

# HIL Validation of Power Plant Controller Model

## FUNCTIONALITIES

- Test communication interface
- Optimize P, Q, PF and AVR modes
- Coordinate multiple PPCs at a POI
- 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 these models against the

performance of actual hardware controller is rarely provided. It is generally assumed that the performance of the model, based on the actual controller source code or, in this case, identical block-diagram, is the same as the hardware controller performance. However, this may not be acceptable to all end-users since the simulation platform and the hardware are two significantly different environments. Validation via field tests is usually narrow in scope. The hardware-in-loop (HIL) validation using a real-time digital simulator is a well accepted, flexible, and cost-effective method for a thorough validation.

RTDS® is a world renowned 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 General Electric 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 R&D phase to System Acceptance Test (SAT) of a fully assembled power plant controller and protection system.

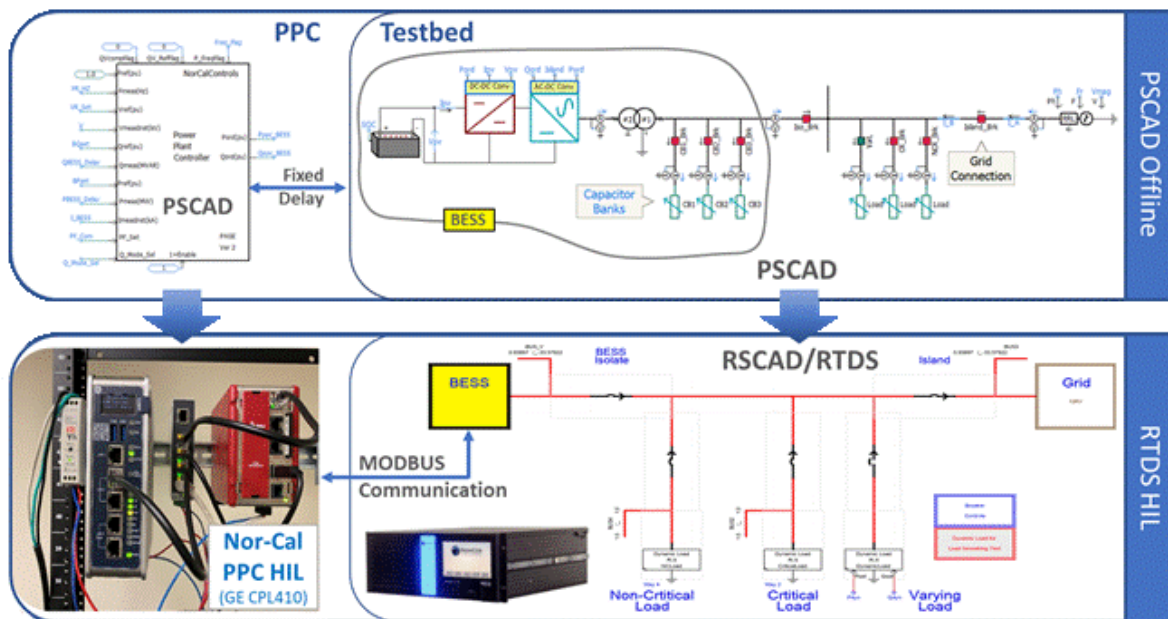


Fig. 1: The testbed setup

## 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\\_proceeds/isonone\\_plan/pp05\\_6/pp5\\_6.pdf](https://www.iso-ne.com/static-assets/documents/rules_proceeds/isonone_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>

# 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 model and PLC were introduced as shown in Fig. 1. Following plots show the results of various validation tests conducted. PSCAD results are overlaid with the corresponding RTDS HIL responses. HIL PPC communicates with the RTDS via MODBUS. This aspect is omitted in a typical PSCAD study. However, to better align the two results, the communication was modeled in PSCAD as a fixed delay using the average MODBUS 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.

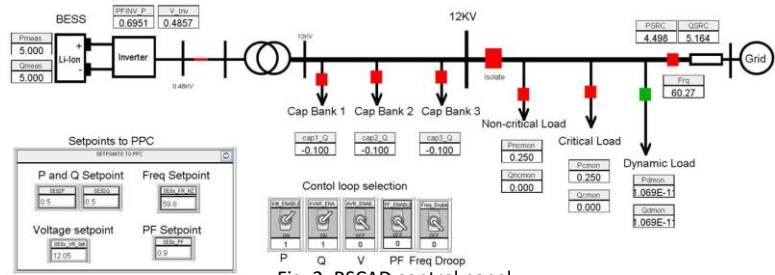


Fig. 2: RSCAD control panel

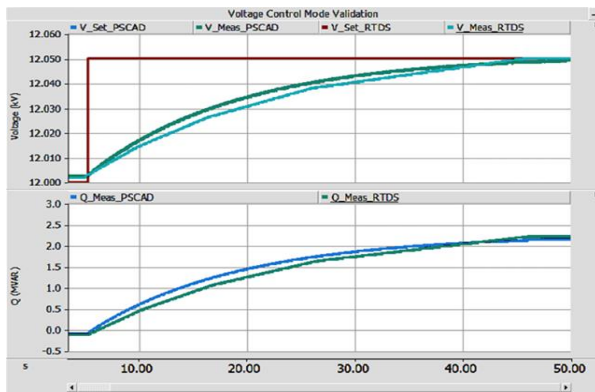


Fig. 3: Voltage regulation mode

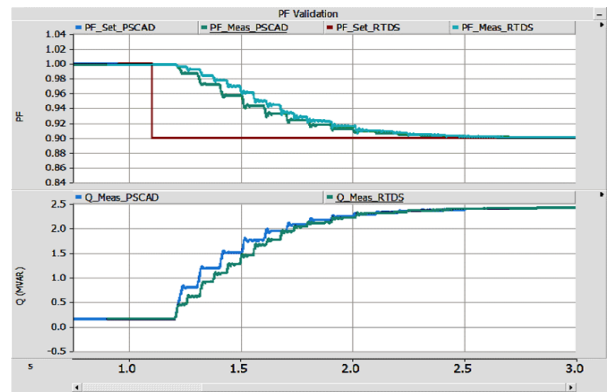


Figure 6: Power factor mode

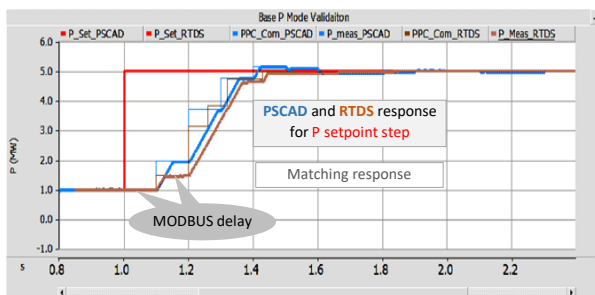


Fig. 4: Real power mode

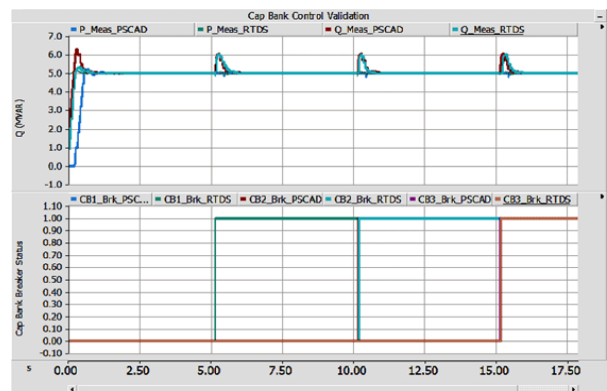


Figure 7: Capacitor bank operation

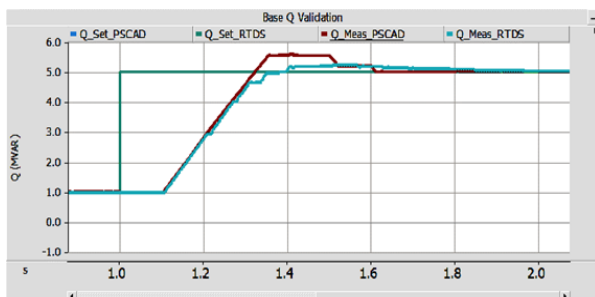


Fig. 5: Reactive power mode

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