EE285:
Modern Power System Protective Relaying

Training Description:

Protection of low, medium and high voltage power systems requires an understanding of system faults and their detection, as well as their safe disconnection from the power system.

This intensive training course presents a comprehensive and systematic description of the concepts and principles of operation and application of protection schemes for various power system elements such as feeders, transformers, motors, buses, generators, etc.

The course begins with an overview of power system faults and the protection scheme requirements for the detection and coordinated clearance of these faults. Protection requirements for cogeneration and non-utility generation, and interconnection with the utility power system are covered in detail.
The course deals with protection systems from a practical perspective and includes important functional aspects such as testing and coordination of protection systems. It is specially designed for industries and utilities, which depend on proper system protection for operational efficiency and minimizing damage to equipment.

Training Objectives:

By the end of the training, participants will be able to:

- ✓ Apply systematic techniques in power system protective relaying and identify the different types of power system faults including their causes, effects and detection
- ✓ Determine the components of protection schemes including the application of Programmable Logic Controllers, circuit breakers, current and voltage transformers
- ✓ Describe the various types of current transformers & voltage transformers, application requirements of C.T.'s for protective relaying and accuracy classifications
- ✓ Discuss the power system neutral grounding for industrial plants and high-voltage substations, calculate ground-fault current and explain the reasons for limiting generator ground-fault current to a low value
- ✓ Illustrate the ground potential rise during power system faults which includes the hazards to individuals working in electrical substations, effects of ground-potential-rise (GPR), effects on telecommunications equipment, etc.
- ✓ Apply the proper feeder overcurrent protection, protective relaying requirements for radial systems, relay setting criteria, load limitations and testing of overcurrent protection scheme
- ✓ Recognize the proper coordination of electrical protection systems, bus protection, motor protection, starting and control
- ✓ Explain the application of differential protection to transformers, winding temperature and oil temperature devices & analysis of transformer oil for dissolved gases in relation to transformer protection
- ✓ Implement the generator protection system including the differential protection, voltage controlled & voltage restrained overcurrent protection and testing of generator protection schemes
- ✓ Employ the appropriate methods of cogeneration & non-utility generation protection as well as transmission lines protection
- ✓ Demonstrate the application of static capacitors on power systems, description of protection schemes used and the testing of capacitor protection schemes in relation to capacitor protection

- ✓ Discuss new numerical relaying technology

Training Designed for:

This course is intended Engineers, designers, supervisors and other technical staff who are involved in the design, regulatory inspection, operation and maintenance of power system protective relaying will benefit from the practical approach of this course. The course will also be very useful to those generally knowledgeable in protective relaying, but who may require a refresher or update.

Training Program:

DAY ONE:

- ❖ PRE-TEST
- ❖ Introduction, Overview & Discussion of Objectives
- ❖ Power System Faults
  - Different Types of Faults, Incidence of Faults on Power System Equipment
  - Effects of Power System Faults, Causes of Power System Faults
  - Magnitude of Fault Current, Detection of Faults
  - Clearance of Faults, Requirements of Protective Relaying Systems
- ❖ Components of Protection Schemes
  - Fault Detecting Relays
  - The Transition from Electro-mechanical Relays to Electronic and Digital Microprocessor-Based Relays
  - Tripping Relays & Other Auxiliary Relays
  - The Application of Programmable Logic Controllers
  - Circuit Breakers - Bulk-Oil, Air-Blast, Vacuum, SF6, Current Transformers
  - Voltage Transformers, Modern Microprocessor-Based Relays - Review of Types Available
- ❖ Current Transformers & Voltage Transformers
  - Various Types of C.T.'s V.T.'s & C.V.T.'s
  - Theory and Characteristics of C.T.'s

DAY TWO:

- ❖ C.T.'S and V.T.'S (cont'd)
  - Application Requirements of C.T.'s for Protective Relaying
  - Accuracy Classifications, Future Trends in C.T. Design using Optics
  - Testing of C.T.'s and V.T.'s
- ❖ Power System Neutral Grounding
  - An Overview of Power System Neutral Grounding
  - System Grounding as Found in Industrial Plants and High-Voltage Substations
  - Ungrounded Systems, Resistance Grounded Systems
  - Reactor Grounded Systems, Solid or Effectively Grounded Systems
  - Resistance Grounded Systems in Industrial Plants, Calculation of Ground-Fault Current
  - Ground-Fault Detection on Resistance Grounded Systems
  - Ground-Fault Detection on Ungrounded Systems
  - Generator Neutral Grounding Methods, Equipment Selection
  - Reasons for Limiting Generator Ground-Fault Current to a Low Value

- Neutral Grounding Transformers and Resistors
- Calculation of Generator Ground-Fault Current
- Sizing and Rating of Grounding Equipment

❖ Ground Potential Rise During Power System Faults

- Hazards to Individuals Working in Electrical Substations
- Substation Grounding System Fundamentals, Step Voltage, Touch Voltage, Mesh Voltage
- Tolerable Limits of Body Currents During Power System Faults
- Calculation of Allowable Step and Touch Potentials
- Effects of Ground-Potential-Rise (GPR), Control of Excessive Ground-Potential-Rise
- Control of Voltage Gradients in High-Voltage Substations
- GPR and Transferred Voltages, Effects on Telecommunications Equipment
- Corrective Measures, Neutralizing Transformers for Telephone Circuits
- Optical Isolation Equipment for Telephone Circuits

❖ Feeder Overcurrent Protection

- Protective Relaying Requirements for Radial Systems
- Elements of Feeder Protection Schemes, High-Set, Low-Set and Inverse-Timed Elements
- Directional Overcurrent Relays, Coordination with Other Devices and Fuses
- Various Types of Overcurrent Relays, Electromechanical, Electronic & Digital Relays
- Relay Setting Criteria, Load Limitations, Testing of Overcurrent Protection Schemes
- Microprocessor-Based Feeder Overcurrent Protection Relays-Features, Applications and Testing

DAY THREE:

❖ Coordination of Electrical Protection Systems

- Fuse to Fuse, Circuit Breaker to Fuse, Fuse to Circuit Breaker
- Computer Software Packages for Protection Coordination Studies
- Auto-Reclosing of Circuit Breakers, Back-Up Protection
- Limitation of Fault Current, Selective Zones of Protection

❖ Bus Protection

- Types of Bus Protection Schemes, Basic Concept of Differential Protection
- Application to Various Bus Configurations
- Application of High Impedance Relays, Relay Setting Criteria
- Testing of Bus Protection Schemes

❖ Motor Protection, Starting & Control

- Applicable Motor Standards, Methods of Starting
- Differential Protection, Phase Unbalance, Overcurrent
- Ground Fault Protection, Electrical Code Requirements
- Microprocessor-Based Motor Control & Protection Devices

❖ Transformer Protection

- Overcurrent and Ground Fault Protection
- Application of Differential Protection to Transformers
- Gas Relays, Pressure and Gas Accumulation
- Restricted Earth Fault Protection Winding Temperature and Oil Temperature Devices
- Testing of Transformer Protection Schemes

- Modern Microprocessor-Based Multi-function Transformer Protection Relays-Functions Available, Applications and Testing
- Analysis of Transformer Oil for Dissolved Gases

DAY FOUR:

❖ Generator Protection
- Differential Protection, Reverse Power, Stator Ground, Out-of-Step, Loss of Field
- Field Ground, Overexcitation, Interturn, etc.
- Over-Frequency, Underfrequency, Overvoltage, Undervoltage
- Negative Phase Sequence, or Phase Unbalance
- Voltage Controlled & Voltage Restrained Overcurrent Protection
- Generator Short-Circuit Current Decrement Curves
- Synchronizing Systems, Synchro-Check Relays
- Comparison of Electro-Mechanical & Electronic Relays
- Testing of Generator Protection Schemes
- Microprocessor-Based Multi-function Generator Protection Relays-Available Functions, Applications and Testing

❖ Cogeneration & Non-Utility Generation Protection
- Protection Requirements for Non-Utility Generating Stations
- Requirements for the Interconnection NUGS to Utility Power Systems
- Typical Protection Schemes for Non-Utility Generators
- Low-Cost Microprocessor-Based Multi-function Relays for Small Generators
- Breaker Failure Protection, Testing of Utility Tie Protection Schemes

❖ Transmission Line Protection
- Interconnected Systems with Two-Way Flow of Fault Current
- Distance or Impedance Protection Schemes, Phase Comparison Protection Schemes
- Line Differential Protection Schemes Communication Channel Requirements Between Terminals
- Coordination and Transfer-Tripping Between Terminals
- Modern Microprocessor-Based Line Protection Relays-Available Relays, Features, Applications and Testing

❖ Practical Sessions
- This hands-on and includes simulator, real-life case studies and exercises

DAY FIVE:

❖ Capacitor Protection
- Application of Static Capacitors on Power Systems
- Description of Protection Schemes Used, Testing of Capacitor Protection Schemes
- Microprocessor-Based Capacitor Protection and Controls Relays

❖ Numerical Relays
- Fundamentals of Numerical Relaying
- Technological Improvements Supplied by Numerical Relays
- Hardware Architecture of Numerical Relays
- Digital Signal Processors, Sample and Hold Circuit
- Simultaneous Sampling, Non-simultaneous Sampling
- Relaying Hardware for Metering, Optical Communications

- Optical Current Transformers, Open System Relaying

❖ Course Conclusion
❖ POST-TEST and EVALUATION

Training Requirement:

"**Hand's on practical sessions, equipment** and **software** will be applied during the course if required and as per the client's request."

Practical sessions will be organized during the course for participants to practice the theory learnt. Participants will be provided with an opportunity to carryout various exercises using our state-of-the-art simulators "GE Multilin Relay 469" and "GE Multilin Relay 750".

Please note that the above topics can be amended as per client's learning needs and objectives. Further, it should be forwarded to us a month prior to the course dates.

Training Methodology:

This interactive training course includes the following training methodologies as a percentage of the total tuition hours:

- 30% Lectures, Concepts, Role Play
- 70% Workshops & Work Presentations, Techniques, Based on Case Studies & Practical Exercises, Software & General Discussions
- Pre and Post Test

Training Certificate(s):

Internationally recognized certificate(s) will be issued to each participant who completed the course.

Training Fees:

As per the course location - This rate includes participant's manual, hand-outs, buffet lunch, coffee/tea on arrival, morning & afternoon of each day.

Note: The 5% VAT (Value Added Tax), will be effective starting 01st of January 2018 as per the new regulation from the UAE Government. The VAT applies for all quotation both for local and abroad.

Training Timings:

Daily Timings:

07:45 - 08:00	Morning Coffee / Tea
08:00 - 10:00	First Session
10:00 - 10:20	Recess (Coffee/Tea/Snacks)
10:20 - 12:20	Second Session
12:20 - 13:30	Recess (Prayer Break & Lunch)
13:30 - 15:00	Last Session

For training registrations or in-house enquiries, please contact:
Aisha Relativo: aisha@cmc-me.com
Tel.: +971 2 665 3945 or +971 2 643 6653 | Mob.: +971 52 2954615
Training & Career Development Department