The University of Texas at Austin
Center for Electromechanics

HIL POWER SYSTEM RESEARCH
FROM SIMULATION TO FIELD DEMONSTRATION

Center for Electromechanics
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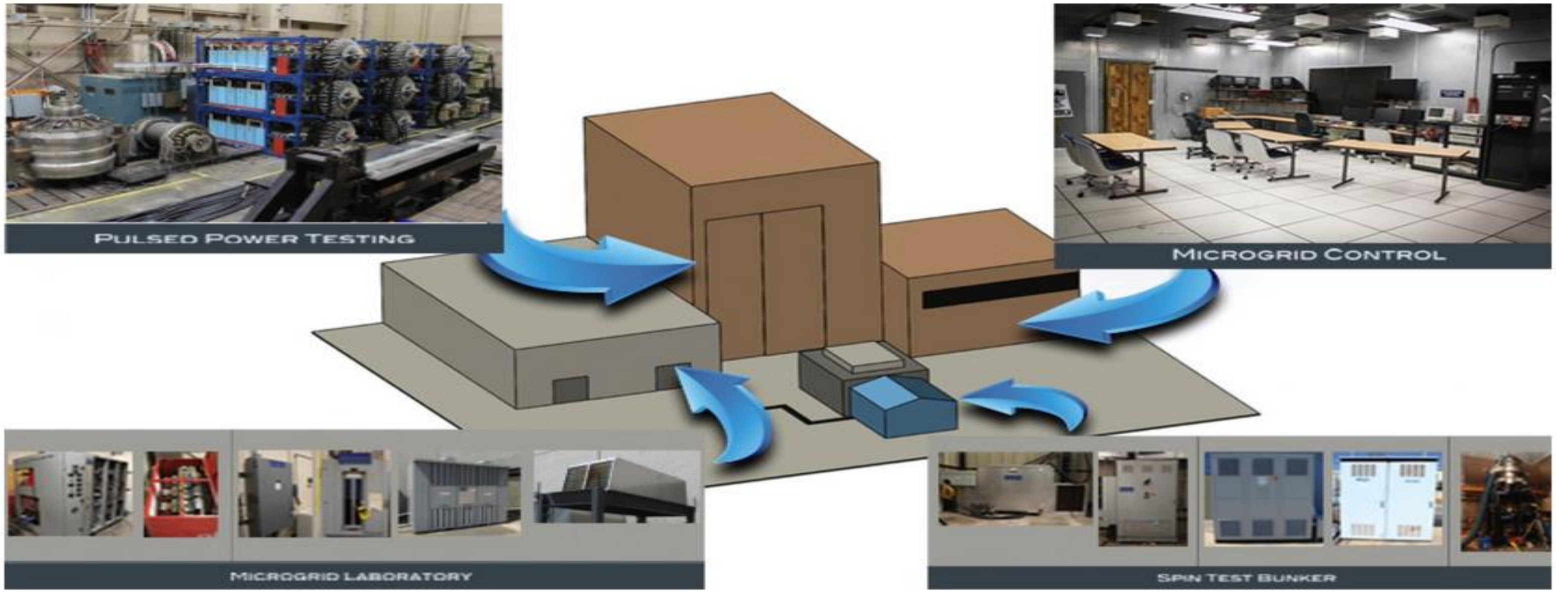
Hardware-in-the-Loop (HIL)

The control and protection strategies are ultimately implemented in the control platform of real hardware power system for final testing and validation. Main benefits include:

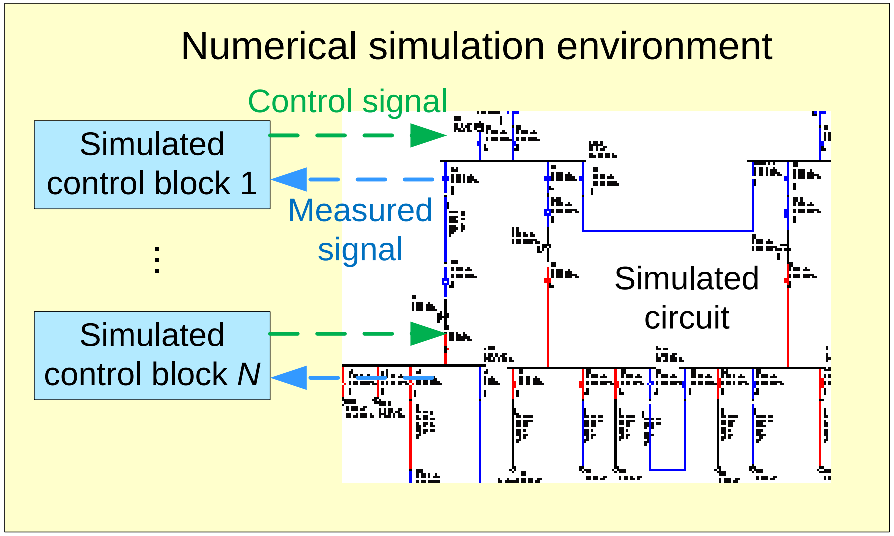
1. Obtain validated engineering data
2. Demonstrate the control system performance in the real operation environment



Simulation Testing

New control and protection strategies are initially implemented in modeling software and verified in numerical simulation. The tools include but not limited to:

1. Matlab / Simulink
2. PSCAD
3. ETAP
4. OpenDSS



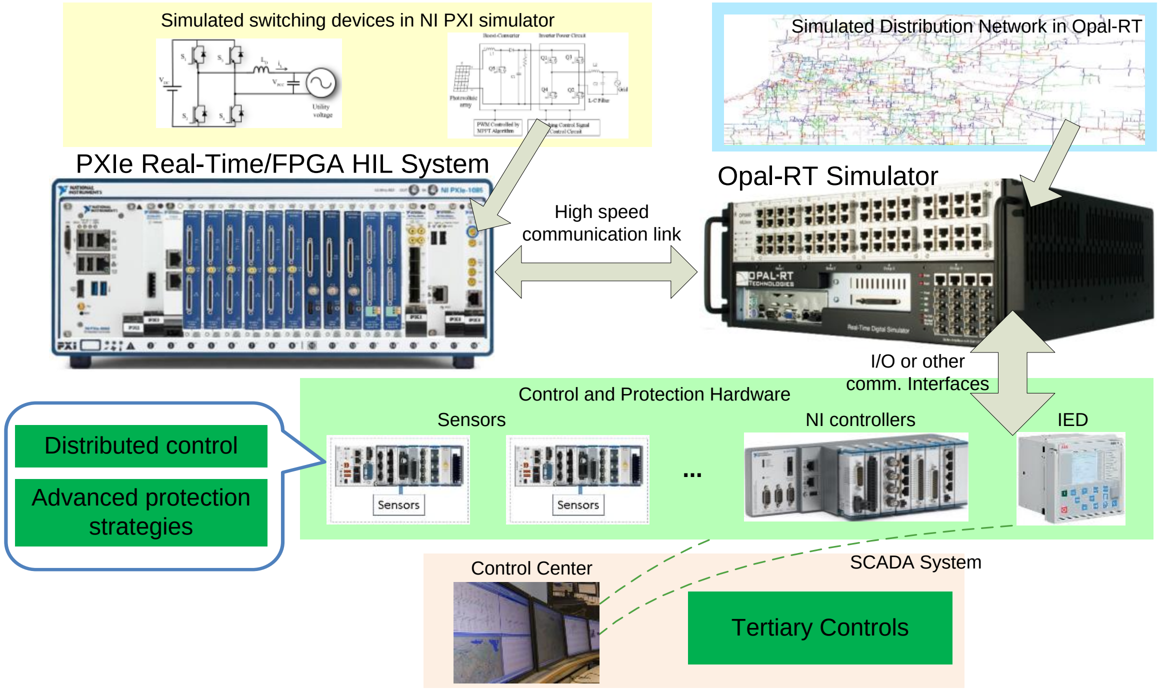
The control or protection strategies are implemented as software blocks in simulation tools; the control system performance can be evaluated and controller parameters can be optimally selected in off-line simulations.

Control Hardware-in-the-Loop (CHIL)

New control and protection strategies are implemented in hardware controllers. The controller is validated and tested in the HIL simulation environment to de-risk field test and demonstration.

Main procedures include:

1. Model the circuit
2. Implement control strategy in hardware
3. Configure the communication interface between real-time simulator and hardware controllers
4. Perform real-time HIL tests

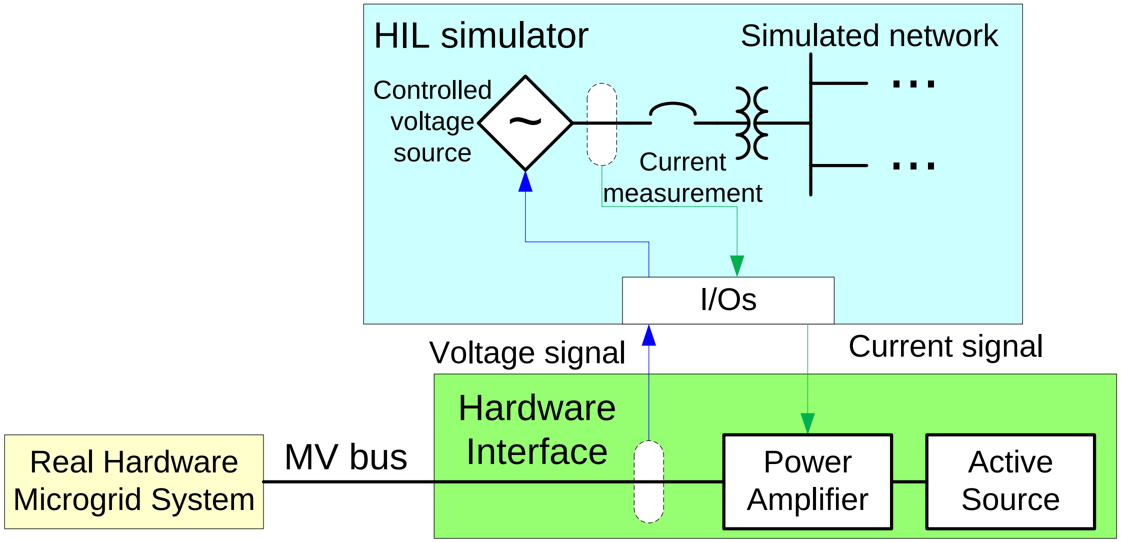


Power Hardware-in-the-Loop (PHIL)

Design the interface between HIL simulator and real power systems such as hardware microgrid system at CEM. Power amplifiers (power converters and emulators) are the interfaces between real-time simulator and real power system.

Key features:

1. Complicated network model is implemented in HIL simulator
2. Power electronics converters and active sources serve as the interface between software simulator and the real system
3. NI FPGA simulator enables the fast response of PE devices



Stability and Economic Control for Microgrids

Develop flexible and robust control technologies that can enable resilient, reliable, efficient, and sustainable microgrid systems.

1. Fast distributed control to reduce the requirement on energy storage systems in residential microgrids
2. Fast coordination control for microgrids with various types of distributed energy resources (DERs)
3. Look-ahead energy management system for single- or interconnected multiple-microgrid systems
4. Inertia control to increase the transient stability of microgrids
5. Distributed dynamic load control to improve isolated power system stability and system efficiency
6. Distributed control and dynamic state estimation for microgrids to facilitate extremely high penetration renewable resources

Smart Grid Control & Protection

Advanced fault identification and location for active distribution systems with high penetration DERs

1. Intelligent algorithms for fault type identification
2. Impedance fault location algorithms for distribution systems
3. Traveling wave-based fault location method for smart grid
4. Autonomous islanding detection method

Smart distributed control and demand side management

1. Fast distributed control for renewable resource and controllable load coordination
2. Intelligent demand side management for peak shaving and energy efficiency
3. Smart building energy management system

DC Distribution System Protection

Develop dc distribution system protection method to enable fast fault detection, localization, isolation, and restoration. Key technologies include but not limited to

1. Fast dc fault detection and location algorithms
    1. Differential protection
    2. Impedance protection
    3. Current derivative protection
    4. Over-current protection
2. Solid state fault current limiting technologies
    i. Full-bridge modular multi-level converters
    ii. Dc-dc buck converters
    iii. Thyristor-based rectifiers
3. Coordination control for multiple-converter dc systems for fault mitigation
4. Engineering design and validation in real hardware system

MVDC Ship Power System Control & Protection

The control and protection research in MVDC all-electric ship power systems includes:

1. Coordination control for pulse load and propulsion load
2. MVDC distribution protection
3. Dynamic reconfiguration and restoration
4. Distributed (agent-based) control to improve ship power system transient stability
5. HIL test and hardware engineering test

Conclusion

Future Research

- Increasingly Electronic Economy
- Rapidly Evolving Networked Systems
- Flexible/Dynamic Test Environment
- Excellent team of research SMEs
- Broad Network of Collaboration Partners