

# POWER SYSTEM PROTECTION & ANALYSIS (REF:OTSPSPA001)

## Course Introduction

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.

## Course Objectives

### 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. The attendee will have a solid background in protection concepts to apply them to power system elements.

## Who Should Attend

The course is designed for the power systems' engineers, Supervisors responsible for the operation, control and protection of distribution, transmission and generation systems.

## Course Outline

### Day 1

#### Introduction and Course Outline

#### Power System Components Modeling

#### Generators/motors, Transformers, Transmission lines

#### Symmetrical Faults

- Three-phase short circuit, Fault currents,
- The selection of circuit breakers
- Symmetrical Components
- Sequence components and networks

### Day 2

#### Unsymmetrical Faults

- Single-line-to ground, Line-to-line, and Double-line-to ground faults, and Open conductor
- Practical examples

#### Protective Devices Characteristics

- Fuses, and Fuse coordination and selection
- Practical examples on fuses selection and coordination
- Transformer fusing
- Automatic circuit reclosers
- Reclosers ratings and control
- Examples on reclosers coordination
- Relays: Electromechanical, Solid state, and
- Microprocessor-based relays



## Day 3

### Transformer Protection

- Factors affecting transformer protection
- Magnetizing inrush current
- Differential protection of  $\Delta$  / transformers
- Differential protection of multi-winding transformers
- Gas detection
- Sudden pressure
- Transformer overcurrent protection
- Principles of differential protection

### Generator Protection

- Generators internal faults
- System disturbances and operational hazards
- Typical protection of direct connected generators
- Connection of generator protection
- Turn to turn fault protection
- Practical examples
- Back up protection
- Ground fault protection
- Rotor protection
- Loss of citation protection

### Motor Protection

- Potential motor hazards
- Motor characteristics involved in protection
- Induction motor equivalent circuit
- General motor protection
- Phase-fault protection
- Differential protection
- Ground-fault protection
- Thermal and locked-rotor protection
- Locked-rotor protection for large motors
- System unbalance and motors
- Unbalance and phase rotation protection
- Undervoltage protection
- Synchronous motor protection

## Day 4

### Protection of Radial Feeders

- Coordination of protective devices
- Radial line protection strategy
- Clearing temporary faults
- Clearing permanent faults
- OC relays coordination
- Phase and ground relays
- Procedure for instantaneous relay setting
- Examples and exercises

### Transmission Line Protection

- Over current protection
- OC protection of radial lines, loop with one source, and of multiple loop systems

### Distance Protection of Transmission Lines

- How  $V/I=Z$  makes a distance relay
- Distance relay characteristics
- Protection zones of distance relays

### Pilot Protection Systems

- Principles and applications
- Pilot protection systems
- General concepts of pilot communication
- Unit protection pilot schemes



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## Day 5

### Bus Protection

- Bus faults
- Bus protection requirement
- Bus differential protection for different bus arrangements

### System Stability and Out of Step Relaying

- Steady state stability
- Transient stability
- Equal area criterion
- Relay operation and transient stability condition
- Impedance measured by relays during power swing
- Out of step detection by distance relays

