CYME INTERNATIONAL T&D

TECHNICAL ENGINEERING COURSES

Modern Protection Systems for Transmission and Distribution — *Fundamentals and Applications*

Introduction

Protection Systems perform an essential function in the safe and reliable operation of Power Systems. Theses systems are designed to react to abnormal operating conditions, such as system faults, in order to isolate the faulted part of the system before equipment damage occurs or safety of personnel or the public is jeopardized.

Protection Systems should be selective in order to minimize the isolated portion of the system at the same time they should be sensitive enough to assure the security of the system. These two objectives may not, always, be compatible and balance between these has to be established.

Modern equipment, including digital relays, have revolutionized the state of the art of designing protection systems and have made it possible to achieve both selectivity and security simultaneously.

Course Language:
English

Duration:
3 days

Instructors:
Arun G. Phaedke
Stanley H. Horowitz

CYME Technical Engineering Courses Program Director:
Dr. Atef S. Morched

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What you will learn

During this intensive course you will study:

- Principles behind the protection of transmission and distribution lines, transformers, rotating machines and other power system components leading to an understanding of overall system protection considerations.
- Performance of transducers and response of protective systems to transients.
- Dependability and security considerations: system protection is biased toward dependability since the system must be able to withstand an outage but cannot withstand a delayed trip.
- Concept of adaptive relaying; a real-time feedback system whereby the protective philosophy changes in response to changing system conditions.

The course instructors will supplement the lectures on protection theory with field experiences and practices including discussions of system performance and notable blackouts.

Audience

- Utility and consulting engineers working on designing, operating and maintaining Protection Systems
- Planning and operating engineers involved in the assessment of system performance and impact of the protection system on the reliability and security of the system.

Course Outline

Day 1

- **Course Introduction**
  - Course organization
  - Role of relaying theory
- **Relaying Fundamentals**
  - Nature of relaying
  - Relay terminology
  - Relay design
- **Transducers**
  - Current transformers
  - Voltage transformers
  - Capacitive potential devices
- **Transient Phenomena**
  - DC offset in fault currents
  - CT and PT transients
  - Restrike
  - Ferroresonance
- **Distribution System Protection**
  - System configuration
  - Circuit breakers, reclosers, sectionalizers
  - Fuses and relays
  - Coordination
- **Sub-transmission System Protection**
  - Non-pilot line protection
  - Relay coordination
  - Time-delay, instantaneous overcurrent relays
  - Distance relays
  - Relay setting philosophy
  - 3-terminal lines
  - Series capacitors, reactors

Day 2

- **Response of Distance Relays**
  - Phasor diagrams
  - Distance relay response
  - Loading and fault conditions
- **Pilot Line Protection**
  - Communication channels
  - Directional comparison
  - Transfer trip
  - Phase comparison
  - Wire pilot
  - Settings
- **Transformer Protection**
  - Magnetizing inrush
  - Differential protection
  - Mechanical devices
- **Rotating Machinery Protection**
  - Phase and ground protection
  - Unbalanced voltage and current
  - Loss of field and volts per hertz
  - Motor protection
  - Plant auxiliary systems
  - Start-up and inadvertent energization

Day 3

- **Station Equipment Protection**
  - Bus configuration
  - Bus protection
  - Reactor protection
  - Capacitor protection
- **Relaying for Stability**
  - Loss of field relaying
  - Phasor diagrams during stability swings
  - Frequency and voltage dynamics (catastrophic changes)
  - Under-frequency load shedding
- **Adaptive Relaying**
  - Dependability vs. security
  - Hidden failures and system vulnerability
  - Typical examples
- **Fault Location**
  - Digital relays and digital fault recorders
  - Limit to accuracy of fault location
  - Complexity of data input requirements
  - GPS signals for record synchronization
- **General Discussion**
  - Questions
  - Blackouts
  - Restoration
  - Ongoing research

Each participant will receive a set of course notes as well as a copy of the textbook Power System Relaying, Second Edition, by Stanley H. Horowitz and Arun G. Phadke, Research Studies Press, Ltd, 1995.

Instructors

Arun G. Phadke is a University Distinguished Professor (Emeritus) at Virginia Tech. His primary research area is the microcomputer based monitoring, protection, and control of power systems. Dr. Phadke is a Fellow of IEEE. He was the Chairman of the Technical Committee of USNC CIGRE, and Editor-In-Chief of IEEE Transactions on Power Delivery.

Dr. Phadke was elected to the US National Academy of Engineering in 1993.

Stanley H. Horowitz is a consultant, author and lecturer. Mr. Horowitz worked for American Electric Power Service Corp. until 1989, as head of the System Protection Section and Assistant Head of the Electrical Engineering Division. He is a Life Fellow of the IEEE and served as chairman of the IEEE/PES Power System Relaying Committee from1975-1978. He was awarded the PSRC Distinguished Service award and is a recipient of the IEEE Third Millennium Medal. He was chairman of the CIGRE Study Committee 34-Protection and from 1980-1986 and in 1997 was awarded the CIGRE Attwood Associates Award for notable contributions to CIGRE.

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