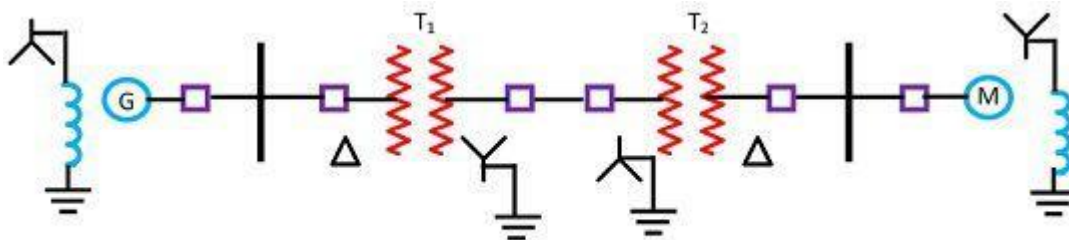


## SINGLE LINE DIAGRAM OF POWER SYSTEM

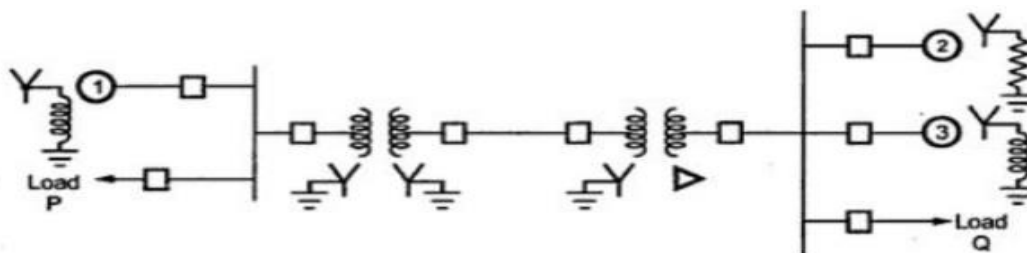
Single line diagram is the representation of a power system using the simple symbol for each component. The single line diagram of a power system is the network which shows the main connections and arrangement of the system components along with their data (such as output rating, voltage, resistance and reactance, etc.).



**Single Line Representation of a Typical Power System**

Circuit breakers are represented by rectangular blocks. It is difficult to draw the line diagram of the few components. So for simplification, the impedance diagram is used for representing the power system components.

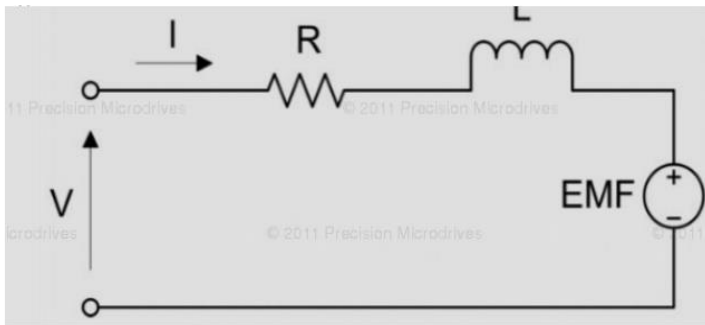
### Single Line diagram of an Electrical system



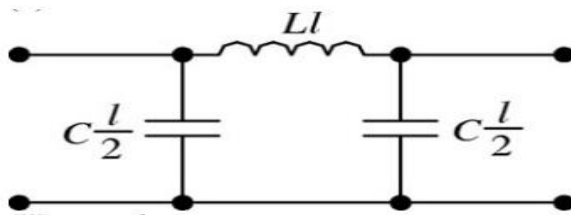
Two generators one grounded through a reactor and one through a resistor connected to a bus and through a step up transformer to a transmission lines. Another generator grounded a reactor is connected a bus and through a transformer to the opposite end of the transmission line. A load is connected to each bus. On the diagram information about the loads the ratings of the generators and transformers and reactance of different components of the circuit is often given. It is important to know the location of points where a system is connected to ground to calculate the amount of current flowing when an unsymmetrical fault involving ground occur.

## Equivalent circuit for various power system components:

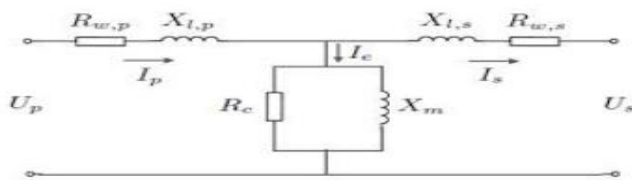
(i). Generators



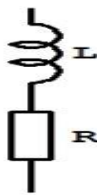
(ii). Transmission lines



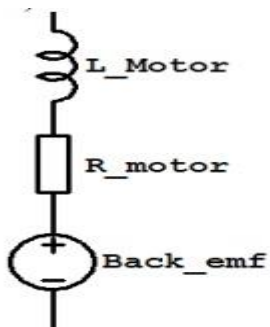
(iii). Transformer



(iv). Static load



(v). Rotating load (motor)



## PER UNIT QUANTITIES

### Definition:

The per-unit value of any quantity is defined as the ratio of actual value in any unit to the base or reference value in the same unit. Any quantity is converted into per unit quantity by dividing the numeral value by the chosen base value of the same dimension. The per-unit value is dimensionless.

$$\text{Per Unit Value} = \frac{\text{Actual value in any unit}}{\text{Base or reference value in the same unit}}$$

The base values can be selected arbitrarily. It is usual to assume the base values as given below

- Base voltage = rated voltage of the machine
- Base current = rated current of the machine
- Base impedance = base voltage /base current
- Base power = base voltage x base current

Firstly, the value of base power and the base voltage are selected, and their choice automatically fixes the other base values. As

$$\text{Per Unit KV} = \frac{\text{Actual KV}}{\text{Base KV}} = \frac{\text{KV}_{\text{actual}}}{\text{KV}_{\text{B}}}$$

So,

$$\text{Base current } I_{\text{B}} = \frac{\text{Base KVA}}{\text{Base KV}} = \frac{\text{KVA}_{\text{B}}}{\text{KV}_{\text{B}}} \dots \dots \dots (1)$$

$$\text{Per unit current } I_{\text{pu}} = \frac{\text{Actual value of current}}{\text{Base current}} \dots \dots \dots (2)$$

Putting the value of base current from the equation (1) in equation (2) we get

$$\text{Per unit current } I_{\text{pu}} = \frac{\text{Actual value of current}}{\text{KVA}_{\text{B}}/\text{KV}_{\text{B}}}$$

$$\text{Per unit current } I_{\text{pu}} = \frac{\text{Actual value of current} \times \text{KV}_{\text{B}}}{\text{KVA}_{\text{B}}}$$

$$\text{Base impedance } Z_{\text{B}} = \frac{\text{Base KV} \times 1000}{\text{Base current}} \dots \dots \dots (3)$$

Putting the value of base current from the equation (1) in the equation (3) we get

$$\text{Base impedance } Z_B = \frac{KV_B \times 1000}{KVA_B / KV_B}$$

$$\text{Base impedance } Z_B = \frac{(KV_B)^2 \times 1000}{KVA_B} \dots \dots \dots (4)$$

$$\text{Base Power} = KVA_B$$

Now,

$$Z_{pu} = \frac{\text{Actual Impedance}}{\text{Base impedance}} \dots \dots \dots (5)$$

Putting the value of base impedance from the equation (4) in the equation (5) we will get the value of impedance per unit

$$Z_{pu} = \frac{\text{Actual Impedance} \times KVA_B}{(KV_B)^2 \times 1000}$$

### Advantages of Per Unit System

There are mainly two advantages of using the Per Unit System.

- The parameters of the rotating electrical machines and the transformer lie roughly in the same range of numerical values, irrespective of their ratings if expressed in a per-unit system of ratings.
- It relieves the analyst of the need to refer circuit quantities to one or the other side of the transformer, making the calculations easy.