Hardware-in-the-Loop (HIL) testing in Microgrid Engineering

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HIL in the Microgrid Development Cycle

Requirements
- Cost Benefit Analysis
- Performance Metrics
- Technical Standards

Concept & System Modeling
- with Virtual Models for Control & Protection
- Grid impact
- Energy management
- DER Integration
- Grid Code Compliance
- KPI Evaluation

Design Studies

Real-Time Implementation
- Model Decoupling
- Hybrid Modeling
- Multi-rate Modeling

Unit HIL Testing

Real-Time Simulation

Integrated HIL Testing

Integrated Verification and Validation
- Test Scenarios with Microgrid Controller
- KPIs Validation

Microgrid Operation
- DER Controller Coordination
- Protection Coordination
- Network and DER with POI

Individual DER Control & Protection

KPI Evaluation

Grid impact
- Energy management
- DER Integration
- Grid Code Compliance
- KPI Evaluation
Controller HIL (CHIL) Testbeds for Microgrid Applications
Power HIL (PHIL) Testbeds for Microgrid Applications

Switching / Linear power amp

DER PoC on \( \mu \text{Grid} \)

Measurements

Control Signals

DER under Test

DER Controller
Studying Power Electronics and Fast Transient Phenomenon

- Assets controller interactions
- Fault response of DERs
- Simulate accurately the effect of commutation dead-times and study harmonics
- Test DER fault-ride through and converter protections
Studying Protection and Control

- Test islanding and reconnection transitions
- Islanding detection
- Inertial response within a microgrid
- Test the reliability of the integrated control and protection systems from design studies
- Tune generator controllers and protection system coordination
Large Systems and Slow Dynamics

- Impact analysis of microgrids on the grid dynamics
- Integrated testing of microgrid(s) with advanced distribution management systems for large distribution networks
- Use 3-phase unbalanced phasors to simulate large distribution system and study asset dispatch (available with ePHASORsim)
- Frequency and voltage stability studies with microgrid clusters
- Use EMT or EMT-Phasor hybrid simulations with models using average converter models

Test Automation

IEEE 2030.8
IEC/TS 62898-2

Grid Codes

Initial conditions & Test parameters Definition

Microgrid Model in HYPERSIM on RTS

Microgrid Controller Under Test

Post Processing

Results

Test Waveforms (COMTRADE, MAT, PS, TXT, PDF, JPG, PNG)

Report Gen

ITES 2030.8
IEC/TS 62898-2

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Report Gen
• Performed extensive testing of the microgrid controller with the UCI network model simulated in real-time (phasor).

• Actual testing performed on the 21st Feb 2018 by islanding from the Southern California Edison (SCE) grid.

• Successfully remained islanded for 75 minutes with some loads intentionally turned on and off to test the systems dynamic response.

Reference:

Source:
http://www.apep.uci.edu/Research/PDF/Microgrid/UCI_Microgrid_APEP_100518_1012am.pdf
Thank You

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