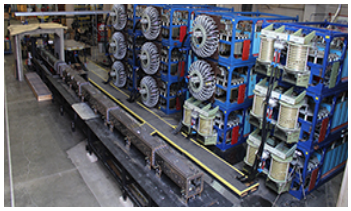
Microgrid Capabilities

Low-Lab – one machine tie-down, overhead crane, chilled water supply

Spin-Test Bunker - The facility also houses a high energy spin test bunker designed to safely contain a 20 psig internal overpressure. The 600 ft2 spin test bunker features 30 in. thick fiberglass reinforced concrete walls with 6 in. thick aluminum door, window, and roof closures. A stainless steel tie down structure is rated for 5 million pound vertical load and torque loads of up to 20 million lb-ft. A metal building located immediately adjacent to the spin test bunker was designed for installation and testing of gas turbines, with openings for intake air and integral exhaust ducting in the roof. This structure can also be used for local instrumentation and data acquisition for experiments being conducted in the spin test bunker. In the spin test bunker, however, full instrumentation wiring and optical fiber is routed to a faraday-shielded control room on this end of the main building.

Turbine Testing - A 21'x23' gas turbine test cell has been added to the high energy spin bunker to operate turbines as a prime power source for direct drive generators. The Turbine Test Cell includes a rigid mounting system that was installed with consideration given to the need to reconfigure a test setup based on a variety of necessary test equipment.



Pulsed Power Test Bed – Currently the pulsed power testbed is powered by an 18 MJ capacitor bank composed of eighteen 1 MJ bank modules. These modules can be independently charged and triggered to provide a tailored current pulse shape for grid stability testing in the presence of large pulse loads. This power bank supplies the High Energy Medium Caliber Launcher (HEMCL) capable of 2 MJ muzzle energy at an exit velocity in excess of 2 km/s. This test bed is also equipped with a projectile recovery tank designed to capture and stop a high velocity test package with minimal deceleration and little to no damage incurred.

Control Rooms - Safety is always of primary concern at CEM. Dedicated control rooms are present in both the low lab area within the main building, and adjacent to the pulsed power test area. Fiber networking connects test equipment to the control rooms for real-time monitoring of test events and electrical isolation.

Power Grid Equipment:

Motors/generators – (1) 2 MVA, 12,000 rpm
Resistive Loads - 1.3 MW Resistive load and 2 MW chopper
Rectifiers: 3.2 MVA (diode), 1.2 MVA (controlled), 1 MVA (Toshiba)
Inverters: 1 MVA (Toshiba), 2 MVA (ARCP)
Utility Power: two 480 Vac 3φ utility supplies
Transformers: 490 kVA, 1.2 MVA multi-tap

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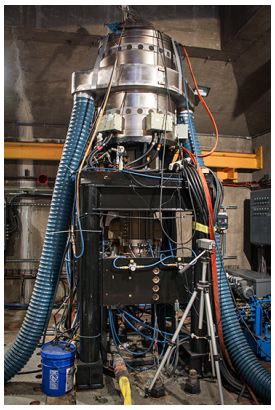
Kahn Water Brake Dynamometer - The 5MW Kahn Series 100 hydraulic dynamometer are designed primarily for testing of high speed turboshaft engines at speeds up to 23,000 rpm and at power absorption levels of up to 7,000 hp. Power is absorbed by vortices generated by the perforated disk rotors and stators; the resulting drag applies a moment to the dynamometer housing which is measured with a strain gage torque reaction sensor. Absorbed power is modulated by controlling the amount of water in the dynamometer with the inlet and outlet control valves. The dynamometer is bi-directional and is capable of both vertical and horizontal orientation; this is critical for testing of vertical axis motor/generators for advanced energy storage flywheels. The electro-pneumatic inlet and outlet control valves control the flow of water to the dynamometer based on commands from the Kahn Series 545 digital dynamometer controller. The hydraulic dynamometer provides a controlled load for a prime mover such as a gas turbine or electric motor.



Digital Real-Time Simulator - The digital real-time simulator was developed by Opal RT to perform real-time simulations of power systems from very large-scale grid models to very fast power electronics. Opal RT offers several software packages designed for different power system levels simulations. Their ePHASORsim was designed for very large-scale powers grid simulations with time steps greater than 10 ms and up to 30,000 nodes. HPERSIM is a large-scale power simulator with a little higher accuracy and shorter time steps. It was designed for time steps greater than 10 µs and up to 3000 nodes. eMEGAsim was designed for smaller grids such as microgrids with faster time transients. It's designed to simulate power systems and power electronic hardware with time steps as low as 10 µs. The eFPGAsim package is specifically designed for power electronic simulations with time steps as low as 10 ns. These packages can be used in co-simulation environments to cover very fast time transients as well as very large scale grid models. Currently the Center for electromechanics has licenses for eMEGAsim and eFPGSsim. The real-time simulation hardware is compatible with the complete suite of Opal RT simulation solvers. Two hardware systems have been combined to perform microgrid level as well as power electronic real-time simulations and co-simulations. The eMEGAsim package currently resides on the Opal OP5600 hardware platform.

Power Electronic Building Block converters (PEBB) - The PEEB power converter concept is to create a single modular electronic power package that can be easily modified to create a variety of different power converter packages. These power converter types include AC to DC (passive and active rectification), DC to AC (inverter), DC to DC step up (boost), and DC to DC step down (Buck). The Center for Electromechanics employs 10 PEBB converter modules. These modules are made up of a Semikron Semistack RE power converter assembly. That feature an IGBT based Skiip 4 intelligent power module (IPM) in a three-phase 3 half-bridge configuration.

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The power module is rated at 1.67 MVA, at 690 V ac with a maximum output of 1400 A continuous current per phase. The power module is liquid cooled and has a 1250 V dc bus rating. It also includes instrumentation to measure module temperature, dc bus voltage, and output phase currents. The PEEB power converter also employs a user programmable controller. The control platform is implemented on a National Instruments (NI) single board RIO (reconfigurable I/O) platform (sbRio-9606) and the NI general-purpose inverter controller mezzanine card (GPIC). The sbRio-9606 embedded controller integrates a real-time processor, a user reconfigurable field programmable gate array (FPGA), and I/O on a single printed circuit board (PCB). It features a 400 MHz industrial processor, a Xilinx Spartan 6 LX 45 FPGA, and a RIO mezzanine card connector, which is a high-speed high-bandwidth connector that provides direct access to the processor and 96 digital I/O FPGA lines. The sbRio also features an ethernet port, CAN Bus port, and RS-232/RS-485 serial ports. The GPIC mezzanine card has been designed to connect high-speed signal conditioned analog and digital inputs directly to the FPGA. This suite of I/O has been purposely developed to interface to a typical power converter, which makes it an ideal controller for the PEEB power converter module. The suite of I/O include 16 simultaneously sampled analog input channels, used for high-speed phase critical sampling of the voltage and current signals, eight scanned analog inputs, used for slower data acquisition such as power electronic temperatures and coolant flow, 14 half-bridge digital output channels, used for power switch gating signals, 28 digital input channels, eight analog outputs, 24 digital outputs, four relay control outputs, as well as an additional 32 low-level digital input/output channels. The GPIC card is then connected to a custom-designed interface card specifically designed to interface with the SemiKron power converter hardware.

Coming Soon:
100 - 500 mF capacitors rated at 2000 V DC
2 - 4000 V 3000 A DC breakers
10- 1600 A 2000 V isolation contactors
This equipment can be used to perform a variety of functions which include energy storage, DC bus stabilization, bus faults, and isolation experiments.

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