Paper 1, TDC Part-1
Chapter– 4, Circuit Theorems
Lecture - 11

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Circuit Theorem

Star – Delta Transformation: -

Sometimes in a circuit passive elements are neither connected in parallel nor in series. They may be connected in star (Y) form or delta (Δ). To solve those type of networks which is having star or delta connection of passive elements, it is required to do necessary transformation that is star network into its equivalent delta network or delta network to star network.

These type of connection are especially useful in 3 phase circuits.

The replacement of star connection by its equivalent delta connection is called Star-Delta transformation

Circuit Theorem

While the replacement of delta connection by its equivalent star connection is called Delta-Star transformation.

The two connections are equivalent or identical to each other if the impedance is measured between any pair of lines irrespective of whether delta is connected between the lines or its equivalent star is connected between that lines.

A single star or delta connection of elements requires 3 passive elements to form the connection.

Circuit Theorem

Star-Delta Transformation :→

Star Connection of resistor.

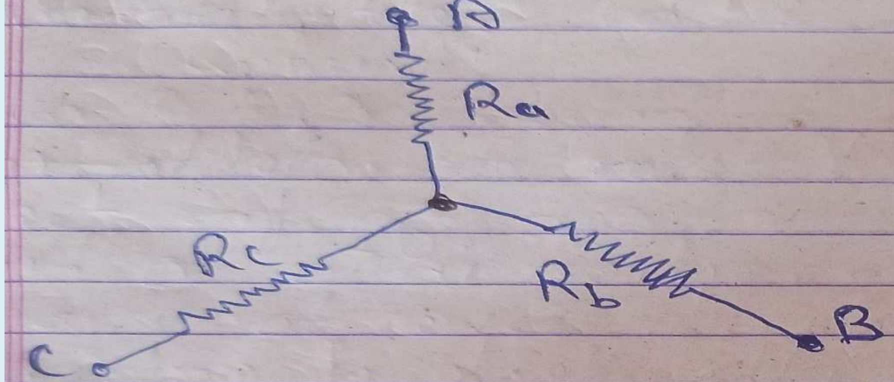


figure 1(a) Star connection of Resistor.

One end of all ~~three~~ resistors are connected ~~at a same~~ together and other end of each resistor is connected to other element or other terminal to form 'Y' like pattern as shown in above figure 1(a).

Delta-~~Star~~ Connection of resistor :→

In a delta connection all three resistors are connected such that one end of ... resistor is connected to one end of

Circuit Theorem

other resistor and all resistors are ~~connected~~ connected to each other. The Δ connection of resistors is shown in figure 1(b).

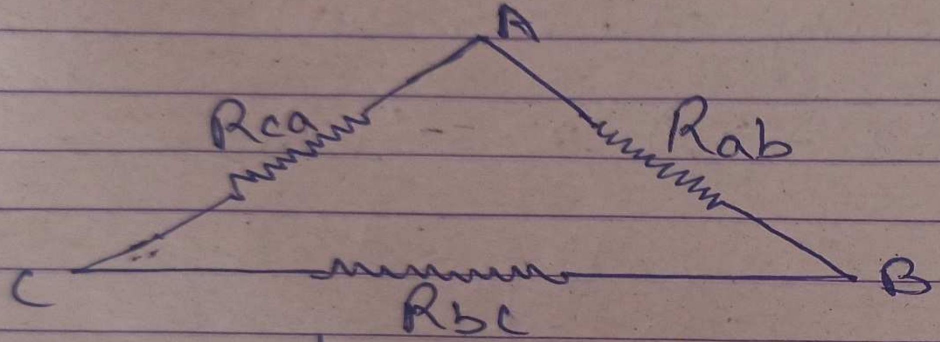


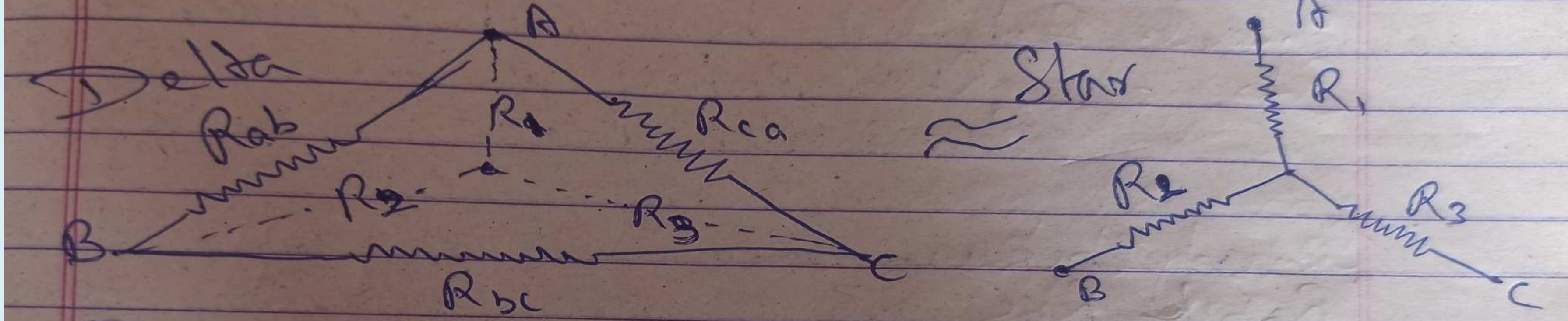
Figure 1(b) Delta Connection of Resistors.

Whenever we get star or delta connection in a network we can go for transformation of one connection into other as per the requirement. Due to this transformation the task of analysing the network become easy.

Circuit Theorem

Delta to Star Transformation :-

Let us consider a delta connection as shown below.



The delta network is having resistors R_{ab}, R_{bc} & R_{ca} connected between terminal AB, BC & CA respectively. The equivalent star connection is having resistor R_1, R_2 & R_3. Now lets us find value of R_1, R_2 & R_3 in terms of R_{ab}, R_{bc} & R_{ca} to find the equivalence Y network, of corresponding delta network.

Circuit Theorem

Equivalent resist. between A & B of delta n/w is given as, $R_{ab} \parallel (R_{bc} + R_{ca})$

$$= \frac{R_{ab}(R_{bc} + R_{ca})}{R_{ab} + R_{bc} + R_{ca}} \quad \text{——— (i)}$$

So when we look into delta n/w through terminal A & B we see that R_{bc} & R_{ca} will be in series and R_{ab} will appear parallel to series connection of $(R_{bc} + R_{ca})$

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Similarly equival. resist. between B & C terminals

Circuit Theorem

Rab & Rca will be series and Rbc will be then ||al to series connection of (Rab + Rca)

So

Equival. ~~Rest~~ Resist. between B & C can be given as

$$= \frac{R_{bc}(R_{ab} + R_{ca})}{R_{bc} + (R_{ab} + R_{ca})} \quad \text{——— (2)}$$

Similarly between terminal A & C we will have Rab & Rbc are in series and this series of (Rab + Rbc) will be in ||al with Rca so,

Equivalent resistance between C & A can be given as,

$$= \frac{R_{ca}(R_{ab} + R_{bc})}{R_{ca} + R_{ab} + R_{bc}} \quad \text{——— (3)}$$

Circuit Theorem

Now consider the star connection,
Eq Resist. between terminal A & B is,
$= R_1 + R_2$ ——— (4)

llarly Eq. Resist. between terminal B & C is,
$= R_2 + R_3$ ——— (5)

llarly Eq. Resist. between terminal C & A is,
$= R_3 + R_1$ ——— (6)

Using these 6 eqns. we will find R_1, R_2, & R_3 in terms of R_{ab}, R_{bc} & R_{ca}

Circuit Theorem

Now equating eq^n. (1) & (4) we get,

$$\frac{R_{ab}(R_{bc}+R_{ca})}{R_{ab}+R_{bc}+R_{ca}} = R_1 + R_2 \quad \text{——} \quad (7)$$

Ilarly equating eqn (2) & (5) we get,

$$\frac{R_{bc}(R_{ab}+R_{ca})}{R_{bc}+R_{ab}+R_{ca}} = R_2 + R_3 \quad \text{——} \quad (8)$$

and equating eqn. (3) & (6) we get,

$$\frac{R_{ca}(R_{ab}+R_{bc})}{R_{ca}+R_{ab}+R_{bc}} = R_3 + R_1 \quad \text{——} \quad (9)$$

Circuit Theorem

Now subtracting eqn. 8 from eqn. 7 we get

$$\frac{R_{ab}(\cancel{R_{bc}}+R_{ca}) - R_{bc}(\cancel{R_{ab}}+R_{ca})}{R_{ab}+R_{bc}+R_{ca}} = R_1 \cancel{+R_2} \cancel{-R_2} - R_3$$

or $$\frac{R_{ab}\cdot R_{ca} - R_{bc}R_{ca}}{R_{ab}+R_{bc}+R_{ca}} = R_1 - R_3 \quad \text{—(10)}$$

Now adding eqn. 9 & 10 we get,

$$\frac{R_{ca}R_{ab} \cancel{+R_{ca}R_{bc}} + R_{ab}\cdot R_{ca} \cancel{-R_{bc}\cdot R_{ca}}}{R_{ab}+R_{bc}+R_{ca}} = R_1 \cancel{+R_3} + R_1 \cancel{-R_3}$$

$$\Rightarrow \frac{\cancel{2}R_{ab}R_{ca}}{R_{ab}+R_{bc}+R_{ca}} = \cancel{2}R_1$$

Circuit Theorem

$$\boxed{\text{So } R_1 = \frac{R_{ab}\,R_{ca}}{R_{ab} + R_{bc} + R_{ca}}}$$

So if we look into the ckt now, then find out that R_1 resistor of star connection is connected to point A ~~of~~ and R_{ab} & R_{ca} are the resistor of Delta connection which is also connected to point A of Delta connection.

~~Therefore we can say that,~~

In similar way we can find R_2 & R_3 in terms of R_{ab}, R_{bc} & R_{ca}.

Circuit Theorem

In similar way we can find R_2 & R_3 in terms of R_{ab}, R_{bc} & R_{ca}

$$\boxed{R_2 = \frac{R_{bc} \times R_{ab}}{R_{ab} + R_{bc} + R_{ca}}} ; \boxed{R_3 = \frac{R_{ca} \times R_{bc}}{R_{ab} + R_{bc} + R_{ca}}}$$

So we can remember the formula for Delta to star transformation as "multiplication of 2 resistors which were initially connected to that particular point divided by addition of all 3 resistors connected in Delta connection.

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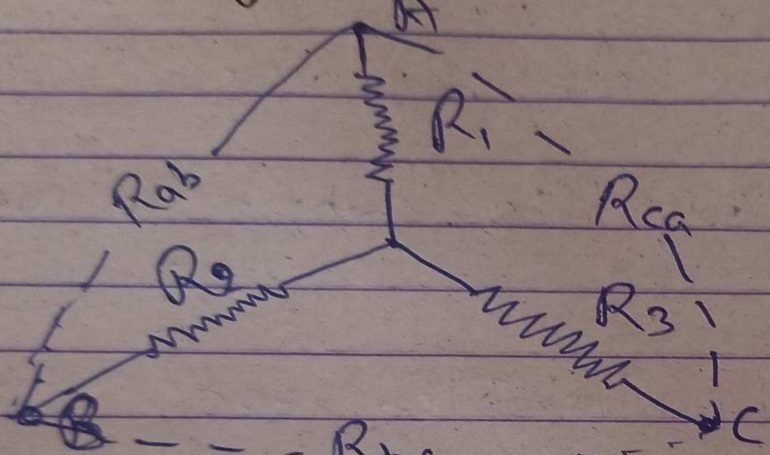
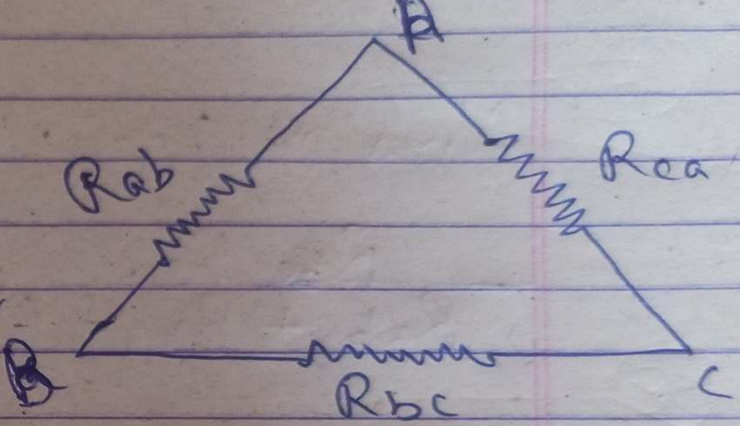
Circuit Theorem

Star Connection to Delta Connection transformation :-



Star Connection

$\approx$



Delta Connection

As we have seen in Delta to Star transformation,

$$R_1 = \frac{R_{ab} \times R_{ca}}{R_{ab} + R_{bc} + R_{ca}} \quad ; \quad R_2 = \frac{R_{bc} \times R_{ab}}{R_{ab} + R_{bc} + R_{ca}}$$

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$$R_1 = \frac{R_{ab} \times R_{ca}}{R_{ab} + R_{bc} + R_{ca}} \quad ; \quad R_2 = \frac{R_{bc} \times R_{ab}}{R_{ab} + R_{bc} + R_{ca}}$$

$$R_3 = \frac{R_{ca} \times R_{bc}}{R_{ab} + R_{bc} + R_{ca}}$$

Now lets find,

$$R_1 R_2 + R_2 R_3 + R_3 R_1 = \frac{R_{ab}^2 R_{bc} R_{ca}}{(R_{ab} + R_{bc} + R_{ca})^2} + \frac{R_{bc}^2 R_{ab} R_{ca}}{(R_{ab} + R_{bc} + R_{ca})^2} + \frac{R_{ca}^2 R_{ab} R_{bc}}{(R_{ab} + R_{bc} + R_{ca})^2}$$

$$R_1 R_2 + R_2 R_3 + R_3 R_1 = \frac{R_{ab} R_{bc} R_{ca} \cancel{(R_{ab} + R_{bc} + R_{ca})}}{(R_{ab} + R_{bc} + R_{ca})^{\cancel{2}}}$$

Circuit Theorem

$$R_1R_2 + R_2R_3 + R_3R_1 = \frac{R_{ab}R_{bc}R_{ca}}{(R_{ab} + R_{bc} + R_{ca})} \quad \text{— (A)}$$

Now in eqn. A we can replace,

$\frac{R_{bc}R_{ca}}{R_{ab} + R_{bc} + R_{ca}}$ by R_3 which is value of R_3

So eqn. A can be written as,

$$R_1R_2 + R_2R_3 + R_3R_1 = R_{ab}R_3$$

So
$$\boxed{R_{ab} = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_3}}$$

$$\boxed{\text{or } R_{ab} = \frac{R_1R_2}{R_3} + R_2 + R_1}$$

Circuit Theorem

So we can ~~rember~~ remember this formula of delta to star connection as, the resistor connected between terminal AB of Delta i.e. R_{ab} can be given as addition of the multiplication of each 2 resistors of star connection divided by the resistor connected at terminal C of star connection.

||arly $$R_{bc} = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_1}$$

& $$R_{ca} = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_2}$$

Circuit Theorem

In next lecture we will discuss some problems on Star-Delta Transformation. For any query or problem discuss on What's App or contact on number available.

THANK YOU