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COURSE BROCHURE

# Advanced Protective Relaying and Numerical Relay Coordination Training Course

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Registered in the United Kingdom and Saudi Arabia

# Advanced Protective Relaying and Numerical Relay Coordination Training Course

Protective Relaying and Numerical Relay Coordination is a 2-week training course for protection, relay testing and substation engineers, built around a relay coordination and settings dossier for a live network section. Grids now carry more inverter-based generation, longer interconnections and denser substations, so a mis-set numerical relay can trip healthy plant or leave a fault uncleared. Jupiter Prime Training delivers this course for engineers who own relay settings and their evidence.

## Why Protective Relaying and Numerical Relay Coordination Matters Now

Three forces shape protective relaying today: the spread of inverter-based resources that supply limited and unusual fault current, the digitalisation of substations through IEC 61850 communication, and asset owners who expect fewer and shorter outages. An organisation that coordinates its numerical relays well isolates faults quickly and keeps unaffected feeders energised; one that does not faces nuisance trips, damaged transformers and long restoration. The course rests on the IEC 61850 substation communication standard, on symmetrical component fault analysis and on time-current grading practice used across transmission and industrial networks.

## Who Gains Most from Protective Relaying and Numerical Relay Coordination

- Engineers who calculate and approve relay settings for transmission lines and feeders
- Specialists who commission and secondary-inject numerical relays before energisation
- Substation engineers responsible for transformer, busbar and breaker failure schemes
- Generation plant engineers who protect generators and step-up transformers
- Engineers who investigate disturbance records after trips and maloperations

A utility or large industrial site gains most when its settings engineers and its testing crews attend together and agree one coordination method.

## Protective Relaying and Numerical Relay Coordination Capabilities

The outcomes move from fault current calculation to grading margins, scheme selection and relay test evidence.

- Calculate symmetrical and unsymmetrical fault currents for relay reach and pickup — settings approval
- Specify distance zone reaches with load encroachment margins — transmission line owners
- Design differential schemes for transformers, generators and busbars — asset protection decisions
- Build time-current grading between overcurrent and earth fault relays — feeder selectivity

- Test numerical relays with secondary injection and end-to-end checks — commissioning sign-off
- Analyse disturbance records to find the cause of a maloperation — post-trip investigations

## Key Protective Relaying and Numerical Relay Coordination Terms

- Numerical relay — a microprocessor protective device that samples currents and voltages and runs protection algorithms in software
- Zone of protection — the part of the network a relay or scheme must clear, bounded by its current transformers
- Grading margin — the time interval kept between upstream and downstream relays so that the nearest relay trips first
- Distance protection — a scheme measuring apparent impedance to the fault and tripping when it falls inside a set zone
- Percentage differential — a scheme comparing currents entering and leaving equipment, with a bias that rises with through current
- Breaker failure protection — a backup function that trips adjacent breakers when the primary breaker fails to interrupt

## Protective Relaying and Numerical Relay Coordination Day by Day

### Day 1: Protection Philosophy and System Faults

- Protection Objectives of Selectivity Speed and Dependability — Scheme Priorities
- Fault Types and Their Causes on Overhead Lines — Exposure Ranking
- Primary and Backup Protection Layers — Redundancy Choices for Critical Bays
- Earthing Methods and Their Fault Current Effect — Earth Fault Scheme Choice
- Single Line Diagram Review for Protection Zones — Zone Boundaries

### Day 2: Fault Calculation for Relay Settings

- Per Unit System and Network Impedance Data — Study Model Accuracy
- Symmetrical Components for Unbalanced Faults — Earth Fault Pickup Values
- Source Impedance Ratio and Infeed Effects — Distance Reach Errors
- Fault Contribution from Inverter-Based Resources — Relay Sensitivity Limits
- Short Circuit Study Software Workflow — Settings Input Data

### Day 3: Instrument Transformers and Relay Hardware

- Current Transformer Saturation and Knee Point — Differential Stability
- Voltage Transformer Fuse Failure Supervision — Distance Blocking Logic
- Numerical Relay Architecture and Sampling — Filtering Choices
- Binary Inputs Outputs and Trip Circuit Supervision — Trip Reliability
- Relay Self-Monitoring and Alarm Handling — Maintenance Intervals

## Day 4: Overcurrent and Earth Fault Grading

- Inverse Definite Minimum Time Curves — Curve Selection per Feeder
- Time-Current Grading Charts — Upstream and Downstream Margins
- Directional Overcurrent Elements — Ring and Parallel Feeder Selectivity
- Sensitive Earth Fault Settings — High Impedance Fault Detection
- Fuse and Recloser Coordination on Distribution Feeders — Customer Outage Scope

## Day 5: Distance Protection of Transmission Lines

- Mho and Quadrilateral Characteristics — Resistive Coverage Choice
- Zone Reach and Time Settings — Remote Backup Coverage
- Load Encroachment and Power Swing Blocking — Stability During Disturbances
- Mutual Coupling on Parallel Lines — Earth Fault Reach Correction
- Teleprotection Schemes Such as POTT and Blocking — End-to-End Clearance Time

## Day 6: Line Differential and Busbar Protection

- Line Current Differential over Communication Channels — Channel Delay Tolerance
- High Impedance Busbar Differential — Stabilising Resistor Sizing
- Low Impedance Busbar Schemes with Check Zone — Busbar Trip Security
- Breaker Failure Timers and Retrip Logic — Adjacent Breaker Tripping
- Autoreclose Dead Times and Synchrocheck — Line Restoration Speed

## Day 7: Transformer and Reactor Protection

- Biased Differential with Vector Group Compensation — Transformer Trip Security
- Inrush and Overexcitation Restraint by Harmonics — Energisation Stability
- Restricted Earth Fault Schemes — Winding Fault Sensitivity
- Buchholz and Thermal Image Devices — Internal Fault Detection
- Shunt Reactor Protection Functions — Reactor Outage Decisions

## Day 8: Generator and Motor Protection

- Generator Stator Differential and Earth Fault — Winding Coverage
- Loss of Excitation and Reverse Power Elements — Unit Tripping Logic
- Negative Phase Sequence and Out of Step — Rotor Heating Limits
- Large Motor Thermal Overload and Stall — Process Restart Decisions
- Frequency and Voltage Elements for Islanding — Load Shedding Coordination

## Day 9: Digital Substations and Relay Testing

- IEC 61850 GOOSE Messaging for Trip and Interlock — Hardwiring Replacement
- Secondary Injection Test Plans — Settings Verification Evidence
- End-to-End Testing with Synchronised Test Sets — Scheme Acceptance
- Disturbance Record and Event Log Analysis — Maloperation Root Cause
- Settings Management and Version Control — Audit Trail for Changes

## Day 10: Practising the Relay Coordination and Settings Dossier

- Fault Study for a Mixed Line and Transformer Section — Settings Basis
- Grading Chart Across Feeders and Incomers — Selectivity Proof
- Distance and Differential Settings Sheet — Approval Package
- Test Plan Linked to Each Protection Function — Commissioning Readiness
- Relay Coordination and Settings Dossier Completion — Sign-Off Pack

## Applying Protective Relaying and Numerical Relay Coordination After the Course

- Re-check the time-current grading chart of one substation against the latest fault levels and record every margin below target
- Review three recent disturbance records with the testing crew and agree setting or logic changes for any maloperation found

## Protective Relaying and Numerical Relay Coordination Questions FAQ

### What is protective relaying and numerical relay coordination and why does it matter now?

It is the practice of setting numerical relays so the nearest device clears each fault and backups stay graded. It matters now because inverter-based generation and digital substations change fault currents and trip paths, so settings made years ago may no longer be selective.

### Which roles gain most from protective relaying and numerical relay coordination?

Settings engineers, relay testing specialists, substation engineers and generation plant protection engineers gain most. You benefit most when you approve settings, commission schemes or investigate trips, because the course links fault calculation, grading and test evidence in one method.

### How does protective relaying and numerical relay coordination differ from a general power system protection course?

It goes deeper into numerical relay settings and coordination proof. A general protection course explains schemes and equipment, while this one has you calculate reaches, grade curves, set differential bias and plan secondary injection tests for each function.

### What do you bring back from protective relaying and numerical relay coordination?

You bring back a settings basis and grading proof for a network section, with a test plan for each protection function. These give your team a repeatable way to approve, commission and review relay settings.

## Protective Relaying and Numerical Relay Coordination: The Way Forward

The relay coordination and settings dossier gathers the fault study, grading chart, settings sheets and test plan for one network section. Its first use is the approval of new or changed settings by the protection lead, with testing crews using it on site. After the first commissioning, revisit the grading margins as new generation connects and fault levels change.