Delomatic 4
DM-4 Land/DM-4 Marine



Common Generator Set Protection
Part 2, chapter 18

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18. Diesel/shaft generator set supervision and protection

The DGU in the DELOMATIC system is able to handle local supervision and protection of the corresponding diesel/shaft generator set.

All local supervision and protective functions are also active during SWBD control.

Response time Delomatic 4 protections < 200ms (delay set to minimum).

Engine supervision

Engine supervision is handled by the DELOMATIC system according to the status on a number of alarm inputs. Each DGU in the DELOMATIC system is able to carry out the following engine supervision functions:

- Tacho feedback
- 8 user programmable alarms

The engine supervision functions are disabled when the engine is not running (stand-by). Disabling of the engine supervision means that no alarms are generated by the supervision functions. The engine supervision functions are furthermore disabled during the automatic start sequence, until the auxiliary engine has obtained running status.

- PARAMETER structure **"DGAlarmInh"**

The engine supervision is activated time-delayed. The programmable timer enables the operator to adjust the delay.

Please refer to technical manual part 1, paragraph 4 for a detailed description of the PARAMETER structure.

Disabled engine supervision is indicated by means of

- a *yellow* "**ALARM INHIBIT**" LED at the DU

Active engine supervision is indicated by means of

- a *dark (turned off)* "**ALARM INHIBIT**" LED at the DU

Each DGU is implemented with the following hardware interface, which is used in coherence with the engine supervision functions.

SIGNAL NAME	SIGNAL TYPE	LOCATION
• ENGINE RUNNING/ ENGINE RPM	Binary input Analogue input *)	(IOM 4.1)
• DG ALARM 1	Binary input (alarm) **)	(IOM 4.1)
• DG ALARM 2	Binary input (alarm) **)	(IOM 4.1)
• DG ALARM 3	Binary input (alarm) **)	(IOM 4.1)

• DG ALARM 4	Binary input (alarm) **)	(IOM 4.1)
• DG ALARM 5	Binary input (alarm) **)	(IOM 4.1)
• DG ALARM 6	Binary input (alarm) **)	(IOM 4.1)

*) Depending on jumper position on the IOM card
**) User programmable alarms

Tacho supervision, PARAMETER-TachoFail

The "TACHO FAILURE" alarm is transmitted, if the running feedback (analogue or binary) disappears and normal voltage and frequency are still to be measured at the generator.

Tacho supervision is activated time-delayed after running status has been detected first time during the automatic start sequence. If a tacho failure is detected, an alarm message is displayed at the DU.

Please refer to technical manual part 1, paragraph 4 for a detailed description of the PARAMETER structure.

An active tacho failure alarm is furthermore indicated by

- **a *yellow* "RUN" LED**

Custom binary alarm inputs, PARAMETER-DGAlarm(n)

Each DGU has 6 custom binary alarm inputs, which may be used e.g. for interfacing with external protective relays or other protective measurements.

The interface is carried out by the following inputs:

SIGNAL NAME	SIGNAL TYPE	LOCATION
• DG ALARM n	Binary alarm input	All DGUs (IOM 4.1)

The custom binary alarm inputs have the following features:

- Programmable alarm status at the input channel (OC/0x or CC/1x)
- Selection of the alarm is to be included in the alarm inhibit function (disabled when the engine is stopped and during start)
- Programmable alarm sequence
  - X0 No alarm
  - X1 Warning
  - X2 Block
  - X3 Safety stop
  - X4 GB trip
  - X5 GB trip without blackout start (ex. short circuit)
  - X6 Shutdown
  - X7 Alarm related to Diesel Generator which causes the TB to be tripped.
- Programmable alarm delay

Programme DGAlarms

The operator is able to programme the PARAMETER structure in order to adapt the custom binary alarm input “n” to the desired functionalism. Activation of the "DG ALARM n" input according to the programmed conditions will initiate the programmed alarm sequence, and an alarm message is displayed at the DU.

CHxxxx DIESEL GEN.Y **Input alarm n SETUP** **In alarm seq. XX** **Seq. Del. Inhibit**

XX for selection of OC/CC and failure class

1st digit for selection of alarm at Open Contact (0) or Closed Contact (1)
2nd digit for selection of fail class (0-9)

- **X0 No alarm**
- **X1 Warning**
- **X2 Block**
- **X3 Safety stop**
- **X4 GB trip**
- **X5 GB trip without blackout start (ex. short circuit)**
- **X6 Shutdown**
- **X7 Alarm related to Diesel Generator which causes the TB to be tripped.**

CHxxxx DIESEL GEN.Y **Input alarm n SETUP** **In alarm del. X.Xs** **Seq. Del. Inhibit**

X.X for selection of delay of alarm

CHxxxx DIESEL GEN.Y **Input alarm n SETUP** **In alarm inhibit X** **Seq. Del. Inhibit**

X for selection of alarm inhibit feature
0 = disabled, 1=enabled

The setup of the binary alarm input is also configurable from the utility software.

Busbar supervision and protection

The DELOMATIC busbar supervision and protective functions are activated, whenever a diesel/shaft generator set is connected to the busbar.

Busbar supervision is also activated at the Main PMS DGU, when a shore connection is supplying the busbar.

Each DGU carries out busbar supervision and protection according to individual programmable set points and delays.

This means that the DGUs may be programmed differently, but it is *highly* recommended to programme the busbar supervision functions with set points and delays common for the entire DELOMATIC system.

The busbar supervision is carried out by the following hardware interface.

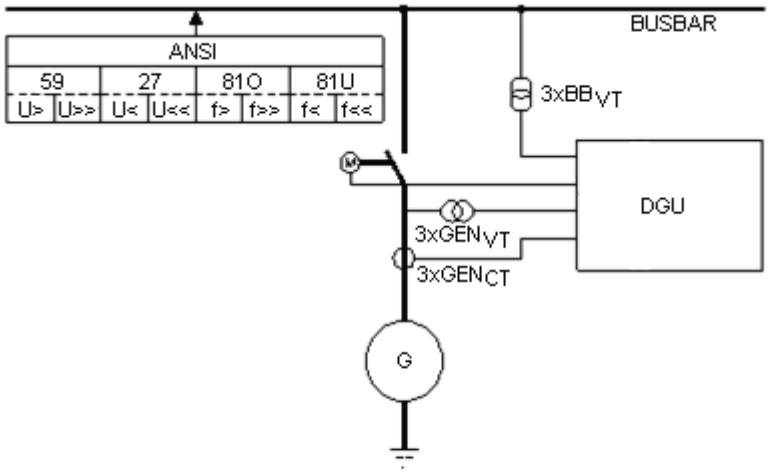
SIGNAL NAME	SIGNAL TYPE	LOCATION
• U_{BB}	3-phase voltage input from the busbar	(SCM)

Each DGU/SG-DGU implements the following busbar supervision (warning) and protective (trip of GB) functions:

- Level undervoltage, U_{BB}<
- Level overvoltage, U_{BB}>
- Level underfrequency, f_{BB} <
- Level overfrequency, f_{BB} >

Whenever the first level on a busbar is reached, the next available stand-by genset will start up and be running idle, until the situation is cleared. This ensures a minimum blackout time.

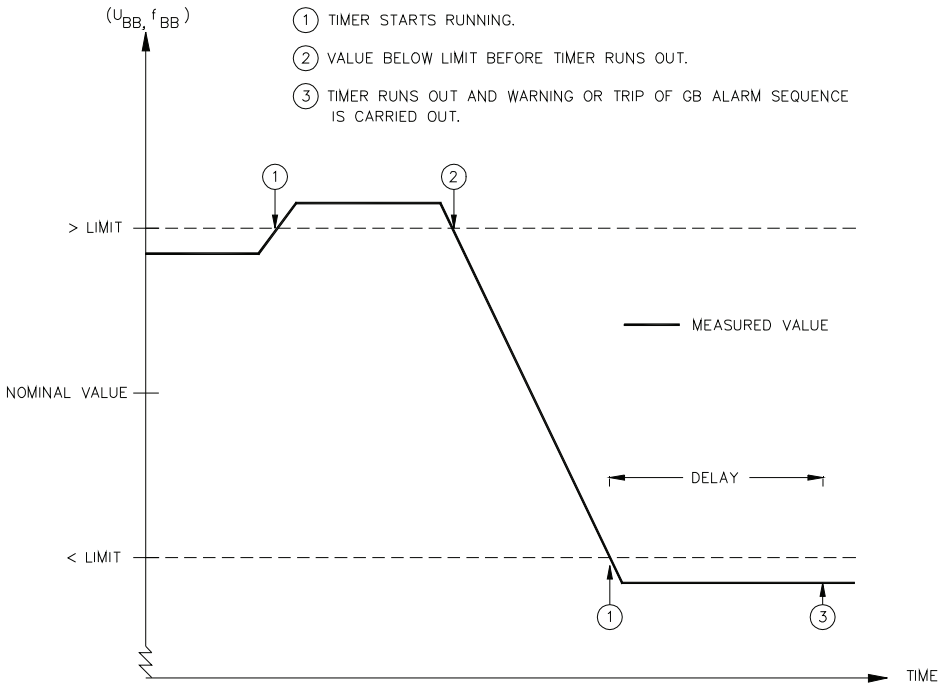
If a shaft generator breaker is tripped, the SG plant mode is cancelled and the AUTO plant mode is automatically selected.



The busbar supervision and protective functions stated with ANSI numbers (VTs may not be present)

Operating principle of the busbar supervision and protective functions

The busbar supervision and protective function operates according to the *definite time principle.*



The busbar/SG busbar supervision and protection operates according to the definite time principle

The programmable definite timer starts running when the programmed limit is exceeded and subsequently initiates the designated alarm sequence, when the delay timer runs out.

The delay timer is reset, if the measured value (here U_{BB} or f_{BB}) goes above or below the limit respectively.

The alarm regarding the supervision of the SCM module called "MEASURE ERROR" will block for the busbar protective functions.

Undervoltage supervision and protection

The undervoltage PARAMETER structure supervises/protects, if the busbar voltage is below one of the programmed limits. A warning and a trip of GB alarm sequence is carried out respectively, if the busbar voltage goes continuously *below* one of the set points (limits) during the programmed delays.

Please refer to technical manual part 1, paragraph 4, for a detailed description of the VTA structure.

Undervoltage supervision, PARAMETER-DGBBULowWarn

The operator is able to programme the PARAMETER structure, by which the busbar undervoltage supervision is controlled. If the busbar undervoltage supervision (warning) is activated, an alarm message is displayed at the DU (DGU, which detected the failure).

Undervoltage protection, PARAMETER-DGBBULowTrip and PARAMETER-DGBBULowTrip2

The operator is able to programme the PARAMETER structure, by which the busbar undervoltage protection is controlled.

The low voltage trips can be programmed as in the example below:

- Low trip 1: Slow low voltage protection (long delay, low< alarm limit)
- Low trip 2: Fast low voltage protection (short delay, low<< alarm limit)

If the busbar undervoltage protection is activated, an alarm message is displayed at the DU (DGU, which detected the failure).

Overvoltage supervision and protection

The overvoltage PARAMETER structure supervises/protects, if the busbar voltage is above one of the programmed limits. A warning or a trip of GB/SGB alarm sequence is carried out, if the busbar voltage goes continuously *above* one of the two set points (limits) during the programmed delays.

Please refer to technical manual part 1, paragraph 4, for a detailed description of the VTA structure.

Overvoltage supervision, PARAMETER-DGBBUHighWarn

The operator is able to programme the PARAMETER structure, by which the busbar overvoltage supervision is controlled. If the busbar overvoltage supervision (warning) is activated, an alarm message is displayed at the DU (DGU, which detected the failure).

Overvoltage protection, PARAMETER-DGBBUHighTrip and PARAMETER- DGBBUHighTrip2

The operator is able to programme the PARAMETER structure, by which the busbar overvoltage protection is controlled.

The high voltage trips can be programmed as in the example below:

- High trip 1: Slow high voltage protection (long delay, high> alarm limit)
- High trip 2: Fast high voltage protection (short delay, high>> alarm limit)

If the busbar overvoltage protection is activated, an alarm message is displayed at the DU (DGU, which detected the failure).

Underfrequency supervision and protection

The underfrequency function supervises/protects the busbar frequency and carries out a warning and a trip of GB/SGB alarm sequence respectively, if the busbar frequency is continuously *below* one of the two set points (alarm limits) during the programmed delays.

Please refer to technical manual part 1, paragraph 4, for a detailed description of the VTA structure.

Underfrequency supervision, PARAMETER-DGfLow

The operator is able to programme the PARAMETER structure, by which the busbar under-frequency supervision is controlled. If the busbar underfrequency supervision (warning) is activated, an alarm message is displayed at the DU (DGU which detected the failure).

Underfrequency protection, PARAMETER-DGBBfLowTrip and PARAMETER-DGBBfLowTrip2

The operator is able to programme the PARAMETER structure, by which the busbar underfrequency protection is controlled.

The low frequency trips can be programmed as in the example below:

- Low trip 1: Slow low frequency protection (long delay, low< alarm limit)
- Low trip 2: Fast low frequency protection (short delay, low<< alarm limit)

If the busbar underfrequency protection (trip of GB/SGB) is activated, an alarm message is displayed at the DU (DGU which detected the failure).

Overfrequency supervision and protection

The overfrequency function supervises/protects the busbar frequency and carries out a warning and a trip of GB/SGB alarm sequence respectively, if the busbar frequency is continuously *above* one of the two set points (alarm limits) during the programmed delays.

Please refer to technical manual part 1, paragraph 4, for a detailed description of the VTA structure.

Overfrequency supervision, PARAMETER-DGBBfHighWarn

The operator is able to programme the PARAMETER structure, by which the busbar overfrequency supervision is controlled. If the busbar overfrequency supervision (warning) is activated, an alarm message is displayed at the DU (DGU which detected the failure).

Overfrequency supervision, PARAMETER-DGBBfHighTrip and PARAMETER-DGBBfHighTrip2

The operator is able to programme the PARAMETER structure, by which the busbar overfrequency protection is controlled.

The high frequency trips can be programmed as in the example below:

- High trip 1: Slow high frequency protection (long delay, high> alarm limit)
- High trip 2: Fast high frequency protection (short delay, high>> alarm limit)

If the busbar overfrequency protection (trip of GB/SGB) is activated, an alarm message is displayed at the DU (DGU which detected the failure).

Diesel/shaft generator protection

The DELOMATIC diesel/shaft generator set protection is separated into the following parts:

Common protection:

- A set of protective functions, which are active when the breaker is closed

Diesel generator:

- Supervision of the generator during an idle run (the breaker is open)

Shaft generator:

- Supervision of the shaft generator during the SGB ON sequence

The diesel/shaft generator supervision and protection is carried out by means of the following hardware interface.

SIGNAL NAME	SIGNAL TYPE	LOCATION
• I_{GEN}	3-phase current input from the diesel/shaft generator	(SCM)
• U_{GEN}	3-phase voltage input from the diesel/shaft generator	(SCM)

The following diesel/shaft generator supervision and protective functions are implemented in each DGU in the DELOMATIC system:

Common protection:

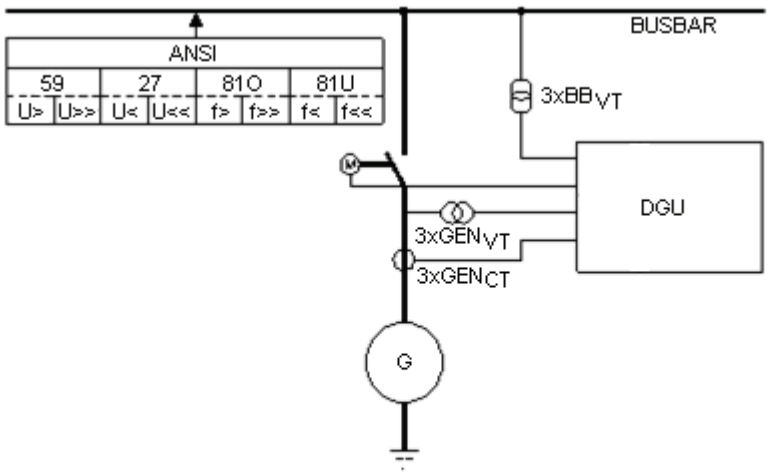
- Protection against overcurrent; I > (4 steps, 2 slow and 2 fast)
- Protection against reverse power; -P> (2 steps)
- Protection against overload; P > (3 steps, 1 high load and 2 overload)
- Other protections/protection levels on request

Diesel generator:

- Supervision of generator voltage and frequency during idle run

Shaft generator:

- Supervision of shaft generator voltage and frequency

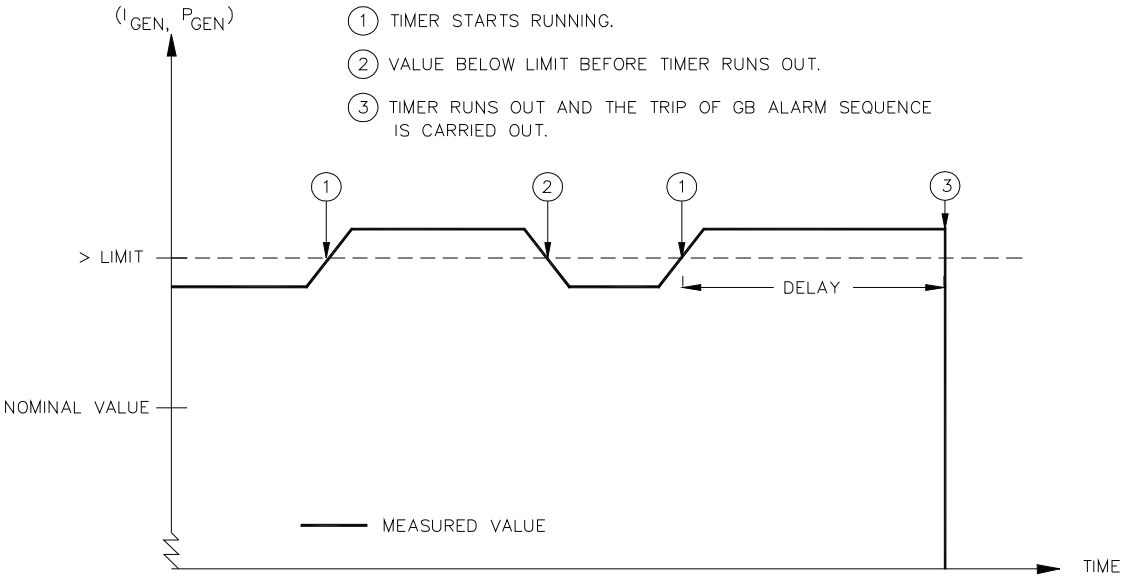


The busbar supervision and protective functions stated with ANSI numbers (VTs may not be present)

Each DGU carries out the diesel/shaft generator protection according to individual programmable set points and delays.

Operating principle of the diesel/shaft generator protective functions

The diesel/shaft generator protective functions operate according to the *defined time principle*.



The diesel/shaft generator supervision and protection operates according to the definite time principle

A programmable definite alarm timer starts running, when the programmed limit is exceeded. The designated alarm sequence is initiated, when the alarm timer runs out. The alarm timer is reset, if the measured value goes below the limit.

The programmable set points (alarm limits) are all stated in percentage of the corresponding nominal value.

Voltage and frequency supervision, PARAMETER-DGVoltFreqOk

The diesel/shaft generator frequency and voltage are supervised according to the principle described in the “BUSBAR SUPERVISION AND PROTECTION” in this paragraph.

Diesel generator:
From the time the generator set obtains a running status and until the generator breaker is closed, the DGU supervises the generator voltage and frequency.

Shaft generator:
During the SGB ON sequence (shaft generator breaker is still open), the SG DGU will supervise the shaft generator voltage and frequency.

The diesel/shaft generator voltage and frequency are examined according to programmed alarm limits for *supervision*:

- $f_{GEN}<$ is compared with **PARAMETER-DGfLowWarn**
- $f_{GEN}>$ is compared with **PARAMETER-DGfHighWarn**
- $U_{GEN}<$ is compared with **PARAMETER-DGULowWarn**
- $U_{GEN}>$ is compared with **PARAMETER-DGUHighWarn**

Please refer to technical manual part 1, paragraph 4, for a detailed description of the VTA structure.

The diesel/shaft generator frequency and voltage have to be continuously *within* the above-mentioned limits for the programmed delay in order to achieve the internal "DGVoltFreqOK" status. This allows the DGU to continue operating the diesel/shaft generator set, e.g. synchronisation.

The programmable PARAMETER structure enables the operator to adjust the delay of obtaining the "DGVoltFreqOK" status.

- **PARAMETER-DGVoltFreqOk**

Diesel/shaft generator voltage and frequency status

Common:
If the diesel/shaft generator voltage and frequency are continuously *outside* the above-mentioned limits, an alarm message is displayed in the corresponding DU.

Diesel generator:
If the diesel generator voltage and frequency are continuously *outside* the above-mentioned limits, the generator set is blocked for *any further participation* in automatic sequences.

Shaft generator:
If the diesel generator voltage and frequency are continuously *outside* the above-mentioned limits, the shaft generator is designated with the "U/f FAIL" status.

An active "U/f FAIL" status during an ongoing SGB ON sequence will block the shaft generator breaker and cancel the SG plant mode.

Overcurrent, I>

The diesel/shaft generator overcurrent protection is based on a comparison between the programmed limits and the largest measured phase current. All 3-phase currents (I_{L1}, I_{L2} and I_{L3}) are continuously measured and supervised. Set point limits are stated in percentage of I-Nom, and I-Nom is calculated on the basis of “DG U-NOM.” and “DG S-NOM.”, please refer to paragraph FACTORY SETTINGS.

The overcurrent protection is implemented in levels:

- Slow overcurrent protection (long delay, low alarm limit)
- Fast overcurrent protection (short delay, high alarm limit)

Please refer to technical manual part 1, paragraph 4, for a detailed description of the VTA structure.

Slow overcurrent protection, PARAMETER-DGIOverSlow and PARAMETER-DGIOverSlow2

The operator is able to programme the PARAMETER structure, by which the *slow* diesel/shaft generator overcurrent protection is controlled.

The slow overcurrent protection is implemented in levels:

- Slow overcurrent protection (long delay, low alarm limit)

If one of the overcurrent alarms are activated, an alarm message is displayed at the DU (DGU which detected the failure).

Fast overcurrent protection, PARAMETER-DGIOverFast and PARAMETER-DGIOverFast2

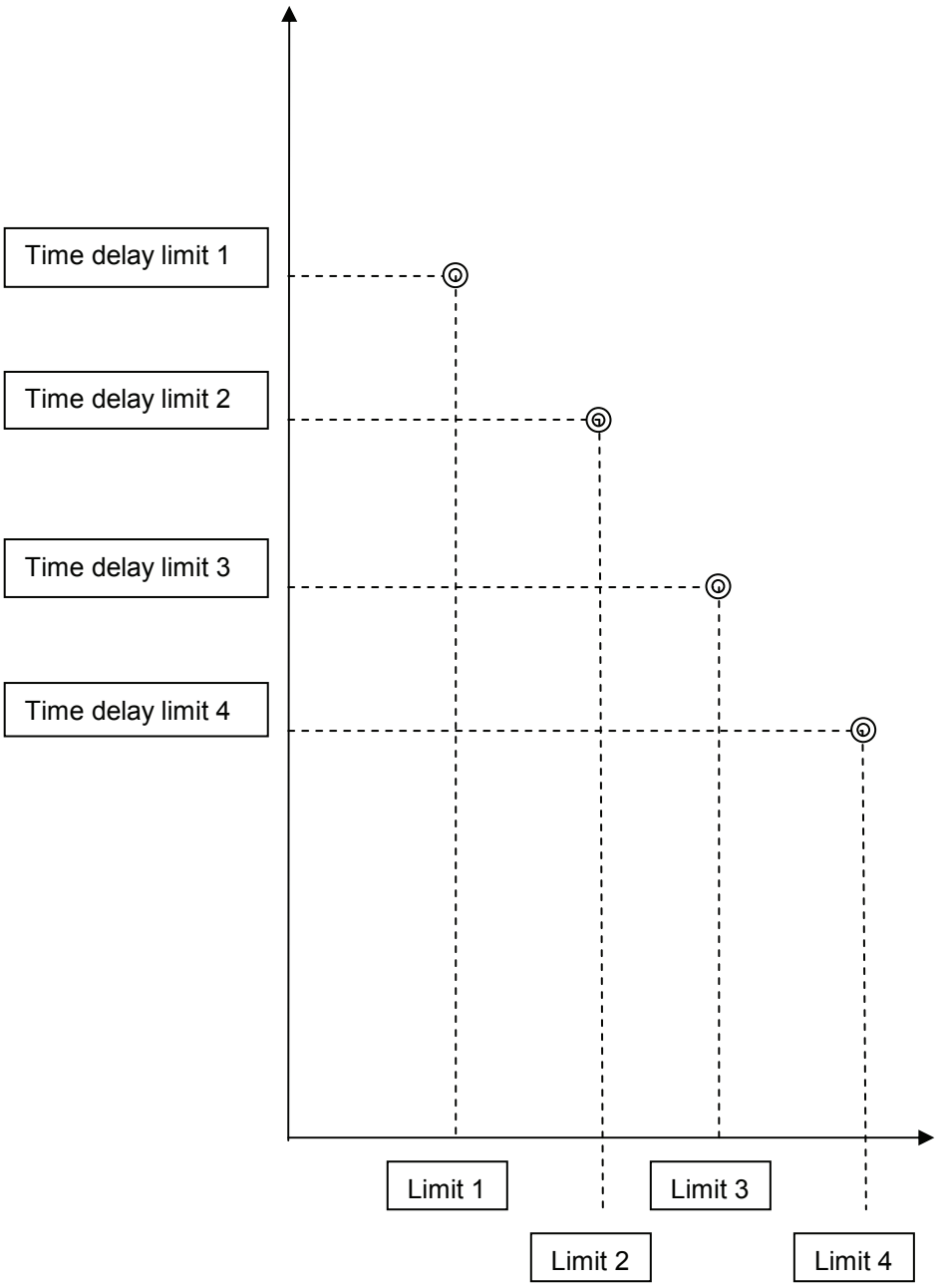
The operator is able to programme the PARAMETER structure, by which the *fast* diesel/shaft generator overcurrent protection is controlled.

The fast overcurrent protection is implemented in levels:

- Fast overcurrent protection (short delay, high alarm limit)

If one of the overcurrent alarms are activated, an alarm message is displayed at the DU (DGU which detected the failure).

The fast overcurrent protection of the diesel/shaft generator set is *not* a short circuit protection!



Overcurrent protection levels

Reverse power -P>, PARAMETER-DGPRev and PARAMETER-DGPRev2

The diesel/shaft generator power is continuously measured by the DGU. The power flow is considered to be positive *from the diesel/shaft generator and towards the busbar*.

This means, if power starts flowing into the diesel/shaft generator instead of out from the diesel/shaft generator, the sign of the measured power is changed to minus (-). The (-) signed power is referred to as *"reverse" power*.

The operator is able to programme the PARAMETER structure, by which the reverse power protection is controlled.

The reverse power trips can be programmed as in the example below:

- Low trip 1: Slow reverse power protection (long delay, low< alarm limit)
- Low trip 2: Fast reverse power protection (short delay, low<< alarm limit)

If the reverse power protection is activated, an alarm message is displayed at the DU (DGU which detected the failure).

Please refer to technical manual part 1, paragraph 4, for a detailed description of the VTA structure.

Overload P>

The diesel/shaft generator overload function is separated into two levels:

- Supervision, high load warning on the diesel/shaft generator set
- Protection, trip of the diesel/shaft generator breaker due to overload

Please refer to technical manual part 1, paragraph 4, for a detailed description of the VTA structure.

Overload P> supervision, PARAMETER-DGPHigh

The operator is able to programme the PARAMETER structure, by which the diesel/shaft generator load supervision is controlled. If the diesel/shaft generator load supervision is activated, an alarm message is displayed at the DU (DGU which detected the failure).

Overload P> protection, PARAMETER-DGPOver and DGPOver2

The operator is able to programme the PARAMETER structure, by which the diesel/shaft generator *overload protection* is controlled.

The overload trips can be programmed as in the examples below:

- High trip 1: Slow overload protection (long delay, high> alarm limit)
- High trip 2: Fast overload protection (short delay, high>> alarm limit)

If the diesel/shaft generator overload protection is activated, an alarm message is displayed at the DU (DGU which detected the failure).

Under Excitation -Q>, PARAMETER-DGQRev and PARAMETER-DGQRev2.
Optional feature
The diesel/shaft generator reactive power is continuously measured by the DGU. The power flow is considered to be positive *from the diesel/shaft generator and towards the busbar*.

This means, if power starts flowing into the diesel/shaft generator instead of out from the diesel/shaft generator, the sign of the measured power is changed to minus (-). The (-) signed power is referred to as *"under excitation"*.

The operator is able to programme the PARAMETER structure, by which the protection of under excitation is controlled.

The reverse power trips can be programmed as in the example below:

- Low trip 1: Slow under excitation protection (long delay, low< alarm limit)
- Low trip 2: Fast under excitation protection (short delay, low<< alarm limit)

If the under excitation protection is activated, an alarm message is displayed at the DU (DGU which detected the failure).

Please refer to technical manual part 1, paragraph 4, for a detailed description of the VTA structure.

Over Excitation Q> protection, PARAMETER-DGQOver1 and DGQOver2.
Optional feature
The operator is able to programme the PARAMETER structure, by which the diesel/shaft generator *over excitation protection* is controlled.

The overload trips can be programmed as in the examples below:

- High trip 1: Slow over excitation protection (long delay, high> alarm limit)
- High trip 2: Fast over excitation protection (short delay, high>> alarm limit)

If the diesel/shaft generator over excitation protection is activated, an alarm message is displayed at the DU (DGU which detected the failure).

Please refer to technical manual part 1, paragraph 4, for a detailed description of the VTA structure.

Trip of non-essential-load groups

The trip of Non Essential Load (NEL) groups is carried out in order to protect the busbar against an imminent blackout situation due to either a high load on a diesel/shaft generator set or a low busbar frequency.

The trip of NEL-groups is implemented in *each* DGU. This means that each DGU executes the trip of NEL-groups according to individual settings. But it is *highly* recommended to programme all DGUs with identical settings in order to obtain a uniform operation.

Each DGU is able to trip NEL groups due to

- the measured load of the diesel/shaft generator set

and

- the measured frequency at the busbar/SG busbar

The 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 etc. *Only* the measurement of either the busbar frequency or the load on the diesel/shaft generator set is able to trip the load groups.

The trip of NEL-groups is controlled via the following hardware interface.

SIGNAL NAME	SIGNAL TYPE	LOCATION
• U_{GEN}	3-phase voltage input from the diesel/shaft generator	(SCM)
• I_{GEN}	3-phase current input from the diesel/shaft generator current transformers	(SCM)
• TRIP OF NEL 1	Relay output	(IOM 4.1)
• TRIP OF NEL 2	Relay output	(IOM 4.1)

The outputs for trip of NEL on all DGUs should be connected in parallel (all NEL 1 connected in parallel and all NEL 2 connected in parallel etc.).

Trip of NEL-groups due to high load

The trip of NEL-groups due to the load of a running diesel/shaft generator set will reduce the load on the busbar and thus reduce the load percentage on the running diesel/shaft generator set. This may prevent a possible blackout at the busbar caused by an overload on the running diesel/shaft generator.

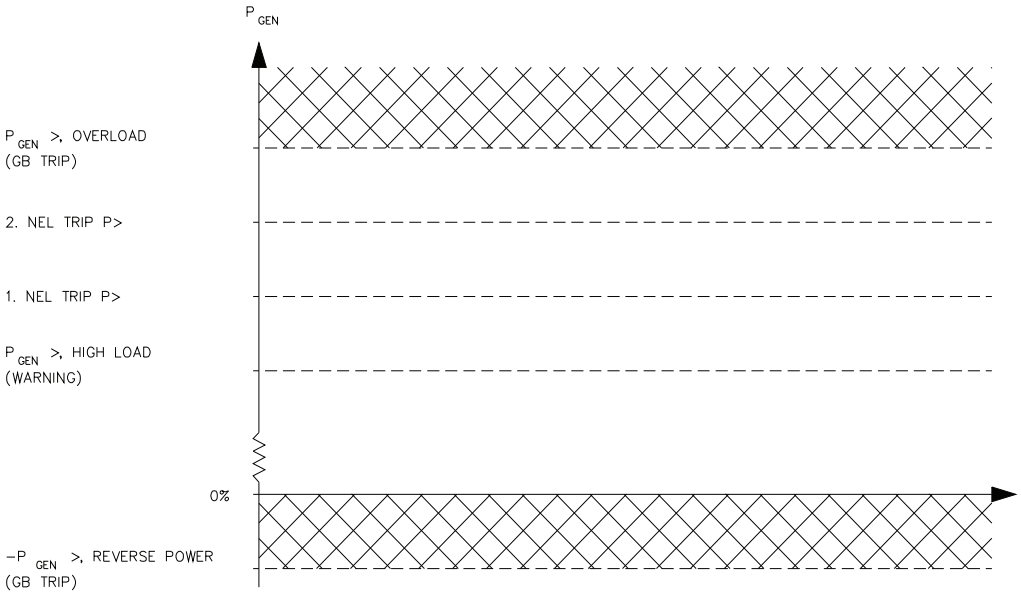
Furthermore, both steps of NEL-groups are tripped at the same time by the DGU, if the corresponding diesel/shaft generator breaker is tripped.

Please refer to technical manual part 1, paragraph 4, for a detailed description of the VTA structure.

Programming trip of NEL-groups due to high load, PARAMETER-DGPNEL(n)Trip

The operator is able to adjust the PARAMETER structure, by which the trip of NEL-groups due to high load at the diesel/shaft generator is controlled. If one of the NEL-groups is tripped due to high load, an alarm message is displayed at the DU (DGU which has tripped the NEL-group).

The operator is given the possibility to choose between trip of NEL due to High Load and High Current.



A suggestion on how to achieve selectivity between the real power protective functions with trip of 2 NEL-groups

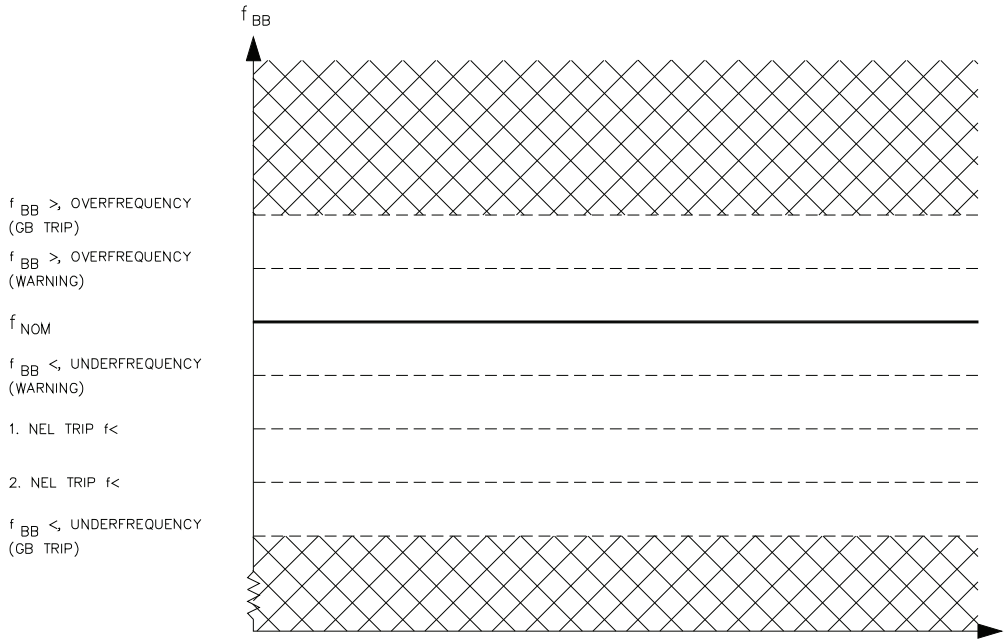
Trip of NEL-groups due to low busbar frequency

Trip of the NEL-groups due to a low busbar frequency will reduce the real power load at the busbar and thus reduce the load percentage on all the running diesel/shaft generator sets. This may prevent a possible blackout at the busbar.

Please refer to technical manual part 1, paragraph 4, for a detailed description of the VTA structure.

Programming trip of NEL-groups due to low frequency, PARAMETER-DGfNEL(n)Trip

The operator is able to adjust the PARAMETER structure, by which the trip of NEL-groups due to low frequency at the diesel/shaft generator is controlled. If one of the NEL-groups is tripped due to low frequency, an alarm message is displayed at the DU (DGU which has tripped the NEL-group).



A suggestion on how to achieve value selectivity between the frequency protective functions with trip of 2 NEL-groups

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