ELG4125: Substations

Substation may be defined as an assembly of apparatus installed to perform switching, voltage transformation, power factor correction, power and frequency-converting operations.

Site Selection

Voltage level; Voltage regulation; Cost of sub-transmission; Primary feeder mains, etc. In general, Substation should be located near the load center

Classification of Substations

- **Transformer Substations:**
  - Transmission or Primary: (11 kv-33 kV) to (220 kV and Above.
  - Sub-transmission or Secondary: Above 132 kV to (11 kv-33 kV).
  - Step-down or Distribution: From Sub-transmission to consumers.
- **Industrial Substations:** For large industrial consumers.
- **Switching Substations:** For switching operations of power lines without the transformation of voltage.
- **Synchronous Substations:** These are phase modifiers for the improvement of power factor.

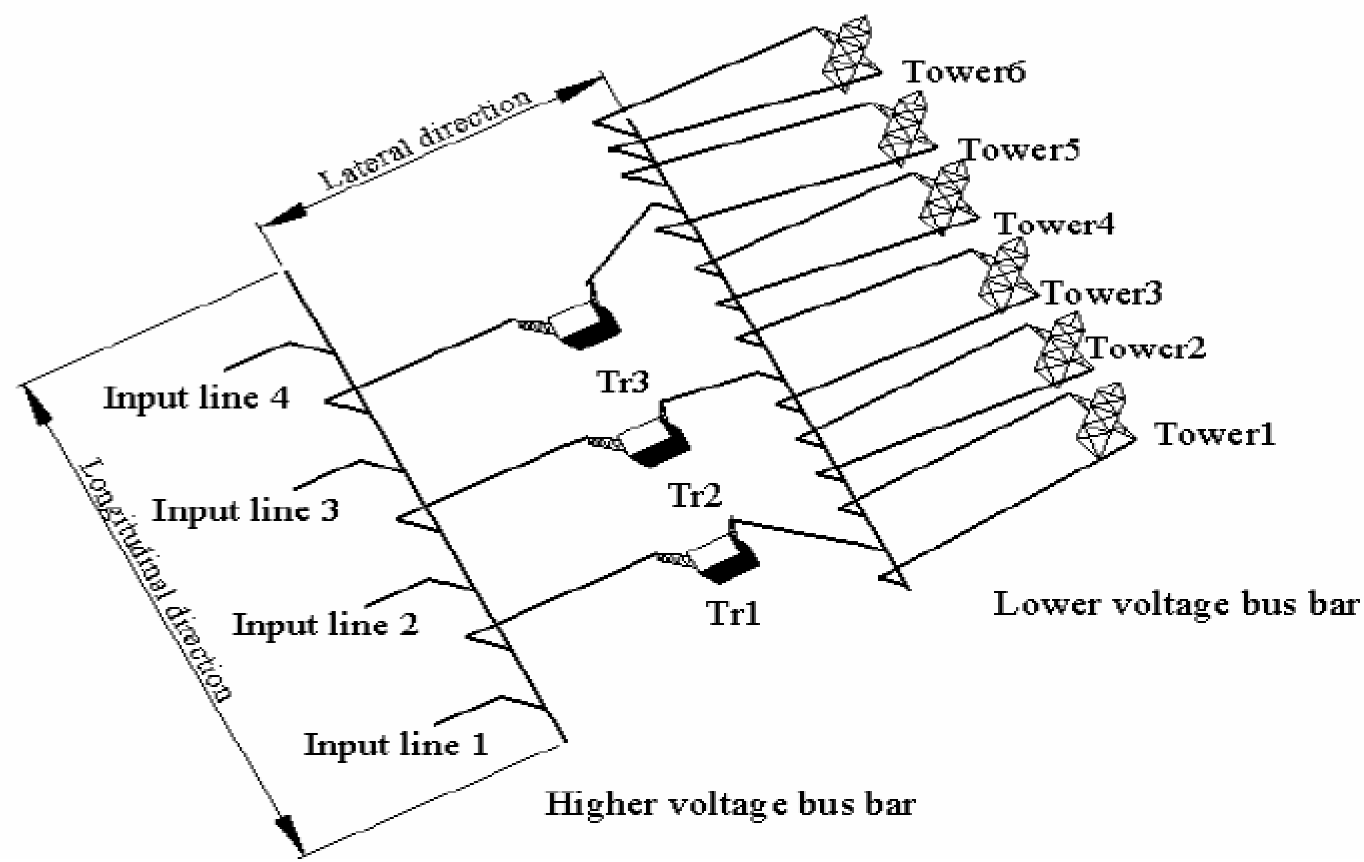
- Substations may be
  - Indoor up to 11 kV.
  - Outdoor (pole-mounted or foundation mounted) for high voltages!

Substation Operation

Substation Equipment

- Bus Bars (Copper or Copper-clad steel)
  - Single
  - Double with circuit breakers (one or two, or more)
  - Ring
- Switchgears
- Isolators
- Transformers
  - Power Transformers
  - Instrument Transformers
- Relays
- Lightning Arresters
- Fire-fighting Equipment
- Substation for Auxiliary Supply.

Layout Diagram of Single Bus Bars

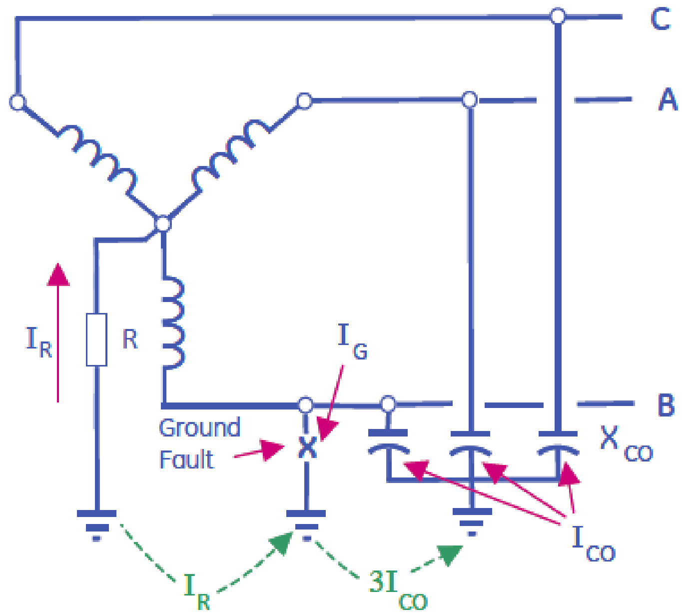


Earthing or Grounding

- The word “**grounding**” and “**earthing**” has the same meaning.
- Equipment grounding refers to connecting the non-current carrying metallic parts to earth (motor body, switch gear, transformer) to ensure safety against damage, fire, etc.
- Neutral grounding refers to connecting the neutral of a Y circuit to earth to ensure that the stator short circuit current is limited. Its main purpose is stability as well as protection. Methods of neutral grounding are:
  - Solid Grounding
  - Resistance Grounding
  - Reactance Grounding
  - Resonant Grounding
  - Voltage Transformer Grounding.

Resistive Grounding

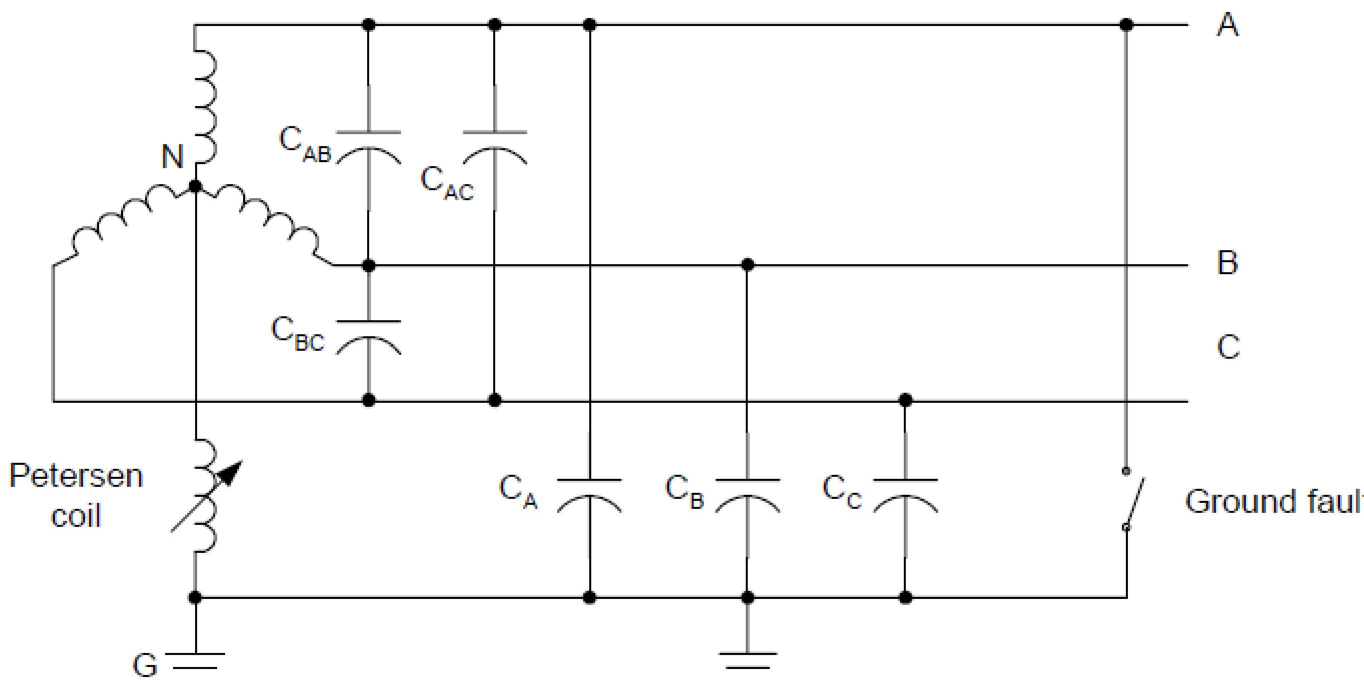
Typical Ground Circuit
(transformer secondary)



$3I_{CO}$ = Total Capacitance Charging Current
I_R = Ground Resistor Current
I_G = Ground Fault Current
R = High Resistance Charging Current
X_{CO} = Inherent System Charging Current

$R \leq X_{CO} / 3$ & $I_R \geq 3I_{CO}$

Peterson-Coil Grounding



$$L = \frac{1}{3w^2C}$$

This condition states that the inductance must be tuned to the capacitance if the Peterson coil is to fulfill its function.