



Arabian Institute For Training

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# Transmission & Distribution Operation & Design Calculations

## INTRODUCTION

- This Transmission & Distribution Operation & Design Calculations training seminar has been designed to provide a good understanding of power system concepts, theories, parameters, and the way such information is analyzed by means of equations, curves, diagrams, and tables.
- This Electrical Engineering training seminar is in fact a quick review on electrical engineering principles and focuses on the technical specifications, operation, and behaviour of power system main equipment such as power transformers, distribution transformers, switchgears, circuit breakers, earthing switches, auto-reclosers, transmission lines, busbars, and protection and control systems.
- Nowadays, the significant trend in load increase in industrial centres, shopping malls, and residential areas requires upgrading and enlargement of power systems and utility grids. This can be achieved by designing highly reliable busbar configurations, interconnecting transmission lines, zone substations, and distribution centres, and also by expanding power plants and embedded generation facilities in appropriate locations.
- As a result, the operation decisions and switching regimes of power networks are continually becoming more complex due to the complicated load flow patterns, complex protection schemes, modern digital technology, and the numerous scenarios for power flow and load dispatch which must be decided upon by system operators and network managers.
- Therefore, maintaining power performance criteria such as reliability, voltage stability, and frequency stability would be of utmost importance in a reliable power system. In other words, by gaining a good knowledge about how system parameters would change under different system operation modes, or different loading, or switching, one can better understand the behaviour of the power system (which is under study); as such the response of the system to different switching scenarios and setting changes would be more predictable.

### This training course will highlight:

- Power system parameters
  - Power flow equations
  - Transmission lines design and operation
  - Power & distribution transformers
  - Distribution system configurations and design
  - Switchgear types and construction
  - HV cable sizing and coefficient factors
  - Power system protection
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## OBJECTIVES

At the end of this training course, you will learn how to:

- Model a power system by means of system parameters
- Create different load flow scenarios through different switching regimes
- How to analyze and interpret the response of the power system to different scenarios
- How to modify the power system behaviour in an area by enhancing system parameters
- Create and analyze protection curves to achieve coordination between different bays

## TRAINING METHODOLOGY

- This Transmission & Distribution Operation & Design Calculations training seminar will be presented by means of power point slides through which all the required theory and equations will be provided. This Electrical Engineering training seminar also includes case studies where the participants are required to take part in class activities including system analysis, calculations, relay settings, etc. The instructor will also use training videos for better understanding of the participants. The participants will be progressively assessed during the training seminar via quizzes, questions, assignments, and worked examples.

## ORGANISATIONAL IMPACT

On successful completion, the organizational impact would be:

- Develop a structured approach to selection of voltage levels and loadability of transmission systems
- Determine minimum technical requirements to achieve transmission reliability & stability
- Learn about the effects of major power disturbances on transmission systems and their solutions
- Practice on distribution system design calculations and safety precautions
- Correct selection of O/H conductors and U/G cables

## PERSONAL IMPACT

Participants from different sectors of engineering companies will enormously benefit from this training programme because they will become quite familiar with:

- Mathematical approach to the interpretation and analysis of system disturbances
  - Design, operation, and protection of distribution and transmission systems
  - Installation & construction switchgears and transformers
  - Power system switching & operation together with proposed solutions
  - Protection coordination, selectivity, sensitivity, and stability
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## WHO SHOULD ATTEND?

- We encourage the staff involved in the operation, planning, design, and maintenance of power systems to attend this training programme. This Transmission & Distribution Operation & Design Calculations training is suitable to a wide range of professionals but will greatly benefit:
- Project Engineers / Managers
- Electrical Engineers / Technicians
- System Operators
- Design Engineers
- Asset Engineers / Managers
- Planning Engineers / Managers
- Protection, Instrumentation, and Commissioning Engineers / Technicians

## Course Outline

### Transmission System Design Considerations

- AC Transmission
  - Grid Network Features
  - Transmission Security
  - Building-up Impedance Models
  - Complex Power Definitions
  - Power Factor
  - Power Factor Compensation (PFC) Techniques
  - Shunt Reactor Compensation
  - Minimum Clearance Distances
  - Line Voltage Drop
  - Electrical Loads Types and Behaviour
  - Single Wire Earth Return (SWER)
  - Balanced 3-phase System
  - Unbalanced 3-phase Systems
  - Symmetrical Components
  - Sequence Networks
  - Wye-connected & Delta-connected Loads
  - Voltage Regulation
  - Power Angle & Power Transfer
  - Steady State Stability Limit
  - Transmission Line Terms (span, sag, cross arm, clearance)
  - Transmission Line Surge Impedance and Propagation
  - Overhead Line Conductors (AAC, AAAC, ACSR)
  - Bundles Conductors
  - Overhead Line Insulators
  - Line Supporting Structure (wood & concrete poles, towers)
  - Power Transfer Capability, Current Carrying Capacity
  - Transmission Line Loadability
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## Transformers & Switchgears

- Transformer Theory
- Transformer Construction
- Transformer Cooling
- Transformer Voltage Control
- Power Transformers vs. Distribution Transformers
- Transformer Installation
- Transformer Fire Protection
- Air Blast Circuit Breakers
- Bulk Oil & Minimum Oil Circuit Breakers
- SF6 Circuit Breakers
- Vacuum Circuit Breakers
- Circuit Breaker Ratings
- Auto-reclosers
- Switchgear Options
- Outdoor & Indoor MV Switchgear
- MV Switchgear Panel Configurations & Auxiliary Devices
- MV Switchgear Ratings
- LV Molded Case Circuit Breaker (MCCB)
- LV Miniature Circuit Breaker (MCB)

## Distribution System Design Considerations

- Load Models
  - Typical Characteristics of An Industrial Distribution System
  - Distribution System Types and Components
  - Electrical Safety & Power Security
  - Voltage Classification
  - Multiple Voltage Levels in Power Distribution
  - Distribution Configurations and Redundancy
  - Distribution Expandability
  - Distribution System Planning
  - Electricity Demand & Future Growth
  - Equipment Sizing / Ratings
  - HV Power Cables Types & Sizing
  - Selection of Appropriate Equipment
  - System Studies & Software Packages
  - Embedded (in-plant) Generation
  - Parallel Operation of Utility with Embedded Generation
  - Integrating Embedded Generation with Plant Distribution
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## Power System Analysis Techniques and Calculations

- Transmission Line Self and Mutual Inductances
- Transmission Line Transposition
- Transmission Line Modeling (short, medium, long)
- Transmission Line ABCD Parameters
- Lossless Line
- Complex Power Flow (single-phase analysis)
- Complex Power Flow (3-phase analysis)
- Bus Admittance Matrix (Ybus)
- Bus Impedance Matrix (Zbus)
- Power Flow Terms and Equations
- Geometric Mean Distance (GMD)
- Geometric Mean Radius (GMR)
- Swing (slack) Bus, Load (PQ) Bus, Voltage Controlled (PV) Bus
- Network Nodal Analysis
- Iterative Solutions to Linear Equations
- Gauss-Seidel Iterative Solution
- Newton-Raphson Iterative Solution

## Power System Protection, Stability, and Switching

- Protection Objectives
  - Protection Sensitivity, Stability, and Reliability
  - Main & Backup Protection
  - Symmetrical & Asymmetrical Faults
  - Power System Stability
  - Impacts of Electric Faults
  - Fuse Protection
  - Circuit Breaker Protection
  - Relay Protection (types, functions, construction, technology)
  - Trip Circuit Supervision (TCS)
  - Per Unit (PU) System
  - Fault Calculations
  - Protection Zones & Overlap
  - Short Circuit Capacity (SCC)
  - Balanced 3-phase Fault
  - Unbalanced Single-Phase-to-Ground Fault
  - Unbalanced Phase-to-Phase Fault
  - Unbalanced Phase-to-Phase-to-Ground Fault
  - Fault Indicator
  - Overcurrent Protection
  - Earth Fault Protection
  - Lightning Protection
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