Substation Engineering: Typical Layout of Substations

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Typical Layout of Substations

- Course: Substation Engineering
- Lecture 6: Typical Layout of Substations
- Unit 2: Substation Layout and Equipment

Agenda

- Introduction to Substation Layout
- Single Line Diagram (SLD)
- Major Switchyard Components
- Busbar Arrangements
- Electrical Clearances
- Control Room Layout

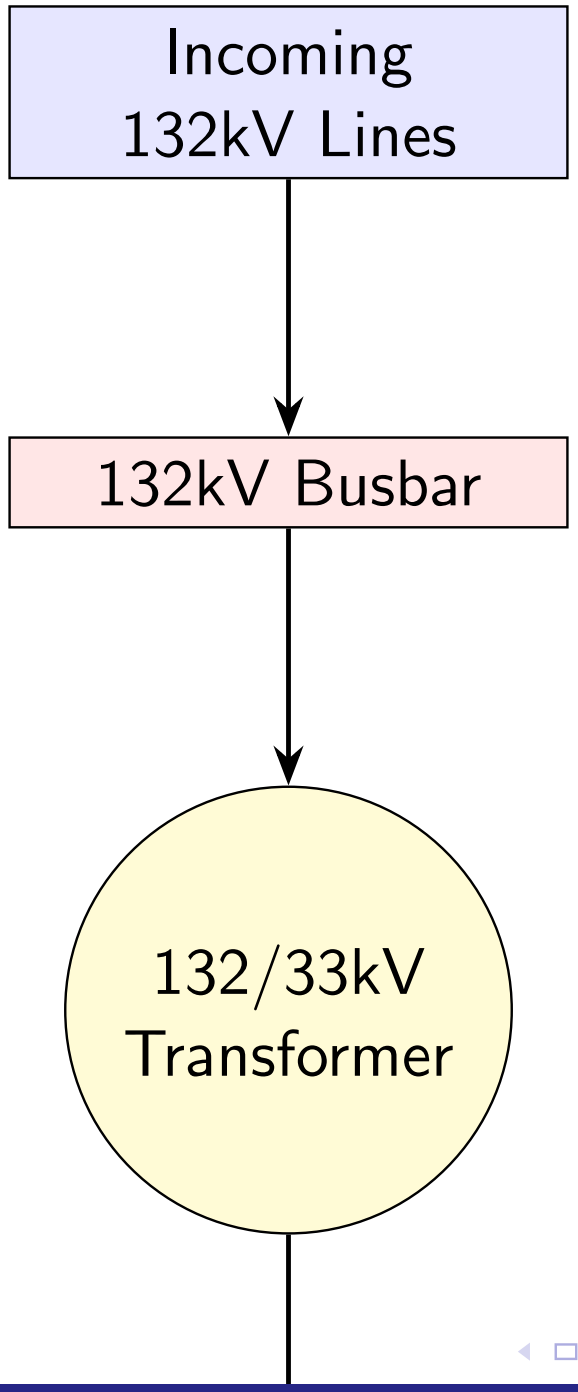
Introduction to Substation Layout

- A substation layout must ensure safe operation and maintenance.
- It provides a physical translation of the electrical circuit.
- Key goals include minimizing land use while maximizing reliability.
- Layouts must account for future expansion (additional bays).
- Separation of high voltage and low voltage zones is mandatory.

Single Line Diagram (SLD)

- The SLD represents the electrical connections of the substation in a simplified manner.
- Uses standardized symbols for components (CB, CT, PT, Isolator).
- Shows the sequence of equipment in a bay.
- Serves as the blueprint for creating the physical 3D layout.
- Essential for operational switching and interlocking logic.

SLD of a Typical 132/33kV Substation



Major Switchyard Components

- Lightning Arresters (LA): Placed at the line entry to protect against surges.
- Current & Potential Transformers (CT & PT): Used for metering and protection.
- Isolators (Disconnectors): Provide visible isolation for maintenance.
- Circuit Breakers (CB): Interrupt fault currents.
- Power Transformers: The heart of the substation for voltage stepping.

Layout Planning Criteria

- Topography and soil conditions of the site.
- Incoming line corridors and approach angles.
- Environmental conditions (pollution, altitude, seismic zone).
- Accessibility for heavy equipment transport (e.g., transformers).
- Statutory regulations and environmental clearances.

Typical Busbar Arrangements

- Single Bus Scheme: Simple, low cost, but low reliability (bus fault causes total outage).
- Main and Transfer Bus: Allows maintenance of bay circuit breaker without interrupting the feeder.
- Double Bus Double Breaker: Highly reliable, but very expensive; used in EHV stations.
- One and a Half Breaker Scheme: Best balance of reliability and cost for 400kV and above.
- Ring Main: Economical with high reliability, but limited expandability.

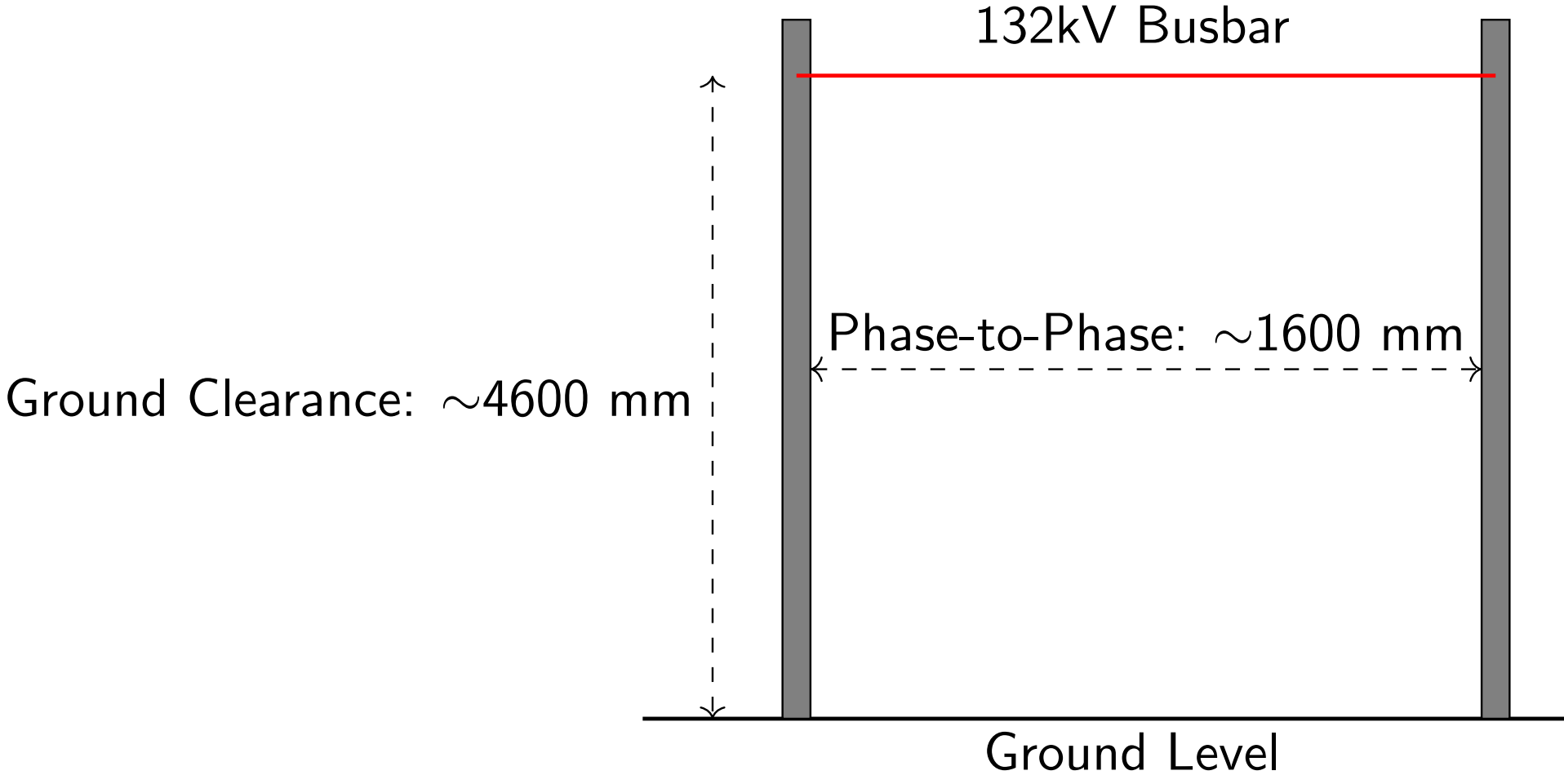
Comparison of Busbar Schemes

Scheme	**Cost**	**Reliability**	**Footprint**
Single Bus	Lowest Cost	Poor Reliability	Smallest Footprint
Main & Transfer	Medium Cost	Good Reliability	Medium Footprint
Double Bus	High Cost	Very Good Reliability	Large Footprint
One and a Half CB	Highest Cost	Excellent Reliability	Very Large Footprint

Electrical Clearances

- Clearances are minimum distances required to prevent electrical flashover in air.
- Phase-to-Earth Clearance: Distance from live part to grounded structure.
- Phase-to-Phase Clearance: Distance between two adjacent live phases.
- Sectional Clearance: Safe distance for a person to work on de-energized equipment near live parts.
- Ground Clearance: Minimum height of live parts above ground level.

Phase and Ground Clearances



Control Room Layout

- Usually located strategically to provide a clear view of the switchyard.
- Houses Control and Relay (C&R) panels, SCADA RTUs.
- Contains the AC and DC distribution boards (Battery banks).
- Requires cable trenches originating from the switchyard to enter the building.
- Air-conditioned environment to protect sensitive electronic relays.

Key Takeaways

- A Single Line Diagram is the foundational blueprint of any substation.
- Busbar arrangement choice dictates the cost, reliability, and physical footprint.
- Electrical clearances are mandatory for safety and preventing flashovers.
- Physical layout must account for heavy equipment access and maintenance space.

Next Lecture Preview

- Introduction to Power Transformers in Substations
- Core and Winding Construction
- Vector Groups and Tap Changers