At the WECC REMTF meeting in Albuquerque, NM, EPRI presented a proposal for the high-level plant controller. S&C made a presentation on observations and practical aspects of the plant controllers. Siemens PTI also made a presentation on test simulations on a plant controller proposal. The group then discussed these proposals and ideas and thus made several suggested changes to the EPRI proposal. The culmination of those discussions was described in the first version of this memo. This memo was then circulated and feedback was obtained. It was also presented and discussed with the IEC TC88 WG27 group at the meeting of this group hosted by EPRI in December 2014. This revised version of the memo therefore captures all this feedback and constitutes the first proposed specification for the complex plant controller.

The plant controller for wind and PV plants that was developed in [1], and approved in [2], is shown below in Figure 1. This plant controller can link to a single aggregate wind (or PV) model, so that the entire plant model is a single aggregate wind turbine and associated single equivalent collector system feeder equivalent, as shown in Figure 2.

The need presently is for the next level of modeling. That is, when one wants to model a more complicated wind (or PV) plant which incorporates for example multiple types of wind turbines and other active devices such as an SVC or STATCOM; see Figure 3. In this case the overarching plant controller will be communicating with several types of devices, the type 3 wind turbine generators (WTGs), the type 4 WTGs, the SVC (or STATCOM) and possibly the MSCs.

Figure 4, we show the final agreed to model. It is the original EPRI proposal with the suggested changes by Siemens PTI (adding a power factor control option) and S&C (adding the delays/time constants to each signal), as well as some comments feedback by others through email, at the IEC TC88 WG27 meeting and follow-up webcasts calls with the various stakeholder groups. Many utilities and the three major commercial software vendors were also presented at these meetings/calls.
Figure 1: Simple plant controller

Figure 2: Simple plant aggregate model
Figure 3: Complex plant aggregate model.

The **REPC_B** Model

The 2nd generation wind turbine generator models were in fact developed as a series of modules that can be connected together in various combinations to yield a type 3 wind turbine generator (WTG), a type 4 WTG or a photovoltaic (PV) system. Thus, the proposal here is to add another module to that set and to call it **REPC_B** (renewable energy plant controller B). A perusal of Figure 4 and [4] will show that all the elements shown in black are identical between the **REPC_B** model and the already developed and now available **REPC_A** model. The additions are the elements shown in red. These are described below:

1. By setting $RefFlag$ to 2, the user may select a constant power factor control mode. Upon initialization of the model sets the parameter $pfaref = \arctan(Q_{\text{branch}}/P_{\text{branch}})$ (i.e. the initial power factor angle from the powerflow solution).

2. For now we will assume that the SVC or STATCOM in the plant is modeled by the SVSMO1 or SVSMO3 models, respectively. It is further assumed that the MSCs at the main substation are controlled by the SVSMO1 or SVSMO3 model.

3. For this initial implementation, there is no logic provided in the **REPC_B** model for switching MSCs in the absence of an SVC/STATCOM.

4. Although actual communication delays between the plant controller and the devices being controlled is a true communication delay, after much discussion within the WECC REMTF group it was agreed that these delays would be “emulated” with small time constants. For cases where there are substantial delays (e.g. 0.5 second or more) the proposed model may not be a faithful representation of the actual dynamics.

5. For each leg (reactive and active power) the output can interface with up to 50 different devices. The 50 outputs from the reactive power control leg ($Wo1, Wo2 \ldots Wo50$) and the 50 outputs from the active power control leg ($Po1, Po2 \ldots Po50$) are linked. That is $Po1$ and $Wo1$ go to the same device.
(e.g. aggregate wind or PV unit model). When the output is going to a reactive device (e.g. SVC, STATCOM or synchronous condenser) then Po_i is ignored and Kz_i is set to 0. The reactive outputs are designated “Wo_i” since they can be either a reactive power bias (e.g. going into an aggregate wind turbine model) or a voltage reference bias (e.g. going into a SVC, STATCOM or exciter summing junction).

6. The 50 outputs pairs (Wo1/Po1, Wo2/Po2 … Wo50/Po50) need to have at least 2 identifiers associated with each output to identify the ID and BUS number of the device to which it is connecting. Also, these outputs should be able to connect to:

   a. Xo1 to Xo50:
      i. Qref on REEC_A, REEC_B or REEC_C1 (renewable energy electrical controls models A, B or C)
      ii. Vsig on SVSMO1, SVSMO2 and SVSMO3. Note an SVC/STATCOM within a wind or PV plant will NOT have an associated power oscillation damper, therefore Vsig can be used for this purpose.
      iii. Vsig on ESST1A, ESST4B, ESAC7B and ESAC8B (four of the most frequently used modern exciter models, so that synchronous condensers can be modeled within the plant also). Note a synchronous condenser within a wind or PV plant will NOT have an associated PSS, therefore Vsig can be used for this purpose.

   b. Po1 to Po 50:
      i. Pref on REEC_A, REEC_B or REEC_C2 (renewable energy electrical controls models A, B or C)
      ii. If the connecting device is an SVC, STATOM or Synchronous Condenser (exciter) then the signal should be ignored, Kz_i set to zero and the user informed upon initialization through a log message.

7. It is assumed that the time lag associated with the signals is the same for the reactive and active power signals. Therefore, one set of up to fifty time constants is needed (Tw1 to Tw50).

8. The model should be initialize as follows to ensure consistency, simplicity and coordination with the powerflow solution:

   a. Wext and Pext (in the REPC_B model shown below) always initialize at the beginning of the simulation to zero (0).
   b. wref1, wref2, ..., wref50 initialize to the initial value of the reactive power output of the respective devices being controlled when connected to a WTG model, and to zero (0) when connected to a voltage controlling device (e.g. SVSMO1, SVSMO3, ESST1A, etc.)
   c. pref1, pref2, ..., pref50 initialize to the initial value of the active power output of the respective devices being controlled (or zero and ignored if the connecting device is a reactive only device, e.g. SVC, STATCOM etc.)
   d. $\phi_{pref} = \arctan(Q_{branch}/P_{branch})$ (i.e. the initial power factor angle from the powerflow solution based on the initial values of the branch Q and P being controlled by the plant controller).

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1 REEC_C is another newly proposed model for BESS models, documented in a separate memo.
2 REEC_C is another newly proposed model for BESS models, documented in a separate memo.
9. Three auxiliary inputs \((V_{aux}, Q_{aux} \text{ and } P_{aux})\) have been added, which should be accessible to the user and always initialized to zero. These can be used for adding user-written components by users for introducing any specialized controllers that may be unique to specific installations.

Note: the weights Kw1 to Kw50 and Kz1 to Kz50 should NOT be normalized – the user may of course normalize them him/herself prior to entering the numbers. These, gains are NOT renormalized, changed or reconfigure automatically by the model after initialization, for example if during a simulation a device trips and thus that particular output is no longer controlling anything, then it simply floats and the remaining gains also remain unchanged. In practice some vendors will renormalize the gains and set the gain of the tripped device to zero, but this is too complicated for the present intended model.

All the other parameters and features of the model are identical with the \(\text{REPC}_A\) model defined in \([1]\) and already released and available in the three major North American commercial software platforms.

This model will have an associated MVA base. By default the model's MVA base will be set to system MVA base, however, the user can change it to any desired value (e.g. total plant MVA base).

**Implementation plan**

After multiple discussions within the November REMTF meeting, December IEC meeting and follow-up webcast/calls with interested members of the REMTF, this final version constitutes the final first draft of the model specification. At this point the interested commercial vendors will start implementing a beta version that will then be tested within the WECC REMTF. Once all is done, the final model specification will be submitted for WECC approval to the MVWG and the official models released.

**References:**


Figure 4: Proposed high-level plant controller – REPC_B.

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