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Power System Operation in the Age of Smart Grid

June 9–13, 2014
Madison, Wisconsin

Learn about the impact of Smart Grid technology on energy control center design and operation

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Power System Operation in the Age of Smart Grid

June 9–13, 2014
Madison, Wisconsin

- The fundamental nature of power systems
- Power system economics and markets
- Power system response to dynamic phenomena
- Information and operation issues in the Smart Grid environment
- Emerging new technologies for energy control centers

ACCEPTED
30 Professional Development Hours
NATIONWIDE

Power System Operation in the Age of Smart Grid

June 9–13, 2014 in Madison, Wisconsin

Practical Content!

Attend this important course to increase your understanding of:

- Concepts fundamental to the operation of power systems as they have evolved over many years of practice
- The impact of markets resulting from the restructuring of the power industry
- The changing view of system operation that accompanies the arrival of the Smart Grid
- The ongoing evolution of energy control centers considering markets, the Smart Grid, and the inclusion of distributed resources

Who Should Attend

This course will be of great practical value to:

- Engineers and senior technicians responsible for the operation of energy management systems
- Engineers responsible for the integration of wind and other renewables into grid operation
- Designers of energy management systems
- Power system analysts and engineers
- ISO/RTO technical staff
- Recently graduated utility engineering staff
- Graduates with technical degrees needing a stronger background in power systems
- Technical staff responsible for Smart Grid integration into power system monitoring and control
- Consultants and researchers in the field of operation and control of power systems
- Operations supervisors and others

The course presumes a basic understanding of matrix formulation. Emphasis will be on balanced power system operation and positive sequence representation.

Key Benefits for You

Discover how large interconnected power systems are reliably operated under steady-state and transient conditions. You will learn:

- How traditional operation and control of large interconnected power systems are achieved
- How distributed resources can be reliably integrated into power system operation and control
- How controllable network elements can contribute to grid reliability
- How wide-area monitoring and control are being integrated into the next generation energy control center

Please note: Our classroom environment facilitates interaction not only with our distinguished instructors but also with your fellow colleagues. Plan to benefit by drawing upon the collective wisdom and experience of all participants.

Tools for Visualization of the Power System

The "state" of a power system has traditionally been determined by the values of parameters such as bus voltages, line currents, and real and reactive power. Under steady-state conditions the state of the system is well defined. But under disturbance conditions it is necessary to know how the system state is changing and whether it is moving into a region of concern. In this course you will see demonstrations of two analysis and visualization tools:

- PowerWorld® (lectures 3, 6, 9), widely used as a presentation package able to perform power flow and contingency analysis on systems containing up to 100,000 buses, and now with the capability of transient stability analysis
- e-terravision™ (lecture 11), a software package that enables operators to visualize the system state in real-time and assists them in taking corrective action through proactive decision-making

A number of software packages are excellent tools for the visualization and analysis of power system operation. We invite providers to send literature and/or demo CDs for distribution to the class.

Course Outline

Day 1

Introduction to the Program: Bill Long
- Welcoming remarks
- What you can expect to learn

1 The Nature of Power Systems: Chris DeMarco
- Overview of major system elements and their role: generation, transmission, distribution, and load
- Roadmap of course coverage in relation to grid elements
- Physics of network flows in the transmission grid
- Concepts of real and reactive power
- Roles in system coordination and control

2 Network Analysis: Arun Phadke
- Methods of large network analysis
- Bus Admittance Matrix YB
- Bus Impedance Matrix ZB
- Adding a branch to network
- Adding a link to network

Day 2

3 Load Flow: Arun Phadke, Chris DeMarco
- Importance of load flow
- Load flow formulation
- Simple load flow
- Large network load flow
- Network controls in load flow
- PowerWorld® simulation

4 Contingency Analysis: Arun Phadke
- Goals of contingency analysis
- Approximations
- Single line outage
- Multiple line outages
- Distribution factors
- Remedial actions
- Generation shift factors

5 The Role of Economics and Markets in Power Systems Operations: Chris DeMarco
- Engineering basis of variable costs in power generation
- Operating costs and generation offer curves
- System objectives in economic optimization
- Optimal operation without losses or congestion: simple incremental cost rules and Locational Marginal Pricing (LMPs)

Day 3

6 The Role of Economics and Markets in Power Systems Operations (continued): Chris DeMarco
- Impact of losses and congestion—treatment via LMPs and Lagrange multipliers
- Impact of congestion and potential for market power
- Longer time horizon issues
- Representation of price response loads in power markets
- PowerWorld® simulation

Outline continues…

Power System Operation in the Age of Smart Grid

June 9–13, 2014 in Madison, Wisconsin

7 State Estimation Based on SCADA: Arun Phadke
- Motivation for state estimation
- Measurements and errors
- Non-linear iterative solution
- Bad data handling

8 Wide Area Measurements (WAMS) and Their Applications: Arun Phadke
- Basics of Synchronized Phasor Measurements
- State estimation with WAMS
- Improved protection with WAMS
- Improved control with WAMS

Day 4

9 Stability Studies: Chris DeMarco
- Swing equation
- Machine and power system equations
- Frequency and voltage dependence of loads
- Voltage stability
- Voltage collapse and mitigation
- Controllable devices
  - synchronous generator excitation
  - synchronous generator governor control
  - power-electronically coupled non-synchronous generation
  - frequency regulation via storage and controllable load
  - HVDC
  - FACTS controllers
- Role of dynamic PMU measurements
- PowerWorld™ simulation

10 Power System Information and Operation Issues in the Smart Grid Environment: Doug Mader
- So what is the Smart Grid anyway?
  - today versus tomorrow
  - transmission "smart" technologies—integrating renewables
  - not your father's distribution system—distribution automation, distributed resources, and distribution management systems
  - AMI and customer empowerment
- Information technology and the Smart Grid
  - Smart Grid architecture
  - Intelligrid and NIST interoperability standards
  - IEC 61850
  - the telecommunication challenge
  - cybersecurity
  - the integration challenge—what do we do with all this data?
- Operation in the world of the Smart Grid
  - power system operation challenges
  - IT operations and asset management

Day 5

11 The Evolution of Energy Control Centers: Jay Giri
- General introduction
- The electricity supply chain
- The genesis of control centers
  - real-time monitoring of grid conditions
  - maintaining system frequency
  - sharing electricity with neighbors
- The digital revolution of control centers
  - minimize electricity production costs in real-time
  - simulating the electrical network of the grid
  - real-time monitoring of network grid conditions
  - what-if studies
  - optimization of grid conditions
  - dynamics of the grid
  - electricity markets
- Today's control center
- Emerging new technologies for control centers
  - synchronous measurements—PMUs
  - distributed computing advances
- Wide-area monitoring and advanced visualization
- PMU-based solutions and actionable information
- Energy control centers of the future
  - future business and industry drivers
  - wide area control
- Concluding remarks

Course Schedule

Registration and course will be held at
The Pyle Center
702 Langdon Street
Madison, WI

Day 1

8:00 a.m. to 8:20 a.m. Registration

8:20 a.m. to 4:30 p.m. Class

Days 2–4

7:45 a.m. to 8:00 a.m. Coffee and Conversation

8:00 a.m. to 4:30 p.m. Class

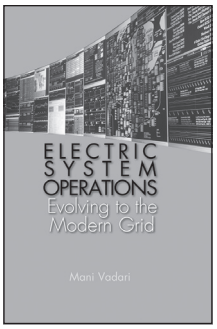
Day 5

7:45 a.m. to 8:00 a.m. Coffee and Conversation

8:00 a.m. to 12:00 p.m. Class

Midmorning and midafternoon refreshment breaks and noon lunch will be provided.

Valuable Textbook Included



You will receive a copy of the text *Electric System Operations: Evolving to the Modern Grid* by Mani Vadari, Artech House, 2014.

Distinguished Course Faculty

Arun Phadke, Distinguished University Research Professor, Virginia Polytechnic Institute and State University, Blacksburg, Virginia. He was previously with American Electric Power Service Corporation as a consulting engineer, Computer Application Division. His pioneering research has been in the development of synchrophasors and wide area measurement systems (WAMS) with applications to Smart Grid control and monitoring. He is a Fellow of IEEE, a member of the National Academy of Engineering, and a recipient of the Benjamin Franklin Medal in Electrical Engineering.

Chris DeMarco, Professor, Department of Electrical and Computer Engineering, University of Wisconsin–Madison. He joined UW–Madison in 1985 and served as department chair 2002-2005. His teaching and research interests center on the dynamics, control, and optimization of electrical energy systems. DeMarco is UW–Madison's site director for the National Science Foundation's IRCUC Power Systems Engineering Research Center (PSERC). He is a recipient of the UW–Madison Chancellor's Distinguished Teaching Award.

Doug Mader, Director, IT Infrastructure and Enterprise Services, Entergy Services, Inc., New Orleans, Louisiana. He has 40 years of experience in the power industry, initially at Nova Scotia Power Corporation, rising to the position of vice president of engineering. He joined Entergy in 1998. His areas of expertise include power system engineering, planning, electromagnetic transients simulation, and insulation coordination. He is responsible for operational support of Entergy's Smart Grid infrastructure.

Jay Giri, Director, Power System Technology and Strategic Initiatives at ALSTOM Grid Inc. He manages a group of power system engineers developing control center software for Smart Grid project deliveries. In 1978 he and 11 others were co-founders of ESCA; after multiple mergers and acquisitions, ESCA is now part of ALSTOM Grid Inc. He is co-author of numerous technical papers and of the "Energy Management Systems" chapter of the Electrical Engineering Handbook. Giri is a Fellow of the IEEE and an affiliate professor at the University of Washington

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Four Easy Ways to Enroll

Internet:
epd.engr.wisc.edu/webP020

ENROLL ONLINE TODAY!

Phone:
800-462-0876 or
608-262-1299 (TDD 265-2370)

Mail to:
The Pyle Center
Attn: Engineering Registration
702 Langdon Street
Madison, Wisconsin 53706

Fax:
800-442-4214 or
608-265-3448

Course Information

- ❑ Please enroll me in **Power System Operation in the Age of Smart Grid Course #P020** June 9–13, 2014 in Madison, Wisconsin Fee: $2195
- ❑ I cannot attend at this time. Please send me brochures on future courses.

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E-mail _____

Additional Enrollees

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Title _____

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Title _____

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What Our Students Say About This Course

"This course presented a great overview of where we are currently with the Smart Grid and where we are heading."
Telecommunications Supervisor, Pedernales Electric Cooperative

"I was looking for practical applications and was pleasantly surprised by how the theory was presented bridging my knowledge gaps."
Senior Engineer, PJM Interconnection

"The presentations by Doug Mader brought Chris' and Arun's presentations into Smart Grid perspective."
Engineer, Centerpoint Energy

"Jay gave us very good control center overview starting with the past and ending with the future."
Operations Manager, Northern Maine ISA

Need to Know More?

Call toll free **800-462-0876** and ask for

Program Director:
Willis F. Long
willis@engr.wisc.edu

Program Associate:
Debbie Benell
benell@engr.wisc.edu

Or e-mail **custserv@epd.engr.wisc.edu**

General Information

Fee Covers Notebook, textbook, course materials, continental breakfasts, break refreshments, four lunches, and certificate. We do not publish proceedings. Course materials are distributed only to participants.

Cancellation If you cannot attend please notify us at least seven days prior to the course start, and we will refund your fee. Cancellations received after that date and no-shows are subject to a $150 administrative fee per course. You may enroll a substitute at any time before the course starts.

Location The Pyle Center, 702 Langdon Street, Madison, WI. Phone messages: 608-262-1122.

Accommodations

We have reserved a block of guest rooms (rates starting at $89, including continental breakfast) at The Lowell Center, 610 Langdon Street, Madison, WI. Reserve a room online at epd.engr.wisc.edu/lodgingP020 or call 866-301-1753 or 608-256-2621 and indicate that you will be attending this course under group code P020EPD. Room requests after May 9 will be subject to availability. Other fees and restrictions may apply.

We have reserved a second block of guest rooms (rates starting at $118, including shuttle) at The Madison Concourse Hotel and Governor's Club, One West Dayton Street, Madison, WI. Reserve a room online at epd.engr.wisc.edu/lodgingBP020 or call 800-356-8293 or 608-257-6000 and indicate that you will be attending this course under group code 330298. Room requests after May 19 will be subject to availability. Other fees and restrictions may apply.

Earn Continuing Education Credit

By participating in this course, you will earn 30 Professional Development Hours (PDHs) or 3.0 Continuing Education Units (CEU).