MULTI-LINE 2
DESCRIPTION OF OPTIONS



Option A1
Mains protection package

- Description of option
- Functional description

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1. Delimitation

1.1 Scope of option A1

This description of options covers the following products:

AGC-3	SW version 3.5x.x or later
AGC-4	SW version 4.2x.x or later
AGC 200 series	SW version 4.2x.x or later
APU 200 series	SW version 3.53.x or later
GPC/GPU Hydro	SW version 3.07.x or later
PPU/GPU	SW version 3.07.x or later
CGC 400	SW version 1.11.x or later

2. General information

2.1 Warnings, legal information and safety

2.1.1 Warnings and notes

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

Warnings

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

Notes

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

2.1.2 Legal information and disclaimer

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

The Multi-line 2 unit is not to be opened by unauthorised personnel. If opened anyway, the warranty will be lost.

Disclaimer

DEIF A/S reserves the right to change any of the contents of this document without prior notice.

2.1.3 Safety issues

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

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

2.1.4 Electrostatic discharge awareness

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

2.1.5 Factory settings

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

3. Description of option

3.1 Option A1

The option A1 is a software option and therefore not related to any hardware apart from the standard-installed hardware. The option A1 is a mix of the below listed protections as follows:

Option A1 (AGC-3, AGC-4, AGC 200 series, GPC-3, GPU-3, GPU-3 Hydro, PPU-3)

- Vector jump
- df/dt (ROCOF)
- Time-dependent undervoltage
- Undervoltage and reactive power low
- Average BB overvoltage

3.2 ANSI numbers

Protection	ANSI no.
Vector jump	78
df/dt (ROCOF)	81
Time-dependent undervoltage, U_t <	27t
Undervoltage and reactive power low, U_Q <	27Q
Average BB overvoltage	59AVG

4. Functional description

4.1 Vector jump and df-dt protections

The loss of mains protection package includes df/dt (Rate Of Change Of Frequency, ROCOF) and/or vector jump protection. The protections are used when the generator is paralleling with the mains.

4.1.1 Measurement

Both the df/dt and vector jump protections are based on three individual single-phase measurements (individual monitoring of phases L1, L2 and L3). Therefore, the relay will trip if a df/dt and/or vector jump occurs in one of the three phases.

4.1.2 Principle

The vector jump and df/dt protections are intended for detection of a mains failure and subsequent opening of the mains breaker. The reasons are:

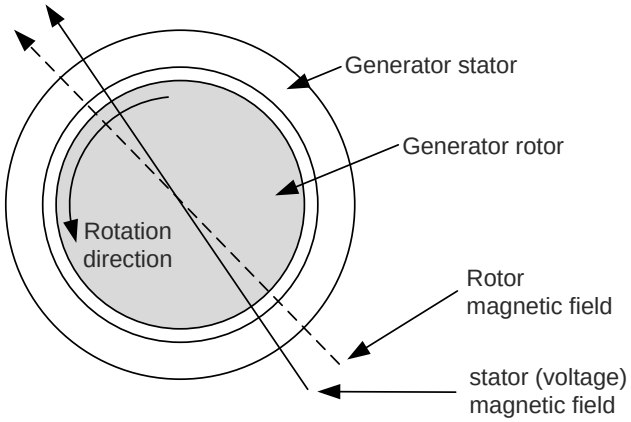
1. In case of mains failure the generator will run "stand-alone" on the grid, attempting to supply power to all consumers. Naturally, this is not possible because of the mains failure, and an overload/overcurrent situation is likely to be the end result, as the mains consumption normally exceeds the generator capacity.
2. Mains transformer protection systems are constructed with a so-called "fast reclosing" feature. This means that if a failure occurs (e.g. a short circuit), then the transformer protection system will open the transformer breaker. But after a while (the actual time period depends on the specific country (e.g. 330 ms in Denmark)), the breaker will be reclosed to check whether it was a short-time failure, e.g. two overhead wires meeting shortly, a lightning strike, a branch falling down from a tree, etc. If the failure is still present, then the breaker will be reopened and remain there.

This reclosing combined with the high overload on the generator means that the generator and the mains will be paralleled again without synchronisation, an operation which will most likely damage the entire genset.

Ordinary protections will not identify a mains failure before it is too late (300 ms). Therefore, the vector jump and/or df/dt protections are used. These will detect the mains failure and open the breaker before reclosing occurs.

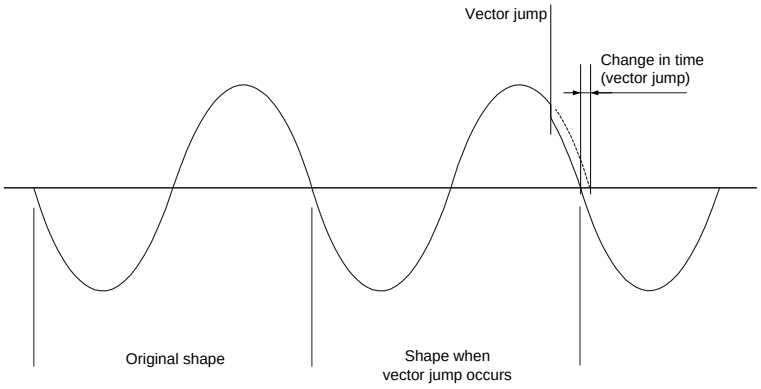
4.1.3 Vector jump

Vector jump is based on the fact that the stator magnetic field – and as a result, the 3-phase voltage from a generator – lag a little behind the rotor magnetic field (in time and position).



If a mains failure occurs, the time lag of the stator magnetic field (and the output voltage) will change (jump). This is called a vector jump.

A vector jump illustrated in a sine wave:

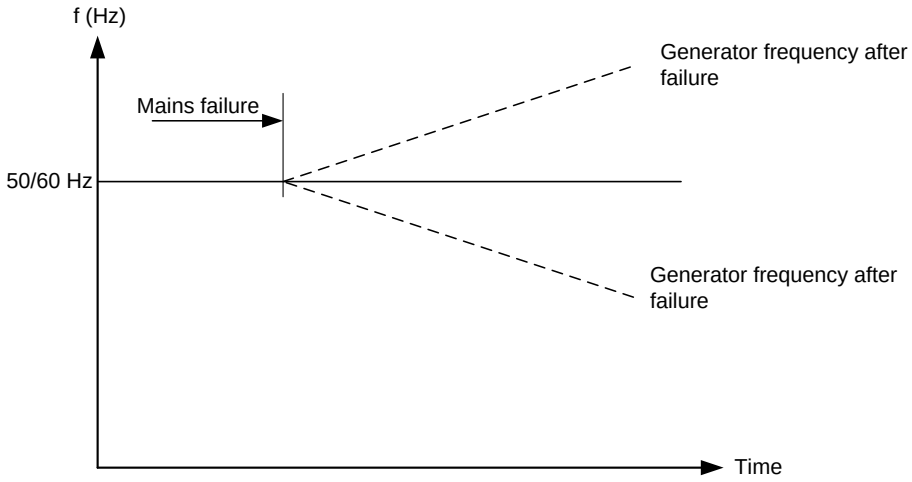


Again, comparing the sine curve time duration with the previous ones, a sudden change in time can be detected. This is the vector jump.

The vector jump setting is made in electrical degrees. The vector jump has no delay setting, since it reacts instantaneously. The delay will be the reaction time.

4.1.4 df/dt (ROCOF)

The df/dt function is based on the fact that the generator, if overloaded, will loose speed dramatically. Alternatively, it will speed up dramatically if a lot of load is dropped instantly.



So, a dramatic drop/increase of frequency over time is a mains failure. The df/dt setting is made in Hz/sec.

The delay is set in periods, i.e. if the setting is set to "6per" (factory setting), the time delay will be 120 ms (50 Hz) or 100 ms (60 Hz). The total delay will be the delay setting + reaction time.

4.1.5 Adjustments

Load jumps
Vector jump and df/dt protections are generally very reliable when used for generator protection to avoid asynchronous reconnection of the generator to the mains after a mains failure.

Nevertheless, the protections may fail to react if no or a very small load change takes place upon mains failure. This can happen when the generator is used in a peak lopping or Combined Heat and Power (CHP) system, where the power flow to the mains is very low.

In general, the system load change necessary to activate the vector jump or the df/dt protections is between 15-20% of the plant's rated power. Attempting to increase the sensitivity of the protection by lowering the set-point value may result in false trips, because even the mains grid is not completely stable.

Distant mains breaker decoupling
If a mains failure occurs in a system where a generator is running as a peak lopping/automatic mains failure generator, and if the loss of mains protections are used to decouple a mains breaker, care must be taken to prevent the generator breaker short circuit from tripping the generator breaker before the mains breaker is tripped.

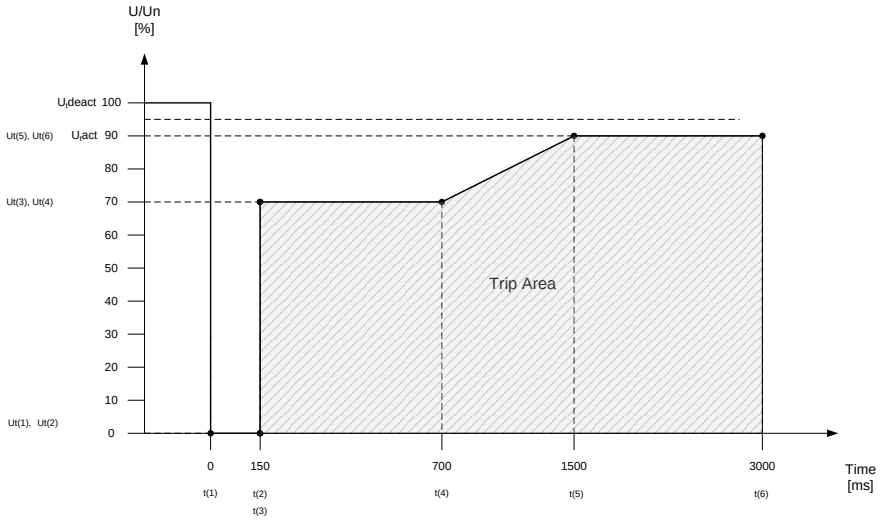
This may happen if the mains failure is a distant one, because it will leave so many remaining consumers connected to the genset that they will appear to be a short circuit when compared to the generator nominal current.

Compare the reaction + delay time of the vector jump/df/dt protection to the delay time of the generator breaker short circuit protection to determine whether this is a problem.

4.2 Time-dependent undervoltage

The time-dependent undervoltage protection is defined by six curve points. Each point consists of a voltage limit value and a time delay. The protection will activate if any phase-phase voltage at any given time drops below the set voltage value (below the curve). Between any two neighbouring points, the resulting curve is a straight line.

Example:



The above example is configured with the following parameter settings:

Menu	Settings	Name	Description
1631	30%	Ut(1) Setting 1	Curve setting for time-dependent undervoltage. Settings relate to nominal generator voltage. The condition has to be true i.e. Ut(1)1≤Ut(2)≤Ut(3)≤Ut(4)≤Ut(5)≤Ut(6). If this is not fulfilled, the worst-case setpoint Ut(6) will be used.
1632	0.00 sec.	t(1) Delay 1	
1633	30%	Ut(2) Setting 1	
1634	0.15 sec.	t(2) Delay 1	
1635	70%	Ut(3) Setting 1	
1636	0.15 sec.	t(3) Delay 1	
1641	70%	Ut(4) Setting 1	
1642	0.70 sec.	t(4) Delay 1	
1643	90%	Ut(5) Setting 1	
1644	1.50 sec.	t(5) Delay 1	
1645	90%	Ut(6) Setting 1	
1646	3.00 sec.	t(6) Delay 1	
1651	90%	$U_t$act (Activate)	Activate is the voltage value where the functiontimer starts.
1652	95%	$U_t$deact (Reset)	Reset is the value where the function timer is reset to 0 ms.
1653	1.00 sec.	Delay	Delay is the delay timer for the reset.
1654		Relay output A	The relay outputs will activate immediately when the function timer starts.
1655		Relay output B	
1656	ON	Enable	
1661		Relay output A	The alarm and fail class is activated instantaneously when the voltage value is below the programmed value curve.
1662		Relay output B	
1663	ON	Enable	
1664	Trip MB	Fail class	

Please add 100 ms to the setpoint to allow for necessary relay reaction. So, if a setpoint of 150 ms is required, the t2 and t3 must be adjusted to [150+100=250 ms].

$U_t$deact: The voltage level in % of nominal voltage where the function is reset (function timer stops and resets)

$U_t$act: The voltage level in % of nominal voltage where the function is activated (function timer starts running)

$U_t(1)$-$U_t(6)$: The voltage setpoints in % of nominal voltage

t(1)-t(6): The time in ms corresponding to the voltage setpoint

U_t can be set with a minimum setting of 30% of Unom. If the setting $U_t(1)$ has a value of 30% of Unom (minimum value), then this alarm is inhibited, allowing the voltage to drop to 0% without tripping.

The underfrequency alarms are also inhibited until the time reaches the value t(2). The settings $U_t(2)$ to $U_t(6)$ will not affect the underfrequency alarm.

4.3 U and Q low

The function U&Q< is active as soon as all three phase-phase generator voltages go below the voltage limit value (U-trip value) and the reactive power is equal to or below 0 (Q-trip value) at the same time. Tripping takes place if the function is active for more than the adjusted delay t(U&Q<).

The practical meaning of this is that the generator has no stabilising effect for the disturbed grid and therefore must be disconnected.

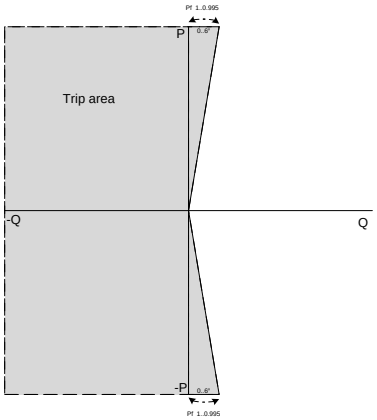
1990 U and Q Inh					
No.	**Setting**		**Min. Max**	**Factory setting**	**Note**
1991	I Min. 1	Setpoint	0% 20%	0%	0° pf = 1.0 6° pf = 0.995
1992	Angle 1	Setpoint	0° 6°	0°	Set setpoints to 0 for backward compatibility

The alarm of menu 1960 will be inhibited until the measured values are inside the limits in menus 1991 and 1992.

The setpoint of menu 1991 "I Min. 1" is required as a minimum current flow in each phase to activate the alarm.

The setpoint of menu 1992 "Angle 1" is required as a limitation of the power factor (PF) to activate the alarm.

Menu 1993-1994 "U and Q Inh 2" is handled the same way as "U and Q Inh".



Alarms in menus 1960 and 1970 will work without inhibits if default settings are used in menus 1991 and 1992.

Positive reactive Q > 0 means overexcited operation.

Not supported by AGC-3 and APU 200.

4.4 Average busbar overvoltage protection (Avg BB >1)

4.4.1 Avg U BB > 1

This is a busbar overvoltage alarm based on an average measurement of the voltage of the busbar. This is different from a conventional definite time type alarm since the setpoint must be reached over an adjustable time period (average calculation).

There are two levels of alarms (Avg U BB> 1 and Avg U BB> 2) which can be configured independently of each other. The parameters used to set up the alarm Avg U BB> 1 are listed in the table below. Parameter settings relating to Avg U BB> 2 are similar and located in parameter menu 7490.

7480 Avg U BB > 1				
No.	**Setting**		**Factory setting**	**Notes**
7481	Avg U BB > 1	Setpoint	100.0% 120.0%	110.0%
7482	Avg U BB > 1	Timer	0.1 s 3200.0 s	10.0 s
7483	Avg U BB > 1	Relay output A	Not used Option-dependent	Not used
7484	Avg U BB > 1	Enable	OFF ON	OFF
7485	Avg U BB > 1	Fail class	F1...F8	Warning (F2)
7486	Avg U BB > 1	AVG Timer	30 s 900 s	600 s

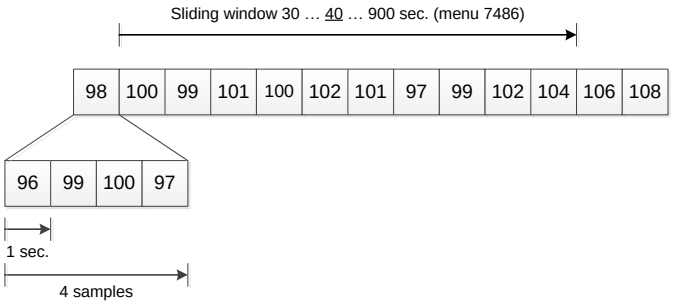
GPC-3, GPU-3 and PPU-3 only have six fail classes. The default fail class is "warning".

Average calculation

The busbar voltage measurement is sampled once every second, and every four seconds an intermediate average value is calculated. This value is an intermediate result which is transferred to an ongoing stack. The average alarm is based on this ongoing stack.

The ongoing stack (sliding window) works by the first in first out (FIFO) principle, and the duration of the average calculation is adjusted in menu 7486. This timer is a sliding window where the oldest intermediate calculation is overwritten every four seconds. This also means that the average value of the alarm is updated every four seconds.

Example:



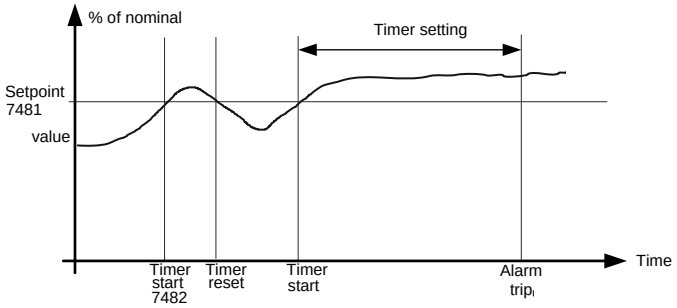
The numbers in the above figure represent the busbar voltage as a percentage of the nominal busbar voltage.

As the figure shows, the value of the first intermediate calculation is 98%, and this is transferred to the ongoing stack. The duration of the sliding window has been set to 40 seconds in menu 7486. This means that the average value of the alarm is based on 10 four sample intermediate average calculations.

In this example the average value will be:

$$Avg.value = \frac{\sum values}{n} = \frac{100+99+101+100+102+101+97+99+102+104}{10} = 100.5\ \%$$

Average alarm
The value of the average calculation can be considered as an actual value. In this context, the alarm works like a conventional definite alarm. Once the value reaches the setpoint in menu 7481, the timer in menu 7482 is initiated and will trip the alarm if the value is higher than the setpoint for this period. If the value goes below the setpoint, the timer in menu 7482 is reset.



Change of setpoint in menu 7486 will reset the Avg U BB > 1 value.

Only supported by AGC-4, AGC 200, GPC-3, GPU-3 and PPU-3.

5. Parameters

5.1 Further information

The option A1 relates to the parameters 1960, 1420-1430, 1630-1700, 1970, 1990-1994, 7480-7486 and 7490-7496.

For further information, please see the separate parameter list for the Multi-line unit in question:

AGC-3	Document number 4189340705
AGC-4	Document number 4189340688
AGC 200	Document number 4189340605
GPC-3/GPU-3 Hydro	Document number 4189340580
PPU-3/GPU-3	Document number 4189340581