Power Electronics in Transmission Systems and Wind Power

Training Course

Industry Need
As the new electric power industry emerges, utilities are incorporating a multitude of new technologies in order to optimize their ability to supply and deliver power efficiently and economically. Among these technologies, HVDC, FACTS, and alternative energy sources, wind power, are most prominent.

Technological advances and economic benefits have made high voltage direct current (HVDC) transmissions and back-to-back substations an effective alternative to AC transmissions. The implications of a DC link on an AC power system are complex and require a good understanding of DC systems, operation, and control.

Flexible AC Transmission System (FACTS) can significantly enhance the controllability and transfer capability of power systems. FACTS, a relatively new technology, can utilize the most advanced power electronics devices. As such, it is critical for application engineers to understand the principles involved and what needs to be considered when these devices are employed on a power system network.

Alternative energy sources, especially wind power plants, are increasingly being used in power systems worldwide. Incorporating power electronics into wind turbines improves their compatibility with AC systems. Power system operators and planners need to understand how alternative energy sources interact with power systems and what analytical tools are available for system studies.

Objectives
This course provides participants with a comprehensive understanding of HVDC systems, FACTS devices, and alternative energy sources as well as technical problems that may be encountered when installing these elements in an existing power system. The course presents operating and control fundamentals along with discussing modeling principles and advanced analytical tools available. Emphasis on use of the Siemens PTI PSS™E program is made and detailed hands-on examples are used to better understand power electronics performance.

Prerequisites
The structure of the course presumes that participants have a degree in electrical engineering and are familiar with load flow and/or dynamic calculations. Experience in using PSS™E is desirable.

Course Structure
The course duration is four and one-half days, presented in three-hour morning and afternoon sessions. The last day concludes at noon. Problems are assigned to demonstrate and reinforce the concepts presented in the lectures.

Documentation
Each participant will receive a bound set of course notes that complement the lecture. The lectures closely follow the notes to minimize the need for note taking in the class.

Instructors
The course will be taught by Siemens PTI engineers with extensive knowledge in the subject technologies, power system planning, analysis and simulation.

Location
The course is conducted on a regular basis at Siemens PTI offices in Schenectady, NY and at other major cities throughout the United States. It is also available for presentation at a client's location by special arrangement.

Continuing Education Units
2.7 Continuing Education Units (CEU's) will be awarded for successful completion of this short course. The CEU is the nationally recognized unit for recording participation in noncredit educational programs. One CEU is equal to ten classroom hours.

Course Outline

While the course content is fixed, it is expected that plenty of participants will want the class presentations to emphasize problems particularly relevant to their power utilities. This will be accommodated when practical.

Day 1

Introduction

Conventional HVDC Systems

- HVDC Application Considerations
  - History of HVDC
  - Existing and proposed projects
  - Advantages and shortcomings
  - HVDC economics
- HVDC System Basics
  - Typical HVDC configurations
  - Two-terminal HVDC transmission
  - Multi-terminal HVDC transmission
  - Back-to-back converter substation
  - Principal applications
- Graetz Bridge Operation
  - Valve commutation
  - Rectifier and inverter modes
  - 6 and 12 pulse operation
  - Basic relationships between voltage, current, and angles
  - Active and reactive power
- HVDC Controls
  - Control hierarchy
  - Valve Control V-I diagrams
  - Transformer tap changers
  - Valve firing system
  - Normal and depressed voltage operation
- Filtering, Reactive Power Compensation, and Electromagnetic Compatibility
  - Converter voltage and current harmonics
  - AC and DC filter configurations
  - Reactive power supplies
  - Connection to a weak power system
- HVDC Transmission as an Element of an AC Power System
  - HVDC run-back
  - Overload capability
  - Damping control
  - Fault Protection
- Modeling HVDC Systems
  - Principles of modeling in system planning and performance studies
  - Load flow modeling
  - Modeling dynamics
  - PSS™E models

Day 2

Conventional HVDC Systems

- Hands-on Examples

Latest HVDC Technologies

- HVDC Light
  - System configurations
  - Voltage Source Converter Operation
  - Pulse width modulation
  - Transmission Characteristics
  - Existing and proposed projects
- Capacitor Commutated Terminals
  - Terminal configurations
  - Phasor diagrams and basic relationships
  - Terminal performance
- HVDC Cables
  - Existing projects
  - Long cable performance
- Modeling Latest HVDC Technologies
  - Modeling principles
  - PSS™E models
- Hands-On Examples

FACTS Technologies

- Problems of Power Systems Resulted in FACTS Concept Development
- Progress in Power Electronics Technology
  - Modern semiconductor devices
  - Current and voltage source converters
  - Bi-directional valve operation
- FACTS Technology Using Conventional Thyristors
  - TCR
  - TCSC
  - STATCOM
  - PAR

Day 3

FACTS Technologies

- FACTS Technology Using Modern Power Electronics Devices
  - STATCOM
  - SCCC
  - UPFC
  - IPFC
  - SMES
  - BES
- Existing and proposed projects
- Modeling FACTS Devices
  - Modeling principles
  - PSS™E models of FACTS devices
- Hands-on Examples
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Alternative Energy Sources

- Survey of Alternative Energy Sources
  - Types of energy sources
  - Power electronics applications
  - General applications
  - Existing and proposed projects

Day 4

Wind Turbines and Plants

- Technology Basics
  - Wind energy conversion
  - Wind turbine unit composition
  - Active power output as a function of wind speed
  - Wind turbines with different electrical machines
  - Power electronics in wind turbines
  - Wind turbines operation and control
  - Modeling Wind Plants and Turbines for Load Flow and Dynamic Simulations
  - Modeling principles
  - PSS™E models
- Hands-on Examples

Day 5

Wind Turbines and Plants (continued)

- Problems of Wind Farm Interconnection
- Hands-on Examples

Discussion

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