



Clarification on REPC_B

Songzhe Zhu

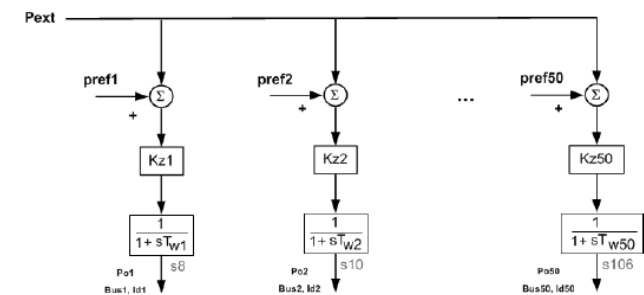
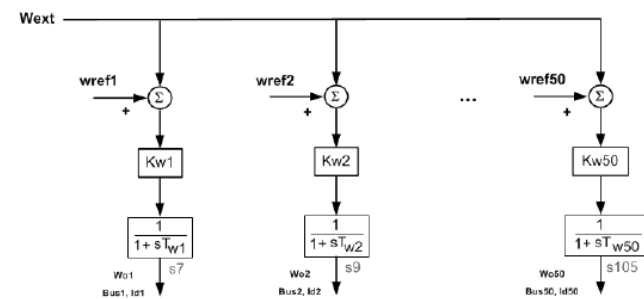
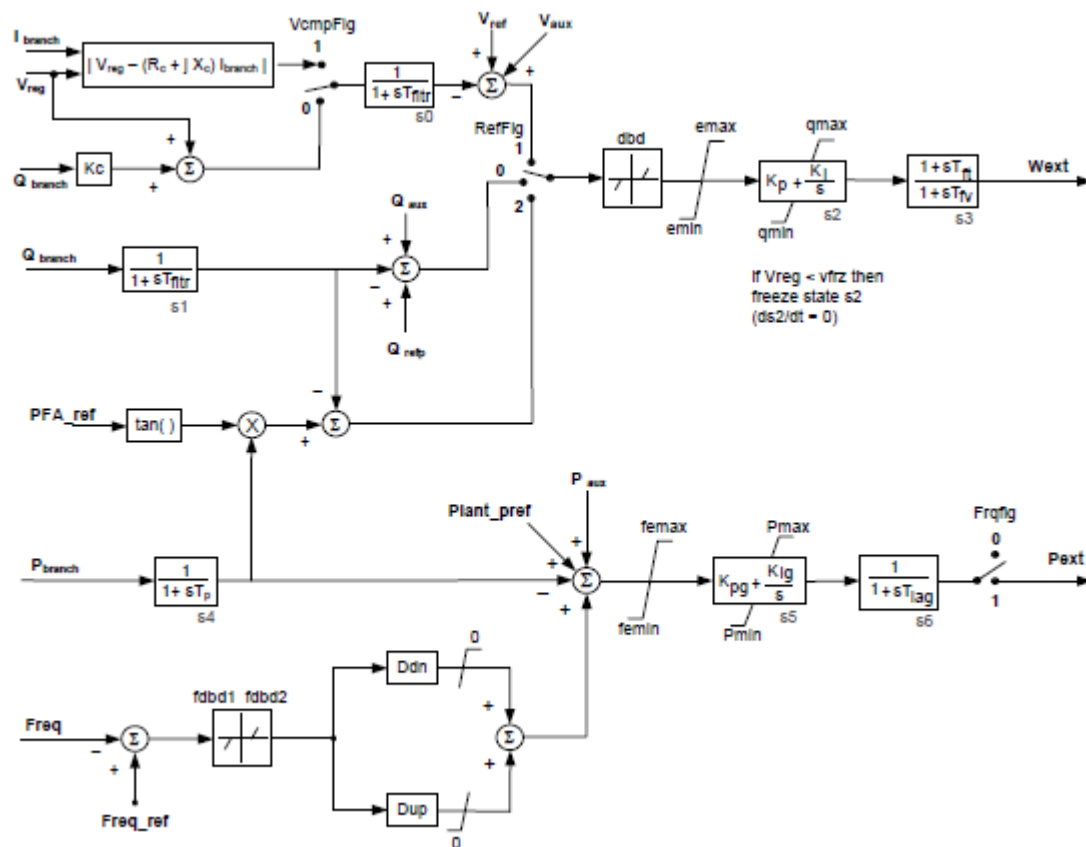
Sr. Advisor Regional Transmission Engineer

Regional Transmission – South

California ISO

May 2021

REPC_B Model



Commonly Overlooked in REPC_B

- In GE PSLF implementation, repc_b is always on the system MVA base, i.e. 100 MVA.
- Wext and Pext always initialize to zero. PMAX/PMIN and QMAX/QMIN are relative limits instead of absolute limits.
- QMAX/QMIN should be voltage limits if Wext signal is voltage
 - determined by the down-stream reec model
 - If pfflag=0, vflag=0 and qflag=1, voltage signal; otherwise, q signal
 - All downstream reec models should require the same type of signal
- Kwi and kzi are not automatically normalized by the software

Dup and Ddn

- Dup and Ddn are reciprocal of the droop

$$- \text{droop} = \frac{\Delta f / 60}{\Delta P_{gen} / P_{max}}$$

$$- \text{dup or ddn} = \frac{\Delta P_{gen} / 100}{\Delta f}$$

- Set dup and ddn in repc_b to*

$$1/\text{droop} \times \sum_{\text{all gens on REPC}_B} \text{Generator } P_{max} / 100$$

Kpg and Kig

- If $K_{ig} = 0$ or virtually 0 (e.g. 0.00001), K_{pg} should be equal or greater than 1 to be considered meeting designed droop. Such control may not be smooth.
- $K_{ig} > 0$ usually provides smoother control performance, but takes longer to reach the steady-state point.

Pmax and Pmin

- Pmax and Pmin are plant level active power limits corresponding to the requested MW injection at POI and charging power at terminal respectively.
- They are relative limits dependent on Pgen.
$$P_{max} = Plant\ P_{max} - Initial\ P_{gen}$$
$$P_{min} = Plant\ P_{min} - Initial\ P_{gen}$$
- The IC can't provide parameters dependent on dispatch.
 - IC sets pmax and pmin as absolute limits on 100 MVA base
 - Use pre-run ecpl to offset pmax and pmin by pgen when performing studies

Numerical ID for Generators on REPC_B

- The latest GE PSLF allows alphanumeric IDs for generators controlled by repc_b. However, only numerical ID can be accessed by getmodpar.
- The pre-run epcl that adjusts pmax/pmin needs access to the gen ID.
- All generators controlled by repc_b must use numerical IDs.

Qmax and Qmin

- When Wext signal is reactive power, Qmax and Qmin should be provided as reactive power limits on 100 MVA base.
 - We can also use pre-run epcl to offset by Qgen when performing studies
- When Wext signal is voltage, Qmax and Qmin are voltage deviation limits, not affected by the MVA base.
- Not as critical as Pmax/Pmin. Under small disturbance, plant qgen rarely hits qmax or qmin . Under large disturbance, reec kqv control kicks in.

Kwi and Kzi

- Kwi and Kzi are not normalized by the software.
- To avoid over-control of Pgen, before the control tuning in the field,

$$Kzi = \text{Generator}_i P_{\max} / \sum_{\text{all gens on REPC}_B} \text{Generator } P_{\max}$$

- If Wext is reactive power, recommend kwi in proportional to generator Qmax if oscillation or significant over-shoot is observed.
- If Wext is voltage, kwi=1
- This setup is for all generators online. If one or more generators are offline, it could under-estimate the response.
 - A pre-run epcl could normalize kwi based on generator status. Kzi shall not be adjusted because ddn and dup are for the entire plant.
- After the control tuning in the field, use actual settings.

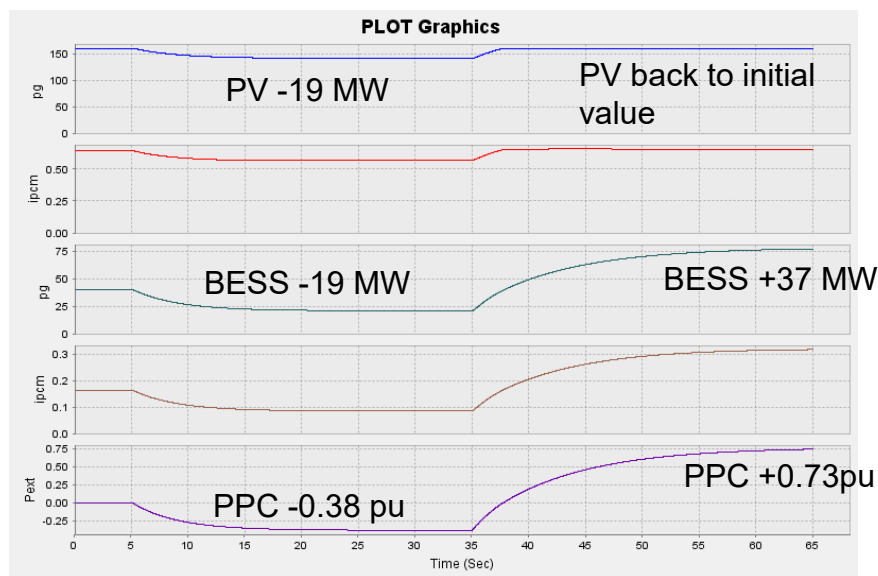
Simulation Examples: frequency reference step change test – pmax/pmin

Plant Pmax =214MW; Initial Pgen PV=160, BESS=40

Baseload PV=1, BESS=0; Kz1=0.5017, kz2=0.4980

[repc_b].Pmax/Pmin = +/-1.0

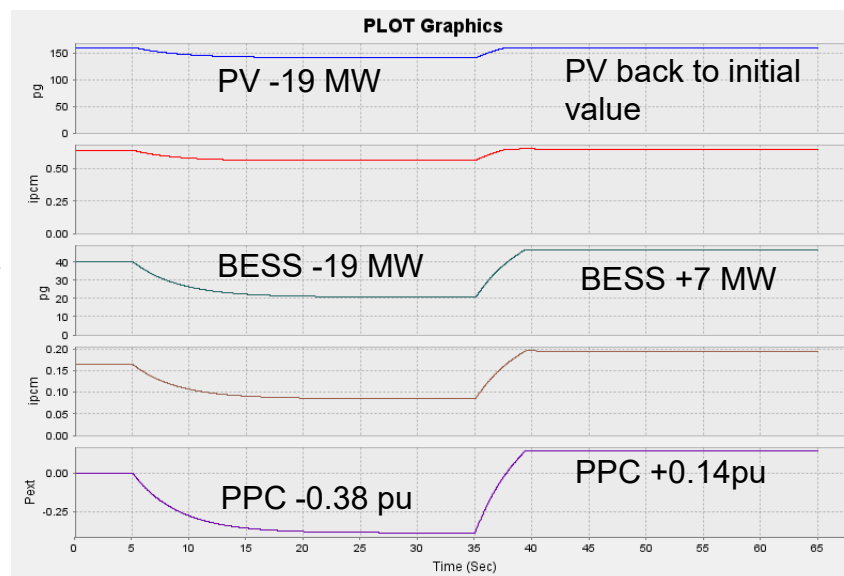
**At the end of simulation, total Pgen is 237 MW
exceeding plant pmax**



[repc_b].Pmax/Pmin = +/-2.14

Adjust Pmax/Pmin with pre-run epcl

At the end of simulation, total Pgen is 207 MW

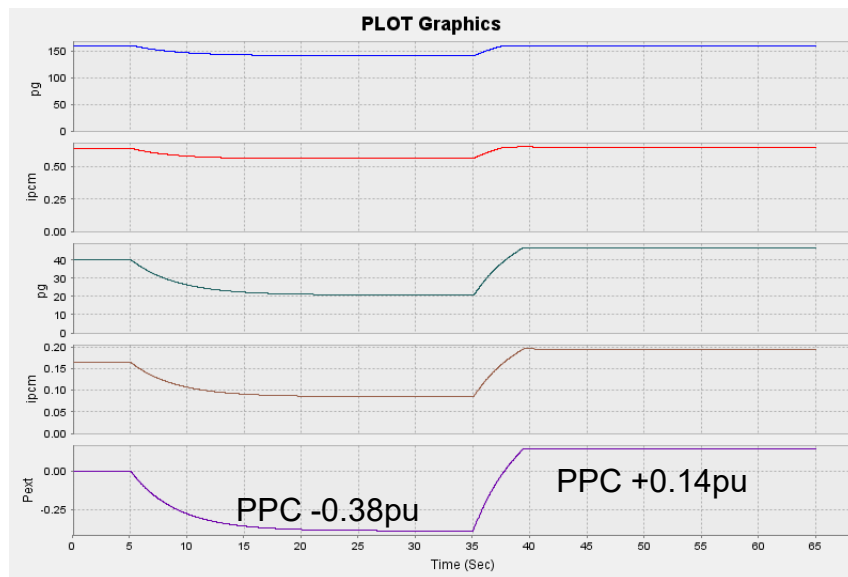


Simulation Examples: frequency reference step change test – impacts of kpg and kig

Adjust kpg and kig in the previous example

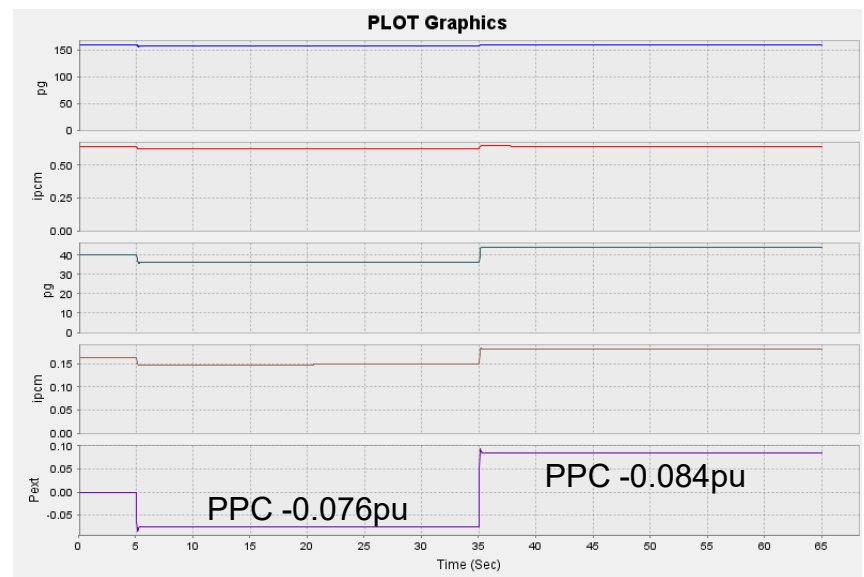
Kpg=0, kig=0.25

If not hitting limits, $P_{ext} = ddn \text{ (or dup)} * \Delta f_{ref}$



Kpg=0.25, kig=0

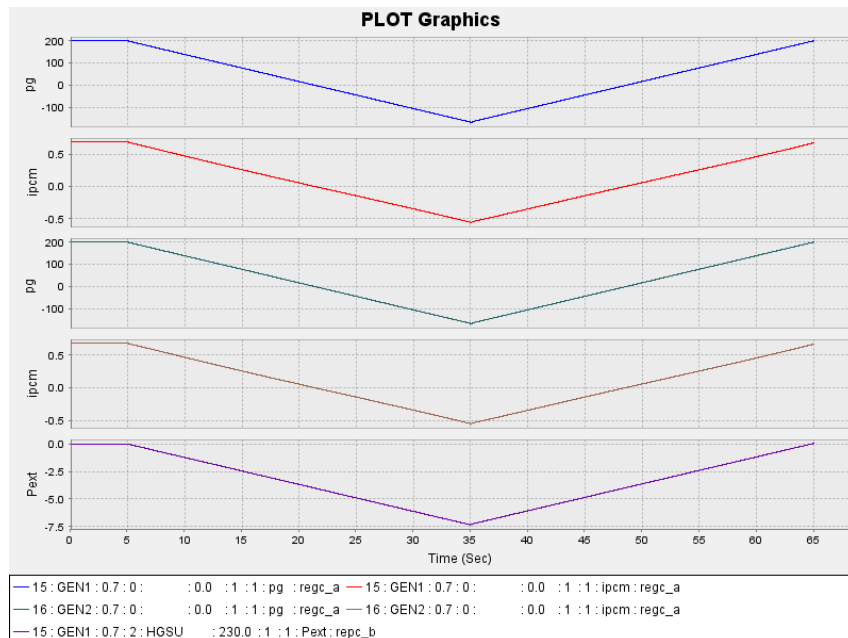
If not hitting limits, $P_{ext} = ddn \text{ (or dup)} * \Delta f_{ref} * \frac{kg}{(1+kg)}$



Simulation Examples: Frequency Reference Step Change - Monitored Branch

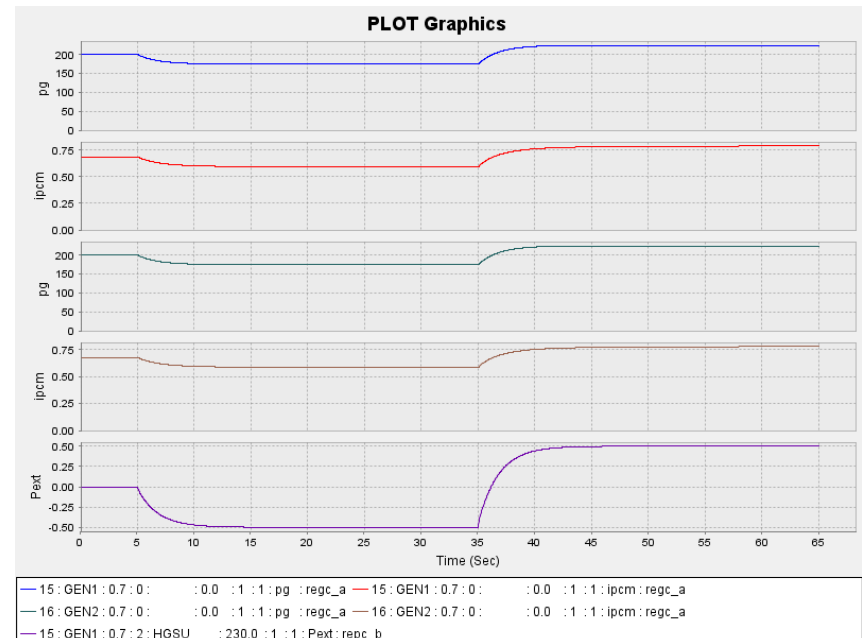
Missing monitored branch

Pbranch = 0, no control feed back



With monitored branch

Pbranch provides control feedback



Simulation Examples: voltage reference step change test – Qmax/Qmin

Initial Qgen at the max limit

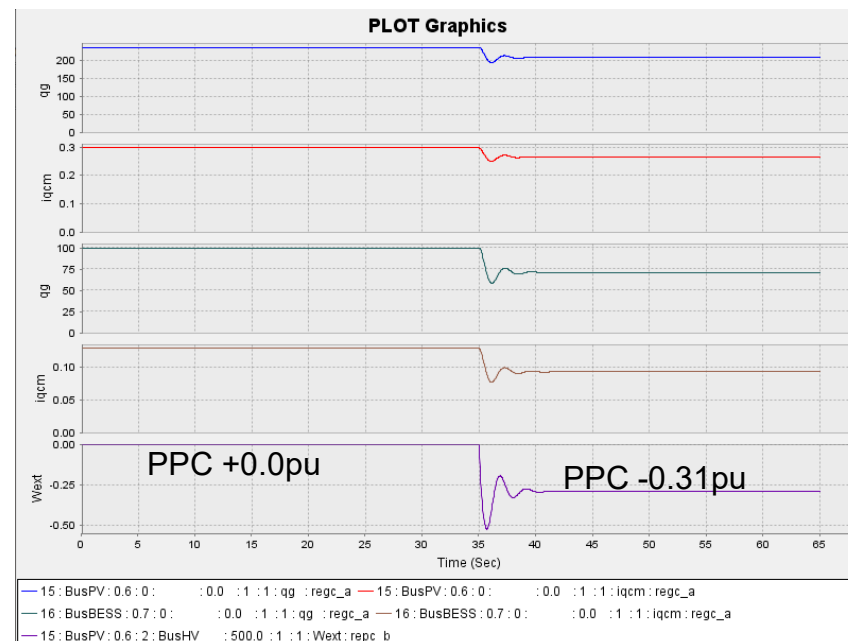
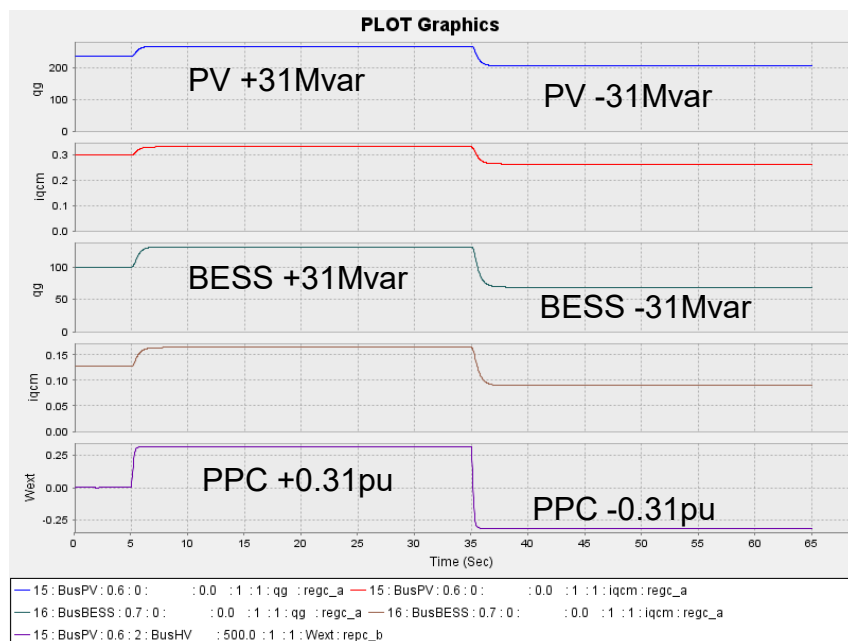
Initial Qgen at the max limit

[repc_b]Qmax=0.31, Qmin=-0.31

[repc_b]Qmax=2.81, Qmin=-2.81

adjust Qmax/Qmin with pre-run epcl

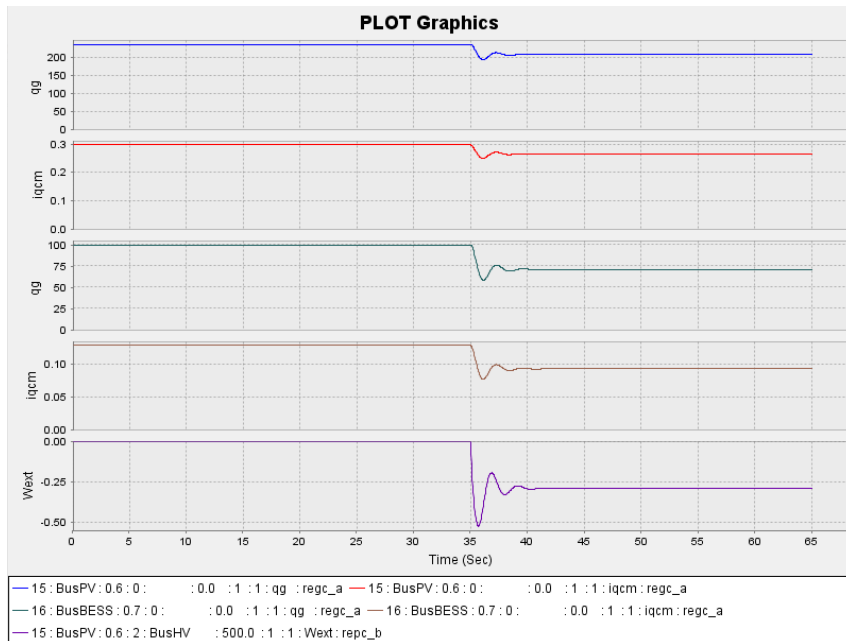
Plant level Qmax/Qmin enforced under small disturbance



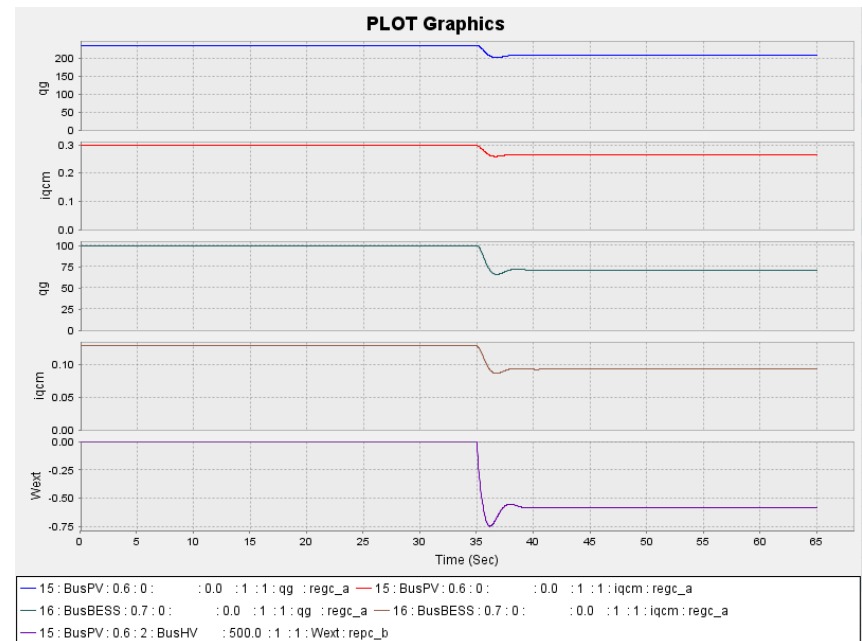
Simulation Examples: voltage reference step change test – impacts of kwi

Adjust kw1 and kw2 in the previous example

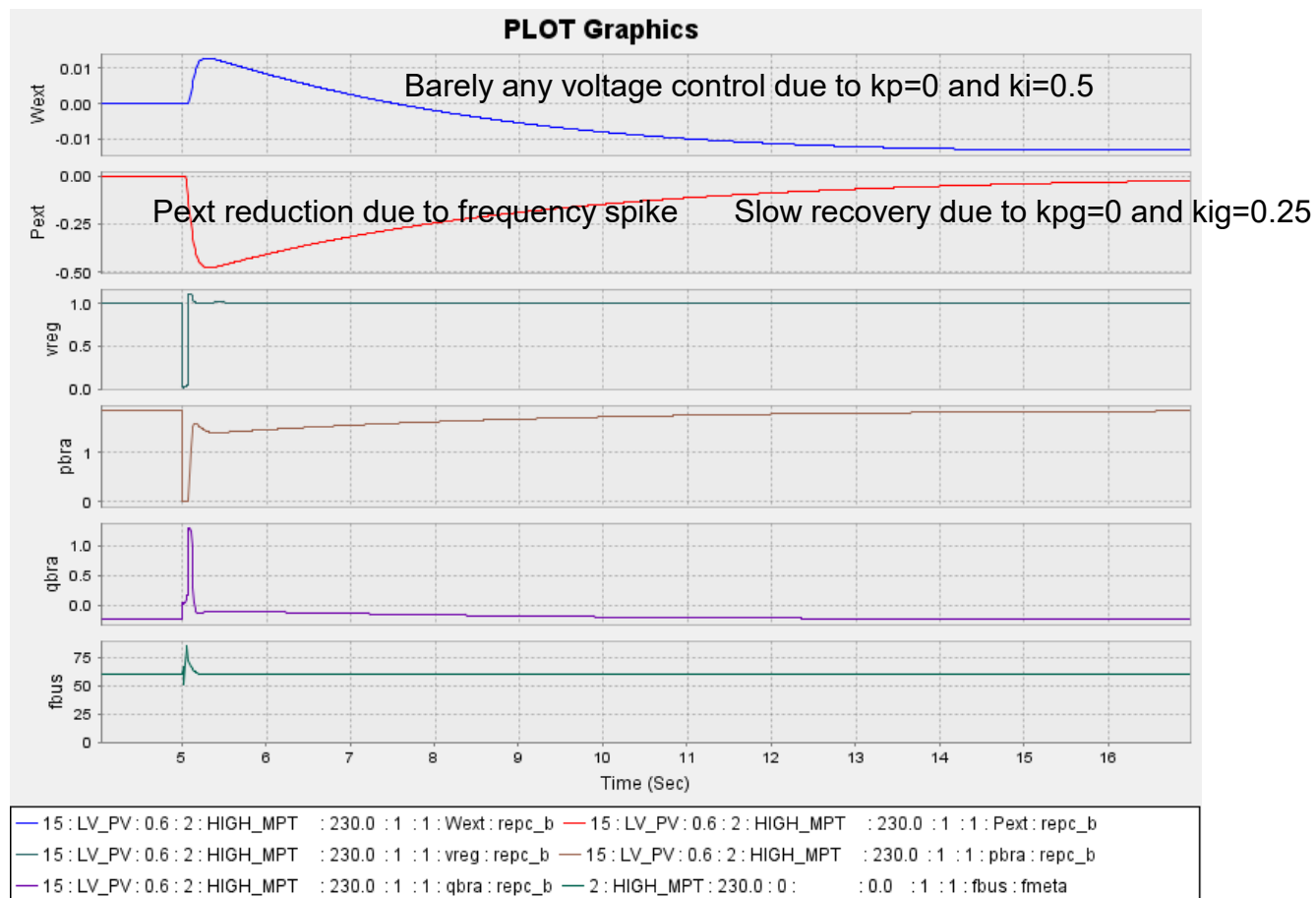
kw1=kw2=1



kw1=kw2=0.5

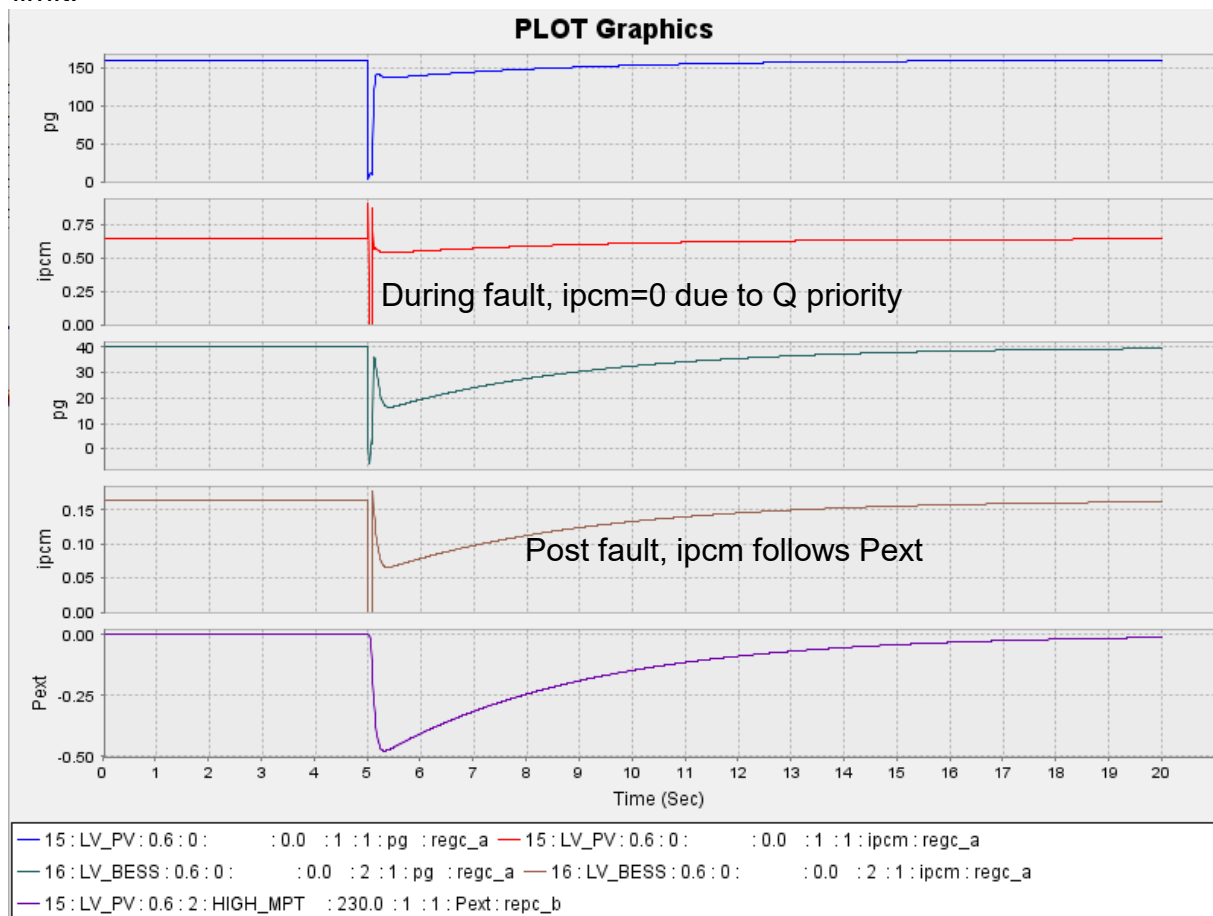


Simulation Examples: bump test – plant control



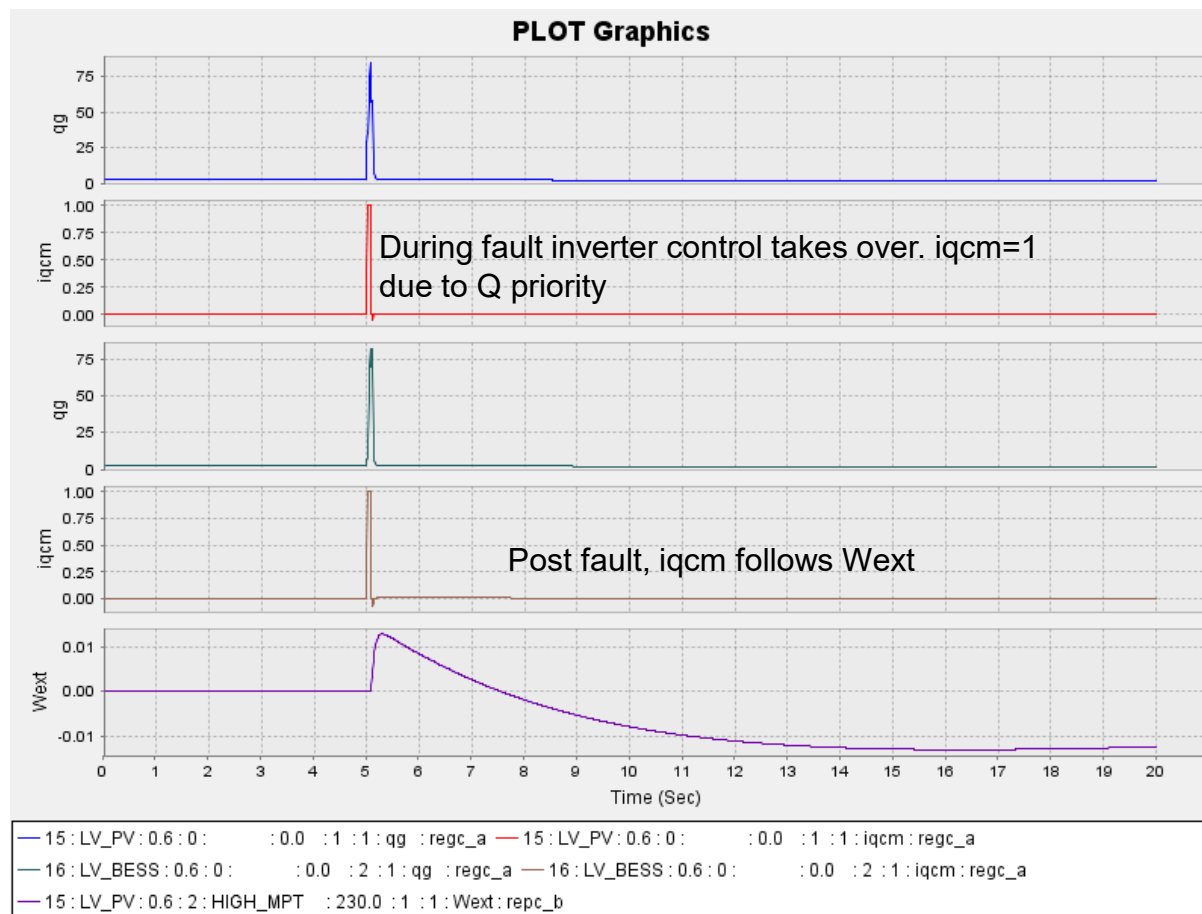
Simulation Examples: bump test – inverter P control

There isn't much P control at inverter level except for pmax/pmin, ip limit and ramping limit.



Simulation Examples: bump test – inverter Q control

Inverter Q control takes over during fault.



REPC_B Model Review

- Numerical gen IDs
- Specify a regulated bus and a monitored branch
 - Monitored branch from gen side to grid side
- Valid voltage control mode
- Valid frequency control mode
- Ddn and dup are on 100 MVA base
- Kpg and kig support desired droop control
- kzi are proportional to gen MW size
- Pmax and Pmin set to plant pmax and pmin on 100 MVA base
- Qmax and Qmin set to plant qmax and qmin on 100 MVA base and meet 0.95pf requirement, if Wext is reactive signal
- Qmax and Qmin set to dvmax and dvmin if Wext is voltage signal
- All downstream reec_* models take the same type of Wext signal