PURC
Workshop
on
Research in Electric Infrastructure Hardening

Gainesville FL

June 9, 2006

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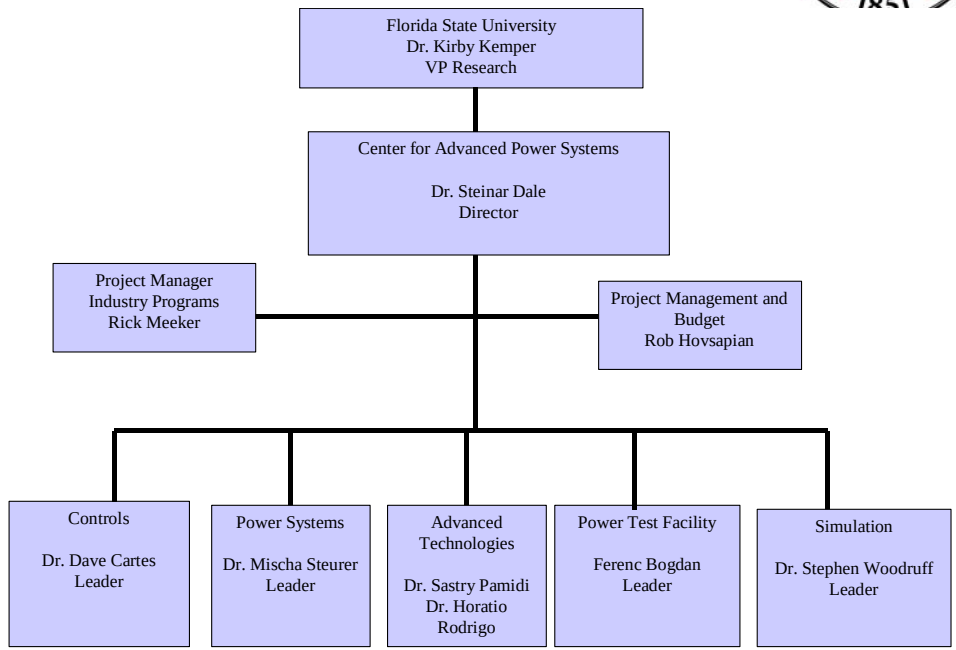
Center for Advanced Power Systems
Florida State University

FSU-Center for Advanced Power Systems

- Established at Florida State University in 2000 under a grant from the Office of Naval Research
- Focus on research and education related to application of new technologies to electric power systems
- $ 5 million annual research funding from ONR, DOE,



–31,000 square feet laboratories and offices located in Innovation Park, Tallahassee

–32 scientists, engineers and supporting staff, including FAMU-FSU College of Engineering faculty

–22 Graduate Student

Research in Electric Infrastructure Hardening

NEEDS:

- **Rapid evaluation of pre-configuration, reconfiguration and restoration options**
- **Assess voltage stability (reactive power) requirements for pre storm re-configuration and post storm reconfiguration and restoration**
- **Predetermined system islanding for optimum power availability and system stability**
- **Training environment for realistic grid scenarios to better understand response (human and system) under unusual storm induced conditions**
- **Emergency analytical response center for rapid decision support**

CAPS CAPABILITIES:

Electric Power Systems

Controls

Converters/Power Electronics

Electrical Insulation

Superconductivity

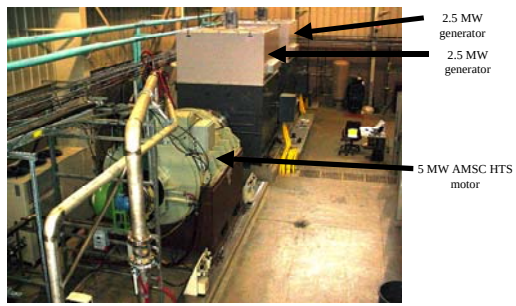
Advanced education and training

Industry –Academic Partnership

Real-time Digital Power System Simulator for:

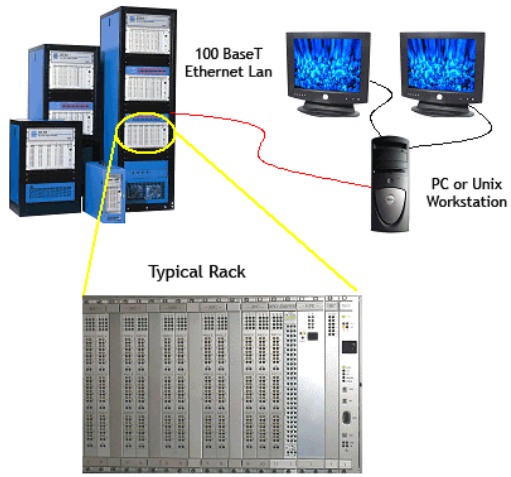
- **Hybrid simulation (hardware with real-time software)**
- **System dynamics**
- **Advanced controls and protection**

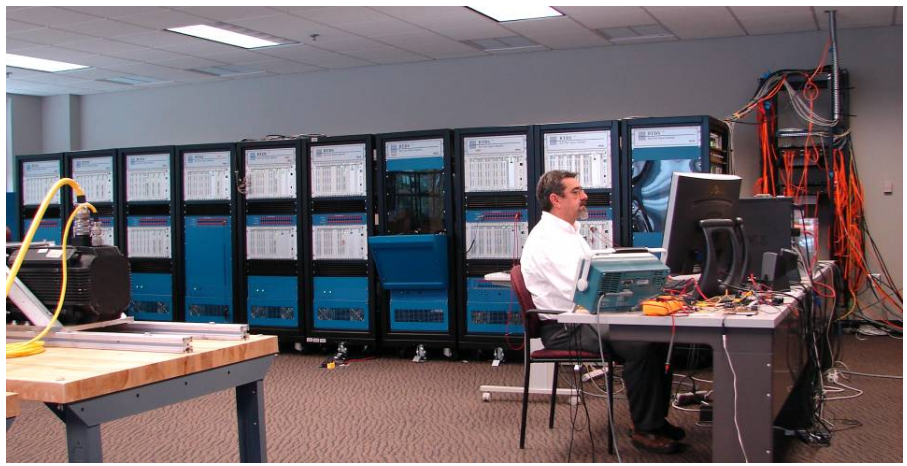
5 MW Dynamometer Test Facility



Real Time Digital Simulator RTDS™

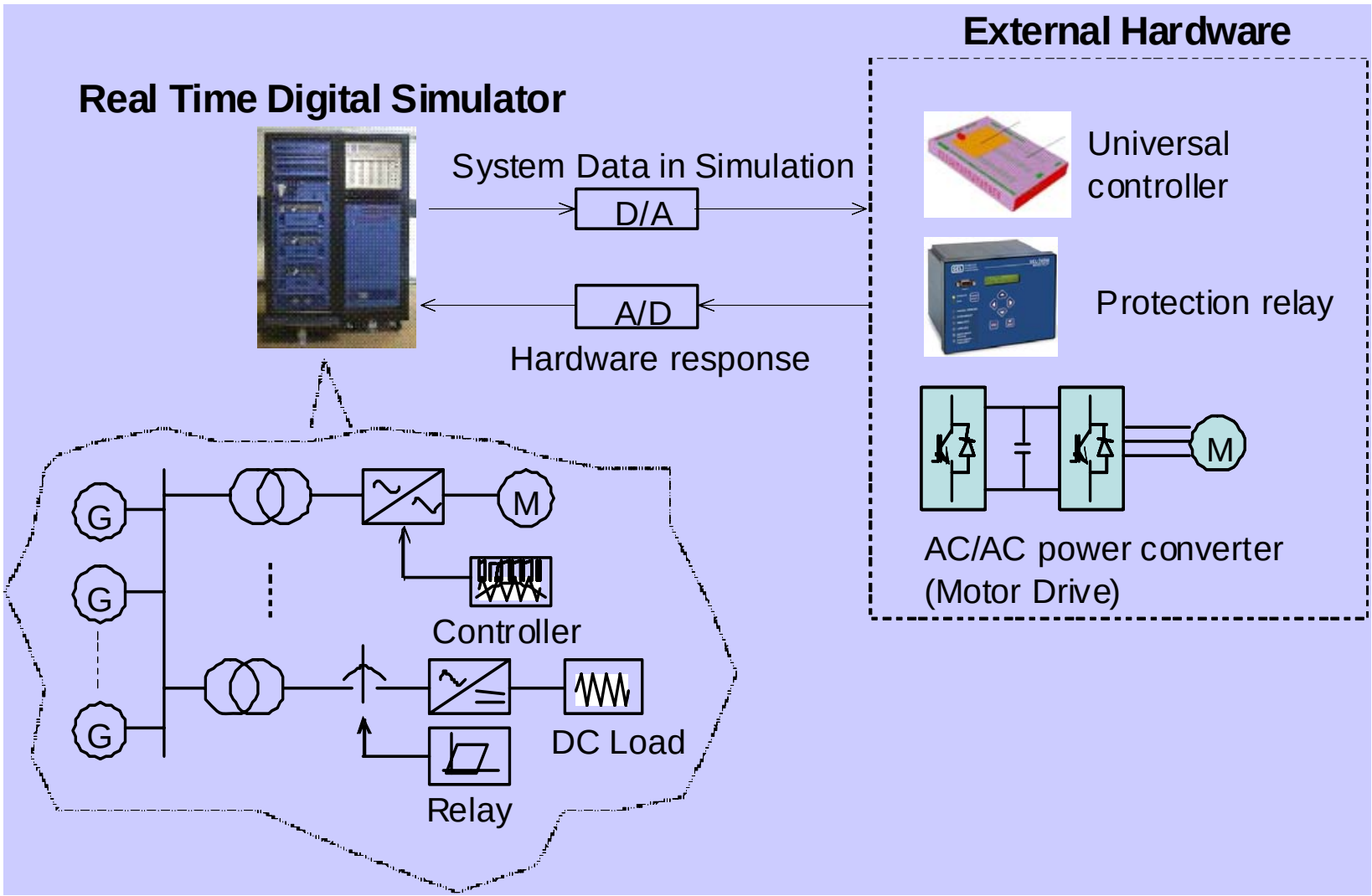
- Large-scale electromagnetic transient simulator developed by RTDS Technologies Inc., Winnipeg, Canada
- EMTP type simulation covers load-flow, harmonic, dynamic, and transient regime
- Designed to simulate systems in real time with typical time step sizes of 50 μs
- Subsystems can be modeled with typical time step sizes of 2 μs → fast switching PE converters
- Provides numerous digital and analog I/O ports for interfacing hardware to simulation
- Each rack has a capacity of 54 electrical (explicit) nodes, i.e. 300+ three-phase buses total
- Larger systems simulated over multiple racks through cross-rack communication
- Capability for remote access over VPN link





14 rack RTDS at CAPS

Hardware in the Loop



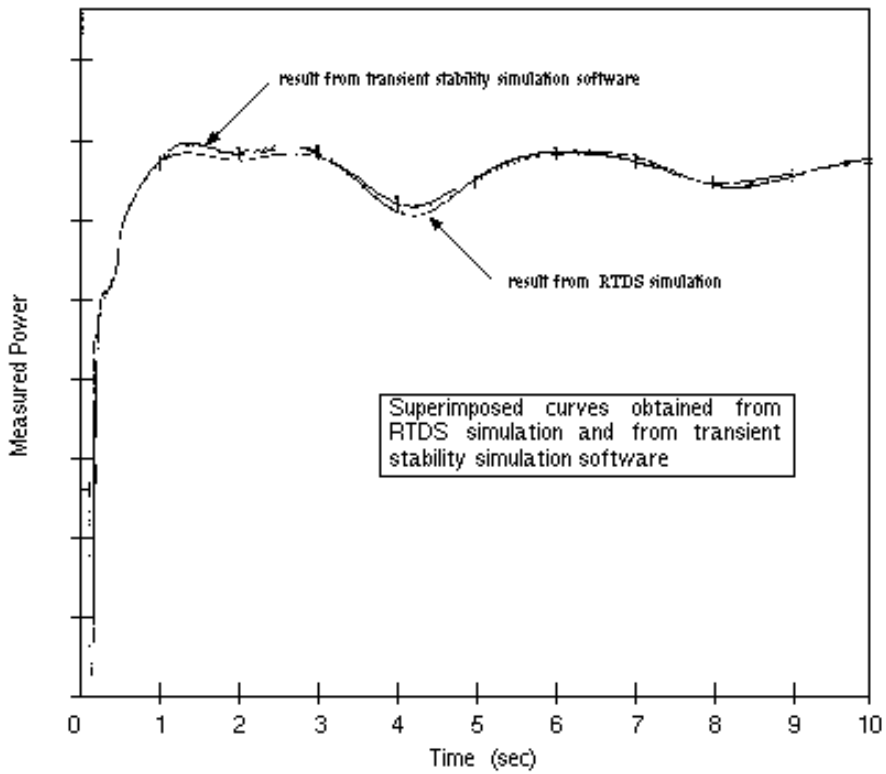
RTDS Simulation - Applications

Typical Result Comparison:
Example Large Scale System:

Japanese Middle Western Interconnection System:

- Includes:
  - AC & HVDC (12-pulse bipole)
  - 16 Synchronous Generators
  - Unit Transformers
  - Single & Twin Circuit AC Lines
  - DC Lines & Cables
  - Generator Controls
  - HVDC Controls
  - Compared to Y-Method results

The Curves Shown Here Illustrate a Very Close Correlation Between the Simulation Results.



RTDS runtime	10secs
Transient Stability	? minutes

Voltage support for BPA's wind farm

What is the problem?

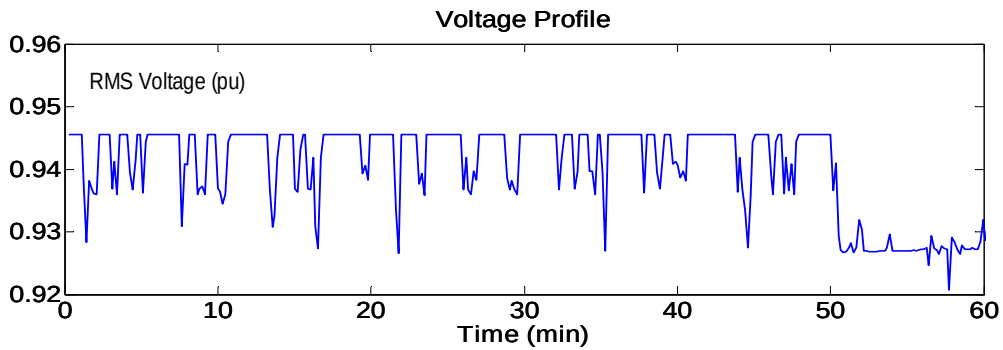
- **When in operation, induction machines based wind farm brings down the voltage profile of grid**

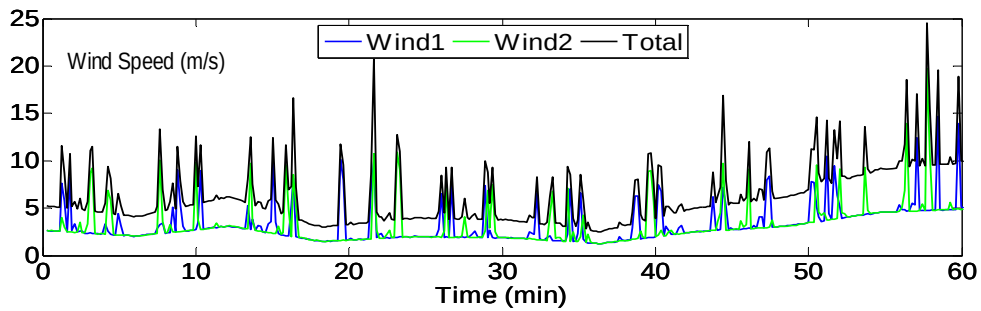
What is the solution?

- **Additional voltage support through VAR management (STATCOM)**

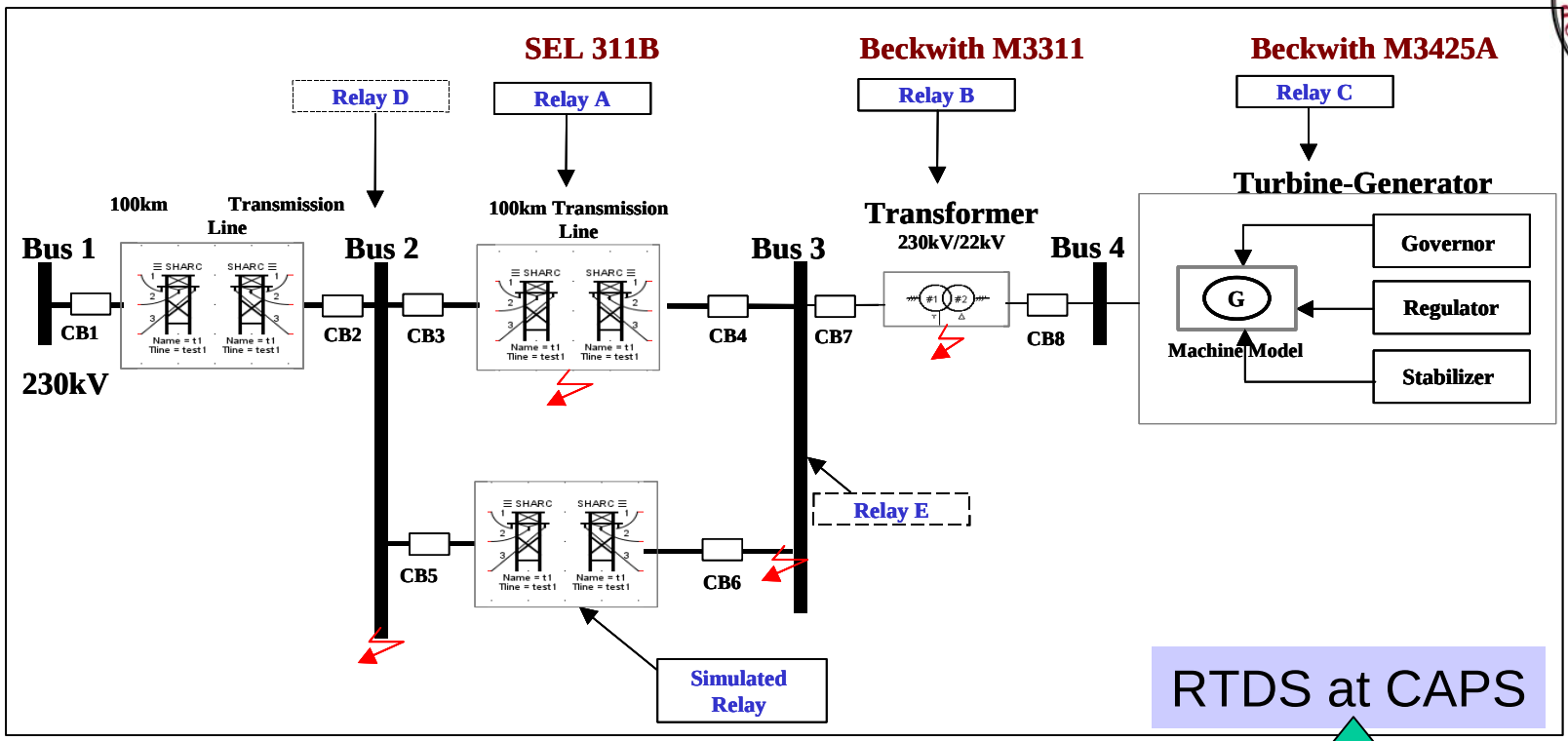
What are we doing?

- **Using the RTDS with detailed real time dynamic models of the BPA network, the wind farm, and STATCOM**
- **Assess and pre-test the STATCOM and hardware controller to solve the problem**





VPN link based SCADA security research with Sandia Nat'l Labs



RTDS at CAPS

VPN link through internet II

SNL SCADA

Investigate multiple attack scenarios on power systems and SCADA responses (security)

Hardware relays, simulated software relay models used in conjunction with dynamic real time models of power systems at CAPS

AREVA Eterra control used for SCADA

Remote access through VPN link with Sandia

Intelligent Defensive Islanding

- What is the problem?

  Power systems are operating closer to stability limits. Unexpected events (hurricanes, earthquakes, terrorist, etc.), system failures, human errors, etc. may cause wide spread failures.

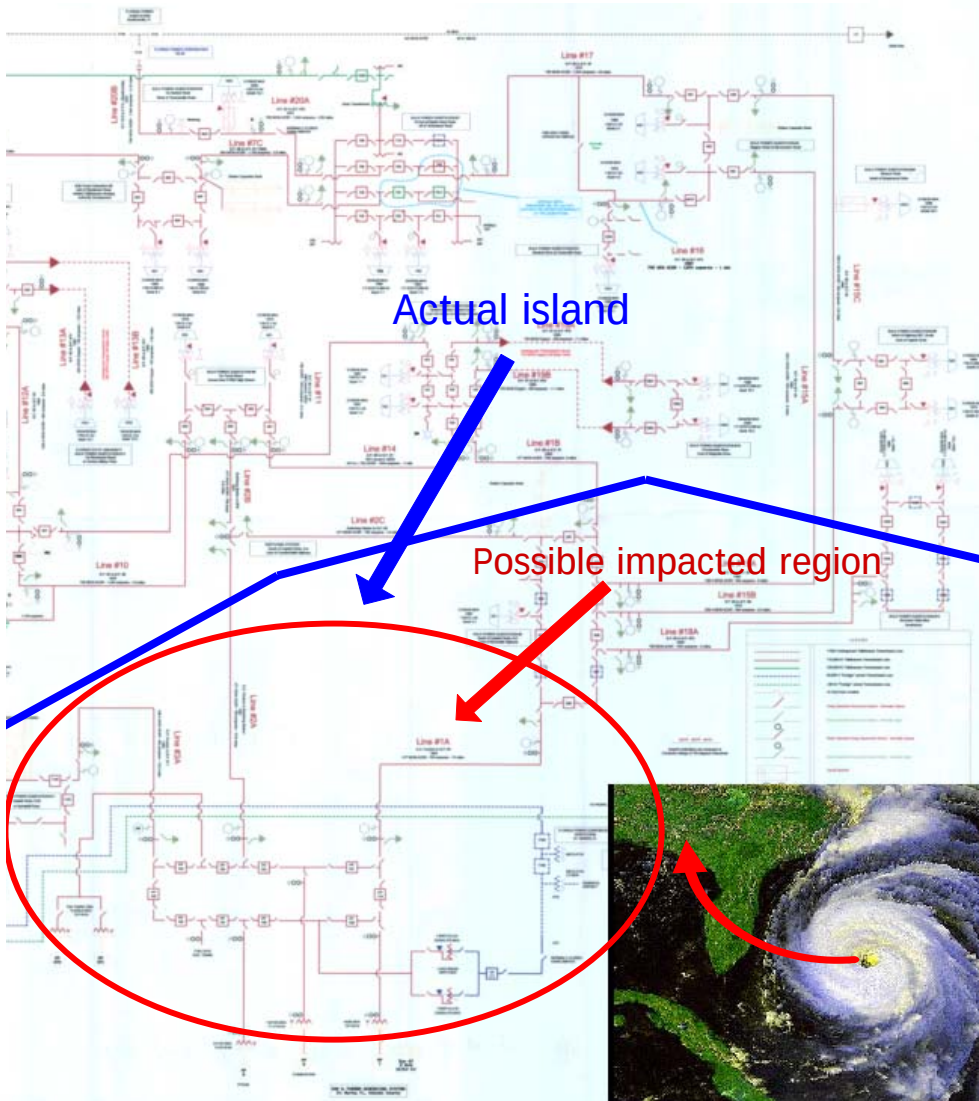
- What is the solution?

  To avoid wide area blackout and minimize losses, defensive islanding intentionally can split power systems into islands to block fault effects from spreading.

- What are we doing?

  We are working on intelligent optimal splitting strategies of large scale power system to get solutions in real time.

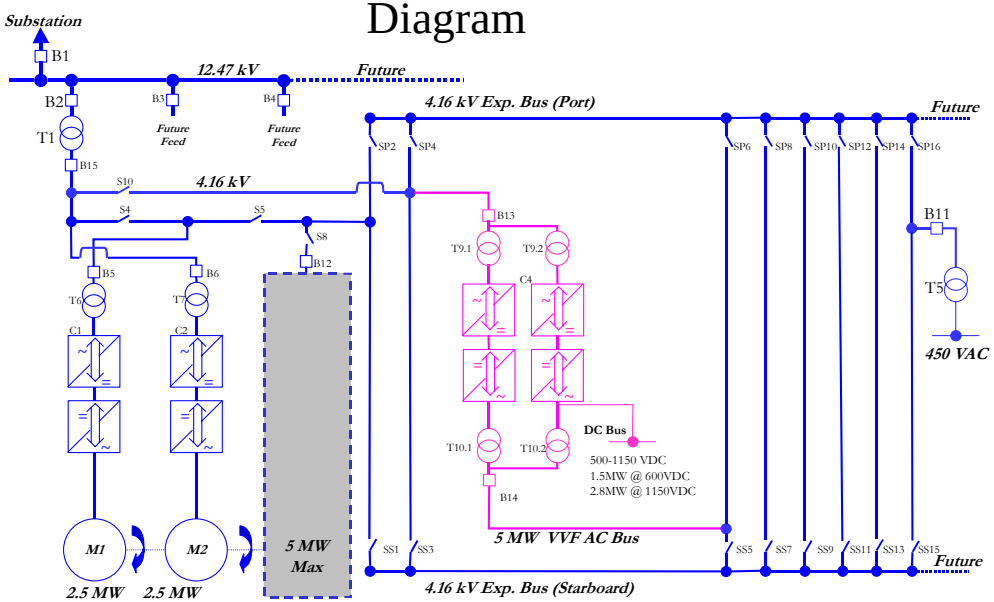
Transmission Line Schematic



Advanced Prototype Test Facility

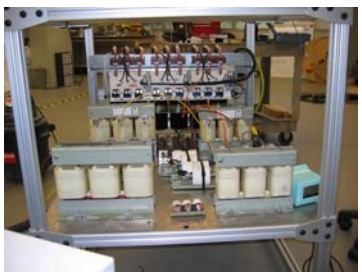
- 5 MW Dynamometer – 2 x 2.5 MW induction machines w/4Q drives
- 5 MW Variable AC and Frequency AC-DC-AC Converter for generator simulation
- 1.5 MW DC Converter for testing and simulation of DC equipment and DC zonal systems
- 200 kW PEBB controller
- High Temperature Superconductor AC loss measurement and characterization capability for shi board motor and transformer development

CAPS Test Facility One-Line Diagram



CAPS Test Facilities

Power Control Laboratory



Low power and 5 MW PEBB, Variable voltage and frequency converter, & variable DC bus

5 MW advanced prototype test facility for motors and converters

High voltage test facility

Superconductor AC Loss Msmt & Quench Stability & Propagation Test

Research in Electric Infrastructure Hardening

Research areas

- Rapid evaluation of reconfiguration and restoration options
- Assess voltage stability (reactive power) requirements for reconfiguration in pre and post storm restoration
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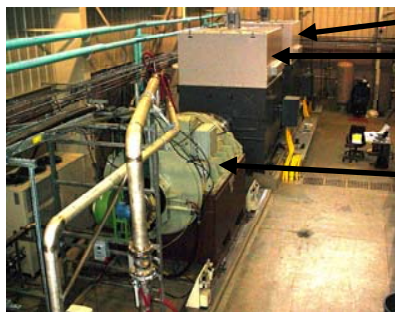

Real-time Digital Power System Simulator for:

- Hybrid simulation (hardware and real-time software)
- Rapid simulation of power system conditions
- Assess technology insertion
- System dynamics
- Reconfiguration options
- Advanced controls and protection
- Model validation