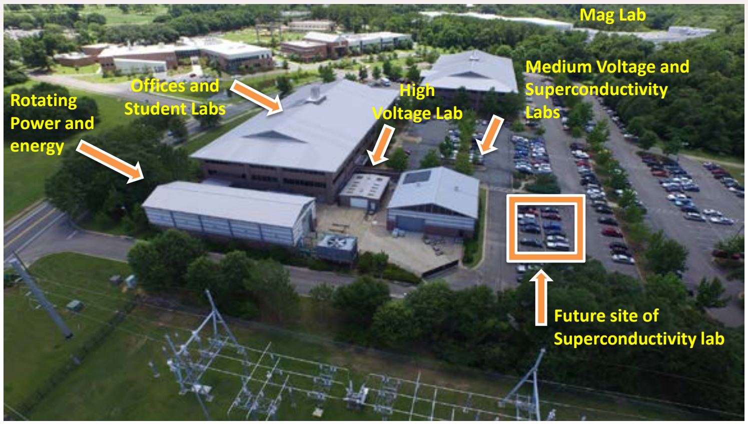
Center for Advanced Power Systems
Florida State University
2000 Levy Drive, Tallahassee, Florida 32310

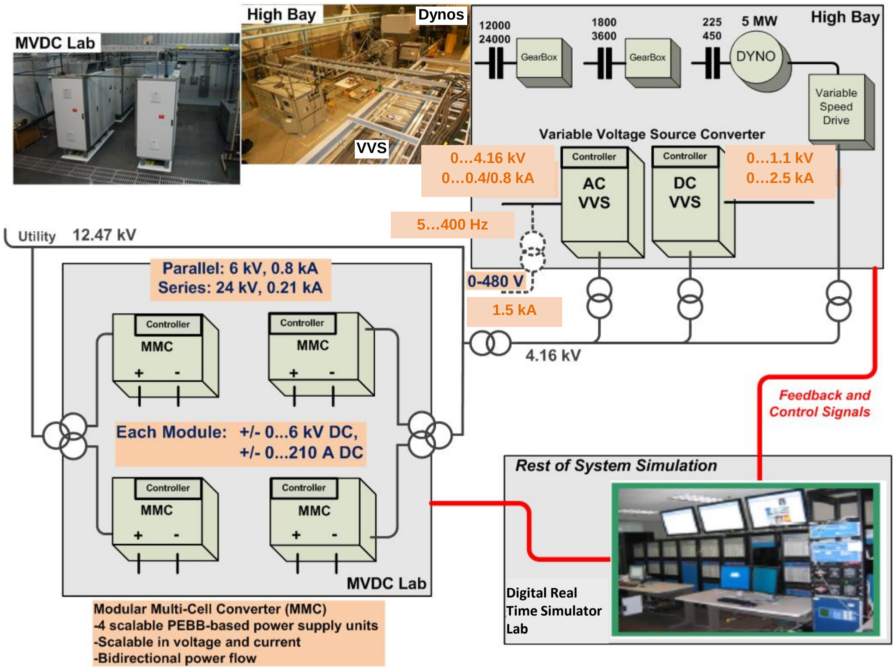
HISTORY AND BACKGROUND



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 FACILITIES

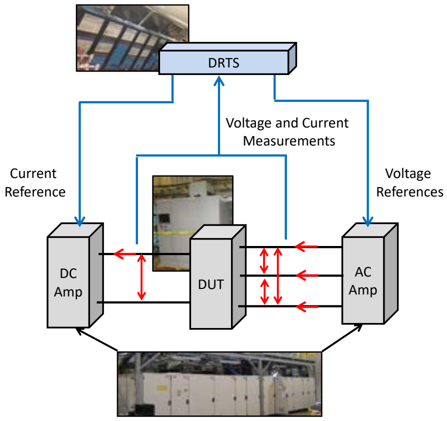
3 x 5 MW Power Hardware in the Loop (PHIL) Advanced Prototype Test Facility



The advanced prototype power systems test bed consists of a highly- flexible, re-configurable 4.16 kV distribution system supplied through a dedicated 7.5 MVA on-site service transformer fed from the adjacent utility substation. The lab's 4.16 kV distribution system supplies a 5 MW back-to-back variable-voltage variable-frequency converter (VVS), a 5 MW dynamometer, and a 1.5 MVA experimental bus at 480 VAC. The bi-directional VVS can supply and absorb ac power up to 8.2 kV and dc power up to 1.1 kV. The 5 MW medium voltage dc (MVDC) lab, composed of four 1.25 MW modular multi-level converters, each capable of dc voltages up to 6 kV, provides additional test points with dc voltages up to 24 kV with various possible grounding configurations. Interconnections between the labs allow additional test configurations which accommodate test equipment with ac voltages up to 13.8 kV. The 5 MW dynamometer is comprised of two 2.5 MW induction motors driven by 4-quadrant variable speed drives. This dynamometer can handle 100% (10 MW) overload for 1 minute. A two-stage gearbox provides the ability to test rotating machines at speeds of up to 24,000 RPM. The VVS and the dynamometer are located in a high-bay test area equipped with two 20-ton cranes, a closed-loop process water cooling water system, and a 50-ton chilled water system. With a seamlessly integrated large-scale digital real-time simulator this unique facility provides a wide range of power hardware-in-the-loop (PHIL) interfaces for advanced testing of power user apparatus. Moreover, the available equipment, integrated with digital real-time simulation, provide the means for highly flexible PHIL experimentation at the system level for concept demonstration and technology de-risking at high power levels. Additional low voltage PHIL labs are also available for low power testing.

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

Digital Real Time Simulators (DRTS) for Hardware-in-the-Loop (HIL) Testing



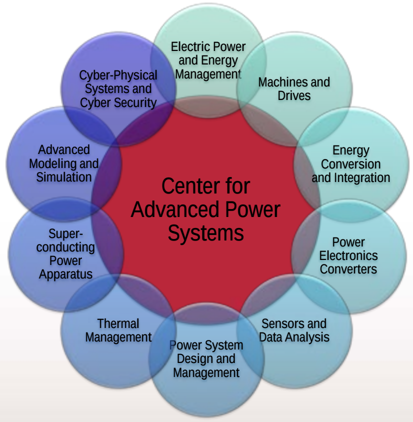
All electrical test beds at CAPS are fully integrated with the various digital real time simulator (DRTS) labs, capable of high-fidelity simulation of transient and dynamic behavior of complex electrical power systems in real-time with time-steps in the low microseconds range and portions of the simulation at time-steps less than a microsecond. One commercial DRTS system currently available at CAPS is RTDS™. With 15 racks this RTDS™ installation is the largest of its kind at any university in the USA. As a parallel-processing machine with over 110 GigaFLOPS, this setup consists of approximately 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. CAPS also deploys multiple Opal-RT systems to complement the available DRTS capabilities for developing and testing advanced control algorithms. 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 advanced components such as a 5 MW high-temperature-superconducting motor, megawatt-class high-speed generators, megawatt-class power conversion modules for naval applications, advanced converters for solar PV and battery storage applications, and superconducting fault current limiters.. For advanced control, visualization, and protection research, the real time simulators are interconnected to commercial control, process information, and protection platforms. Recent additions to the testbed allow 100s of interacting control nodes to be emulated in combination with simulated communication system. 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 test beds support R&D in controls, communication, visualization, human factors engineering, and wide area measurement.

The US Navy accredited the CAPS facility for PHIL testing of a specific class of power conversion modules

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). In the helium-based cryo-cooled systems lab CAPS tested a 30 m long He gas cooled DC superconducting cable at high currents for studying the design, operation, and control of cryogenic systems for a variety of power systems applications.

RESEARCH FACULTY and COLLABORATION



Research at CAPS is headed by faculty with background in multiple engineering disciplines and university departments, and provides the basis for fundamental and applied research of today's advanced power and cyber-physical systems. 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 (EPIRS) ($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). CAPS led the DOE-funded Sunshine State Solar Grid Initiative (SUNGRIN) ($4.5M over 5 years), studying the effects of high penetration levels of solar PV. CAPS is a member of the DOE-funded PowerAmerica Institute based at North Carolina State University. CAPS also works closely with industry through an established industrial advisory board and participation in industry-led research, development, and demonstration projects.

APPLICATION AND DEMONSTRATION

With its full-time research and engineering staff and its substantial 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.

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