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

$$\text{Per Unit KV} = \frac{\text{Actual KV}}{\text{Base KV}} = \frac{KV_{actual}}{KV_B}$$

So,

$$\text{Base current } I_B = \frac{\text{Base KVA}}{\text{Base KV}} = \frac{KVA_B}{KV_B} \quad \dots \dots \dots (1)$$

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

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

$$\text{Per unit current } I_{pu} = \frac{\text{Actual value of current}}{KVA_B / KV_B}$$

$$\text{Per unit current } I_{pu} = \frac{\text{Actual value of current x } KV_B}{KVA_B}$$

$$\text{Base impedance } Z_B = \frac{\text{Base KV x 1000}}{\text{Base current}} \quad \dots \dots \dots (3)$$

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

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

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

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

Now,

$$Z_{pu} = \frac{\text{Actual Impedence}}{\text{Base impedence}} \quad \dots \dots \dots (5)$$

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

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

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.