Center for Advanced Power Systems

Florida State University

2000 Levy Drive, Tallahassee, Florida 32310

History and Background

The Center for Advanced Power Systems (CAPS) was established at Florida State University (FSU) in 2000 to perform basic and applied research to advance the field of power systems technology, with emphasis on application to electric utility, defense, and transportation, and, to develop a power systems engineering education program to train the next generation of power systems engineers.

With support from the U.S. Navy, the U.S. Dept. of Energy, Industry, and other Federal and State funding sources, CAPS has developed a unique test and demonstration facility and a vibrant research and development program aimed at advancing power systems innovation and application for the future terrestrial power grid as well as future all-electric naval surface combatants. The center is supported by a research team comprised of dedicated and highly skilled researchers, scientists, faculty, engineers, and students, recruited from across the globe, with strong representation from both the academic/research community and industry.

The 40,000 sq. ft. CAPS research, development, test and demonstration facility is located in Innovation Park in Tallahassee, Florida, adjacent to the National High Magnetic Field Laboratory (NHMFL), the Applied Superconductivity Center, and the FAMU-FSU College of Engineering.

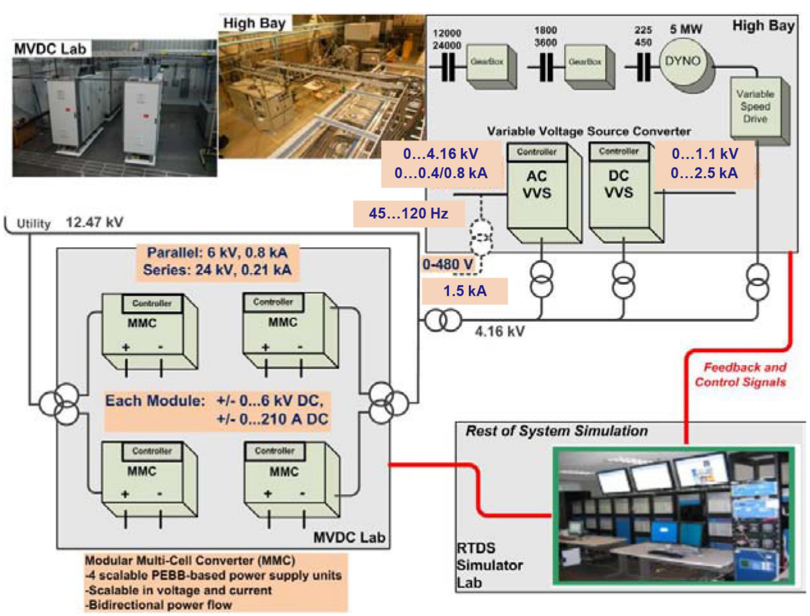
R&D Facility

5 MW Advanced Prototype Test Facility

The advanced prototype power systems test bed consists of a highly- flexible, re-configurable 4.16kV distribution system supplied through a dedicated 7.5 MVA, 12.5kV:4.16kV site service transformer, in turn supplied by a 115:12.5kV distribution transformer in the adjacent utility substation. The lab 4.16kV distribution system supplies a 5MW variable voltage variable frequency converter, a 5 MW dynamometer, and, through another transformer, a 480VAC lab experimental system. On the 4.16kV distribution bus is ample switchgear to accommodate simultaneous connection of additional electrical equipment for testing and characterization.

The 5MW variable-voltage variable-frequency converter, provides a for dynamic power hardware-in-the-loop (PHIL) testing at up to 4.16 kV AC (over a range of 42-66 Hz) and 1.15 kV DC. Additionally, a 5MW controllable DC converter provides PHIL capability at up to 24,000 VDC.

The 5 MW dynamometer is comprised of two (2) 2.5 MW GE induction motors driven by Toshiba 4-quadrant PWM variable frequency drives. This dynamometer can handle 100% overload for 1 minute. A gearbox provides the ability to test rotating machines at speeds of up to 24,000 RPM.



These physical systems, integrated with real-time digital simulation, provide the means for highly flexible and interactive PHIL experimentation, demonstration and technology de-risking at high power levels. The converter and dynamometer and associated systems are housed in a high-bay test area equipped with two 20-ton cranes providing 40-tons of total lift capacity and a closed-loop cooling water system distributed throughout the building.

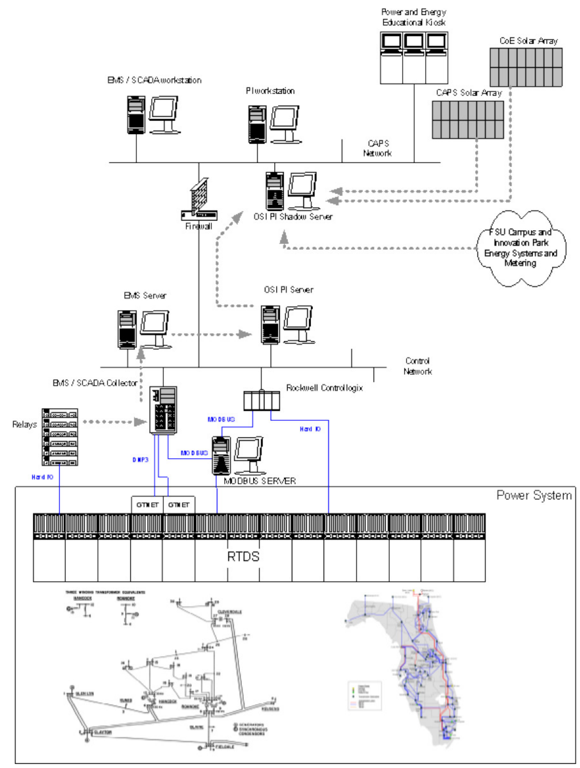
A 480VAC experimental bus is also available. This bus supplies lower power dynamometer and converter systems and is available for other electrical experiments at that voltage level. A number of converter, motor drive, and dynamometer systems in the 15-20 HP range are permanently installed, incorporating AC induction, DC, and permanentmagnet synchronous motors. These testbeds are also integrated with the facility's real-time digital simulation systems.

Develop and fully evaluate, understand, demonstrate, and de-risk electric power technologies under realistic dynamic conditions for successful scale-up, commercialization, and deployment.

Real Time Digital Simulator (RTDS™)

The electrical test bed is fully integrated with a real time digital power system simulator, capable of high-fidelity simulation of transient and dynamic behavior of complex power systems in real-time – entire simulations at time-steps down to 50 microseconds and portions of the simulation at time-steps down to less than 2 microseconds. A parallel-processing machine (performance at over 110 GigaFLOPS) this "14-rack" system consists of ~380 parallel processors and employs optimized EMTP-based nodal network simulation methods to solve the electrical portion of complex models. Extensive digital and analog I/O provide a real-time interface between the simulator and devices under test, such as controllers or power equipment. Remote collaboration is possible through high-speed LAN. The simulator system is the largest of its kind in an academic environment. CAPS also employs other simulation tools, including an Opal-RT real-time simulation system, and PC-based tools such as MATLAB/Simulink, PSCAD/EMTDC, PSS/E, P-Spice, and more.

The value of the integrated advanced prototype test facility and real time digital simulator has been demonstrated in extensive full-power and dynamic testing and characterization of a 5 MW high-temperature-superconducting motor manufactured by American Superconductor and Alstom Power as a prototype for the U.S. Navy, and, in the testing of high-speed machines, large solar PV inverters, power electronics devices for shipboard and electric utility grid use (e.g. control hardware and software systems for a 10 MVA ETObased STATCOM), and superconducting fault current limiters.



Controls Test Bed

For advanced control, visualization, and protection research, the RTDS has connected to it commercial control, process information, and protection platforms, including an OSI PI™ real-time process information system, Alstom Grid e-terra™ SCADA and EMS systems, Rockwell Automation Controllogix™ PLC systems, a Rockwell Automation intelligent distributed agent development framework, SEL™ and Beckwith™ protection relays, and an SEL™ communications processor. A Distributed Grid Intelligence (DGI) test-bed has been assembled to develop and test communications and controls for the electric distribution systems of the future. These CAPS testbeds support R&D in controls, communication, visualization, human factors engineering, and wide area measurement.

High Temperature Superconductivity

With U.S. Dept. of Energy and U.S. Navy support, and in cooperation with the National High Magnetic Field Laboratory, CAPS has developed research and testing facilities with specialized capabilities in AC loss measurement and quench stability of superconducting materials, with capability to characterize high-temperature superconducting materials under a wide temperature and frequency range under different magnetic field orientations. CAPS has also developed unique capabilities for investigation and testing properties of dielectric materials at up to 100,000 volts AC or 140,000 volts DC under cryogenic temperatures down to 30° Kelvin (-400°F). CAPS has also developed a helium-based cryo-cooled systems laboratory test-bed for studying the design, operation, and control of cryogenic systems for a variety of power systems applications, and, has tested the first 30-m DC superconducting cable in He gas at high currents.

Application and Demonstration

With a permanent, full-time research, engineering, technical, and administrative staff, and very unique research and test facilities, FSU CAPS is uniquely equipped to comprehensively assess, demonstrate, and de-risk new and emerging technologies under realistic dynamic conditions. This approach can build confidence and acceptance among risk-averse stakeholders in electric utility and defense industries, facilitating progress toward more evolved and highly capable, secure, and reliable electric power systems.

Collaboration

FSU CAPS has substantial experience leading large multi-institution research and development efforts, including the ONR-funded Electric Ship Research and Development Consortium, ESRDC (Over $100 million to-date), and the U.S. Dept. of Energy (DOE) funded Electric Power Infrastructure Reliability and Security Project ($8 million over 3 years). ESRDC includes eight leading universities from across the U.S. and EPIRS includes six universities from within the Florida state university system. CAPS is a founding member of the NSF-funded Future Renewable Energy Electric Delivery and Management, FREEDM, systems engineering research center and the State of Florida funded Florida Energy Systems Consortium, FESC, and, CAPS is leading the DOE-funded Sunshine State Solar Grid Initiative, SUNGRIN ($4.5M over 5 years), studying the effects of high penetration levels of solar PV on the power grid. CAPS also works closely with industry through an established industrial advisory board and participation in industry-led research, development, and demonstration projects.

Contacts

Director:
Roger McGinnis, Ph.D.
850.645.1183
mcginnis@caps.fsu.edu