HIL Validation of Power Plant Controller Model

PPC HIL Testbed Capabilities
- Test communication interface
- Optimize P, Q, PF and AVR modes
- Coordination of multiple PPCs
- Validate capacitor bank controls
- Test protective relay settings

There is an increasing requirement to supply Inverter Based Resource (IBR) models compiled using the actual code used in the inverter-controls to allow detailed electro-magnetic transient (*emt*) studies[1][2]. Similarly, *emt* models of Power Plant Controllers (PPC)[3] which are commonly used for managing these utility-scale renewable energy plants are also required by the utilities. However, validation of such emt models against the performance of actual hardware controller is rarely presented. Because the actual controller source code is used in the emt model, it is presumed that the performance is identical. However, this assumption may not be satisfactory to all end-users since there are differences between the two hardware platforms. Validation via field tests is narrow in scope and can be cost prohibitive. The hardware-in-loop (HIL) validation using a real-time digital simulator is a good approach.

RTDS™ is a world reknowned real-time digital simulator for HIL testing of power system controls and protection systems. This article discusses a unique usecase where the RTDS simulator was used for validating a PSCAD™ model of Nor-Cal Control's PPC against its PLC based hardware controller. In addition, the testbed can also be used as a productivity tool for a wide range of functions from testing a PPC concept in the development phase to factory accpetance test of a fully assembled power plant controller and protection system.

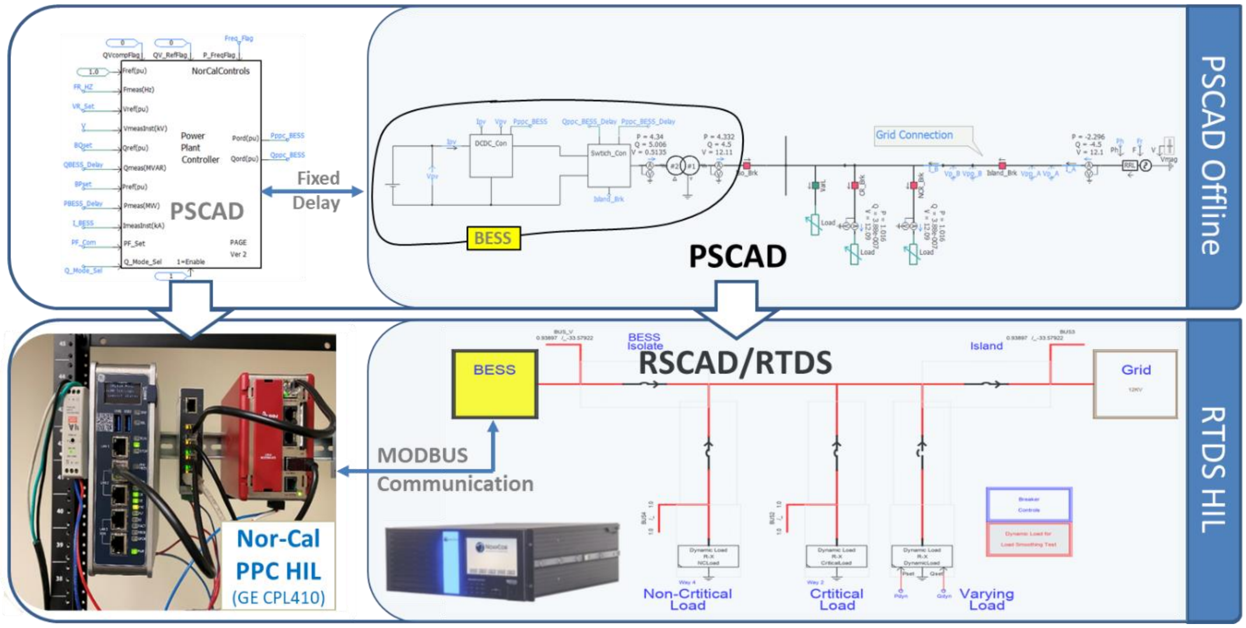

Fig. 1: The testbed setup

References:

[1] ERCOT Website: *"Resource Integration - Model Quality Guide"*
http://www.ercot.com/services/rq/integration

[2] ISO New England Website: *"Interconnection Planning Procedure No. 5.6"*
https://www.iso-ne.com/static-assets/documents/rules_proceds/isone_plan/pp05_6/pp5_6.pdf

[3] Nor-Cal Controls Website, *"Power Plant Controllers: Typical Control Requirements for PV Sites"*
https://blog.norcalcontrols.net/power-plant-controllers-typical-control-requirements-pv-sites

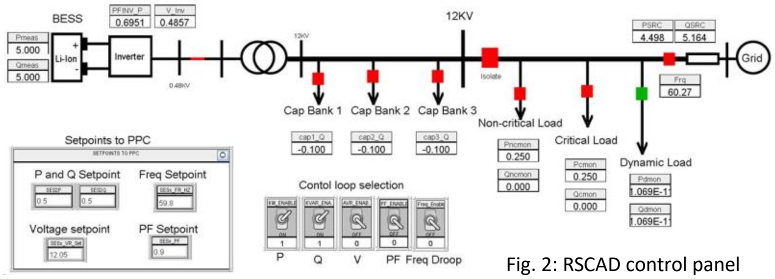

Fig. 2: RSCAD control panel

Validation Results

The PPC dynamics were validated while it is managing a battery energy storage system (BESS) plant. First, the BESS plant response, without the PPC, was compared in both PSCAD and RTDS platforms to establish a common baseline. Then the PPC (emt model and PLC) were introduced as shown in Fig. 1. Following plots show the results of various validation tests conducted for the PPC model in PSCAD overlaid with the HIL response. HIL PPC communicates with the BESS in RTDS via MODBUS. In a normal PSCAD study, this aspect is omitted. To better align the two results, the communication was included in the PSCAD model as a fixed delay based on the average MOBUS delay observed from the HIL setup. The phase shift in the dynamic response between the two simulations is caused by the differences between the actual MODBUS delays (random) in RTDS simulation and the fixed delay in PSCAD. The two responses agree very well on all aspects despite these differences. This shows that the PSCAD model is an exceptionally good representation of the hardware PPC and its settings.

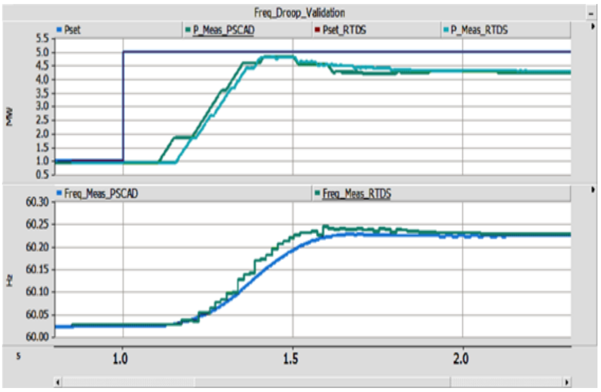

Fig. 3: Frequency droop operation during increase in real power

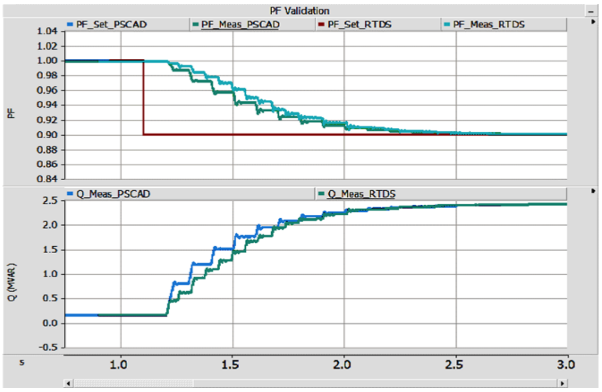

Figure 6: Power factor correction mode

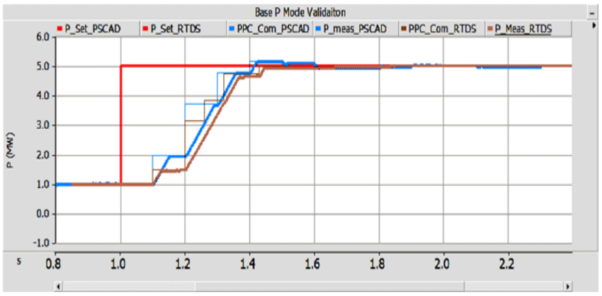

Fig. 4: Base P mode

Figure 7: Capacitor bank closing operation

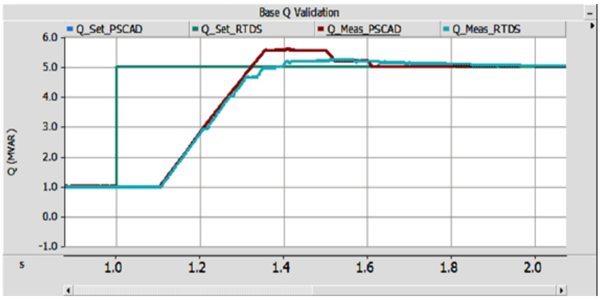

Fig. 5: Base Q mode

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