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

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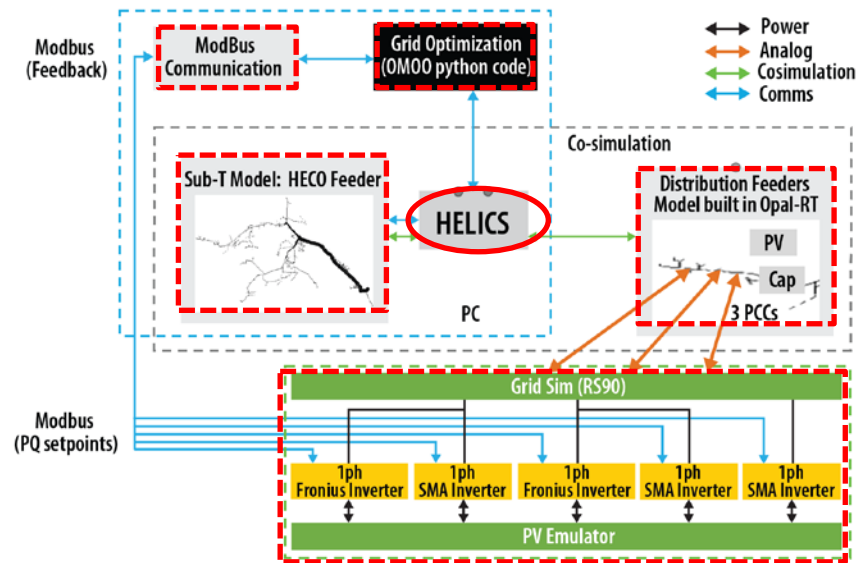
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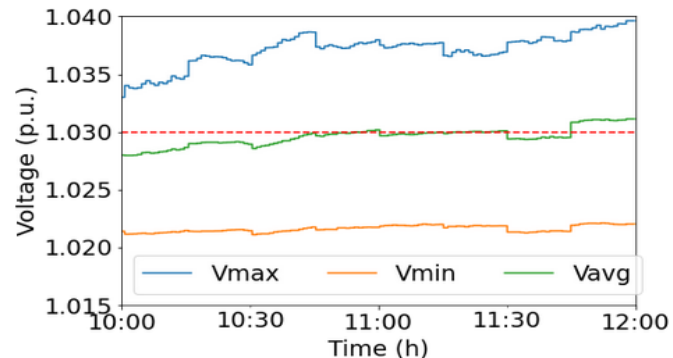
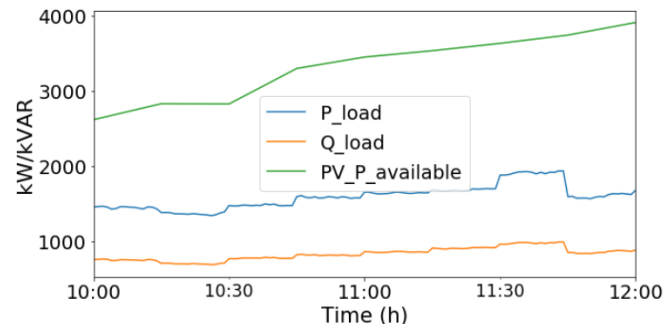
HIL Evaluation Overview

- Objective: Validate the control and optimization solution against a simulated real-world 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

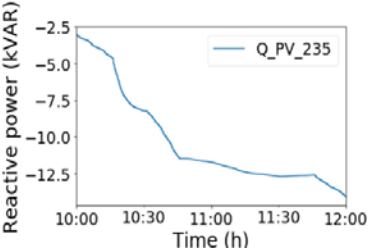
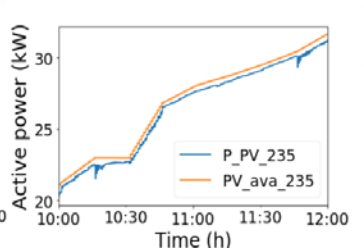
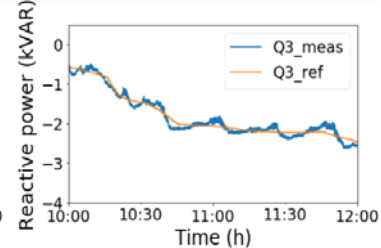
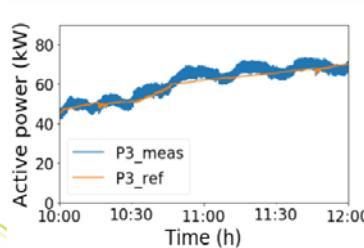
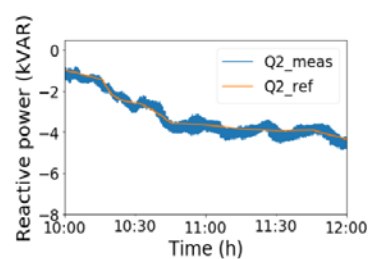
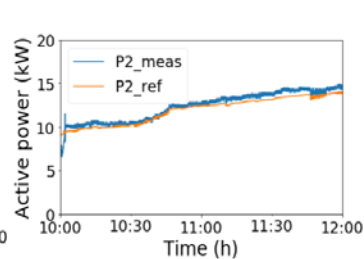
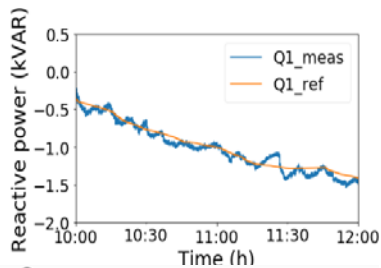
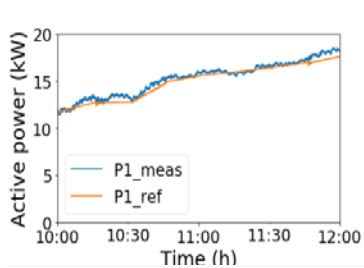
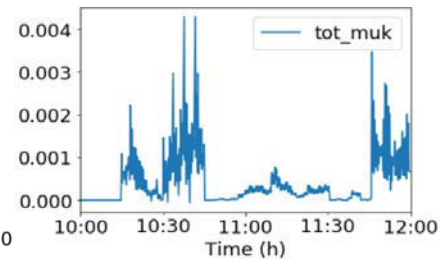
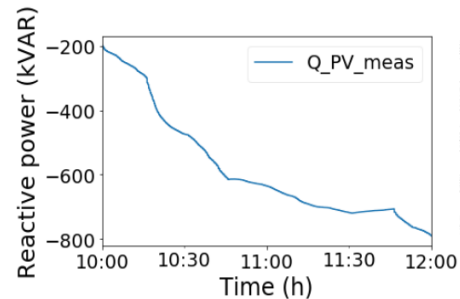
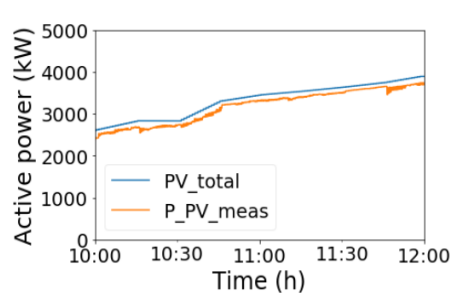
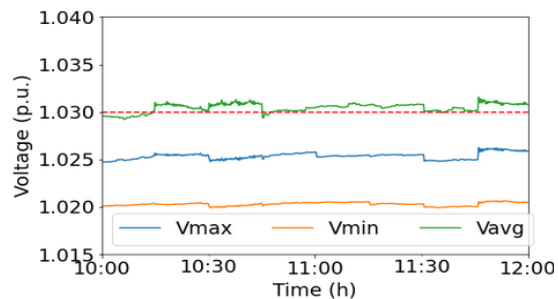


Experimental Results

- 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.

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