PURC
Workshop
on
Research in Electric Infrastructure Hardening

Gainesville FL
June 9, 2006

Steinar J. Dale Ph.D.

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:

Real-time Digital Power System Simulator for:

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

Electric Power Systems
Controls
Converters/Power Electronics
Electrical Insulation
Superconductivity
Advanced education and training
Industry – Academic Partnership
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

Real Time Digital Simulator

System Data in Simulation

D/A

A/D

Hardware response

External Hardware

Universal controller

Protection relay

AC/AC power converter (Motor Drive)

Controller

DC Load

Relay

G

G

G

M

M
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

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.
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 shipboard motor and transformer development
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
• 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

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