Proposal to Retire REPC_B Model

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for WECC Model Validation Subcommittee

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REPC_B Limitations

- Discussed in MVS document “Clarification on Proper Use of REPC Models” (https://www.wecc.org/wecc-document/13376)
  - The model is on system MVA base (resolved; all four software platforms allow defining a model MVA base)
  - The model is attached to a generator. The attaching generator must be online to invoke the model.
  - All active and reactive power quantities are deviation from the initial condition in the power flow case. Power limits (Pmax/Pmin and Qmax/Qmin) are relative.
- Although there are work-around to overcome the issues, they could be overlooked and result in incorrect simulation results.

REPC_D Enhancements

- REPC_D controls multiple generators/devices downstream without the limitations of REPC_B
  - The model has its own MVA base.
  - The model is attached to its own bus.
  - The model p and q commands are initialized to the power flow outputs.
  - Kwi and Kzi are normalized.
- REPC_D includes all modeling enhancements in REPC_C over REPC_A/B.

Convert REPC_B to REPC_D

- The following parameters need to be converted from REPC_B model MVA base to REPC_D base.

REPC_D Parameter	Description	Conversion from REPC_B
Qvmax	Maximum Q control output, pu	REPC_B.qmax * REPC_B MVA base / REPC_D MVA base
Qvmin	Minimum Q control output, pu	REPC_B.qmin * REPC_B MVA base / REPC_D MVA base
PImax	Maximum output of the active power PI controller, pu	REPC_B.pmax * REPC_B MVA base / REPC_D MVA base
PImin	Minimum output of the active power PI controller, pu	REPC_B.pmin * REPC_B MVA base / REPC_D MVA base
Kc	Voltage droop	REPC_B.kc * REPC_D MVA base / REPC_B MVA base
Ddn	reciprocal of downward frequency droop	REPC_B.ddn * REPC_B MVA base / REPC_D MVA base
Dup	reciprocal of upward frequency droop	REPC_B.dup * REPC_B MVA base / REPC_D MVA base

Adding New Parameters to REPC_D

- Utilize the enhanced modeling capability and obtain parameter values from the plant controller settings.
- If the additional feature associated with the parameter is not used by the plant controller, set the value according to the table below.

Additional Parameters in REPC_D (1)

If the additional feature associated with the parameter is not used, enter the value in the table.

REPC_D Parameter	Description	Value if Parameter not Used
Pefd_Flag	Enable (1) or disable (0) electrical power feedback	1
Ffwrd_Flag	Feedforward flag (1) include feedforward and (0) disable	0
QVFlag	0 means Q/V control is a fixed output; <> 0 means QV control is enabled.	1
MSSFlag	0 means shunt switching is disabled; <> 0 means shunt switching is enabled.	0
Tc	Reactive-current compensation time-constant, sec	0
Tfrq	Frequency time constant, sec	0
dbd1	QV deadband downside (<= 0)	-dbd
dbd2	QV deadband upside (<= 0)	dbd

Additional Parameters in REPC_D (2)

If the additional feature associated with the parameter is not used, enter the value in the table.

REPC_D Parameter	Description	Value if Parameter not Used
Vrefmax	Maximum voltage reference, pu	2
Vrefmin	Minimum voltage reference, pu	0
Qrefmax	Maximum Q-reference, pu	Qmax
Qrefmin	Minimum Q-reference, pu	Qmin
dqrefmax	Maximum rate if increase of Q-reference, pu/s	99
dqrefmin	Maximum rate if decrease of Q-reference, pu/s	-99
qvrmax	Maximum rate if increase of Qext (Vext), pu/s	99
qvrmin	Maximum rate if decrease of Qext (Vext), pu/s	-99
pfmax	For positive Mvar, the minimum power factor setpoint allowed	1
pfmin	For negative Mvar, the minimum power factor setpoint allowed	-1

Additional Parameters in REPC_D (3)

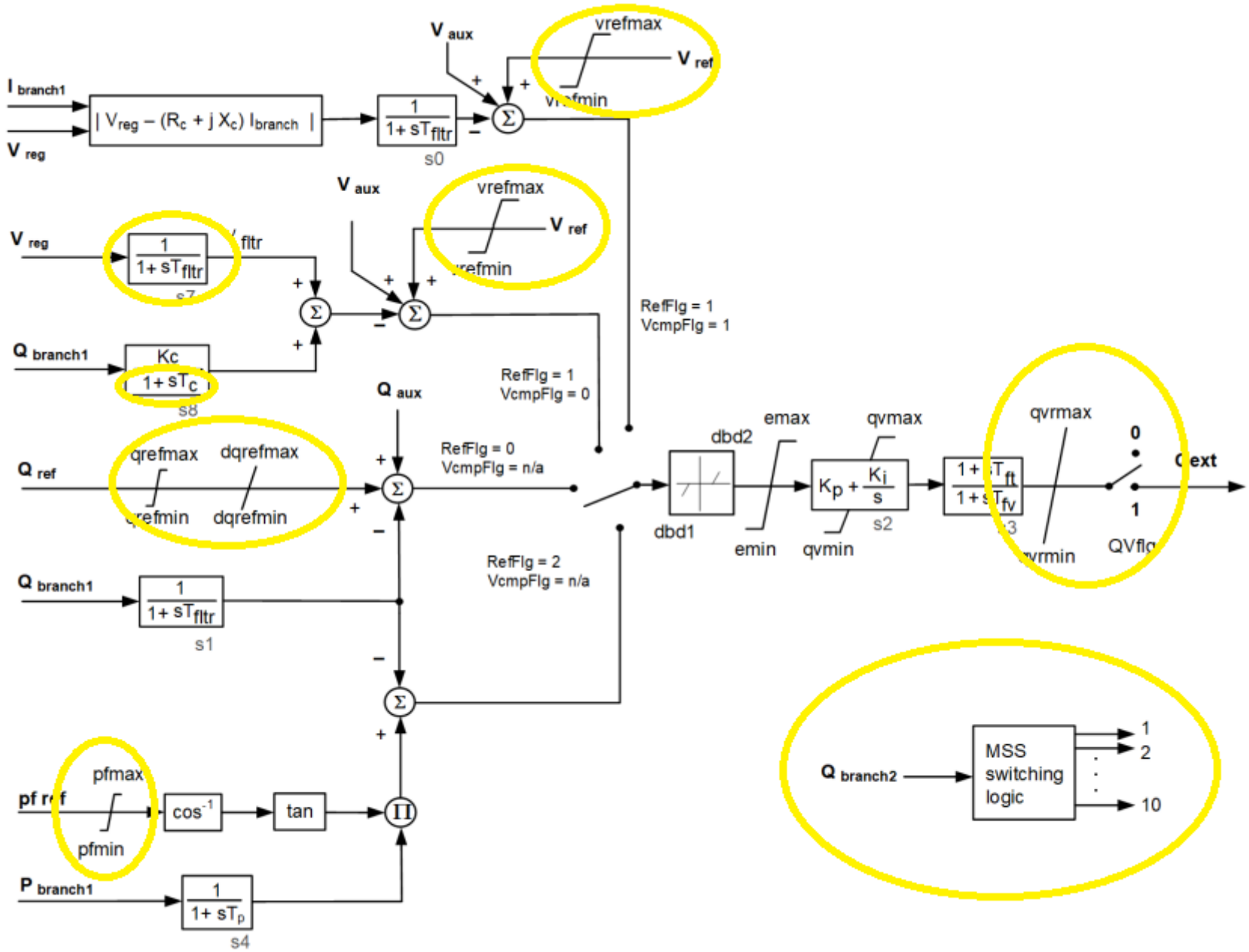
If the additional feature associated with the parameter is not used, enter the value in the table.

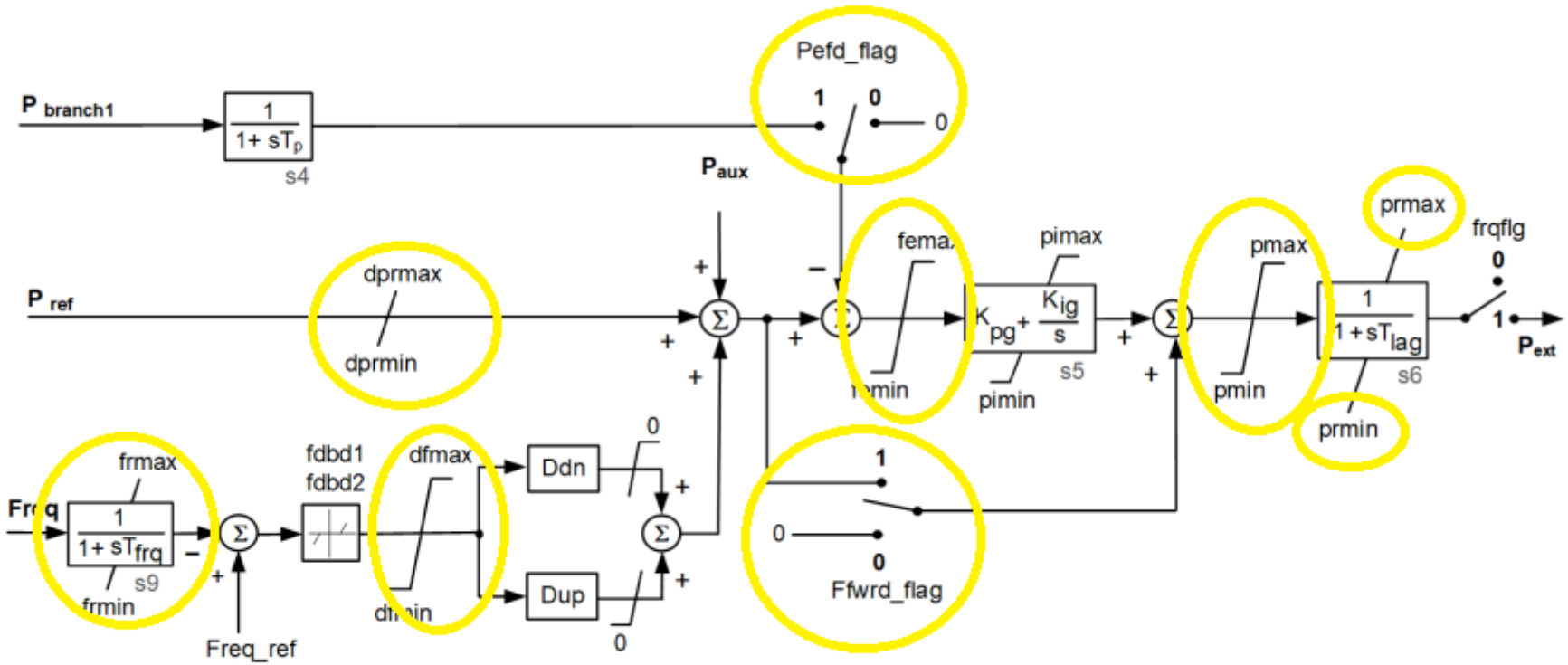
REPC_D Parameter	Description	Value if Parameter not Used
dprmax	Maximum rate if increase of Plant Pref, pu/s	99
dprmin	Maximum rate if decrease of Plant Pref, pu/s	-99
Prmax	Maximum rate if increase of Pref, pu/s	99
Prmin	Maximum rate if decrease of Pref, pu/s	-99
dfmax	Maximum frequency error, pu	99
dfmin	Minimum frequency error, pu	-99
frmax	Maximum rate limit on measured frequency, pu/s	99
frmin	Minimum rate limit on measured frequency, pu/s	-99

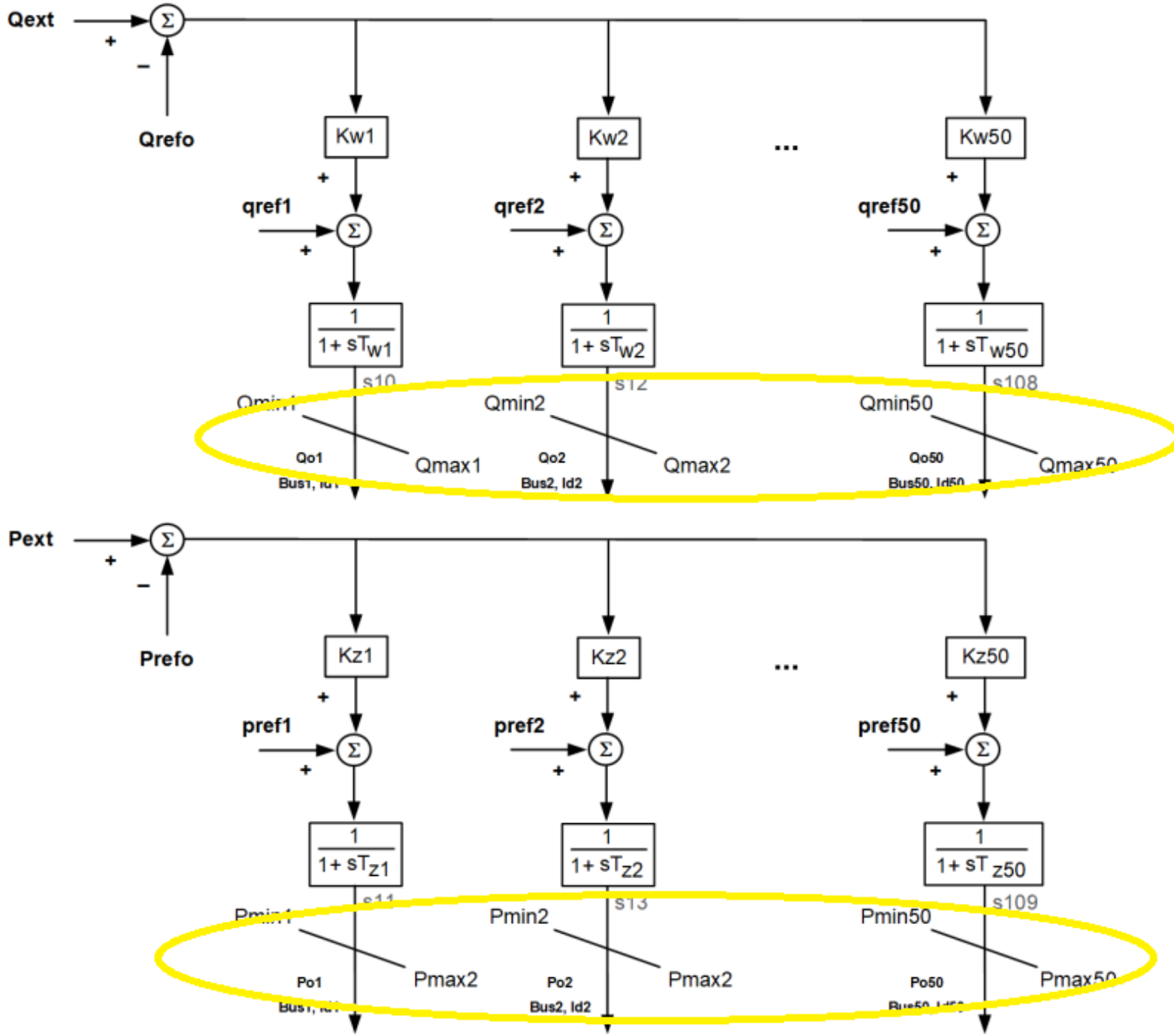
Additional Parameters in REPC_D (4)

If the additional feature associated with the parameter is not used, enter the value in the table.

REPC_D Parameter	Description	Value if Parameter not Used
Tfrz	A time delay during which the states are kept frozen even after the filtered voltage recovers above Vfrz. This can be used to ensure the plant controller does not iteract with the inverter LVRT	0
Vfrzhigh	Voltage above which plant control integrator state is frozen	2
Qdn1	First stage of capacitor (reactor) switching out (in), pu	0
Qdn2	Second stage of capacitor (reactor) switching out (in), pu	0
Qup1	First stage of capacitor (reactor) switching in (out), pu	0
Qup2	Second stage of capacitor (reactor) switching in (out), pu	0
Tdelay1	Time delay after which if Q < Qdn1 (or Q > Qup1) a capacitor (reactor) is switched, sec	0
Tdelay2	Time delay after which if Q < Qdn2 (or Q > Qup2) a capacitor (reactor) is switched, sec	0
Tmssbrk	Time it takes to switch in (out) a mechanically switched shunt, sec	0
TOUT	Time for discharging of a capacitor that has just beed switched out; the same capacitor cannot be switched back in until Tout (sec) has elapsed	0


I branch1
V reg
| V_reg – (R_c + j X_c) I_branch |
1 / 1+ sT_fltr
s0
V aux
vrefmax
V ref
vrefmin
V reg
fltr
s7
V aux
vrefmax
V ref
refmin
Q branch1
Kc / 1+ sT_c
s8
RefFlg = 1
VcmpFlg = 1
RefFlg = 1
VcmpFlg = 0
Q aux
Q ref
qrefmax
dqrefmax
qrefmin
dqrefmin
RefFlg = 0
VcmpFlg = n/a
dbd2
emax
qvmax
qvrmax
0
Q ext
dbd1
emin
qvmin
s2
1
QVflg
qvrmin
RefFlg = 2
VcmpFlg = n/a
Q branch1
1 / 1+ sT_fltr
s1
pf ref
pfmax
pfmin
cos^-1
tan
P branch1
1 / 1+ sT_p
s4
Q branch2
MSS switching logic
1
2
10

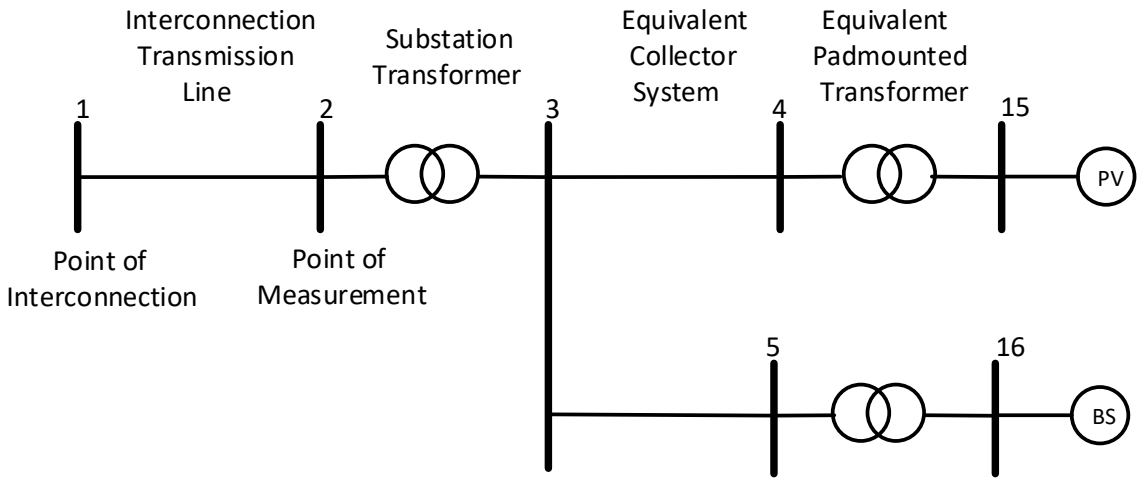

P branch1
1
1+ sTp
s4
Pefd_flag
1
0
0
Paux
P ref
dprmax
dprmin
frmax
Freq
1
1+ sTfrq
s9
frmin
Freq_ref
fdbd1
fdbd2
dfmax
dfmin
Ddn
Dup
0
0
1
0
0
Ffwrd_flag
pimax
pimin
Kpg + Kig/s
s5
pmax
pmin
prmax
prmin
1
1 + sTlag
s6
frqflg
0
1
Pext


Qext
Qrefo
Kw1
Kw2
Kw50
qref1
qref2
qref50
1 / 1+ sTw1
1 / 1+ sTw2
1 / 1+ sTw50
s10
s12
s108
Qmin1
Qmin2
Qmin50
Qmax1
Qmax2
Qmax50
Qo1
Qo2
Qo50
Bus1, Id1
Bus2, Id2
Bus50, Id50
Pext
Prefo
Kz1
Kz2
Kz50
pref1
pref2
pref50
1 / 1+ sTz1
1 / 1+ sTz2
1 / 1+ sTz50
s11
s13
s109
Pmin1
Pmin2
Pmin50
Pmax2
Pmax2
Pmax50
Po1
Po2
Po50
Bus1, Id1
Bus2, Id2
Bus50, Id50

Example of Replacing RECP_B with REPC_D

Power Flow Setup

A hybrid plant: 250 MW max injection at POI



	PV Solar	BESS
Pmax/Pmin (MW)	258.3 / 0	258.3 / -258.3
Qmax/Qmin (MVA)	95.4 / -95.4	100.6 / -100.6
MVA	275.4	277.2

REPC_B

repc_b 15 "PV " 0.63 "1 " 2 "HGSU " 500.00 ! ! 2 "HGSU " 500.00 1 "POI " 500.00 "1 " 1 : #9 "tfltr" 0.050000 "kp" 0.500000 "ki" 3.0000 "tft" 0.0 "tfv" 0.050000 "refflg" 1.000000 "vfrz" 0.900000 "rc" 0.0 "xc" 0.0 "kc" 0.0 /

"vcmpflg" 1.000000 "emax" 0.050000 "emin" -0.050000 "dbd" 0.010000 "qmax" 0.77 "qmin" -0.77 "kpg" 0.500000 "kig" 0.250000 "tp" 0.250000 "fdbd1" -0.000600 /

"fdbd2" 0.000600 "femax" 999.00 "femin" -999.00 "pmax" 2.58 "pmin" -2.58 "tlag" 0.700000 "ddn" 103.33 "dup" 103.33 "frqflg" 1.000000 /

"busn1" 15 "idn1" 1 "Kw1" 0.49 "Kz1" 0.50 "Tw1" 0.020000 /

"busn2" 16 "idn2" 1 "Kw2" 0.51 "Kz2" 0.50 "Tw2" 0.020000

REPC_D

Always define the invocation bus even if it is not required by the software and defaulted to the regbus.

repc_d 2 "HGSU" 500.0 "1 " : #9 "mvab" 100 "regbus" 2 "mon_i" 2 "mon_j" 1 "mon_ck" 1 "tfltr" 0.050000 "kp" 0.500000 "ki" 3.0000 "tft" 0.0 "tfv" 0.050000 "refflg" 1.000000 "vfrz" 0.900000 "vfrzhigh" 2.0 "tfrz" 0.0 "rc" 0.0 "xc" 0.0 "kc" 0.0 "tc" 0.0 /

"vcmpflg" 1.000000 "emax" 0.050000 "emin" -0.050000 "dbd1" -0.010000 "dbd2" 0.01 "qvmax" 0.77 "qvmin" -0.77 "kpg" 0.500000 "kig" 0.250000 "tp" 0.250000 "fdbd1" -0.000600 /

"fdbd2" 0.000600 "femax" 999.00 "femin" -999.00 "pimax" 2.58 "pimin" -2.58 "pmax" 2.58 "pmin" -2.58 "prmax" 99.0 "prmin" -99.0 "dprmax" 99.0 "dprmin" -99.0 /

"tlag" 0.700000 "ddn" 103.33 "dup" 103.33 "frqflg" 1.000000 "vrefmax" 2.0 "vrefmin" 0.0 "qrefmax" 0.77 "qrefmin" -0.77 "dqrefmax" 99.9 "dqrefmin" -99.0 "qvrmax" 99.0 "qvrmin" -99.0 "pfmax" 1.0 "pfmin" -1.0 /

"MSSflag" 0.0 "MSSbus1" 0.0 "MSSbus2" 0.0 "Qdn1" 0.0 "Qdn2" 0.0 “Qup1” 0.0 “Qup2” 0.0 "Tdelay1" 0.0 "Tdelay2" 0.0 "Tmssbrk" 0.0 "Tout" 0.0 /

"tfrq" 0.0 "Ffwrd_flag" 0.0 "Pefd_flag" 1.0 "vfreq" 0.0 "frmax" 99.0 "frmin" -99.0 "QVflg" 1.0 "dfmax" 99.0 "dfmin" -99.0 "fbus" 0.0 /

"busn1" 15 "idn1" 1 "Kw1" 1.0 "Kz1" 1.0 "Tw1" 0.020000 "Tz1" 0.02 "Qmax1" 0.954 "Qmin1" -0.954 "Pmax1" 2.583 "Pmin1" 0.0 /

"busn2" 16 "idn2" 1 "Kw2" 1.0 "Kz2" 1.0 "Tw2" 0.020000 "Tz2" 0.02 "Qmax2" 1.006 "Qmin2" -1.006 "Pmax2" 2.583 "Pmin2" -2.583

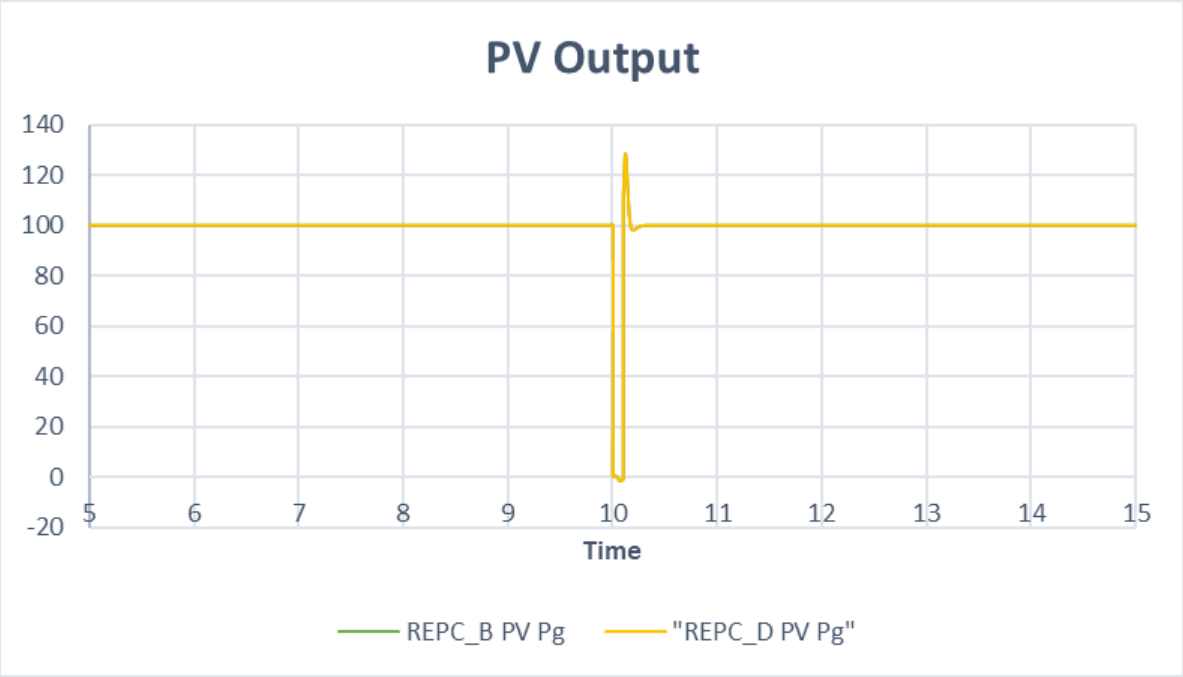
Simulation

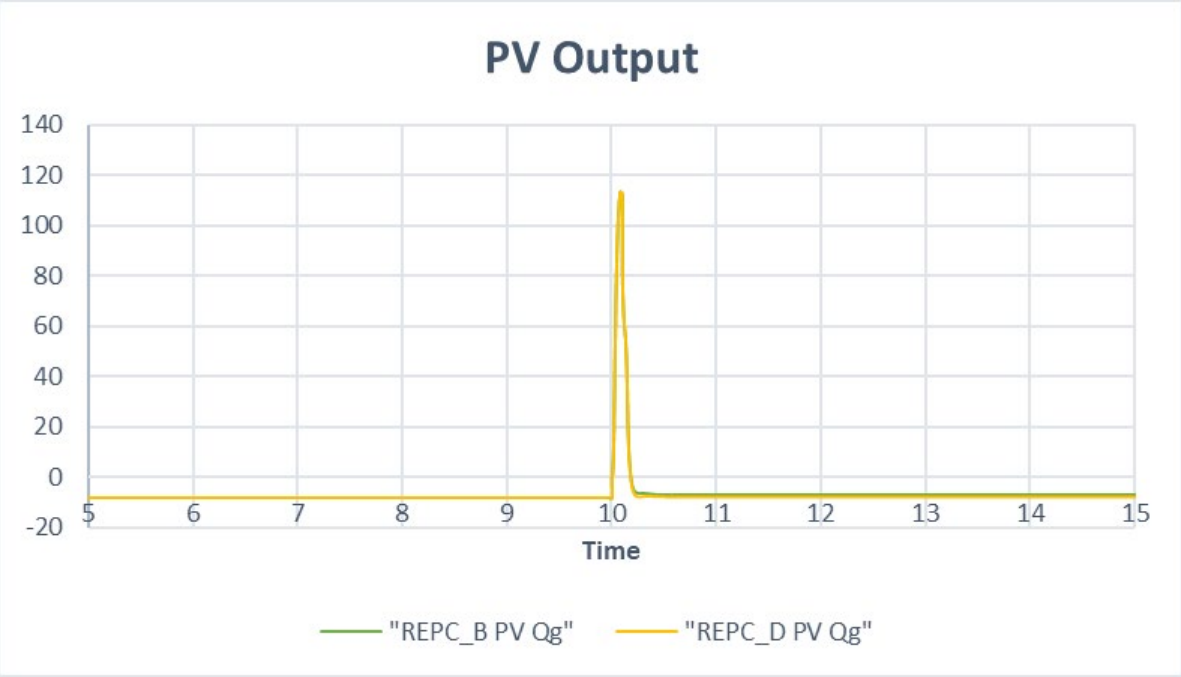
- Two dispatch scenarios

	PV MW Output	BESS MW Output
Test 1	100	100
Test 2	250	-200

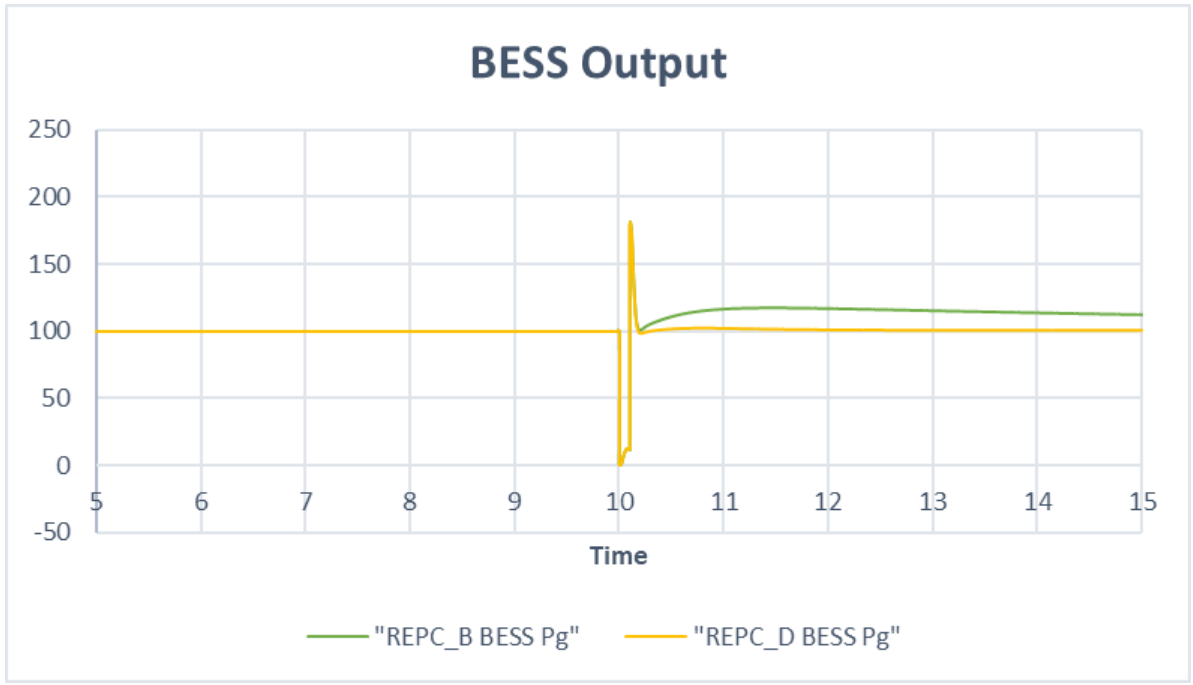
- 3-phase to ground fault at bus 1

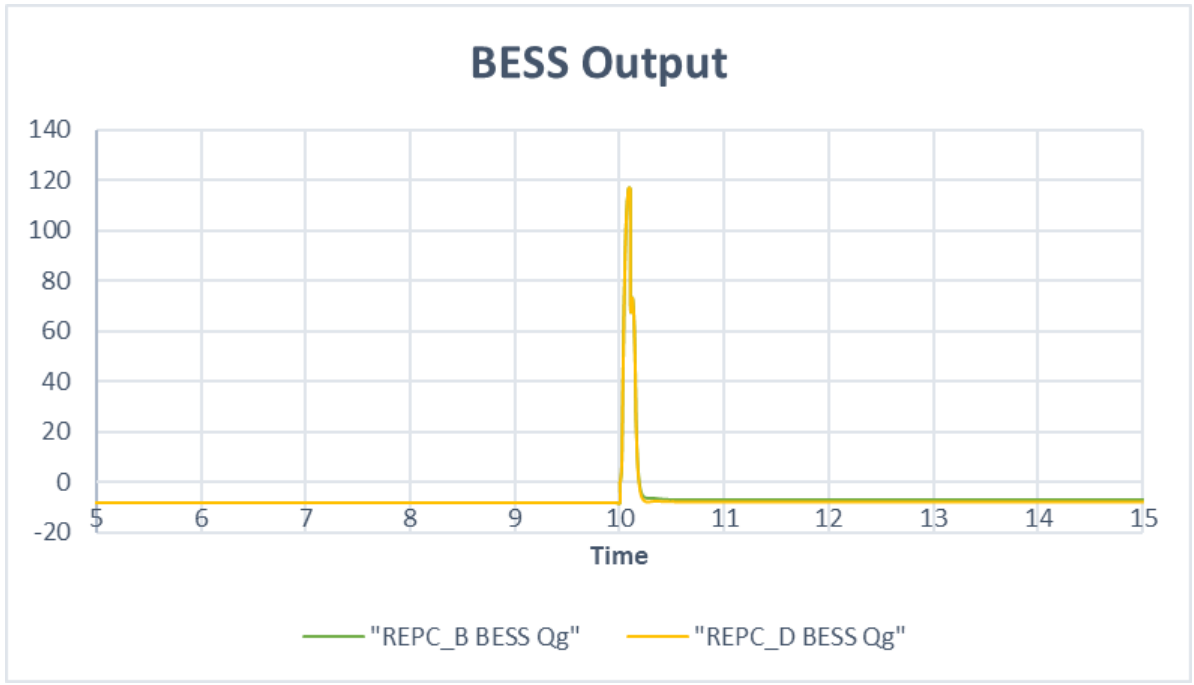
Test 1: PV Plots



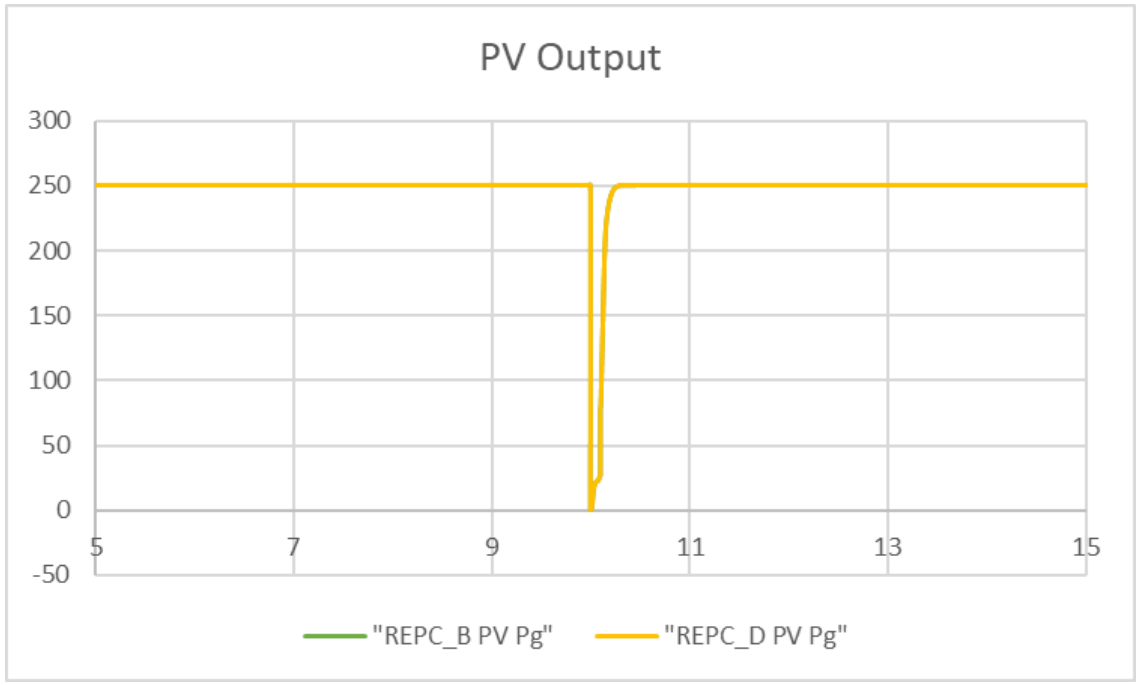


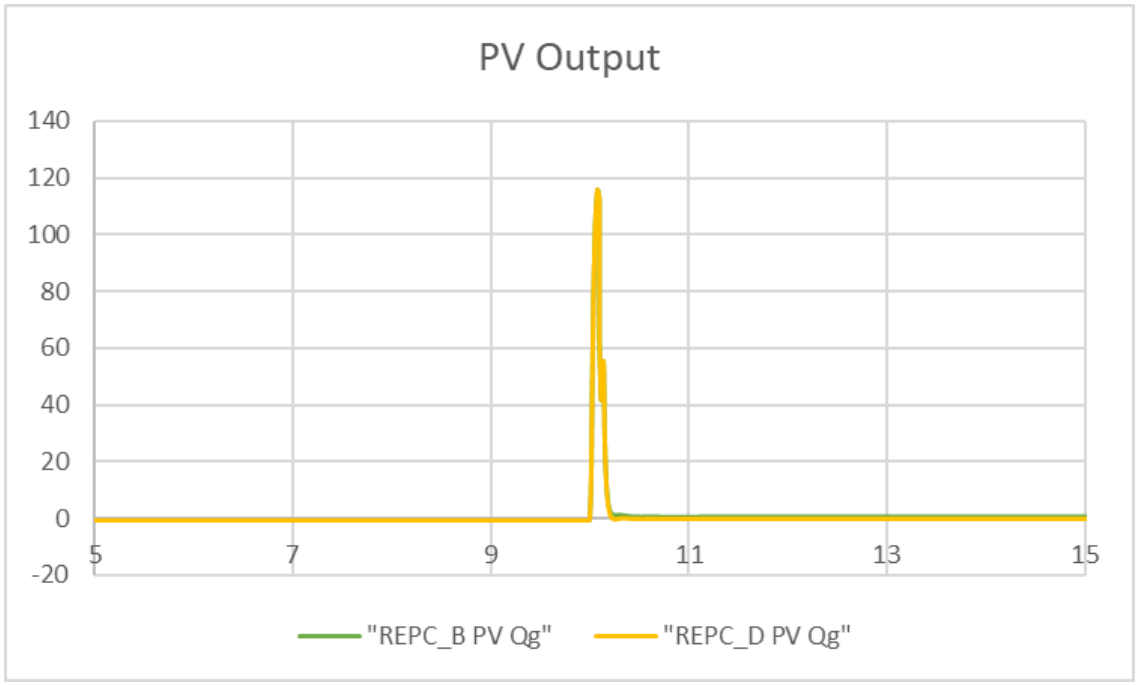
Test 1: BESS Plots



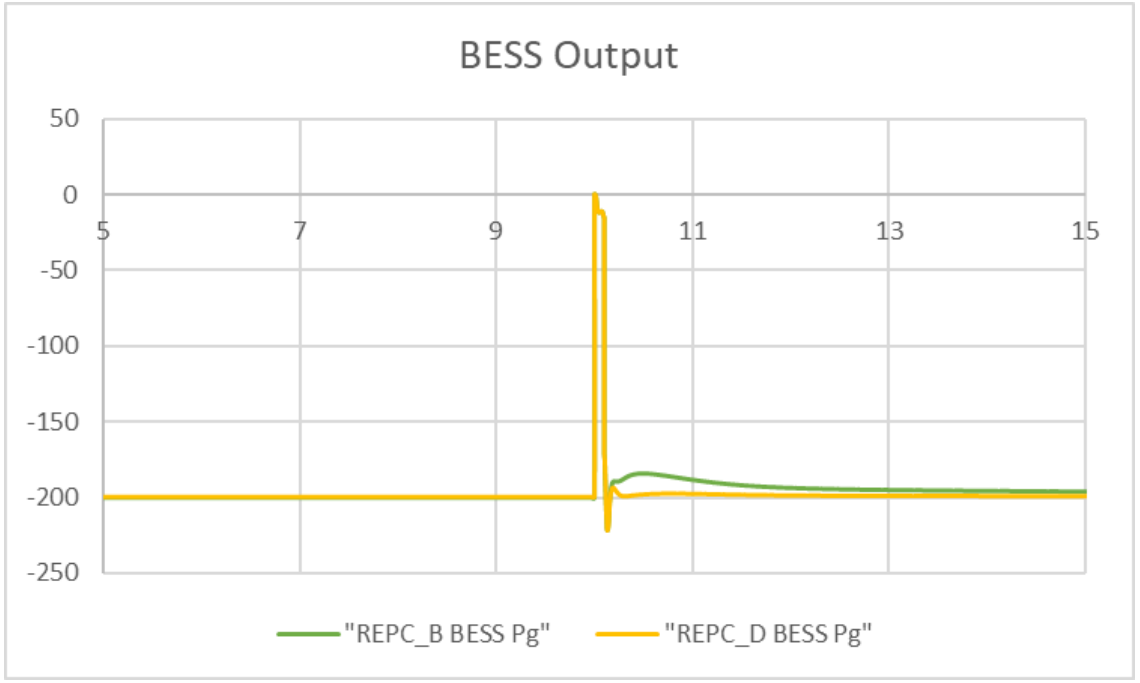


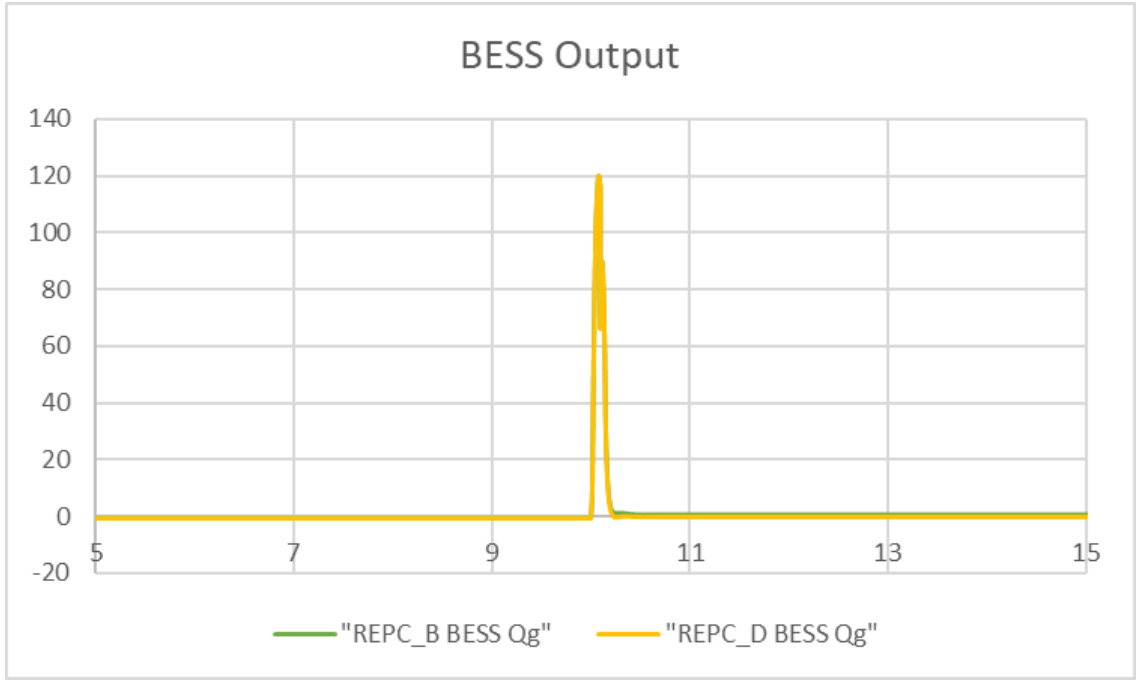
Test 2: PV Plots





Test 2: BESS Plots





Recommendation

- Seek MVS approval to:
  - Retire REPC_B model
  - Replace all REPC_B models with REPC_D
- Timeline to be discussed at MVS meeting