Paper No: 21ISGT1191

Hardware-in-the-Loop Evaluation of an Advanced Distributed Energy Resource Management Algorithm

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February 16-18, 2021

NREL/PR-5D00-78884

HIL Evaluation Overview

- Objective: Validate the control and optimization solution against a simulated real-word distribution system in a realistic testing environment
  - Accurate modeling of distribution system, power hardware inverters, communications
  - Four major elements of the HIL platform:
    - Co-simulation
    - Grid Optimization algorithm
    - ModBus communication interface
    - PHIL with PV inverters
  - Software controller interacts with the real-time simulation model and hardware inverters as if the controller were interacting with a real-world system
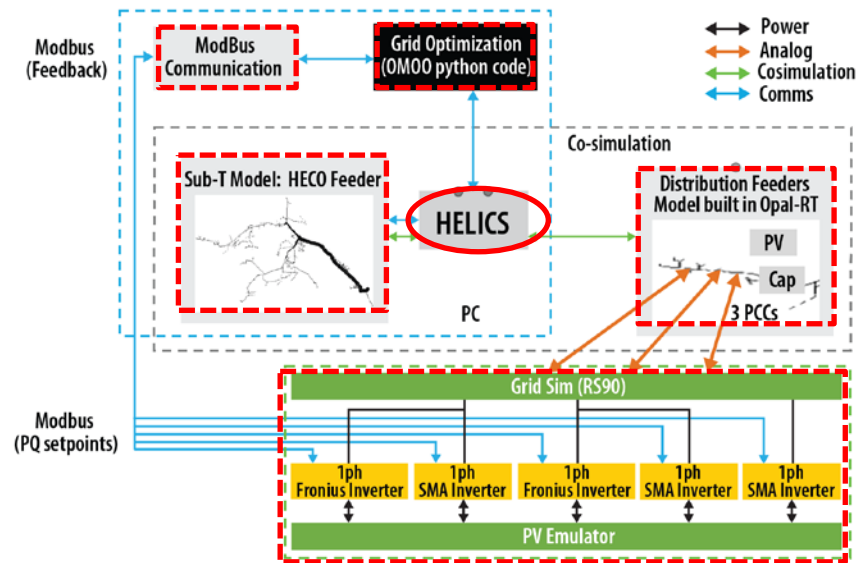
Experimental Results

— Distribution feeder from Hawaiian Electric Company

- Over 2,000 nodes

- 245 loads and 245 PVs (242 simulated and 3 PCCs with hardware PV inverters)

- 50% PV penetration

— Implementation details

- HELICS agents: OPAL 0.1 s, OpenDSS 4 s, Optimization 10 s and ModBus 10 s

- PHIL: 3 PCCs with 5 PV inverters (rated capacity of 3-5 kVA) for simulated capacities of 23.5 kVA, 19.5 kVA and 93.6 kVA

- Voltage regulation target: 0.95 – 1.03 p.u.

- Simulation time 10:00-12:00 2-hour run at high solar irradiance
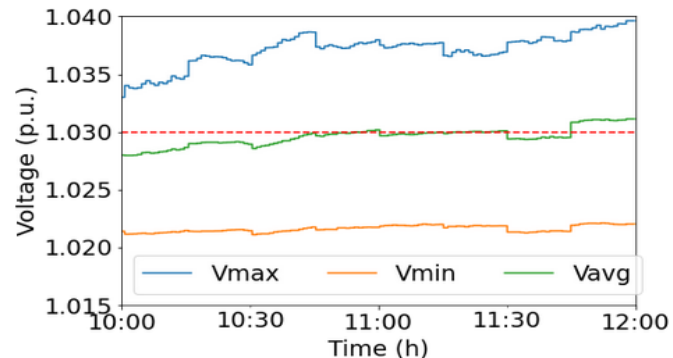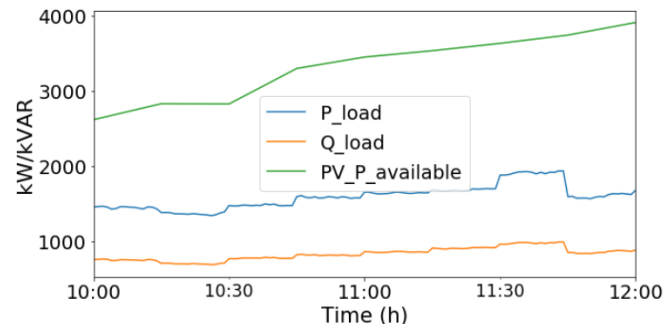
Experimental Results
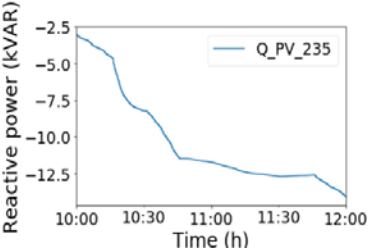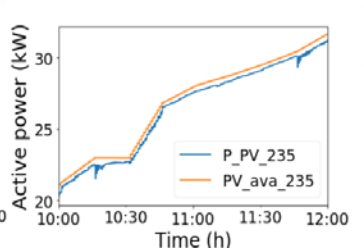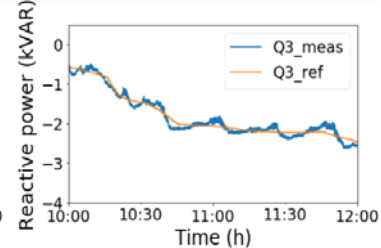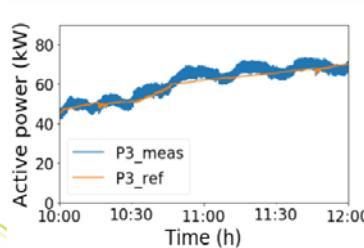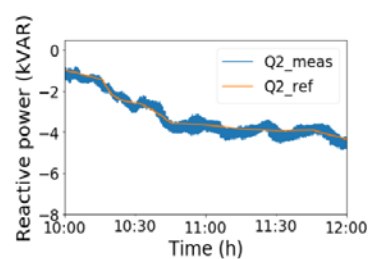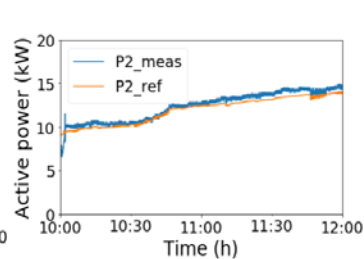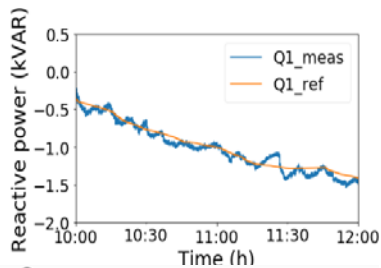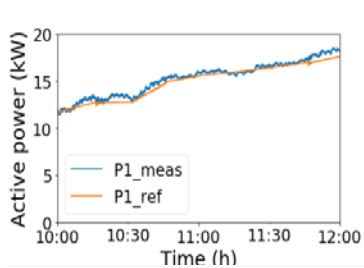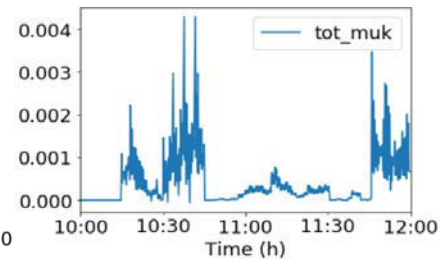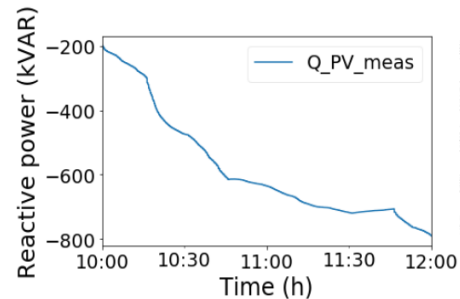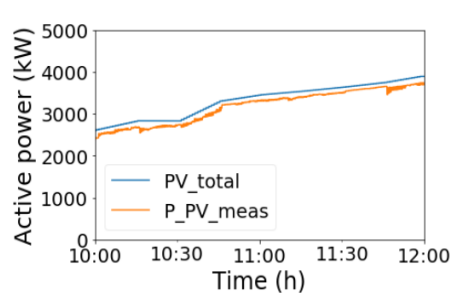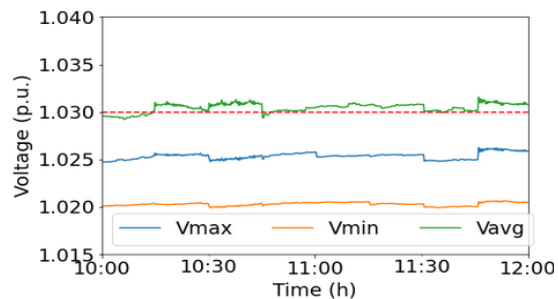
Conclusions

- The voltage regulation performance of the developed Grid Optimization control is effectively evaluated with the laboratory HIL simulation.

- HELICS is a key tool to integrate and synchronize all the software and hardware pieces together

- Software controller sees the real-time simulation model and hardware inverters as if the controller were interacting with a real-world system

- The setup showcases the testbed's flexibility to focus on specific control function to coordinate distribution resources for system level target functions and supports early-stage validation.