SHORT COURSE

POWER SYSTEMS FAULT ANALYSIS AND PROTECTION

To develop a solid background in protection concepts and apply them to power system elements, and To get exposed to the state of the art in microprocessor-based protection.

A cooperative effort between

The Electrical Engineering Department

THE PETROLEUM INSTITUTE

and

CLEMSON UNIVERSITY

Electric Power Research Association

Clemson, South Carolina, USA

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@ The Petroleum Institute

Abu Dhabi, U.A.E.

OVERVIEW

The addition of new power system facilities, e.g., power plants, lines, new loads, etc. complicate the power network. Faults occur frequently in all parts of the system.

As producers and users of Electrical Energy, you must increase your awareness of present and future power system protection. System integrity depends on a well conceived and properly implemented protection philosophy. It is important to learn how to design a system where equipment or line removal and system restoration occur quickly and reliably. To do this, it is essential to understand how present mechanical and microprocessor-based relaying systems function, how they communicate, how their performance can be analyzed and what are the future challenges.

Protection system's main function is to clear faults from the power system in high speed to: enhance people's safety and minimize equipment damage and maintain power system stability. Protection of power systems requires an understanding of system faults and their detection, and the safe isolation of the faulted device from the system.

This course covers the analysis of power system faults for small and large scale systems. This will be followed by the basic protection functions and their applications to the protection of all elements of power systems. The course emphasizes advanced protection schemes required for practical systems experienced in industrial plants, distribution, transmission and generation systems.

Upon successful completion of the course, attendees will be able to:

- Have a background on how to design protection systems for power system elements
- Optimize protection zones and complete understanding of system performance under emergency (faults) conditions.

In summary, at the end of the course, the attendee will have a solid background in protection concepts to apply them to power system elements. They will also be exposed to the state of the art in microprocessor-based protection.

All attendees will receive course notes and upon completion, they will receive certificates of completion.

WHO SHOULD ATTEND?

The course is designed for the power systems' engineers responsible for the operation, control and protection of distribution, transmission and generation systems. It is also targeting consulting and manufacturing engineers, engineers in industrial plants, etc.

COURSE INSTRUCTORS

Dr. Adly A. Girgis

Adly A. Girgis, Duke Power Distinguished Professor of Power Engineering, Department of Electrical and Computer Engineering, Clemson University, South Carolina (CU). He received the BS (with distinction first-class honor) and MS degrees in Power Systems from Assiut University, Egypt (AU). He received the Ph.D. degree in electrical engineering from Iowa State University (ISU). He taught at AU, ISU and North Carolina State University. His industrial experience includes consulting for IBM, ASEA/Brown Boveri and power utilities. Dr. Girgis joined CU in 1985 to direct the research activities of Clemson University Electric Power Research Association (CUEPRA) and to promote power-engineering education. He has published more than a hundred technical papers and holds four U.S. patents. He is a recipient of the McQueen-Quattlebaum Faculty Outstanding Achievement Award, the Edison Electric Institute Power Engineering Educator Award, and the Professional Achievement Citation in Engineering Award. His present research interests are power system analysis, protection, instrumentation and control, signal processing, harmonic analysis and Kalman filtering applications in power systems. Dr. Girgis is a member of Phi Kappa Phi, Sigma Xi, CIGRE and numerous professional societies. He is a registered professional engineer in South Carolina. Dr. Girgis is an IEEE Fellow; Citation: For Leadership in Power Engineering Education, Research in Digital Protection and Studies of Power System Harmonics. He is a recipient of the CU Alumni Award for outstanding achievement in research.

Dr. Abdurrahim El-Keib

Dr. El-Keib received his BS from university of Tripoli, Libya (UoT), MSc from University of Southern California, and PhD from North Carolina State University (NCSU). He joined The University of Alabama (UoA) in 1985 and became Professor in 1996. He has taught at The UoT, NCSU, The UoA, the American University of Sharjah (AUS), and at The Petroleum Institute, Abu Dhabi, UAE (PI). He supervised MS and PhD Theses and is recipient of several teaching and research awards. His teaching experience includes delivering regular and short courses and tutorials in power systems. Currently, he is the director, the electrical engineering department at the PI. On leave from the UoA, during 1999-2001, he served as director the Division of Electrical and Computer Engineering at AUS.

Dr. El-Keib research is in the area of Power Systems. His research was sponsored by the US National Science Foundation, the Electric Power Research Institute, the US Department of Energy, Southern Company Services, and Alabama Power Company. He has published numerous papers. His work on Emissions Constrained Dispatch and VoltIVar compensation on primary distribution feeders has been implemented by several companies in the US. He also served as a consultant to several industries.

He is a Board member, the Arab Science and Technology Foundation, a member of the Science and Technology Panel, the IDB Bank, Senior member of IEEE, was Associate Editor for the IEEE Power Engineering Society Letters, and Member of the Advisory Board, the International Journal of Innovations in Energy Systems and Power, and the World Science and Engineering Academy and Society Transactions on Power

Systems, and the Editorial Advisory Board of the Korean Institute of Electrical Engineers/Society of Power Engineering. He is also a member of several IEEE/PES Committees, subcommittees, and Task Forces and a member of the Executive Committee of the UAE Section of IEEE.

Dr. Elham Makram

Dr. Makram, South Carolina Distinguished Professor of Power Engineering, Department of Electrical and Computer Engineering, Clemson University, South Carolina. She received the MS and Ph.D. from Iowa State University. She has over eight years of industrial experience serving as a power system planning engineer in Egypt, and as a Senior Project Engineer at Siemens-Allis, Inc., in Raleigh, NC. From 1983 to 1985, she was an Assistant Professor at North Carolina A&T State University. She has been at Clemson University since 1985. She is a recipient of the Clemson University Alumni Award for outstanding achievement in research, the NSF Faculty Award for Women Scientists and Engineers, and the distinguished engineering educator award from the Society of Women in Engineering. She is a registered professional engineer in the state of South Carolina.

Dr. Makram is a Fellow of IEEE, a member of ASEE, CIGRE, and Sigma Xi. She has published numerous technical papers in modeling and simulation of machines and transformers, fault analysis, power system education and power system analysis in the presence of harmonics and distortion.

Dr. Majid Poshtan

Dr. Poshtan received his Ph.D. from Tulane University, USA, BS and MS from Tehran University, Iran and MS from University of New Brunswick, Canada. His industrial experience includes working for Entergy, USA. He has done research on voltage stability and collapse and had worked on industrial projects in power systems reliability, expansion feasibility, interconnection, short circuits analysis, and economic operation studies for power systems planning dynamic studies for generators stability under contingency, bus voltage and branch thermal limits during fault condition. He was also a member of a research group that looked at the capacitor banks operation scheduling for optimal switching structure. He is a user of PSS/E, MUST, IPLAN, VSTAB, and ETAP. He is an assistant professor at the Petroleum Institute, UAE, where has been teaching power systems courses. Dr. Poshtan's current interests include system protection, condition monitoring, and harmonics and power quality. He is a recipient of the PI Outstanding teaching and service Awards, a US State Department Recognition Medal for 44th International Senior Seminar, and twice the First Place Award, the IEEE Graduate Paper Contest Region 5.

REGISTRATION

To register please, go to **http://www.pi.ac.ae/EE/PSFAP** and send an e-mail note to Mr. M.A. Sheikh **sali@pi.ac.ae.**
For further information call **+971-2607-5375** or send a note to **sali@pi.ac.ae.**

COURSE FEE

Full 5 days: US$**1,800**/person if registration is made before March 30, 2008 and US$**2,000**/person after.
First 3 Days: US$**1,600**/person if registration is made before, March 30, 2008 and US$**1,800**/person after.

COURSE OUTLINE

Day 1

- **INTRODUCTION AND COURSE OUTLINE**
- **POWER SYSTEM COMPONENTS MODELING**
  - (i) Generators/motors, Transformers, Transmission lines
  - (ii) Examples
- **SYMMETRICAL FAULTS**
  - (i) Three-phase short circuit, Fault currents using Zbus
  - (ii) The selection of circuit breakers
  - (iii) Practical examples
- **SYMMETRICAL COMPONENTS**
  - (i) Sequence components and networks
  - (ii) Practical examples

Day 2

- **UNSYMMETRICAL FAULTS**
  - (i) Single-line-to ground, Line-to-line, and Double-line-to ground faults, and Open conductor
  - (ii) Practical examples
- **PROTECTIVE DEVICES CHRACTERISTICS**
  - (i) Fuses, and Fuse coordination and selection
  - (ii) Practical examples on fuses selection and coordination
  - (iii) Transformer fusing
  - (iv) Automatic circuit reclosers
  - (v) Reclosers ratings and control
  - (vi) Examples on reclosers coordination
  - (vii) Relays: Electromechanical, Solid state, and Microprocessor-based relays
  - (viii) OC relays and exercises
  - (ix) Examples on relays coordination

Day 3

- **TRANSFORMER PROTECTION**
  - (i) Factors affecting transformer protection
  - (ii) Magnetizing inrush current
  - (iii) Magnetizing inrush current harmonics
  - (iv) Sympathetic inrush current
  - (v) Protection against incipient faults
  - (vi) Differential protection of Δ / Y transformers
  - (vii) Differential protection of multi-winding transformers
  - (viii) Gas detection
  - (ix) Sudden pressure
  - (x) Transformer overcurrent protection
  - (xi) Principles of differential protection
  - (xii) Examples and practical systems
- **GENERATOR PROTECTION**
  - (i) Generators internal faults
  - (ii) System disturbances and operational hazards
  - (iii) Typical protection of direct connected generators
  - (iv) Connection of generator protection
  - (v) Turn to turn fault protection
  - (vi) Practical examples
  - (vii) Back up protection
  - (viii) Ground fault protection
  - (ix) Rotor protection
  - (x) Loss of citation protection
  - (xi) Examples
- **MOTOR PROTECTION**
  - (i) Potential motor hazards
  - (ii) Motor characteristics involved in protection
  - (iii) Induction motor equivalent circuit
  - (iv) General motor protection
  - (v) Phase-fault protection
  - (vi) Differential protection
  - (vii) Ground-fault protection
  - (viii) Thermal and locked-rotor protection
  - (ix) Locked-rotor protection for large motors (21)
  - (x) System unbalance and motors
  - (xi) Unbalance and phase rotation protection
  - (xii) Undervoltage protection
  - (xiii) Bus transfer and reclosing
  - (xiv) Repetitive starts and jogging protection
  - (xv) Multifunction microprocessor motor protection units
  - (xvi) Synchronous motor protection
  - (xvii) Summary: typical protection for motors
  - (xviii) Practical considerations of motor protection
  - (xix) Examples

Day 4

- **PROTECTION OF RADIAL FEEDERS**
  - (i) Coordination of protective devices
  - (ii) Radial line protection strategy
  - (iii) Clearing temporary faults
  - (iv) Clearing permanent faults
  - (v) Recloser-fuse coordination
  - (vi) OC relays coordination
  - (vii) Phase and ground relays
  - (viii) Procedure for instantaneous relay setting
  - (ix) Examples and exercises
- **TRANSMISSION LINE PROTECTION**
  - (i) Over current protection
  - (ii) OC protection of radial lines, loop with one source, and of multiple loop systems
  - (iii) Examples and exercises
- **DISTANCE PROTECTION OF TRANSMISSION LINES**
  - (i) How V/I=Z makes a distance relay
  - (ii) Distance relay characteristics
  - (iii) Protection zones of distance relays
  - (iv) Practical examples and exercises
- **PILOT PROTECTION SYSTEMS**
  - (i) Principles and applications
  - (ii) Pilot protection systems
  - (iii) General concepts of pilot communication
  - (iv) Unit protection pilot schemes
  - (v) Single phase comparison blocking
  - (vi) Dual phase comparison unblocking
  - (vii) Examples and exercises

Day 5

- **BUS PROTECTION**
  - (i) Bus faults
  - (ii) Bus protection requirement
  - (iii) Bus differential protection for different bus arrangements
  - (iv) Examples
- **SYSTEM STABILITY AND OUT OF STEP RELAYING**
  - (i) Steady state stability
  - (ii) Transient stability
  - (iii) Equal area criterion
  - (iv) Relay operation and transient stability condition
  - (v) Impedance measured by relays during power swing
  - (vi) Out of step detection by distance relays
  - (vii) Synchrophasors based out of step relays
  - (viii) Examples
- **COURSE SUMMARY, FEEDBACK AND EVALUATION.**