Definition and Purpose of Substations (Part 2)

Milav Dabgar

Definition and Purpose of Substations (Part 2)

- Course: Substation Engineering (DI04009011)
- Unit 1: Introduction
- Lecture 2

Recap of Primary Purposes

- Voltage Transformation (Transformers)
- Switching (Circuit Breakers and Isolators)
- Protection (Relays)
- Power Factor Correction
- Voltage Regulation

Purpose 4: Data Acquisition and Metering

- Substations serve as major data collection points.
- Voltage, current, real power (MW), and reactive power (MVAR) are continuously monitored.
- Energy meters record the power flowing through for billing and accounting.
- Instrument Transformers (CTs and PTs) scale down high values for measuring instruments.

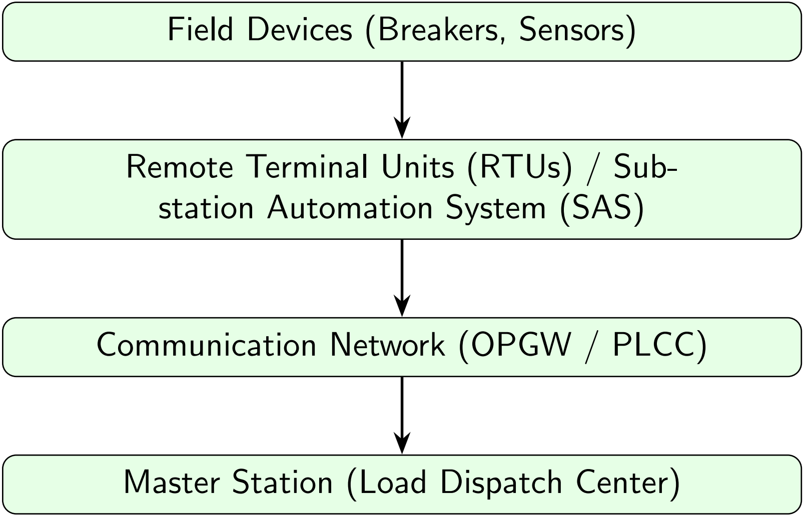
Instrument Transformers (CTs and PTs)

Current Transformer (CT)	Potential Transformer (PT)
Steps down high current (e.g., 1000A to 1A) for relays and meters.	Steps down high voltage (e.g., 220kV to 110V) for measurement.

Purpose 5: Communication Hub

- Substations communicate with the central Load Dispatch Center (LDC).
- Power Line Carrier Communication (PLCC) uses transmission lines for data transfer.
- Modern substations use Optical Ground Wire (OPGW) for high-speed fiber-optic communication.
- Transmits SCADA (Supervisory Control and Data Acquisition) data.

SCADA Integration



Purpose 6: Grid Synchronization

- Connecting two grids or bringing a generator online requires synchronization.
- Voltage magnitude, frequency, and phase angle must match exactly.
- Substations provide the point of connection and the synchronizing relays to perform this safely.
- Prevents massive electrical and mechanical shocks to the system.

Purpose 7: Load Shedding and Frequency Control

- When generation falls short of demand, grid frequency drops.
- To prevent a blackout, load must be temporarily disconnected (Load Shedding).
- Under-Frequency Relays (UFR) in substations detect this drop.
- They automatically trip specific distribution feeders to balance the grid.

Role of Substations in Smart Grids

- Transitioning from passive nodes to active, intelligent hubs.
- Integration of renewable energy sources (solar/wind farms).
- IEC 61850 standard for Substation Automation.
- Bi-directional power flow management.

IEC 61850 standard

- International standard for communication in electrical substations.
- Replaces hardwired connections with ethernet-based digital communications.
- Enables interoperability between equipment from different vendors.
- Features GOOSE (Generic Object Oriented Substation Event) messaging for fast protection.

Grid Stability and FACTS

- Flexible AC Transmission Systems (FACTS).
- Installed in key substations to enhance controllability and increase power transfer capability.
- Examples: STATCOM, SVC, TCSC.
- Provide fast-acting reactive power compensation.

Safety and Grounding

- Substations provide a safe environment for high-voltage operations.
- Extensive earth mat (grounding grid) installed below the substation.
- Ensures step and touch potentials remain within safe limits during a fault.
- Provides a low-resistance path for fault currents to earth.

Substation Security

- Physical Security: Fencing, lighting, cameras, access control.
- Cyber Security: Protecting SCADA and automation networks from hackers.
- Both are critical, as substations are vital national infrastructure.

Summary

- Substations are the brains and the brawn of the grid.
- They gather vital operational data and house communication links.
- They protect the grid from collapse via synchronization and load shedding.
- They are evolving rapidly to meet the demands of the Smart Grid.