HIL VALIDATION OF POWER PLANT CONTROLLER MODEL

DR. OM NAYAK

NAYAK CORPORATION

USER SPOTLIGHT SERIES BY RTDS Technologies

IN COLLABORATION WITH

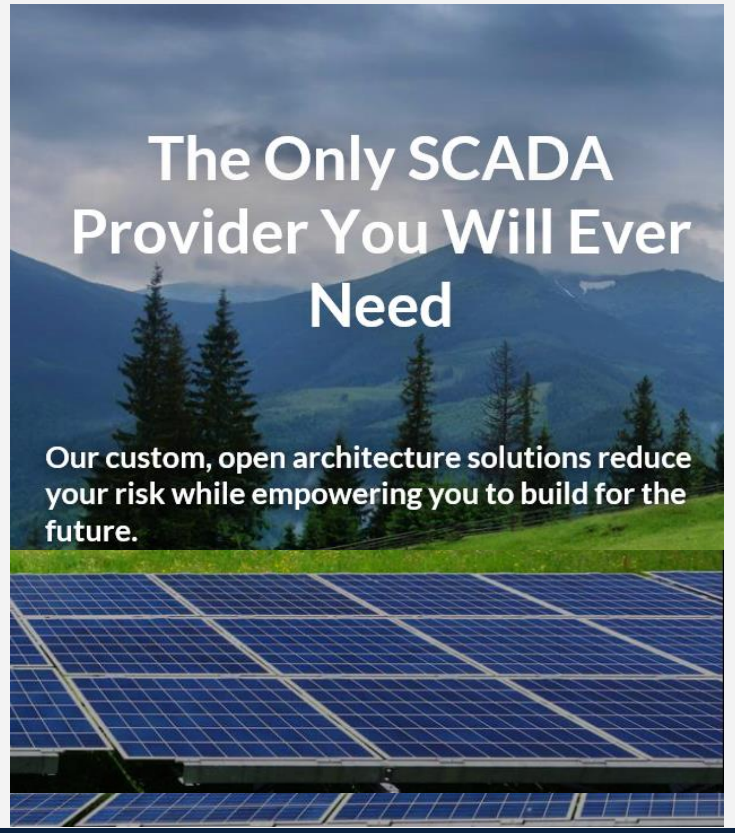
- **Nor-Cal Controls** www.norcalcontrols.net
  - Robert (Bob) Lopez, President
  - Seth White, Sr. Controls Engineer

- **Nayak Corporation** www.nayakcorp.com
  - Dr. Venkat Lakshminarayanan, Sr. Engineer
  - Chathura Patabandi, Manager

ABOUT NOR-CAL CONTROLS

NOR-CAL CONTROLS
ENERGY SOLUTIONS

- Open source automation and controls engineering solutions
- Flexible, scalable, and completely customized
- Systems-agnostic turnkey DAS and SCADA systems
- Training, consulting and troubleshooting support
- Reputed as the **“strongest in controls”** for Solar PV system integration



ABOUT NAYAK

- Specialist in power systems simulation tools and services
- Independent representatives for:
  - **RTDS®** real time digital simulator from RTDS Technologies
  - **PSCAD™** emt simulator from Manitoba Hydro International
  - **DSATools™** from PowerTech Labs
  - **Power Amplifiers** from Spitzenberger and Spies
- Sales, support, and training
- Study services:
  - PSCAD model development
  - Renewable energy integration studies
  - HIL testing using RTDS
  - DER model development using PSSE and TSAT

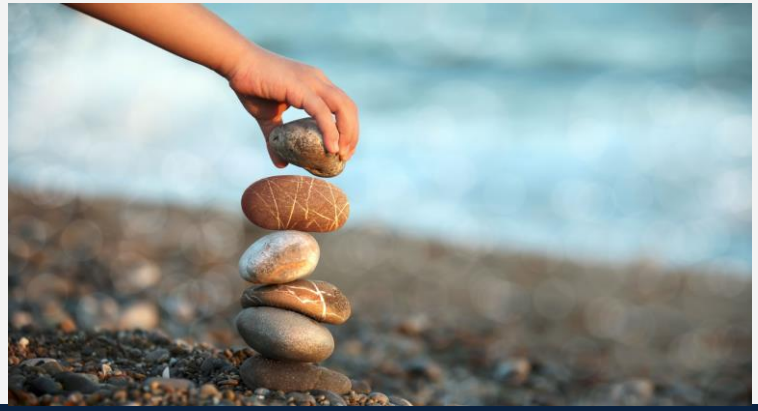
INTRODUCTION

Unique use-case where the RTDS simulator is used for validating a PSCAD model of a Power Plant Controller against its PLC based hardware controller.

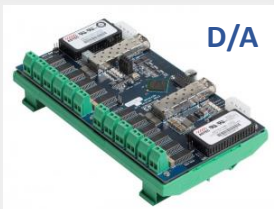
Why model?

- Most North American utilities and ISO's require DER installations to supply detailed PSCAD models of Inverter Based Resources (IBR)
- Power Plant Controller is a critical infrastructure.
- Controls 100's of MWs per site and many sites
- Validation options
  - field measurements – restrictive

➔ Real-time HIL testing – **well accepted, flexible and economical**

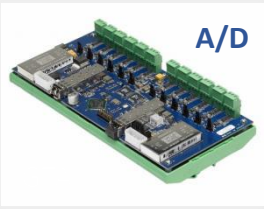


HIL SETUP



Measurements
V, I, P, Q, etc.

Ethernet Based
Protocol
Communication



Control signals from
DUT

DUT

- Relays
- Converter Controls
- Microgrid Controller
- PPC / SCADA

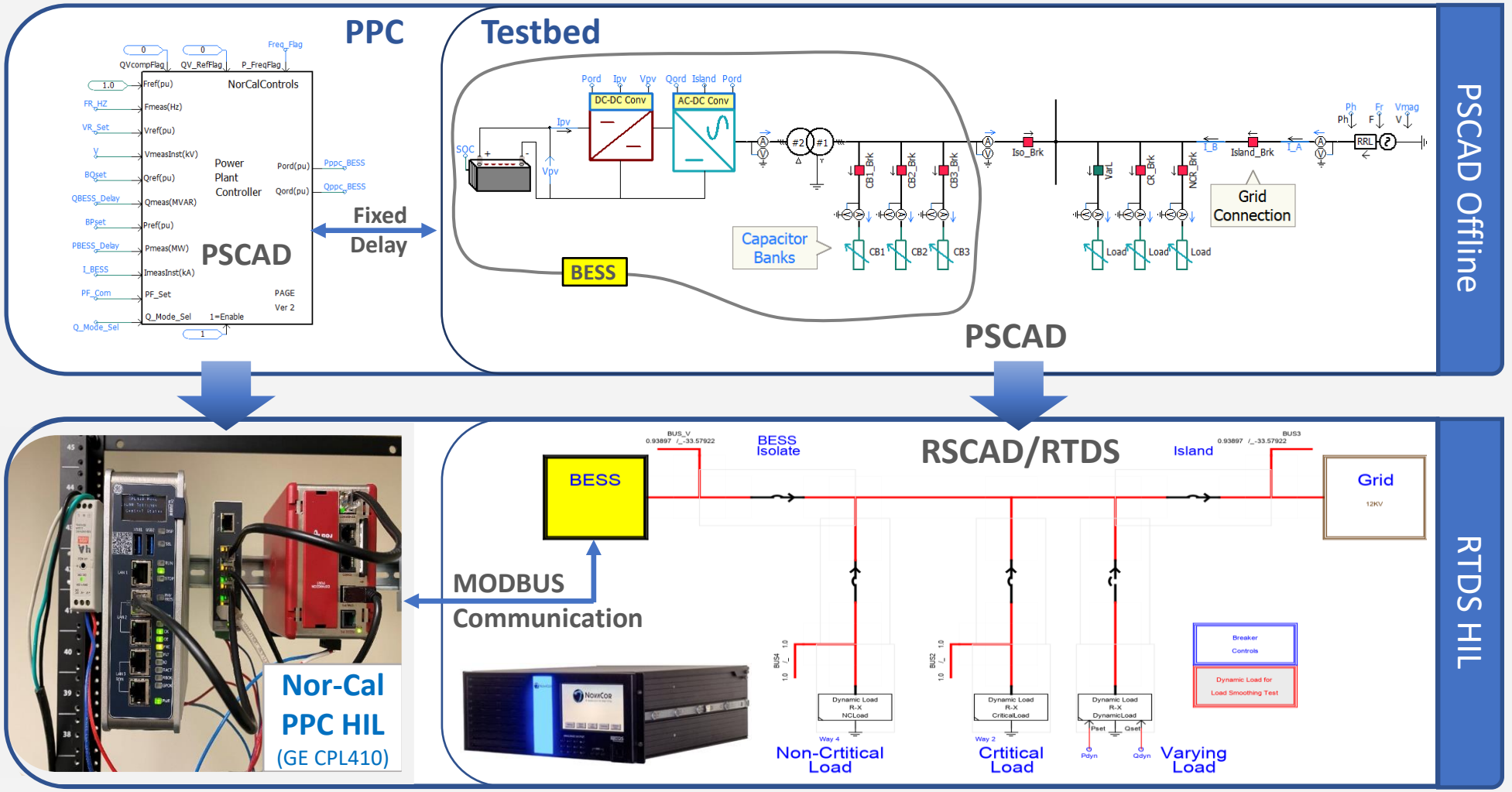
Replica Controls
- LCC HVDC Controls
- VSC HVDC Controls
- MMC Controls
- STATCOM and SVC
- Generator Controls:
  - Sync Cond. Exciter
  - PSS

Protective Relays
- Digital Relays
  - Analog I/O
  - Process bus
  - Station bus
- WAMPAC

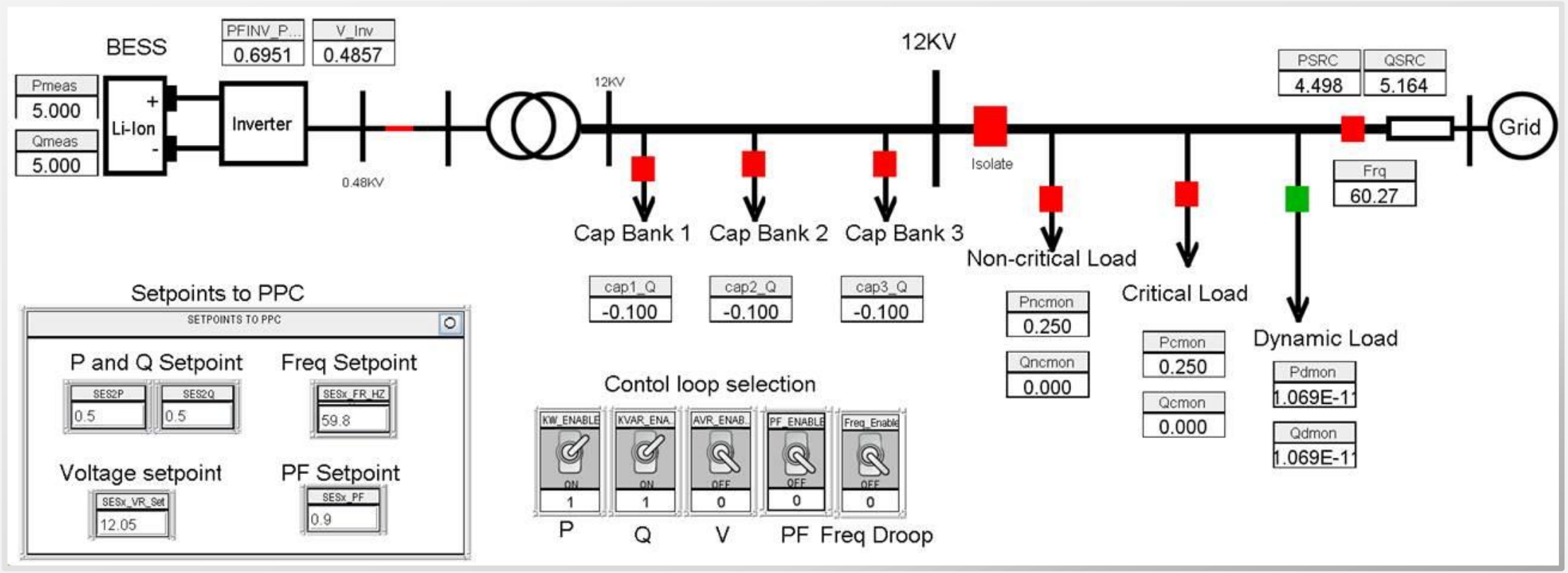
Smart Grid and Microgrid
- SCADA, DMS, ADMS
- IEC 61850 (GOOSE, SV)
- DNP3, MODBUS
- PMU (C37.118)
- Grid-Edge Controls

DER Controls
- WTG Control
- PV Conv Control
- BESS Conv Control
- Power Plant Controller (PPC)

PPC TESTBED – PSCAD & RSCAD



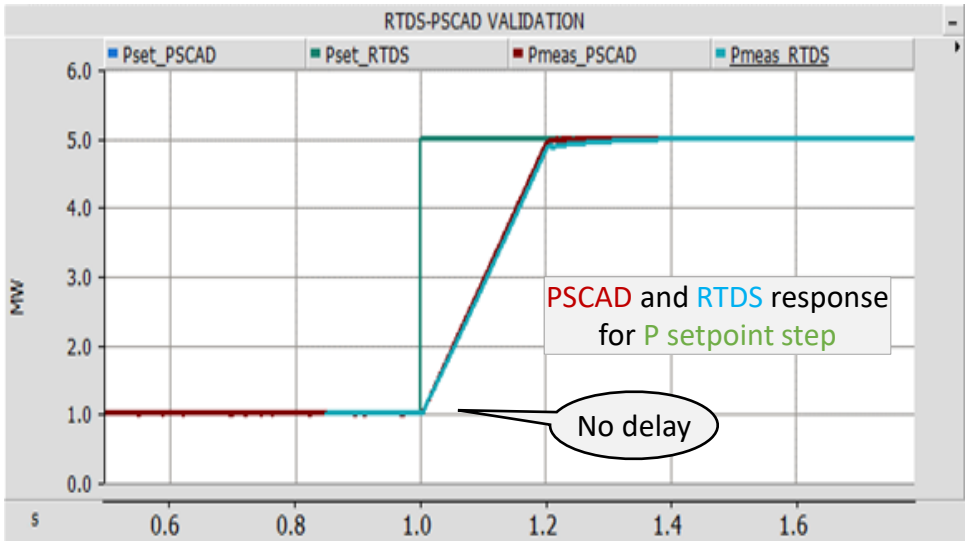
RSCAD RUNTIME CONTROLS

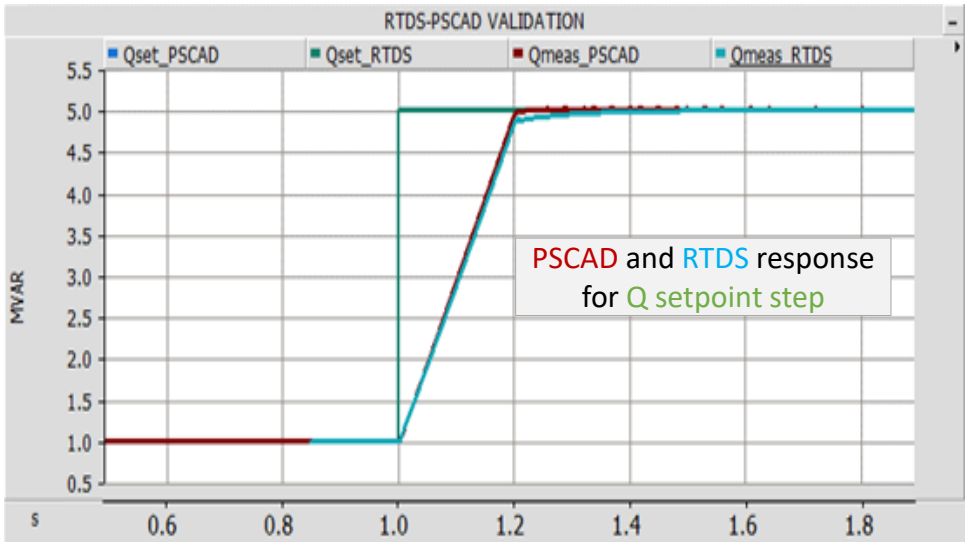


TESTBED VALIDATION

Base case validation of PSCAD and RTDS Model

- The initial validation of the BESS model <u>without the PPC model</u>
- Tested with a step change to P and Q order to the BESS model in both the platforms
- Overlay responses are plotted using ENERPLOT™ – a very useful post-processing software, a new addition to the PSCAD suite.

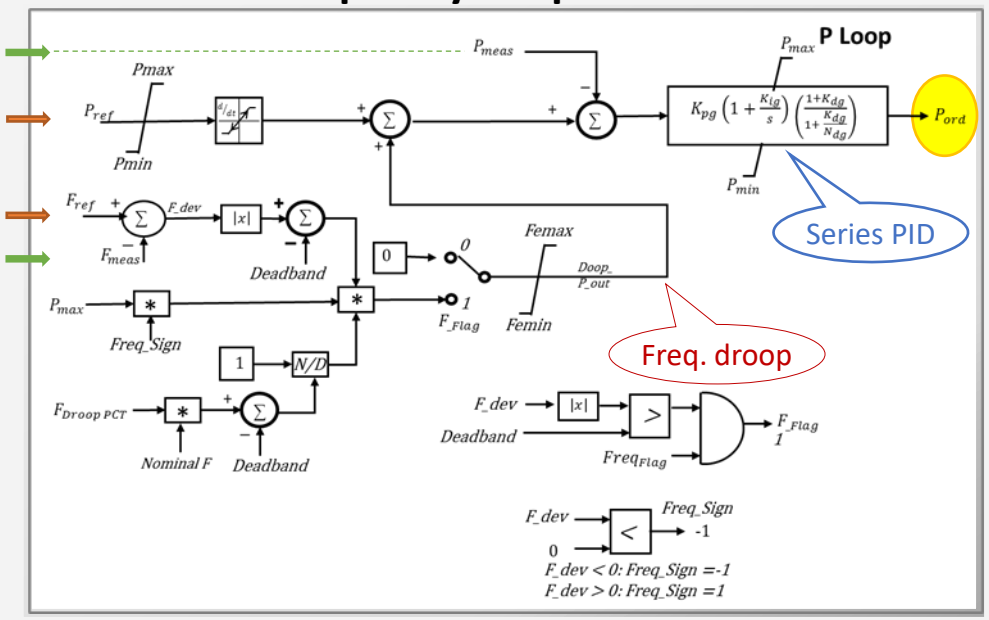




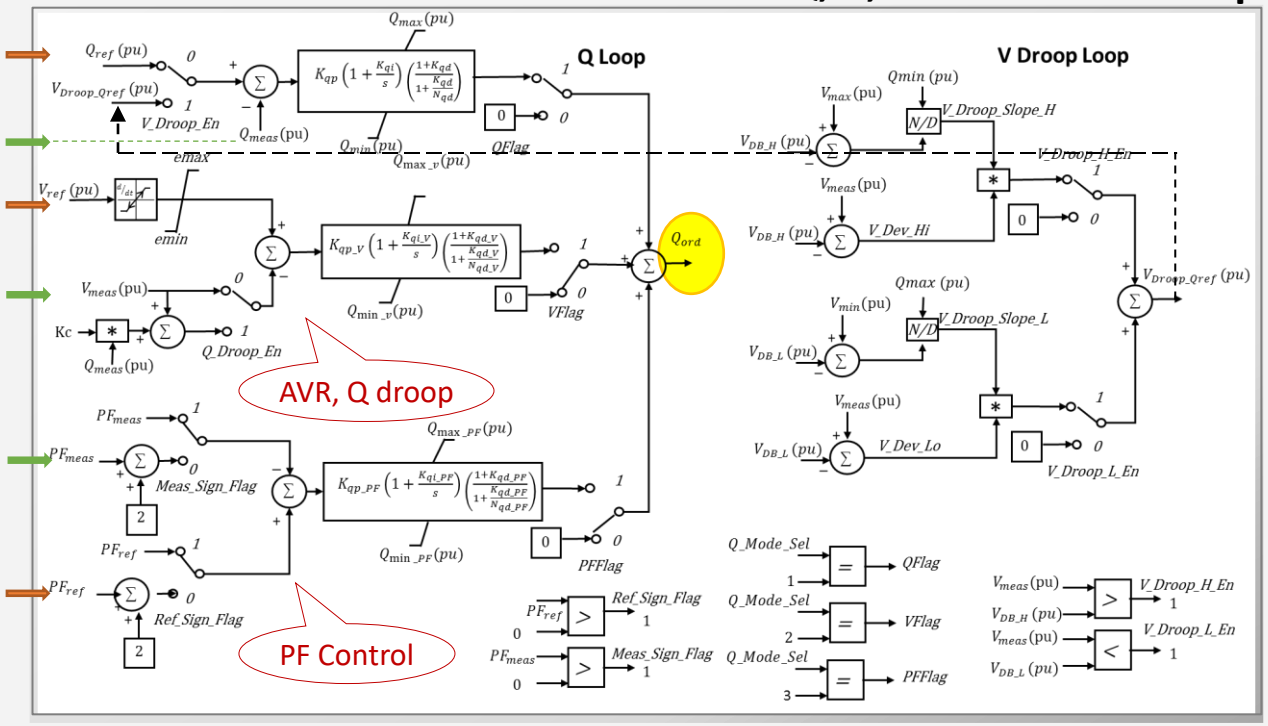
PPC MODEL

Real power modes	Reactive power modes	Capacitor bank control
Base P	Base Q or Voltage droop	Automatic or Manual
Base P with frequency droop	Voltage regulation with/without Q droop	
	PF correction	

Power and Frequency Loop

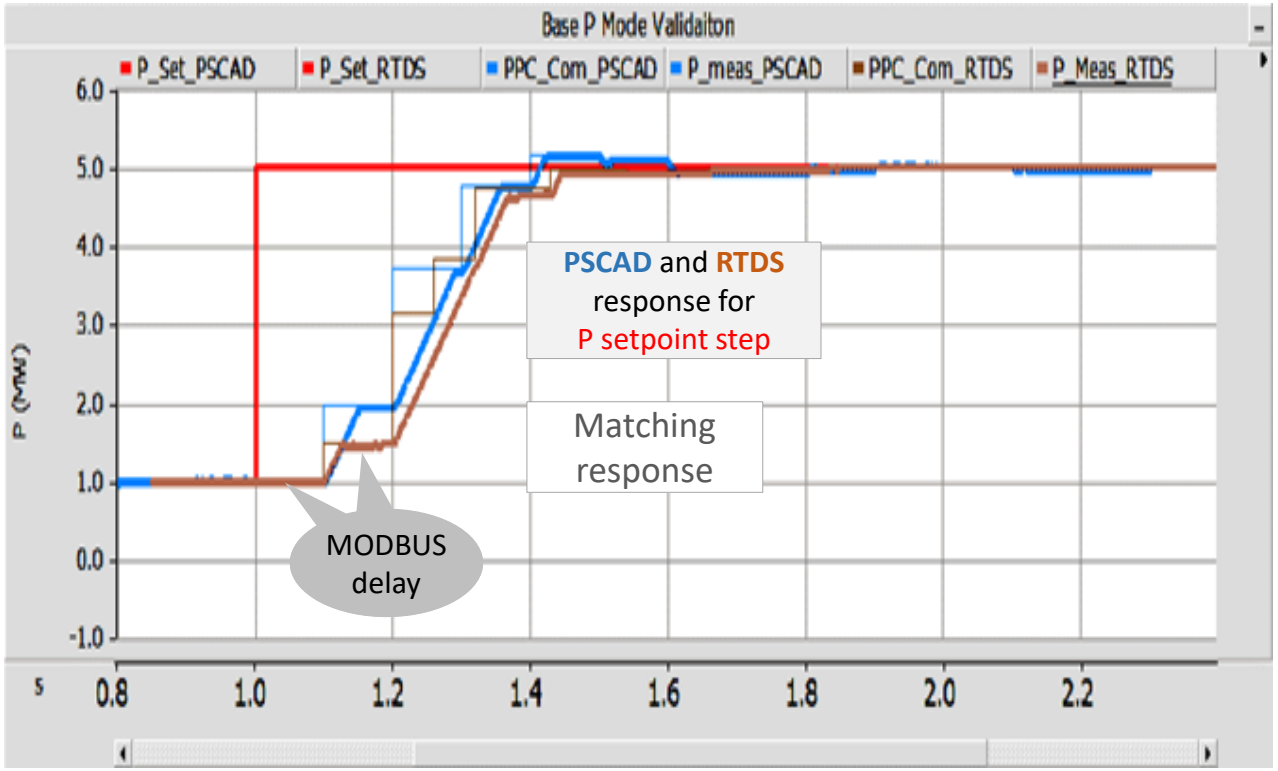


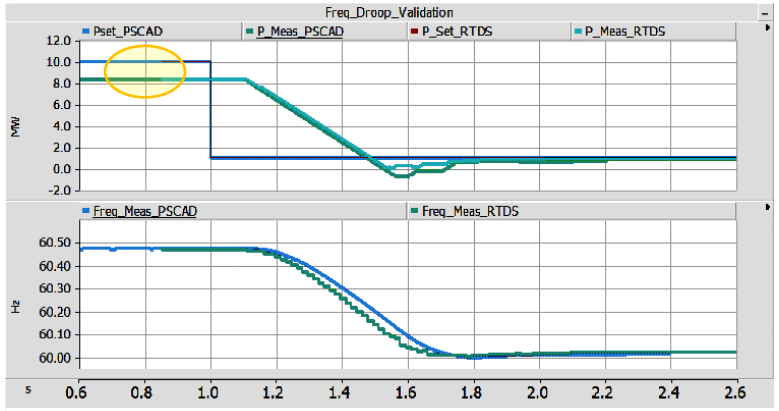
Q, V, Power Factor Loop



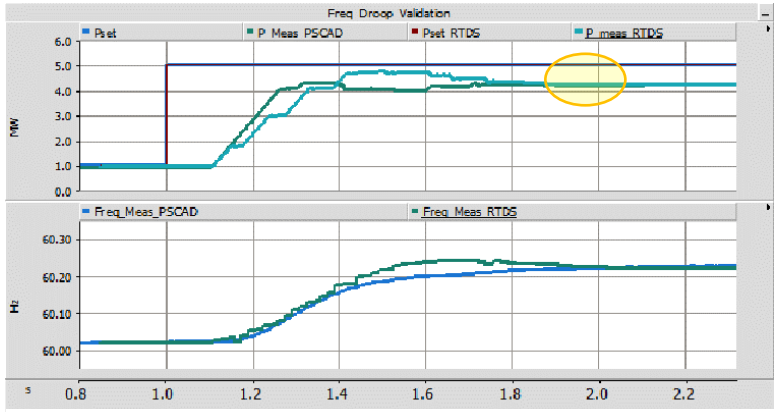
POWER AND FREQUENCY CONTROL

Power and Frequency Control





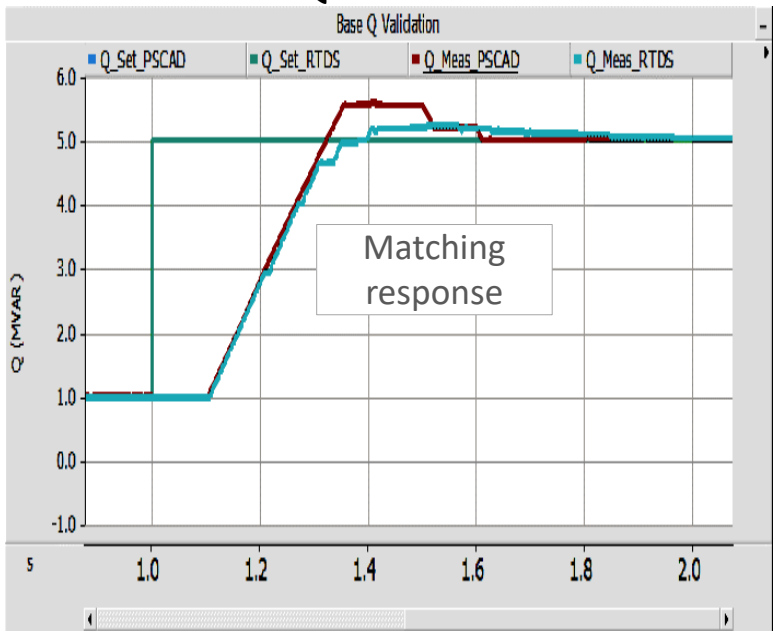
Freq. Droop Operation for Decrease in P



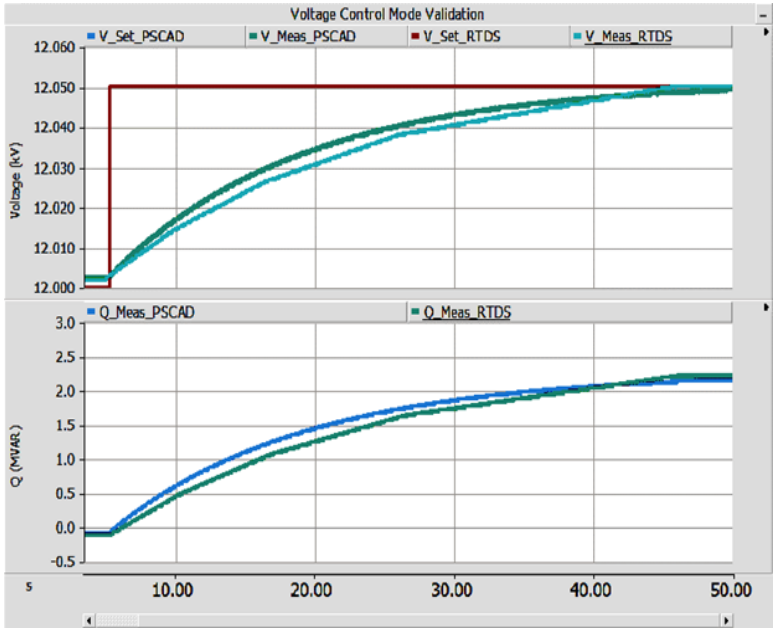
Freq. Droop Operation for Increase in P

Q, V, AND POWER FACTOR CONTROL

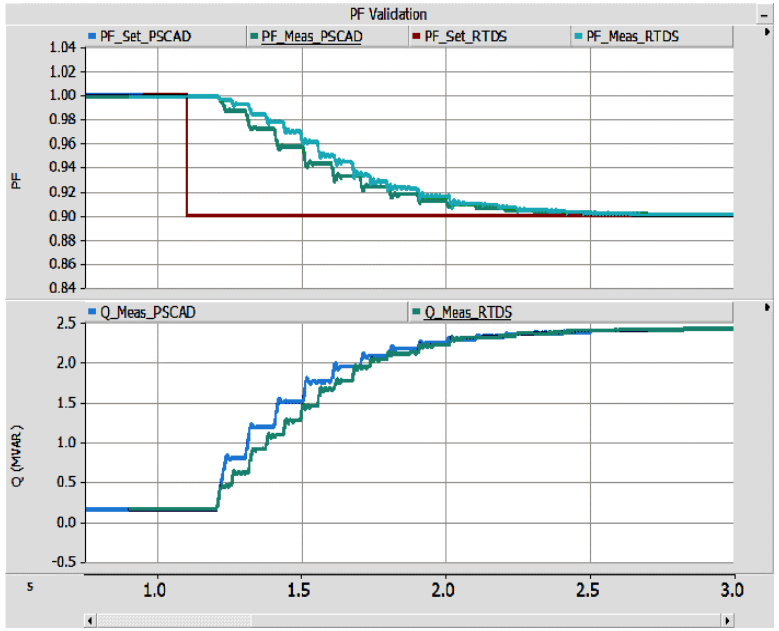
Q Control



V Control



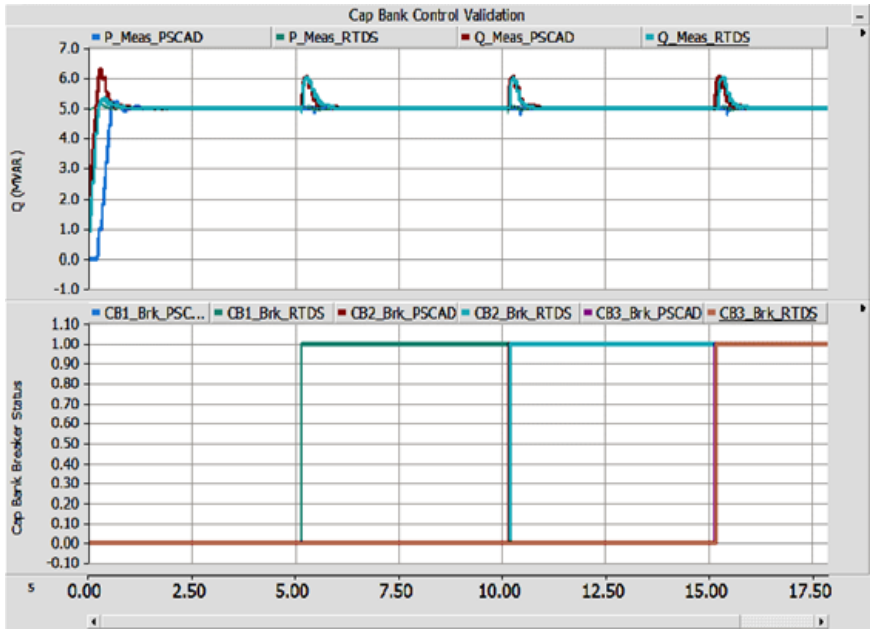
Power Factor Control



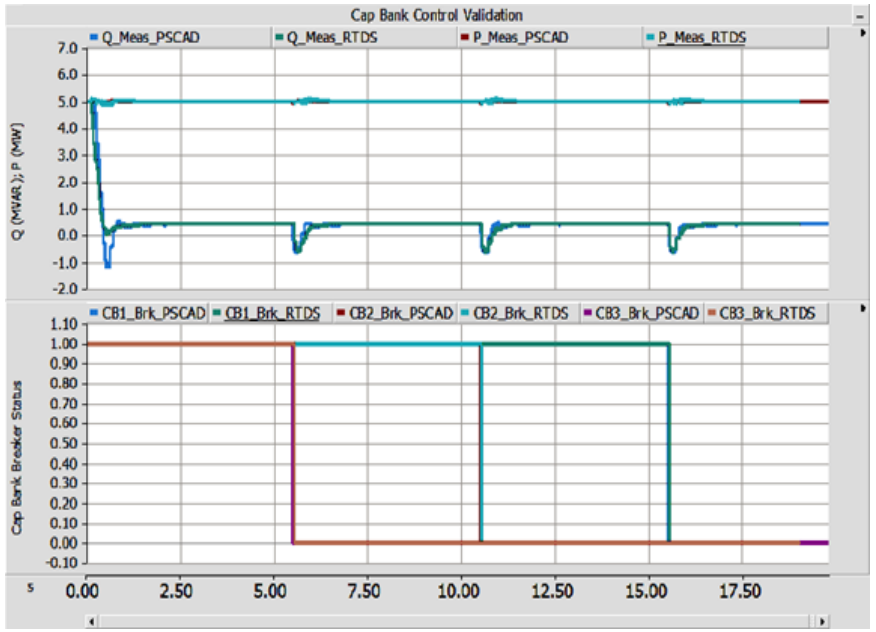
CAPACITOR BANK CONTROL

Cap Banks	Closing	Open	Close delay	Open delay
Cap bank 1	Q at POI >70% of its capacity	Q at POI <45% of its capacity	5s	5s
Cap bank 2	Q at POI >140% of its capacity	Q at POI <90% of its capacity	5s	5s
Cap bank 3	Q at POI >210% of its capacity	Q at POI <135% of its capacity	5s	5s
Cap bank 4	Q at POI >280% of its capacity	Q at POI <180% of its capacity	5s	5s

Capacitor Bank Closing Operation



Capacitor Bank Opening Operation



FUTURE WORK

- Complex HIL testing with
  - multiple PPCs
  - large renewable plants
  - tightly coupled low SCR POIs

- Study
  - dynamic interaction during large disturbances
  - tuning
  - coordination

CONCLUSIONS

- PSCAD model is a true representation of the hardware PPC
- HIL validation is a worthwhile exercise to bring-in that added security to a critical infrastructure such as a power plant controller
- There is a significant feedback loop delay present in the PPC hardware communication interface. These tests helped quantified it.
- RTDS HIL Testbed is useful for
    - Model validation
    - Controller design and development
    - Parameter tuning and system coordination
    - System Acceptance Tests

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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
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5. PSCAD Website, www.pscad.com
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THANK YOU