TO: WECC REMWG

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SUBJECT: PROPOSAL FOR NEW PLANT CONTROLLER AND ELECTRICAL CONTROLLER

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Revision Note:

This is the first revision of this memo capturing in more detail some items discussed at the last WECC MVS meeting in January, 2022 during the REMWG part of the meeting. The items here are presented for further enhancements in the electrical controls model and plant controller model (specifically for hybrid-plants or plants with multiple aggregated inverter-based generation models). These will need to be discussed and refined, and then implemented for benchmark testing and final approval.

1.0 Electrical Control Model:

Presently, there are three (4) existing REEC_* models in the WECC RES generic models:

1. **REEC_A:** the most commonly used model for both wind and PV plants.
2. **REEC_B:** a simplified version of the electrical controls, which was previously used for PV plants but is no accepted and has been disbanded. **This model should not be used moving forward.**
3. **REEC_C:** a model intended primarily for use in modeling battery energy storage systems (BESS).
4. **REEC_D:** the most recent electrical controller model for use with wind, PV and BESS.

As indicated above, the REEC_B model is no longer accepted for use by WECC (and other regions) since it is devoid of the ability to represent the voltage-dependent limits (VDL) on the inverter current, and cannot emulate inverter blocking. The REEC_A and REEC_C models, although quite comprehensive, and though both do include the VDL tables, there are some improvements that where pointed out in recent past by several vendors, and thus REEC_D incorporates these improvements (see [1]).

Here in this memo we present yet another proposed new version of the electrical controls model, which is called REEC_E, to provide even more updates. This is not intended to replace the earlier versions (REEC_A, REEC_C and REEC_D) but simply to give even more features for modeling newer plants.

1.1 REEC_E (new model)

The REEC_E (Figure 1) model is identical to the REEC_D model [1], with the following additions/modifications:

1. Allow for local PI Q or pf control: Add another path forward through *QFlag* to allow for local PI control of constant-Q or constant-pf.
2. Active power PI control: Add a new flag *PEFlag* and two additional PI gains *Kpp*/*Kpi* to allow for local PI control of active power.
3. P/Q-priority during Faults: Add a new flag, *PqflagFRT*, to allow for a different P/Q priority during fault conditions.

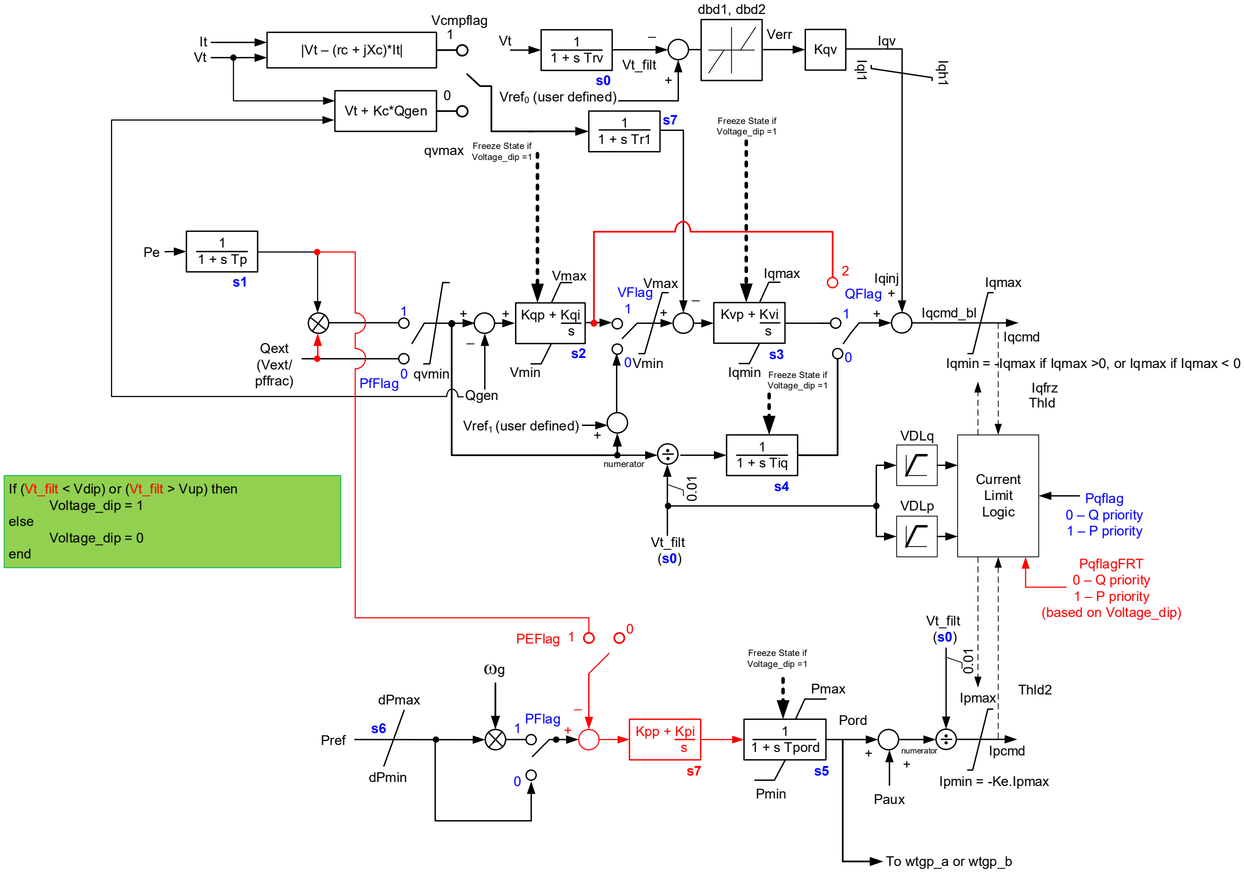

Figure 1: REEC_E model.

Table 1: Additional Parameters REEC_E – only new additional parameters are listed here; all other parameters are identical to REEC_D.

Parameter	Description	Typical Range/Value
Qflag	2 – new option to allow for PI control of constant-Q or constant-pf	N/A
PEFlag	0 – no PI control of active power; in this case Kpi MUST be set to 0 1 – allow for local PI control of active power	N/A
PqflagFRT	0 – Q priority and 1 – P priority Gets invoked under fault conditions (when Voltage_dip = 1) and can be set opposite to the *Pqflag,* which applies to no-fault (Voltage_dip = 0) conditions	N/A
Kpp	Proportional control gain for active power [pu/pu]	N/A
Kpi	Integral control gain for active power [pu/pu/s] **Important Note:** if SWT3 = 0 then Kpi MUST be set to 0	N/A

2.0 Plant Controller Models

4.1 REPC_D (new model)

This proposed new plant-controller model is based off of the existing REPC_C model, which interfaces to a single aggregated WTG model. This model then builds on REPC_C to make it like REPC_B for controlling multiple aggregated renewable system models downstream, but without some of the limitations of REPC_B.

Figure 2 shows the proposed REPC_D model. In essence the only difference between REPC_C and REPC_D is the end interface. The concept behind the interface may be explained as follows:

1. The model has its own MVA base, as with REPC_D.
2. All the down-stream devices must receive a Q-command. Mixing down-stream devices with Q-command and voltage-reference control is more complex and outside of the present context. Likewise, for down-stream devices where all receive a voltage-reference from the plant controller.
3. Here we will assume that there can be up to fifty (50) downstream inverter-based resources (IBR).
4. If the initial power flow condition is such that:
    a. IBR 1 has an output of $Q1_o$ (MVar) and $P1_o$ (MW), and
    b. IBR 2 has an output of $Q1_2$ (MVar) and $P1_2$ (MW), etc.

    then upon initialization

    $Qext_o = \frac{\sum_{i=1}^{n} Qi_o}{MVAplt}$ and $Pref_o = \frac{\sum_{i=1}^{n} Pi_o}{MVAplt}$

    $qref_i = \frac{Qi_0}{MVA_i}$ and $pref_i = \frac{Pi_0}{MVA_i}$

    By initializing the model in this way (as opposed to the current REPC_B model), the limitations of the REPC_B model are removed. This is because, the initial Q-command and P-command will initialize to the total sum of the Q-output and P-output of the down-stream connected devices, in per-unit on the total plant MVA base. Moreover, the model will always flat-start for a no-disturbance simulation. **Important Note:** this does, however, put burden on the user to ensure that the initial power flow solution is meaningful.
5. As for the gains, they may be scaled three (3) different ways:
    a. Based on the related MVA bases, i.e. $Kp_i = Kp_i \times \frac{MVAplt}{MVA_i}$ and $Kq_i = Kq_i \times \frac{MVAplt}{MVA_i}$, or
    b. Based on the initial relative outputs, i.e. $Kp_i = Kp_i \times \frac{Pi_o}{\sum_{i=1}^{n} Pi_o}$ and $Kq_i = Kq_i \times \frac{Qi_o}{\sum_{i=1}^{n} Qi_o}$, or
    c. Both of the above options, which effectively yields:

        $Kp_i = Kp_i \times (|pref_i| / |Pref_o|)$

        $Kq_i = Kq_i \times (|qref_i| / |Qext_o|)$

PowerTech Labs has graciously already implemented the interface shown in Figure 2 (i.e. what is marked in RED) as an end-block and it has been used in some user-developed models (UDMs) and shown to be effective. For actual UDMs additional complexities apply in some cases. What is shown is the simplest form.

Limits have been added on each of the outputs in the interface, but this is likely to be superfluous in most cases since the down-stream devices will have their own limits. So based on consultation at the WECC MVS and REMWG meeting, the collective group may decide to eliminate the limits.

Thus, for this model, there will be:

- 10 × *N* new parameters, namely:
  - (Bus_i, id_i, Kw_i, Kz_i, $Pmax_i$, $Pmin_i$, $Qmax_i$, $Qmin_i$,Tw_i and Tz_i) × *N* where

  N – is the number of down-stream connected devices (to be decided by WECC MVS)

  Bus_i – is the bus number of the i^{th} device

  id_i – is the id of the i^{th} device

  and the other parameters are self-explanatory from Figure 2.

- Two (2) additional flags will be needed (one for the reactive power path and one for the active power path) to defined the method of scaling the K's in each path, i.e. option 5a., 5b., 5c. or straight pass through.

For this initial proposed implementation, the intent is that the *N* downstream devices can be any combinations of:

1. Any REEC_* model (and note for a type 3 WTG the active power reference needs to go to the WTGQ_A and WTGP_* models), and
2. A REPC_C model, where the model is confirmed with constant-Q control (or straight pass through Q control) and pass-through P control

Other possibilities exist in real plants, but for now this may need to be the first step.

Important Note: With this model the limitations of REPC_B are removed (i.e. the model has its own MVA base and the limits on the controls are now the same as any plant controller model and no longer relative limits). *However, this introduces a significant burden on the user to ensure that the initial power flow solution for the plant is reasonable. For example, the initial Q output of all the downstream aggregated units in general should be in proportion to their respective MVA bases, etc.*

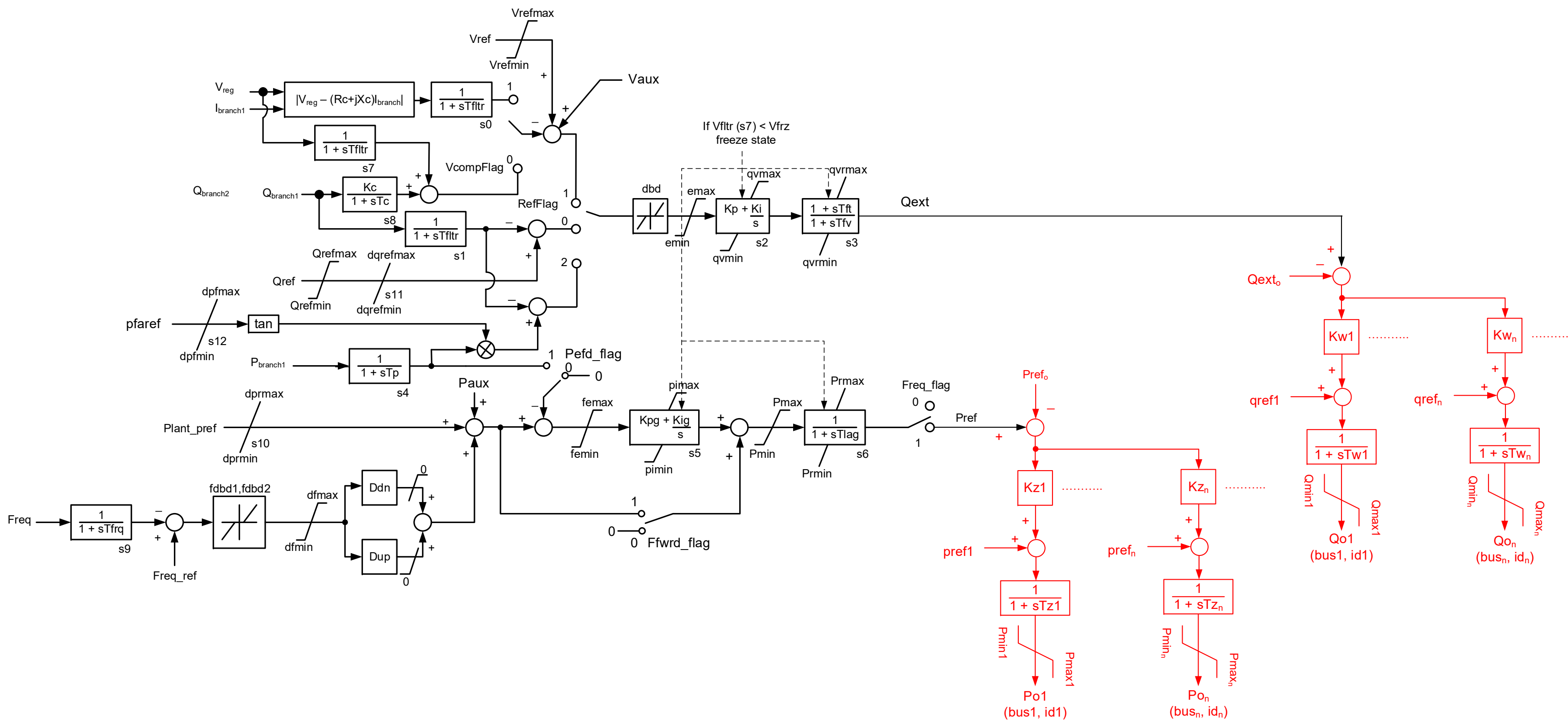

Figure 2: REPC_D model

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PEACE® also very gratefully acknowledges PowerTech Labs, and in particular Pouya Zadkhast, for their implementation of the end-block that already accomplishes the task of the end interface shown in Figure 2 (in RED).

We apologize for any inadvertent omissions.

References:

[1] Memo on *Proposal for New Features for the Renewable Energy System Generic Models,* Revisions 22, Dated: 1/11/21

https://www.wecc.org/Reliability/Memo_RES_Modeling_Updates_111121_Rev22_Clean.pdf