Substation Engineering
Lecture 11: Busbars (Part 1 of 2)

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Busbars in Substations

- Substation Engineering (DI04009011)
- Lecture 11: Busbars (Part 1 of 2)
- Functions, Materials, and Basic Configurations

Agenda

- Introduction to Busbars
- Functions of a Busbar System
- Busbar Materials (Copper vs. Aluminum)
- Types of Busbar Profiles
- Basic Busbar Configurations
- Single Busbar System
- Double Busbar System

What is a Busbar?

- A busbar is a metallic strip or bar that conducts electricity within a switchboard, distribution board, substation, or other electrical apparatus.
- It serves as a common connection point for multiple incoming and outgoing circuits.
- Derived from the Latin word 'omnibus', meaning 'for all' (a common collector).
- They carry large currents and are uninsulated in outdoor switchyards, supported by insulators.

Primary Functions

- Collects electrical power from incoming feeders.
- Distributes electrical power to outgoing feeders.
- Provides flexibility in routing power during maintenance or faults.
- Acts as a rigid or flexible structural element capable of withstanding electromagnetic forces during short circuits.

Busbar Materials

- Copper (Cu): Traditionally used due to high electrical conductivity and superior mechanical strength.
- Aluminum (Al): Currently the most common material for outdoor substations due to lower cost and lighter weight.
- Silver (Ag): Used for contact plating to reduce contact resistance, but not for the main busbar.
- Galvanized Steel: Sometimes used for very high voltage, low current applications or as a reinforcing core.

Copper vs. Aluminum Properties

Property	Copper	Aluminum
Conductivity	100% (IACS reference)	$\sim$ 61% (IACS)
Density (g/cm^3)	8.96 (Heavy)	2.70 (Light)
Tensile Strength	High	Moderate
Cost	High	Low
Corrosion Resistance	Very Good	Good (forms protective oxide layer)

Types of Busbar Profiles

- Flat Strips: Common in indoor panels; easy to connect and bend.
- Tubular (Hollow Cylinder): Standard for high voltage outdoor substations; excellent rigidity and reduced corona loss.
- Solid Round: Used for lower currents; heavy and prone to skin effect at larger diameters.
- Stranded Flexible Cables: Used in 'strain' bus systems, suspended between gantry towers like transmission lines.

Skin Effect and Corona in Busbars

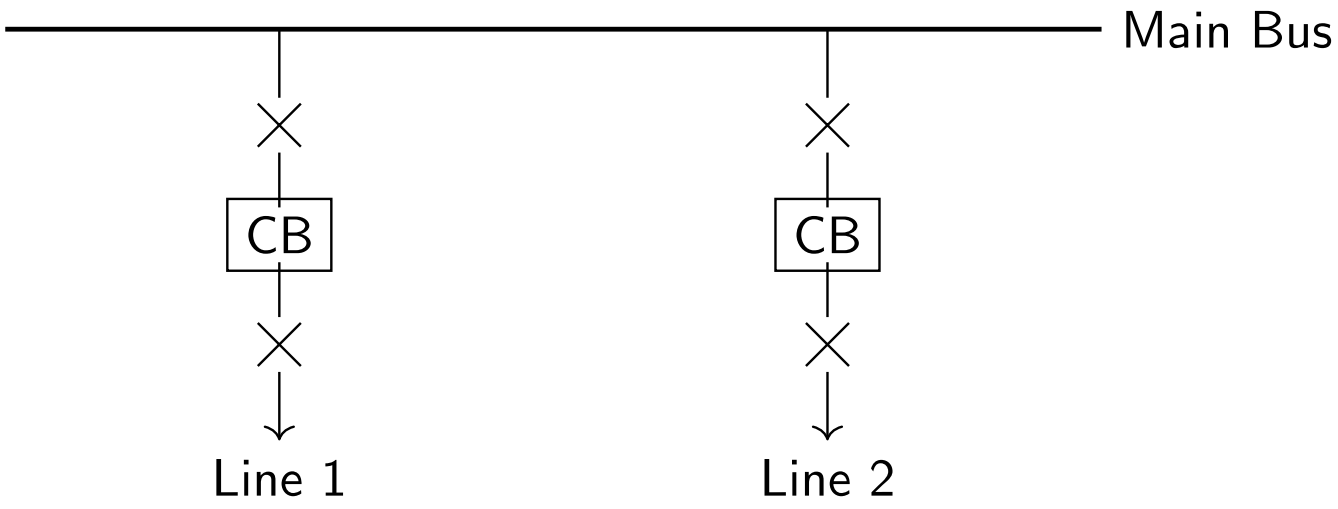
- Skin Effect: Alternating current tends to flow near the surface of the conductor. A hollow tube uses material efficiently.
- Corona Discharge: High electric field at sharp edges ionizes the surrounding air.
- Round and tubular profiles eliminate sharp edges, mitigating corona loss and audible noise at EHV (Extra High Voltage) levels.
- Spacing: Adequate clearance between phases is critical to prevent flashovers.

Busbar Arrangement Criteria

- Selecting a busbar arrangement depends on several factors:
- System Voltage and Capacity.
- Reliability and Continuity of Supply (Can a fault shut down the whole station?).
- Flexibility for Maintenance (Can breakers be isolated without losing load?).
- Initial Cost and Available Space.
- Simplicity of Protection Schemes.

Single Busbar System

- The simplest and least expensive configuration.
- All incoming lines and outgoing loads are connected to a single, continuous busbar.
- Each line has one circuit breaker and two isolators.
- Requires minimal space and is easy to operate.

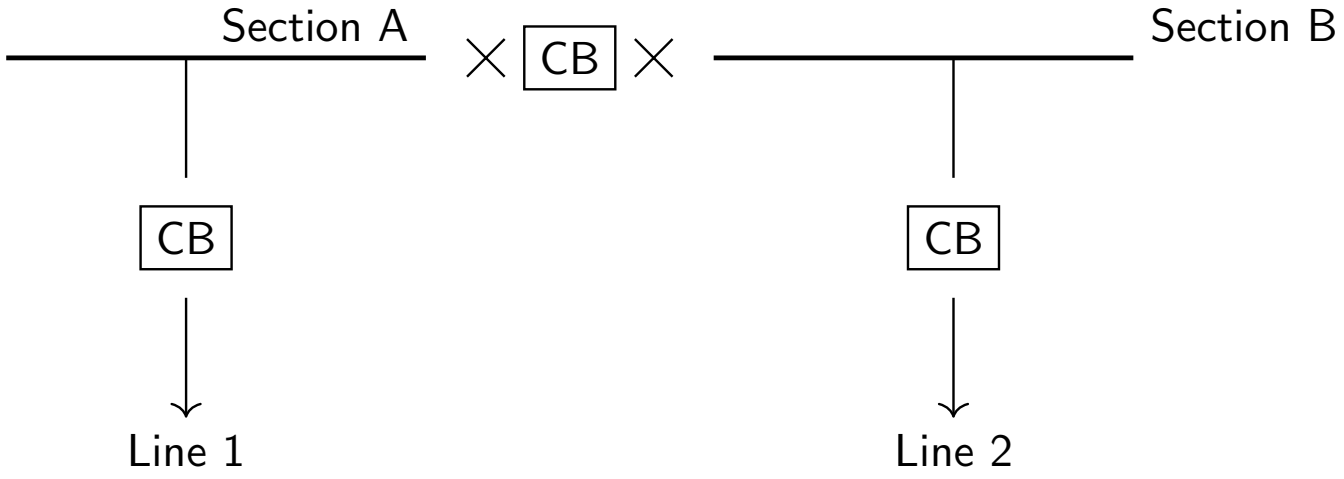


Single Busbar System: Disadvantages

- Low Reliability: A fault on the busbar causes a complete station outage.
- Difficult Maintenance: To clean or maintain the busbar, the entire substation must be de-energized.
- Breaker Maintenance: If a circuit breaker fails or needs maintenance, its associated line must be shut down.
- Usage: Typically limited to small, low-voltage distribution substations.

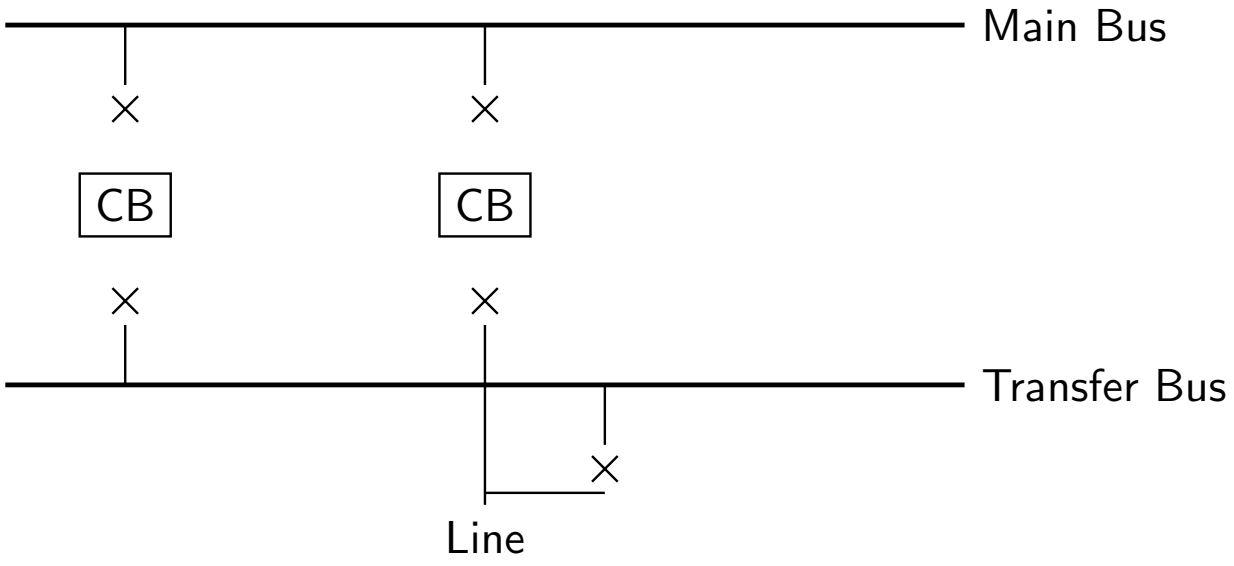
Single Busbar System with Sectionalization

- The main bus is divided into sections by a bus-coupler breaker and isolators.
- If a fault occurs on one section, only half the substation is lost.
- Allows maintenance on one bus section while the other remains active.
- Improves reliability over a plain single bus with minimal extra cost.



Main and Transfer Bus System

- Consists of a 'Main' busbar and an auxiliary 'Transfer' busbar.
- Includes a special 'Bus Coupler' breaker connecting the two buses.
- Allows any line breaker to be taken out of service for maintenance while keeping the line active.
- The line is temporarily routed through the Transfer Bus and protected by the Bus Coupler breaker.



Operation of Main and Transfer Bus

- To maintain Feeder 1's breaker:
- 1. Close the Bus Coupler breaker (energizes the Transfer Bus).
- 2. Close Feeder 1's isolator to the Transfer Bus.
- 3. Open Feeder 1's main circuit breaker.
- Feeder 1 is now supplied via the Transfer Bus and protected by the Bus Coupler breaker.
- Drawback: A fault on the Main Bus still causes a total outage.

Summary of Basic Configurations

- Busbars act as the main electrical junction in a substation.
- Aluminum is the preferred material for outdoor high-voltage busbars.
- Tubular shapes are favored to mitigate corona and skin effect.
- Single Bus: Cheap but unreliable.
- Sectionalized Bus: Better reliability for minimal cost.
- Main & Transfer Bus: Allows breaker maintenance without losing the load.