AGC-4 Mk II

4189341295B

OIEEE std. 1547™-2018 grid protection

Option A20

DEIF Improve Tomorrow

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1. Option description

1.1 Option A20

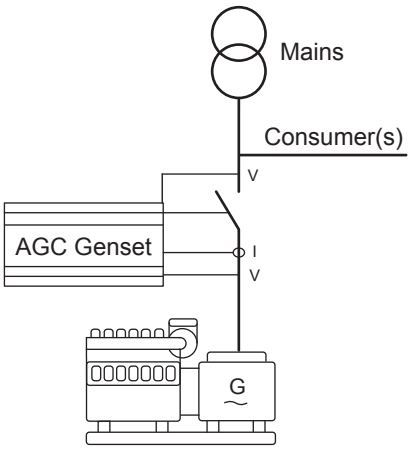
Option A20 is a software option for an AGC-4 Mk II genset controller, so that it can meet the IEEE std. 1547™-2018 grid connection requirements.

Option A20 compliance with IEEE std. 1547™-2018

	Complies with	Does not comply with
Reactive power capability and voltage/power control requirements	Category A	Category B
Response to Area EPS abnormal conditions	Category I and II	Category III

Application requirements

Option A20 can only be used for a stand-alone genset controller that controls a genset and the genset breaker. The genset controller cannot control the mains breaker. For this option, the genset breaker is the IEEE std. 1547™-2018 distribution energy resources point of connection (PoC). The genset must be configured to produce fixed power.



NOTE If a controller has option A20 activated, the controller cannot be used for operation that is not included in option A20. For example, the controller cannot be used for power management.

AC configuration

You can select the AC configuration for the controller in parameter 9130. However, you can only use option A20 with **3-phase L1L2L3** (or L1L3L2).

System accuracy

The IEEE std. 1547™-2018 grid connection requirements apply to the whole system. The option A20 accuracy is based on a single genset.

About the option A20 manual

This document describes the installation and configuration required to meet the IEEE std. 1547™-2018 grid connection requirements.

This document does not describe all of the inner workings of the controller to meet the IEEE std. 1547™-2018 grid connection requirements. If you need more information, please contact DEIF.

1.2 Software version

This document is based on ACG-4 Mk II SW version 6.05 and USW SW version 3.52.

Meeting the IEEE std. 1547™-2018 requirements

To meet the requirements of IEEE std. 1547™-2018 and the Area EPS operator, you can enable the option A20 functions. Configure the parameters and settings to meet the IEEE std. 1547™-2018 requirements.

Carefully configure and check all relevant parameters and settings before the generator set is started.

1.3 Other options

Required: Option Q2

To meet all the IEEE std. 1547™-2018 system voltage accuracy requirements, the controller must have hardware option Q2. **Option Q2** is an expanded temperature range for AC voltage measurements. When ordering option A20, option Q2 is automatically included.

Required: Standard options

The following options are used by option A20, and are included in the standard AGC-4 Mk II:

- **Option C2**: Generator add-on protection package
- **Option A1**: Mains protection package

Required: Modbus

The interoperability interface uses SunSpec Modbus communication. TCP/IP Modbus is included in the standard AGC-4 Mk II. If you need Modbus RTU (RS-485), the controller must have option H2.

Incompatible options

The controller can include the following options. However, the controller cannot use these options while using option A20:

- **Option A10**: Includes advanced protections for VDE AR-N 4110/4105, and G99 at 50 Hz
  - If a controller has option A20 activated, it cannot have option A10 activated.
- **Any multi-generator power management options**
  - Option A20 is only for a single generator, with a single breaker, parallel to the grid.

1.4 Activating option A20

If option A20 is included when you order the controller, then the controller is delivered with option A20 activated. You do not have to activate option A20.

Option A10 and option A20 cannot be activated at the same time. However, it is possible to have a controller with both option A10 and option A20. To activate option A20 or to change from option A10 to A20, use this procedure.

1. Check that option A20 is available on the controller. Use the utility software to look at the **Options** page.
2. Make sure that you have a backup of the controller's configuration.
3. Push the JUMP button on the DU-2 display unit.
4. Use the arrow buttons to select **9101**, then push the **SEL** button.
5. **9101 National regula** is shown. Push the **SEL** button.
6. Push the up/down button to select **Activate IEEE1547**, then push the **SEL** button.
   - The controller is reset to factory defaults and restarts.
7. Configure the controller as required.

NOTE To meet the grid connection requirements of IEEE 1547™-2018, the controller must also have option Q2. You cannot add option Q2. If your controller does not have option Q2, contact DEIF.

1.5 Abbreviations and glossary

Abbreviations

Abbreviation	Explanation
Area EPS	Area electric power system, that is, the utility or grid
AVR	Voltage regulator
DER	Distributed energy resource, for example, a genset
EPS	See Area EPS
FRT	Fault Ride Through
GB	Generator breaker
GOV	Speed regulator
HVRT	High Voltage Ride Through
IEEE	Institute of Electrical and Electronics Engineers
LVRT	Low Voltage Ride Through
Pnom	Genset nominal power
P %	Active power (P) as a percentage of the nominal power (Pnom).
p.u.	Per unit, equivalent to the percentage value divided by 100. Example: For *Enter service*, the default *Voltage low* is 0.917 p.u. This corresponds to 91.7 % of the nominal voltage.
SunSpec	The interoperability interface that the AGC-4 Mk II uses to comply with the IEEE std. 1547™-2018 standard.
U	Measured voltage
Unom	Nominal grid voltage - see here for more information.
USW	DEIF's PC utility software

Glossary

Term	Explanation
capacitive	Used on the capability curve to show the area where the generator absorbs reactive power. This corresponds to an under-excited generator. You can select capacitive in parameter 7053.
genset	An electricity generating set with controllable speed (governor) and excitation (AVR). In the IEEE std. 1547™-2018 standard, a genset is a distributed energy resource (DER).
genset controller	The DEIF AGC-4 Mk II genset controller.
grid	The national electricity supply. Also called *mains*. In the IEEE std. 1547™-2018 standard, the grid is a utility electric power system (EPS).
inductive	Used on the capability curve to show the area where the generator injects reactive power. This corresponds to an over-excited generator. You can select inductive in parameter 7053.

1.6 Safety, warnings and legal information

1.6.1 Safety during installation and operation

When you install and operate the equipment, you may have to work with dangerous currents and voltages. The installation must only be carried out by authorised personnel who understand the risks involved in working with electrical equipment.

DANGER!

Hazardous live currents and voltages

Do not touch any terminals, especially the AC measurement inputs and the relay terminals, as this could lead to injury or death.

1.6.2 Factory settings

The 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.

1.6.3 Legal information

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 controller, the company responsible for the installation or the operation of the set must be contacted.

NOTE The controller is not to be opened by unauthorised personnel. If opened anyway, the warranty will be lost.

1.6.4 Trademarks

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1.6.5 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.

1.6.6 Copyright

2. Setting up the controller

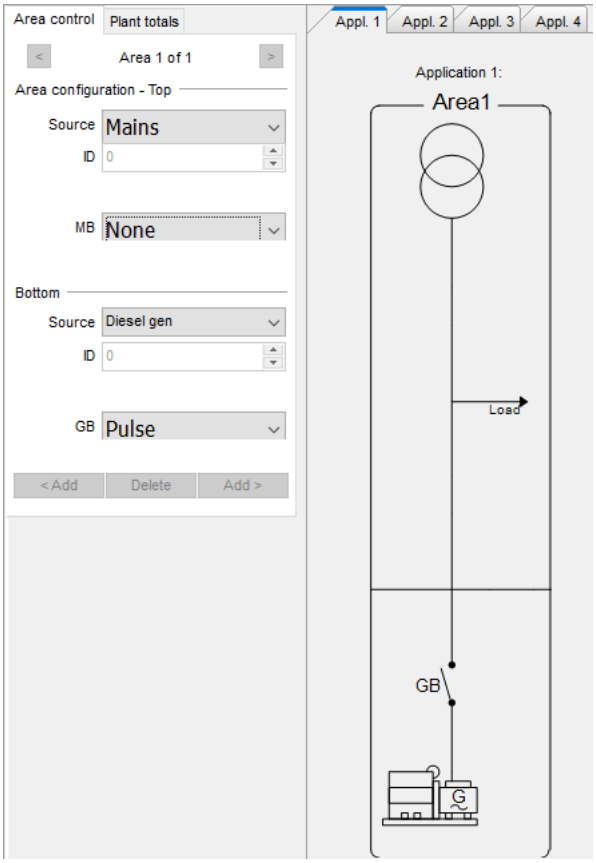
2.1 Creating the application configuration

In the utility software, under **Application configuration**, select **New plant configuration**. 

In the **Plant options** window, under **Plant type** select **Single DG**, then select **OK**.

In the **Area control** pane, under **Area configuration - Top, MB**, select **None**.

NOTE Remember to write the application to the controller.



2.2 Setting the scaling

For maximum accuracy, use the lowest possible voltage scaling range (parameter 9030). The scaling range must be okay for both the nominal voltage and the nominal power.

Scaling (9030)	Voltage range for the generator and the busbar	Nominal power range
10V-2500V	10 to 2500 V	1 to 900 kW
100V-25000V (default)	100 to 25000 V	10 to 20000 kW
0.4kV-75kV	400 V to 75 kV	100 kW to 90 MW
10kV-250kV	10 to 250 kV	1 to 900 MW

Voltage scaling range example

The genset's nominal voltage is **600 V** and its nominal power is **1500 kW**. The voltage scaling choices are:

- *10V-2500V*: The nominal voltage is inside this range: However, the nominal power is more than 900 kW, so you cannot use this range.
- **100V-25000V**: This range is okay for both nominal voltage and nominal power.
- *0.4kV-75kV*: This range is okay, but accuracy would be reduced.
- *10kV-250kV*: This range is too high.

The lowest possible voltage scaling range for this genset is thus **100V-25000V**.

NOTICE

Incorrect configuration is dangerous

Correct all nominal values and the primary VT settings after the scaling (parameter 9030) is changed.

Effect of scaling when using a parameter file

You can use a parameter file from a genset controller that does not have option A20. However, you must check all parameters (not just voltage) carefully, since the parameter scaling is not necessarily the same.

NOTE For importing a settings file, when the scaling range is not the default, you must import the file twice. This is to make sure that all parameters are correct. If you only import the file once, the ranges will be correct, but some of the values will be wrong.

2.3 Nominal values

For option A20, you can find the generator's information on the *Nameplate information* page. The controller automatically inserts the relevant nominal values on the *Nameplate information* page.

Nominal grid voltage and scaling

Some functions are based on the nominal grid voltage.

The nominal grid voltage is defined in *BB Nominal U 1*, parameter 6053, or *BB Nominal U 2*, parameter 6063. *Bus nom. set*, parameter 6052, determines which value is used.

Scaling, parameter 9030, also affects some of the functions. Some functions refer to this as *Meas area*. Different ranges can be used for *10V-2500V*, *100V-25000V* (default), *10kV-250kV* and *0.4kV-75kV*.

NOTICE

Incorrect configuration is dangerous

If you need to change the scaling, do so before configuring the parameters and settings.

Nominal frequency

Some functions are based on the nominal frequency. The default configuration for the option A20 settings is based on a nominal frequency of 60 Hz.

The nominal frequency is defined in *Nom. f 1*, parameter 6001; *Nom. f 2*, parameter 6011; *Nom. f 3*, parameter 6021; or *Nom. f 4*, parameter 6031. *Enable nom. set*, parameter 6006, determines which value is used.

Nominal genset power

Some functions are based on the genset nominal power.

The nominal power is defined in *Nom. P 1*, parameter 6002; *Nom. P 2*, parameter 6012; *Nom. P 3*, parameter 6022; or *Nom. P 4*, parameter 6032. *Enable nom. set*, parameter 6006, determines which value is used.

Nominal genset voltage

The nominal genset voltage is defined in *Nom. U 1*, parameter 6004; *Nom. U 2*, parameter 6014; *Nom. U 3*, parameter 6024; or *Nom. U 4*, parameter 6034. *Enable nom. set*, parameter 6006, determines which value is used.

2.4 Operating modes

Use the following operating modes.

Genset mode

In *Genset mode* (parameter 6070), you must select *Fixed power*.

Controller operating mode

The AGC-4 Mk II controller must be in AUTO mode. In AUTO mode, if there is no trip or block alarm, the controller is available for remote control. If the controller is not in AUTO mode, push the MODE button on the display unit, then select AUTO.

NOTE If the controller is in SEMI-AUTO mode, remote control (that is, using SunSpec Modbus interoperability) is limited.

2.5 Configuring voltage, frequency and power parameters

To use IEEE 1547™-2018, configure these parameters in the controller.

Parameter	Name	Default	Range	Description
7051	Contr. settings P	100 % of nominal power	0 to 100 %	The fixed power set point.
2111	Blackout dfMin	3 Hz	0 to 5 Hz	The controller uses these parameters for voltage and frequency OK. These must be set outside the IEEE 1547™-2018 enter service range.
2112	Blackout dfMax	3 Hz	0 to 5 Hz	
2113	Blackout dUMin	5 % of nominal voltage	2 to 20 %	
2114	Blackout dUMax	5 % of nominal voltage	2 to 20 %	
7063	Low Voltage	90 % of nominal voltage	30 to 100 %	These parameters must be set outside the IEEE 1547™-2018 enter service range.
7064	High Voltage	110 % of nominal voltage	100 to 130 %	
7073	Low Frequency	95 % of nominal frequency	80 to 100 %	
7074	High Frequency	105 % of nominal frequency	100 to 120 %	

2.6 Synchronisation hardware and parameters

Hardware requirements for governor regulation

The following hardware can be used to interface to the governor:

- Engine interface communication: For frequency and phase angle regulation
- Analogue outputs: For frequency and phase angle regulation

You cannot use relay regulation, since this is not precise enough.

Hardware requirements for AVR regulation

The following hardware can be used to regulate the AVR:

- Digital AVR control (selected in parameter 7565) for voltage regulation:
  - DEIF DVC 550
  - DEIF DVC 550 + PSS
  - DEIF DVC 310
  - Caterpillar CDVR
  - Leroy Somer D510C
  - NIDEC D550
- Analogue outputs: For voltage regulation

You cannot use relay regulation, since this is not precise enough.

Parameters

For dynamic synchronisation, configure these synchronisation parameters to meet the requirements specified in IEEE std. 1547™-2018.

Parameter	Name	Range	Default
2031	Maximum df	0.00 to 0.50 Hz	0.10 Hz
2032	Maximum dU*	1 to 10 %	5 %
2033	Closing window	0.1 to 20 deg	10 deg

NOTE * For static synchronisation (parameter 2000), you only have to configure the maximum voltage difference.

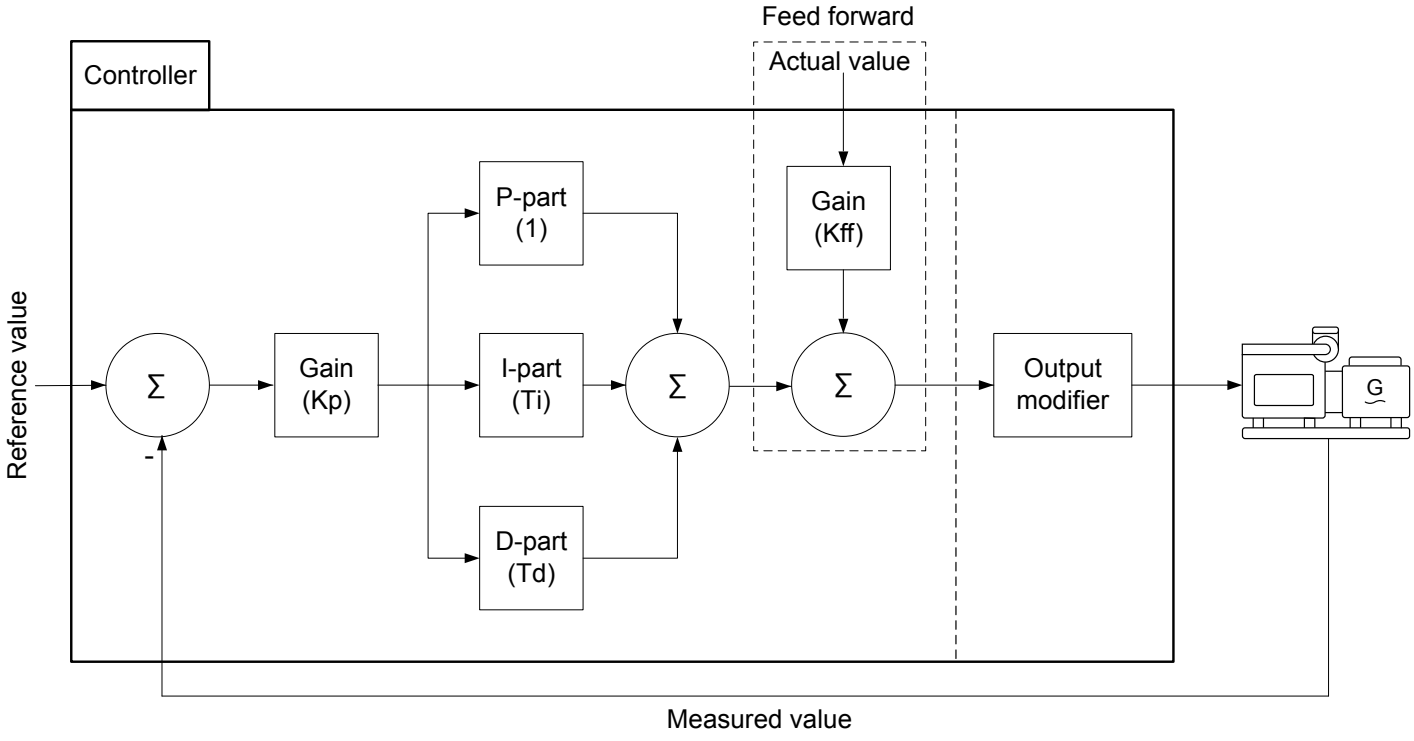
2.7 Feed forward

The regulation loop performance must meet the IEEE 1547™-2018 requirements. We therefore strongly recommend that you activate the power regulator feed forward function (P FF Ena). This suppresses the effect of frequency disturbances. You should also activate the reactive power regulator feed forward function (Q FF Ena) to suppress voltage disturbances.

For example, without feed forward, if the frequency on the busbar increases, the controller could decrease the power from the genset. With feed forward, the effect of the busbar frequency change is minimised. Similarly, without feed forward, if the busbar voltage drops, the controller could reduce the reactive power from the genset. With feed forward, the effect of the busbar voltage change is minimised.

NOTE To support the grid and respond to frequency and voltage disturbances, the controller uses the frequency droop and reactive power regulation functions.

How the feed forward function works



For the power regulator feed forward function:

1. The controller calculates the PID regulation.
2. The controller calculates a contribution from the actual frequency and the configured gain.
3. The controller adds the feed forward contribution to the regulation output.

Parameters

Text	Parameter	Default	Range	Description
P FF Ena	2831	OFF	OFF; ON	Enable the power regulator feed forward.
P FF KFF	2832	12.5	0 to 50	The power feed forward gain*.
Q FF Ena	2833	OFF	OFF; ON	Enable the reactive power regulator feed forward.
Q FF KFF	2834	10	0 to 50	The reactive power feed forward gain*.

NOTE * The feed forward gain is calculated (as described below) and then set. The gain is not used for tuning the system. You can use a feed forward gain that is lower than the calculated gain. However, do not use a higher gain, since it will cause positive feedback.

Calculating the feed forward gain

To calculate the gain for a frequency disturbance (*P FF KFF*), you need the frequency range for the governor. For a symmetrical system, you can assume that the governor output in the middle of the range is 0.5. You can then calculate KFF using this formula:

KFF = Governor output / ((Frequency/Nominal frequency) - 1)

The gain for a voltage disturbance (Q FF KFF) is similar.

Power feed forward gain example

For example, for a nominal frequency of 60 Hz, the governor range is 56 to 64 Hz, that is ±4 Hz. When the frequency is 62 Hz, the governor output is 0.5.

KFF = 0.5 / ((62 Hz / 60 Hz) - 1) = 15

Reactive power feed forward gain example

For example, for a nominal voltage of 1 p.u., the AVR range is 0.88 to 1.12 p.u., that is ±0.12 p.u. When the voltage is 1.06 p.u., the AVR output is 0.5.

KFF = 0.5 / ((1.06 / 1) - 1) = 8.3

2.8 Set point outputs

The controller can output the P, Q and cos phi set points using analogue outputs and/or Modbus. See the **Modbus tables**. For example, you can use the holding register (function code 03; 06; 16) to see the power regulator set point at Modbus address 0.

To set up the analogue outputs, configure the following parameters in the parameter list.

Text	Parameter	Default	Range	Description
P ref Output type	5693	Disabled	Disabled 0-20mA 4-20mA 0-10V -10V-0-10V	Output for the *Power* set point. Select the AGC analogue output under *Transducer A* and/or *B*.
P ref Output max	5694	500 kW	0 to 20000 kW	The maximum of the range for the power set point.
P ref Output min	5695	0 kW	-9999 to 20000 kW	The minimum of the range for the power set point.

Text	Parameter	Default	Range	Description
Q ref Output Type	5703	Disabled	Disabled 0-20mA 4-20mA 0-10V -10V-0-10V	Output for the *Reactive Power* set point. Select the AGC analogue output under *Transducer A* and/or *B*.
Q ref Output max	5704	400 kvar	0 to 16000 kvar	The maximum of the range for the reactive power set point.
Q ref Output min	5705	0 kvar	-8000 to 16000 kvar	The minimum of the range for the reactive power set point.
Cosphi ref Outp type	5713	Disabled	Disabled 0-20mA 4-20mA 0-10V -10V-0-10V	Output for the cos phi set point. Select the AGC analogue output under *Transducer A* and/or *B*.
Cosphi ref Outp max	5714	0.8	0.5 to 0.99	The maximum of the range for the cos phi set point.
Cosphi ref Outp min	5715	-0.8	-0.99 to -0.5	The minimum of the range for the cos phi set point.

2.9 Display selections

For Option A20, you can use the USW to show additional operating information on the display.

To change the information shown on the display:

1. Select the *Configuration of the user views* icon  .
   - The *Device display* window opens.
2. Select one of the views, then click one of the three display lines.
   - The *View line configuration* window opens.
3. Select the required display information under *Electrical data* > *Grid support* and select **OK**.
   - The USW shows the display line with the selection.
4. Select *Write views to the device*  .

Display information	Description
Active power ramp #	**1** for parameters 2612 and 2621; **2** for parameters 2616 and 2623.
Consec. Dist. Cntr. #	Consecutive disturbance counter. See FRT activated by cumulative time.
f-Bus Avg #.###Hz	Averaged grid frequency measurement (the resolution is 1 mHz).
f-Gen Avg #.###Hz	Averaged generator frequency measurement (the resolution is 1 mHz).
Grid connection state	The grid connection state.
IEEE Vref:	See Volt-var (Q(U)).
Operating state	The operating state.
Regulation variant	The regulation variant: • IEEE: Watt-VAR mode • IEEE: Volt-VAR mode • IEEE: Const.PF mode • IEEE: Const. Q mode

3. General IEEE 1547-2018 requirements

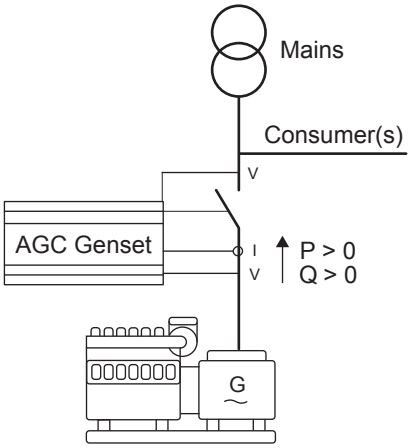
3.1 Installation requirements for EMC protection

IEEE std. 1547™-2018 requires protection from electromagnetic interference (EMI) and a surge withstand performance test.

These requirements apply to the overall system. The overall system includes not only the AGC-4 Mk II controller, but also the AVR, and any other equipment. In particular, some conditions specified in IEEE std. 1547™-2018 may make the AGC-4 Mk II exceed the EMC levels specified on the data sheet. DEIF recommends that the installation (components, harness, cubicle, and so on) is designed to mitigate this.

3.2 Power direction

The active power and the reactive power from the genset is positive.

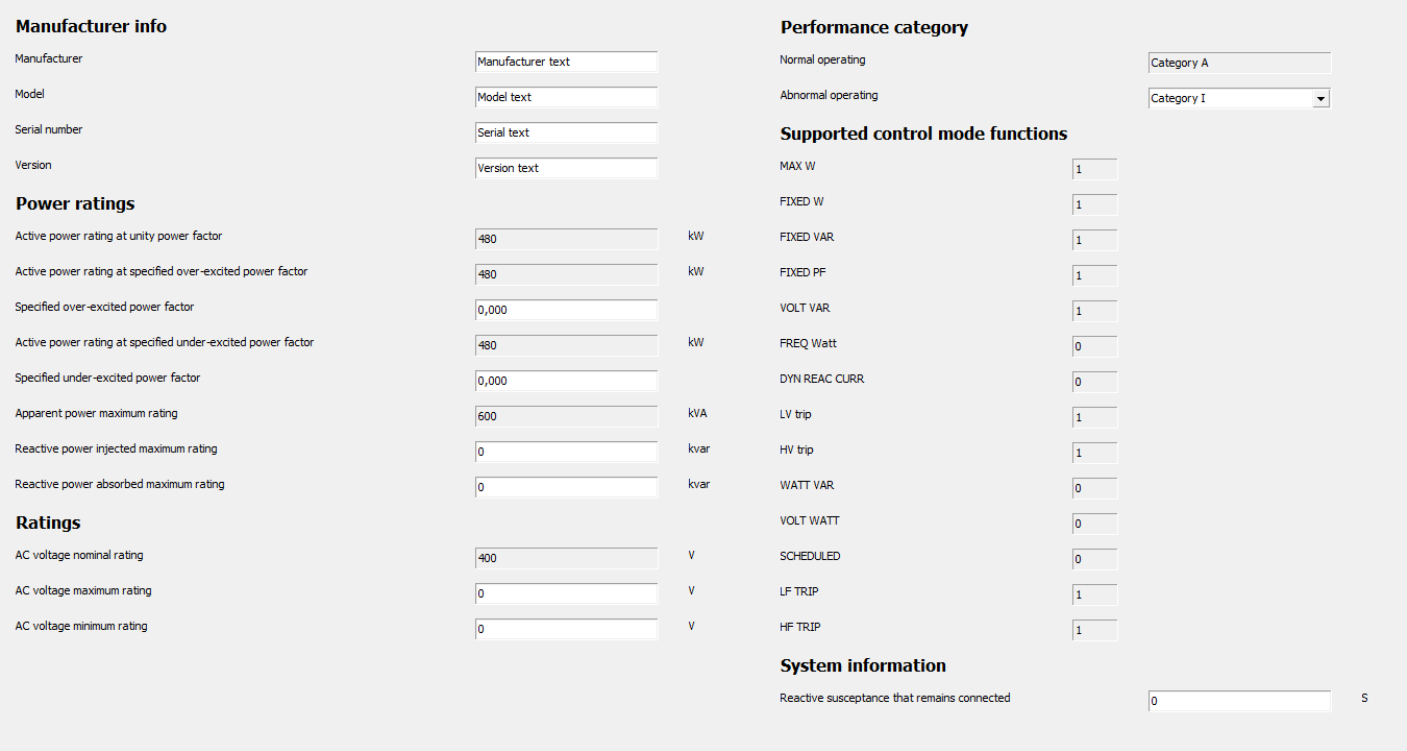


3.3 Nameplate information

The controller uses the nameplate information in the genset control and grid protection. The SunSpec interoperability interface makes the nameplate information available to the Area EPS operator.

You must use the *Identifiers, Nameplate information* page in the utility software to enter the generator's nameplate information. To open the *Identifiers* box, select: 

Default *Nameplate information* page



Nameplate information settings

Setting	Default	Range	Description
Manufacturer info			
Manufacturer	Manufacturer	40 characters	The generator manufacturer. The first 32 characters are shown in the SunSpec Modbus.
Model	Model text	40 characters	The generator model. The first 32 characters are shown in the SunSpec Modbus.
Serial number	Serial text	40 characters	The generator serial number. The first 32 characters are shown in the SunSpec Modbus.
Version	Version text	20 characters	The generator version. The first 16 characters are shown in the SunSpec Modbus.
Power ratings			
Active power rating at unity power factor	480 kW	-	The controller inserts the nominal power (parameter 6002/6012/6022/6032).
Active power rating at specified over-excited power factor	480 kW	-	The controller inserts the nominal power (parameter 6002/6012/6022/6032).
Specified over-excited power factor	0.000	0 to 1.000	Configure the over-excited power factor. This limits the power factor for constant power factor (see *Reactive power regulation*).
Active power rating at specified under-excited power factor	480 kW	-	The controller inserts the nominal power (parameter 6002/6012/6022/6032).
Specified under-excited power factor	0.000	0 to 1.000	Configure the under-excited power factor. This limits the power factor for constant power factor (see *Reactive power regulation*).

Setting	Default	Range	Description
Apparent power maximum rating	600 kVA	-	The controller inserts the nominal apparent power here. You can configure this under *Advanced Protection, Capability curve, Q curve, S nominal*.
Reactive power injected maximum rating	0 kvar	Depends on scaling (parameter 9030)	Configure the maximum reactive power from the generator here. To meet the IEEE std. 1547™-2018 requirements, the generator must be able to inject this reactive power.
Reactive power absorbed maximum rating	0 kvar	Depends on scaling (parameter 9030)	Configure the maximum reactive power to the generator here. To meet the IEEE std. 1547™-2018 requirements, the generator must be able to absorb this reactive power.
Ratings			
AC voltage nominal rating	400 V	-	The controller inserts the nominal voltage (parameter 6004/6014/6024/6034).
AC voltage maximum rating	0 V	Depends on scaling (parameter 9030)	Maximum voltage rating.
AC voltage minimum rating	0 V	Depends on scaling (parameter 9030)	Minimum voltage rating.
Performance category			
Normal operating	Category A	-	The IEEE std. 1547™-2018 normal operating performance category.
Abnormal operating	Category I	Category I; Category II	The IEEE std. 1547™-2018 abnormal operating performance category.
Supported control mode functions			
MAX W	1	-	The controller shows the number of available functions for each of these IEEE std. 1547™-2018 control modes.
FIXED W	1	-	
FIXED VAR	1	-	
FIXED PF	1	-	
VOLT VAR	1	-	
FREQ Watt	0	-	
DYN REAC CURR	0	-	
LV trip	1	-	
HV trip	1	-	
WATT VAR	0	-	
VOLT WATT	0	-	
SCHEDULED	0	-	
LF TRIP	1	-	
HF TRIP	1	-	
System information			
Reactive susceptance that remains connected	0 S	Depends on scaling (parameter 9030)	The reactive susceptance that remains connected to the Area EPS after a trip. **NOTE** The cease to energize state is not relevant for synchronous generators.

3.4 Applicable voltages

You can use these parameters to configure applicable voltages that meet the IEEE 1547™-2018 requirements. The voltages are used for the enter service requirements and relevant protections.

Parameter	Name	Default	Range	Description
1201	G voltage trip	Ph-Ph	Ph-Ph Ph-N Ph-Ph OR Ph-N	Select phase-phase or phase-neutral voltage detection. When phase-phase tripping is selected, the voltage alarms relate to the nominal voltage. When phase-neutral tripping is selected, the voltage alarms relate to the nominal voltage divided by √3.
1202	BB voltage trip	Ph-Ph	Ph-Ph Ph-N Ph-Ph OR Ph-N	

3.5 Enter and permit service

You can control whether the genset is allowed to enter service. You can also configure the ramp used when the generator first connects to the grid.

Settings

Configure these settings under *Advanced Protection, Controls, Permit service*.

Setting	Default	Range	Description
Permit service	ON	OFF; ON	**OFF**: The controller cannot close the genset breaker (GB). If the GB is closed then this setting is changed to OFF, the controller opens the GB. **ON**: If all requirements are met, the controller can close the GB.
Ramp time setting	300 s	0 to 1000 s	Activate power ramp time (0 to 100 %) used when the generator first connects to the grid. This is an IEEE requirement. The Area EPS operator can use the interoperability interface to configure this.
Minimum ramp time setting	0 s	0 to 1000 s	Protects the generator from a ramp time that is too fast. This is a protection from the controller, and not an IEEE requirement.

Configure these settings under *Advanced Protection, Controls, Enter service*.

Setting	Default	Range	Description
Enable	ON	OFF; ON	**OFF**: The controller does not check the grid voltage and frequency. **ON**: If all requirements are met, the controller starts the delay timer. If the grid voltage and frequency stay in the required range for this time, the controller can close the GB.
Voltage low*	0.917 p.u.	0.88 to 0.95 p.u.	The grid voltage must be in this range for the GB to close. The voltage must also be inside the mains okay parameter range (see below).
Voltage high*	1.050 p.u.	1.05 to 1.06 p.u.	
Frequency low**	59.5 Hz	45 to 59.9 Hz	The grid frequency must be in this range for the GB to close. The frequency must also be inside the mains okay parameter range (see below).
Frequency high**	60.1 Hz	50.1 to 61.0 Hz	
Delay	300.0 s	0 to 600 s	If the grid voltage and/or frequency are outside the required range for this period, an alarm is activated.

NOTE * To allow option A20 to function, configure the mains voltage parameters 7063 and 7064, and blackout voltage parameters 2113, and 2114, outside this range.

NOTE ** To allow option A20 to function, configure the mains frequency parameters 7073 and 7074, and blackout frequency parameters 2111 and 2112, outside this range.

Status texts

Status text	Description	Permit service
SERVICE NOT PERMIT	Permit service is not enabled.	OFF
ENT. SRV. GB CL. INH	Enter service GB close inhibit.	ON
ENT. SRV. GB ON BLK*	Enter service GB close block.	ON
ENT. SRV. OK IN ###s	Genset will enter service in the time shown.	ON

NOTE *This text is only shown in the event log. If the GB close is blocked, the display shows ENT. SRV. GB CL. INH.

3.6 Limit maximum active power

Configure these settings under *Advanced Protection, Controls, Limit maximum active power*.

Setting	Default	Range	Description
Limit max active power enable	OFF	OFF; ON	**OFF**: This function does not limit the active power. **ON**: This function limits the active power to the *Limit max active power SP* (or the set point in parameter 7051, whichever is lower).
Limit max active power SP	100 % of nominal active power	0 to 100 %	The controller makes sure that the active power from the genset is below this limit.

NOTE If enabled, the controller uses power ramp 2 for the frequency droop. The controller uses power ramp 1 for everything else (parameters 2611, 2612, and 2615 for ramp up, and parameters 2621 and 2622 for ramp down).

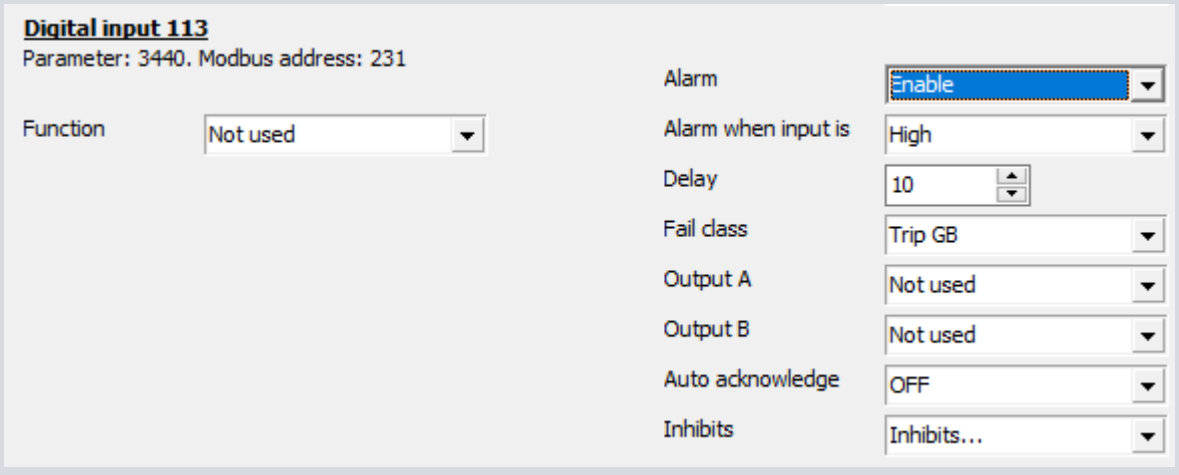
3.7 Islanding

The AGC does not detect islanding. You can however configure the AGC so that an external signal trips the generator breaker.

Islanding example

External equipment detects islanding and sends a signal to the AGC.

The signal is wired to digital input 113, and an alarm is configured to trip the GB when the signal is activated.



4. Reactive power capability and voltage/power control

4.1 Alternator capability curve with limiting

Active power-dependent reactive power limiting is a generator protection feature which is part of option C2. It limits the reactive power production relative to actual power production.

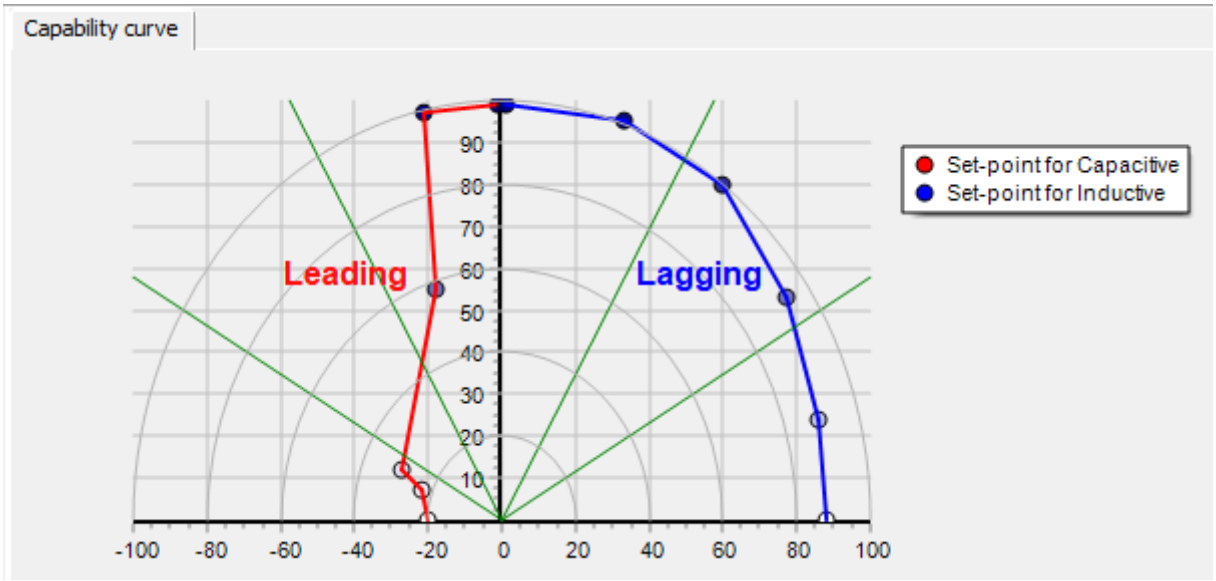
Active power-dependent reactive power limiting can use the generator steady state reactive power capability curve. The actual curve depends on the generator. The curve should be included in the generator's data sheet. Contact the generator manufacturer to get this information.

To activate the reactive power limitation based on the capability curve, set *AVR limiting type*, parameter 2811, to *Capability curve Q*.

Protections can also be activated to disconnect the generator from the grid. Use *G P dep. Q<*, parameter 1761, for import (that is, to configure an alarm for exceeding the capability curve under the excitation limit). Use *G P dep. Q>*, parameter 1791, for export (that is, to configure an alarm for exceeding the capability curve over the excitation limit).

The curves are configured under *Advanced Protection*, *Capability curve*. Six active power and reactive power co-ordinates define the curve for import of reactive power. Similarly, six co-ordinates define the curve for export of reactive power.

Example of generator capability curve from the USW



If the set point for reactive power is outside the limiting curve, the controller restricts the reference to the regulator. When the reactive power set point moves inside the limiting curve, the controller regulates reactive power (or cos phi).

The *AVR lim. setpoint*, parameter 2812, defines when regulation is stopped. If this parameter is *100 %*, the controller regulates all the way to the capability curve. For *95 %*, regulation stops at 5 % away from crossing the limit curve.

S nominal under *Advanced Protection*, *Capability curve*, defines the limit of the y-axis. It can relate to active power (P/Q diagram) or apparent power (S/Q diagram).

Example of apparent and active power for the capability curve

The generator has a 1000 kW nominal power and a 1250 kVA nominal apparent power.

For an S/Q diagram as the capability curve, use 1250 kVA for the *S nominal* setting (under *Advanced Protection*, *Capability curve*). On the capability curve, 100 % of nominal apparent power is then 1250 kVA.

	Alternatively, for a P/Q diagram as the capability curve, use 1000 kVA for the *S nominal* setting. On the capability curve, 100 % of nominal power is then 1000 kW.

4.1.1 Parameters for capability curve

These parameters and settings define the active power-dependent reactive power limiting.

The settings are configured under *Advanced Protection*, *Capability curve*.

***Set-point for Capacitive (Under-excited; Absorption)* (red curve)**

Reactive power	Default	Active power	Default
G P dep Q<Q1	20 %	G P dep P<P1	0 %
G P dep Q<Q2	22 %	G P dep P<P2	7 %
G P dep Q<Q3	27 %	G P dep P<P3	12 %
G P dep Q<Q4	18 %	G P dep P<P4	55 %
G P dep Q<Q5	21 %	G P dep P<P5	97 %
G P dep Q<Q6	1 %	G P dep P<P6	99 %

***Set-point for Inductive (Over-excited; Injection)* (blue curve)**

Reactive power	Default	Active power	Default
G P dep Q>Q1	88 %	G P dep P>P1	0 %
G P dep Q>Q2	86 %	G P dep P>P2	24 %
G P dep Q>Q3	77 %	G P dep P>P3	53 %
G P dep Q>Q4	60 %	G P dep P>P4	80 %
G P dep Q>Q5	33 %	G P dep P>P5	95 %
G P dep Q>Q6	1 %	G P dep P>P6	99 %

AVR limiting type*, parameter 2811

Set point	Default	Description
OFF		The controller does not limit the regulation of cos phi or reactive power.
Droop curve	X	Depending on which regulator is active, the controller limits the regulation. For cos phi, the controller uses settings *Cosphi min set* and *Cosphi max set* (under *Advanced Protection*, *Droop curve 2*, *Cosphi curve*). For reactive power, the controller uses settings *Q min* and *Q max* (under *Advanced Protection*, *Droop curve 2*, *Q curve*).
Capability curve Q		The controller limits the regulation using the parameter settings for power-dependent reactive power limiting.

NOTE * The controller ensures that the AVR regulation stays within the nameplate power factor settings.

***AVR lim. setpoint*, parameter 2812**

Default	Range	Description
95 %	20 to 100 %	The cos phi/reactive power regulation stop with respect to the capability curve

Scaling, parameter 9030, determines which *S nominal* the controller uses. The setting for the default scaling is shown below.

S nominal* for *100-25000V

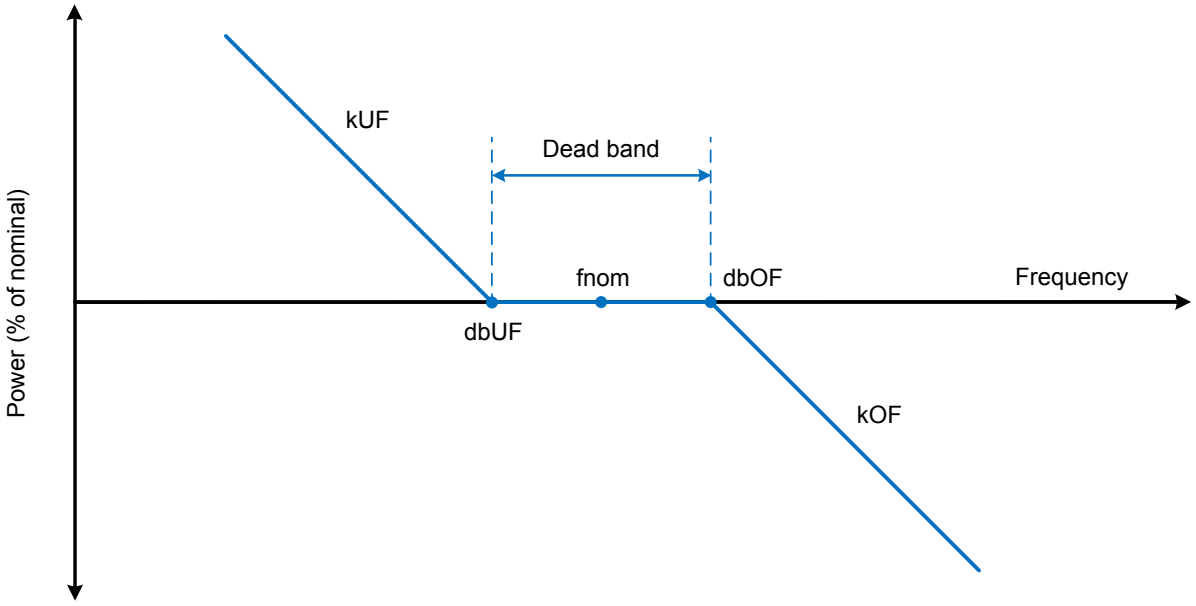
Setting	Default for scaling 100-25000V	Range for scaling 100-25000V	Description
S nominal	600 kVA	10 to 32000 kVA	Nominal apparent power

4.2 Frequency droop

You can configure IEEE std. 1547™-2018 frequency droop under *Advanced Protection*, *Frequency droop*.

Setting	Default	Range	Description
P(f) droop enable	OFF	OFF; ON	Enable frequency droop.
Overfrequency Droop dbOF	0.036 Hz	0.017 to 1.000 Hz	IEEE std. 1547™-2018 over-frequency droop deadband.
Underfrequency Droop dbUF	0.036 Hz	0.017 to 1.000 Hz	IEEE std. 1547™-2018 under-frequency droop deadband.
Overfrequency Droop kOF	0.05	0.03 to 0.05	IEEE std. 1547™-2018 over-frequency droop gain.
Underfrequency Droop kUF	0.05	0.03 to 0.05	IEEE std. 1547™-2018 under-frequency droop gain.
Open Loop Response Time	5 s	1.0 to 10.0 s	For a 90 % output change, the open loop time response = Tau (time constant time) x 2.3

Frequency droop diagram



4.3 Reactive power regulation

For option A20, there are three types of reactive power regulation that can be enabled in the genset controller. Select the regulation type under *Advanced Protection*, *var(Q) grid support*.

It is possible to enable more than one regulation type. The controller then uses this priority list to decide the regulation type:

1. Constant reactive power; Q (fixed)
2. Volt-var; Q(U)
3. Constant power factor; Cosphi (fixed)

4.3.1 Q ramp

You can activate a *Linear* or *Time constant* Q ramp. The ramp is used when the controller increases or decreases the reactive power.

NOTE If the controller is using *Volt-var; Q(U)* regulation, it uses its *Open Loop Response Time* setting (instead of this Q ramp).

Configure these parameters in the USW.

Text	Parameter	Default	Range	Description
Q ramp to setp.	2821	2 %/s	0.1 to 20 %/s	Ramp up for reactive power
Q ramp to zero	2822	2 %/s	0.1 to 20 %/s	Ramp down for reactive power
Q ramp enable	2823	OFF	OFF Linear Time constant	**OFF**: Deactivate the ramp. **Linear**: Parameters 2821 and 2822 are used. **Time constant**: Parameter 2824 is used.
Q time constant	2824	2 s	1 to 30 s	First order system time constant, used if **Time constant** is selected in parameter 2823.

4.3.2 Default reactive power regulation

If no other reactive power regulation is enabled, and droop curve 2 is enabled, the controller uses the curves configured under *Advanced Protection, Droop curve 2*. Otherwise, the controller uses the cos phi set point in parameters 7052 and 7053 or Q set point in parameters 7054 and 7055.

4.3.3 Ramp for changing reactive power regulation mode

Configure the settings under *Advanced Protection, var(Q) grid support, Basic/General*.

Setting	Default	Range	Description
Switching Ramp Time	30 s	5 to 300 s	The time to ramp up/down to the new set point when switching control type.

4.3.4 Constant power factor (fixed cos phi)

The controller can have a fixed power factor set point for regulation. The set point can correspond to generator over-excitation or under-excitation. An offset value can be added to the cos phi value using the setting *Cosphi offset*, or Modbus.

For offset control using Modbus, see the **Modbus tables**.

Settings

Setting	Default	Range	Description
Enable	OFF	OFF; ON	**ON**: Enable constant power factor. The controller uses the *Constant Power Factor* set point below (and ignores the set point in parameter 7052).
Constant Power Factor	1.00	0.00 to 1.00	Power factor set point.
Excitation	Over-excited	Over-excited Under-excited	**Over-excited**: The *Constant Power Factor* set point above is for over-excitation in the generator. **Under-excited**: The *Constant Power Factor* set point above is for under-excitation in the generator.

4.3.5 Volt-var (Q(U))

If *Volt-var; Q(U)* is enabled, the reactive power is regulated with respect to the grid voltage. When the grid voltage is increasing, the reactive power is regulated in a capacitive direction. When the grid voltage is decreasing, the reactive power is regulated in an inductive direction.

If the capability curve is enabled (parameter 2811), then the Volt-var result is limited by the capability curve.

Q(U) is configured under *Advanced Protection*, *var(Q) grid support*.

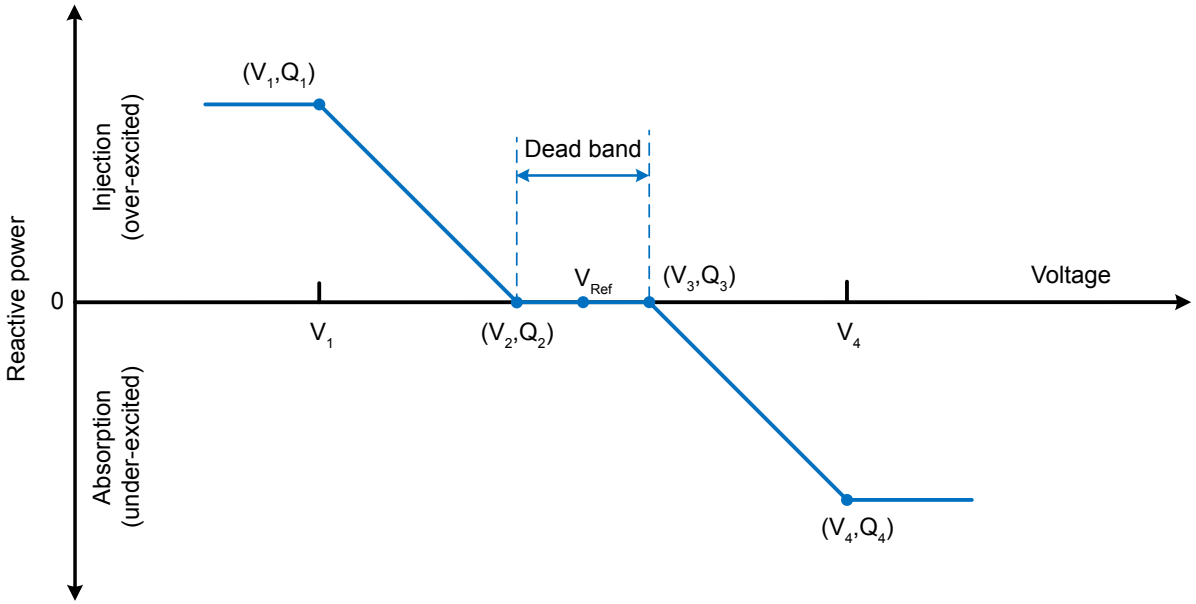
NOTE You can use the Volt-var curve deadband to also meet the IEEE 1547™-2018 Category B requirements.

Settings

Configure the settings under *Advanced Protection*, *var(Q) grid support*, *Volt-var; Q(U)*.

Setting	Default	Range	Description
Enable	OFF	OFF; ON	Enable Q(U).
Vref	100 %	95 to 105 %	Reference voltage.
Vref Adjust Enable	OFF	OFF; ON	**OFF**: Vref is used without any filtering. **ON**: The controller uses a first order filter on the measured grid voltage to calculate the Vref. The controller uses the Vref to shift the Volt-var curve.
Vref Adjust Time Constant	300 s	300 to 5000 s	Used by the first order filter to get a filtered Vref.
Vref Limit Min	70 %	50 to 100 %	If the filtered Vref is below this value, the Vref Limit Min is used.
Vref Limit Max	130 %	100 to 150 %	If the filtered Vref is above this value, the Vref Limit Max is used.
V1	90 %	70 to 130 %	V-Q curve (see below), as a percentage of nominal voltage and the dependent reference.
Q1	25 %	-75 to 75 %	
V2	100 %	70 to 130 %	
Q2	0 %	-75 to 75 %	
V3	100 %	70 to 130 %	
Q3	0 %	-75 to 75 %	
V4	110 %	70 to 130 %	
Q4	-25 %	-75 to 75 %	
Q setting mode	Q / P nameplate	Q / P nameplate Q / Q nameplate Q / S nameplate	Reference used to adjust Q values. The selections use the nameplate P, Q, and S (respectively).
Open Loop Response Time	10 s	1 to 90 s	For regulating the Q set point.

Volt var (Q(U)) diagram



4.3.6 Constant reactive power (fixed Q)

The controller can have a fixed reactive power set point for regulation.

Settings

Configure the settings under *Advanced Protection, var(Q) grid support, Constant reactive power; Q (fixed)*.

Setting	Default	Range	Description
Enable	OFF	OFF; ON	Enable fixed Q.
Q setting mode	Q / P nameplate	Q / P nameplate Q / Q nameplate Q / S nameplate	Reference used to adjust Q values. The selections use the nameplate P, Q, and S (respectively).
Constant reactive power	0 %	-100 to 100 %	Q set point.

5. Abnormal conditions

5.1 df/dt (ROCOF)

More information
See **Option A1 Mains protection package** for information about the df/dt function.

The df/dt function is not required to meet the IEEE 1547™-2018 requirements. If you use df/dt as a generator protection, configure parameter 1422 as **6 periods or more**.

5.2 Advanced current unbalance

When using option A20, you can activate the advanced current unbalance (for open phase detection) protection.

Configure these settings under *Advanced Protection, Trip parameters, Advanced current unbalance*.

Setting	Default	Range	Description
Enable	Disable	Enable, Disable	Enable and configure the advanced current unbalance alarm.
Low threshold	2 % of nominal current	1 to 10 %	The protection can only be activated if at least one phase's current relative value is at or below the low threshold.
High threshold	25 % of nominal current	5 to 100 %	The protection can only be activated if at least one phase's current relative value is at or above the high threshold.
Unbalance threshold	80 %	0 to 100 %	The protection can only be activated if the unbalance is at or above this threshold. See the example below.
Delay	1.8 s	0.1 to 10 s	The protection can only be activated if the activation requirements are met for the duration of the delay.
Fail class	GB trip	All fail classes	Select the alarm action.

Unbalance calculation 1

The L1 and L2 current relative value is 2 %, while the L3 current relative value is 5 %. The low threshold is 2 %, the high threshold is 5 % and the unbalance threshold is 80 %.

The low threshold is met by L1 and L2, and the high threshold is met by L3.
Minimum current relative value = 2 %
Maximum current relative value = 5 %
Mean current relative value = (L1 + L2 + L3) / 3 = (2 % + 2 % + 5 %) / 3 = 3 %
Unbalance = (Maximum - Mean) / Mean OR (Mean - Minimum) / Mean = (5 % - 3 %) / 3 % OR (3 % - 2 %) / 3 % = 67 % or 33 %
→ The current unbalance alarm activation requirements are not met.

Unbalance calculation 2

The L1 current relative value is 1 %, the L2 current relative value is 2 %, while the L3 current relative value is 6 %. The low threshold is 2 %, the high threshold is 5 % and the unbalance threshold is 80 %.

The low threshold is met by L1 and L2, and the high threshold is met by L3.
Minimum current relative value = 1 %
Maximum current relative value = 6 %
Mean current relative value = (L1 + L2 + L3) / 3 = (1 % + 2 % + 6 %) / 3 = 3 %
Unbalance = (Maximum - Mean) / Mean OR (Mean - Minimum) / Mean = (6 % - 3 %) / 3 % OR (3 % - 1 %) / 3 % = **100 %** or 66 %

→ The current unbalance alarm activation requirements are met.

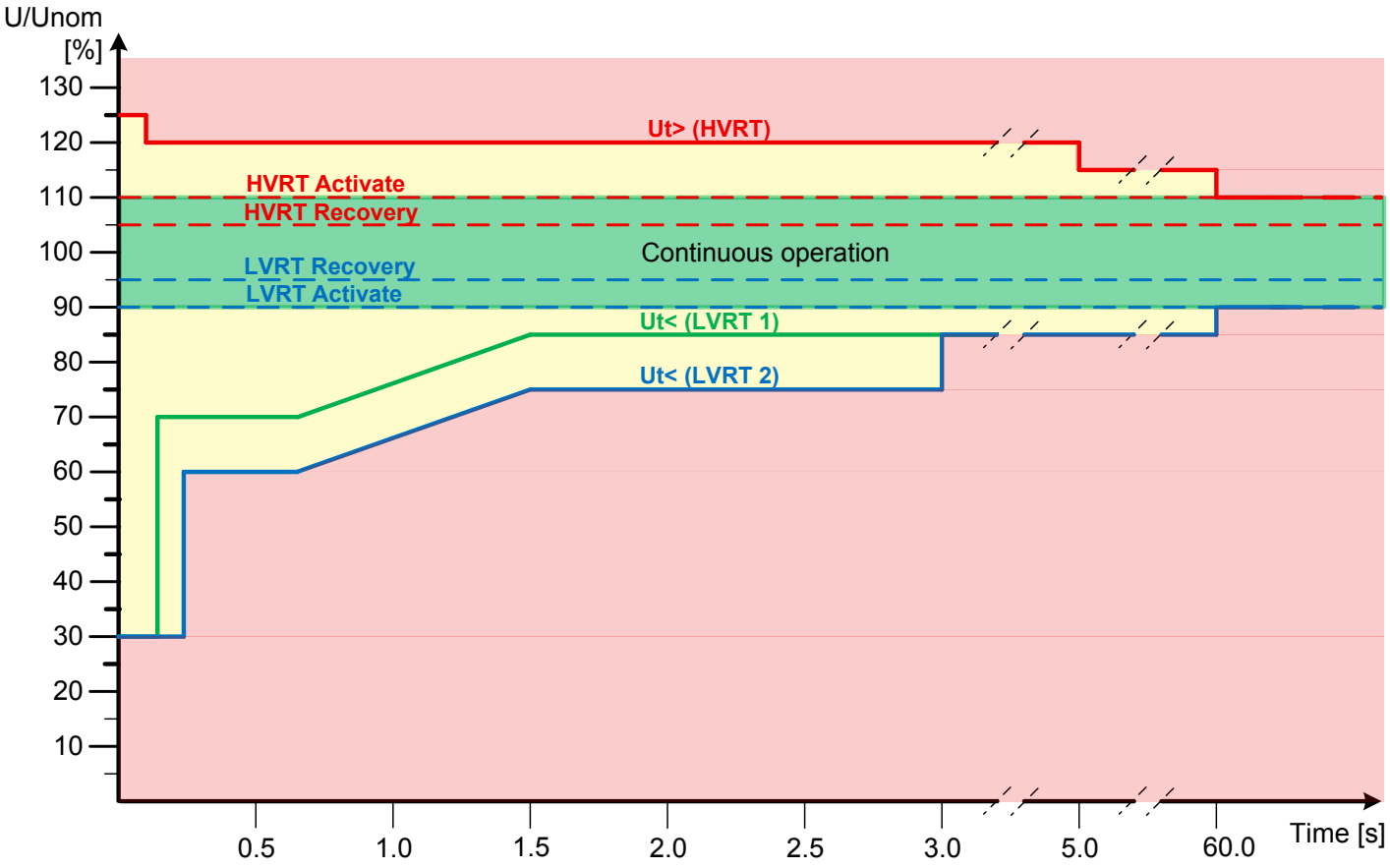
5.3 FRT curves (LVRT and HVRT)

Fault ride through (FRT) keeps the generator connected even though the grid voltage is not at the expected value. The FRT curves define the voltage windows for FRT and how long the generator remains connected to the grid.

For dynamic grid support, the controller has two Low Voltage Ride Through (LVRT) curves and one High Voltage Ride Through (HVRT) curve. You can use ten points define each curve.

Configure each curve to meet the IEEE 1547™-2018 requirements.

Example of FRT curves



For each curve, configure a protection to disconnect the generator from the grid. Each activate and recovery level can also be set. The LVRT protection activates if the specified phases drop below the set voltage values (below the curve). Between any two neighbouring points, the curve is a straight line.

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

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

NOTE The "cease to energise" FRT requirement is not relevant for a genset.

5.3.1 FRT parameters

Configure these HVRT and LVRT thresholds and alarms in the parameter list.

Text	Parameter	Default	Range	Description
HVRT Activate 1	1631	110 %	30 to 130 %	Threshold for activation of the HVRT curve
HVRT Recovery 1	1632	105 %, 0 s*	30 to 130 %, 0 to 320 s	Threshold for de-activation of the HVRT curve, with time delay
HVRT Activate 1	1634	Not enabled	-	Alarm, when parameter 1631 is active
HVRT 1	1640	Not enabled	-	Alarm, when the HVRT curve is exceeded (trip area)
Ut< Activate 1	1651	90 %	30 to 120 %	Threshold for activation of the LVRT 1 curve
Ut< Recovery 1	1652	95 %, 0 s*	30 to 120 %, 0 to 320 s	Threshold for de-activation of LVRT 1 curve, with time delay
Ut< Activate 1	1654	Not enabled	-	Alarm, when parameter 1651 is active
Ut< 1	1660	Not enabled	-	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 %, 0 s*	30 to 120 %, 0 to 320 s	Threshold for de-activation of LVRT 2 curve, with time delay
Ut< Activate 2	1694	Not enabled	-	Alarm, when parameter 1691 is active
Ut< 2	1700	Not enabled	-	Alarm, when the LVRT 2 curve is exceeded (trip area)

NOTE * When using **Cumulative Time**, the recovery time must be 0 seconds.

5.3.2 LVRT settings

LVRT 1 settings

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

LVRT 1 curve

Voltage	Default*	Timer	Default**
Ut< U SP1	30 %	Ut< t SP1	0 s
Ut< U SP2	30 %	Ut< t SP2	0.15 s
Ut< U SP3	70 %	Ut< t SP3	0.15 s
Ut< U SP4	70 %	Ut< t SP4	0.7 s
Ut< U SP5	85 %	Ut< t SP5	1.5 s
Ut< U SP6	85 %	Ut< t SP6	60 s
Ut< U SP7	90 %	Ut< t SP7	60 s
Ut< U SP8	90 %	Ut< t SP8	70 s
Ut< U SP9	90 %	Ut< t SP9	70 s
Ut< U SP10	90 %	Ut< t SP10	70 s

NOTE *The range is 4 to 120 % of nominal voltage.
NOTE **The range is 0 to 300 s.

LVRT 2 settings

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

LVRT 2 curve

Voltage	Default*	Timer	Default**
Ut< U SP1	30 %	Ut< t SP1	0 s
Ut< U SP2	30 %	Ut< t SP2	0.22 s
Ut< U SP3	60 %	Ut< t SP3	0.22 s
Ut< U SP4	60 %	Ut< t SP4	0.7 s
Ut< U SP5	75 %	Ut< t SP5	1.5 s
Ut< U SP6	75 %	Ut< t SP6	3 s
Ut< U SP7	85 %	Ut< t SP7	3 s
Ut< U SP8	85 %	Ut< t SP8	60 s
Ut< U SP9	90 %	Ut< t SP9	60 s
Ut< U SP10	90 %	Ut< t SP10	70 s

NOTE *The range is 4 to 120 % of nominal voltage.
NOTE **The range is 0 to 300 s.

5.3.3 HVRT settings

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

Voltage	Default*	Timer	Default**
Ut> U SP1	125 %	Ut> t SP1	0 s
Ut> U SP2	125 %	Ut> t SP2	0.1 s
Ut> U SP3	120 %	Ut> t SP3	0.1 s
Ut> U SP4	120 %	Ut> t SP4	5 s
Ut> U SP5	115 %	Ut> t SP5	5 s
Ut> U SP6	115 %	Ut> t SP6	60 s
Ut> U SP7	110 %	Ut> t SP7	60 s
Ut> U SP8	110 %	Ut> t SP8	70 s
Ut> U SP9	110 %	Ut> t SP9	70 s
Ut> U SP10	110 %	Ut> t SP10	70 s

NOTE *The range is 100 to 130 % of nominal voltage.
NOTE **The range is 0 to 300 s.

5.3.4 FRT activated by cumulative time

Under *Advanced Protection*, *FRT setup*, *Activation mode*, select **Cumulative Time**. The two other FRT event activation modes (number of phases, and symmetrical - asymmetrical) are not relevant.

You can then configure these settings.

NOTE You can only see these settings if the *Activation mode* is *Cumulative Time*.

Setting	Default	Range	Description
LVRT 1 type select LVRT 2 type select HVRT1 type select	Any phase-neutral or phase-phase	Any phase-neutral Any phase-phase Any phase-neutral or phase-phase	The measurements evaluated to activate the fault ride through curve.

Consecutive disturbance alarm

Parameter	Name	Default	Range	Description
1730	Consec D. alarm	3	1 to 5	Consecutive disturbance alarm (VRT)
	Fail class	Trip MB/GB	Fail classes	Alarm action when the protection is activated.

Consecutive disturbances

Setting	Default	Range	Description
Min. time between disturbances	20 s	5 to 30 s	After an FRT disturbance event, if another FRT activation starts within this time, then the two FRT activations are treated as one FRT activation. If the FRT curve is exceeded as a result, then the controller activates the FRT trip. If the timer runs out without another FRT disturbance event, the next FRT disturbance event is treated as a new FRT activation.
Disturbance counter reset	3600 s	600 to 5400 s	If there are no FRT activations during this time, the disturbance counter (parameter 1730) is reset.

Causes of FRT trips

If the FRT event(s) exceed the FRT curve, the controller activates the FRT trip.

The controller also activates an FRT trip if there are too many FRT events (parameter 1730) before the disturbance counter reset timer runs out.

How the FRT curves work for cumulative time

If there is more than one FRT event and the minimum time between disturbances timer has not run out, the controller treats the FRT events as cumulative. The cumulative contribution of each FRT event depends on the voltage level during the FRT event and the duration of the FRT event.

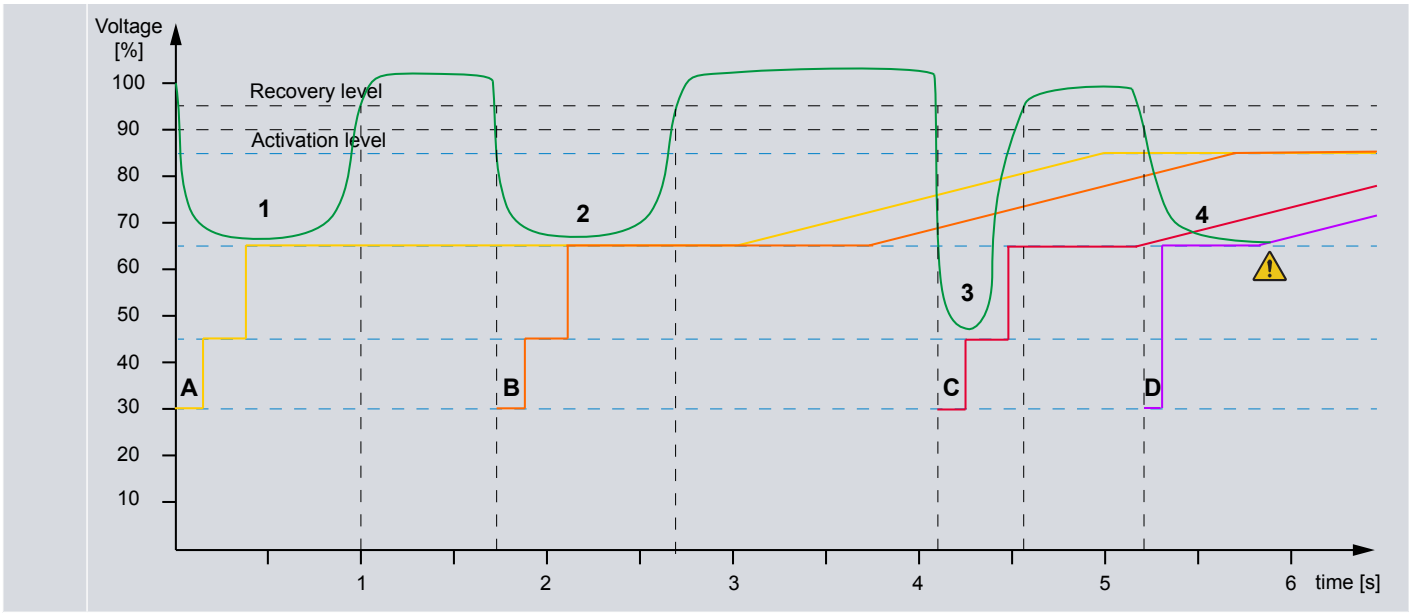
NOTE The FRT curve calculations and timers are handled separately for each FRT curve (that is, LVRT 1, LVRT 2 and HVRT 1).

The following example shows the cumulative effect of four successive LVRT activations. The time between these activations is less than the disturbance counter reset.

LVRT and cumulative time example

The LVRT curve is shown in yellow (A). The voltage curve is shown in green. For this example, the minimum time between disturbances is 20 seconds, and parameter 1730 (consecutive disturbance alarm) is 5.

LVRT activation event 1 reduces the available LVRT time at the start of the next LVRT activation. This is shown by the orange LVRT curve (B). LVRT activation event 2 reduces the available LVRT time at the start of the next LVRT activation. This is shown by the red LVRT curve (C). LVRT activation event 3 reduces the available LVRT time at the start of the next LVRT activation. This is shown by the purple LVRT curve (D). Note that there is effectively no longer an LVRT curve section at 45 % of nominal voltage. In addition, since the voltage was below 65 % for longer than the length of the curve section for 45 %, the curve section for 30 % is also shorter. Finally, LVRT activation event 4 exceeds the LVRT curve, and the controller activates the LVRT protection.



5.3.5 Suspend regulation during FRT

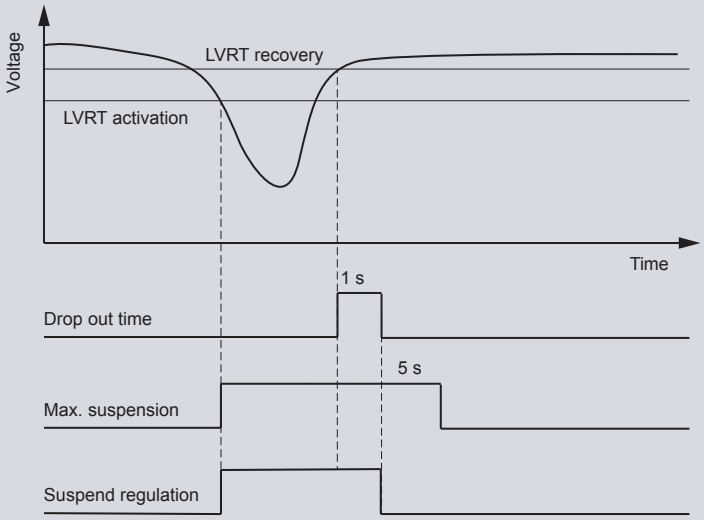
To prevent counter-productive regulation during an FRT event, you can suspend the governor and/or AVR regulation. While the regulation is suspended, the controller keeps the governor and/or AVR output at the level it was the regulation suspension started. This also improves the transition from the FRT event to normal.

Setting	Default	Range	Description
Suspend GOV regulation - Enable	Disable	Disable Enable	*Disable*: GOV regulation is not affected when there is an FRT event. *Enable*: GOV regulation is stopped when there is any FRT event.
Suspend GOV regulation - Drop out time	0 s	0 to 5 s	Suspension of GOV regulation after recovery from the FRT event. See the examples below.
Suspend GOV regulation - Max suspension time	5 s	0 to 5 s	Timer for the maximum suspension duration of GOV regulation during the FRT event. See the examples below.
Suspend AVR regulation - Enable	Disable	Disable Enable	*Disable*: AVR regulation is not affected when there is an FRT event. *Enable*: AVR regulation is stopped when where is any FRT event.
Suspend AVR regulation - Drop out time	0 s	0 to 5 s	Minimum time for suspension of AVR regulation during the FRT event.
Suspend AVR regulation - Max suspension time	5 s	0 to 5 s	Timer for the maximum suspension duration of AVR regulation during the FRT event.

Examples for drop out and max. suspension time

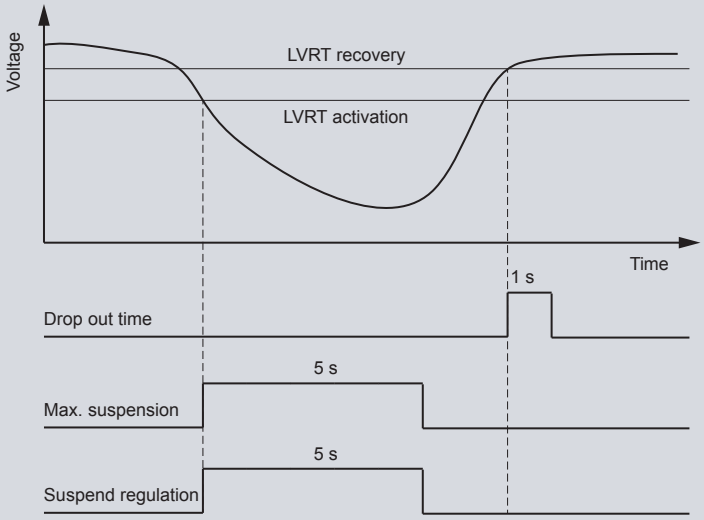
In these examples, the drop out time is 1 second, the maximum suspension time is 5 seconds. A low voltage ride through is shown.

Example: The drop out time governs regulator suspension



The voltage falls below the LVRT activation level for a short time. Regulation is suspended when the FRT event starts. When the voltage recovers from the LVRT event, the drop out timer starts. When the drop out timer runs out, regulation restarts. In this case, the maximum suspension time does not have any effect.

Example: The maximum suspension time governs regulator suspension



The voltage falls below the LVRT activation level for a longer time. Regulation is suspended when the FRT event starts. The maximum suspension timer runs out before the voltage recovers from the LVRT event. The regulation therefore restarts, even though the FRT event is still active. The drop out timer starts after the voltage recovers from the LVRT event, but does not have any effect.

5.4 Voltage and frequency trips

You can enable and configure these voltage and frequency trips under *Advanced Protection, Trip parameters* to meet the IEEE std. 1547™-2018 mandatory tripping requirements. The clearing time is important for these protections.

Note that the ranges in the AGC-4 Mk II controller for the set points and delays are generally wider than the IEEE std. 1547™-2018 requirements.

NOTE If option A20 is not used, the voltage alarms are in menus 1270, 1280, 1300 and 1310. The frequency alarms below are also only available in option A20.

Voltage tripping

Alarm	Default	Range	Description
Overvoltage 1	1.03 p.u., 10.00 s	1.000 to 1.300 p.u., 0.00 to 99.99 s	Over-voltage alarm
Overvoltage 2	1.05 p.u., 5.00 s	1.000 to 1.300 p.u., 0.00 to 99.99 s	Over-voltage alarm
Undervoltage 1	0.97 p.u., 10.00 s	0.100 to 1.000 p.u., 0.00 to 99.99 s	Under-voltage alarm
Undervoltage 2	0.95 p.u., 5.00 s	0.100 to 1.000 p.u., 0.00 to 99.99 s	Under-voltage alarm

Frequency tripping

Alarm	Default	Range	Description
Overfrequency 1	61.2 Hz, 300 s	50 to 72 Hz, 0.000 to 2000 s	Over-frequency alarm
Overfrequency 2	62 Hz, 0.160 s	50 to 72 Hz, 0.000 to 2000 s	Over-frequency alarm
Underfrequency 1	58.5 Hz, 300 s	40 to 60 Hz, 0.000 to 2000 s	Under-frequency alarm
Underfrequency 2	56.5 Hz, 0.160 s	40 to 60 Hz, 0.000 to 2000 s	Under-frequency alarm

5.4.1 Clearing time

For the mandatory trip protections, the clearing time must meet the IEEE std. 1547™-2018 requirements.

Clearing time = Fault detection time + Time delay + External clearing time contribution

- **Fault detection time**: The time that the AGC-4 Mk II takes to detect the fault. For the IEEE std. 1547™-2018 mandatory tripping protections, this is 50 ms.
- **Time delay**: The time that the AGC-4 Mk II takes to respond to the fault. You can change the delay configured in the AGC-4 Mk II to change this time.
- **External clearing time contribution**: The time is from when the controller output is activated to when the breaker is opened. Configure *Ext. clearing time* in the AGC-4 Mk II (under *Advanced Protection, Trip parameters, External equipment clearing time*).

NOTE You might need to use a very fast breaker to get the necessary clearing time.

For each protection, the minimum operate time is listed in the **Data sheet**:

Operate time = Fault detection time + Time delay

6. Interoperability - SunSpec Modbus

The Area EPS operator can use interoperability to configure the genset's parameters and settings. To meet the IEEE 1547™-2018 requirements for interoperability, the AGC-4 Mk II option A20 includes SunSpec Modbus. SunSpec Modbus is an open communication standard that uses SunSpec Information Models.

Modbus

The controller supports both Modbus TCP/IP over Ethernet, and Modbus RS-485. To use Modbus RS-485, the controller must have option H2.

The SunSpec Modbus addresses are in the holding register (function code 0×03), and start at 40000. The Modbus addresses are fixed for a controller software release, but might change for in a future controller software release.

NOTE The SunSpec models are fixed and will not change in future controller software releases.

Communication settings

To use TCP/IP Modbus to monitor interoperability, you can use these settings:

- Device type: Modbus TCP
- IP address: The controller's IP address
- IP port: 502
- Slave ID: 1

6.1 PICS file

Contact DEIF if you need a PICS file. The PICS file applies to a specific AGC-4 Mk II software release, and includes all the SunSpec model info. The AGC-4 Mk II supports the following SunSpec standard models: 1, 701, 702, 703, 704, 705, 707, 708, 709, 710, 711.