Power System Design

Unit-1

Per unit system representation

Per unit system (pu)

- The per unit value of any quantity is defined as the ration of the actual value of quantity to its base value.
- PU of any quantity $=\dfrac{\text{Actual value of quantity in any unit}}{\text{Base value of same quantity in same unit}}$
- It is expressed as in decimal.
- Voltage ,current, KVA and impedance are so related that selection of base values for any two of them determines the base values of remaining two. If we specify the base base values of current and voltage , than base impedance and base KVA can be determined.
- Per unit of line to neutral voltage is on line to neutral base voltage is same as the per unit of line to line voltage is on line to line base voltage if system is balanced .

Base value formulation of different quantities

$$\text{Base current, A} = \frac{\text{base kVA}_{1\phi}}{\text{base voltage, kV}_{LN}}$$

$$\text{Base impedance, } \Omega = \frac{\text{base voltage, V}_{LN}}{\text{base current, A}}$$

$$\text{Base impedance, } \Omega = \frac{(\text{base voltage, kV}_{LN})^2 \times 1000}{\text{base kVA}_{1\phi}}$$

$$\text{Base impedance, } \Omega = \frac{(\text{base voltage, kV}_{LN})^2}{\text{MVA}_{1\phi}}$$

$$\text{Base power, kW}_{1\phi} = \text{base kVA}_{1\phi}$$

$$\text{Base power, MW}_{1\phi} = \text{base MVA}_{1\phi}$$

$$\text{Per-unit impedance of an element} = \frac{\text{actual impedance, } \Omega}{\text{base impedance, } \Omega}$$

Base quantity in 3-phase system.

$$\text{Base current, A} = \frac{\text{base kVA}_{3\phi}}{\sqrt{3} \times \text{base voltage, kV}_{LL}}$$

$$\text{Base impedance} = \frac{\left(\text{base voltage, kV}_{LL}/\sqrt{3}\right)^2 \times 1000}{\text{base kVA}_{3\phi}/3}$$

$$\text{Base impedance} = \frac{(\text{base voltage, kV}_{LL})^2 \times 1000}{\text{base kVA}_{3\phi}}$$

$$\text{Base impedance} = \frac{(\text{base voltage, kV}_{LL})^2}{\text{base MVA}_{3\phi}}$$

PU value of changing base values

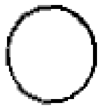
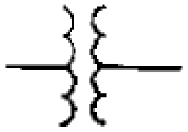
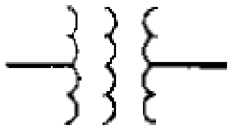
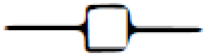
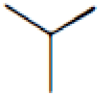
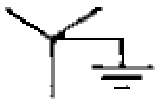
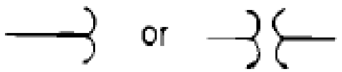
- The pu value of any quantities may calculate from old base vaue to new base (given) base value. As for example the pu value of impedance on new base value.

$$\text{Per-unit } Z_{new} = \text{per-unit } Z_{given}\left(\frac{\text{base kV}_{given}}{\text{base kV}_{new}}\right)^2\left(\frac{\text{base kVA}_{new}}{\text{base kVA}_{given}}\right)$$

Single line diagram

- Power system components is represented by simplified diagram as single line and some standard symbol of connected transmission line and associated equipment in electrical power system.
- The purpose of the one line diagram is to supply in concise form of the significant information about the system.

Apparatus symbol

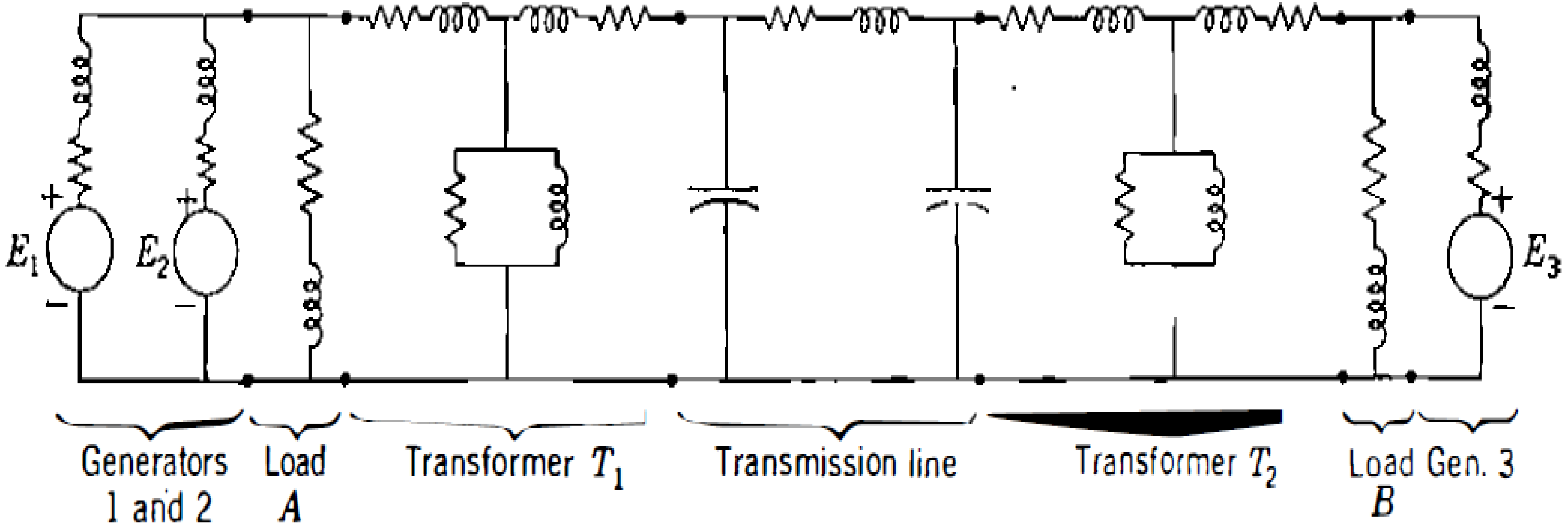
Machine or rotating armature (basic)	
Two-winding power transformer	
Three-winding power transformer	
Fuse	
Current transformer	
Power circuit breaker, oil or other liquid	
Air circuit breaker	
Three-phase, three-wire delta connection	
Three-phase wye, neutral ungrounded	
Three-phase wye, neutral grounded	
Potential transformer	
Ammeter and voltmeter	

Example of single line diagram

Impedance diagram formation procedure

- Choose an appropriate common MVA (or kVA) base for the system.
- Consider the system to be divided into a number of sections by the transformers. Choose an appropriate kV base in one of the sections. Calculate kV bases of other sections in the ratio of transformation
- Calculate per unit values of voltages and impedances in each section and connect them up as per the topology of the one-line diagram. The result is the single-phase per unit impedance diagram.

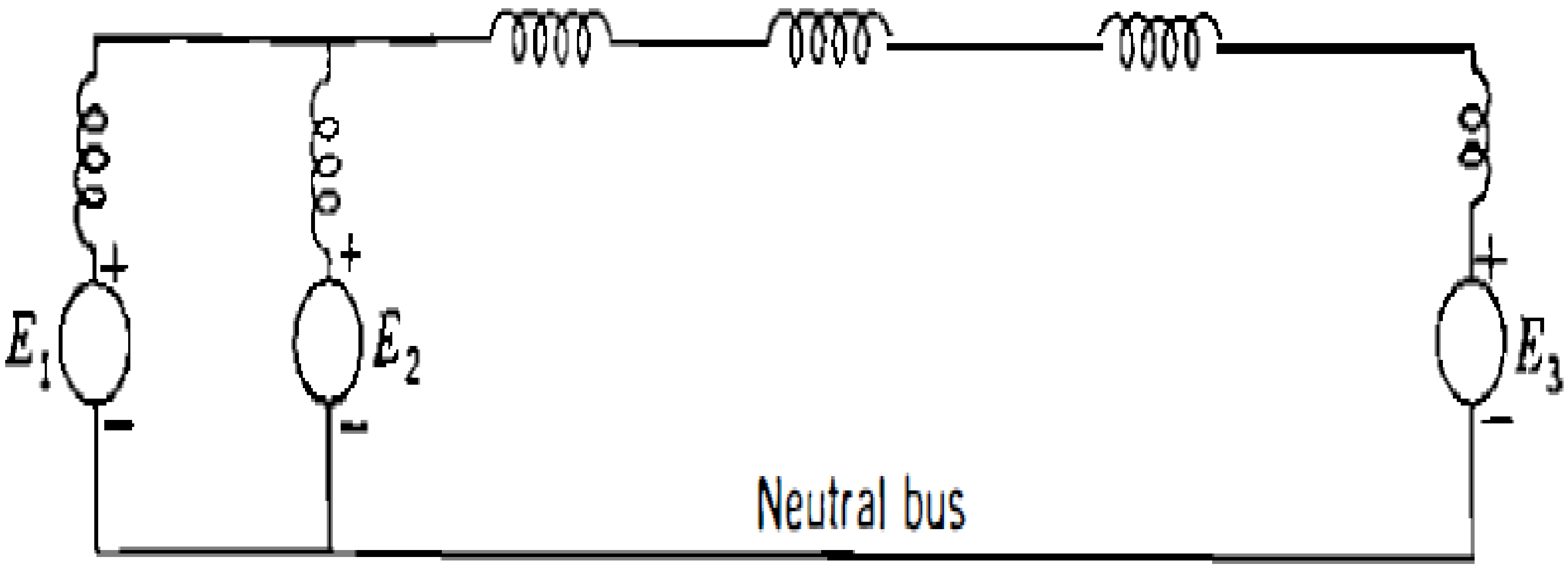
Example of Impedance diagram



Reactance diagram

- To draw the reactance diagram the following quantities are omitting from impedance diagram.
  - ✓All static loads.
  - ✓All resistances.
  - ✓Shunt admittance of each transformer.
  - ✓Capacitance of the transmission line.

Example of Reactance diagram



Thank You