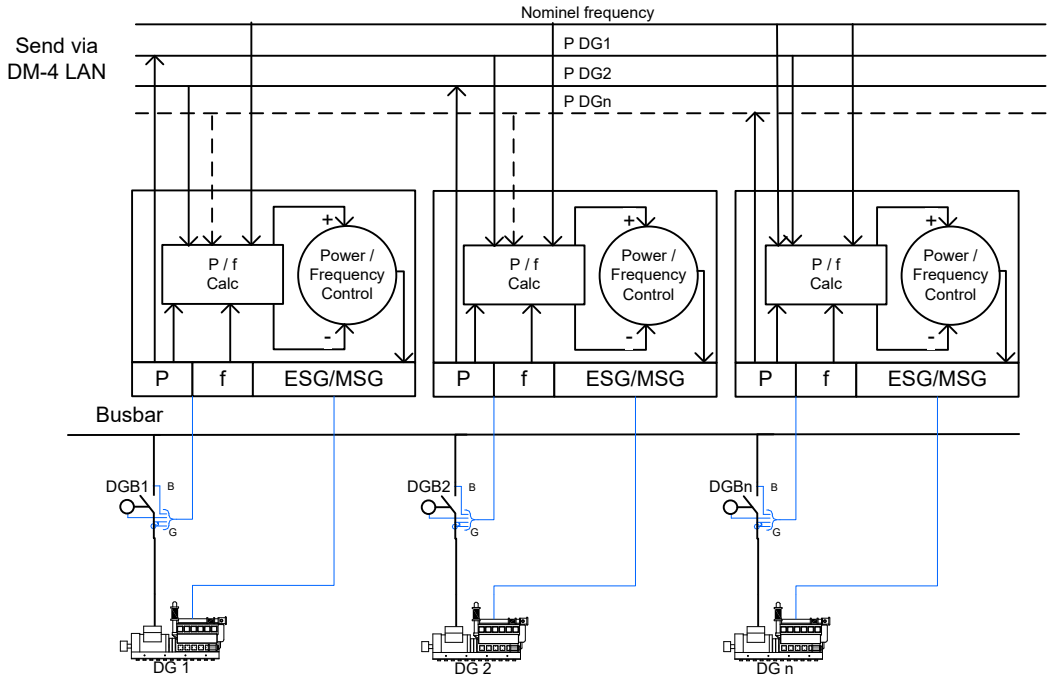
The DM-4 system handles the frequency control for the entire power plant in each DGU, which fulfils the following conditions:

- PMS control is selected
- Does not carry out base load

The DGU ensures the plant frequency control and load control.

Implementation of frequency control

The target for the plant frequency control is always the nominal frequency. Each DGU has an internal frequency reference characteristic. By means of the measured frequency, each DGU controls the frequency, until the frequency is inside the dead band for the frequency. This means that each DGU has influence on the common plant frequency.



Automatic load share

The DM-4 system is able to handle two types of automatic load share:

- Symmetrical load share
- Asymmetrical load share (optional feature)

Symmetrical load share

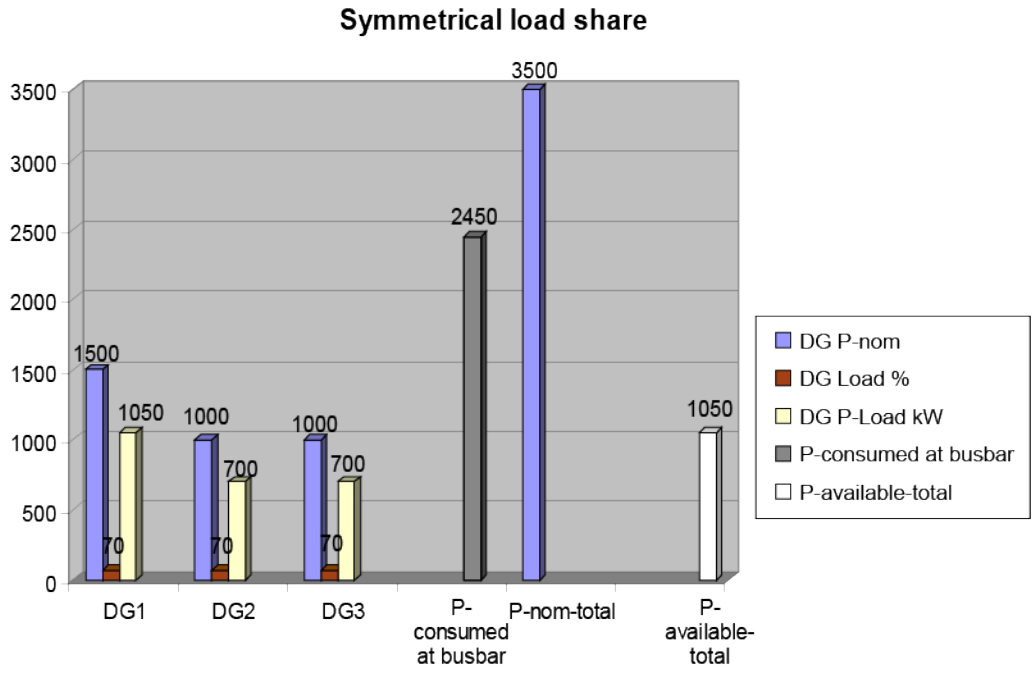
The DM-4 system handles symmetrical load sharing control in each DGU, which fulfils the following conditions:

- PMS control is selected
- Does not carry out asymmetrical load share (base load)

Symmetrical load sharing is always carried out as default by the DM-4 system.

During symmetrical load share, all running generators are producing the same percentage of their nominal power. Each DGU calculates the sum of power and the number of generators, which fulfil the conditions for running symmetrical load sharing. The load reference for each generator is the power consumed at the busbar divided with the sum of generators connected.

	DG P-nom	DG Load %	DG P-Load kW	P-consumed at busbar	P-available-total
DG1	1500	70	1050		
DG2	1000	70	700		
DG3	1000	70	700		
P-consumed at busbar				2450	
P-nom-total	3500				
P-available-total					1050



Symmetrical load share with 3 generator sets

For symmetrical load share:

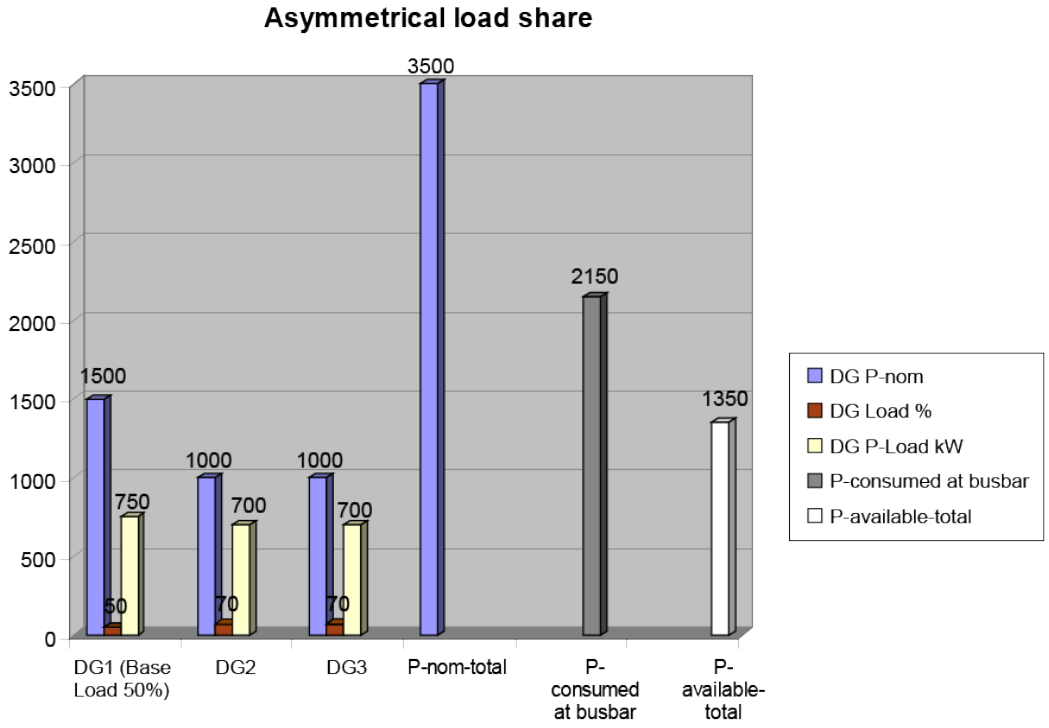
- If the running generator sets have the **same nominal power**, they are loaded equally with real power (kW).
- If, however, the generators have **different nominal power**, they are loaded proportionally according to their capacity.
  This loads all generators with the same percentage of their nominal power.

Asymmetrical load share/Base load

Asymmetrical load sharing is **only** carried out when selected by the operator. (Please refer to the paragraph HMI SETUP for detailed information on how to activate asymmetrical load share).

When asymmetrical load share is selected, the generator set chosen to have the **highest start priority** will produce a programmable fixed base load.

	DG P-nom	DG Load %	DG P-Load kW	P-consumed at busbar	P-available-total	P-prod non base load gen.
DG1 (Base Load 50%)	1500	50	750			
DG2	1000	70	700			
DG3	1000	70	700			
P-nom-total	3500					
P-consumed at busbar				2150		
P-available-total					1350	
P-prod. non base load gen.						1400



Asymmetrical load share carried out with the base load

Load variations are handled and shared symmetrically by all other started generator set(s), except the one carrying out asymmetrical load share (base load).

The operator is able to adjust the following set point, by which the asymmetrical load share function is controlled:

- "**Asym load setp. ##%**"

Active asymmetrical load share is indicated at the display unit corresponding to the DGU which carries out asymmetrical load share by

- a green "**Base load**" LED

Automatic cancellation of the asymmetrical load share function

The asymmetrical load share is automatically cancelled by the PMS DGU, if

- the generator set running asymmetrical produces 90% or more of the total busbar load
- the load on one of the additional generator sets becomes less than 2% of nominal power
- the load on one of the additional generator sets becomes higher than 98% of nominal power
- a blackout situation is detected
- the number of generator sets on the busbar under PMS control is below 2
- the plant mode changes from AUTO mode

The status is indicated at the display unit (PMS DGU), when cancellation is performed:

- A yellow "**Base load**" LED

After stable acceptable conditions for 30 seconds, the base load operation is activated again.

Blackout function

The blackout function is active, whenever one of the following plant modes is selected:

- SEMI-AUTO

In case of blackout in any other plant mode, the system switches to plant mode SEMI-AUTO. This results in an alarm message on the display unit, and the blackout start sequence is performed.

The blackout function consists of two separate functions:

- A common detection of **"dead busbar"** status
- The blackout start sequence

An individual detection of **"dead busbar"** status is made by all DGUs in the system.

The blackout start sequence is initiated once the PMS DGU receives the internal "dead busbar" status from all DGUs in the DM-4 system.

Please refer to **Appendix A.16.3** where the operating principle for generation of the blackout start is presented by means of a flow chart.

Dead busbar detection

The individual "**dead busbar**" internal signal is transmitted, when the following conditions have been continuously registered by a DGU during the programmable delay:

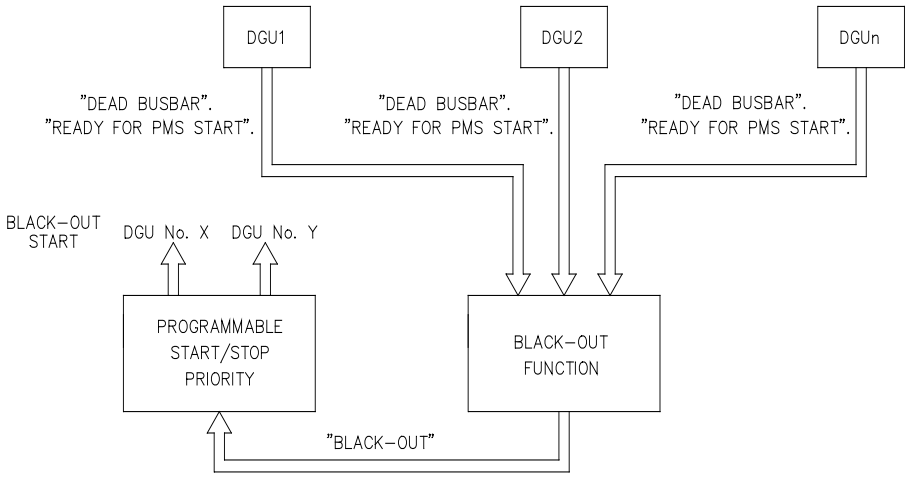
- The largest measured busbar phase-phase voltage (U_{L-L}) is below 20% of nominal value
- The corresponding generator breaker is in OFF position
- **No short-circuit alarm** is active in the DGU *

*A short-circuit alarm at any of the DGUs will block the entire blackout start sequence.
In such cases, the operator must acknowledge the short circuit alarm(s) (on both the external protection equipment and DM-4) in order to enable the blackout start sequence.

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

A synchronisation alarm is automatically acknowledged (reset) in case of an active "dead busbar" status in the DGU. This allows the generator set in question to attempt to connect to the busbar.

Activation of the blackout start sequence is only possible, if at least one of the DGUs is selected to be in PMS control and "ready for PMS start".



Operating principle of the blackout function

The blackout start sequence carries out the following step-by-step sequence:

a) A PMS start command (activates the automatic start sequence in the DGUs) is transmitted to the generator sets with the highest and second highest start priority, which at the same time are "ready for PMS start".

b) The generator set which first obtains normal running feedback and normal voltage/frequency will close the breaker immediately (after receiving an acknowledge signal from the PMS DGU).

   b_1) If this does not result in the closing of the generator breaker, the other blackout-started generator set will (after approx. 2 sec. delay) be requested to close its breaker without synchronisation.

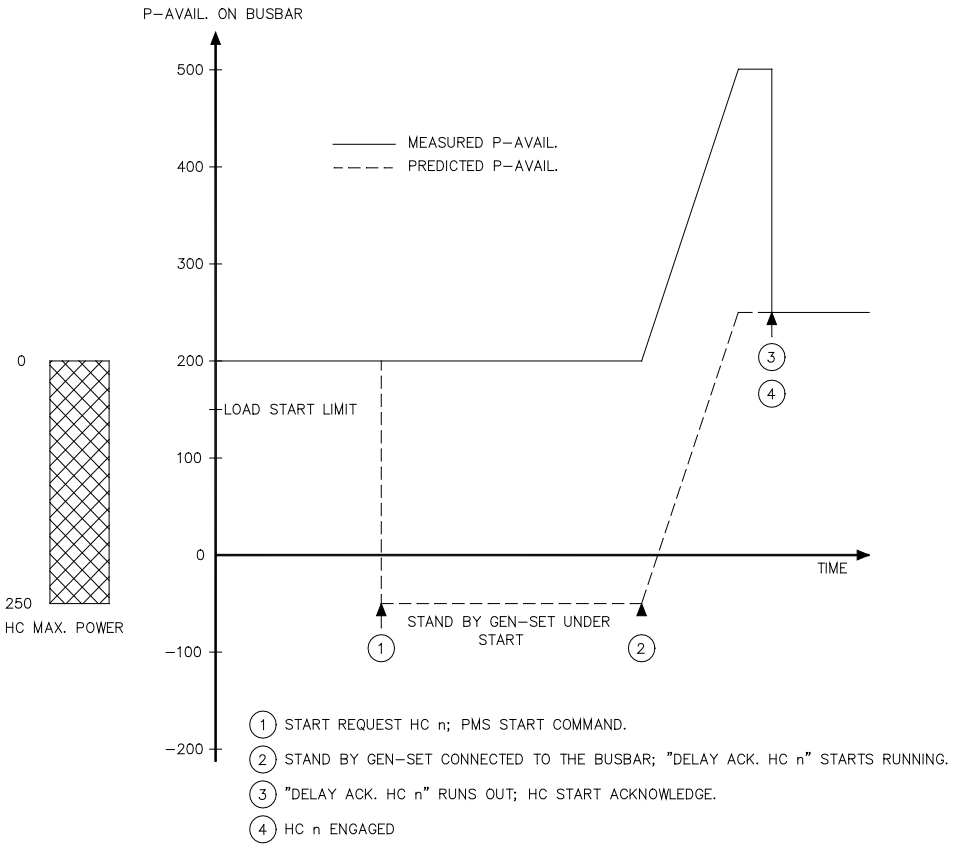
c) The second blackout-started generator set initiates synchronisation of the generator breaker approx. 2 sec. after satisfactory voltage and frequency have been detected at the busbar.

d) If any of the two chosen generator sets fails during the start sequence, the PMS start command is transferred to the next stand-by generator set, as long as the blackout situation is present.

e) When one generator set is successfully connected to the busbar, the blackout function is considered to be completed, and the DM-4 system switches back to "normal" operation again, which will be plant mode SEMI-AUTO.

Conditional connection of heavy consumers (HC)

When requested by a HC, the function for conditional connection of HCs reserves the programmed max. power at the busbar and blocks for engagement of the HC, until sufficient predicted available power is present at the busbar.



P-reservation at the busbar before engagement of a HC (here 250 kW)

After achieving sufficient predicted available power, the HC is subsequently blocked, until the programmed time delay runs out.

It may be necessary to delay the acknowledge signal 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 acknowledge delay can be adjusted on the parameter **Ack Delay**.

The length of the acknowledge signal can be adjusted on the parameter **Ack pulse**.

The operator is able to change the maximum expected power consumption separately for each heavy consumer on the parameter **Start Request HC x**.

The programmed maximum power is reserved at the busbar during the programmed delay time.

Please refer to the paragraph Parameter List for a detailed description of the parameter structure.

The HCs are connected according to their priority. HC1 is designated with the highest priority, e.g.: HC1 is handled before HC3, if they request start at the same time. If there are any preferential HCs, they must be connected to the hardware interface for HC1 in order to ensure 1st priority handling.

The DM-4 system carries out the following step-by-step sequence, when a HC requests start acknowledgement:

a) The programmed "START REQUEST HC x" load [kW] value is reserved at the busbar.

b) A PMS start command is transmitted to the next stand-by generator set, if the predicted available power is below the programmed load-dependent start limit.

   b_1) If the predicted available power at the busbar is below 0 kW, the timer "**Ack Delay"** is blocked, until the stand-by generator set is connected and sufficient predicted available power can be measured at the busbar.

   b_2) The timer "**Ack Delay"** starts running at this point, if the predicted available power at the busbar is above 0 kW.

c) When sufficient predicted available power is present at the busbar, the timer "**Ack Delay"** starts running.

d) The start acknowledge signal is transmitted to the HC in question, when the timer "**Ack Delay"** runs out and sufficient available power is still measured at the busbar.

Selection of heavy consumer power feedback type

The DM-4 system is able to handle two types of power feedback:

- Binary feedback
- Analogue feedback

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

The power feedback type should be considered according to the type of the heavy consumer:

- A heavy consumer with variations in load (**variable load** as a thruster) should always be assigned with an analogue power feedback (kW).

- A heavy consumer with **constant load** can be assigned with binary power feedback, and the signal should be parallel to the circuit breaker for the load, meaning when the breaker is closed and the load is actually on the busbar, the power feedback signal should be high (CC). In this way ON/OFF control like e.g. heating elements and compressors can be handled.

Changing the power feedback type is simply done by setting the jumpers (for designation as binary or analogue input channels) at the IOM 4-1 module. Please refer to the paragraph INSTALLATION INSTRUCTIONS for a more detailed review

The power feedback type may be selected as:

- Binary feedback (CC)
- Voltage feedback (0...10V DC, 2...10V DC is software-controlled)
- Current feedback (0...20 mA, 4...20 mA is software-controlled)

Cable supervision is automatically activated at all power feedback signals, which are selected as analogue inputs and set up for a 20% offset.

In order to avoid false cable supervision alarms, unused power feedback input channels should be jumped into the binary position.

Start of heavy consumers with binary power feedback

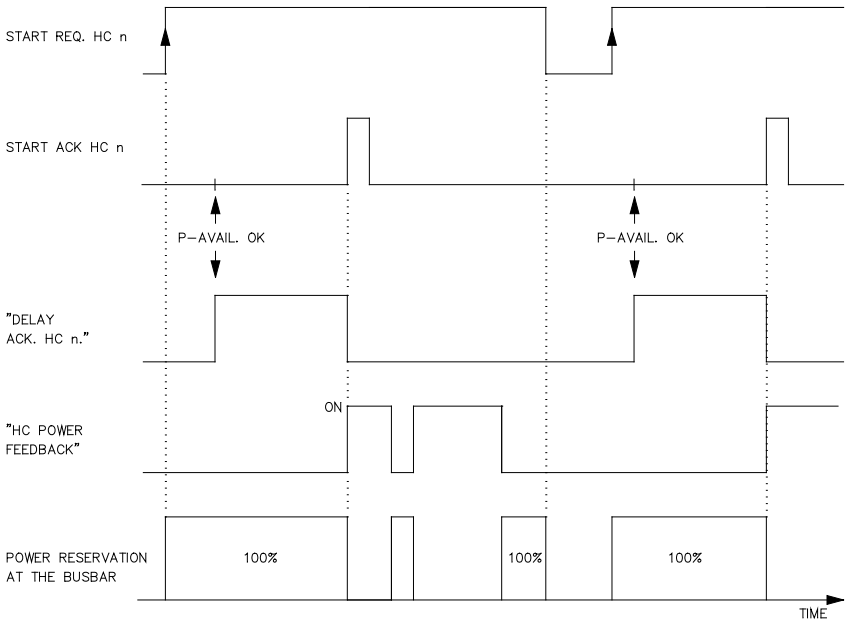
The conditional connection of heavy consumers with binary power feedback is controlled via the following hardware interface.

SIGNAL NAME	SIGNAL TYPE	LOCATION
• START REQ. HC n	Binary input	Main PMS DGU (IOM 4.1)
• HC no. n POWER FEEDBACK	Binary input	Main PMS DGU (IOM 4.1)
• START ACK. HC n	Relay output	Main PMS DGU (IOM 4.1)

Activating start request binary input makes start of a specific heavy consumer (HC n) with binary power feedback.
The start request signal must remain activated, as long as the HC is to be in operation. Power reservation ends after the start request signal has disappeared.

The DM-4 system transmits a start acknowledge signal when sufficient predicted available power is present at the busbar and the timer "**ACK delay"** have run out.

The start acknowledge signal has a programmable ON duration, which the operator is able to adjust on the timer **"Ack pulse"**. Once the acknowledge pulse is transmitted, the HC is considered to be turned ON.



The engagement sequence for HCs with binary feedback

The power reservation by means of the power feedback input is enabled, as long as the start request signal is active.

An OFF status (indicates that the HC is not operating) at 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.

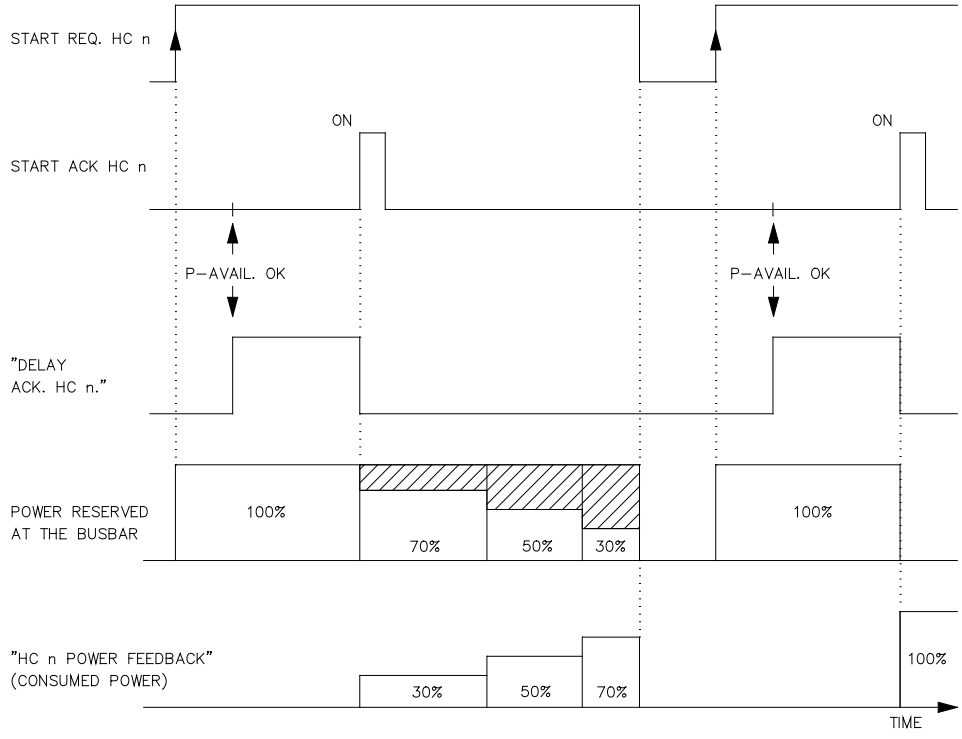
Start of HCs with analogue power feedback

The conditional connection of HCs with analogue power feedback operates via the following hardware interface.

SIGNAL NAME	SIGNAL TYPE	LOCATION
• START REQ. HC n	Binary input	Main PMS DGU (IOM 4.1)
• HC no. n POWER FEEDBACK	Analogue input	Main PMS DGU (IOM 4.1)
• START ACK. HC n	Relay output	Main PMS DGU (IOM 4.1)

Start of a specific heavy consumer with variable load (HC n) is made by activating the corresponding start request input.

In order to prevent overload at the busbar during operation of HCs with analogue power feedback, the actual power consumed by the HC (represented by the power feedback) is taken into consideration.



The engagement sequence for HCs with analogue feedback

Based on this knowledge, the reserved power at the busbar for this HC is reduced (from maximum power) with the actually consumed power. This calculation is done continuously in order to optimise the reserved power at the busbar.

Adjusting the scale of the analogue power feedback signals

The scale of the HC's power feedback signals is defined as:

- 4...20mA correspond to 0...Max. scale

The operator is able to designate an arbitrary value as the max. scale of the analogue power feedback signal from the heavy consumers on the parameter structure **Inp.max scale**.

Cable supervision is active at all analogue HC power feedback inputs.

Please refer to the paragraph Parameter List for a detailed description of the parameter structure.

Thruster control interface

The purpose of this interface is to optimise the fuel consumption of the diesel generators and to prevent blackout caused by the propulsion/thrusters overloading the generators.

The interface has an analogue and a digital part. The analogue output is used for the normal regulation and stabilising of the power consumption. The digital output is to be used as a fast reduction/cutback of power consumption in case of malfunctions in the power plant ex. trip of one or more GB.

The propulsion control/frequency drives in the propulsion system must be adjusted in a way so they can use up to approximate 95-98 % available power on the busbar. At that limit, the power limitation/reduction should be active and the load should stabilise.

The load-dependent start limit for the generators is set 10-20% below the reduction limit, with a timer of approx. 5 sec. This will make the next standby generator start when the propulsion/thrusters need more power.

Analogue outputs

The analogue power available signal from DM-4 to the propulsion system can be scaled in % or kW and can be sent to each thruster individual.

THR x.x P-AVAIL: output for power available on busbar
4...20 mA = -20…100%

THR x.x P-AVAIL: output for power available on busbar
4...20 mA = 0…XXXX kW

The scaling is adjustable from the DM-4 Utility SW.

Term	Signal	Signal type	Signal Name	Active status	SP	Description
17	AO 0+	4-20 mA	THR n.1 P-AVAIL.			Available power on busbar
18	AO 0-	4-20 mA				
19	AO 1+	4-20 mA	THR n.2 P-AVAIL.			Available power on busbar
20	AO 1-	4-20 mA				

If the analogue output is scaled as power available in %, it is typical scaled -20…100%.
The power available is calculated as the nominal power of the, at any time running and connected generators subtracted their actual load. Only generators which are selected and accepted to be in PMS mode are taken in consideration when calculating P- available.

If the analogue power available output is scaled in kW, it is typically scaled according to the nominal power of the thruster with 10 % in over scale. This is to obtain the best possible resolution of the 4-20 mA signals.

Example:
Main propulsion drive, max nominal power: 2000 kW
Analogue power available signal: 4-20 mA = 0-2200 kW
This means that whenever the P-available is higher than 110% of the nominal power of the frequency drive, the output will give 20 mA.

Digital inputs

On the thruster interface IOM4.1, card there is several digital inputs. The specific functions are described below:

THR POS ON: Feeder breaker in main switchboard to thruster starter cabinet/frequency drives, position ON feedback. Must be CC (closed contact) before THR REQ is activated.

Term	Signal	Signal type	Signal Name	Active status	SP	Description
1	0	Binary	THR. POS ON	CC		Thruster Breaker Pos On
45	com	Binary	n.1 MAIN PROP			

THR REQ: Request start of thruster. Must be a constant CC (closed contact) all the time the thruster is requested and running.

Term	Signal	Signal type	Signal Name	Active status	SP	Description
2	1	Binary	THR. REQ	CC		Start Request Thruster
46	com	Binary	n.1 MAIN PROP			

THR RUN: Must be closed contact all the time the thruster is running.

Term	Signal	Signal type	Signal Name	Active status	SP	Description
3	2	Binary	THR. RUN	CC		Thruster is running
47	com	Binary	n.1 MAIN PROP			

THR POWER: Power feedback from thruster. If reservation is selected by parameter the reservation is THR POWER REQUEST kW set point, minus THR POWER

Term	Signal	Signal type	Signal Name	Active status	SP	Description
4	3	4-20 mA	THR. POWER			Power Feedback
48	com	4-20 mA	n.1 MAIN PROP			(4…20mA = 0…XXXX kW)

Digital Outputs

On the thruster interface IOM card there is several digital outputs. The specific functions are described below:

THR CB ON: ON commando to Feeder breaker to starter cabinet/frequency drives. Only controlled from Modbus serial interface.

Term	Signal	Signal type	Signal Name	Active status	SP	Description
21	DO 0	Relay Output	THR. CB ON	CC		Command to close breaker
22	com	Relay Output	n.1 MAIN PROP			(pulse)

THR CB OFF: OFF commando to Feeder breaker to starter cabinet/frequency drives. Only controlled from Modbus serial interface.

Term	Signal	Signal type	Signal Name	Active status	SP	Description
23	DO 1	Relay Output	THR. CB OFF	CC		Command to open breaker
24	com	Relay Output	n.1 MAIN PROP			(pulse)

THR START ACK: Start acknowledges pulse to allow thruster to start when P available is sufficient.

Term	Signal	Signal type	Signal Name	Active status	SP	Description
25	DO 2	Relay Output	THR. START ACK	CC		Start acknowledge thruster
26	com	Relay Output	n.1 MAIN PROP			

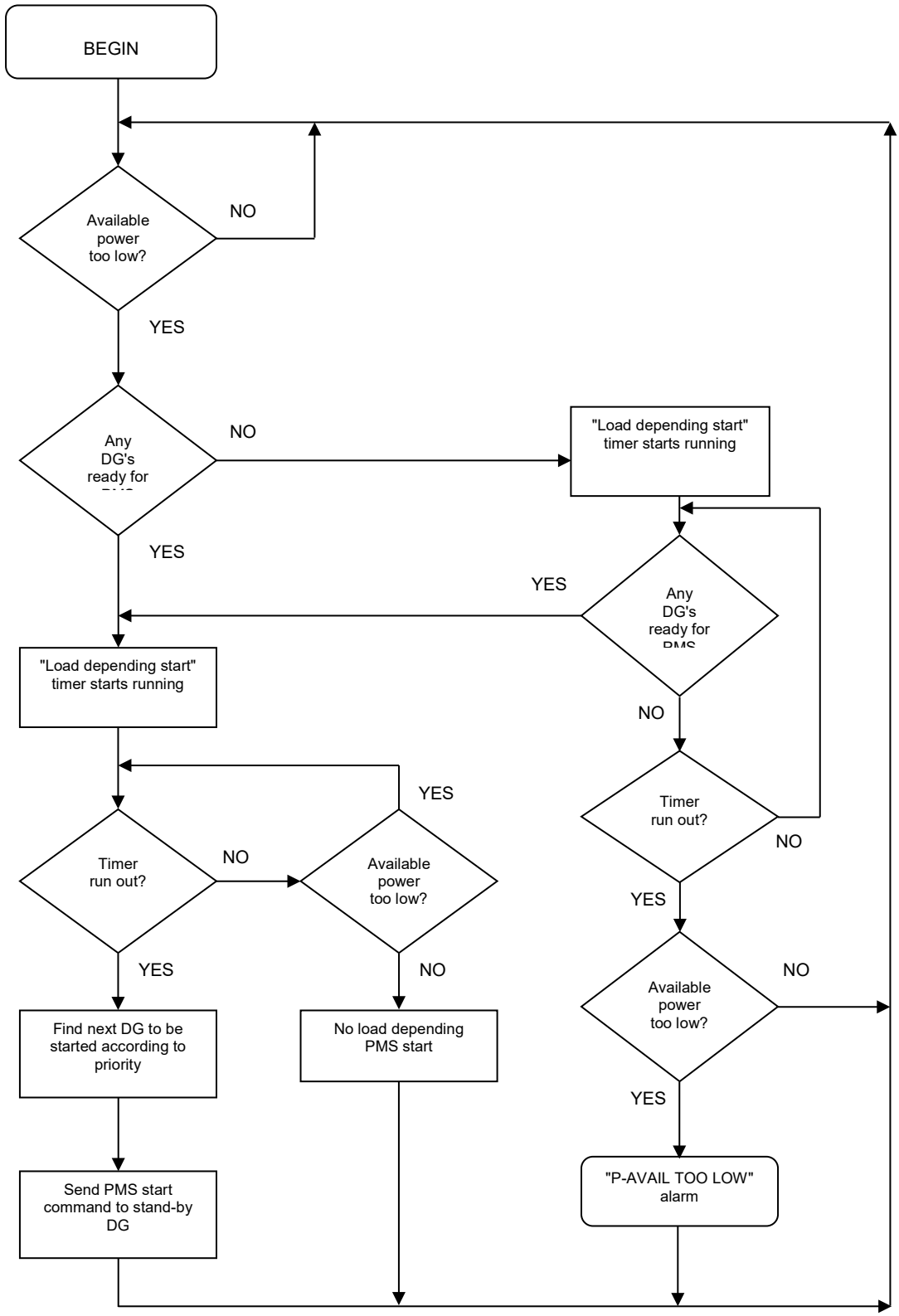
THR REDUCE P: Activated when limit for power reduction has been exceeded.
Output is activated if P available or BB frequency is too low, or active TRIP or SHUTDOWN alarm appears. The output is to be used for fast reduction / cutback of power consumption. When this output is activated, the load should reduce to a minimum and slowly ramping up again until the P available limit is reached.

Typical Settings:
THR. Reduce Freq Low: 95% 0-1 sec.
Power Avail Reduce: -10% 0-1 sec.

Term	Signal	Signal type	Signal Name	Active status	SP	Description
27	DO 3	Relay Output	THR. REDUCE P	CC		Power reduction on thruster
28	com	Relay Output	n.1 MAIN PROP			

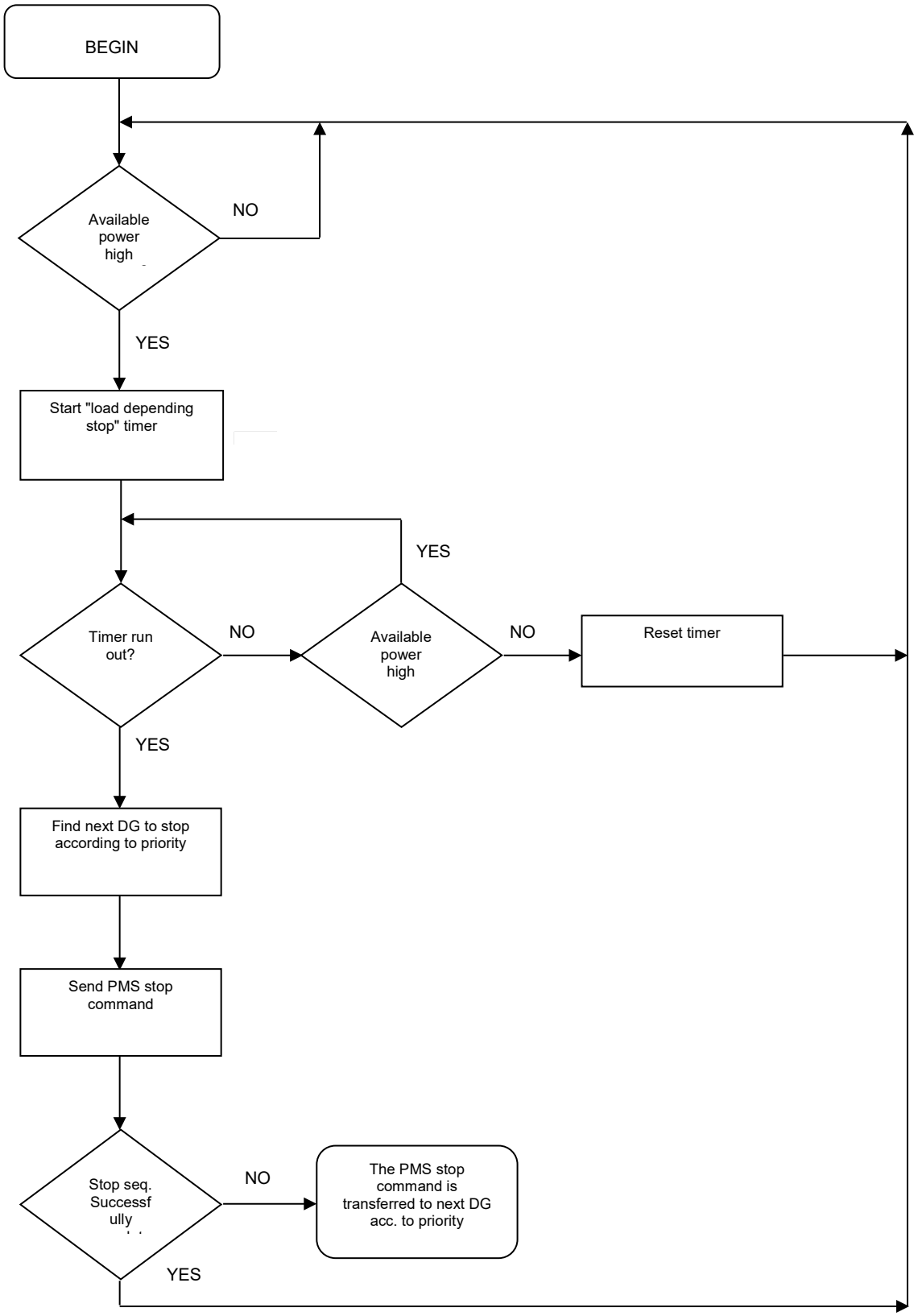
Appendix 16.1

Load-dependent PMS start command flow chart



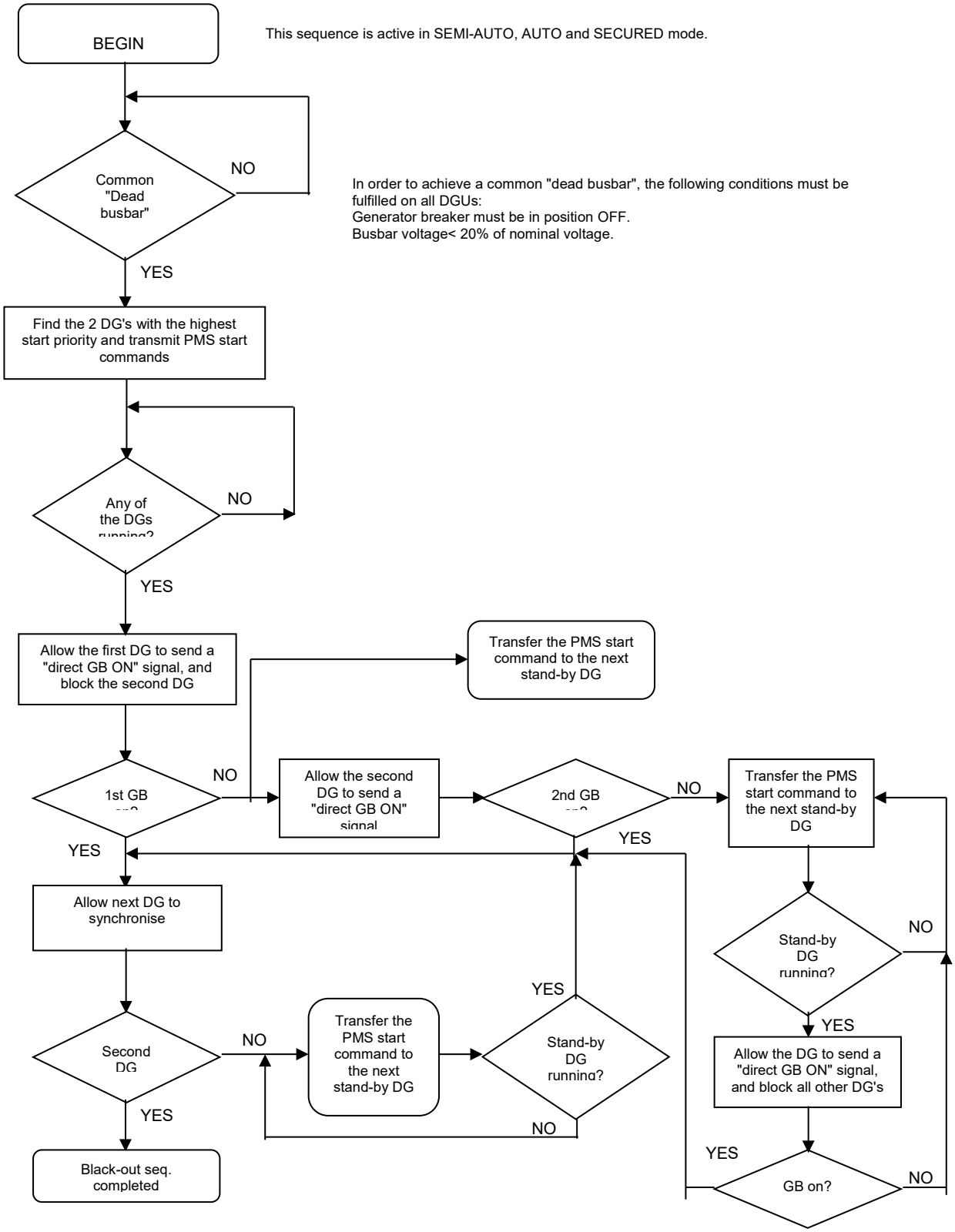
Appendix 16.2

Load-dependent PMS stop command flow chart



Appendix 16.3

Blackout start sequence flow chart



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