1.5 Star/ Delta transformation

Star-delta transformation:

It is a method of obtaining equivalent star of delta. Consider a delta circuit ABC, made up of three resistors R12, R23 and R31 as shown fig.1.17 (a). Suppose its equivalent star circuit be represented by R1, R2 and R3.

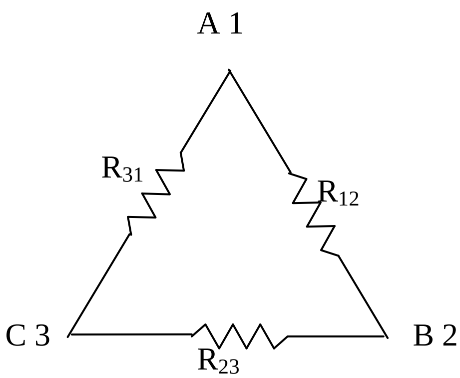

Fig.1.22 (a) Delta connection

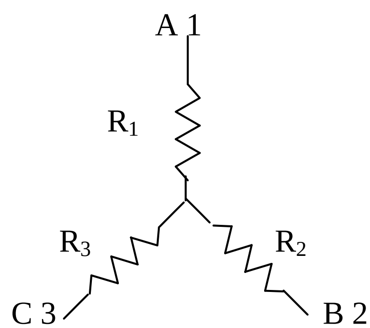

Fig.1.22 (b) Star connection

The resistance between terminals A and B in delta connection

$$= \frac{R_{12} x \left(R_{23} + R_{31}\right)}{R_{12} + R_{23} + R_{31}} \tag{1.9}$$

And the resistance between the same terminals A and B in the star connection

$$= R_1 + R_2 \tag{1.10}$$

Since the terminals are same, so:

$$R_1 + R_2 = \frac{R_{12} x \left(R_{23} + R_{31}\right)}{R_{12} + R_{23} + R_{31}} \tag{1.11}$$

Similarly, by solving for terminals BC and CA, we get:

$$R_2 + R_3 = \frac{R_{23} x \left(R_{12} + R_{31}\right)}{R_{12} + R_{23} + R_{31}} \tag{1.12}$$

And

$$R_3 + R_1 = \frac{R_{31} x \left(R_{12} + R_{23} \right)}{R_{12} + R_{23} + R_{31}} \tag{1.13}$$

Adding eq. 1.11 and 1.13 and subtracting eq. 1.12 we get:

$$R_1 = \frac{R_{12} x R_{31}}{R_{12} + R_{23} + R_{31}} \tag{1.14}$$

Similarly,

$$R_2 = \frac{R_{12} x R_{23}}{R_{12} + R_{23} + R_{31}} \tag{1.15}$$

And

$$R_3 = \frac{R_{23} x R_{31}}{R_{12} + R_{23} + R_{31}} \tag{1.16}$$

Thus in delta to star transformation " the resistance of any arm of star is equal to the product of the resistance of the two delta side meeting it divided by the sum of three delta resistances.

Star-delta transformation:

Adding eq. 1.14, 1.15 and 1.16 we get:

$$R_1 + R_2 + R_3 = \frac{R_{12}R_{23} + R_{23}R_{31} + R_{31}R_{12}}{R_{12} + R_{23} + R_{31}} \tag{1.17}$$

Dividing eq.1.14 by eq. 1.15 we get:

$$R_1 / R_2 = R_{31} / R_{23} ...or. R_{31} = R_1.R_{23} / R_2 \tag{1.18}$$

Similarly we get:

$$R_3 / R_1 = R_{23} / R_{12} ...or. R_{12} = R_1.R_{23} / R_3 \tag{1.19}$$

Substituting the value of R_{31} and R_{12} from eq. 1.18 and 1.19 respectively in eq. 1.11 we get:

$$R_2 + R_3 = \frac{R_{23}\left(R_1.R_{23} / R_2 \right) + R_{23}\left(R_1.R_{23} / R_3 \right)}{R_{12} + R_{23} + R_{31}}$$

$$R_2 + R_3 = \frac{R_1.R_{23}\left(R_3 + R_2 \right)}{R_1R_2 + R_2R_3 + R_3R_1}$$

$\therefore$

$$R_1.R_{23} = R_1R_2 + R_2R_3 + R_3R_1$$

Or

$$R_{23} = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_1} \quad (1.20)$$

Similarly, we get:

$$R_{12} = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_3} \quad (1.21)$$

$$R_{31} = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_2} \quad (1.22)$$

Thus in star-delta transformation, the equivalent delta resistance between any two terminals is the sum of star resistances between the involved terminals plus the ratio of the product of these two resistances and the remaining star resistance.

1.6 Work Energy and Power

Let us consider the motion of a charged particle between two metallic plates (at a distance d apart) to which a potential difference of V volt is applied. Then from Coulomb's law, the force acting on the particle is given by:

Force (F) = Electric intensity (E) x Charge (q)

$\therefore$ Work (W) = Force (F) x distance (d)

= Electric intensity (E) x Charge (q) x distance (d)

But Voltage (V) = Electric intensity (E) x distance (d)

$\therefore$ Work (W) = V x q

Or Power (P) = Work / time

$= Vx\frac{q}{t} = VxI$ Watt.

Or $P = VxI = I^2R = \frac{V^2}{R}$ watt

Energy = Power x time = $Pxt = I^2Rt$ Joule.

