Focus on applications, installations, and project aspects of power-electronic-based equipment that enables rapid control of reactive power and voltage…

Dynamic Reactive Power Control

December 8–11, 2009
Las Vegas, Nevada

Attend and Benefit!

- ☑ **Master the essential elements of reactive power control**
- ☑ **Understand today's interconnected North American transmission network**
- ☑ **Make dynamic reactive power control an effective tool in minimizing the effects of transmission bottlenecks and regional constraints to power delivery**

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THE UNIVERSITY of WISCONSIN MADISON

Department of Engineering Professional Development
432 North Lake Street Madison, Wisconsin 53706

NATIONWIDE ACCEPTED
21 Professional Development Hours

THE UNIVERSITY of WISCONSIN MADISON

College of Engineering
Department of Engineering Professional Development

Dynamic Reactive Power Control

- Fundamental concepts in reactive power
- Design and operation of dynamic reactive power controllers
- Comparisons of power-electronic and non-power-electronic solutions
- Case studies of problem-solving T&D installations
- HVDC installations and reactive power
- Utility perspective on dynamic reactive power control

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Course at a Glance

- This course describes applications of power-electronic-based equipment that enable rapid control of reactive power and voltage in transmission and distribution systems.
- Electric utility-related engineers responsible for system operation, reactive power/voltage control, and asset planning, management, and reliability will benefit.

Why This Course Now

The University of Wisconsin–Madison first presented its landmark short course on reactive power control in May 1983. A major part of that course addressed static var compensators (SVCs), a new technology at that time. In later years, the course evolved to emphasize FACTS technology—flexible ac transmission systems, due primarily to the evolution of voltage-source converters for higher voltage applications.

Now in 2009, electric-utility related engineers must understand the essential elements of dynamic reactive power control:

- Hundreds of SVCs are applied worldwide in both transmission and distribution systems, primarily for dynamic voltage control
- Voltage-source-based compensators, or STATCOMs, are applied in T&D applications where speed of response is critical (e.g., steel-mill flicker, systems serving railways)
- Other members of the FACTS family of controllers are being used in numerous special applications (e.g., for damping inter-area oscillations).

Enhance Power System Response

This important course will help you enhance your power system's ability to respond rapidly to deteriorating operating conditions through the proper use of dynamic reactive power control. By participating you will further your understanding of reactive power and its control, including how inadequate or poorly located reactive power impacts blackouts.

Could a better understanding of the capabilities and limitations of reactive power help to arrest the cascading failure of events resulting in blackouts such as the Northeast blackout of August 2003?

Reactive power cannot by its very nature be transmitted over long distances. The August 2003 blackout involved numerous instances of low voltage attributed to insufficient reactive power availability. The system was unable to supply sufficient VARs to maintain voltages in the normal range. Network conditions deteriorated and voltage levels became progressively lower until system separation and collapse were inevitable.

The application of dynamic reactive power control together with wide-area monitoring and control could have enabled the power system to respond rapidly to deteriorating operating conditions and perhaps mitigate the blackout event.

Who Should Attend

- Power system engineers
- Power system analysts
- Generation and transmission planners
- ISO/RTO technical staff
- Operations supervisors
- Asset planners, managers, and reliability engineers
- Others interested in dynamic reactive power control and voltage stabilization in electrical power systems

You should be familiar with the basic relationships in electric power systems and with concepts of real and reactive power, but you do not need previous exposure to power electronics.

Take Home Practical Knowledge

This comprehensive course offers practical information and approaches on a range of topics including:

- Techniques available for dynamic reactive power control and voltage stabilization in electric power transmission and distribution systems
- Reactive power/voltage interdependencies in electric power systems, including where transmission system reactive power upgrades are included in interconnection agreements
- Effects of power-electronic-based (FACTS) controllers and HVDC links as applied on power systems
- System operation and reactive power control in transmission and distribution systems, especially in a deregulated utility environment
- Asset planning, management, and reliability

Key Benefits for You

- Master the essential elements of reactive power, including how inadequate or poorly located reactive power impacts blackouts
- Understand today's interconnected North American transmission network with its bottlenecks and regional constraints to delivering power from where it is generated to where it is needed
- Learn how to make dynamic reactive power control an effective tool in minimizing the effects of transmission bottlenecks and regional constraints
- Know how power-electronic-based shunt reactive power controllers operate
- Gain practical tips and approaches from case study examples of installations of SVCs, STATCOMs, and HVDC and other power flow controllers
- Hear one utility's perspective on effective reactive power and voltage control throughout their network

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Your Instructors

Fernando Alvarado, Professor Emeritus, University of Wisconsin–Madison

Fernando is recognized for his work on the integration of economics and electric power systems. He developed a methodology for incorporating congestion costs into transmission pricing, taking into consideration security restrictions. He has also developed methods for efficient trading in power networks, including the co-development of a method for hedging against price uncertainty.

Michael Bahrman, Fellow Engineer, ABB Inc., Raleigh, North Carolina

Mike has 26 years of experience with ABB Inc., including system analysis, system design, multiterminal HVDC control development, and project management for various HVDC and FACTS projects in North America. He had previously been with Minnesota Power as transmission planning engineer, HVDC control engineer, and manager of system operations.

Douglas Mader, Director, IT Infrastructure, Entergy Services, Inc., New Orleans, Louisiana

Doug joined Entergy in 1998 as director of value engineering. In 2000 he took over responsibility for all transmission business engineering, project management, and construction functions. In 2004 he was appointed director, technology delivery and business unit CIO for Entergy Transmission. In 2007 he was named director of infrastructure services. Doug has been intimately involved in the specification and factory acceptance testing for two 8 MVAr D-SMES units, a 10 MVAr Adaptive Var Compensator, and two 300 MVAr Static Var Compensators on the Entergy system.

John Paserba, Product Line Manager, Medium Voltage Department, Mitsubishi Electric Power Products, Inc., Warrendale, Pennsylvania

John joined Mitsubishi Electric Power Products in 1998 and spent nine years in the Power Systems Engineering Services Department where he led a team performing engineering studies on numerous STATCOM and SVC installations. In 2007 he was named product line manager in the Medium Voltage Circuit Breaker Department. He began his career with General Electric's Power Systems Energy Consulting Department in 1988. John is a Fellow of IEEE and past chair of the IEEE Power Engineering Society Power System Dynamic Performance Committee. He is on the IEEE PES Governing Board in the role of VP-meeting activities.

Program Director

Willis Long, Professor Emeritus, University of Wisconsin–Madison

Bill joined the University of Wisconsin–Madison from Hughes Research Laboratories, Malibu, California, in 1973. His research has focused on transient (EMTP) analysis of power systems with HVDC and FACTS equipment. He was the initial director of the ASEA (now ABB) Power System Center in New Berlin, Wisconsin. He is past secretary of Paris-based CIGRE Study Committee B4, HVDC and Power Electronic Equipment and is a Life Fellow of IEEE.

Course Outline

Tuesday, December 8

8:00 Registration
The Riviera Hotel and Casino
2901 Las Vegas Boulevard South
Las Vegas, Nevada

8:20 Introduction to the Program
- Welcoming remarks
- What you can expect to learn

Bill Long, Program Director

1. Fundamental Concepts in Reactive Power: Alvarado
- Real power, reactive power, apparent power, power factor, etc.—understanding the conventions
- Sources and sinks of reactive power
- Generator P/Q limits and trade-offs
- Distance limitations–how far can we move it?
- The influence of deregulation
- Reactive power pricing and reserves
- The impact of reactive power on blackouts

2. The Nature of AC Power Systems: Paserba
- The power system as we know it: strengths and limitations
- Characteristics of transmission bottlenecks and regional constraints
- Conventional solutions to bottleneck/constraint problems
- Limitations of conventional solutions
- Why consider power electronic controllers? The need for speed

3. Basic Design and Operation for Dynamic Reactive Power Controllers: Paserba
- Shunt compensation evolution
- Mechanically switched capacitor banks
- Static var compensators (SVCs)
  – branches of an SVC
  – loss characteristics
  – control characteristics
  – SVC equipment
- Static compensators (STATCOMs)
  – SVC/STATCOM comparisons
  – basic operating characteristics
  – control and V/I characteristics
  – STATCOM equipment
- Secondary control, SVC/STATCOM and capacitor banks

Wednesday, December 9

4. Additional SVC and STATCOM Details: Bahrman
- Operational characteristics
- Harmonic generation
- Valve characteristics
- Cooling systems
- Basic control
- Building the control and protection system
- Coordinated control–local and remote capacitor banks, LTCs

5a. Case Studies of SVC and STATCOM Installations: Bahrman
- PG&E Newark, Potrero SVCs
- PHI SVC
- XCEL Forbes SVC
- Allegheny Power SVC
- Duke Energy SVC
- AEP Wind Application SVC
- Austin Energy Holly STATCOM
- Industrial steelmaking applications

5b. Case Studies of SVC and STATCOM Installations: Paserba
- Georgia Power Dublin SVC
- PacifiCorp St. George SVC
- Southern California Edison Rector SVC
- Vermont Electric Company STATCOM

6. A Brief Look at Other Power Electronic Controllers and Conventional Alternatives: Paserba
- Series compensation
- Thyristor-controlled series capacitor (TCSC)
- Phase shifting transformers/regulators
- Static series synchronous compensator (SSSC)
- Unified power flow controller (UPFC)
- Convertible static compensator (CSC)

Thursday, December 10

7. Phases of Power System Engineering Studies for the Life Cycle of a Project: Paserba
- Initial feasibility studies to identify system constraints and reinforcement needs
- Studies to determine type of equipment, location, ratings
- Pre-specification studies to determine equipment requirements
- Pre-manufacturing equipment design and verification studies
- Post-commissioning system operation studies

8. HVDC and Reactive Power: Bahrman
- Review of HVDC fundamentals
- Reactive power requirements of HVDC converters
- Coordination of HVDC converter requirements and system operation
- Voltage source converter-based DC transmission
- VSC capabilities for black start, reactive power supply

Four Easy Ways to Enroll

Internet:
http://epd.engr.wisc.edu/webK472

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

Mail to:
Engineering Registration
The Pyle Center, Dept. 108
702 Langdon Street
Madison, Wisconsin 53706

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

Course Information

❑ Please enroll me in **Dynamic Reactive Power Control**
Course #K472 December 8–11, 2009 in Las Vegas, Nevada Fee: $1895

Team discount: $1595 each when three or more people enroll from the same organization.

❑ I cannot attend at this time. Please send me brochures on future courses.

Personal Information (Please print clearly.)

Name _____

Title _____

Company _____

Address _____

City/State/Zip _____

Phone (_____) _____ Fax (_____) _____

E-mail _____

Additional Enrollees

Name _____

Title _____

E-mail _____

Name _____

Title _____

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9. HVDC Light® Voltage Source Converter Applications: Bahrman
- Gotland Island, Sweden
- Directlink, Murraylink, Australia
- Cross-Sound Cable, U.S.
- Troll A offshore gas platform, Norway
- Estlink Estonia-Finland link

Friday, December 11

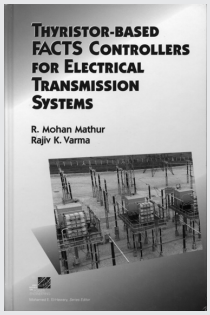
10. Utility Perspective on Dynamic Reactive Power Control: Mader
- Locations with need for dynamic reactive power control
- Options considered
- Economic factors, including losses
- Specifications
- Commissioning
- Coordination with existing system control and protection

12:00 Final Adjournment

Daily Schedule

8:00 Coffee and conversation
8:30 Class session
9:30 Break–coffee and rolls
9:50 Class session
10:50 Break
11:00 Class session
12:00 Lunch
1:00 Class session
2:15 Break–soft drinks
2:30 Class session
3:30 Break
3:45 Class session
5:30 Adjournment

Course Textbook Included



You will receive a copy of *Thyristor-based FACTS Controllers for Electrical Transmission Systems*, by R. Mohan Mathur and Rajiv K. Varma, IEEE Press/ Wiley Interscience, 2002. To quote from the foreword, "Given the heavily stressed state of today's deregulated and restructured electric power industry and the concomitant need for transmission system security and reliability, it seems apparent that sophisticated control elements will play a major role in future system operations. FACTS controllers are representative of these sophisticated control elements; this book makes a valuable contribution to their understanding."

Need to Know More?

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

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

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

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

General Information

Fee Covers Notebook, the course textbook, *Thyristor-based FACTS Controllers for Electrical Transmission Systems*, course materials, continental breakfasts, three lunches, and certificate. We do not publish proceedings. Course materials are distributed only to participants.

Cancellation If you cannot attend, please notify us by December 1, and we will refund your fee. Cancellations received after this date and no-shows are subject to a $150 administrative fee. You may enroll a substitute at any time before the course starts.

Location The course will be held at the Riviera Hotel and Casino, 2901 Las Vegas Boulevard South, Las Vegas, Nevada.

Accommodations We have reserved a block of sleeping rooms at a reduced rate for course participants at the Riviera Hotel and Casino, 2901 Las Vegas Boulevard South, Las Vegas, Nevada. A deposit equal to the room rate for one night is charged at time of booking. This deposit is refundable if the reservation is canceled 48 hours prior to scheduled arrival. Room block rates may not be available for Friday or Saturday night stays. To reserve a room, call 800-634-6753 or 702-794-9412 and indicate that you will be attending this course under group code University of Wisconsin–Madison. Room requests made later than November 16 will be subject to availability.

Continuing Education Credits Earn 21 Professional Development Hours (PDH) or 2.1 Continuing Education Units (CEU) when you attend this course.