Heywood BESS

Releasable User Guide - PSCAD

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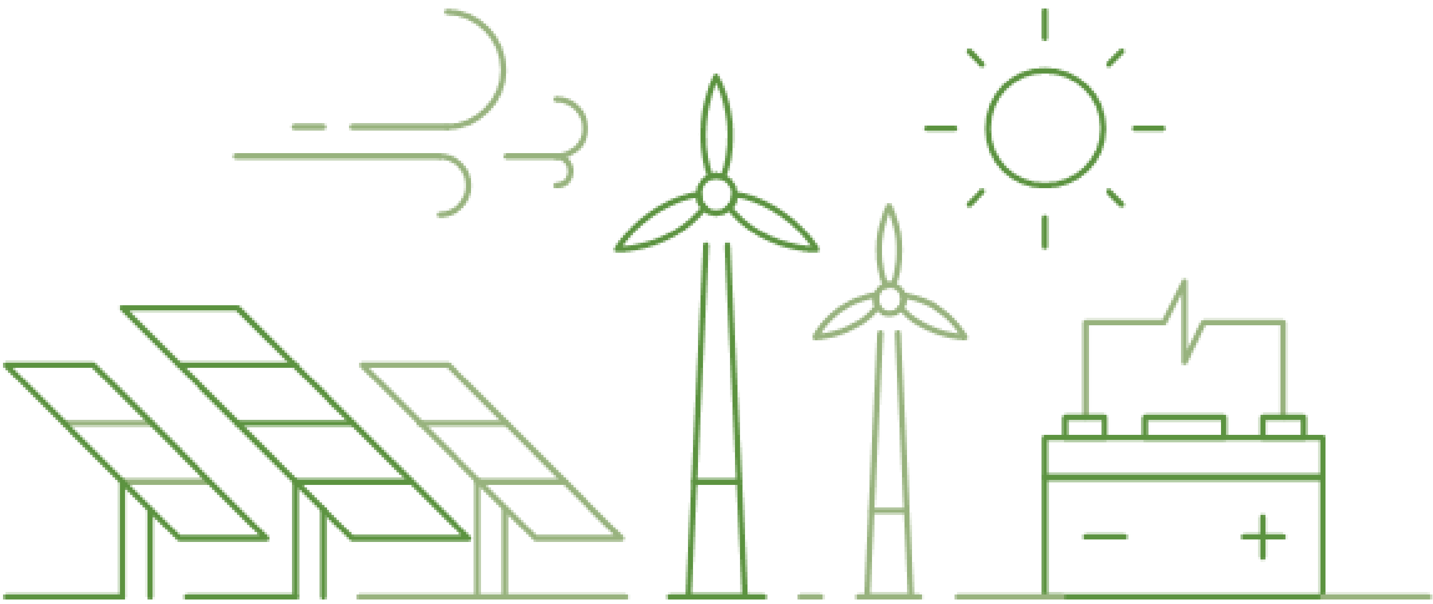

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Contents

Revision History

Table 1: Revision history

Rev.	Date	Prepared By	Reviewed By	Description
1-0-0	16/07/2025	Alvin Bai	Luke Hyett	Draft release to Atmos
1-1-0	25/07/2025	Alvin Bai	Luke Hyett	Preliminary Submission to AEMO

This document uses *Semantic Versioning for Documents* for revision numbering.

Given a version number *MAJOR-MINOR-FIX*, the

- *MAJOR* is incremented when the document has undergone significant changes
- *MINOR* is incremented when new information has been added to the document or information has been removed from the document, and
- *FIX* is incremented when minor changes are made (e.g. fixing typos)

Where appropriate, several revisions may be represented in one table entry with all notable changes described in the *Description* column.

1. Introduction

1.1 Overview of generating station

The Heywood Battery Energy Storage System (HEYWOODBESS) is a $\pm 285MW/1140MWh$ Battery Energy Storage Project, is located 5 km from the town of Heywood and 300 km west of Melbourne in Victoria as shown in Figure 1.1. The project is expected to connect directly to the existing 275 kV Heywood terminal station via a single high voltage cable.

HEYWOODBESS will include 92 SMA Sunny Central 4.6 MVA (SCS 4600 UP-S) converters which will be connected to two 275/33/33kV, 160MVA three winding transformers through a 33kV reticulation system. Each converter will have a dedicated 33/0.69kV, 4.6 MVA step up transformer.

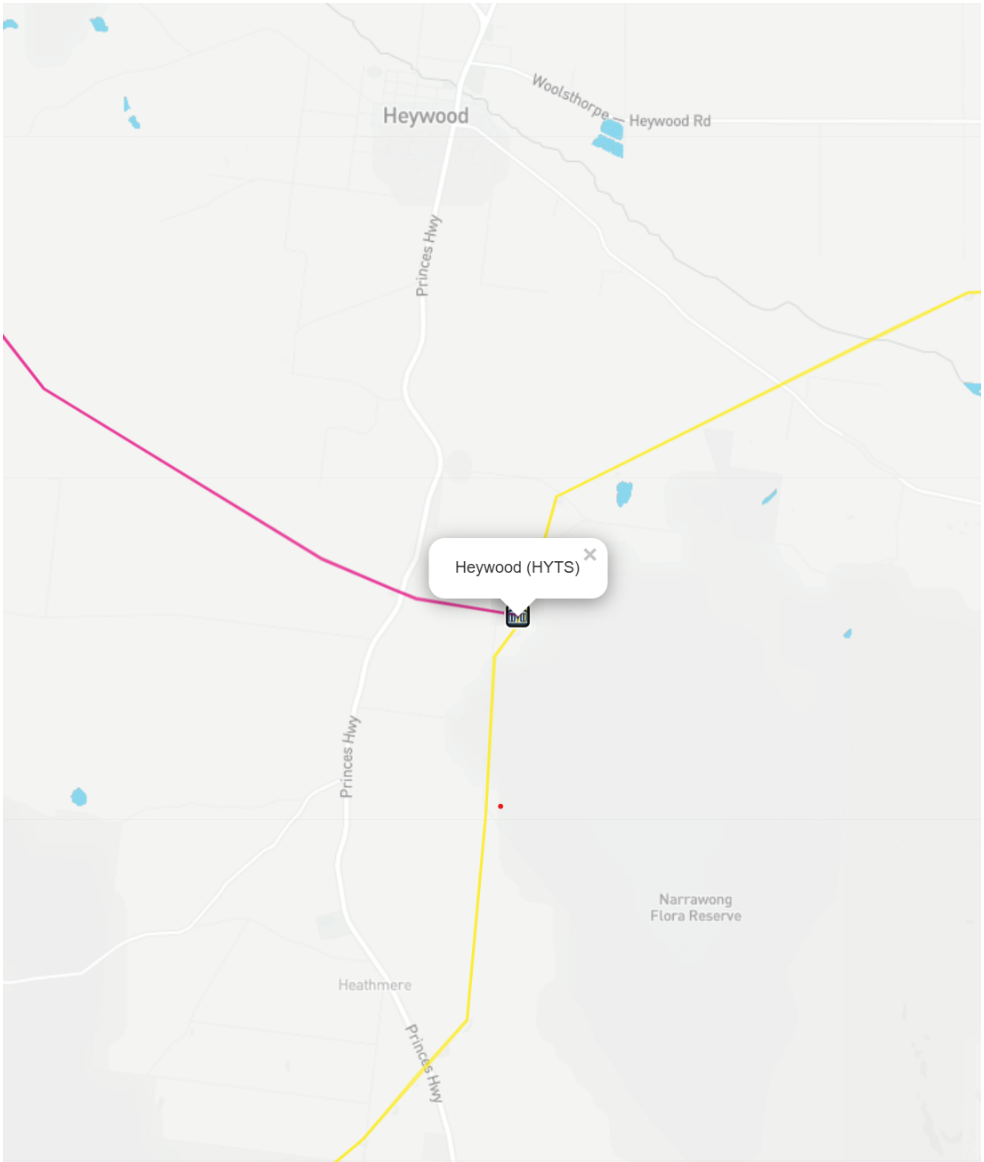


Figure 1.1: Project location

Project information is given as Table 1.1.

Table 1.1: Project Information

Feature	Description
Type and configuration of generation	92 x SMA SC 4600-UP converters
Project Rating	423.2 MVA
Point of connection nominal voltage	275 kV
Point of connection normal voltage	1.06 p.u.
Active power rating	±285 MW
Reactive power rating	±112.575 MVAr
Geographical Location	Victoria Heywood 3304
Point of connection	Victoria Heywood 275 kV substation
Transmission Network Service Provider for the connection	AEMO Victoria / Ausnet

2. Reactive Capability

The reactive capability curves for Heywood Battery Energy Storage System (Heywood BESS) at 35°C, 40°C and 50°C are shown in Figures 2.1, 2.2 and 2.3. The automatic access standard has been shown as a dotted line, and is defined by the upper corner points P_{max}=285 MW, Q_{max}=112.575 MVAr, P_{max}=285 MW, Q_{min}=-112.575 MVAr, and the lower corner points P_{min}=-285 MW, Q_{min}=-112.575 MVAr, P_{min}=-285 MW, Q_{max}=112.575 MVAr.

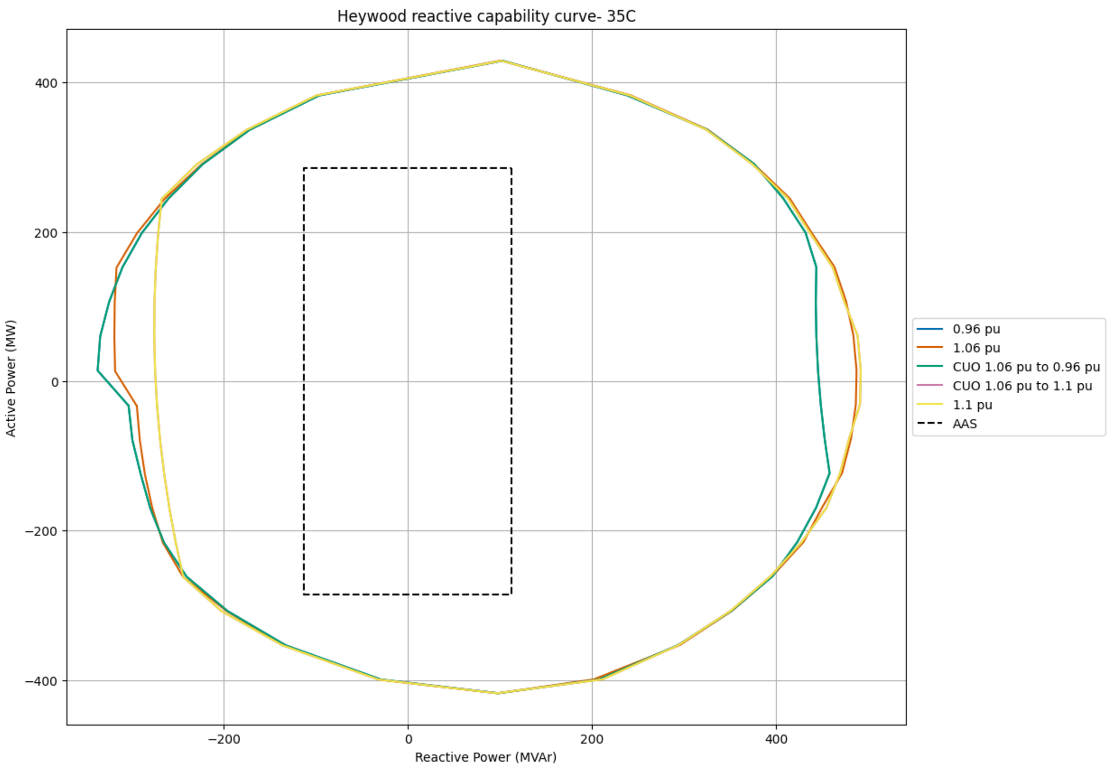


Figure 2.1: 35°C Reactive capability curve for HEYWOODBESS

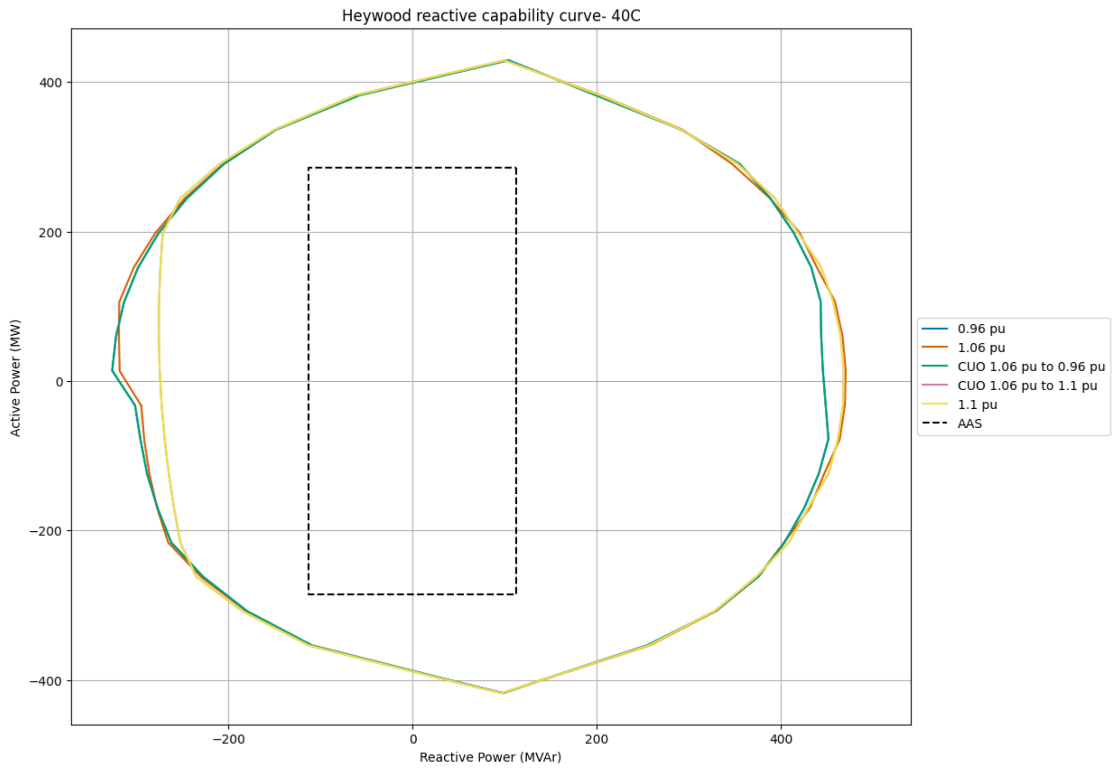


Figure 2.2: 40°C Reactive capability curve for HEYWOODBESS

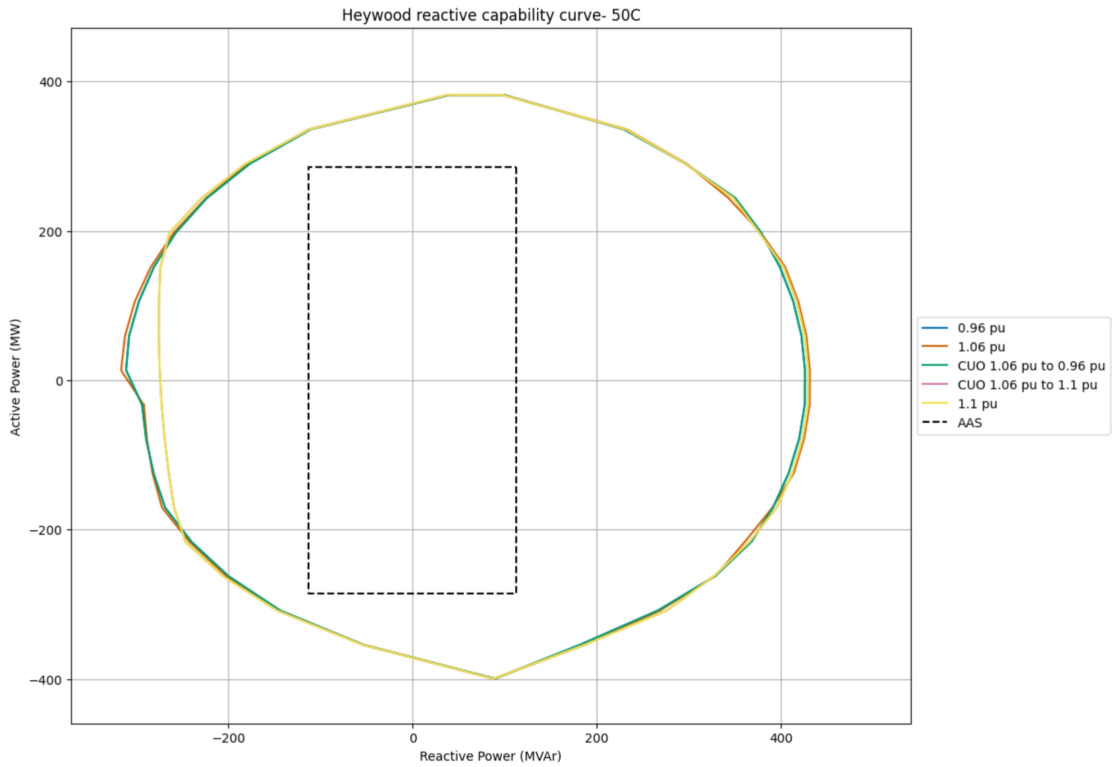


Figure 2.3: 50°C Reactive capability curve for HEYWOODBESS

3. Model Structure

3.1 Layout

The HEYWOODBESS PSCAD model is divided into several regions:

- The main circuit diagram shows the Single Machine, Infinite Bus (SMIB) representation of the generating system.
- The Power Plant Controller (PPC) region contains the Fluence Power Plant Controller and associated logic.
- The On-Load Tap Changer (OLTC) region contains the tap changer logic for the grid transformer on load tap changers.
- The Grid Stimuli region defines the state of the circuit breakers in the SMIB model.
- The Plant Configuration section maps some key Global Substitution values, such as bases, to variables.
- The HMI control panel allows users to operate the model through manual configuration.
- The Plotting / Signal Derivation region at the bottom of the canvas is where signals, including derived signals, are assigned to output channels.
- The Automation region, which is used for automated execution, has been disabled by setting the global substitution variable AUTO_Automation_Mode_Enabled to 0.

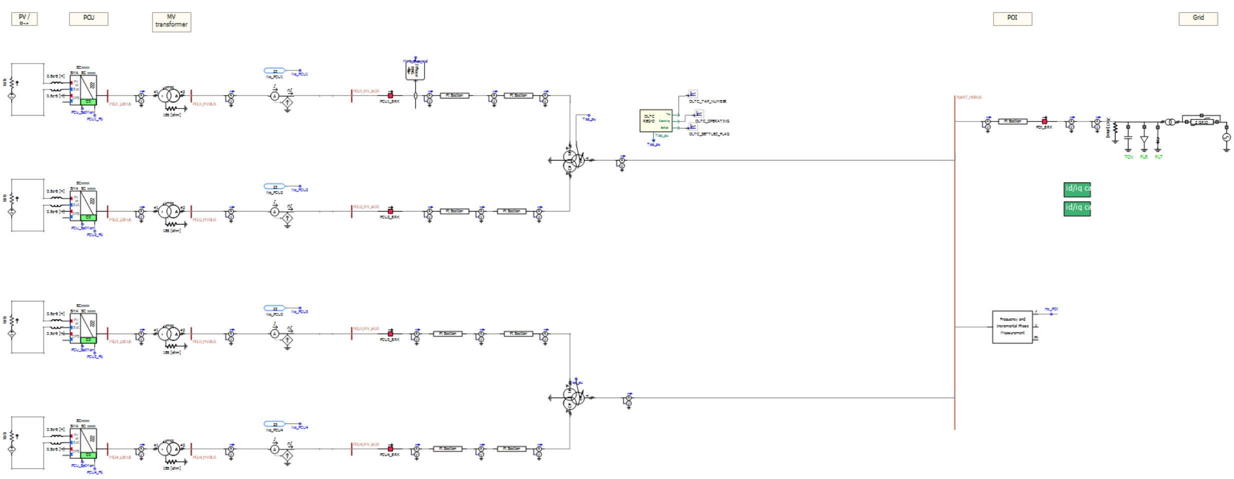


Figure 3.1: Model layout - main circuit

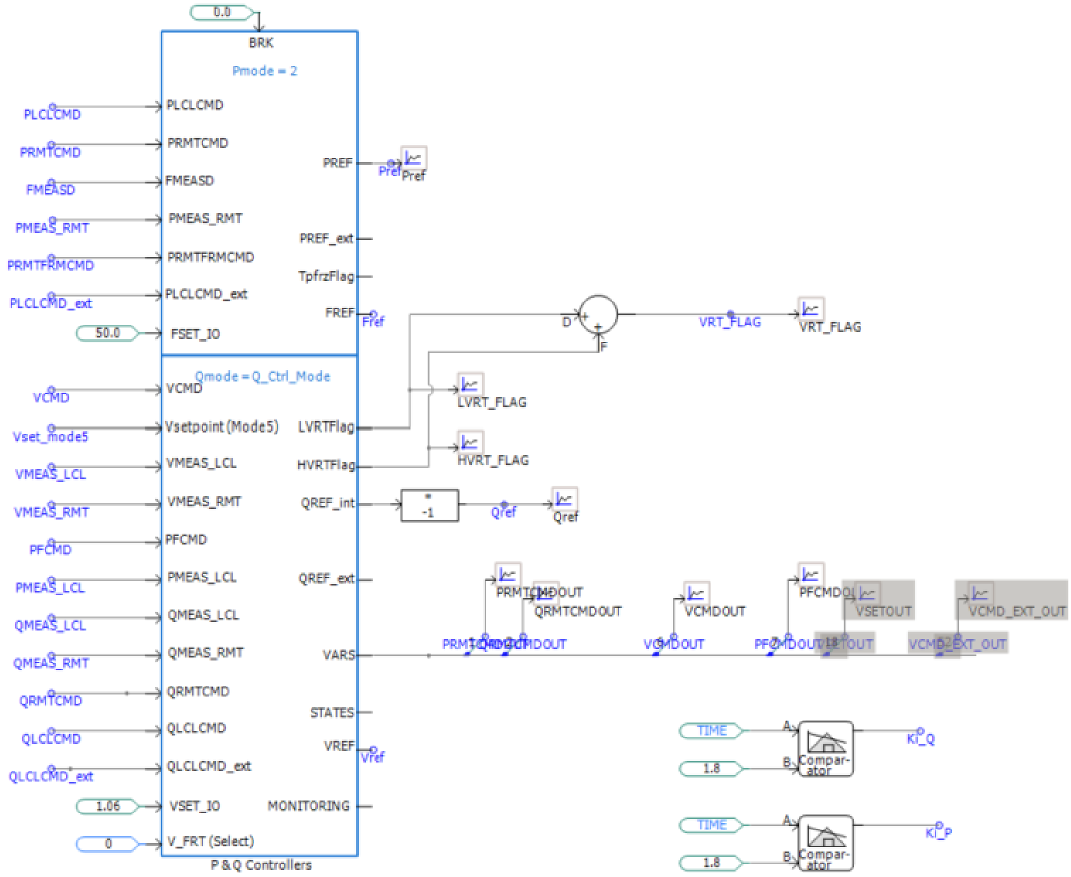


Figure 3.2: Model layout - P and Q control

3.2 Dependencies

The HEYWOODBESS PSCAD model includes several libraries, which provide components for the main canvas:

- SMA libraries SMA_Tools, FLNCPPC10_1, SC_Lib, SCAvg_Lib provide the converter transformer current scaling module, the PPC module, the converter module and an average voltage source converter module respectively (average voltage source converter module is not in use for this model).
  - SMASC_K_100015R03 is the active converter model version.
  - FLNCPPC10_1 is the active PPC model version.
- Grid-Link module Pallet provides the grid model, the OLTC model, i_d and i_q calculation modules and control signal merging/unmerging blocks.

All models are tested in PSCAD v5 and are provided with libraries for x86 and x86_64 architectures.

3.3 Parameter Configuration Files

The converter models read in text-based configuration files that contain the parameters that will remain fixed for the duration of the simulation (i.e. not set points). These are read by the model at the beginning of the simulation, then not read again during the run. The converter configuration file CfgFile57.txt has been supplied with the model.

The PPC parameters are defined within the model itself; therefore separate parameter configuration file is required.

3.4 SMIB representation

Figure 3.3 shows the SMIB representation of the generating unit as presented in the PSCAD model. From right to left, the key elements are:

- The grid element, which provides facilities to configure the grid Short Circuit Ratio (SCR) and X/R, apply faults and other disturbances.
- The point of connection.
- 1 x 275 kV underground cable between substation and point of connection (POC)
- Two main three-winding 275/33/33 kV transformer with OLTC.
- Eight aggregated MV impedances representing the lumped impedance of 33kV feeders (modelled as X,R,B quantities).
- Four aggregated two-winding MV 33/0.69 kV converter transformers and current multiplier to represent all ninety-two (92) converters.
- Four lumped SCS 4600 UP-S converter model.

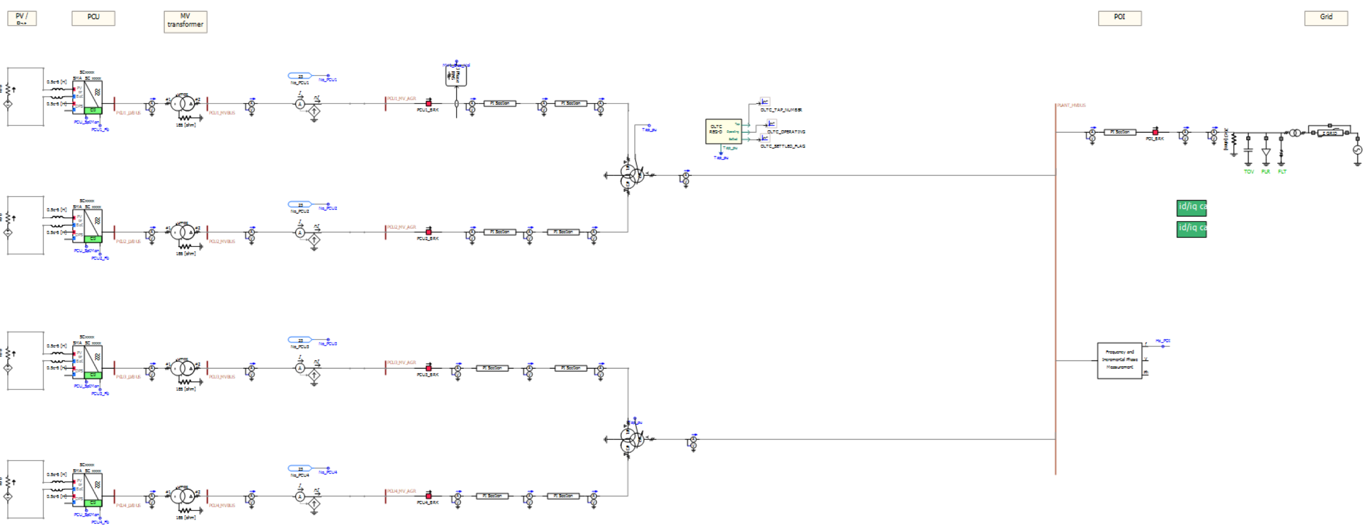


Figure 3.3: SMIB representation of the generating system

Parameters for each electrical object and controller can be found in the appendix.

3.5 Control scheme configuration

This section will explain the default expected mode of operation for the plant, as well as how to operate the plant under alternative control modes if required, for both normal and abnormal operating conditions.

Under normal conditions, the plant will seek to control active and reactive power at its point of connection, via reference signals passed from the power plant controller to the converters. The normal operating voltage at the point of connection is 1.06 p.u. The plant also has a seperate operating mode for fault / overvoltage conditions, where the PPC may temporarily freeze to allow the converters to operate under reactive current control. Details of the operating modes and interactions between plant are explained in the following sections.

Fluence supplies the PPC FLNCPPC10_1 as an integrator, with parameters configurable directly within the model itself. SMA provides access to the majority of their converter settings through the configuration files CfgFile57.txt.

3.5.1 Reactive Power Control Schemes

The FLUENCE PPC supports multiple reactive power control modes, selectable via the **General Reactive Power Parameters (Q) - Q Control Mode**. Under voltage disturbances, the plant operates under droop control and will diverge from its reference setpoint. The plant operates with a droop characteristic of 4.0% on a 1 pu base, the voltage deadband is not used. The default reactive power control mode is the remote voltage control mode with voltage stack logic droop control (Q Control Mode=5). The available reactive power control modes and their configurations are summarised below:

Q Control Mode = Mode 5 — Remote Voltage Control Mode

When Q Control Mode is set to 5, the BESS enters remote voltage control mode, which operates with Voltage Stackable Logic (VSL) droop logic. In order to use this control mode the VSL is required to be always enabled (General Reactive Power Parameters(Q) - Voltage stack Logic). Key parameters to adjust reactive power control are shown below:

- Q Control Mode - must be set to Mode 5 for the PPC to operate in remote voltage control mode.
- General Reactive Power Parameters(Q) - Voltage Stack Logic - must be set to Enable when operating in Mode 5.
- VCMD - can be adjusted to set the remote voltage setpoint.

Voltage Droop Characteristics

Given the 4% voltage droop characteristic of the Heywood BESS, the corresponding relationship is defined as follows:

$$\text{Droop} = \left[\frac{\text{p.u.}}{\text{p.u.}}\right] = \frac{(U - U_{\text{set}})/U_n}{(Q - Q_{\text{set}})/Q_n} = \frac{U - U_{\text{set}}}{Q - Q_{\text{set}}} \cdot \frac{Q_n}{U_n}$$

(with Qn = 112.575 MVAr)

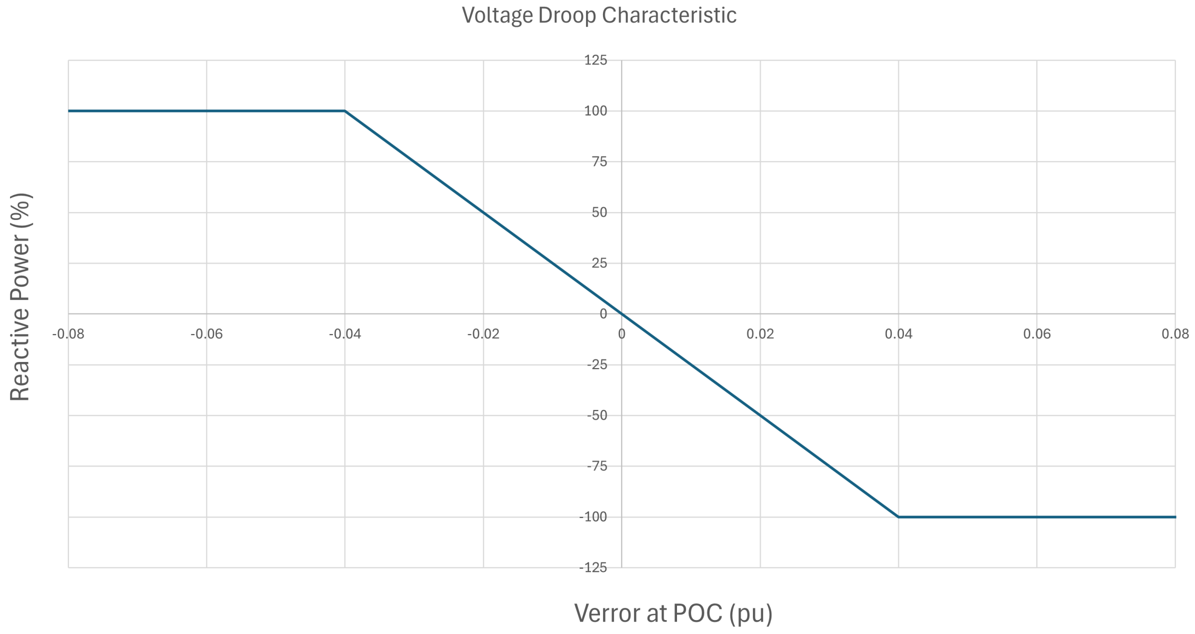


Figure 3.4: Voltage droop characteristic

Table 3.1: Voltage droop characteristic tabulated

	Normal voltage (pu)	Voltage at POC (pu))	Reactive Power (MVAr)
First Over Voltage	1.06	1.1	-112.575
Second Over Voltage	1.06	1.1	-112.575
Third Over Voltage	1.06	1.1	-112.575
First Under Voltage	1.06	1.02	112.575
Second Under Voltage	1.06	1.02	112.575
Third Under Voltage	1.06	1.02	112.575

Q Control Mode = Mode 2 — Power Factor Control Mode

When Q Control Mode is set to 2, the BESS operates in power factor control mode, controlling power factor at its point of connection. Key parameters to adjust power factor control are shown below. Note that voltage stack logic should be disabled when operating in Mode 2.

- Q Control Mode - must be set to Mode 2 for the PPC to operate in power factor control mode.
- PFCMD - can be adjusted to set power factor target at the POC.

Q Control Mode = Mode 3 — Remote Reactive Power Control Mode

When Q Control Mode is set to 3, the BESS enters remote reactive power control mode. In this mode, the reactive power at the point of connection is regulated based on a command signal QRMTCMD. Key parameters to adjust droop control are shown below. Note that voltage stack logic should be disabled when operating in Mode 3.

- Q Control Mode - must be set to Mode 3 for the PPC to operate in remote reactive power control mode.
- QRMTCMD - can be adjusted to control the reactive power at the remote branch.

OLTC control

The 275/33/33 kV three-winding grid transformers are equipped with an on-load tap changer. The OLTC have been specified to regulate the voltage at the medium voltage side of the main transformers to be 1 p.u.The OLTC auto-voltage regulation (AVR) relay utilises a deadband ensuring that the voltage target is achieved to within ± 0.015 pu. An initial tap change in response to a voltage deviation beyond the control dead band is undertaken after a defined delay of 20 seconds. This is commonly understood as an AVR constant time program.

The transformer is set to operate with a time delay of 20 seconds and 7s mechanical operation time. If after a single tap change operation the voltage is still outside the deadband, another tap will be expected after an additional 20 seconds. This time delay has been selected to ensure no unwanted interference between primary and secondary control loops while ensuring it is fast enough to ensure the generator maintains continuous uninterrupted operation for a variety of network disturbances.

Table 3.2: Grid transformer OLTC Details

Parameter	Value
Tap Changer Type	On-load
OLTC Number of Taps	25
OLTC Nominal Tap	13
OLTC Tap Size	1.25%
OLTC Tapping Range	± 15%
OLTC Voltage Deadband (pu)	0.015
OLTC Voltage Setpoint (pu)	1.0
OLTC Tapped Winding	275kV side
OLTC Total Time Between Taps	20s
OLTC Mechanical Operation Time	7s

3.5.2 Active power and frequency control

The PPC regulates active power output through setpoint commands to the converters to target a fixed active power setpoint at the point of connection. Under frequency disturbances, the plant operates under droop control and will diverge from its reference setpoint. The plant operates with a droop characteristic of 5.0% on a 50 Hz base, and a frequency deadband of +/- 0.015 Hz.

The PPC can operate in both local active power control and remote active power control, to be defined by the user. The PPC operates in remote active power control mode by default. This characteristic is shown in Figure 3.5 and Table 3.3.

P Control Mode = Mode 1 — Local Active power Control Mode

Key parameters for local active power and frequency control are shown below:

- P Control Mode - must be set to mode 1 to enable local active power control mode
- PLCLCMD - can be adjusted to set local active power

P Control Mode = Mode 2 — Remote Active power Control Mode

Key parameters for remote active power and frequency control are shown below:

- P Control Mode - must be set to mode 2 to enable remote active power control mode
- PRMTCMD - can be adjusted to set the remote active power command

Frequency Droop Characteristics

Given the 5% frequency droop characteristic of the Heywood BESS, the corresponding relationship is defined as follows:

$$\text{Droop=}\left[\frac{\text{MW}}{\text{Hz}}\right] = \frac{1}{\Delta f/\Delta P} = \frac{\Delta P}{\Delta f} = \frac{P - P_{\text{set}}}{f - f_{\text{set}}}$$

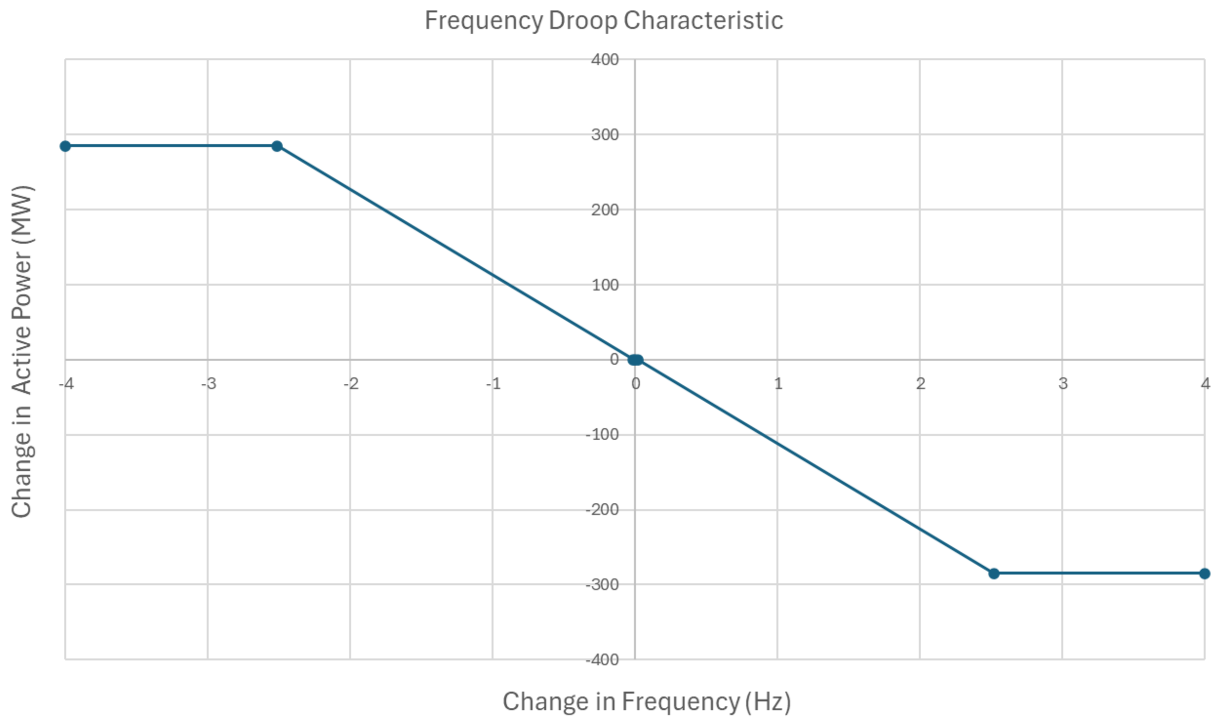


Figure 3.5: Frequency droop characteristic

Table 3.3: Frequency droop characteristic tabulated

Change in Frequency (Hz)	Active Power (MW)
3	-285
2.5	-285
0.015	0
0	0
-0.015	0
-2.5	285
-3	285

3.5.3 Fault ride through mode

Unlike a typical grid following plant, the grid forming BESS converters do not have a defined set of voltages at which they enter an FRT mode. The converters instead have a "virtual impedance" mode, which is activated following large voltage step change deviations at the converter terminals, which serves as its FRT mode. Under this mode, the plant injects current according to the reciprocal of a defined impedance, which acts as an equivalent to a "k-factor" commonly used in grid following FRT applications.

Seperately to the converters, the plant PPC will freeze following point of connection voltages dropping below 0.85 or above 1.15 p.u. The risk of PPC windup during FRT causing disturbances in operation is therefore mitigated.

3.6 Protection

The converters are equipped with frequency and voltage protection, which are set to keep the plant connected as per the NER requirements, but trip to avoid the plant supplying onto a faulted system. The frequency protection characteristic is shown in Figure 3.6. The voltage protection characteristic is shown in Figure 3.7.

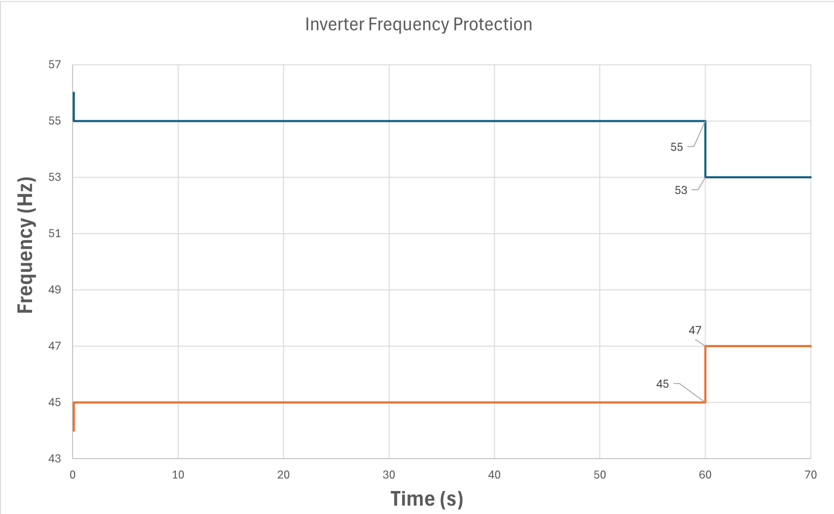


Figure 3.6: Frequency protection characteristics

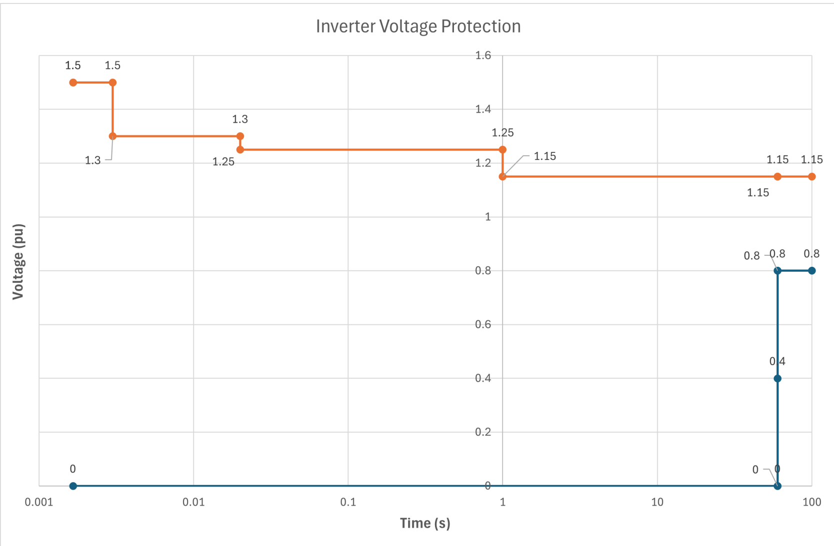


Figure 3.7: Voltage protection characteristics

3.7 Simulation with a reduced number of converters

To perform simulations with a reduced number of converters on each branch,n, the following parameters need to be adjusted in the model

- Modify the No_PCU signal above each branch to adjust the number of converters to the correct amount.

- Modify the MVA rating of the "BESS MVA" variable in the PPC.

All other parameters are in pu and will be adjusted automatically.

3.7.1 Initialisation-specific modifications

The model initialises in 7 seconds at all combinations of Pmax/Pmin, Qmax/Qmin and SCRmin/SCR-max. Note: The converter control mode is initially set to 21521 for the first 6 seconds to enable fast initialization, and then it switches back to 22321 after 6 seconds.

3.7.2 HMI controls

When automation mode is disabled, control of set points and disturbances is available from the control panels in the PPC region of the canvas, as shown in Figure 3.8. The controls in this category can be grouped as follows: Grid representation configuration section:

- Grid state determines whether to use the 'initial' fault level and X/R provided or the 'recovery' fault level and X/R. Most studies will be performed with a single fault level and X/R, so this should be set to 'INIT,' but studies involving a switch to a different SCR mid simulation can do so by toggling the Grid state to 'RECOV.'
  - Init Grid MVA and Init Grid X/R are the initial fault level and X/R values for the grid.
  - Rec. Grid MVA And Rec. Grid X/R are the 'recovery' fault level and X/R values to be switched to.
    IMPORTANT: these must be set to values greater than 0 even when not used, or PSCAD may treat the impedance as a short circuit. It is suggested to use values equivalent to SCR=1 when not in use.
- Infinite Grid: 'INF' short circuits the grid impedance, directly connecting the slack bus to the Connection Point. 'GRID' puts the grid impedance in between these buses.
- Vslack (pu) sets the voltage of the slack bus.
- Fslack (Hz) sets the frequency of the slack bus.
- Grid phase (deg) sets the phase angle of the slack bus (default = 0°)
- Vpoc disturbance (pu) uses a dummy transformer at the Connection Point to apply a percentage voltage change at the Connection Point.

TOV (Temporary Over-Voltage) section:

- Fault Duration Sec sets the number of seconds that the next TOV will be applied for.
- Shunt uF sets the size of the shunt to be applied.
- TOV Fault Trigger initiates the application of the TOV capacitor for the required duration. It is automatically reset after this.

Faults section:

- Fault X/R sets the X/R of the fault impedance.
- Fault Type sets the faulted phases based on the PSCAD fault enumeration (e.g. 7 is a balanced fault).
- Fault duration pre-defines the duration of the fault in seconds.
- Fault Strategy allows the user to configure the fault based on a per unit residual voltage ('Ures') or a ratio of fault impedance to source impedance (Zf/Zs).
  - If Ures is selected, only the Residual Voltage (pu) slider is used.
  - If Zf/Zs is selected, the ratio of Zf/Zs is set using the Zf/Zs slider, then an additional R and X can be added to the calculated fault impedance. This allows, for example, a 10Ω fault could be applied with Zf/Zs = 0, Rf Offset = 10, Xf Offset = 0.
- Fault trigger engages a fault for the duration specified in Fault Duration

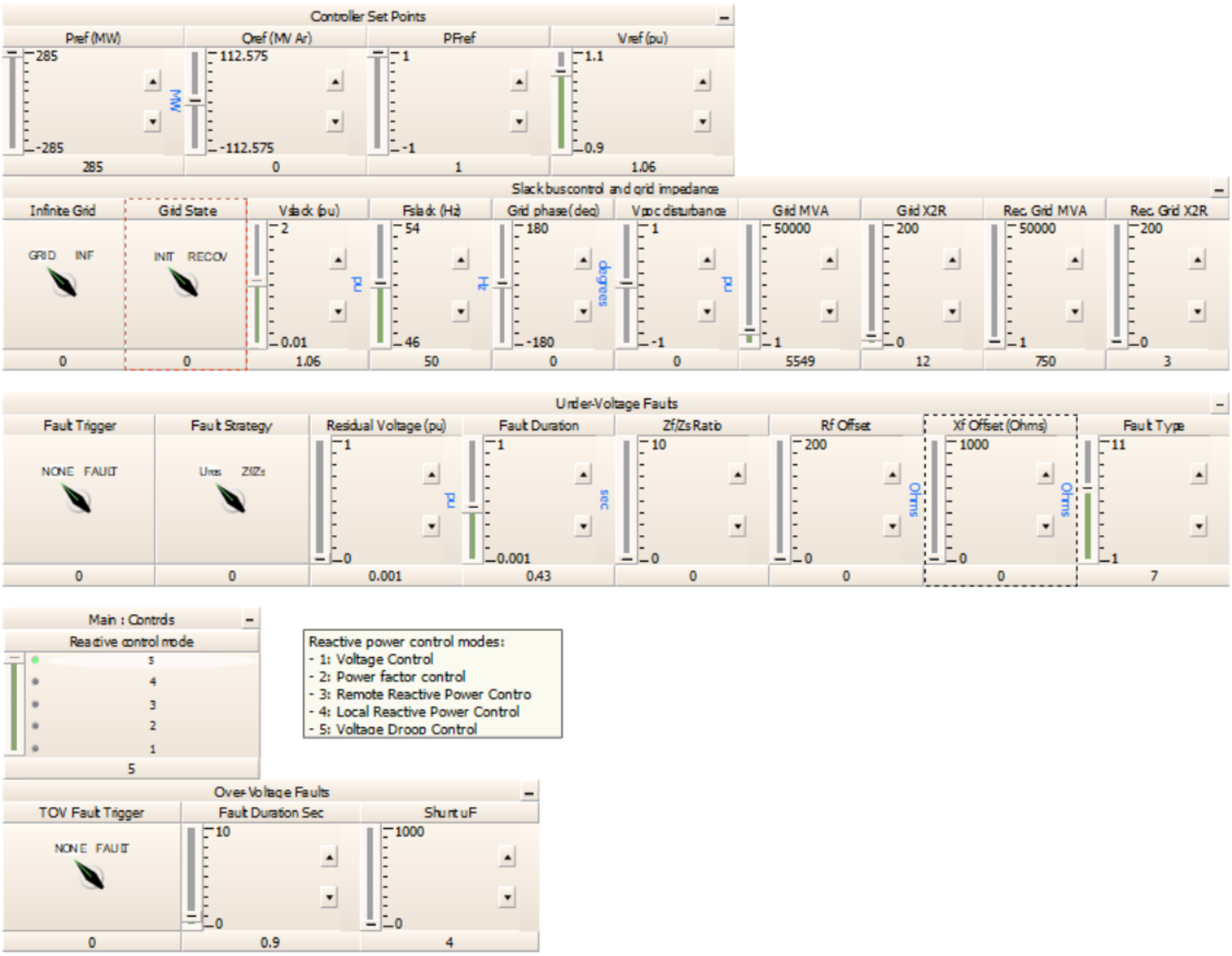


Figure 3.8: Controls region of the canvas

These set points are fed into the PPM module in the model as shown in Figure 3.9. PPC input/output table in Fluence PPC manual as shown in Table 3.4.

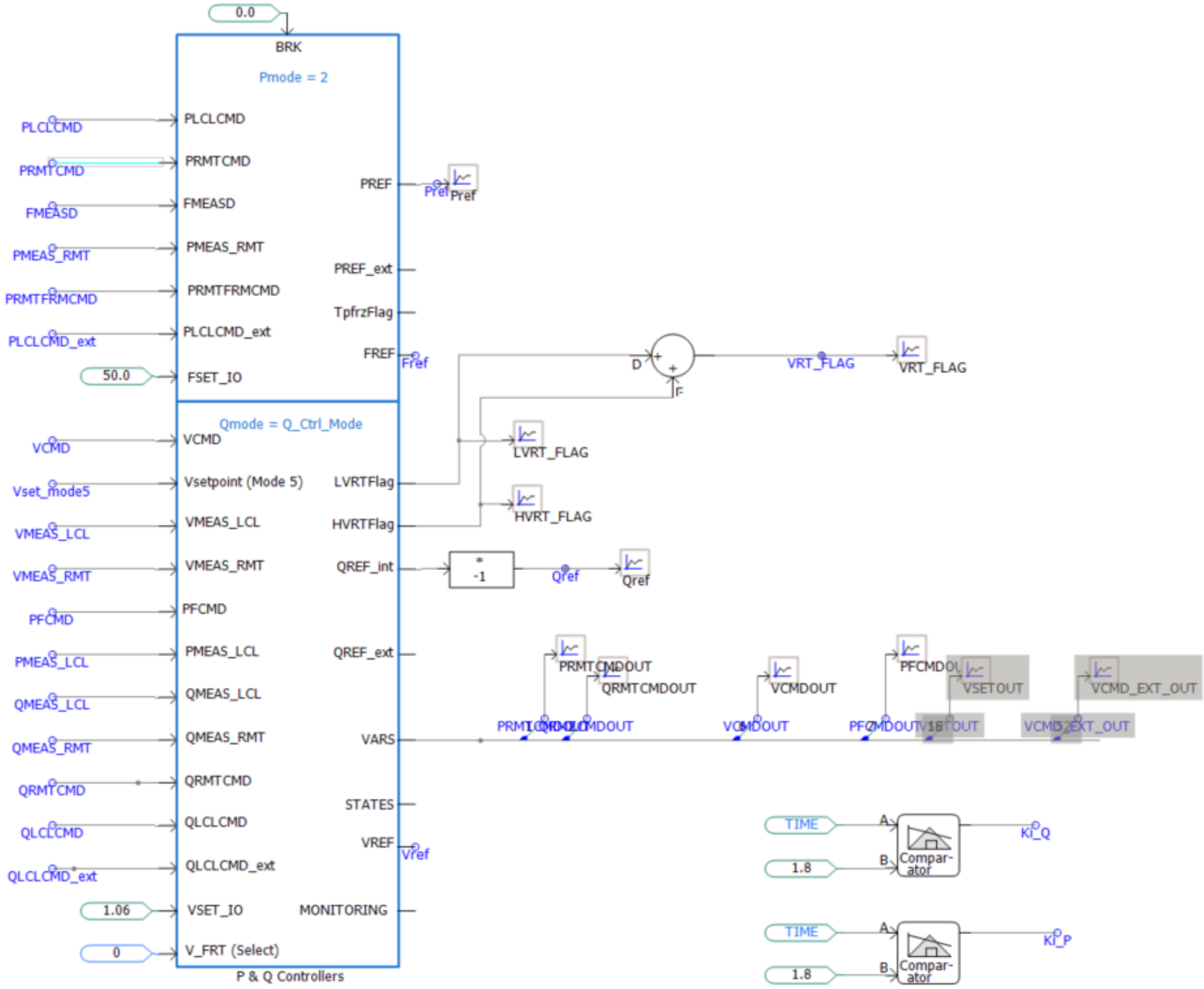


Figure 3.9: Inputs to the PPM

Table 3.4: PPC input set point table

Parameter	Type	Description
PLCLCMD	Input	Active power reference for BESS in local mode (MW)
PRMTCMD	Input	Active power reference for BESS in remote mode (MW)
FMEASD	Input	Measured frequency (Hz)
PMEASD	Input	Measured active power at remote branch/bus (MW)
PRMTFRMCMD	Input	Active power reference for firming mode (MW)
PLCCMD_ext	Input	Active power reference for the external project in local mode (MW)
FSET_IO	Input	Frequency setpoint in island operation (Hz)
PREF	Output	Active power reference for BESS (pu)
PREF_ext	Output	Active power reference for the external project (pu)
TpfrzFlag	Output	VRT extra time delay freeze flag for PPC

Table 3.4: PPC input set point table

Parameter	Type	Description
FREF	Output	Frequency reference for BESS (Hz)
VCMD	Input	Voltage reference for a bus/branch (pu)
VSETPOINT	Input	Voltage set point for voltage droop control (pu)
VMEAS_LCL	Input	Measured voltage at a local bus/branch (pu)
VMEAS_RMT	Input	Measured voltage at a remote bus/branch (pu)
PFCMD	Input	Power factor reference for a bus/branch (pu)
PMEAS_LCL	Input	Measured active power at a local bus/branch (MW)
QMEAS_LCL	Input	Measured reactive power at a local bus/branch (MVAr)
QMEAS_RMT	Input	Measured reactive power at a remote bus/branch (MVAr)
QRMTCMD	Input	Reactive power reference for a remote bus/branch (MVAr)
QLCLCMD	Input	Reactive power reference for a local bus/branch (MVAr)
QLCLCMD_ext	Input	Reactive power reference for the external project (MVAr)
VSET_IO	Input	Voltage reference in island operation (pu)
VRTFlag	Output	Voltage ride-through flag
QREF_int	Output	Reactive power reference for BESS (pu)
QREF_ext	Output	Reactive power reference for the external project (pu)
VARS	Output	Array of values matching the PSSE FLNCPPC VARS
STATES	Output	Array of values matching the PSSE FLNCPPC STATES
VREF	Output	Voltage reference for BESS (pu)
MONITORING	Output	Provides the PCS control mode

3.7.3 Simulation with a reduced number of converters and MV auxiliary transformers

To perform simulations with a reduced number of converters, the following parameters needs to be adjusted in each branch by modifying the input to the scaling component as pictured below in Figure 3.10.

All other parameters of the converter and converter transformer are in pu and will be adjusted automatically.

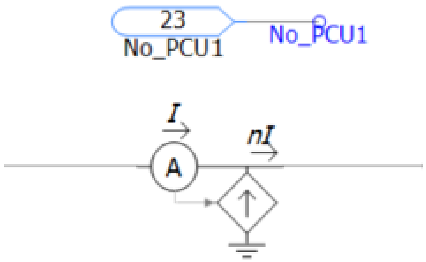


Figure 3.10: Converters and Auxiliary transformers scaling component

3.7.4 Use of external automation

A user wanting to apply their own set points from some external module can do so by setting the $(AUTO_Automation_Mode_Enabled) global substitution to 1, then replacing the top branch of the automation switch with their own automation module, as shown in Figure 3.11. The automation module used should produce a 50 element list of signals to be applied to the 50 elements in the UNMERGER list. If this is not practical, the user can take the signals they want to control out of the UNMERGER list and connect them to their own automation as required without using the MERGER and UNMERGER elements.

IMPORTANT: The disabled 'Pallet' block is used by Grid-Link for automation and should not be enabled unless directed to do so by Grid-Link as it will cause PSCAD to error unless other infrastructure is present. A 50 element array of '1's is assigned to this branch instead as it is assumed that most users will not manipulate this section.

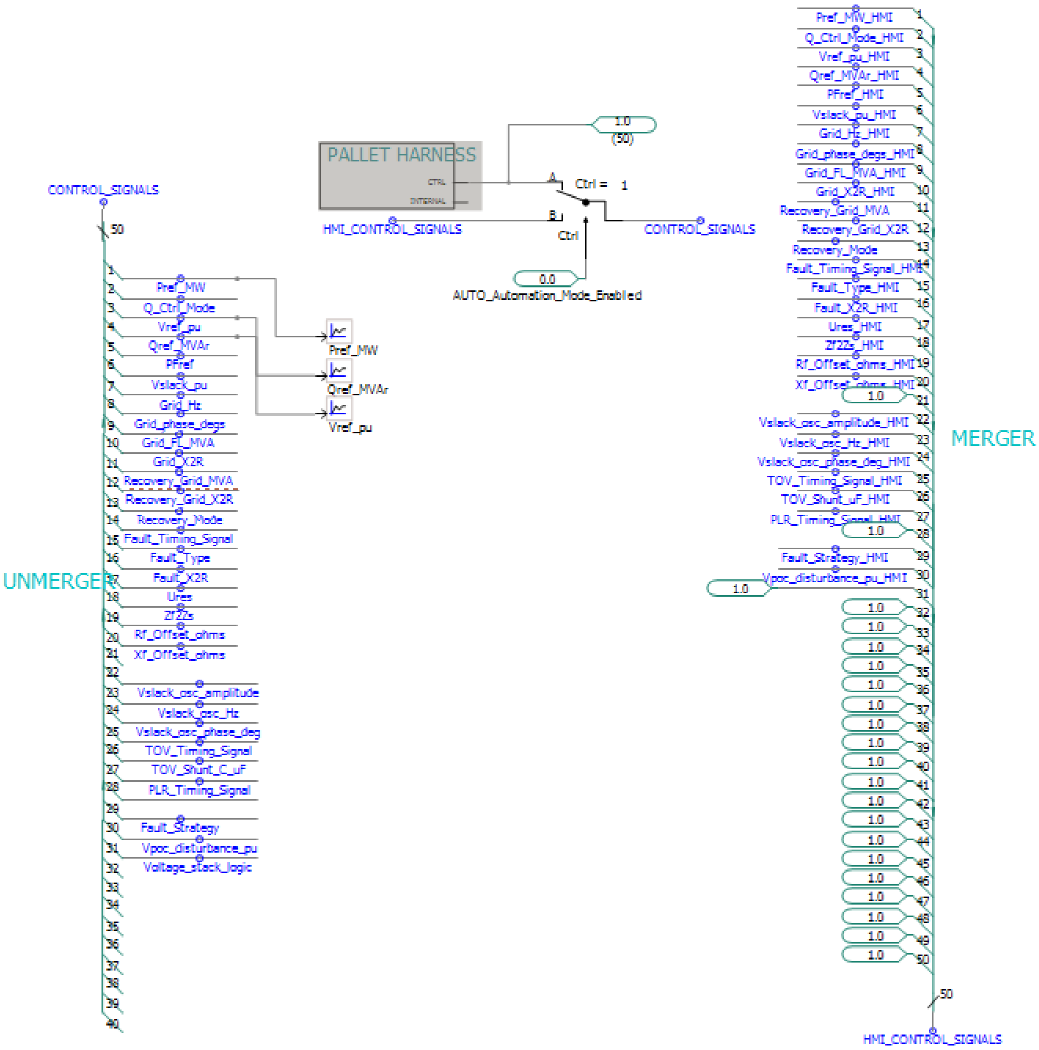


Figure 3.11: Use of external automation

Acronyms

VSL **Voltage Stackable Logic** 8

Heywood BESS **Heywood Battery Energy Storage System** 3

OLTC **On-Load Tap Changer** 5

PPC **Power Plant Controller** 5

SCR **Short Circuit Ratio** 7

SMIB **Single Machine, Infinite Bus** 5

4. Appendix A: Model parameters

4.1 Aggregated transformer parameters

Table 4.1: Grid transformer parameters

Parameter	Value
3 Phase Transformer MVA	160/80/80 [MVA]
Winding #1 Type	Delta
Winding #2 Type	Wye
Winding #3 Type	Delta
Delta Lags or Leads Y	Leads
Positive Sequence Leakage Reactance (#1-#2)	0.25 [pu]
Positive Sequence Leakage Reactance (#1-#3)	0.5 [pu]
Positive Sequence Leakage Reactance (#2-#3)	0.25 [pu]
Copper Losses (#1-#2)	0.005544 [pu]
Copper Losses (#1-#3)	0.011088 [pu]
Copper Losses (#2-#3)	0.005544 [pu]
Winding 1 Line to Line Voltage (RMS) (V1)	33.0 [kV]
Winding 2 Line to Line Voltage (RMS) (V2)	275.0 [kV]
Winding 3 Line to Line Voltage (RMS) (V3)	33.0 [kV]

Table 4.2: Inverter transformer parameters (aggregated)

Parameter	Value
Transformer Name (Name)	Unit TX
3 Phase Transformer MVA	105.8[MVA]
Winding #1 Type	Wye
Winding #2 Type	Delta
Delta Lags or Leads Y (Lead)	Lags
Positive sequence leakage reactance	0.07563122[pu]
No load losses	0.0015543478[pu]
Copper losses	0.00747784[pu]

Table 4.2: Inverter transformer parameters (aggregated)

Parameter	Value
Winding 1 Line to Line voltage (RMS) (V1)	0.69[kV]
Winding 2 Line to Line voltage (RMS) (V2)	33[kV]

4.2 275kV Underground Cable

Table 4.3: Lines and Cable parameters for Cable connecting from HV Transformer to POC (based on 100MVA and 275kV)

Cable-Group	Parameter	Description	Units	HEYWOODBESS
1	R1	Positive Sequence Resistance	pu	0.0000496
1	X1	Positive Sequence Reactance	pu	0.0002404
1	B1	Positive Sequence Susceptance	pu	0.0527
1	R0	Zero Sequence Resistance	pu	0.0001383
1	X0	Zero Sequence Reactance	pu	0.0007648
1	B0	Zero Sequence Susceptance	pu	0.0527

4.3 33kV reticulation

Table 4.4: Lines and Cable parameters for Cable connecting from 33kV switchboard to HV transformer (based on 100MVA and 33kV)

Cable-Group	Parameter	Description	Units	HEYWOODBESS
1	R1	Positive Sequence Resistance	pu	0.000051
1	X1	Positive Sequence Reactance	pu	0.000087
1	B1	Positive Sequence Susceptance	pu	0.000163
1	R0	Zero Sequence Resistance	pu	0.000272
1	X0	Zero Sequence Reactance	pu	0.00004
1	B0	Zero Sequence Susceptance	pu	0.0001629
2	R1	Positive Sequence Resistance	pu	0.000051
2	X1	Positive Sequence Reactance	pu	0.000087
2	B1	Positive Sequence Susceptance	pu	0.000163
2	R0	Zero Sequence Resistance	pu	0.000272

Table 4.4: Lines and Cable parameters for Cable connecting from 33kV switchboard to HV transformer (based on 100MVA and 33kV)

Cable-Group	Parameter	Description	Units	HEYWOODBESS
2	X0	Zero Sequence Reactance	pu	0.00004
2	B0	Zero Sequence Susceptance	pu	0.0001629
3	R1	Positive Sequence Resistance	pu	0.000051
3	X1	Positive Sequence Reactance	pu	0.000087
3	B1	Positive Sequence Susceptance	pu	0.000163
3	R0	Zero Sequence Resistance	pu	0.000272
3	X0	Zero Sequence Reactance	pu	0.00004
3	B0	Zero Sequence Susceptance	pu	0.0001629
4	R1	Positive Sequence Resistance	pu	0.000051
4	X1	Positive Sequence Reactance	pu	0.000087
4	B1	Positive Sequence Susceptance	pu	0.000163
4	R0	Zero Sequence Resistance	pu	0.000272
4	X0	Zero Sequence Reactance	pu	0.00004
4	B0	Zero Sequence Susceptance	pu	0.0001629

Table 4.5: Lines and Cable parameters for Cable connecting from MV transformers to 33kV switchboard(based on 100MVA and 33kV)

Cable-Group	Parameter	Description	Units	HEYWOODBESS
1	R1	Positive Sequence Resistance	pu	0.000141
1	X1	Positive Sequence Reactance	pu	0.000163
1	B1	Positive Sequence Susceptance	pu	0.000821
1	R0	Zero Sequence Resistance	pu	0.000522
1	X0	Zero Sequence Reactance	pu	0.00008
1	B0	Zero Sequence Susceptance	pu	0.000821
2	R1	Positive Sequence Resistance	pu	0.00035
2	X1	Positive Sequence Reactance	pu	0.000402
2	B1	Positive Sequence Susceptance	pu	0.002199
2	R0	Zero Sequence Resistance	pu	0.00129
2	X0	Zero Sequence Reactance	pu	0.000199
2	B0	Zero Sequence Susceptance	pu	0.002199
3	R1	Positive Sequence Resistance	pu	0.00022
3	X1	Positive Sequence Reactance	pu	0.000254

Table 4.5: Lines and Cable parameters for Cable connecting from MV transformers to 33kV switchboard(based on 100MVA and 33kV)

Cable-Group	Parameter	Description	Units	HEYWOODBESS
3	B1	Positive Sequence Susceptance	pu	0.001334
3	R0	Zero Sequence Resistance	pu	0.000813
3	X0	Zero Sequence Reactance	pu	0.000125
3	B0	Zero Sequence Susceptance	pu	0.001334
4	R1	Positive Sequence Resistance	pu	0.000169
4	X1	Positive Sequence Reactance	pu	0.000192
4	B1	Positive Sequence Susceptance	pu	0.000964
4	R0	Zero Sequence Resistance	pu	0.000612
4	X0	Zero Sequence Reactance	pu	0.000094
4	B0	Zero Sequence Susceptance	pu	0.000958

Table 4.6: System strength conditions

Condition	Fault Level (MVA)	X/R Ratio
System Normal (N)	5591	12.04
System Abnormal (N-1)	3185	11.24

4.4 Converters

```
#Sunny Central PSCAD configuration file, Plant: DMAT
#Version           SCxxxx R10

#Nameplate
VARtg                        4600                              # Apparent power rating in
    kVA
WRtg                         4600                              # Active power rating in
   kW
VArRtg                       3680                              # Reactive power rating in
    kVAr
HzRtg                        50.0                              # Frequency rating (and
   Frequency set point HzSpt)

InvCtlMod                    INVCTLMOD_BAT                     # Inverter control mode /
   INVCTLMOD_GRIFEED_MPP: Grid tie MPP Tracking mode / INVCTLMOD_GRIFEED_DCLVOLCNST: Grid
   tie constant DC Link voltag / INVCTLMOD_BAT: Battery inverter
Bsc_InvStrMod                1
UseSCSOpCmd                  1                                 # Activate external
   commands (For Battery Inverter only)
```

```
VArOpMod                      VAR_MOD_CNST                       # External reactive power
   setpoint handling / VAR_MOD_NONE: no external reactive power setpoint / VAR_MOD_CNST:
   external reactive power setpoint / VAR_MOD_PF_CNST: external powerfactor setpoint
Aid_Mod                       SWITCH_STT_DISABLE                 # Active islanding
   detection / SWITCH_STT_ENABLE: on / SWITCH_STT_DISABLE: off
Pld_Mod                       SWITCH_STT_DISABLE                 # Phase loss (YgD)
   detection / SWITCH_STT_ENABLE: on / SWITCH_STT_DISABLE: off

WGraMod                       SWITCH_STT_ENABLE                  # Power Set Point
   Gradients mode / SWITCH_STT_ENABLE: on / SWITCH_STT_DISABLE: off
VArGraMod                     SWITCH_STT_ENABLE                  # Power Set Point
   Gradients mode / SWITCH_STT_ENABLE: on / SWITCH_STT_DISABLE: off
WGra                          100.0                              # Power Set Point
   Gradients (Range VArGra: [0.01 ...1]; Range WGra: [0.01 ...2])
VArGra                        100.0                              # Power Set Point
   Gradients (Range VArGra: [0.01 ...1]; Range WGra: [0.01 ...2])

WFilMod                       SWITCH_STT_ENABLE                  # Power Set Point Filter
   mode / SWITCH_STT_ENABLE: on / SWITCH_STT_DISABLE: off
VArFilMod                     SWITCH_STT_ENABLE                  # Power Set Point Filter
   mode / SWITCH_STT_ENABLE: on / SWITCH_STT_DISABLE: off
WFilTm                        0.1                                # Power Set Point PT1
   filters in sec (Range WFilTm: [0.01 ...2]; Range VArFilTm: [0.01 ...2])
VArFilTm                      0.1                                # Power Set Point PT1
   filters in sec (Range WFilTm: [0.01 ...2]; Range VArFilTm: [0.01 ...2])

VADrtPriMod                   VADRTPRIMOD_VAR                    # Power Priority (
   Recommendation: VADRTPRIMOD_VAR) / VADRTPRIMOD_W: active power / VADRTPRIMOD_VAR:
   reactive power
GriMng_InvVArMod              GRIMNG_INVVARMOD_OFF               # Reactive power as a
   function of voltage / GRIMNG_INVVARMOD_OFF: off / GRIMNG_INVVARMOD_VARCTLVOL: Q/V
   function
VArCtlVol_VArSptFilTm         0.01

WCtlHzMod                     SWITCH_STT_DISABLE                 # Active Power as a
   function of frequency for PV: Mode over frequency / SWITCH_STT_DISABLE: off /
   SWITCH_STT_ENABLE: on
WCtlHzBatMod                  SWITCH_STT_DISABLE                 # Active Power as a
   function of frequency for BESS: Mode over frequency / SWITCH_STT_DISABLE: off /
   SWITCH_STT_ENABLE: on
WCtlHzLoHiMod                 SWITCH_STT_DISABLE

GriMng_HzFilTm                0.1                                # Time constant frequency
   filter, grid managment in s
VCtl_CorrTm                   0.0                                # CorrTm: correction of
   the internal delay of the measurement algorithms - Set to 0 if you want the inverter to
    stay connected and trip after the time (e.g. BDEW) - set to negative values if you
   want the the inverter to trip before the given time (e.g. UL1741)
HzCtl_CorrTm                  0.0                                # CorrTm: correction of
   the internal delay of the measurement algorithms - Set to 0 if you want the inverter to
    stay conno stay connected and trip after the time (e.g. BDEW) - set to negative values
    if you want the the inverter to trip before the given time (e.g. UL1741)
```

```
VCtl_OpMaxNom              1.10                          # Upper and lower voltage
   for connection
VCtl_OpMinNom              0.90                          # Upper and lower voltage
   for connection
VCtl_OpMaxNomRecon         1.10                          # Upper and lower voltage
   for connection
VCtl_OpMinNomRecon         0.90                          # Upper and lower voltage
   for connection

HzCtl_OpMaxNom             50.5                          # Upper and lower
   frequency limit for connection
HzCtl_OpMinNom             49.3                          # Upper and lower
   frequency limit for connection
HzCtl_OpMaxNomRecon        50.5                          # Upper and lower
   frequency limit for connection
HzCtl_OpMinNomRecon        49.3                          # Upper and lower
   frequency limit for connection

VCtl_PkLim                 1.4                           # Instantaneous voltage
   protection in p.u. - in real firmware this can be set to maximum 1.5pu.
VCtl_PkLimTm               102                           # instantaneous voltage
   protection time in 6kHz steps: e.g. 6 = 1ms

VCtl_Hi5Lim                2.0                           # Over voltage trip limits
    VCtl_Hi[1..5]Lim in p.u. (Range: [1.0 ...2.0]). 2 decimal places only - !!!check
   technical information regarding voltage limits of specific inverter models!!!
VCtl_Hi4Lim                1.5                           # Over voltage trip limits
    VCtl_Hi[1..5]Lim in p.u. (Range: [1.0 ...2.0]). 2 decimal places only - !!!check
   technical information regarding voltage limits of specific inverter models!!!
VCtl_Hi3Lim                1.3                           # Over voltage trip limits
    VCtl_Hi[1..5]Lim in p.u. (Range: [1.0 ...2.0]). 2 decimal places only - !!!check
   technical information regarding voltage limits of specific inverter models!!!
VCtl_Hi2Lim                1.25                          # Over voltage trip limits
    VCtl_Hi[1..5]Lim in p.u. (Range: [1.0 ...2.0]). 2 decimal places only - !!!check
   technical information regarding voltage limits of specific inverter models!!!
VCtl_Hi1Lim                1.15                           # Over voltage trip
   limits VCtl_Hi[1..5]Lim in p.u. (Range: [1.0 ...2.0]). 2 decimal places only - !!!check
    technical information regarding voltage limits of specific inverter models!!!

VCtl_Hi5LimTm              1.66                           # Over voltage trip limit
    times VCtl_Hi[1..5]LimTm in ms (Range: [100 ...1000000]). - !!!check technical
   information regarding voltage limits of specific inverter models!!!
VCtl_Hi4LimTm              3                            # Over voltage trip limit
   times VCtl_Hi[1..5]LimTm in ms (Range: [100 ...1000000]). - !!!check technical
   information regarding voltage limits of specific inverter models!!!
VCtl_Hi3LimTm              20                            # Over voltage trip limit
   times VCtl_Hi[1..5]LimTm in ms (Range: [100 ...1000000]). - !!!check technical
   information regarding voltage limits of specific inverter models!!!
VCtl_Hi2LimTm              1000                           # Over voltage trip limit
   times VCtl_Hi[1..5]LimTm in ms (Range: [100 ...1000000]). - !!!check technical
   information regarding voltage limits of specific inverter models!!!
```

```
VCtl_Hi1LimTm                 60000                        # Over voltage trip limit
   times VCtl_Hi[1..5]LimTm in ms (Range: [100 ...1000000]). - !!!check technical
   information regarding voltage limits of specific inverter models!!!

VCtl_Lo1Lim                   0.8                           # Under voltage trip
   limits VCtl_Lo[1..5]Lim in p.u. (Range: [0.0 ...1.0]). 2 decimal places only. - !!!
   check technical information regarding voltage limits of specific inverter models!!!
VCtl_Lo2Lim                   0.4                           # Under voltage trip
   limits VCtl_Lo[1..5]Lim in p.u. (Range: [0.0 ...1.0]). 2 decimal places only. - !!!
   check technical information regarding voltage limits of specific inverter models!!!
VCtl_Lo3Lim                   0.0                           # Under voltage trip
   limits VCtl_Lo[1..5]Lim in p.u. (Range: [0.0 ...1.0]). 2 decimal places only. - !!!
   check technical information regarding voltage limits of specific inverter models!!!
VCtl_Lo4Lim                   0.0                           # Under voltage trip
   limits VCtl_Lo[1..5]Lim in p.u. (Range: [0.0 ...1.0]). 2 decimal places only. - !!!
   check technical information regarding voltage limits of specific inverter models!!!
VCtl_Lo5Lim                   0.0                           # Under voltage trip
   limits VCtl_Lo[1..5]Lim in p.u. (Range: [0.0 ...1.0]). 2 decimal places only. - !!!
   check technical information regarding voltage limits of specific inverter models!!!

VCtl_Lo1LimTm                 21000                          # Under voltage trip
   limit times VCtl_Lo[1..5]LimTm in ms (Range: [100 ...1000000]). - !!!check technical
   information regarding voltage limits of specific inverter models!!!
VCtl_Lo2LimTm                 21000                          # Under voltage trip
   limit times VCtl_Lo[1..5]LimTm in ms (Range: [100 ...1000000]). - !!!check technical
   information regarding voltage limits of specific inverter models!!!
VCtl_Lo3LimTm                 21000                          # Under voltage trip
   limit times VCtl_Lo[1..5]LimTm in ms (Range: [100 ...1000000]). - !!!check technical
   information regarding voltage limits of specific inverter models!!!
VCtl_Lo4LimTm                 21000                          # Under voltage trip
   limit times VCtl_Lo[1..5]LimTm in ms (Range: [100 ...1000000]). - !!!check technical
   information regarding voltage limits of specific inverter models!!!
VCtl_Lo5LimTm                 21000                          # Under voltage trip
   limit times VCtl_Lo[1..5]LimTm in ms (Range: [100 ...1000000]). - !!!check technical
   information regarding voltage limits of specific inverter models!!!

HzCtl_Hi6Lim                  55.0                          # Over frequency trip
   limits HzCtl_Hi[1..6]Lim in Hz. 2 decimal places only. - !!!check technical information
    regarding voltage limits of specific inverter models!!!
HzCtl_Hi5Lim                  55.0                          # Over frequency trip
   limits HzCtl_Hi[1..6]Lim in Hz. 2 decimal places only. - !!!check technical information
    regarding voltage limits of specific inverter models!!!
HzCtl_Hi4Lim                  54.0                          # Over frequency trip
   limits HzCtl_Hi[1..6]Lim in Hz. 2 decimal places only. - !!!check technical information
    regarding voltage limits of specific inverter models!!!
HzCtl_Hi3Lim                  53.0                          # Over frequency trip
   limits HzCtl_Hi[1..6]Lim in Hz. 2 decimal places only. - !!!check technical information
    regarding voltage limits of specific inverter models!!!
HzCtl_Hi2Lim                  53.0                          # Over frequency trip
   limits HzCtl_Hi[1..6]Lim in Hz. 2 decimal places only. - !!!check technical information
    regarding voltage limits of specific inverter models!!!
```

```
HzCtl_Hi1Lim                 53.0                              # Over frequency trip
   limits HzCtl_Hi[1..6]Lim in Hz. 2 decimal places only. - !!!check technical information
    regarding voltage limits of specific inverter models!!!

HzCtl_Hi6LimTm               100                              # over frequency trip limit
    times HzCtl_Hi[1..5]LimTm in ms (Range: [100 ...1000000]) - !!!check technical
   information regarding voltage limits of specific inverter models!!!
HzCtl_Hi5LimTm               100                              # over frequency trip limit
    times HzCtl_Hi[1..5]LimTm in ms (Range: [100 ...1000000]) - !!!check technical
   information regarding voltage limits of specific inverter models!!!
HzCtl_Hi4LimTm               60000                             # over frequency trip
   limit times HzCtl_Hi[1..5]LimTm in ms (Range: [100 ...1000000]) - !!!check technical
   information regarding voltage limits of specific inverter models!!!
HzCtl_Hi3LimTm               60000                             # over frequency trip
   limit times HzCtl_Hi[1..5]LimTm in ms (Range: [100 ...1000000]) - !!!check technical
   information regarding voltage limits of specific inverter models!!!
HzCtl_Hi2LimTm               60000                             # over frequency trip
   limit times HzCtl_Hi[1..5]LimTm in ms (Range: [100 ...1000000]) - !!!check technical
   information regarding voltage limits of specific inverter models!!!
HzCtl_Hi1LimTm               60000                             # over frequency trip
   limit times HzCtl_Hi[1..5]LimTm in ms (Range: [100 ...1000000]) - !!!check technical
   information regarding voltage limits of specific inverter models!!!

HzCtl_Lo1Lim                 45.0                              # Under frequency trip
   limits HzCtl_Lo[1..6]Lim in Hz. 2 decimal places only. - !!!check technical information
    regarding voltage limits of specific inverter models!!!
HzCtl_Lo2Lim                 46.0                              # Under frequency trip
   limits HzCtl_Lo[1..6]Lim in Hz. 2 decimal places only. - !!!check technical information
    regarding voltage limits of specific inverter models!!!
HzCtl_Lo3Lim                 47.0                              # Under frequency trip
   limits HzCtl_Lo[1..6]Lim in Hz. 2 decimal places only. - !!!check technical information
    regarding voltage limits of specific inverter models!!!
HzCtl_Lo4Lim                 47.0                              # Under frequency trip
   limits HzCtl_Lo[1..6]Lim in Hz. 2 decimal places only. - !!!check technical information
    regarding voltage limits of specific inverter models!!!
HzCtl_Lo5Lim                 47.0                              # Under frequency trip
   limits HzCtl_Lo[1..6]Lim in Hz. 2 decimal places only. - !!!check technical information
    regarding voltage limits of specific inverter models!!!
HzCtl_Lo6Lim                 47.0                              # Under frequency trip
   limits HzCtl_Lo[1..6]Lim in Hz. 2 decimal places only. - !!!check technical information
    regarding voltage limits of specific inverter models!!!

HzCtl_Lo1LimTm               100                              # Under frequency trip
   limit times HzCtl_Lo[1..5]LimTm in ms (Range: [100 ...1000000]) - !!!check technical
   information regarding voltage limits of specific inverter models!!!
HzCtl_Lo2LimTm               60000                             # Under frequency trip
   limit times HzCtl_Lo[1..5]LimTm in ms (Range: [100 ...1000000]) - !!!check technical
   information regarding voltage limits of specific inverter models!!!
HzCtl_Lo3LimTm               60000                             # Under frequency trip
   limit times HzCtl_Lo[1..5]LimTm in ms (Range: [100 ...1000000]) - !!!check technical
   information regarding voltage limits of specific inverter models!!!
```

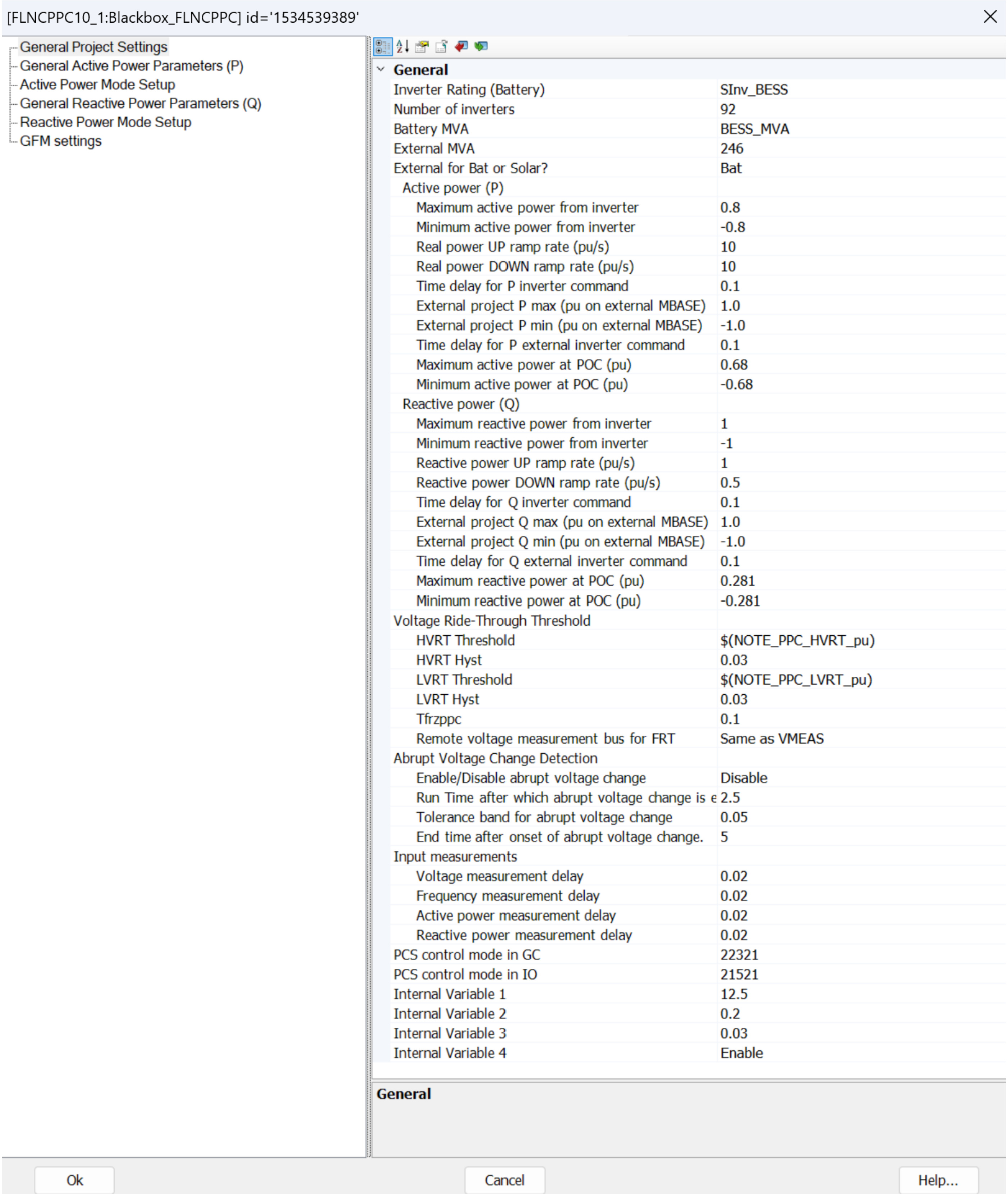
```
HzCtl_Lo4LimTm                  60000                              # Under frequency trip
    limit times HzCtl_Lo[1..5]LimTm in ms (Range: [100 ...1000000]) - !!!check technical
    information regarding voltage limits of specific inverter models!!!
HzCtl_Lo5LimTm                  60000                              # Under frequency trip
    limit times HzCtl_Lo[1..5]LimTm in ms (Range: [100 ...1000000]) - !!!check technical
    information regarding voltage limits of specific inverter models!!!
HzCtl_Lo6LimTm                  60000                              # Under frequency trip
    limit times HzCtl_Lo[1..5]LimTm in ms (Range: [100 ...1000000]) - !!!check technical
    information regarding voltage limits of specific inverter models!!!

Pll_Inv_HzGraLim                300                                # PLL parameters - DO NOT
    change without permission from SMA
Pll_GriMon_HzGraLim             300                                # PLL parameters - DO NOT
    change without permission from SMA
Pll_Inv_DmpRto                  2.0                                # PLL parameters - DO NOT
    change without permission from SMA
Pll_GriMon_DmpRto               2.0                                # PLL parameters - DO NOT
    change without permission from SMA
Pll_Inv_SetTm                   0.045                              # PLL parameters - DO NOT
    change without permission from SMA
Pll_GriMon_SetTm                0.045                              # PLL parameters - DO NOT
    change without permission from SMA
Pll_Inv_On2Srch_NomSum          300                                # Pll model backwards
    compatibility of non SC/SCS UP inverters
Pll_GriMon_On2Srch_NomSum       300                                # PLL parameters - DO NOT
    change without permission from

Pll_Inv_HzFilOff2On_Vol         0.3                                # PLL parameters - DO NOT
    change without permission from SMA
Pll_GriMon_HzFilOff2On_Vol      0.3                                # PLL parameters - DO NOT
    change without permission from SMA
Pll_Inv_HzFilWt2On_Vol          0.65                               # PLL parameters - DO NOT
    change without permission from SMA
Pll_GriMon_HzFilWt2On_Vol       0.6                                # PLL parameters - DO NOT
    change without permission from SMA
Pll_Inv_HzFilOn2Wt_Vol          0.75                               # PLL parameters - DO NOT
    change without permission from SMA
Pll_GriMon_HzFilOn2Wt_Vol       0.7                                # PLL parameters - DO NOT
    change without permission from SMA
Pll_Inv_HzFilWt2Off_HysTm       50                                 # PLL parameters - DO NOT
    change without permission from SMA
Pll_GriMon_HzFilWt2Off_HysTm    50                                 # PLL parameters - DO NOT
    change without permission from SMA


###########################   GridForming     ######################################
# Control Mode Setting Options:
# ScsOpCmd=22321: GridForming Angle Inertia and Q/V Droop
#################################################################

GriForm_AcCtl_DrpVol            0.167                              # Droop: Reactive Current
     -Voltage Droop positive sequence; only active for ScsOpCmd = 21521 or 22321; (
```

```
   accessible via Modbus interface)
GriForm_AcCtl_DrpVolNs         0.167                              # Droop: Negative
   sequence droop; active for ScsOpCmd = 21521/22321/22322/22323

GriForm_AcCtl_WSptScal         1.0                                # Droop: Active Power
   Scaling of plant control setpoints
GriForm_AcCtl_VArSptScal       1.0                                # Droop: Reactive Power
   Scaling of plant control setpoints

GriForm_PwrCtl_VolDQLim        0.75                               # PARAMETER NORMAL
   OPERATION - Current setpoint calculation: voltage filter freeze limit, Grid forming
   mode
GriForm_AmpQFilTm              0.02                               # PARAMETER NORMAL
   OPERATION - Grid forming: Q current positive sequence, filter time constant
GriForm_AmpNsDQFilTm           0.02                               # PARAMETER NORMAL
   OPERATION - Grid forming: DQ current negative sequence, filter time constant

License_Inertia                SWITCH_STT_ENABLE                  # Inertia: Licence
   Activation / SWITCH_STT_DISABLE: Inertia off (default) / SWITCH_STT_ENABLE: Inertia on
   - ANGLE INERTIA CONTROL (existing license is prerequisite for activation of inertia
   control modes via AuxCtl.ScsOpCmd interface)
GriForm_AcCtl_InertiaThetaH    1                                # Inertia: Voltage angle
   inertia constant H_theta = 0.5*(dP/Snom)/(RoCoF/Fnom); only active for ScsOpCmd = 22321
    or 22323; attention: AmpRtg and WRtg dependence; (accessible via Modbus interface)
GriForm_AcCtl_InertiaHzDmp    -1.8                                # Inertia: Voltage
   frequency damping gain of voltage angle inertia control; only active for ScsOpCmd =
   22321 or 22323; (accessible via Modbus interface)

GriForm_Frt_AMaxNomInit        1.3                                # Grid forming FRT: Init
   value of maximum short circuit current in the virtual impedance; AmpRtg dependend
GriForm_Frt_AmpPsQPrioEna      SWITCH_STT_ENABLE                  # Grid forming FRT:
   Virtual impedance, activation of the reactive current priority (positive sequence)

GriForm_Frt_Mod                GRIFORM_FRT_MOD_FULL_VI_K_FAC_ADVANCED # Grid forming FRT:
   Mode / GRIFORM_FRT_MOD_FULL_VI_GRA_ADVANCED: k-factor compatibility with advanced
   parametrization

GriForm_Frt_VirtImpKeSec2Lim   0.2                                # Grid forming FRT:
   Virtual impedance, Limit for resonant controller gain in sector 2
GriForm_Frt_VirtImpKeFilTm     0.006                              # Grid forming FRT:
   Virtual impedance, resonant controller gain, filter time constant
GriForm_Frt_VirtImpKeInit      900                                # Grid forming FRT:
   Virtual impedance, resonant controller gain, initialization
GriForm_Frt_FFWVolFilTm        0.001                              # Grid forming FRT:
   Virtual impedance, time constant of voltage adjustment of feedforward of virtual
   reactance

GriForm_Frt_VirtImpReact       0.167                              # Grid forming FRT:
   Virtual impedance, positive sequence reactance
GriForm_Frt_VirtImpReactMin    0.167                              # Grid forming FRT:
   Virtual impedance, positive sequence minimum reactance
```

```
GriForm_Frt_VirtImpReactFFWOfs 0.03                              # Grid forming FRT:
   Virtual impedance, offset of feedforward of virtual reactance
GriForm_Frt_VirtImpReactNs     0.167                             # Grid forming FRT:
   Virtual impedance, negative sequence reactance
GriForm_Frt_VirtImpRisInit     0.05                             #added looking at SMA docs

GriForm_Frt_AmpCtlOfsKiFac     8.0                               #Grid forming FRT:
   Adaptive current control, factor of current control offset
GriForm_Frt_AmpCtlFilTm        0.001                             #Grid forming FRT:
   Adaptive current control, filter time constant
GriForm_Frt_ArmsMsMaxLim       1.3                               #Grid forming FRT: maximum
    limit for measured short circuit current in the virtual impedance
GriForm_Frt_CtlDevLimMax       0.3                               #Grid forming FRT:
   Adaptive apparent current control, maximum control deviation
GriForm_Frt_AmpCtlKi           10                                 #Grid forming FRT: added
   after SMA comment

GriForm_Frt_VolPsQCtlKp        -7                              # Phase angle jump - phase
   following control - Grid forming FRT: VolPsQ control during virtual impedance,
   proportional gain
GriForm_Frt_VolPsQCtlHzOfsMax  1                                 #Grid forming FRT: added
   after SMA comment

GriForm_Frt_VirtImpLimTm       20000                             # Virtual Impedance
   duration and locking for repetitive FRTs / Reclosure events
GriForm_Frt_VirtImpLockTm      500                                # Virtual Impedance
   duration and locking for repetitive FRTs / Reclosure events
GriForm_Frt_VirtImpWaitTm      50                                # Virtual Impedance
   duration and locking for repetitive FRTs / Reclosure events
GriForm_Frt_VirtImpDlTm        5.0                               # Virtual Impedance
   duration and locking for repetitive FRTs / Reclosure events

ACtl_Hi3Lim                    2.0                               # Over current trip limits
    ACtl_Hi[1..3]Lim in p.u. (Range: [1.0 ...2.0]). 2 decimal places only.
ACtl_Hi2Lim                    1.4                               # Over current trip limits
    ACtl_Hi[1..3]Lim in p.u. (Range: [1.0 ...2.0]). 2 decimal places only.
ACtl_Hi1Lim                    1.25                              # Over current trip limits
    ACtl_Hi[1..3]Lim in p.u. (Range: [1.0 ...2.0]). 2 decimal places only.

ACtl_Hi3LimTm                  140                               # Over voltage trip limit
   times ACtl_Hi[1..3]LimTm in ms (Range: [0 ...1000000]).
ACtl_Hi2LimTm                  1000                              # Over voltage trip limit
   times ACtl_Hi[1..3]LimTm in ms (Range: [0 ...1000000]).
ACtl_Hi1LimTm                  5000                              # Over voltage trip limit
   times ACtl_Hi[1..3]LimTm in ms (Range: [0 ...1000000]).

GriForm_GriOkTm                500                               # Transition AcRmpUp ->
   GriFeed.Bat.GriForm during Blackstart (ms)
GriForm_AcCtl_HarmCtlEna       SWITCH_STT_ENABLE                 # Mitigation of decaying
   DC component / SWITCH_STT_DISABLE: off / SWITCH_STT_ENABLE: on
```

```
#End of SC configuration file
```

4.5 Power Plant Control



General	
Inverter Rating (Battery)	SInv_BESS
Number of inverters	92
Battery MVA	BESS_MVA
External MVA	246
External for Bat or Solar?	Bat
Active power (P)	
Maximum active power from inverter	0.8
Minimum active power from inverter	-0.8
Real power UP ramp rate (pu/s)	10
Real power DOWN ramp rate (pu/s)	10
Time delay for P inverter command	0.1
External project P max (pu on external MBASE)	1.0
External project P min (pu on external MBASE)	-1.0
Time delay for P external inverter command	0.1
Maximum active power at POC (pu)	0.68
Minimum active power at POC (pu)	-0.68
Reactive power (Q)	
Maximum reactive power from inverter	1
Minimum reactive power from inverter	-1
Reactive power UP ramp rate (pu/s)	1
Reactive power DOWN ramp rate (pu/s)	0.5
Time delay for Q inverter command	0.1
External project Q max (pu on external MBASE)	1.0
External project Q min (pu on external MBASE)	-1.0
Time delay for Q external inverter command	0.1
Maximum reactive power at POC (pu)	0.281
Minimum reactive power at POC (pu)	-0.281
Voltage Ride-Through Threshold	
HVRT Threshold	$(NOTE_PPC_HVRT_pu)
HVRT Hyst	0.03
LVRT Threshold	$(NOTE_PPC_LVRT_pu)
LVRT Hyst	0.03
Tfrzppc	0.1
Remote voltage measurement bus for FRT	Same as VMEAS
Abrupt Voltage Change Detection	
Enable/Disable abrupt voltage change	Disable
Run Time after which abrupt voltage change is e	2.5
Tolerance band for abrupt voltage change	0.05
End time after onset of abrupt voltage change.	5
Input measurements	
Voltage measurement delay	0.02
Frequency measurement delay	0.02
Active power measurement delay	0.02
Reactive power measurement delay	0.02
PCS control mode in GC	22321
PCS control mode in IO	21521
Internal Variable 1	12.5
Internal Variable 2	0.2
Internal Variable 3	0.03
Internal Variable 4	Enable

Figure 4.1: General Project Settings

[FLNCPPC10_1:Blackbox_FLNCPPC] id='1534539389'

- General Project Settings
- General Active Power Parameters (P)
- Active Power Mode Setup
- General Reactive Power Parameters (Q)
- Reactive Power Mode Setup
- GFM settings

General

P Control Mode	Mode 2
Frequency Stack Logic?	Enable
Over Freq Deadband	50.015
1st Over Freq	50.015
2nd Over Freq	51.5
3rd Over Freq	52.5
1st Power Over Freq	-0.00402
2nd Power Over Freq	-0.402
3rd Power Over Freq	-0.67
Under Freq Deadband	49.985
1st Under Freq	49.985
2nd Under Freq	48.5
3rd Under Freq	47.5
1st Power Under Freq	0.00402
2nd Power Under Freq	0.402
3rd Power Under Freq	0.67
Deload LFSMU?	Disable
Droop of the LFSMU Deload logic	2
Maximum contribution during Deload	0
Active power POD	Disable
POD Gain	1
Washout time constant	0.5
Lead time constant	0.245
Lag time constant	0.411
Gain exponent	1
Nominal frequency	50
Upper limit	0.1
Lower limit	-0.1
Synthetic Inertia ?	Disable
RoCoF averaging time window	0.5
RoCoF measurement delay	0.02
Discontinuous mode	Disable
Internal parameter	0.3
+ dfdt deadband	0.1
1st + dfdt	0.2
2nd + dfdt	0.5
3rd + dfdt	1
1st + Delta P	-0.01
2nd + Delta P	-0.02
- dfdt deadband	-0.1
3rd + Delta P	-0.05
1st - dfdt	-0.2
2nd - dfdt	-0.5
3rd - dfdt	-1.0
1st - Delta P	0.01
2nd - Delta P	0.02
3rd - Delta P	0.05

General

Ok | Cancel | Help...

Figure 4.2: General Active Power Parameters (P)

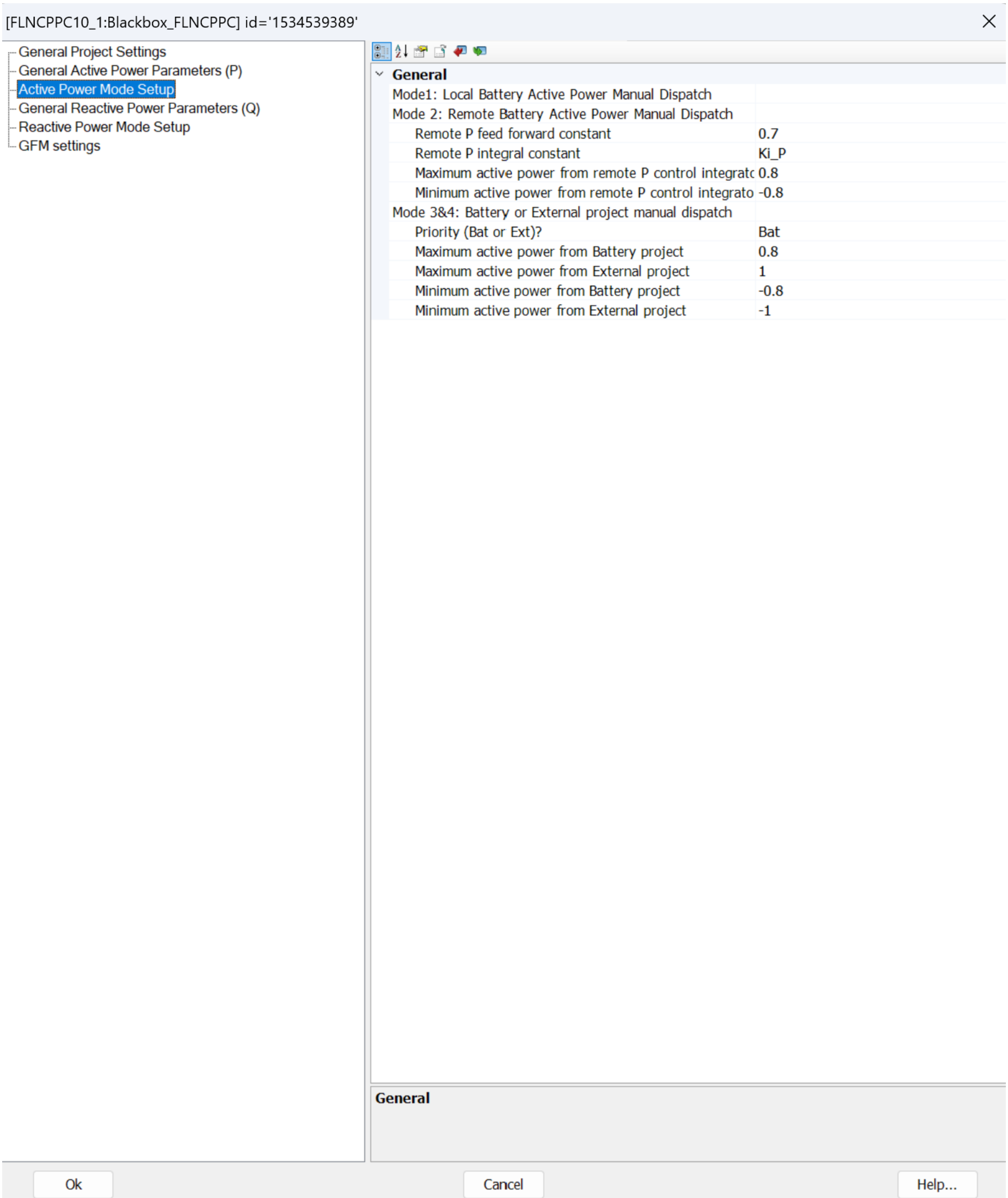


Figure 4.3: Active Power Mode Setup

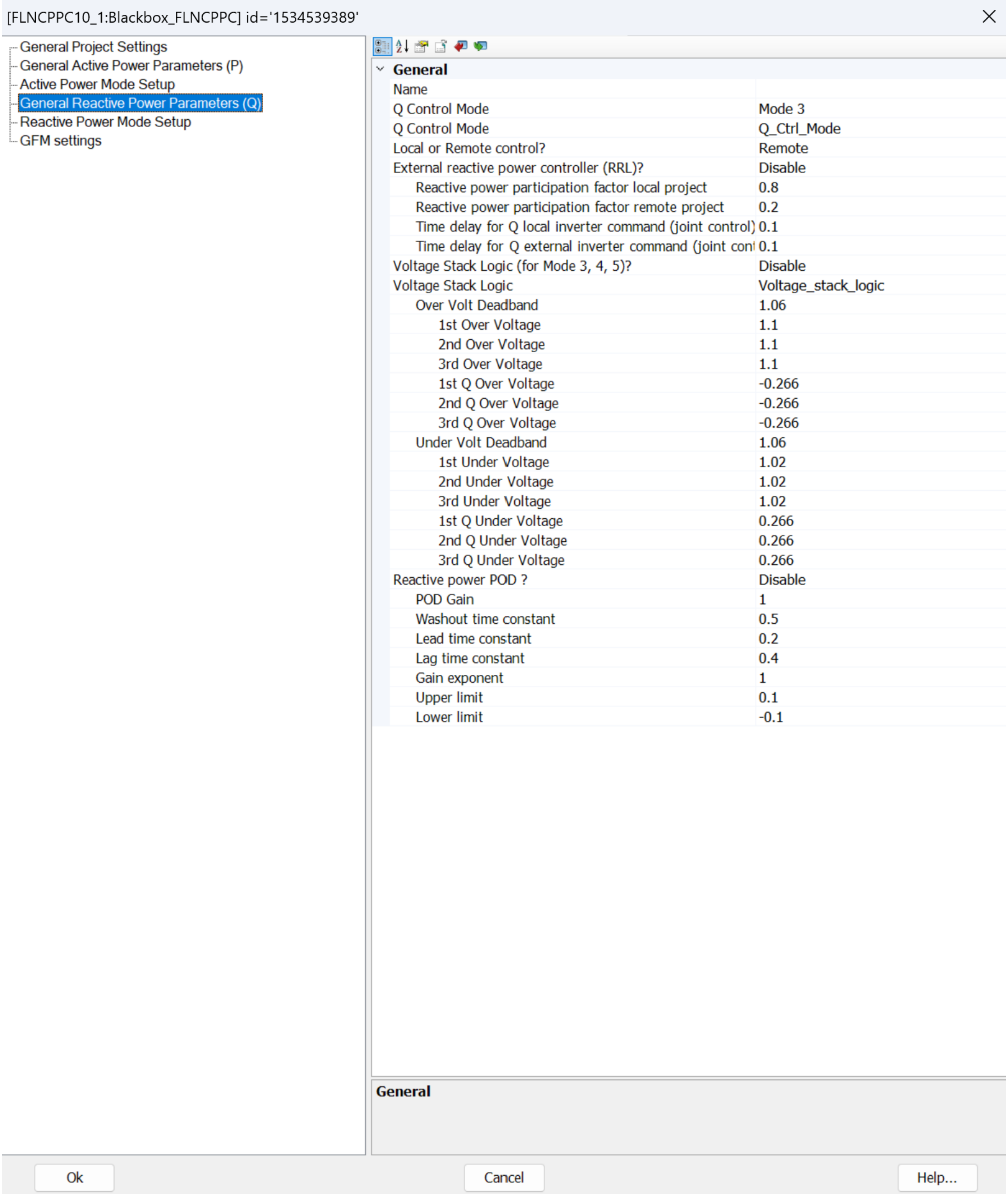


Figure 4.4: General Reactive Power Parameters (Q)

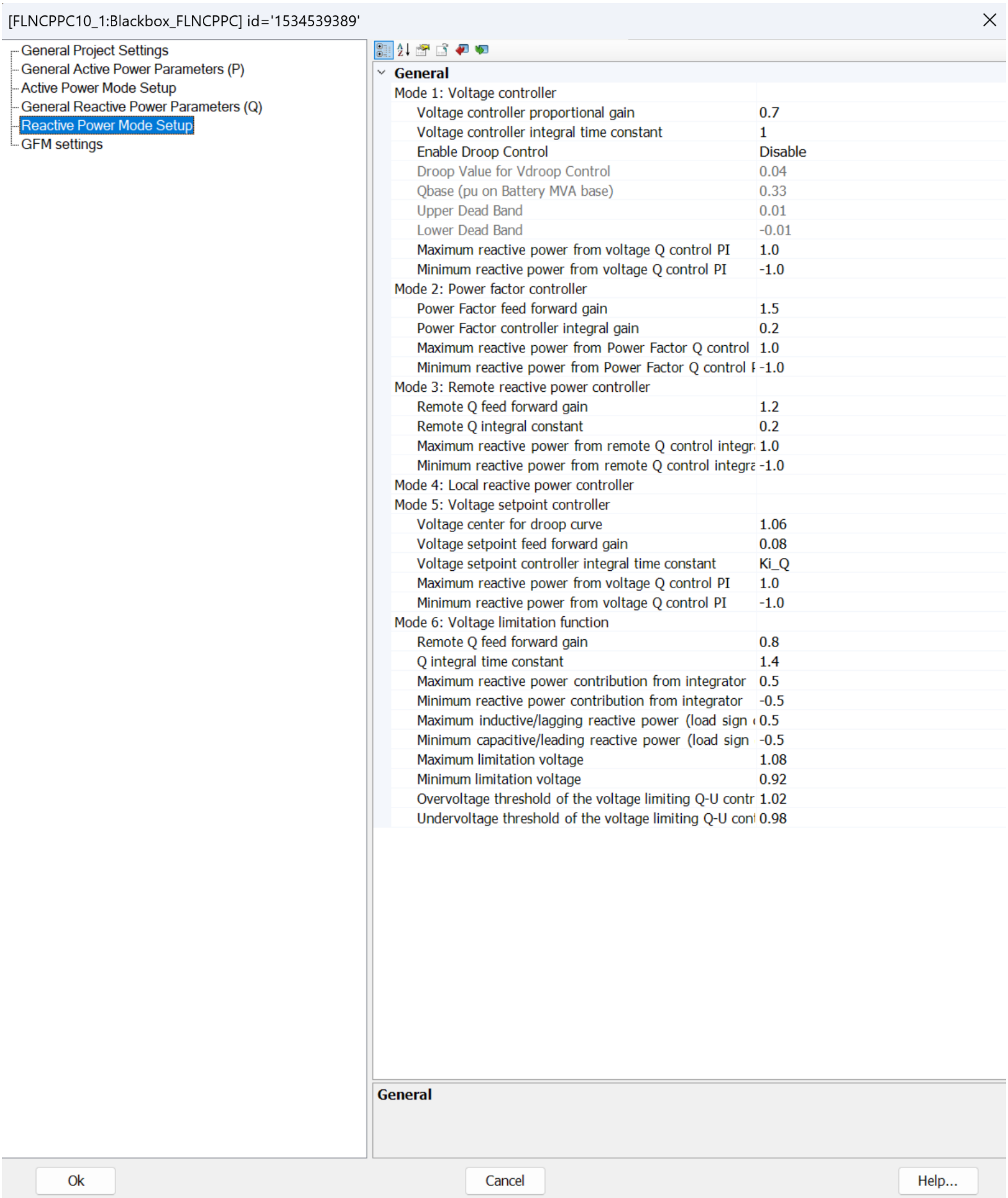


Figure 4.5: Reactive Power Mode Setup

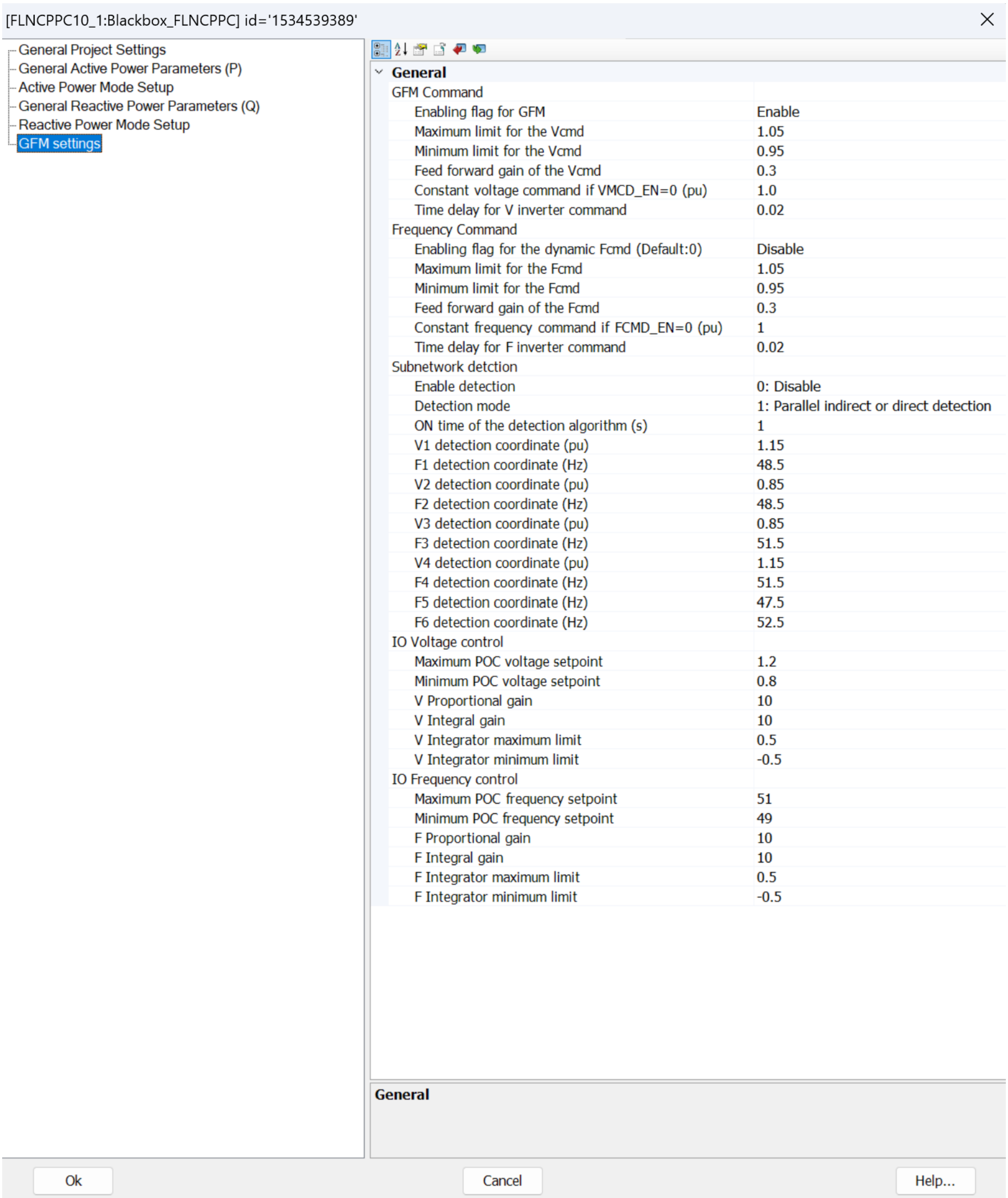


Figure 4.6: GFM settings

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