

KOENIG SOLUTIONS • COURSE OUTLINE

# ETAP Substation: Load Flow, Fault & Relay Coordination

Learn to design, model and protect substations using ETAP, covering load flow, fault analysis and relay coordination.

**5 Days**

DURATION

**71**

TOPICS

**6**

HANDS-ON ACTIVITIES

## COURSE OVERVIEW

This comprehensive course covers the essential aspects of substation design and operation within power networks. Participants will gain insights into the role of substations, detailed equipment knowledge, system studies, protection and control strategies, as well as safety practices. The course also incorporates practical training using ETAP software for modeling and analysis to enhance understanding and application.

## WHO THIS COURSE IS FOR

**Electrical engineers involved in power system design, operation, and maintenance**

**Utility professionals seeking to improve substation design skills**

**Protection and control engineers**

**Graduate students specializing in power systems**

## PREREQUISITES

- Basic knowledge of electrical power systems and circuit analysis
- Familiarity with complex numbers and engineering mathematics

## LEARNING OBJECTIVES

- To understand the fundamental roles and components of substations in power networks
- To learn about major substation equipment and their applications
- To develop skills in substation studies and calculations including load flow and fault analysis
- To gain proficiency in substation protection and control principles
- To explore safety considerations and grounding system design
- To acquire hands-on experience with ETAP software for substation modeling, analysis, and protection coordination

# 71 Topics

## DAY 1 Fundamentals & Substation Overview

### TOPICS

- 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 Switchyard Location and Mitigation Techniques
- Introduction to Digital Substation Design Tools (Overview of ETAP, DlgSILENT PowerFactory, and why ETAP is used in utility systems)

## DAY 2 Substation Major Equipment

### TOPICS

**3 Activities**

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

## TOPICS

- Power System Studies
- Power System Planning
- Substation Load Studies
- Per Unit System
- Fault Calculations
- Switchyard Lightning Protection
- Instrument Transformers (CTs & VTs)
- Earthing Systems

## ETAP MODULES

- ETAP Load Flow Analysis (Voltage profile, real & reactive power loss, bus voltages)
- ETAP Short Circuit Analysis (3-phase, L-G, L-L-G, L-L fault types - ANSI/IEC standards)
- ETAP Ground Grid Modeling (Touch and step potential calculations)

## TOPICS

3 Activities

- |                                                         |                                                                |
|---------------------------------------------------------|----------------------------------------------------------------|
| ■ Power System Studies                                  | ■ Definite Time (DT) Protection                                |
| ■ Power System Planning                                 | ■ High-set Instantaneous Protection                            |
| ■ Protection Zones, Local & Backup Protection           | ■ Transient Overreach                                          |
| ■ Sequence Networks                                     | ■ Transformer O/C and E/F Protection                           |
| ■ Fuse Types, Applications, Selection, and Coordination | ■ Transformer Unit Protection (REF and Differential)           |
| ■ Protection Relay Types and Functions                  | ■ Buchholz & Pressure Relief                                   |
| ■ Protection Relaying Technology                        | ■ Transformer Differential Protection Complexities & Solutions |
| ■ Overcurrent Protection                                | ■ Interposing CTs                                              |
| ■ Earth Fault Protection                                | ■ Transformer-Feeder Protection Schemes                        |
| ■ IDMT O/C & E/F Protection                             |                                                                |

## TOPICS

- 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
- ETAP Ground Grid Safety Simulation (Mesh voltage, Step/Touch analysis, EPR mitigation)

## ETAP REPORT GENERATION &amp; PROJECT WRAP-UP

- How to export one-line diagrams, study reports, TCC plots

## Hands-On Labs Using ETAP (Suggested Daily)

## TOPICS

**Day 2:** Equipment modeling & one-line diagram · **Day 3:** Load Flow & Fault Study · **Day 4:** Protection coordination with TCC · **Day 5:** Grounding system analysis

## HANDS-ON ACTIVITIES

## Practise What You Learn

| MODULE                          | ACTIVITY                                                                        |
|---------------------------------|---------------------------------------------------------------------------------|
| Substation Major Equipment      | <b>ETAP PRACTICAL: SUBSTATION EQUIPMENT MODELING</b>                            |
|                                 | ■ Create one-line diagram with transformers, breakers, switches                 |
|                                 | ■ Define busbars, CTs/VTs, and instrument transformers                          |
|                                 | ■ Model GIS vs AIS switchgear                                                   |
| Substation Protection & Control | <b>ETAP RELAY COORDINATION STUDY</b>                                            |
|                                 | ■ Time-Current Characteristic (TCC) Curve plotting and relay grading            |
|                                 | ■ Protection coordination between relays, breakers, fuses                       |
|                                 | ■ ETAP Protection Zone Simulation (Create overlapping primary and backup zones) |

#### WHAT IS INCLUDED

## Everything You Need to Succeed

- Koenig course material for every module
- Delivery by certified instructors and subject matter experts
- Hands-on exercises throughout the course
- Course completion certificate from Koenig

#### ABOUT KOENIG

## Who We Are

Established in 1993, Koenig Solutions is a globally recognised training provider with 35+ technology partnerships, 5,000+ training programmes and a network of certified instructors and subject matter experts, supporting individuals and enterprise teams worldwide.

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