Power electronics, Energy storage, Microgrids and Subsea Electrical Consortium (PEMSEC)

(pemses.ece.uh.edu)

UNIVERSITY of HOUSTON

CULLEN COLLEGE of ENGINEERING

Scope of Work

- The scope of research and education development activities of the PEMSEC is in the broad area of power electronics, energy storage, and electrical power systems with special emphasis on power converters, Microgrids, and subsea power systems

- The scope of work includes power converter topologies, drive systems, protection, power flow studies, reliability, renewable energy, safety and reliability of batteries, cyber security and power system operations.

Faculty

- Dr. Kaushik Rajashekara {RAJA}- Director
- Dr. Yan Yao – Co-Director
- Dr. Harish Krishnamoorthy- Associate Director
- Dr. Xingpeng Li – Associate Director
- Four post docs and other research staff

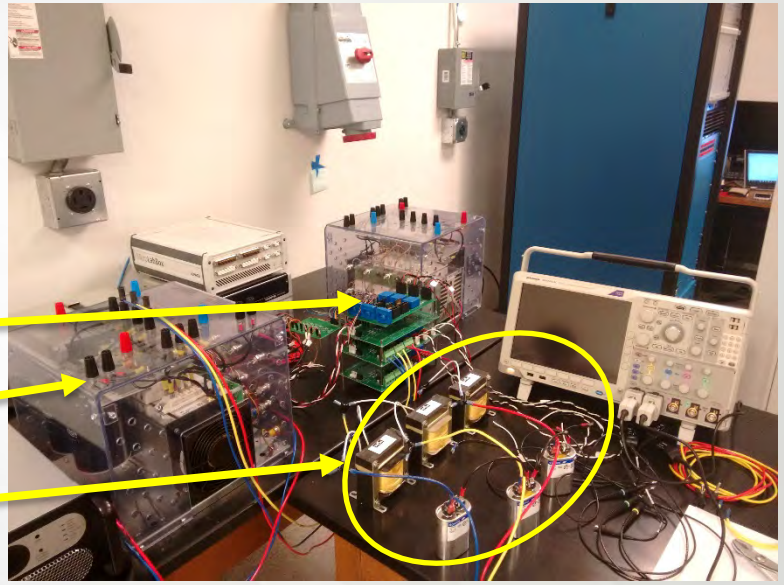
Laboratory Infrastructure-I

Regenerative Grid Simulator
0-300V, 10-100Hz, 30KVA

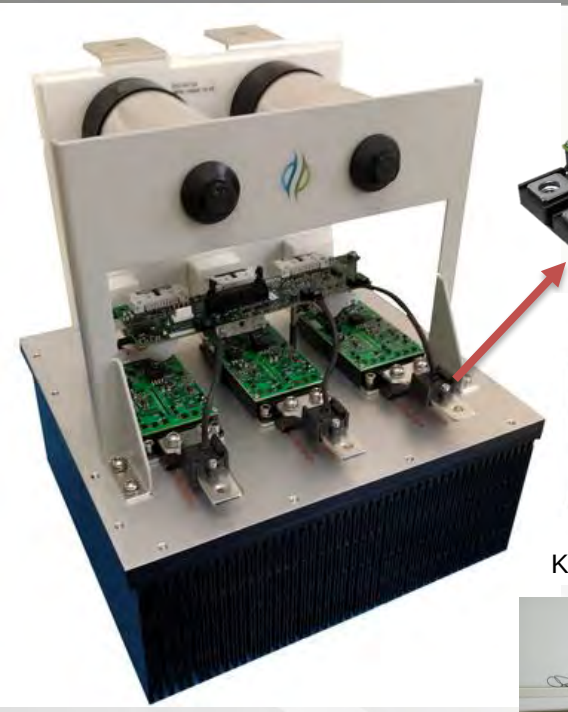
Real Time Digital Simulator (RTDS)

dSPACE Microlab Box

Thermal Chamber



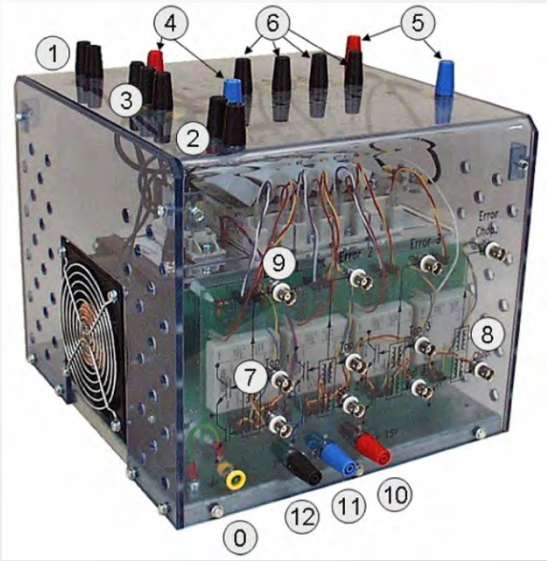
Laboratory Infrastructure-II



Agileswitch SiC Based150 kW Inverter

SiC Power Module

Probes



Semikron Inverter

Keysight N9010B EXA Signal nalyzer

LeCroy HD Oscilloscope 8 channel

Tektronix 4 Channel MDO and TPS series Oscilloscopes

Laboratory Infrastructure-III

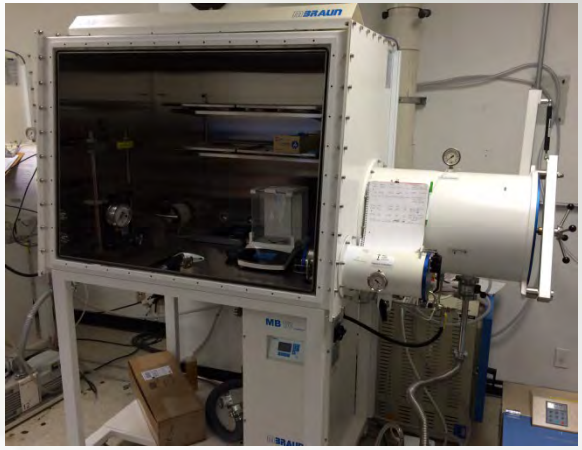
HIL 402

TI DSP TMS 28335 Delfino

- Real time simulation of power electronic switches and converter topologies
- Extensively used for testing the controller before actual implementation
- Simulating parallel operation of inverters and power sharing algorithms

Laboratory Infrastructure-IV

Planetary mill

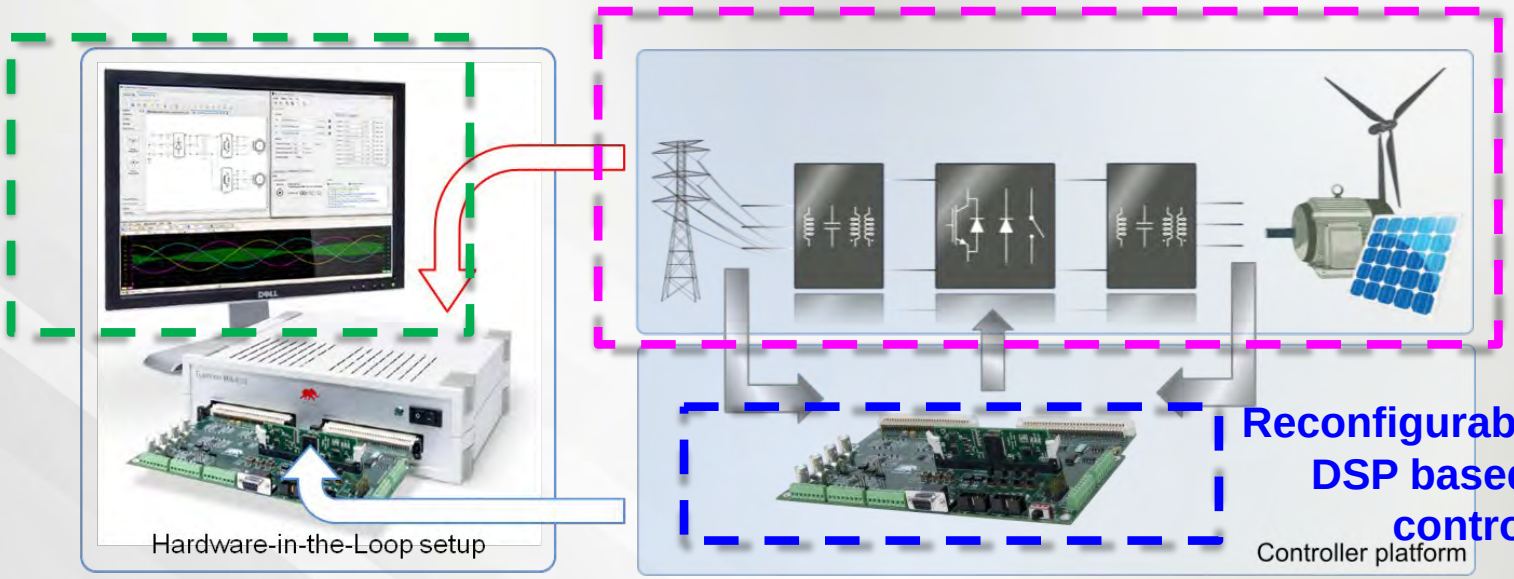


Glove box

Battery testers with EIS (1MHz~0.01Hz)

- Synthesis and processing facility for various kinds of battery materials.
- Electrochemical workstation with impedance spectroscopy (100 testing channels).
- Facilities for processing and testing solid oxide fuel cell and redox flow batteries.

Real Time Power Electronics HIL Simulation Architecture



Picture of the experimental setup with HIL and DSP controller

Power Electronics

- Power converter topologies for AC/DC, DC/AC, AC/AC and DC/DC power conversion for various applications such as renewable energy systems, transportation electrification, adjustable speed drives, power quality and utility applications.
- Analysis, modeling, and control of power devices and components.
- Silicon carbide based power converters to increase the power density, efficiency, and for high temperature operation. Gate drivers, advanced controls and modulation strategies.
- Control of ac motors such as induction and permanent magnet motors. Investigation of induction machine based power generation systems for more electric aircraft
- Power converters for Integration of renewable energy sources and for unbalanced loads
- Fault-Tolerant Power Converter and Real-time Health Monitoring
- Reliaibility and Health monitoring of power converters

Energy Storage

- Raising the lithium-ion battery energy density by discovering new electrode materials, searching for new solid-state electrolytes, and understanding electrolyte-electrode interfaces and reaction mechanisms.
- Discovering novel materials for stationary energy storage using abundant electrode materials for multivalent ion (Mg^{2+}, Zn^{2+}) storage, safe electrolytes (aqueous, solid-state), and earth abundant organic electrode materials.
- Developing high throughput manufacturing platform to reduce cost, such as 3D printing polymer-ceramic composite membrane for all-solid-state batteries and solid oxide fuel cells.
- Synthesizing low-cost materials for redox flow batteries. Redox flow batteries are a promising platform for large-scale energy storage applications due to their flexible design, long lifetimes, high reliability, and eco-friendly chemistries. Unlike conventional batteries, RFBs have the unique ability to separate power and energy density.

Microgrid and renewable energy systems

- Power System Reliability, Operations, and Optimization
- Developing efficient for fast operation process provide better solutions in terms of reliability and cost.
- Power System Cyber-security - State estimation is critical for power system real-time operations and provides a base for other EMS applications.
- Integrating Renewables into Contemporary Power Systems- New methodologies or procedures are needed to allow large penetration of renewables into modern power systems.
- Microgrid Sizing, Operations, and Energy Management - The optimal EM control can provide bidirectional power flow capabilities in grid connected mode during excess availability.
- Real-time simulation to conduct critical load flow studies, motor starting studies, short circuit analysis and protection co-ordination studies.

Subsea Power Systems

- Investigation of Subsea power transmission architectures: Different types of power transmission systems such as ac, high voltage dc (HVDC), and low frequency systems will be investigated to obtain the optimized system in terms of reducing the contactors, transformers, penetrators, etc. with higher reliability
- High Voltage DC Circuit Breaker for Subsea -The principal focus areas are new topologies, design and demonstrating the prototype circuit breakers.
- DC-DC converters for subsea power transmission
- Health monitoring and prediction algorithms for subsea application: Health monitoring system being under development for subsea application will monitor the healthy or faulty operation of power electronic circuits and predict Remaining-Useful-Lifetime (RUL) of the whole system.
- Analysis of harmonics in subsea power transmission cables used in VSC–HVDC transmission systems operating under steady-state conditions
- Investigation of power supplies and power converters for electrically heated subsea pipeline-very low harmonic content and be delivered with little or no direct current.

PEMSEC

Available membership levels are:

1. Principal Member (≥$50,000 contribution)
2. Member (≥$10,000 annual contribution):

Membership

Members are entitled to the following benefits:

- Access to the PEMSEC secure website. Reports, papers, theses, and dissertations produced as a result of PEMSEC Core Research program will be made available free of charge to all MEMBERS in a timely manner via a password-protected website.
- Complimentary registration for the Annual Conference organized by PEMSEC to present the previous year's research results.
- Access to and participation in all PEMSEC programs which may include Education, Industrial Collaboration, and Outreach programs, which includes Industry Resident Program, Summer Internships, Graduate Co-op, Faculty Research Leave, short courses, monthly seminars, annual conference, and other distance learning opportunities.
- One representative on the PEMSEC Industry Advisory Board (IAB). The representative will have one vote. The IAB MEMBERS will participate in recommending priorities of research programs to the Center Director and Leadership Team, defined in the PEMSEC bylaws, and in evaluation of progress towards the PEMSEC goals and objectives.
- Direct and continuous link with PEMSEC faculty, and to the extent legally or otherwise possible, access to information on graduate and undergraduate students for future employment

Principal Membership

- **Principal Members are entitled to all the benefits listed for the Members and in addition:**
- One representative on the PEMSEC IAB. The representative will have five votes.
- Rights to intellectual property developed in the performance of PEMSEC Core Research as per UH and Industry agreement
- PEMSEC shall grant to Principal Members, a non-exclusive royalty-free license for internal use of Intellectual Property developed by PEMSEC employees via sponsored research. Such internal use is limited to use for internal research purposes only and not for commercial purposes.
- Priority access to faculty and students receiving industry fellowships and conducting PEMSEC Core Research in the thrust areas consistent with the Principal Member's technology and business interests.
- Opportunity to have consultation meetings with the Director or Associate Directors to receive technical advice on existing issues or challenges in the respective organization.

Special Consortium Sponsored Research Projects can be set up at any membership level with additional Consortium Sponsored Research Agreement.