

# GULF INSTITUTE



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# Substation Design & Operation

## INTRODUCTION

- This Substation Design & Operation training seminar has been designed to provide a clear and perfect understanding of transmission & zone substation primary and secondary systems.
- Power systems are comprised of transmission, distribution, and generation. In order to control the line losses and voltage drop percentages within these systems, power companies and industrial consumers normally design and install substations at different locations and at different voltage levels, which facilitate not only the monitoring and instrumentation of system parameters, but also they will help companies, utilities, and industrial loads to bring under control and improve their power factor, demand factor, load factor, tele-protection, overload, fault clearance times, critical and essential loads, and equipment ratings.
- The primary system component covers the installation, commissioning, testing, maintenance, operation and design of switchgears and switchyards, power transformers, service transformers, switching devices (circuit breakers, disconnect switches, earthing switches, etc.), gantry towers, cable trenches and cable ducts, and substation buildings. The primary component also discusses clearance distances, cable and transformer sizing, lightning/switching impulse/power frequency protection (surge arresters and surge diverters), basic insulation level (BIL), instrument transformer types, substation geotech and feasibility studies, substation location, and load studies. In this training seminar the participants will have the opportunity to discuss the pros and cons of different busbar configurations and build up single line diagrams and layout diagrams as the main tools for system analysis. The participants will also have the opportunity to determine the system voltage profile together with the technical specifications of switchgears, outdoor circuit breakers and busbars, power cables, etc.
- The secondary system component covers the installation, commissioning, testing, maintenance, operation and design of protection relays, fuses, circuit breakers, reclosers, sectionalizers/load break switches, fault recorders, and other protection, control, and instrumentation devices. The secondary system component also discusses some popular protection and control logics, SCADA systems, COMMS protocols and applications, intertripping techniques, overload control, load shedding, automation and remote control, earthing systems, batteries and battery chargers, AC and DC auxiliary systems and panels, power factor compensation (PFC) techniques, power quality issues (such as harmonics, voltage flicker, sag, swell, etc.), and the impacts and applications of embedded generation. In this training course, the participants will have the opportunity to calculate fault currents and system impedances by means of Per Unit system, and practice power system circuitry analysis, fault root cause analysis, propose appropriate protection schemes and choose suitable CT's, VT's, and relays for different scenarios through industry-based practical worked examples and mini projects to achieve an optimized and coordinated operation of control and protection devices in typical complex power systems.

This training seminar will highlight:

- Substation construction, installation, and operation
- Power system protection
- Substation equipment selection and specifications
- Substation automation
- Substation earthing systems

## OBJECTIVES

- Determine the location and busbar configuration of a typical substation
- Propose specifications for major substation equipment
- Create single line, layout, and schematics diagrams
- Select fit-for-the-purpose protection relays and other related devices
- Calculate fault levels and loadings of feeders and branches
- Analyze protection logics and coordination between protection devices

## TRAINING METHODOLOGY

- This Electrical Engineering training programme will be presented by means of Power Point slides through which all the required theory and equations will be provided. This training programme 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 programme via quizzes, questions, assignments, and worked examples.

## ORGANISATIONAL IMPACT

- Develop a structured approach and understanding of substation types and functions
- Build up a systematic approach to substation planning and feasibility studies
- Correct selection of substation busbar configuration to ensure flexible switching and loading
- Calculation of fault levels, propose protection settings, and demonstrate protection coordination
- Become familiar with substation construction challenges and solutions
- Practice on substation equipment sizing/rating and the associated calculations

## PERSONAL IMPACT

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

- Power system analysis including load and fault studies
- Role of zone substations and their associated protection and control gears
- Theoretical concepts and practical equations of earthing and power system protection
- Power system switching & operation

## WHO SHOULD ATTEND?

- We encourage the staff involved in the operation, planning, design, and maintenance of power systems to attend this training course.

This training course 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

### Role of Substations in Power Networks

- Power System Principles & Circuit Analysis
- Complex Numbers and Engineering Math
- Substation Types
- Substation Drawings and Diagrams (SLD, Layout, Schematics, Auxiliary AC & DC)
- Substation Main Components
- Substation Location
- Soil Parameters and Calculations
- Substation Busbar Configuration
- Substation Voltage Selection
- Environmental issues in the location of a switchyard and mitigation techniques

### Substation Major Equipment

- Circuit Breaker Types & Applications
- Switchgear Types, Components, and Applications
- Auto-reclosers
- Sectionalizers
- Disconnect Switches
- RMU's
- Earthing Switches
- SF6 Properties
- GIS Substations
- HV Cables Types & Calculations
- Power & Distribution Transformers
- Batteries & Battery Chargers
- Power Conditioner

## Substation Studies & Calculations

- Power System Studies
- Power System Planning
- Substation Load Studies
- Per Unit System
- Fault Calculations
- Switchyard Lightning Protection
- Instrument Transformers (CT's & VT's)
- Earthing Systems

## Substation Protection & Control

- Power System Studies
- Power System Planning
- Protection Zones, Local & Backup Protection
- Sequence Networks
- Fuse Types, Applications, Selection, and Coordination
- Protection Relay Types and Functions
- Protection Relaying Technology
- Overcurrent Protection
- Earth Fault Protection
- IDMT O/C & E/F Protection
- Definite Time (DT) Protection
- High-set Instantaneous Protection
- Transient Overreach
- Transformer O/C and E/F Protection
- Transformer Unit Protection (REF and Diff)

## Substation Safety Issues

- Ungrounded vs. Grounded Systems
- Touch & Step Voltages, Mesh Voltage
- Earth Potential Rise (EPR), Transferred Voltages
- Soil Resistivity
- Verification of Adequacy
- Lightning Protection Techniques (rolling spheres, cone of protection)
- Embedded Generation
- Power Factor Compensation (PFC)
- Power Quality (harmonics, voltage flicker)
- Clearance Distances

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