Heywood BESS

Releasable User Guide - PSSE

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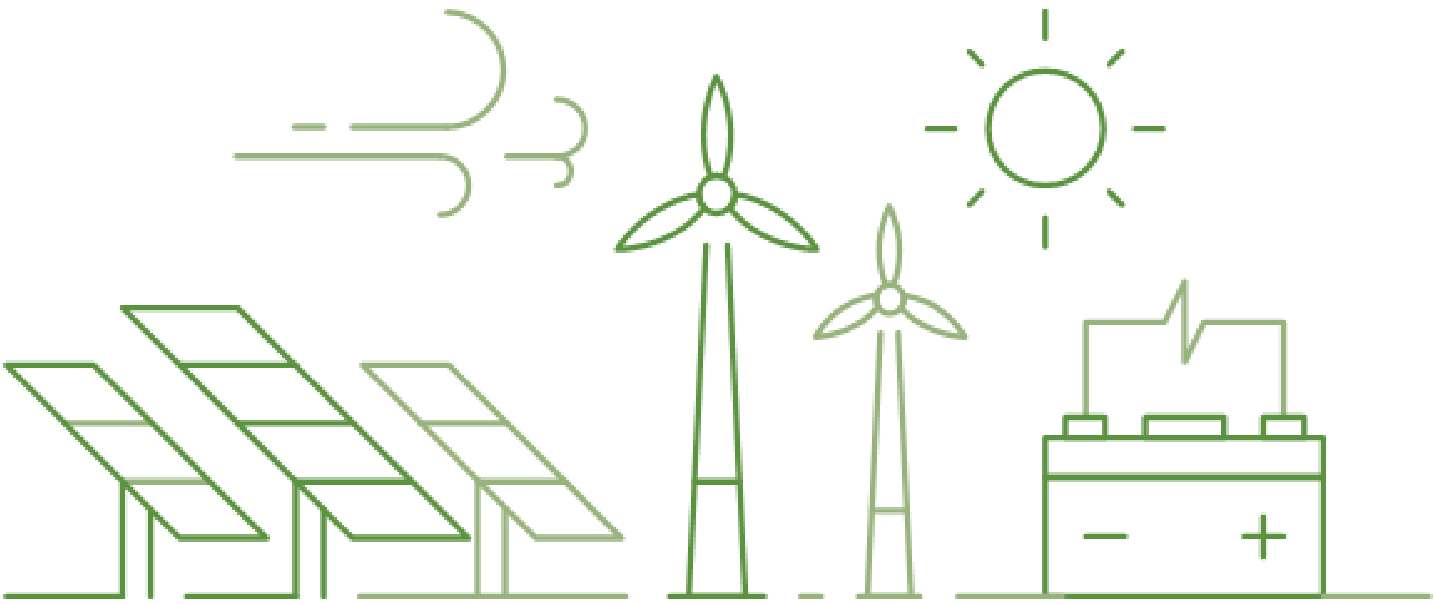

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Contents

Revision History

Table 1: Revision history

Rev.	Date	Prepared By	Reviewed By	Description
1-0-0	21/07/2025	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 Project Overview

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.

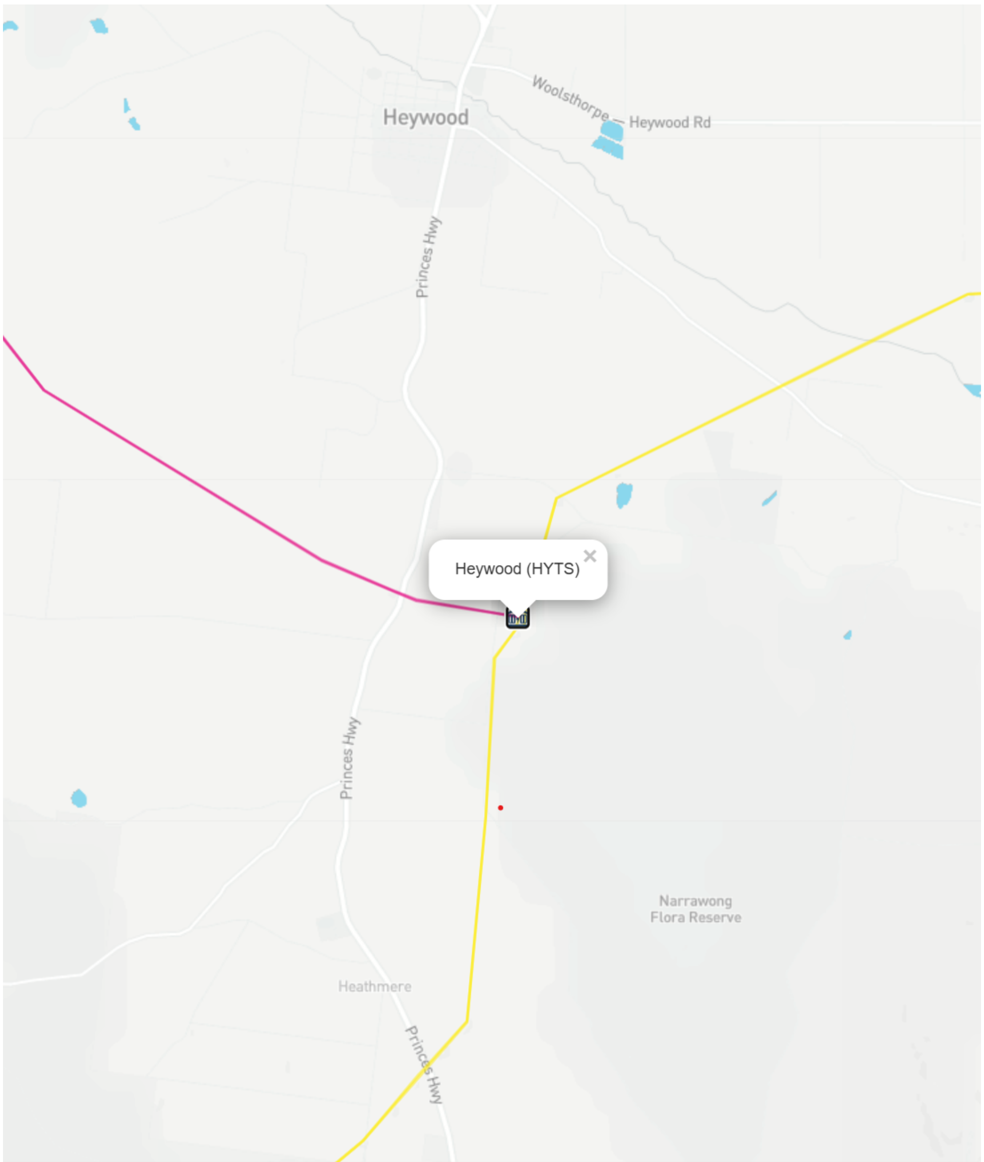

Figure 1.1: Project location

Project information is given as Table 1.1.

Table 1.1: Project Information

Feature	Description
Type and configuration of generation	92 x SMA SCS 4600 UP-S inverters
Inverter 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. Model Overview

2.1 PSSE load flow model description

The PSSE model is an aggregated representation of the Battery Energy Storage System (BESS). Four aggregated generator machine, including an aggregated converter transformer from 33 / 0.69 kV are connected to the LV sides of two 275 / 33 / 33 kV grid transformers via lumped impedances representing the reticulation network. The equivalent impedance of the 33 kV reticulation network is calculated based on a detailed model of the reticulation network which accommodates all 92 4.6 MVA converters.

Tables 2.1 - 2.6 summaries the details on the aggregated plant and equipment models. The following equipment are included in the load flow model of the plant:

- 4 X lumped generator representing project converters.
- 4 x lumped two-winding MV 33/0.69 kV converter transformers
- 4 x aggregated MV reticulation representing the lumped impedance from converter transformers to 33kv switchboard (modelled as X,R,B quantities)
- 4 x aggregated MV reticulation representing the lumped impedance from 33kV switchboard to grid transformers (modelled as X,R,B quantities)
- 2 x 275 / 33 / 33 kV grid transformers
- 1 x 275 kV underground cable between grid transformer and connection point (POC)

The connection point of HEYWOODBESS is located 1.4 km away from the 275 kV side of the main grid transformer, connected via a 275 kV underground cable. Additional items are included in the PSSE model to represent the external grid, and allow for adequate testing of the model to be carried out. The below list summarises these items.

- 1 x generator at 275 kV infinite bus representing external grid.
- 1 x 275 kV dummy line (impedance variable to represent various grid strength conditions)
- 1 x zero impedance dummy line at 275 kV (measurement purposes only)
- 1 x zero impedance 275 / 275 kV transformer (for phase angle shifting testing).

The PSSE single line diagram of the single machine infinite bus load flow model for the HEYWOODBESS is shown in the below Figure 2.1.

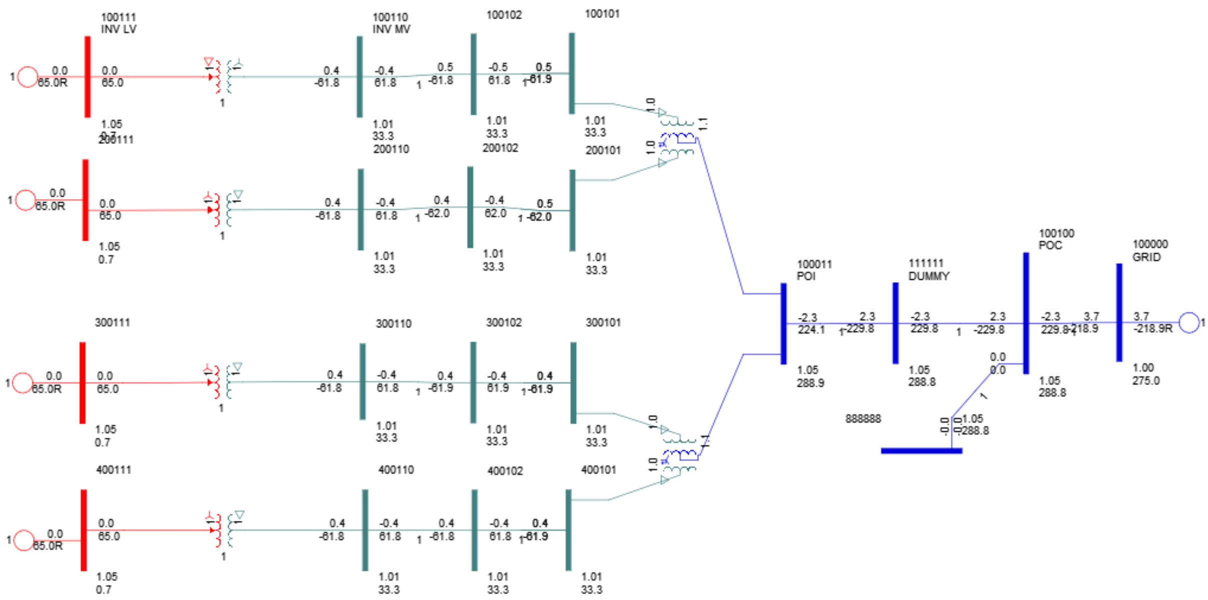

Figure 2.1: PSSE load flow model SLD

The rated capability of the generator load flow model is shown in Table 2.1. Transformer parameters are shown in Table 2.2 and Table 2.3. Lines parameters are shown in Table 2.4 - 2.6. This model was prepared under the system strength conditions shown in Table 2.7.

It should be noted that the generator load flow capability is based on rated data rather than the expected capability of the plant under steady state conditions. Active power flow at the generator point of connection should be restricted to $\pm$285 MW, and reactive power should be restricted to limits of $\pm$112.575 MVAr [1] under steady state conditions. The maximum generator active power [2] and reactive power are given in Table 2.1.

Table 2.1: Aggregated plant parameters

Parameters	Description	Units	HEYWOODBESS
M_{base}	Rated generator MVA	MVA	285
P_{Max}	Maximum active power at inverter terminals	MW	285
P_{Min}	Minimum active power at inverter terminals	MW	-285
Q_{Max}	Maximum reactive power at inverter terminals	MVAr	112.575
Q_{Min}	Minimum reactive power at inverter terminals	MVAr	-112.575
V_{POC}	Point of Connection voltage	kV	275

[1] The machine must be dispatched so as to not exceed the limits at the POC

[2] The maximum active power and reactive power must not exceed Mbase limitations; $\sqrt{P_{\text{gen}}^2 + Q_{\text{gen}}^2} \leq M_{\text{base}}$

Table 2.2: Grid transformer parameters

Parameter	Value
3 Phase Transformer MVA	160/80/80 [MVA]
Vector Group	YNd11d11
Positive Sequence Leakage Reactance (#1-#2)	0.25 [pu]
Positive Sequence Leakage Reactance (#1-#3)	0.25 [pu]
Positive Sequence Leakage Reactance (#2-#3)	0.5 [pu]
Copper Losses (#1-#2)	0.005544 [pu]
Copper Losses (#1-#3)	0.005544 [pu]
Copper Losses (#2-#3)	0.011088 [pu]
Winding 1 Line to Line Voltage (RMS) (V1)	275.0 [kV]
Winding 2 Line to Line Voltage (RMS) (V2)	33.0 [kV]
Winding 3 Line to Line Voltage (RMS) (V3)	33.0 [kV]

Table 2.3: Inverter transformer parameters

Parameter	Value
Transformer Name (Name)	Unit TX
3 Phase Transformer MVA (Tmva)	105.8
Winding #1 Type	Wye
Winding #2 Type	Delta
Delta Lags or Leads Y (Lead)	Lags
Positive sequence leakage reactance (pu)	0.076
No load losses (W)	155340.1094
Copper losses (W)	791155.6875
Winding 1 Line to Line voltage (RMS) (V1)	0.69
Winding 2 Line to Line voltage (RMS) (V2)	33

Table 2.4: 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

Table 2.5: 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
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 2.6: 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
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 2.7: System strength conditions

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

3. Reactive Capability

The reactive capability curves for HEYWOODBESS at 35°C, 40°C and 50°C are shown in Figures 3.1, 3.2 and 3.3. 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.

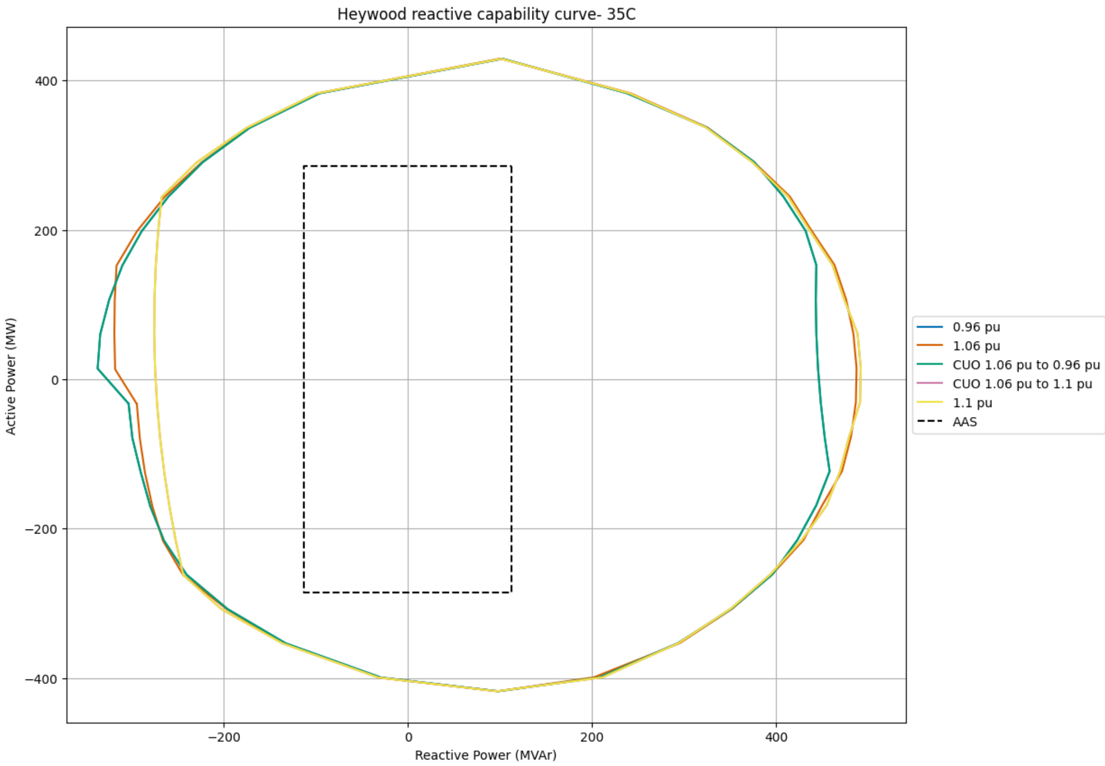

Figure 3.1: 35°C Reactive capability curve for HEYWOODBESS

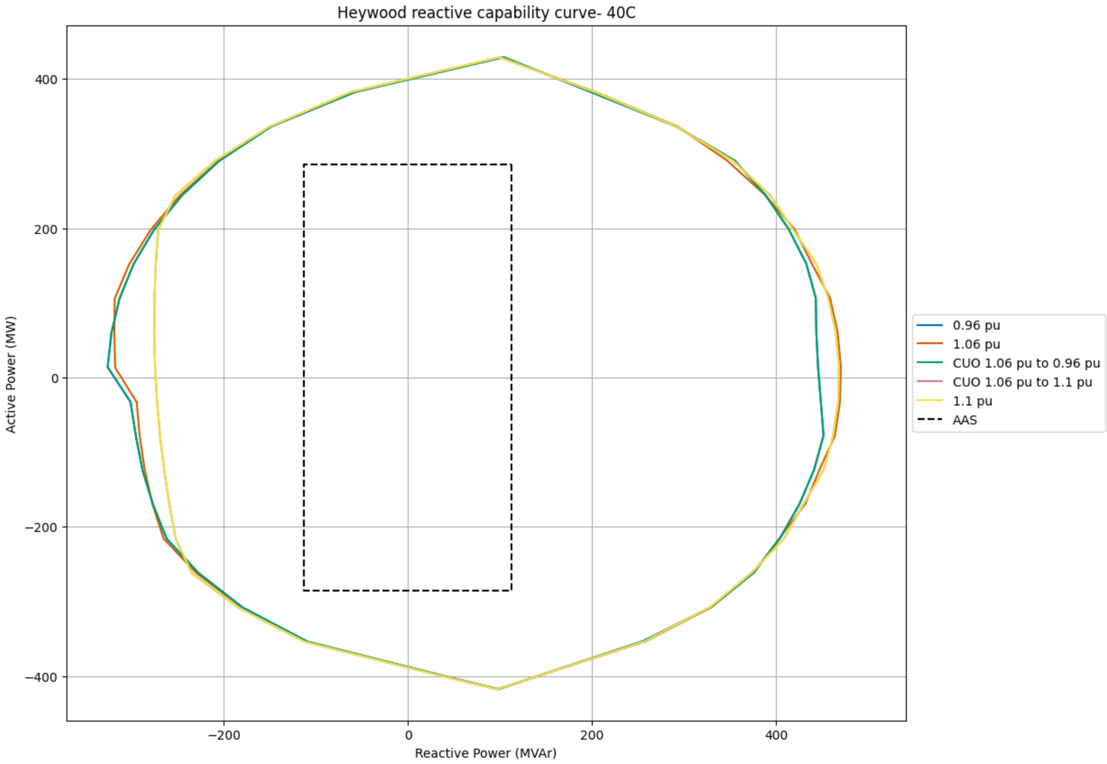

Figure 3.2: 40°C Reactive capability curve for HEYWOODBESS

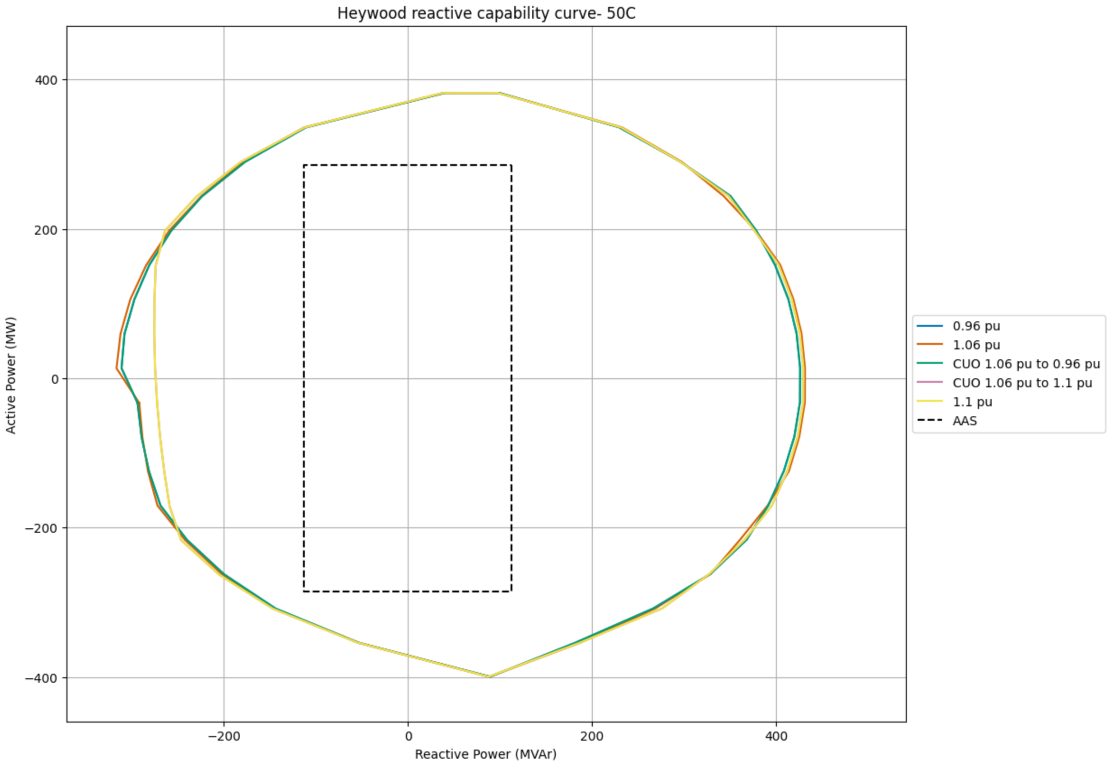

Figure 3.3: 50°C Reactive capability curve for HEYWOODBESS

4. Dynamic Model

4.1 Overview

The PSSE plant model has six dynamic models that will control the response of the plant for dynamic RMS simulations in PSSE. These are:

- 4 x converter SMAGF308 models which control the response of the four lumped generator representing the plant converters, taking instructions from the Power Plant Controller (PPC).
- 1x PPC FLNCPPC_V1020 model which controls the aggregate response of the plant under ”normal” operating conditions.
- 1x OLTC On-Load Tap Changer (OLTC) model which assist to regulate the voltage at the LV side of the grid transformers.

SMAGF_G308_344_IVF150.dll and FLUENCE_v349_V1020_IVF150.dll dynamic link libary (dll) are included for the SMA models. The ”FLUENCE_v349_V1020_IVF150.dll” file must be added for the PPC model to operate. The ”SMAGF_G308_344_IVF150.dll” file must be added for the converter models to operate. The OLTC model is the default library model included in PSSE and does not require any external libraries to operate.

The PPC’s control loops prepare active and reactive power set points in per unit, which are then sent to each converter. Each converter then multiplies these per unit control values by their MVA rating to determine the MW and MVAr set points.

4.2 Initialisation

The HEYWOODBESS model is initialised from the solved load flow, with dynamic models taking their initial STATEs and VARs from these conditions.

The dynamic plant model does not take inputs from default PSSE load flow limit parameters, i.e. Qmax, Qmin, Pmax, and Pmin. Users should therefore take care that the model is not initialised outside of its active and reactive power capability limits, despite this being possible to do so under load flow conditions. Initialising outside of these limits can result in D-state warnings, and will prevent the model from achieving a flat run. The model should normally be set to control voltage at its point of connection to 1.06, unless an alternative voltage control mode such as reactive power or power factor is activated, or this would result in the model initialising outside of a limit.

4.3 Plant control

This section will explain the default expected mode of operation of 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 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.

4.3.1 Reactive Power Control Schemes

The Fluence PPC supports multiple reactive power control modes, selectable via the **RPCM** setting (ICON(M+5)). The default reactive power control mode is the remote voltage control mode with VSL droop control(ICON(M+5)=5) and the available modes and their configurations are summarised below:

RPCM = 5 — Remote Voltage Control Mode

When RPCM is set to 5, the system operates in remote voltage control mode with Voltage Stackable Logic (VSL) droop logic. In this mode, the reactive power output is determined based on the deviation of the measured remote bus voltage from a target voltage setpoint. In order to use this control mode the VSL is required to be always enabled. Key parameters to adjust reactive power control are shown below:

- ICON M+5 - must be set to 5 for the PPC to operate in remote voltage control mode
- ICON M+7 - must be set to 1 for enabling the VSL function
- VAR L+18 - can be adjusted to set the remote voltage setpoint Vset

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)

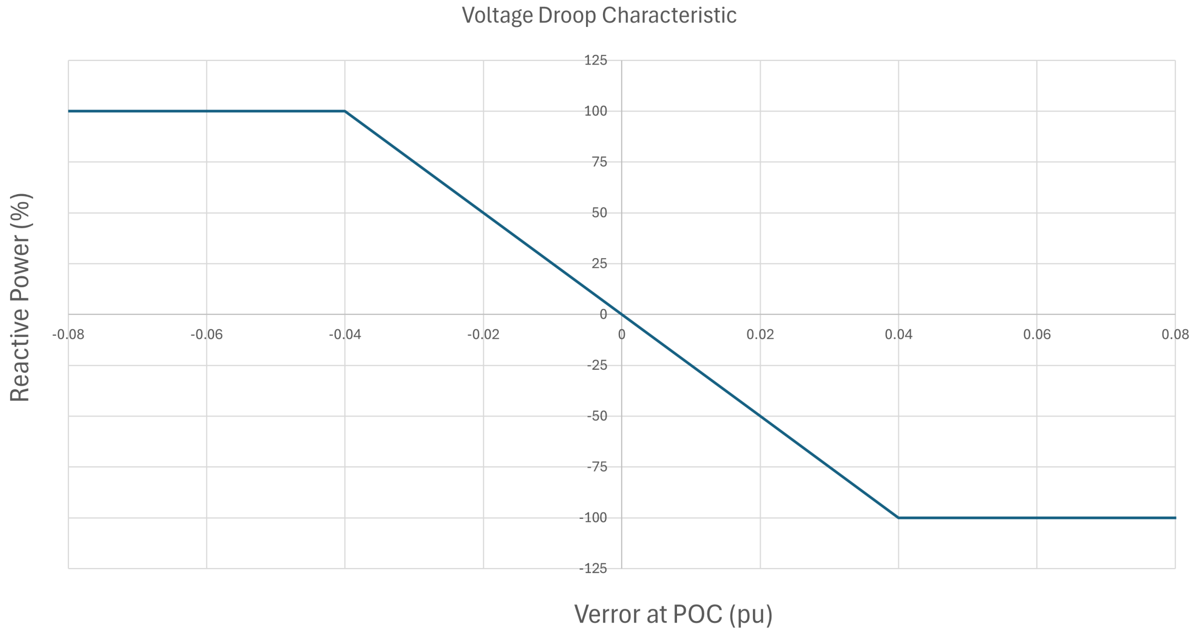

Figure 4.1: Voltage droop characteristic

Table 4.1: Voltage droop characteristic tabulated

Voltage Error at POC (pu)	Reactive Power (MVAr)
-0.13	112.575
-0.12	112.575
-0.11	112.575
-0.04	112.575
-0.02	56.2875
0.02	-56.2875
0.04	-112.575
0.11	-112.575
0.12	-112.575
0.13	-112.575

RPCM = 2 — Power Factor Control Mode

When RPCM is set to 2, the BESS operates in power factor control mode, Key parameters to adjust power factor control are shown below:

- ICON M+5 - must be set to 2 for the PPC to operate in power factor control mode
- VAR L+7 - can be adjusted to set power factor target at the POC

RPCM = 3 — Remote Reactive Power Control Mode

When RPCM is set to 3, the BESS enters remote reactive power control mode. In this mode, the reactive power at a specified remote branch is regulated based on a command signal (QRMTCMD, set via VAR(L+1)). Key parameters to adjust droop control are shown below:

- ICON M+5 - must be set to 3 for the PPC to operate in remote reactive power control mode
- ICON M+2 - can be adjusted to set the location of the controlled branch (Should not be changed under normal operation)
- VAR L+1 - can be adjusted to set the reactive power at a specified remote branch

OLTC control

The OLTC have been specified to regulate the voltage at the medium voltage side of the main transformers to be 1 p.u.

The OLTC1 model, as a PSSE library model, takes inputs from the load flow parameters of their transformers. The Vmax(pu) and Vmin(pu) parameters are used to specify voltage regulation, with Rmax and Rmin defining range of regulation, and tap size defined by the formula $\frac{Rmax-Rmin}{tappositions}$.

The transformer is set to operate with a time delay of 20 seconds and 7s mechanical operation time. These delays are adjustable by the model CONS J and J+2.

Table 4.2: 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	$\pm$ 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

4.3.2 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 4.2.

PRCF = 1 — Local Active power Control Mode

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

- ICON M+6 - must be set to 1 to enable local active power control mode
- VAR L+2 - can be adjusted to set local active power

PRCF = 2 — Remote Active power Control Mode

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

- ICON M+6 - must be set to 2 to enable remote active power control mode
- ICON M+0 to ICON M+2 - can be adjusted to set the branch at which the active power is controlled (Should not be changed under normal operation)
- VAR L+0 - can be adjusted to set the remote active power command

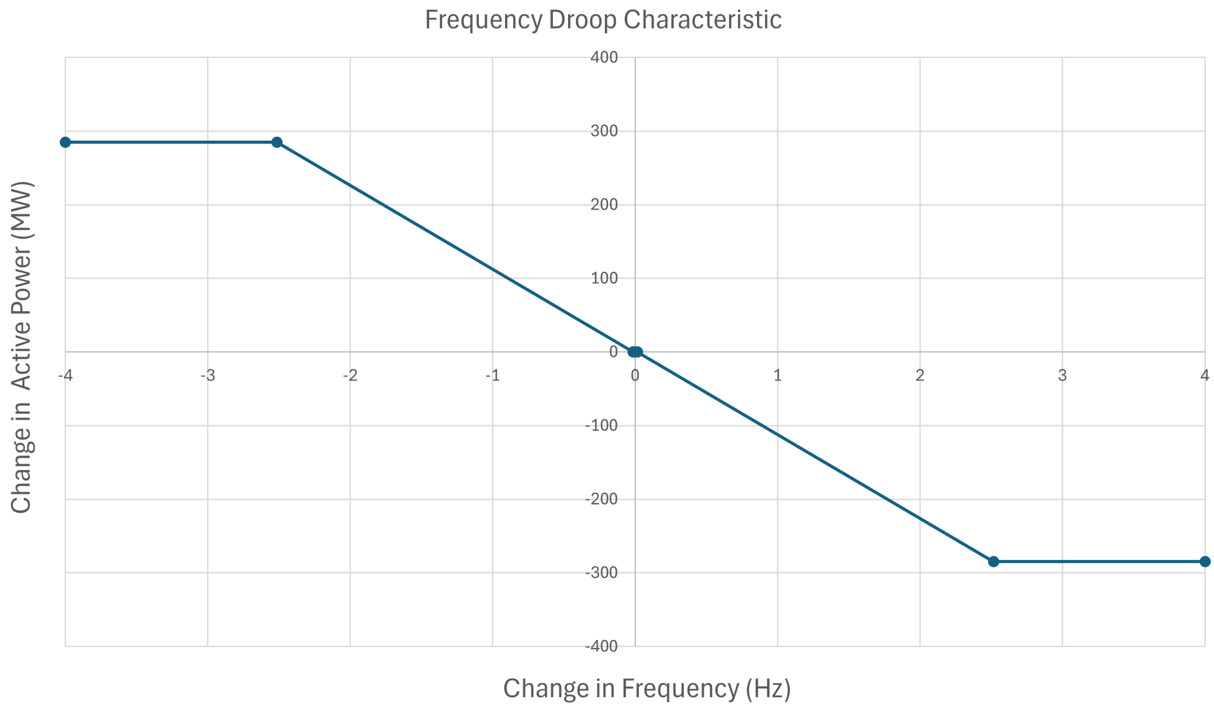

Figure 4.2: Frequency droop characteristic

Frequency Droop Characteristics

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

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

Table 4.3: 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

4.3.3 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 1.15 p.u. The risk of PPC windup during FRT causing disturbances in operation is therefore mitigated.

4.4 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 4.3. The voltage protection characteristic is shown in Figure 4.4.

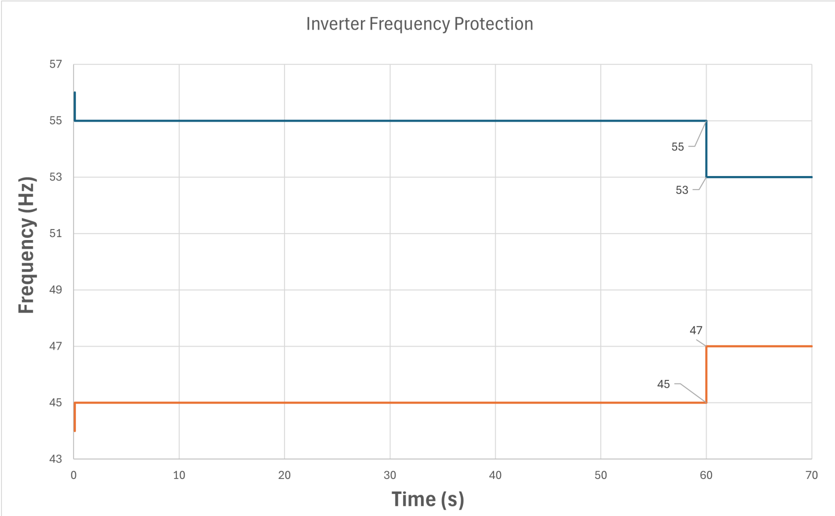

Figure 4.3: Frequency protection characteristics

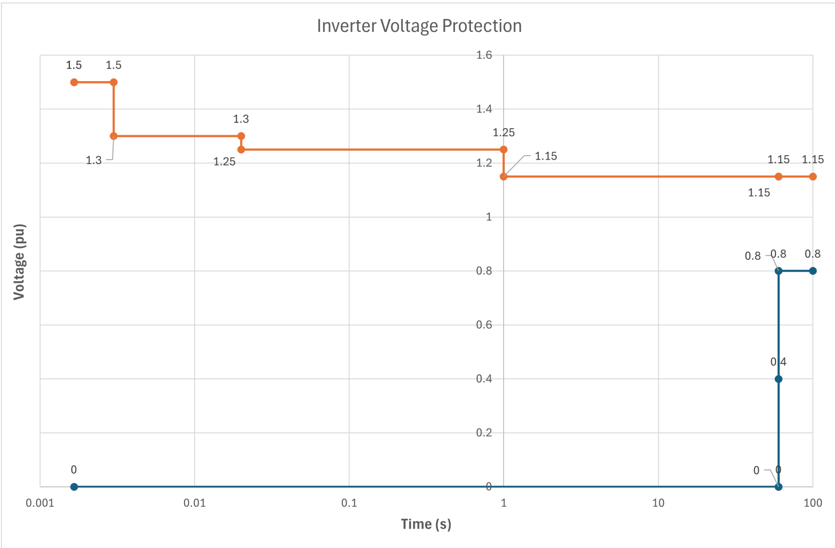

Figure 4.4: Voltage protection characteristics

4.5 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 Mbase of each aggregated converter to n x 4.6 MVA.
- Modify the Winding MVA of each aggregated converter transformer to n x 4.6 MVA.

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

Acronyms

VSL Voltage Stackable Logic 11

BESS Battery Energy Storage System 3

OLTC On-Load Tap Changer 10

PPC Power Plant Controller 10

5. Appendix A - PPC Model ICONs

ICON	Value	Description
M+0	111111	POI from bus number (0: Local)
M+1	100100	POI to bus number (0: Local)
M+2	1	POI circuit identifier (0: Local)
M+3	0	Reference Power to be Measured at (0: From BUS of POI. 1: To BUS of POI)
M+4	100100	Remote frequency measurement bus number (0: Local)
M+5	100100	Remote voltage measurement bus number (0: Local)
M+6	5	RPCM - Q Mode (1: Voltage. 2: PF. 3: Remote Q. 4: Local Q. 5: V-Stack)
M+7	2	PRCF - P Mpde (1: Local P. 2: Remote P. 3: Power Firm. 4: Local+Joint)
M+8	1	VSL - 1: Enable voltage reactive power stackable logic
M+9	1	FSL - 1: Enable frequency active power stackable logic
M+10	0	RRL - 1: Enable external reactive power controller command: 0: Disable
M+11	0	PRJPRIOR - 0: Internal project priority: 1: External project priority
M+12	0	EXTRNPRJBUS - External project machine bus (0: No external project)
M+13	0	EXTRNPRJID - External project machine ID (0: No external project)
M+14	0	EXTRNLRPJTP- External project type (0: Disabled. 1: PE. 2: SMA)
M+15	0	SISL - 1: Enable Synthetic inertia power stackable logic
M+16	0	DM - Discontinuous Mode for SI Enable = 1. Disable =0
M+17	0	PPOD_ON - P POD Enable = 1. Disable =0
M+18	0	QPOD_ON - Q POD Enable = 1. Disable =0
M+19	0	LFDD - Low Frequency Demand Disconnection Enable = 1. Disable =0
M+20	1	VCMD_EN - GFM control Enable=1. Disable=0
M+21	0	FCMD_EN - Fcmd control Enable=1. Disable=0
M+22	100111	Local Gen. 1 Bus Number
M+23	200111	Local Gen. 2 Bus Number
M+24	300111	Local Gen. 3 Bus Number
M+25	400111	Local Gen. 4 Bus Number
M+26	0	Local Gen. 5 Bus Number
M+27	0	Local Gen. 6 Bus Number
M+28	0	Local Gen. 7 Bus Number
M+29	0	Local Gen. 8 Bus Number
M+30	0	Local Gen. 9 Bus Number
M+31	0	Local Gen. 10 Bus Number
M+32	0	Local Gen. 11 Bus Number
M+33	0	Local Gen. 12 Bus Number
M+34	0	Local Gen. 13 Bus Number
M+35	0	Local Gen. 14 Bus Number

M+36	0	Local Gen. 15 Bus Number
M+37	0	Local Gen. 16 Bus Number
M+38	0	Local Gen. 17 Bus Number
M+39	0	Local Gen. 18 Bus Number
M+40	0	Local Gen. 19 Bus Number
M+41	0	Local Gen. 20 Bus Number
M+42	0	Local Gen. 21 Bus Number
M+43	0	Local Gen. 22 Bus Number
M+44	0	Local Gen. 23 Bus Number
M+45	0	Local Gen. 24 Bus Number
M+46	0	Local Gen. 25 Bus Number
M+47	0	Local Gen. 26 Bus Number
M+48	0	Local Gen. 27 Bus Number
M+49	0	Local Gen. 28 Bus Number
M+50	0	Local Gen. 29 Bus Number
M+51	0	Local Gen. 30 Bus Number
M+52	9999	Gen. VAR Number for the P command 9999 : Internal WPCMD / XADIFD
M+53	9999	Gen. VAR Number for the Q command 9999 : Internal WQCMND / EFD
M+54	3	Gen. VAR Number for the V command 9999 : Internal VREF
M+55	2	Gen. VAR Number for the F command
M+56	0	Remote voltage measurement bus number for FRT (0: ICON(M+4) is used)
M+57	1	IBR_INT (Inverter Interface - Default = 1: WELEC. 2: WGEN)
M+58	1	INV_MODEL (Machine Type 1: Conventional. 2: Wind Machine)
M+59	1	Internal - Default = 1. Else = 0

6. Appendix B - PPC Model CONs

CONs	Value	Description
J	0.7	KVP - Voltage controller proportional gain
J+1	1	KVI - Voltage controller integral gain
J+2	0.02	TVM - Voltage measurement delay
J+3	0.02	TPM - Active power measurement delay
J+4	0.02	TQM - Reactive power measurement delay
J+5	1.2	KPFFF - Power Factor controller feed forward gain
J+6	0.3	TPFI - Power Factor controller integral time constant
J+7	1.2	KQFF - Remote Q feed forward gain
J+8	0.2	TQI - Remote Q integral time constant
J+9	0.7	KPFF - Remote P feed forward constant
J+10	1	TPI - Remote P integral time constant
J+11	0.02	TDF - Frequency measurement delay
J+12	10	PRamp_UP - Active power ramp up rate. pu/s
J+13	10	PRamp_DN - Active power ramp down rate. pu/s
J+14	0.08	KVFFSP - V-Stack remote Q feed forward gain
J+15	0.4	TVISP - V-Stack Q integral time constant
J+16	1800	TSOC - Integral time constant for charging/discharging
J+17	1.06	OVDB - Over voltage deadband for stackable voltage logic
J+18	1.1	OVV1 - Stackable voltage logic first high voltage V point
J+19	1.1	OVV2 - Stackable voltage logic second high voltage V point
J+20	1.1	OVV3 - Stackable voltage logic third high voltage V point
J+21	-0.266	OVQ1 - Stackable voltage logic first high voltage Q point
J+22	-0.266	OVQ2 - Stackable voltage logic second high voltage Q point
J+23	-0.266	OVQ3 - Stackable voltage logic third high voltage Q point
J+24	1.06	UVDB - Under voltage deadband for stackable voltage logic
J+25	1.02	UVV1 - Stackable voltage logic first low voltage V point
J+26	1.02	UVV2 - Stackable voltage logic second low voltage V point
J+27	1.02	UVV3 - Stackable voltage logic third low voltage V point
J+28	0.266	UVQ1 - Stackable voltage logic first low voltage Q point
J+29	0.266	UVQ2 - Stackable voltage logic second low voltage Q point
J+30	0.266	UVQ3 - Stackable voltage logic third low voltage Q point
J+31	50.015	OFDB - Over frequency deadband for stackable frequency logic
J+32	50.015	OFF1 - Stackable frequency logic first high frequency F point
J+33	51.5	OFF2 - Stackable frequency logic second high frequency F point
J+34	52.5	OFF3 - Stackable frequency logic third high frequency F point
J+35	-0.00402	OFP1 - Stackable frequency logic first high frequency P point
J+36	-0.402	OFP2 - Stackable frequency logic second high frequency P point
J+37	-0.67	OFP3 - Stackable frequency logic third high frequency P point
J+38	49.985	UFDB - Under frequency deadband for stackable frequency logic
J+39	49.985	UFF1 - Stackable frequency logic first low frequency F point
J+40	48.5	UFF2 - Stackable frequency logic second low frequency F point
J+41	47.5	UFF3 - Stackable frequency logic third low frequency F point

J+42	0.00402	UFP1 - Stackable frequency logic first low frequency P point
J+43	0.402	UFP2 - Stackable frequency logic second low frequency P point
J+44	0.67	UFP3 - Stackable frequency logic third low frequency P point
J+45	1	QMAXINV - Maximum reactive power from inverter
J+46	-1	QMININV - Minimum reactive power from inverter
J+47	0.8	PMAXINV - Maximum active power from inverter
J+48	-0.8	PMININV - Minimum active power from inverter
J+49	1	QMAXINT - Maximum reactive power from remote Q control integrator
J+50	-1	QMININT - Minimum reactive power from remote Q control integrator
J+51	0.8	PMAXINT - Maximum active power from remote P control integrator
J+52	-0.8	PMININT - Minimum active power from remote P control integrator
J+53	1	QMAXPI - Maximum reactive power from Power Factor Q control PI
J+54	-1	QMINPI - Minimum reactive power from Power Factor Q control PI
J+55	1	QMAXPIVSP - Maximum reactive power from remote V-Stack control integrator
J+56	-1	QMINPIVSP - Minimum reactive power from remote V-Stack control integrator
J+57	12	SOCMIN - Minimum battery charge
J+58	98	SOCMAX - Maximum battery charge
J+59	50	SOCINI - Initial battery charge
J+60	0.1	TQC - Time delay for Q inverter command. sec
J+61	0.02	TPC - Time delay for P inverter command. sec
J+62	0.1	TPE - Time delay for P external inverter command
J+63	0.1	TQE - Time delay for Q external inverter command
J+64	0.85	LVRT - Low voltage threshold for PPC freeze. pu
J+65	0.03	LVRT_HYST - Low voltage hysteresis for PPC freeze (>0). pu
J+66	1.15	HVRT - High voltage threshold for PPC freeze. pu
J+67	0.03	HVRT_HYST - High voltage hysteresis for PPC freeze (>0). pu
J+68	1	EXTPRJMAXP - External project P max (p.u. on external MBASE)
J+69	-1	EXTPRJMINP - External project P min (p.u. on external MBASE)
J+70	1	EXTPRJMAXQ - External project Q max (p.u. on external MBASE)
J+71	-1	EXTPRJMINQ - External project Q min (p.u. on external MBASE)
J+72	0.8	KQF1 - Reactive power participation factor local project
J+73	0.2	KQF2 - Reactive power participation factor remote project
J+74	0.1	TQ1 - Time delay for Q local inverter command (joint control). sec
J+75	0.1	TQ2 - Time delay for Q external inverter command (joint control). sec
J+76	0.4	Tfrzppc - Extra Time delay for PPC. sec
J+77	1.06	VCNTR - Voltage center for droop curve. pu
J+78	0.68	PMAXPOC - Maximum active power at POC. pu
J+79	-0.68	PMINPOC - Minimum active power at POC. pu
J+80	0.266009	QMAXPOC - Maximum reactive power at POC. pu
J+81	-0.266009	QMINPOC - Minimum reactive power at POC. pu
J+82	0.2	PDFDTF1 - 1st Positive dfDT. Hz/s
J+83	0.5	PDFDTF2 - 2nd Positive dfDT. Hz/s
J+84	1	PDFDTF3 - 3rd Positive dfDT. Hz/s

J+85	-0.01	PDFDTP1 - 1st Power for Positive dfDT. pu
J+86	-0.02	PDFDTP2 - 2nd Power for Positive dfDT. pu
J+87	-0.05	PDFDTP3 - 3rd Power for Positive dfDT. pu
J+88	-0.2	NDFDTF1 - 1st Negative dfDT. Hz/s
J+89	-0.5	NDFDTF2 - 2nd Negative dfDT. Hz/s
J+90	-1	NDFDTF3 - 3rd Negative dfDT. Hz/s
J+91	0.01	NDFDTP1 - 1st Power for Negative dfDT. pu
J+92	0.02	NDFDTP2 - 2nd Power for Negative dfDT. pu
J+93	0.05	NDFDTP3 - 3rd Power for Negative dfDT. pu
J+94	0.5	T_SISL - SISL dfDT rolling time window (s)
J+95	0.02	T_DFDT - dfDT measurement delay (s)
J+96	0.5	TwP - P POD Washout filter time constant (s)
J+97	-0.1	POD_MINP - P POD Min. POD contribution (pu)
J+98	0.1	POD_MAXP - P POD Max. POD contribution (pu)
J+99	0.245	T1P - P POD Lead Time Constant (s)
J+100	0.411	T2P - P POD Lag Time Constant (s)
J+101	1	K_PODP - Q POD Gain
J+102	1	exp_PPOD - P POD Gain exponent ()
J+103	0.5	TwQ - Q POD Washout filter time constant (s)
J+104	-0.1	POD_MINQ - Q POD Max. POD contribution (pu)
J+105	0.1	POD_MAXQ - Q POD Min. POD contribution (pu)
J+106	0.2	T1Q - Q POD Lead Time Constant (s)
J+107	0.4	T2Q - Q POD Lag Time Constant (s)
J+108	1	K_PODQ - Q POD Gain
J+109	1	exp_QPODQ - Q POD Gain exponent ()
J+110	0.3	INT_CON - Internal CON
J+111	49.5	LFDDDB - Start frequency for the LFDD function (Hz)
J+112	49.1	LFDDMIN - Minimum frequency defining the LFDD function (Hz)
J+113	1.1	VCMD_MAX - Maximum limit for the Vcmd (pu)
J+114	0.95	VCMD_MIN - Minimum limit for the Vcmd (pu)
J+115	0.3	KVCMD - Feed forward gain of the Vcmd
J+116	1.05	FCMD_MAX - Maximum limit for the Fcmd (pu)
J+117	0.95	FCMD_MIN - Minimum limit for the Fcmd (pu)
J+118	0.3	KFCMD - Feed forward gain of the Fcmd
J+119	0.02	TVC - Time delay for V inverter command. sec
J+120	0.02	TFC - Time delay for F inverter command. sec
J+121	0.08	Internal Use
J+122	423.2	Plant MVA Base
J+123	0.03	Internal Use

7. Appendix C - PPC Model VARs

VAR	Description
L	PRMTCMD – Remote active power command (MW)
L+1	QRMTCMD – Remote reactive power command (MVAR)
L+2	PLCLCMD – Local active power command (MW)
L+3	QLCLCMD – Local reactive power command (MVAR)
L+4	PRMTMEAS – Active power measurement at POI
L+5	QRMTMEAS – Reactive power measurement at POI
L+6	VCMD – Voltage command
L+7	PFCMD – Power factor command
L+8	PREFINT – Output active power reference to battery PSSE WPCMD array
L+9	QREFINT – Output reactive power reference to battery PSSE WQCMND array
L+10	SOC – State of charge for the battery
L+11	PRMTFRMCMD – Remote branch for joint firming (MW)
L+12	PLCLCMDEXT – Local active power command for external project (MW)
L+13	QLCLCMDEXT – Local reactive power command for external project (MVAR)
L+14	PREFEXT – Output active power reference to external project PSSE WPCMD array
L+15	QREFEXT – Output reactive power reference to external project PSSE WQCMND array
L+16	Internal variable
L+17	Internal variable
L+18	VSET – Voltage set point for RPCM = 5
L+19	VCNTR – Voltage droop center for RPCM = 5
L+20	Internal variable
L+21	HVRT_FLAG – Status of HVRT mode
L+22 to L+43	Internal variable. except for VAR(L+33)
L+33	LVRT_FLAG – Status of LVRT mode
L+44	FRZ_FLAG – PPC freeze flag with 'Tfrzppc' delay
L+45 to L+51	Internal variables
L+52	VCMD_EXT – Voltage command PPC-PCS (pu)
L+53	VCMD_CNST – Constant Voltage command offset (pu)
L+54	FCMD_EXT – Frequency command PPC-PCS (Hz)
L+55	FCMD_CNST – Constant Frequency command offset (pu)
L+56	VMEASD_FRT – FRT Bus Voltage measurement
L+57 to L+247	Internal variables

8. Appendix D - PPC Model STATEs

STATE	Description
K	Project or remote voltage measurement
K+1	Voltage controller PI state
K+2	Project or POI delayed active power measurement
K+3	Project or POI delayed reactive power measurement
K+4	Power factor controller integrator state
K+5	Remote reactive power command logic integrator state
K+6	Remote active power command logic integrator state
K+7	Project or remote frequency measurement
K+8	Charging integrator state
K+9	Delayed active power command - battery
K+10	Delayed reactive power command - battery
K+11	Delayed active power command – external project
K+12	Delayed reactive power command – external project
K+13	Delayed reactive power command – battery; Join logic
K+14	Delayed reactive power command – external project; Join logic
K+15	RPCM = 5 Integrator state
K+16	Delayed frequency measurement for DFDT calculation
K+17	P POD washout filter state
K+18	P POD lead-lag filter state
K+19	Q POD washout filter state
K+20	Q POD lead-lag filter state
K+21	DFDT delayed value
K+22	FRT Bus Voltage measurement

9. Appendix E - Converter Model ICONs

ICON	Value	Parameter	Description
M	1	PlntCtlType	1 = HyCon. 0 = no plant control (PSS/E Specific)
M+1	100100	PlntCtlBus	Number of plant controller bus (PSS/E Specific)
M+2	4600	InvType	InvType used. Refer Table 1 – Similar to Inverter Type selection in mask of inverter model block in PSCAD
M+3	22321	SCSOpCmd	21521: Grid Forming P/f and Q/V droop 22321: Grid Forming angle inertia and Q/V droop 22322: Grid Forming P/f droop and voltage inertia 22323: Grid Forming angle inertia and voltage inertia (PSS/E Specific)

10. Appendix F - Converter Model CONs

CON	Value	Parameter	Description
J+0	4600	Rtg.VARtg	Apparent power rating in kVA can be set using this parameter. If set to 0.0. then rated apparent power as per Inverter type (ICON(M+2)) will be used
J+1	4600	Rtg.WRtg	Active power rating in kW can be set using this parameter. If set to 0.0. then rated Active power as per Inverter type (ICON(M+2)) will be used
J+2	0	Rtg.VarRtg	Reactive power rating in kVar can be set using this parameter. If set to 0.0. then rated reactive power as per Inverter type (ICON(M+2)) will be used
J+3	0	Rtg.AmpRtg	Current rating in A can be set using this parameter. If set to 0.0. then rated current rating as per Inverter type (ICON(M+2)) will be used
J+4	0	Rtg.VADrtPriMod	Prioritizing of control in case of derating 0: Q Priority. 1: P Priority
J+5	1	Rtg.DrtFac	Derating Factor to emulate the thermal derating of the device
J+6	1	Spt.WGraMod	Active power gradient. activation
J+7	1	Spt.VArGraMod	Reactive power gradient. activation
J+8	100	Spt.WGra	Gradient for active power p.u./s
J+9	100	Spt.VArGra	Gradient for reactive power p.u./s
J+10	1	Spt.WFilMod	Filter for active power setpoint. activation
J+11	1	Spt.VArFilMod	Filter for reactive power setpoint. activation
J+12	0.1	Spt.WFilTm	WSpt. filter time constant in s
J+13	0.1	Spt.VArFilTm	VArSpt. filter time constant in s
J+14	0.46	Filt.VolDQFilTm	DQ Voltage. filter time constant in s
J+15	0.005	Filt.VolPsFilTm	Voltage filter time constant for conversion VA to Amp in s
J+16	0.01	Filt.AmpDFilTm	D axis current. filter time constant in s
J+17	0.02	Filt.AmpQFilTm	Q axis current. filter time constant in s
J+18	0.01	Filt.ABControlDFilTm	Filter time constant for D-axis voltage for AB Control in s (PSS/E Specific)
J+19	0.01	Filt.ABControlQFilTm	Filter time constant for Q-axis voltage for AB Control in s (PSS/E Specific)
J+20	0.1	Filt.AvalPwrFilTm	Filter time constant for calculated available active and reactive power in s
J+21	0.1	Filt.HzFilTm	Grid Management. time constant frequency filter
J+22	5	Filt.VolSptGra	Rate limiter in p.u/s over voltage setpoint (VAR(L+3)) applied to the inverter
J+23	1	AcCtl.WSptScal	AC current control. active power setpoint scaling factor
J+24	1	AcCtl.VArSptScal	AC current control. reactive power setpoint scaling factor

J+25	-2	AcCtl.DrpHz	Active power frequency droop
J+26	0.167	AcCtl.DrpVol	Reactive power voltage droop
J+27	-0.12	AcCtl.DrpTheta	Factor angle pre-control
J+28	1.5	AcCtl.InertiaVolH	Inertia: Voltage magnitude inertia constant
J+29	1	AcCtl. InertiaThetaH	Inertia: Voltage angle inertia constant
J+30	0	AcCtl.DrpThetaFilTm	AC current control. Time constant of low pass filter for bandwidth limitation of phase feed forward damping
J+31	0	AcCtl.InertiaHzFbDmp	Inertia: Frequency feedback gain of voltage angle inertia control
J+32	0	AcCtl.InertiaHzFbFilTm	Inertia: Frequency feedback time constant of voltage angle inertia control
J+33	0	AcCtl.InertiaHzFb-Fil2Tm	Inertia: Frequency feedback time constant of voltage angle inertia control
J+34	0	AcCtl.InertiaHzFwd-Dmp	Inertia: Feed-forward damping gain of voltage angle inertia control
J+35	0	AcCtl.InertiaVolFwd-Dmp	Inertia: Feed-forward damping gain of voltage magnitude inertia control
J+36	0	AcCtl.InertiaVolFbDmp	Inertia: Voltage feedback gain of voltage magnitude inertia control
J+37	0	Ac-Ctl.InertiaVolFbDmp-FilTm	Inertia: Voltage feedback time constant of voltage magnitude inertia control
J+38	0	Ac-Ctl.InertiaVolFbDmp-Fil2Tm	Inertia: Voltage feedback time constant of voltage magnitude inertia control
J+39	0.6	AcCtl.AmpDLimKp	AC current control. proportional amplification for active current limit
J+40	22.5	AcCtl.AmpDLimKi	AC current control. integral amplification for active current limit
J+41	0.6	AcCtl.InertiaAm-pDLimKp	Inertia: AC current control. proportional amplification for active current limit
J+42	22.5	AcCtl.InertiaAm-pDLimKi	Inertia: AC current control. integral amplification for active current limit
J+43	0.0003333	AcCtl.AmpPsDLim_-Ki2Fac	AC current control. double integral amplification for active current limit
J+44	6	Ac-Ctl.AmpPsDLim_-I2RocofLi m	AC and DC limit control. minimum/maximum range control signal
J+45	3	Ac-Ctl.AmpPsDLim_-I2CtlDow nGain	AC current control. additional double integral amplification. if active current limit is not exceeded
J+46	2.4	AcCtl.AmpQLimKp	AC current control. proportional amplification for reactive current limit
J+47	90	AcCtl.AmpQLimKi	AC current control. integral amplification for reactive current limit
J+48	2.4	AcCtl.InertiaAm-pQLimKp	Inertia: AC current control. proportional amplification for reactive current limit
J+49	90	AcCtl.InertiaAm-pQLimKi	Inertia: AC current control. integral amplification for reactive current limit

J+50	0.0003333	Ac-Ctl.AmpPsQLim_-Ki2Fac	AC current control. double integral amplification for reactive current limit
J+51	6	Ac-Ctl.AmpPsQLim_-I2RocofLi m	AC current control. minimum/maximum range control signal
J+52	3	Ac-Ctl.AmpPsQLim_-I2CtlDow nGain	AC current control. additional double integral amplification. if reactive current limit is not exceeded
J+53	0	AcCtl.InertiaThetaW-CtlEna	Inertia: Enable active power inertia control
J+54	0.5	AcCtl.Inertia-ThetaWCtlVolLim	Voltage limit for power regulation in phase inertia
J+55	0	AcCtl.Inertia-VolVArCtlEna	Inertia: Enable reactive power inertia control
J+56	0.5	Ac-Ctl.InertiaVolVArCtlVol-Lim	Voltage limit for power regulation in the voltage inertia
J+57	0	AcCtl.InertiaThetaFwd-DmpFilTm	Inertia: Time constant for bandwidth limitation of angle feed-forward damping
J+58	-0.12	AcCtl.InertiaThetaFwd-Dmp	Inertia: Voltage angle feed-forward damping gain of voltage angle inertia control
J+59	1	AcCtl.AmpPsDFbEna	Inertia: Activation of inner active current feedback of voltage angle inertia control
J+60	1	AcCtl.AmpPsQFbEna	Inertia: Activation of inner reactive current feedback of voltage magnitude inertia control
J+61	1	Ac-Ctl.AmpDLim_-VolPsNomLi m	AC current control. active current limiation. voltage limit for accurate active power limitation
J+62	1	Ac-Ctl.AmpQLim_-VolPsNomL im	AC current control. reactive current limiation. voltage limit for accurate reactive power limitation
J+63	1	AcCtl.AmpDQLimEna	AC current control. limiting controller activation
J+64	0	AcCtl.PriModPsRelEna	AC current control. Prioritization mode - positive sequence relative - for current limitation. activation
J+65	60	AcCtl.VolABKi	AC voltage control integral gain
J+66	0.01	AcCtl.VolABKp	AC voltage control Proportional gain (PSS/E Specific)
J+67	0.02	AcCtl.AmpDQFilTm	AC current control. DQ current filter time constant
J+68	10	AcCtl.ParamFilTm	Inertia: Low pass filter time constant for smooth inertia parameter change
J+69	20	AcCtl.PreFreezeDlTm	PreFreeze delay time [ms]
J+70	0.02	AcCtl.PreFreezeFilTm	PreFreeze filter time constant
J+71	-1.8	AcCtl.InertiaHzDmp	Inertia: Voltage frequency damping gain of voltage angle inertia control
J+72	0.03	AcCtl.InertiaVolDmp	Inertia: Voltage magnitude damping gain of voltage magnitude inertia control
J+73	0	AcCtl.PlantLevelInertia	Enable plant level inertia
J+74	4	Frt.Frt_Mod	Grid forming FRT: Mode
J+75	0.8	Frt.LoVolOnLim	Grid forming FRT: Lower voltage limit for entering FRT Mode (PSS/E Specific)
J+76	1.1	Frt. HiVolOnLim	Grid forming FRT: Upper voltage limit for entering FRT Mode (PSS/E Specific)

J+77	0.9	Frt.LoVolOffLim	Grid forming FRT: Lower voltage limit for return to normal mode
J+78	1.1	Frt.HiVolOffLim	Grid forming FRT: Upper voltage limit for return to normal mode
J+79	0	Frt.DynVolOnLimEna	Grid forming FRT: Activation of dynamic offset voltage limits for entering FRT mode (PSS/E Specific)
J+80	0	Frt.DynVolOffLimEna	Grid forming FRT: Activation of dynamic offset voltage limits for return to normal mode
J+81	1.4	Frt.VirtImpSwDetLim	Grid forming FRT: Current threshold for activation of virtual impedance
J+82	5	Frt.VirtImpDlTm	Grid forming FRT: Delay time for activation of virtual impedance
J+83	500	Frt.VirtImpLockTm	Grid forming FRT: Minimum duration time of virtual impedance
J+84	50	Frt.VirtImpWaitTm	Grid forming FRT: Minimum duration time for reactivation of virtual impedance
J+85	30	Frt.ResetTm	Time to jump back to initial state in FRT-Detection-Statemachine
J+86	1	Frt.AmpCtlEna	Grid forming FRT: Activation of adaptive current control
J+87	1.3	Frt.AMaxNomInit	Grid forming FRT: Init value of maximum short circuit current in the virtual impedance
J+88	1	Frt.AMaxNom	Grid forming FRT: maximum short circuit current
J+89	0.001	Frt.AmpCtlFilTm	Grid forming FRT: Adaptive current control. filter time constant
J+90	0.3	Frt.CtlDevLimMax	Grid forming FRT: Adaptive apparent current control. maximum control deviation
J+91	1	Frt.NegCtlDev_Gain	Amplification or reduction of the negative control deviation of the VI controller
J+92	0	Frt.AmpCtlKp	Grid forming FRT: Adaptive current control. proportional gain
J+93	10	Frt.AmpCtlKi	Grid forming FRT: Adaptive current control. integral gain
J+94	0.167	Frt.VirtImpReact	Grid forming FRT: Virtual impedance. reactance
J+95	0.167	Frt.VirtImpReactMin	Grid forming FRT: Virtual impedance. minimum reactance
J+96	1	Frt.VirtImpReactFFWEna	Activation of the pre-control of the virtual reactance of the difference
J+97	0.68	Frt.VirtImpReactFFWFac	Grid forming FRT: Virtual impedance. factor of feedforward of virtual reactance
J+98	0	Frt.VirtImpRis	Grid forming FRT: Virtual impedance. resistance
J+99	0.05	Frt.VirtImpRisInit	Grid forming FRT: Virtual impedance. resistance. init Value
J+100	0.008	Frt.VirtImpRisFilTm	Grid forming FRT: Virtual impedance. time constant for decaying resistance
J+101	0.004	Frt.VolPsQFilTm	Grid forming FRT: VolPsQ control during virtual impedance. filter time constant of VolPsQ voltage
J+102	-7	Frt.VolPsQCtlKp	Grid forming FRT: VolPsQ control during virtual impedance. proportional gain

J+103	0.25	Frt.VolPsQCtlDZn	Grid forming FRT: VolPsQ Control during virtual impedance. limit of proportional zone gain
J+104	0	Frt.VolPsQCtlDZnKp	Grid forming FRT: VolPsQ Control during virtual impedance. proportional zone gain
J+105	1	Frt.VolPsQCtlHzOfs-Max	Grid forming FRT: VolPsQ control during virtual impedance. maximum actuating variable in Hz
J+106	1	Frt.VolPsQCtrlEna	Value of the VolPsQ P controller
J+107	0	Frt.AMaxNomInitTm	Grid forming FRT: Initialization time of maximum short circuit current in the virtual impedance
J+108	1.3	Frt.ArmsMsMaxLim	Grid forming FRT: maximum limit for measured short circuit current in the virtual impedance
J+109	8	Frt.AmpCtlOfsKiFac	Grid forming FRT: Adaptive current control. factor of current control offset
J+110	1.3	Frt.AmpCtlOf-sAMaxSpt	Grid forming FRT: Adaptive current control. maxi-mum short circuit current of current control offset
J+111	0.03	Frt.VirtImpReactFF-WOfs	Grid forming FRT: Virtual impedance. offset of feed-forward of virtual reactance
J+112	6	Frt.KFacPs	Grid forming: K-Factor positive sequence
J+113	0.001	Frt.FFWVolFilTm	Grid forming FRT: Virtual impedance. time constant of voltage adjustment of feedforward of virtual re-actance
J+114	1	Frt.AmpPsQPrioEna	Grid forming FRT: Virtual impedance. activation of the reactive current priority
J+115	0.25	Frt.PsDCtlRng	Grid forming FRT: Virtual impedance. amplification factor for limitation of the active current with reac-tive current priority
J+116	0.18	Frt.AmpPsDFFWMin	Grid forming FRT: Virtual impedance. minimum short circuit current of feedforward of virtual re-actance
J+117	0.03	Frt.FFWAmpLimOfs	Grid forming FRT: Virtual impedance. short circuit current offset of feedforward of virtual reactance
J+118	0	Frt.EnaAmpPsDSptMan	Enable Manual setpoint for active current compo-nent
J+119	0	Frt.AmpPsDSptMan	Manual setpoint for active current component
J+120	0.3	Frt.AmpPsDFilTm	Grid forming FRT: Virtual impedance. time constant of the active current adjustmen
J+121	-1	Frt.AmpPsDMin	Grid forming FRT: Virtual impedance. current d axis positive sequence. maximum charge limit
J+122	0.3	Frt.AmpPsQFilTm	Grid forming FRT: Virtual impedance. time constant of the reactive current adjustment
J+123	0.02	OvAmp.Amp-MaxNomSe cFilTm	Overcurrent: Filter time constant of overcurrent factors
J+124	76000	OvAmp.Amp-MaxNomSe c0Tm	Overcurrent: Duration in milliseconds for sector 0
J+125	100	OvAmp.Amp-MaxNomSe c1Tm	Overcurrent: Duration in milliseconds for sector 1
J+126	900	OvAmp.Amp-MaxNomSe c2Tm	Overcurrent: Duration in milliseconds for sector 2

J+127	4000	OvAmp.Amp-MaxNomSe c3Tm	Overcurrent: Duration in milliseconds for sector 3
J+128	9000	OvAmp.Amp-MaxNomSe c4Tm	Overcurrent: Duration in milliseconds for sector 4
J+129	13900	OvAmp.Amp-MaxNomSe c4TransTm	Overcurrent: Duration in milliseconds for sector 4 in transition mode
J+130	2000	OvAmp.Amp-MaxNomSe c4ThmDrtTm	Intermediate time within the fourth and last sector in the virtual impedance in milliseconds
J+131	1	OvAmp.Amp-MaxNomSe c0	Overcurrent: Nominal current factor for maximum apparent current in sector 0
J+132	1.57	OvAmp.Amp-MaxNomSe c1	Overcurrent: Nominal current factor for maximum apparent current in sector 1
J+133	1.25	OvAmp.Amp-MaxNomSe c2	Overcurrent: Nominal current factor for maximum apparent current in sector 2
J+134	1.16	OvAmp.Amp-MaxNomSe c3	Overcurrent: Nominal current factor for maximum apparent current in sector 3
J+135	0.95	OvAmp.Amp-MaxNomSe c4	Overcurrent: Nominal current factor for maximum apparent current in sector 4
J+136	1	OvAmp.Amp-MaxNomSe c3Obs	Overcurrent: Nominal current factor for current observation to move in sector 3
J+137	1	OvAmp.Amp-MaxNomSe c4Obs	Overcurrent: Nominal current factor for current observation to move in sector 4
J+138	0.03	OvAmp.Amp-MaxNomSe c4ObsHys	Overcurrent: Nominal current factor for current Hysteresis observation to move in sector 4
J+139	1	OvAmp.AmpPsD-MaxNo mSec0	Overcurrent: Nominal current factor for maximum active current in sector 0
J+140	1.57	OvAmp.AmpPsD-MaxNo mSec1	Overcurrent: Nominal current factor for maximum active current in sector 1
J+141	1.25	OvAmp.AmpPsD-MaxNo mSec2	Overcurrent: Nominal current factor for maximum active current in sector 2
J+142	1.16	OvAmp.AmpPsD-MaxNo mSec3	Overcurrent: Nominal current factor for maximum active current in sector 3
J+143	1	OvAmp.AmpPsQ-MaxNo mSec0	Overcurrent: Nominal current factor for maximum reactive current in sector 0
J+144	1.57	OvAmp.AmpPsQ-MaxNo mSec1	Overcurrent: Nominal current factor for maximum reactive current in sector 1
J+145	1.25	OvAmp.AmpPsQ-MaxNo mSec2	Overcurrent: Nominal current factor for maximum reactive current in sector 2
J+146	1.16	OvAmp.AmpPsQ-MaxNo mSec3	Overcurrent: Nominal current factor for maximum reactive current in sector 3
J+147	0	OvAmp.VirtImpEna	Overcurrent: Activation of overcurrent for virtual impedance
J+148	0	OvAmp.AcCtlEna	Overcurrent: Activation of overcurrent for grid forming
J+149	1.57	OvAmp.AmpMaxNo-mInit	Overcurrent: Init value of nominal current factor for maximum apparent current in the virtual impedance
J+150	0.5	OvAmp.TmpStkFilTm	Time constant of the low-pass filtering of the stack temperature

J+151	142	OvAmp.TmpLimNormal	Overcurrent: Temperature limit for normal mode
J+152	147	OvAmp.TmpLimTrans	Overcurrent: Temperature limit for transition mode
J+153	1000	OvAmp.NormalMod-HysTm	Overcurrent: Duration of hysteresis to move from normal mode to emergency mode
J+154	150	OvAmp.TransMod-HysTm	Time hysteresis in milliseconds for switching between emergency and transition mode
J+155	125	OvAmp.Change-ModHysTm	Time hysteresis in milliseconds for switching between modes
J+156	1.62	OvAmp.ArmsMs-MaxLim	Overcurrent: Maximum limit for measured short circuit current in the virtual impedance
J+157	3000	OvAmp.StkAmpLimOn	Overcurrent: Hardware current limit at which the FPGA activates the FRT
J+158	1.62	OvAmp. AmpCtlOfsAMaxSpt	Overcurrent: Adaptive current control. maximum short circuit current of current control offset
J+159	5	Ctl.HzOutLim	AC and DC limit control. minimum/maximum range control signal [Hz]
J+160	0.75	Ctl.VolDQLim	Current setpoint calculation: voltage filter freeze limit. Grid forming modeGriF
J+161	0	HW.OvAmpLimEna	Hardware current limit: Activation of overcurrent hardware current limits
J+162	10	HW.StkAmpLimOnFac	Calibration Factor for HW_StkAmpLimOn (PSS/E Specific)
J+163	0	InertiaWCtlHzBatMod	P(f) mode for battery inverter. at activated angular inertia
J+164	44	WCtlHzBat.Hz1	Battery operation: Active power droop point 1 on Hz-axis
J+165	46	WCtlHzBat.Hz2	Battery operation: Active power droop point 2 on Hz-axis
J+166	48	WCtlHzBat.Hz3	Battery operation: Active power droop point 3 on Hz-axis
J+167	49.5	WCtlHzBat.Hz4	Battery operation: Active power droop point 4 on Hz-axis
J+168	50.5	WCtlHzBat.Hz5	Battery operation: Active power droop point 5 on Hz-axis
J+169	52	WCtlHzBat.Hz6	Battery operation: Active power droop point 6 on Hz-axis
J+170	54	WCtlHzBat.Hz7	Battery operation: Active power droop point 7 on Hz-axis
J+171	56	WCtlHzBat.Hz8	Battery operation: Active power droop point 8 on Hz-axis
J+172	1	WCtlHzBat.W1	Battery operation: Active power droop point 1 on W-axis
J+173	0.7	WCtlHzBat.W2	Battery operation: Active power droop point 2 on W-axis
J+174	0.2	WCtlHzBat.W3	Battery operation: Active power droop point 3 on W-axis
J+175	0	WCtlHzBat.W4	Battery operation: Active power droop point 4 on W-axis

J+176	0	WCtlHzBat.W5	Battery operation: Active power droop point 5 on W-axis
J+177	-0.2	WCtlHzBat.W6	Battery operation: Active power droop point 6 on W-axis
J+178	-0.7	WCtlHzBat.W7	Battery operation: Active power droop point 7 on W-axis
J+179	-1	WCtlHzBat.W8	Battery operation: Active power droop point 8 on W-axis
J+180	53	HzCtl.Hi1Lim	Monitoring the power frequency: upper switch-off limit 1
J+181	60000	HzCtl.Hi1LimTm	Monitoring the power frequency: waiting time upper switch-off limit 1
J+182	53	HzCtl.Hi2Lim	Monitoring the power frequency: upper switch-off limit 2
J+183	60000	HzCtl.Hi2LimTm	Monitoring the power frequency: waiting time upper switch-off limit 2
J+184	53	HzCtl.Hi3Lim	Monitoring the power frequency: upper switch-off limit 3
J+185	60000	HzCtl.Hi3LimTm	Monitoring the power frequency: waiting time upper switch-off limit 3
J+186	54	HzCtl.Hi4Lim	Monitoring the power frequency: upper switch-off limit 4
J+187	60000	HzCtl.Hi4LimTm	Monitoring the power frequency: waiting time upper switch-off limit 4
J+188	55	HzCtl.Hi5Lim	Monitoring the power frequency: upper switch-off limit 5
J+189	100	HzCtl.Hi5LimTm	Monitoring the power frequency: waiting time upper switch-off limit 5
J+190	55	HzCtl.Hi6Lim	Monitoring the power frequency: upper switch-off limit 6
J+191	100	HzCtl.Hi6LimTm	Monitoring the power frequency: waiting time upper switch-off limit 6
J+192	45	HzCtl.Lo1Lim	Monitoring the power frequency: lower switch-off limit 1
J+193	100	HzCtl.Lo1LimTm	Monitoring the power frequency: waiting time lower switch-off limit 1
J+194	46	HzCtl.Lo2Lim	Monitoring the power frequency: lower switch-off limit 2
J+195	60000	HzCtl.Lo2LimTm	Monitoring the power frequency: waiting time lower switch-off limit 2
J+196	47	HzCtl.Lo3Lim	Monitoring the power frequency: lower switch-off limit 3
J+197	60000	HzCtl.Lo3LimTm	Monitoring the power frequency: waiting time lower switch-off limit 3
J+198	47	HzCtl.Lo4Lim	Monitoring the power frequency: lower switch-off limit 4
J+199	60000	HzCtl.Lo4LimTm	Monitoring the power frequency: waiting time lower switch-off limit 4

J+200	47	HzCtl.Lo5Lim	Monitoring the power frequency: lower switch-off limit 5
J+201	60000	HzCtl.Lo5LimTm	Monitoring the power frequency: waiting time lower switch-off limit 5
J+202	47	HzCtl.Lo6Lim	Monitoring the power frequency: lower switch-off limit 6
J+203	60000	HzCtl.Lo6LimTm	Monitoring the power frequency: waiting time lower switch-off limit 6
J+204	1.15	VCtl.Hi1Lim	Monitoring the grid voltage: upper switch-off limit 1
J+205	60000	VCtl.Hi1LimTm	Monitoring the grid voltage: waiting time upper switch-off limit 1
J+206	1.25	VCtl.Hi2Lim	Monitoring the grid voltage: upper switch-off limit 2
J+207	1000	VCtl.Hi2LimTm	Monitoring the grid voltage: waiting time upper switch-off limit 2
J+208	1.3	VCtl.Hi3Lim	Monitoring the grid voltage: upper switch-off limit 3
J+209	20	VCtl.Hi3LimTm	Monitoring the grid voltage: waiting time upper switch-off limit 3
J+210	1.5	VCtl.Hi4Lim	Monitoring the grid voltage: upper switch-off limit 4
J+211	3	VCtl.Hi4LimTm	Monitoring the grid voltage: waiting time upper switch-off limit 4
J+212	2	VCtl.Hi5Lim	Monitoring the grid voltage: upper switch-off limit 5
J+213	1.66	VCtl.Hi5LimTm	Monitoring the grid voltage: waiting time upper switch-off limit 5
J+214	2	VCtl.Hi6Lim	Monitoring the grid voltage: upper switch-off limit 6
J+215	10000	VCtl.Hi6LimTm	Monitoring the grid voltage: waiting time upper switch-off limit 6
J+216	0.8	VCtl.Lo1Lim	Monitoring the grid voltage: lower switch-off limit 1
J+217	21000	VCtl.Lo1LimTm	Monitoring the grid voltage: waiting time lower switch-off limit 1
J+218	0.4	VCtl.Lo2Lim	Monitoring the grid voltage: lower switch-off limit 2
J+219	21000	VCtl.Lo2LimTm	Monitoring the grid voltage: waiting time lower switch-off limit 2
J+220	0	VCtl.Lo3Lim	Monitoring the grid voltage: lower switch-off limit 3
J+221	21000	VCtl.Lo3LimTm	Monitoring the grid voltage: waiting time lower switch-off limit 3
J+222	0	VCtl.Lo4Lim	Monitoring the grid voltage: lower switch-off limit 4
J+223	21000	VCtl.Lo4LimTm	Monitoring the grid voltage: waiting time lower switch-off limit 4
J+224	0	VCtl.Lo5Lim	Monitoring the grid voltage: lower switch-off limit 5
J+225	21000	VCtl.Lo5LimTm	Monitoring the grid voltage: waiting time lower switch-off limit 5
J+226	0	VCtl.Lo6Lim	Monitoring the grid voltage: lower switch-off limit 6
J+227	1000	VCtl.Lo6LimTm	Monitoring the grid voltage: waiting time lower switch-off limit 6
J+228	0.3	Spk.dVol	1-time step change in voltage to activation entry and exit of spike mitigation logic (PSS/E Specific)
J+229	0.005	Spk.AmpHoldTm	Time in seconds during which the current is held to its [Pre-fault Value*Spk.AmpHoldFac(X)] (PSS/E Specific)

J+230	0	Spk.AmpHoldFacD	Factor to scale the active part of Pre-fault value between 0.0 and [Pre-fault value] (PSS/E Specific)
J+231	0	Spk.AmpHoldFacQ	Factor to scale the reactive part of Prefault value between 0.0 and [Pre-fault value] (PSS/E Specific)
J+232	1.1	SoC. DcVolIni	SoC Model: Initial value of the DC voltage for battery in kV (PSS/E Specific)
J+233	1.3	SoC. DcVolMax	SoC Model: Maximum value of the DC voltage for battery in kV (PSS/E Specific)
J+234	0.8	SoC. DcVolMin	SoC Model: Minimum value of the DC voltage for battery in kV (PSS/E Specific)
J+235	10000	SoC. DcAh	SoC Model: Capacity of the battery in Ah (PSS/E Specific)
J+236	0	DcCtl.AmpKp	DC current control. proportional amplification. Grid forming mode
J+237	5	DcCtl.AmpKi	DC current control. integral amplification. Grid forming mode
J+238	0.00033	DcCtl.AmpKi2Fac	DC current control. double integral amplification for DC current limit. Grid forming mode
J+239	3	DcCtl.AmpI2CtlDown-Gai n	DC current control. additional double integral amplification. if DC current limit is not exceeded. Grid forming mode

11. Appendix G - Converter Model VARs

VAR	Parameter
VAR(L+0)	WSpt – Use this VAR to set active power setpoint when ICON(M) is set to 0
VAR(L+1)	VarSpt – Use this VAR to set reactive power setpoint when ICON(M) is set to 0
VAR(L+2)	FrqSpt - Use this VAR to set frequency setpoint
VAR(L+3)	VolSpt - Use this VAR to set voltage setpoint
VAR(L+4)	TmpStk – Use this VAR to set the temperature of stack – Default is 119 degrees
VAR(L+5)	Xpu – X part of impedance for current injection – should be equal to X for gen. in LF
VAR(L+6)	Rpu - R part of impedance for current injection – should be equal to R for gen. in LF
VAR(L+7)	Unused
VAR(L+8)	Unused
VAR(L+9)	SetpointChangeFlag – Flag to detect setpoint change when ICON(M) is set to 0
VAR(L+10)	Meas1.Vinv_d – d-axis inverter terminal voltage
VAR(L+11)	Meas1.Vinv_q – q-axis inverter terminal voltage
VAR(L+12)	Meas1.Iinv_d – d-axis inverter current
VAR(L+13)	Meas1.Iinv_q – q – axis inverter current
VAR(L+14)	Vth_r – real part of thevenin voltage applied in the current injection routine
VAR(L+15)	Vth_i – imaginary part of thevenin voltage applied in the current injection routine
VAR(L+16)	FRTDetect – Flag to Check whether FRT is enabled or not
VAR(L+17)	VI_X – reactive part of Virtual impedance when in FRT
VAR(L+18)	VI_R – real part of Virtual impedance when in FRT
VAR(L+19)	Unused
VAR(L+20)	AmpDQRtg
VAR(L+21)	StkAmpLimOn
VAR(L+22)	PreFaultCurrD
VAR(L+23)	PreFaultCurrQ
VAR(L+24)	SpikeFlagOn
VAR(L+25)	SpikeFlagOff
VAR(L+26)	SpikeTimer
VAR(L+27)	Meas1.Pinv_hold
VAR(L+28)	Meas1.Qinv_hold
VAR(L+29)	Unused
VAR(L+30)	VCtlHi1Lim_Out – Flag to check whether High Voltage Protection 1 is activated
VAR(L+31)	VCtlHi1Lim_timer
VAR(L+32)	VCtlHi2Lim_Out - Flag to check whether High Voltage Protection 2 is activated
VAR(L+33)	VCtlHi2Lim_timer
VAR(L+34)	VCtlHi3Lim_Out - Flag to check whether High Voltage Protection 3 is activated
VAR(L+35)	VCtlHi3Lim_timer
VAR(L+36)	VCtlHi4Lim_Out - Flag to check whether High Voltage Protection 4 is activated
VAR(L+37)	VCtlHi4Lim_timer
VAR(L+38)	VCtlHi5Lim_Out - Flag to check whether High Voltage Protection 5 is activated
VAR(L+39)	VCtlHi5Lim_timer
VAR(L+40)	VCtlHi6Lim_Out - Flag to check whether High Voltage Protection 6 is activated
VAR(L+41)	VCtlHi6Lim_timer

VAR(L+42)	VCtlLo1Lim_Out - Flag to check whether Low Voltage Protection 1 is activated
VAR(L+43)	VCtlLo1Lim_timer
VAR(L+44)	VCtlLo2Lim_Out - Flag to check whether Low Voltage Protection 2 is activated
VAR(L+45)	VCtlLo2Lim_timer
VAR(L+46)	VCtlLo3Lim_Out - Flag to check whether Low Voltage Protection 3 is activated
VAR(L+47)	VCtlLo3Lim_timer
VAR(L+48)	VCtlLo4Lim_Out - Flag to check whether Low Voltage Protection 4 is activated
VAR(L+49)	VCtlLo4Lim_timer
VAR(L+50)	VCtlLo5Lim_Out - Flag to check whether Low Voltage Protection 5 is activated
VAR(L+51)	VCtlLo5Lim_timer
VAR(L+52)	VCtlLo6Lim_Out - Flag to check whether Low Voltage Protection 6 is activated
VAR(L+53)	VCtlLo6Lim_timer
VAR(L+54)	HzCtlHi1Lim_Out - Flag to check whether High Frequency Protection 1 is activated
VAR(L+55)	HzCtlHi1Lim_timer
VAR(L+56)	HzCtlHi2Lim_Out - Flag to check whether High Frequency Protection 2 is activated
VAR(L+57)	HzCtlHi2Lim_timer
VAR(L+58)	HzCtlHi3Lim_Out - Flag to check whether High Frequency Protection 3 is activated
VAR(L+59)	HzCtlHi3Lim_timer
VAR(L+60)	HzCtlHi4Lim_Out - Flag to check whether High Frequency Protection 4 is activated
VAR(L+61)	HzCtlHi4Lim_timer
VAR(L+62)	HzCtlHi5Lim_Out - Flag to check whether High Frequency Protection 5 is activated
VAR(L+63)	HzCtlHi5Lim_timer
VAR(L+64)	HzCtlHi6Lim_Out - Flag to check whether High Frequency Protection 6 is activated
VAR(L+65)	HzCtlHi6Lim_timer
VAR(L+66)	HzCtlLo1Lim_Out - Flag to check whether Low Frequency Protection 1 is activated
VAR(L+67)	HzCtlLo1Lim_timer
VAR(L+68)	HzCtlLo2Lim_Out - Flag to check whether Low Frequency Protection 2 is activated
VAR(L+69)	HzCtlLo2Lim_timer
VAR(L+70)	HzCtlLo3Lim_Out - Flag to check whether Low Frequency Protection 3 is activated
VAR(L+71)	HzCtlLo3Lim_time
VAR(L+72)	HzCtlLo4Lim_Out - Flag to check whether Low Frequency Protection 4 is activated
VAR(L+73)	HzCtlLo4Lim_timer
VAR(L+74)	HzCtlLo5Lim_Out - Flag to check whether Low Frequency Protection 5 is activated
VAR(L+75)	HzCtlLo5Lim_timer
VAR(L+76)	HzCtlLo6Lim_Out - Flag to check whether Low Frequency Protection 6 is activated
VAR(L+77)	HzCtlLo6Lim_timer
VAR(L+78)	Control_Angle
VAR(L+79)	Inverter_Voltage_Angle
VAR(L+80)	CosPhi
VAR(L+81)	SinPhi
VAR(L+82)	Meas1.Vinv_d
VAR(L+83)	Meas1.Vinv_q
VAR(L+84)	Meas1.Vth_d
VAR(L+85)	Meas1.Vth_q
VAR(L+86)	Meas1.Iinv_d
VAR(L+87)	Meas1.Iinv_q
VAR(L+88)	AmaxSpt
VAR(L+89)	Vmag_Filt
VAR(L+90)	Vmag.Filt

VAR(L+91)	Result_enaGoToSec2
VAR(L+92)	ErrorCounter1
VAR(L+93)	Result_enaGoToSec3
VAR(L+94)	ErrorCounter2
VAR(L+95)	Result_enaGoToSec4
VAR(L+96)	ErrorCounter3
VAR(L+97)	Result_enaGoToSec3FromSec0
VAR(L+98)	ErrorCounter4
VAR(L+99)	TempStk_Filt
VAR(L+100)	CounterSec0
VAR(L+101)	OvAmpStt
VAR(L+102)	SubStt
VAR(L+103)	noOvercurrentStt
VAR(L+104)	HWTresholdHi
VAR(L+105)	EnaThmDerating
VAR(L+106)	AmaxNom
VAR(L+107)	AmaxNomD
VAR(L+108)	AmaxNomQ
VAR(L+109)	AmaxNomInit
VAR(L+110)	HysMode
VAR(L+111)	HysMode_timer
VAR(L+112)	TmpAcCtlOvAmpActive
VAR(L+113)	Unused
VAR(L+114)	disaOverCurrent_delay
VAR(L+115)	AmaxNom_filt
VAR(L+116)	AmaxNomD_filt
VAR(L+117)	AmaxNomQ_filt
VAR(L+118)	AMaxSpt
VAR(L+119)	StkAmpLimOn
VAR(L+120)	Vinv_d_filt
VAR(L+121)	Vinv_q_filt
VAR(L+122)	SW_FRT
VAR(L+123)	SW_FRT_timer
VAR(L+124)	VirtImpEna
VAR(L+125)	FRT_States_timer
VAR(L+126)	VirtImpEna_delay
VAR(L+127)	Local_ResetTm_timer
VAR(L+128)	AmaxSpt_Filt
VAR(L+129)	AmpMax_Filt
VAR(L+130)	Meas.Iinv_q_Filt
VAR(L+131)	VI_X_PiCtrlWithLimit_Out
VAR(L+132)	VI_X_PiCtrl_Integrator
VAR(L+133)	VI_R_Filt
VAR(L+134)	VI_R_PiCtrlWithLimit_Out
VAR(L+135)	VI_R_PiCtrl_Integrator
VAR(L+136)	VI_X
VAR(L+137)	VI_R
VAR(L+138)	AmaxSpt_Filt2
VAR(L+139)	AmaxSpt_timer

VAR(L+140)	FFW_VolDiff_Filt
VAR(L+141)	FFW_VI_X1_delay
VAR(L+142)	VolPsDSpt_Ofs
VAR(L+143)	VI_AmpPsDSpt
VAR(L+144)	AWFFWAmpPsD
VAR(L+145)	VolPsQSpt_Ofs
VAR(L+146)	Soc_sat
VAR(L+147)	DcVol
VAR(L+148)	CtlOut_P_Dc
VAR(L+149)	CtlOut_I_Dc
VAR(L+150)	Ki_max_hold
VAR(L+151)	Ki_min_hold
VAR(L+152)	PiCtrlWithLimit_Output
VAR(L+153)	PiCtrl_Integrator
VAR(L+154)	PiCtrl_Integrator2
VAR(L+155)	PiCtrl_Integrator3
VAR(L+156)	PiCtrlWithLimit_Output
VAR(L+157)	PiCtrl_Integrator
VAR(L+158)	PiCtrl_Integrator2
VAR(L+159)	PiCtrl_Integrator3
VAR(L+160)	CtlOut_Dc
VAR(L+161)	AmpDOfs_DcLim_Stt
VAR(L+162)	Iinv_d_fil
VAR(L+163)	Iinv_q_fil
VAR(L+164)	Vmag_fil1
VAR(L+165)	Vmag_fil2
VAR(L+166)	CtlOut_P_D
VAR(L+167)	CtlOut_I_D
VAR(L+168)	Ki_max_hold
VAR(L+169)	Ki_min_hold
VAR(L+170)	PiCtrlWithLimit_Output
VAR(L+171)	PiCtrl_Integrator
VAR(L+172)	PiCtrl_Integrator2
VAR(L+173)	PiCtrl_Integrator3
VAR(L+174)	PiCtrlWithLimit_Output
VAR(L+175)	PiCtrl_Integrator
VAR(L+176)	PiCtrl_Integrator2
VAR(L+177)	PiCtrl_Integrator3
VAR(L+178)	CtlOut_D
VAR(L+179)	CtlOut_P_Q
VAR(L+180)	CtlOut_I_Q
VAR(L+181)	Ki_max_hold
VAR(L+182)	Ki_min_hold
VAR(L+183)	PiCtrlWithLimit_Output
VAR(L+184)	PiCtrl_Integrator
VAR(L+185)	PiCtrl_Integrator2
VAR(L+186)	PiCtrl_Integrator3
VAR(L+187)	PiCtrlWithLimit_Output
VAR(L+188)	PiCtrl_Integrator

VAR(L+189)	PiCtrl_Integrator2
VAR(L+190)	PiCtrl_Integrator3
VAR(L+191)	CtlOut_Q
VAR(L+192)	VirtImpEna_delay
VAR(L+193)	WAval
VAR(L+194)	VarAval
VAR(L+195)	IC1_Delay
VAR(L+196)	IC2_Delay
VAR(L+197)	IC1_Delay
VAR(L+198)	IC2_Delay
VAR(L+199)	AmpDOfs_DrtStt
VAR(L+200)	AmpQOfs_DrtStt
VAR(L+201)	WSptOut
VAR(L+202)	VarSptOut
VAR(L+203)	WSptFilt
VAR(L+204)	VarSptFilt
VAR(L+205)	WSptOut
VAR(L+206)	Hz_Filt
VAR(L+207)	Ud_filt
VAR(L+208)	Uq_filt
VAR(L+209)	AmpPsDSpt
VAR(L+210)	AmpPsQSpt
VAR(L+211)	dHz
VAR(L+212)	dTheta
VAR(L+213)	dVol
VAR(L+214)	Iinv_d_filt
VAR(L+215)	Iinv_q_filt
VAR(L+216)	Vmag.filt
VAR(L+217)	DrpAmpDFilTm_filt
VAR(L+218)	HPF_Filt_out_dHz
VAR(L+219)	dHz_HPF_delay
VAR(L+220)	DrpAmpDFilTm2_filt
VAR(L+221)	HPF_Filt_out_dHz2
VAR(L+222)	dHz2_HPF_delay
VAR(L+223)	DrpAmpD_filt
VAR(L+224)	InteriaPhsCtl_Kp_filt
VAR(L+225)	InteriaPhsCtl_Ki_filt
VAR(L+226)	AmpPsD_int
VAR(L+227)	DrpAmpQFilTm_filt
VAR(L+228)	HPF_Filt_out_dVol
VAR(L+229)	dVol_HPF_delay
VAR(L+230)	DrpAmpQFilTm2_filt
VAR(L+231)	HPF_Filt_out_dVol2
VAR(L+232)	dVol2_HPF_delay
VAR(L+233)	DrpAmpQ_filt
VAR(L+234)	InteriaVolCtl_Kp_filt
VAR(L+235)	InteriaVolCtl_Ki_filt
VAR(L+236)	AmpPsQ_int
VAR(L+237)	dAmpD_filt

VAR(L+238)	DrpHz_Filt
VAR(L+239)	DrpTheta_Filt
VAR(L+240)	DrpVol_Filt
VAR(L+241)	Vinv_q_filt
VAR(L+242)	VirtImpEna_delay
VAR(L+243)	dHz_out
VAR(L+244)	dHz_filt
VAR(L+245)	dHz_Filt_delay1
VAR(L+246)	dHz_Filt_delay2
VAR(L+247)	dHz_Filt_delay3
VAR(L+248)	dHz_Filt_delay4
VAR(L+249)	dHz_Filt_delay5
VAR(L+250)	dHz_Filt_delay6
VAR(L+251)	dHz_Filt_delay7
VAR(L+252)	dHz_Filt_delay8
VAR(L+253)	dHz_Filt_delay9
VAR(L+254)	dHz_Filt_delay10
VAR(L+255)	dHz_Filt_delay11
VAR(L+256)	dHz_Filt_delay12
VAR(L+257)	dHz_Filt_delay13
VAR(L+258)	dHz_Filt_delay14
VAR(L+259)	dHz_Filt_delay15
VAR(L+260)	dHz_Filt_delay16
VAR(L+261)	dHz_Filt_delay17
VAR(L+262)	dHz_Filt_delay18
VAR(L+263)	dHz_Filt_delay19
VAR(L+264)	dHz_Filt_delay20
VAR(L+265)	dHz_Filt_delay21
VAR(L+266)	dTheta_out
VAR(L+267)	dTheta_filt
VAR(L+268)	dTheta_Filt_delay1
VAR(L+269)	dTheta_Filt_delay2
VAR(L+270)	dTheta_Filt_delay3
VAR(L+271)	dTheta_Filt_delay4
VAR(L+272)	dTheta_Filt_delay5
VAR(L+273)	dTheta_Filt_delay6
VAR(L+274)	dTheta_Filt_delay7
VAR(L+275)	dTheta_Filt_delay8
VAR(L+276)	dTheta_Filt_delay9
VAR(L+277)	dTheta_Filt_delay10
VAR(L+278)	dTheta_Filt_delay11
VAR(L+279)	dTheta_Filt_delay12
VAR(L+280)	dTheta_Filt_delay13
VAR(L+281)	dTheta_Filt_delay14
VAR(L+282)	dTheta_Filt_delay15
VAR(L+283)	dTheta_Filt_delay16
VAR(L+284)	dTheta_Filt_delay17
VAR(L+285)	dTheta_Filt_delay18
VAR(L+286)	dTheta_Filt_delay19

VAR(L+287)	dTheta_Filt_delay20
VAR(L+288)	dTheta_Filt_delay21
VAR(L+289)	dVol
VAR(L+290)	dVol_filt
VAR(L+291)	dVol_Filt_delay1
VAR(L+292)	dVol_Filt_delay2
VAR(L+293)	dVol_Filt_delay3
VAR(L+294)	dVol_Filt_delay4
VAR(L+295)	dVol_Filt_delay5
VAR(L+296)	dVol_Filt_delay6
VAR(L+297)	dVol_Filt_delay7
VAR(L+298)	dVol_Filt_delay8
VAR(L+299)	dVol_Filt_delay9
VAR(L+300)	dVol_Filt_delay10
VAR(L+301)	dVol_Filt_delay11
VAR(L+302)	dVol_Filt_delay12
VAR(L+303)	dVol_Filt_delay13
VAR(L+304)	dVol_Filt_delay14
VAR(L+305)	dVol_Filt_delay15
VAR(L+306)	dVol_Filt_delay16
VAR(L+307)	dVol_Filt_delay17
VAR(L+308)	dVol_Filt_delay18
VAR(L+309)	dVol_Filt_delay19
VAR(L+310)	dVol_Filt_delay20
VAR(L+311)	dVol_Filt_delay21
VAR(L+312)	VolPsDSpt
VAR(L+313)	VolPsDSpt_rate
VAR(L+314)	Vinv_d
VAR(L+315)	Vinv_q
VAR(L+316)	Vinv_d_FRT
VAR(L+317)	Vinv_q_FRT
VAR(L+318)	Vinv_d_filt
VAR(L+319)	Vinv_q_filt
VAR(L+320)	Vinv_d_int
VAR(L+321)	Vinv_q_int
VAR(L+322)	Iinv_d_filt
VAR(L+323)	Iinv_q_filt
VAR(L+324)	ur
VAR(L+325)	ui

12. Appendix H - Extra Reactive Power Control Mode

The following reactive power control modes are supported by Fluence functions but are not implemented in this project.

RPCM = 1 — Voltage Control Mode (VCMD)

When RPCM is set to 1, the converter operates in voltage control mode, where reactive power is controlled to regulate the voltage at either a local or remote bus. Key parameters to adjust voltage control are shown below:

- ICON M+5 - must be set to 1 for the PPC to operate in voltage control mode
- VAR L+6 - can be adjusted to control the loca+l or remote bus voltage in pu
- ICON M+7 - can be set to 0 for local voltage or to a bus number for remote measurement

RPCM = 4 — Local Reactive Power Control Mode

When RPCM is set to 4, the system enters local reactive power control mode. The reactive power command is provided directly by the user through VAR(L+2) (QLCLCMD). This mode can optionally be used with VSL enabled, by setting ICON(M+7) to 1, to allow the local Q reference to respond to bus voltage conditions. Key parameters to adjust reactive power control are shown below:

- ICON M+5 - must be set to 4 for the PPC to operate in local reactive power control mode
- ICON M+7 - can be set to 1 for enabling the VSL function
- VAR L+2 - QLCLCMD can be adjusted to set the reactive power at the local branch

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