Power System Protection and Relaying: Schemes, Settings and Testing

10 – 14 May 2027
Amsterdam - Zuidas business district hotel



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Introduction:

Power system protection and relaying decides whether a fault clears in milliseconds at one breaker or cascades into a wider blackout, yet many relay settings were calculated years ago, CT saturation was never checked and disturbance records sit unread. This Core Concept course equips protection engineers to design and verify relay schemes for lines, transformers, busbars and generators, calculate distance, differential and overcurrent settings, test numerical relays by secondary injection and read COMTRADE records after a trip. Participants build a Protection Setting Calculation and Relay Test Dossier for a scheme from their own network.

Course Objectives:

- Calculate symmetrical-component fault currents and apparent impedances as seen by relays, and select CT and VT ratios, classes and knee-point voltages that stay out of saturation for through faults
- Set phase and earth-fault overcurrent and directional elements ANSI 50, 51, 67 and prove selectivity across zones of protection with local and remote backup
- Define distance protection zones, reach and resistive coverage for overhead lines and cables, and choose a communication-aided scheme for the line
- Configure biased differential protection ANSI 87 for transformers, busbars and generators, including inrush and overexcitation restraint and stability checks
- Specify generator protection functions such as loss of excitation, reverse power, negative sequence, stator earth fault and out-of-step, and justify each pickup and delay
- Test numerical relays by secondary injection, verify IEC 61850 GOOSE trip paths at overview level and analyse COMTRADE disturbance records to confirm correct or incorrect operation

Target Audience:

- Protection engineers who calculate, issue and revise relay setting files for transmission and distribution substations
- Relay test and maintenance engineers who carry out secondary injection, scheme checks and periodic protection testing
- Power plant electrical engineers responsible for generator, unit transformer and auxiliary protection
- Substation engineers who review protection drawings, trip logic and interlocks for new bays and extensions
- System operations and fault analysis engineers who investigate trips and maloperations from relay event and oscillography records

Course Outline:

Day 1: Protection Philosophy, Fault Quantities and Instrument Transformers

- Zones of Protection, Overlap at Breakers and Primary Versus Backup Philosophy
- Symmetrical Components and Sequence Networks for Relay Fault Studies
- Apparent Impedance and Fault Current Phasors Seen From the Relay Location
- Protection CT Accuracy Classes, Knee-Point Voltage and Saturation Checks
- Protection VT Connections, Open-Delta Residual Voltage and Fuse Failure Supervision

Day 2: Overcurrent, Directional and Distance Schemes for Lines

- ANSI 50, 51 and 67 Elements with IEC 60255-151 Inverse Characteristics
- Directional Polarisation Methods and Sensitive Earth-Fault Detection
- Mho and Quadrilateral Distance Characteristics and ANSI 21 Zone Reach Settings
- Resistive Reach, Load Encroachment and Power Swing Blocking Logic
- Permissive Underreach, Permissive Overreach and Blocking Teleprotection Schemes

Day 3: Unit Protection for Transformers, Busbars and Generators

- Biased Percentage Differential Slope and Minimum Pickup Calculation
- Transformer Differential Vector Group Compensation and Zero-Sequence Filtering
- Second and Fifth Harmonic Restraint for Inrush and Overexcitation
- High-Impedance and Low-Impedance Busbar Protection with Check Zone Logic
- Restricted Earth Fault and Line Current Differential ANSI 87L Principles

Day 4: Generator Protection, Numerical Relays and Protection Communications

- Stator Earth Fault Coverage Using Neutral Overvoltage and Third-Harmonic Schemes
- Loss of Excitation ANSI 40, Reverse Power ANSI 32 and Negative Sequence ANSI 46 Settings
- Out-of-Step ANSI 78, Volts per Hertz ANSI 24 and Frequency ANSI 81 Elements
- Numerical Relay Architecture, Setting Groups and Programmable Trip Logic
- IEC 61850 Logical Nodes, GOOSE Messages, Sampled Values and SCL Files Overview

Day 5: Setting Studies, Relay Testing and Disturbance Record Analysis

- Setting Calculation Sheet Build for a Line, Transformer and Generator Bay
- Secondary Injection Test Plan: Pickup, Timing, Distance Zone and Differential Slope Checks
- End-to-End and Trip Circuit Tests with Lockout Relay ANSI 86 Verification
- COMTRADE Record Analysis to IEEE C37.111 and IEC 60255-24 for a Maloperation Case
- Protection Setting Calculation and Relay Test Dossier Peer Review

Skills You Will Gain:

- Protection Fault Study
- Instrument Transformer Dimensioning
- Distance Zone Setting
- Differential Scheme Configuration
- Generator Protection Setting
- Teleprotection Scheme Selection
- Secondary Injection Testing
- Disturbance Record Interpretation

Why Attend This Course:

- Return with a Protection Setting Calculation and Relay Test Dossier for a line, transformer or generator bay from your own network
- Find settings that overreach, underreach or lose stability on through faults before a real event exposes them
- Explain a relay operation to operations and management with evidence taken from oscillography and event logs
- Compare protection practice with engineers from utilities, power generation, oil and gas, petrochemicals and heavy industry

Conclusion:

Dependable protection comes from settings that are calculated, tested and checked against real disturbances. The course moves from zones of protection, sequence quantities and instrument transformers, through overcurrent, directional and distance schemes for lines, to unit protection of transformers, busbars and generators, then to generator functions, numerical relays and substation communications. The final day brings the work together in a Protection Setting Calculation and Relay Test Dossier that participants review with peers and apply to their next setting revision or trip investigation.