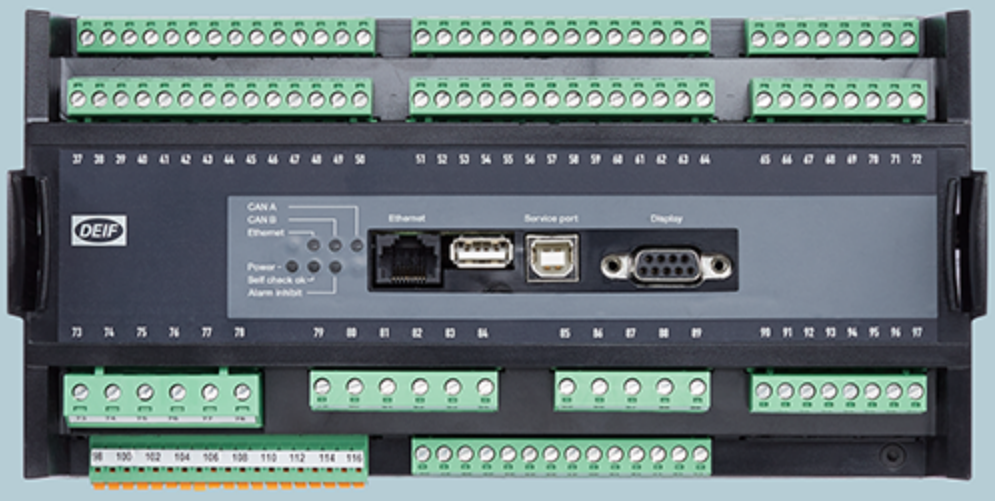
AGC-4

Option A1
Mains protection package



DEIF A/S · Frisenborgvej 33 · DK-7800 Skive
Tel.: +45 9614 9614 · Fax: +45 9614 9615
info@deif.com · www.deif.com

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1. Description of option

2. Function description

1. Description of option

1.1 Option A1

Option A1 is a software option. Option A1 only requires the standard hardware. Option A1 includes the following protections:

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

1.2 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

1.3 Software version

This document is based on the AGC-4 software version 4.76.

1.4 Parameters

The relevant parameters are 1420-1436, 1650-1700, 1960, 1970, 1990-1994, 7480-7486 and 7490-7496. For more information, see the **Parameter list**.

There are also relevant settings under *Advanced Protection* in the utility software.

1.5 Warnings, legal information and safety

1.5.1 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

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

Notes

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

1.5.2 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.

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

Disclaimer

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

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

1.5.3 Factory settings

The Multi-line 2 unit is delivered from the factory with default settings. These are not necessarily correct for the engine/generator set. Check all the settings before running the engine/generator set.

2. Function description

2.1 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.

The controller cannot use the df/dt and vector jump protections at the same time. If both are enabled, the controller uses df/dt and ignores vector jump.

INFO
After a controller power up, the controller can only execute fast AC alarms (that is, df/dt and vector jump) after the controller checks confirm that the system is OK.

2.1.1 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.

2.1.2 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:

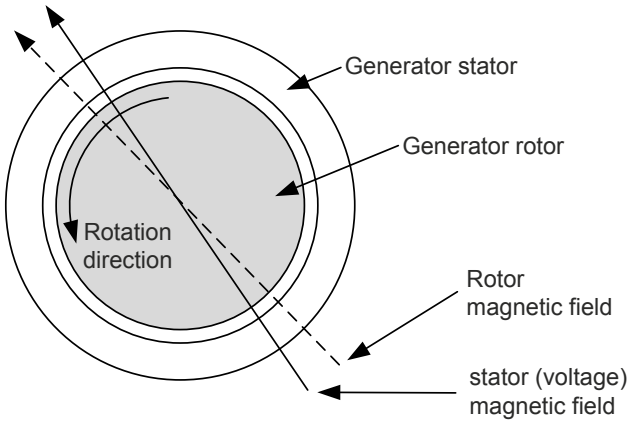
1. In case of mains failure the generator will run "stand-alone" on the grid, attempting to supply power to all consumers. Naturally, this is not possible because of the mains failure, and an overload/overcurrent situation is likely to be the end result, as the mains consumption normally exceeds the 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.

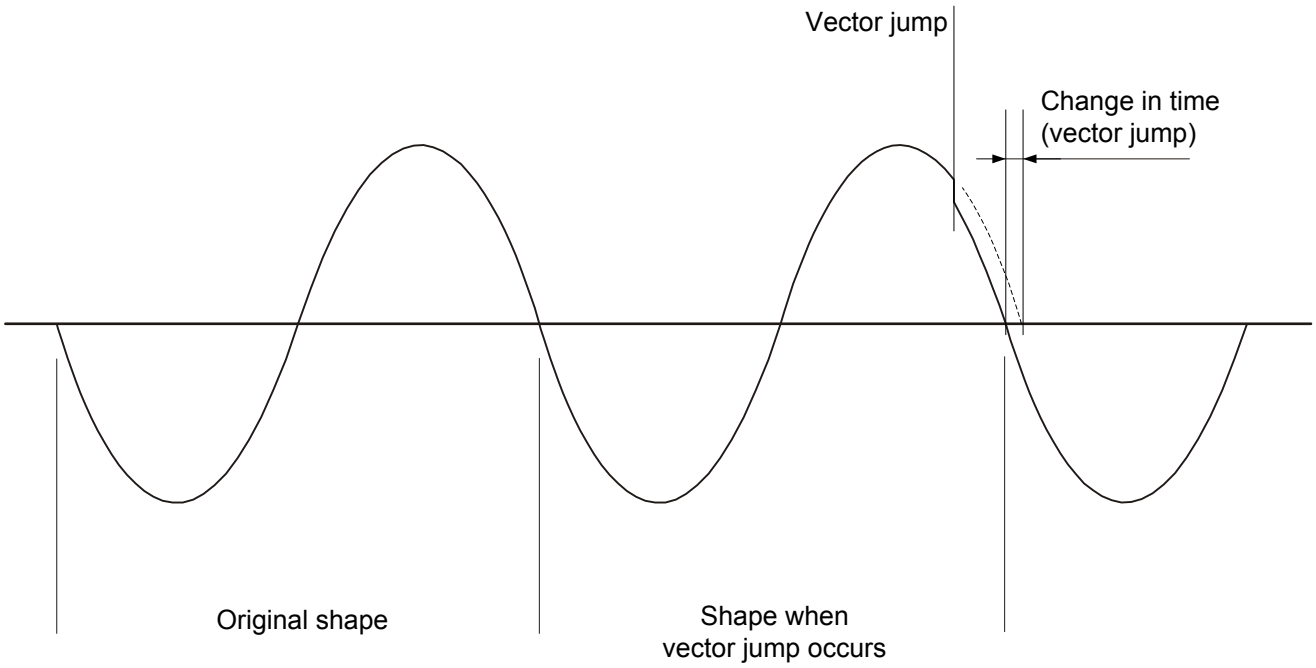
2.1.3 Vector jump

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.

2.1.4 df/dt (ROCOF)

The df/dt function is based on the real performance of generators during a mains failure. If the generator is suddenly overloaded, it loses speed rapidly. If a large load is suddenly dropped, the generator speeds up rapidly. A mains failure can therefore be seen in the rapid decrease or increase of frequency.

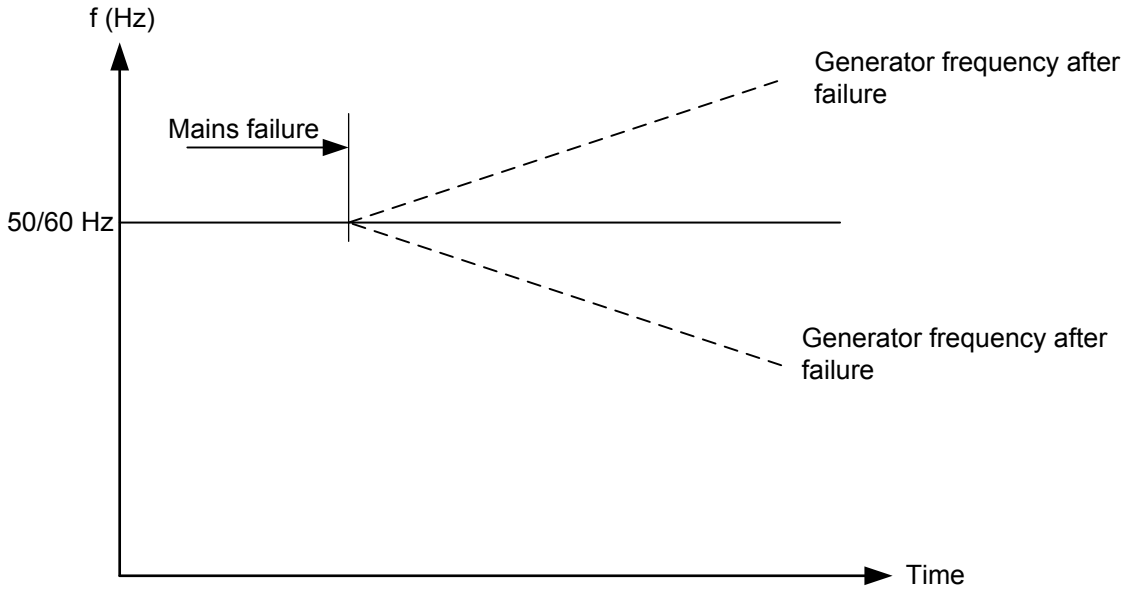


Table 2.1 df/dt (ROCOF) configuration (menu 1420)

Parameter	Name	Range	Default	Description
1205	df/dt type	Standard df/dt	Standard df/dt	If you have option A10, you can also select *G99 df/dt*.
1421	Set point	1.5 to 10 Hz/s	5 Hz/s	The df/dt protection set point.
1422	Set point	3 to 20 periods	6 periods	The measurement time for the df/dt protection. For example: At 50 Hz, for 6 periods, to activate the protection, the df/dt must exceed the set point over the last 120 ms. If you have option A10, you can also select a delay (0 to 3 s).
1425	Enable	Off or On	Off	
1426	Fail class	F1 to F9	Trip MB (F6)	

INFO
For *G99 dt/dt*, the function is most precise for a nominal frequency of 50 Hz (and is not recommended for 60 Hz systems).

2.1.5 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 15 to 20 % of the plant's rated power. Attempting to increase the sensitivity of the protection by lowering the set point 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.

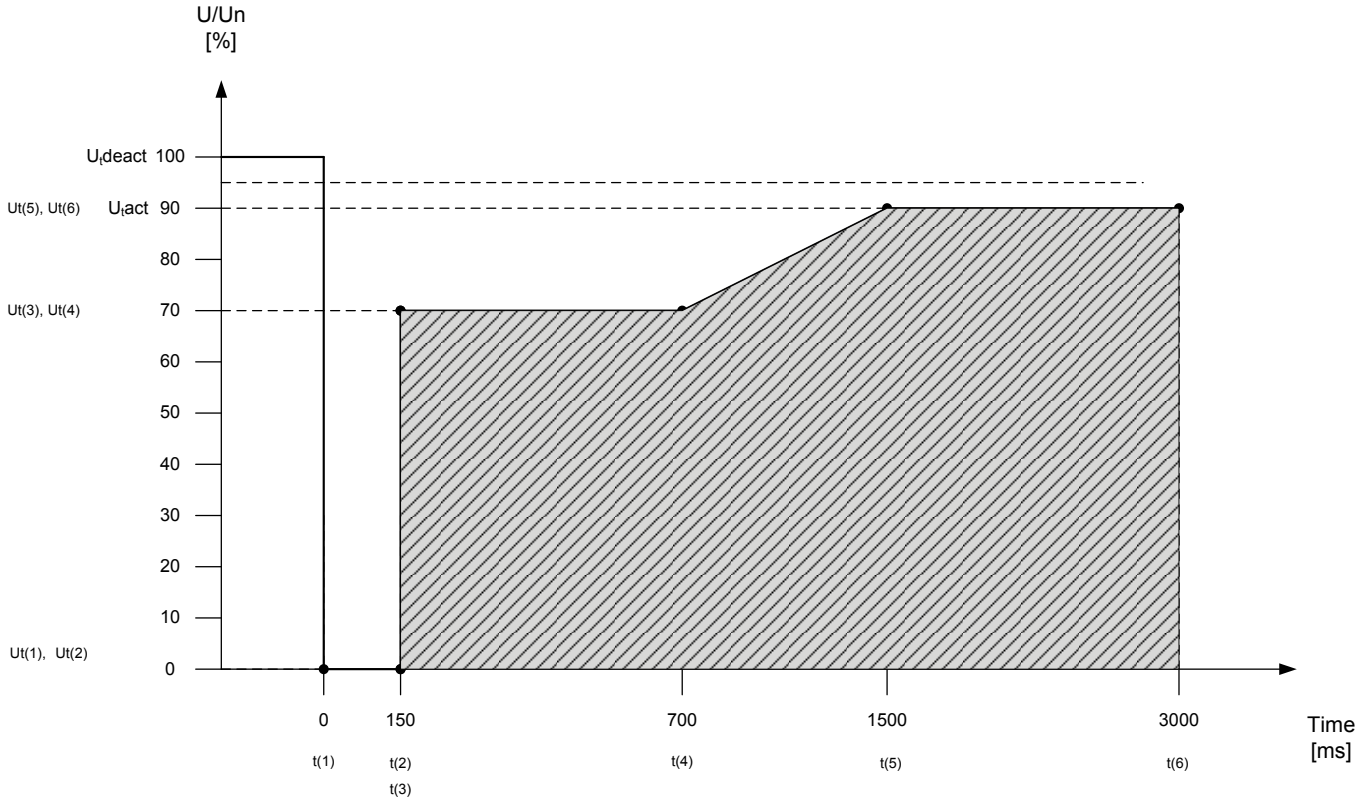
Compare the reaction and delay time of the vector jump or df/dt protection to the delay time of the generator breaker short circuit protection to determine whether this is a problem.

2.2 Time-dependent undervoltage (LVRT)

Time-dependent undervoltage, also known as Low Voltage Ride Through (LVRT), keeps the generator connected even though the grid voltage is below the expected value. LVRT is a type of Fault Ride Through (FRT). The LVRT curves define how long the generator remains connected to the grid.

The protection activates if any phase-phase voltage at any time drops below the set voltage value (below the curve). Between any two neighbouring points, the curve is a straight line.

Figure 2.1 Time-dependent undervoltage protection example



The controller counts LVRT activations. In the USW, select the *Counters* icon to open the *Counters* window, then select *LVRT/HVRT*. For each curve, the number of activations and trips are shown.

FRT setup settings

Configure these settings under *Advanced Protection*, *FRT setup*.

Table 2.2 LVRT trip type

Setting	Default	Range	Description
LVRT 1 trip type select LVRT 2 trip type select	Any phase-phase fault	Any phase-phase fault 1 phase-phase fault 2 phase-phase fault	The measurement type for the fault ride through curve

Setting	Default	Range	Description
		3 phase-phase fault 1 phase-neutral fault 2 phase-neutral fault 3 phase-neutral fault Any phase-neutral fault	

There are configurable settings to stop GOV and/or AVR regulation for up to 5 seconds during LVRT.

Table 2.3 Suspend GOV and AVR

Setting	Default	Range	Description
Suspend GOV regulation	Disable	Disable Enable	*Disable*: GOV regulation is not affected when an FRT curve is activated. *Enable*: GOV regulation is stopped when any FRT curve is activated.
GOV reg suspension timer	5 s	0 to 5 s	Time duration for stopping the GOV, when an FRT curve is activated.
Suspend AVR reg	Disable	Disable Enable	*Disable*: AVR regulation is not affected when an FRT curve is activated. *Enable*: AVR regulation is stopped when any FRT curve is activated.
AVR reg suspension timer	5 s	0 to 5 s	Time duration for stopping the AVR, when an FRT curve is activated.

LVRT 1 settings

Configure these settings under *Advanced Protection*, *LVRT 1*.

INFO
Some configurable settings, which previously had parameter numbers, have been moved to *Advanced Protection*. These settings no longer appear in the parameter list. To help the user, the old parameter number is shown in brackets. Where a new configurable setting has been created, this is shown by *(New)*.

Table 2.4 LVRT 1 curve

Voltage	Default*	Timer	Default**
Ut< U SP1 (1631)	30 %	Ut< t SP1 (1632)	0 s
Ut< U SP2 (1633)	30 %	Ut< t SP2 (1634)	0.15 s
Ut< U SP3 (1635)	70 %	Ut< t SP3 (1636)	0.15 s
Ut< U SP4 (1641)	70 %	Ut< t SP4 (1642)	0.7 s
Ut< U SP5 (1643)	85 %	Ut< t SP5 (1644)	1.5 s
Ut< U SP6 (1645)	85 %	Ut< t SP6 (1646)	60 s
Ut< U SP7 (New)	90 %	Ut< t SP7 (New)	60 s
Ut< U SP8 (New)	90 %	Ut< t SP8 (New)	70 s
Ut< U SP9 (New)	90 %	Ut< t SP9 (New)	70 s
Ut< U SP10 (New)	90 %	Ut< t SP10 (New)	70 s

*Note: The range is 4 to 120 % of nominal voltage.

**Note: The range is 0 to 70 s.

LVRT 2 settings

Configure these settings under *Advanced Protection*, *LVRT 2*.

Table 2.5 LVRT 2 curve

Voltage	Default*	Timer	Default**
Ut< U SP1 (1671)	30 %	Ut< t SP1 (1672)	0 s
Ut< U SP2 (1673)	30 %	Ut< t SP2 (1674)	0.22 s
Ut< U SP3 (1675)	60 %	Ut< t SP3 (1676)	0.22 s
Ut< U SP4 (1681)	60 %	Ut< t SP4 (1682)	0.7 s
Ut< U SP5 (1683)	75 %	Ut< t SP5 (1684)	1.5 s
Ut< U SP6 (1685)	75 %	Ut< t SP6 (1686)	3 s
Ut< U SP7 (New)	85 %	Ut< t SP7 (New)	3 s
Ut< U SP8 (New)	85 %	Ut< t SP8 (New)	60 s
Ut< U SP9 (New)	90 %	Ut< t SP9 (New)	60 s
Ut< U SP10 (New)	90 %	Ut< t SP10 (New)	70 s

*Note: The range is 4 to 120 % of nominal voltage.

**Note: The range is 0 to 70 s.

Parameters

Configure these parameters in the parameter list.

Table 2.6 Parameters

Text	Parameter	Default	Range	Description
Ut< Activate 1	1651	90 %	30 to 120 %	Threshold for activation of the LVRT 1 curve
Ut< Recovery 1	1652	95 %, 1 s	30 to 120 %, 0 to 320 s	Threshold for de-activation of LVRT 1 curve, with time delay
Ut< Activate 1	1654	OFF	-	Alarm, when parameter 1651 is active
Ut< 1	1660	OFF	-	Alarm, when the LVRT 1 curve is exceeded (trip area)
Ut< Activate 2	1691	90 %	30 to 120 %	Threshold for activation of the LVRT 2 curve
Ut< Recovery 2	1692	95 %, 1 s	30 to 120 %, 0 to 320 s	Threshold for de-activation of LVRT 2 curve, with time delay
Ut< Activate 2	1694	OFF	-	Alarm, when parameter 1691 is active
Ut< 2	1700	OFF	-	Alarm, when the LVRT 2 curve is exceeded (trip area)

INFO
High Voltage Ride Through (HVRT) is not included in Option A1. HVRT is only available with Option A10.

2.3 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				
Menu	**Name**	**Min.**	**Factory setting**	**Note**

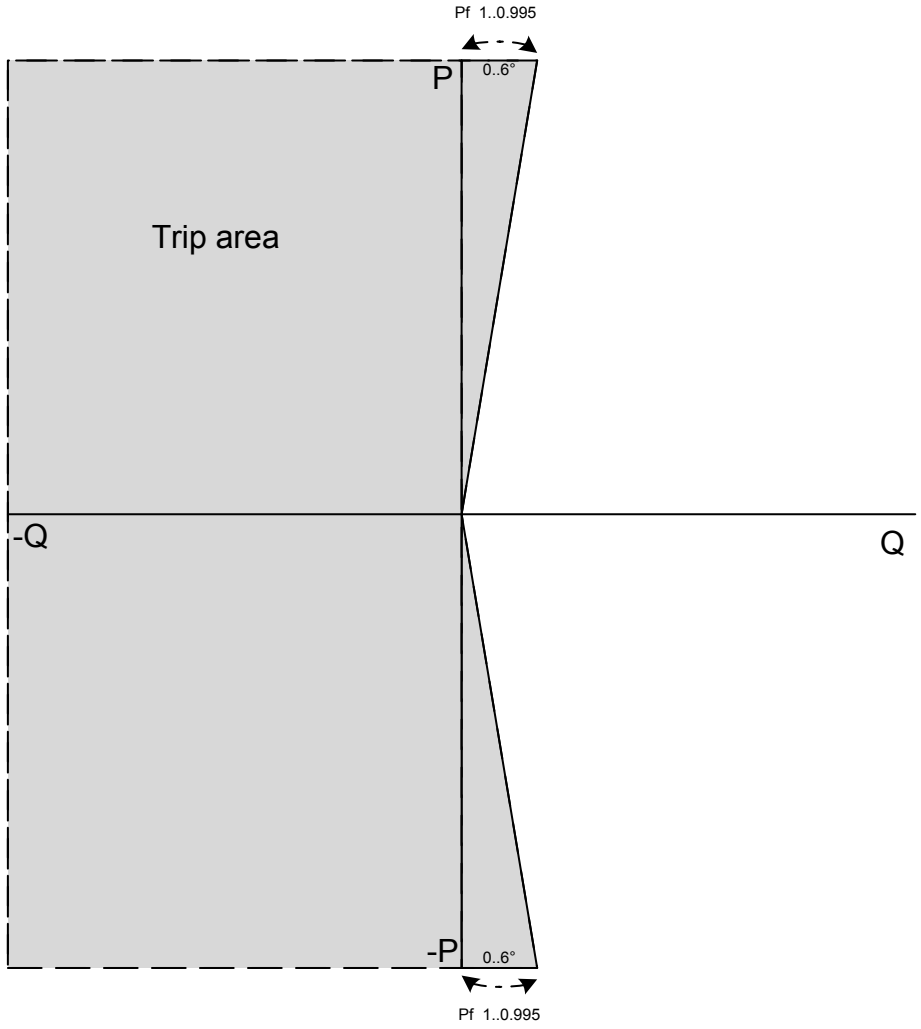
		Max		
1991	I Min. 1	0 to 20 %	0 %	0° pf = 1.0 6° pf = 0.995 Set the set points to 0 for backward compatibility
1992	Angle 1	0 to 6°	0°	

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

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

The set point 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".



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

INFO
Positive reactive Q > 0 means overexcited operation.

2.4 Average busbar overvoltage protection

There are two busbar overvoltage alarms based on an average measurement of the voltage of the busbar. These differ from a conventional definite time alarm, since the average voltage (for an adjustable time period, parameter 7486 or 7496) must exceed the set point (for the time in parameter 7482 or 7492).

The two busbar overvoltage alarms can be configured independently.

Table 2.7 *Avg U BB > 1* and *Avg U BB > 2*

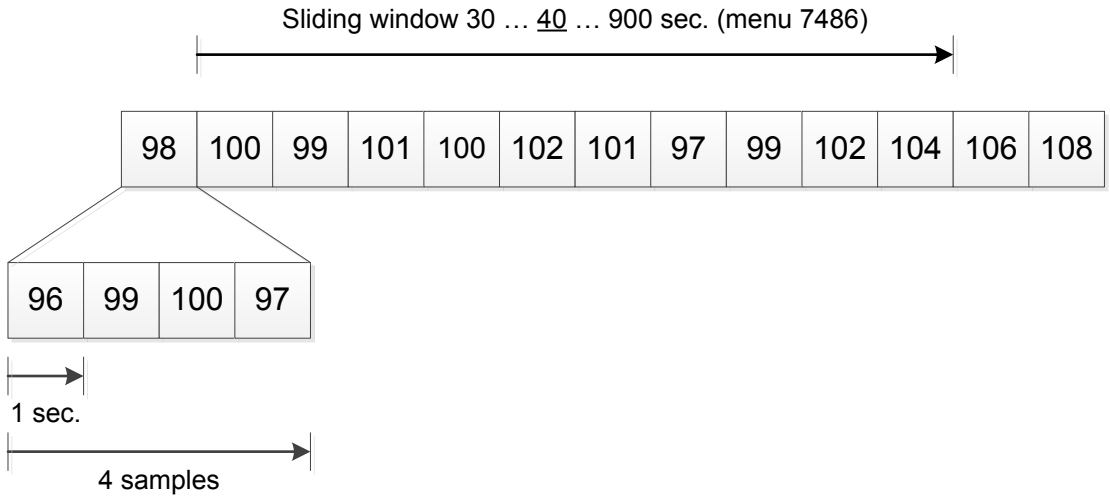
Parameter	Name	Range	Default
7481, 7491	Set point	100.0 to 120.0 %	110.0 %
7482, 7492	Timer	0.1 to 3200.0 s	10.0 s
7483, 7493	Relay output A	Not used Option-dependent	Not used
7484, 7494	Enable	OFF ON	OFF
7485, 7495	Fail class	F1...F8	Warning (F2)
7486, 7496	AVG Timer	30 to 900 s	600 s

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 (or 7496). 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.

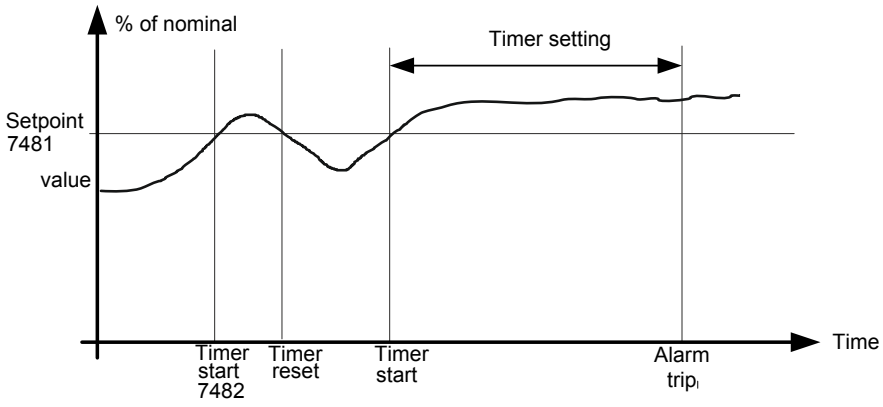
As the figure shows, the value of the first intermediate calculation is 98 %, and this is transferred to the ongoing stack. The duration of the sliding window has been set to 40 seconds in menu 7486. This means that the average value of the alarm is based on 10 four sample intermediate average calculations.

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. For *Avg U BB > 1*, once the value reaches the set point in menu 7481, the timer in menu 7482 is initiated and will trip the alarm if the value is higher than the set point for this period. If the value goes below the set point, the timer in menu 7482 is reset.



INFO
Change of set point in menu 7486 (or 7496) will reset the *Avg U BB > 1* (or *Avg U BB > 2*) value.