Ohm's Law

The ratio of potential difference (V) between any two points on a conductor to the current (I) flowing between them, is constant, provided the temperature of the conductor does not change.

$$\frac{V}{I} = \text{constant} \quad \text{or} \quad \frac{V}{I} = R.$$

ASSI

1. Derive the vector form of ohm's law.

OR

Relation b/w current Density and electric field

$$\vec{J} = ne\vec{V_d} \qquad V_d = \text{drift velocity.}$$

$$\vec{J} = ne\left(\frac{e\vec{E}\tau}{m}\right) \qquad \tau = \text{Tao.}$$

$$\Rightarrow \vec{J} = \left(\frac{ne^2\tau}{m}\right)\vec{E}$$

Also, $\rho = \frac{m}{ne^2\tau}$

$$\Rightarrow \vec{J} = \frac{\vec{E}}{\rho} \qquad \left[\sigma = \frac{1}{\rho}\right]$$

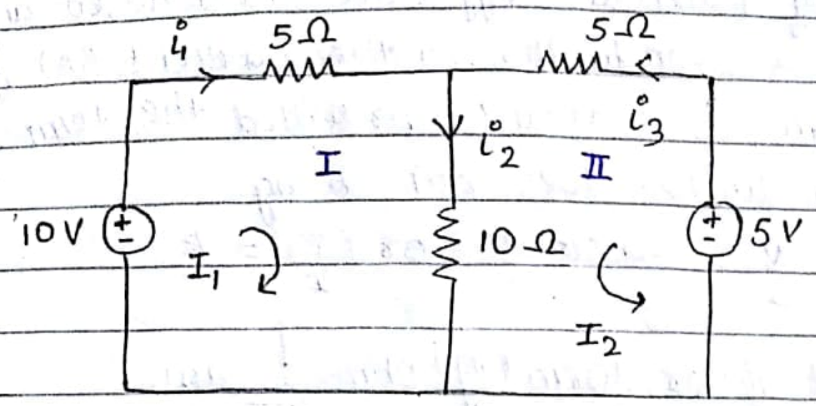
$$\Rightarrow \boxed{\vec{J} = \sigma\vec{E}}$$

KVL The sum of voltage rises = sum of voltage drop in closed loop.

KCL The sum of current entering through a ~~functi~~junction is equal to the sum of current leaving through junction.

KVL

1. Find the Branch currents and loop currents in the circuit



Branch currents are : i_1, i_2 and i_3
Loop currents are : I_1 and I_2

From loop I,

$$5i_1 + 10i_2 = 10 \quad \text{—(i)}$$

From loop II,

$$5i_3 + 10i_2 = 5 \quad \text{—(ii)}$$

$$i_1 = I_1 \;;\; i_2 = I_1 + I_2 \;;\; i_3 = I_3$$

Replace it in (i) and (ii),

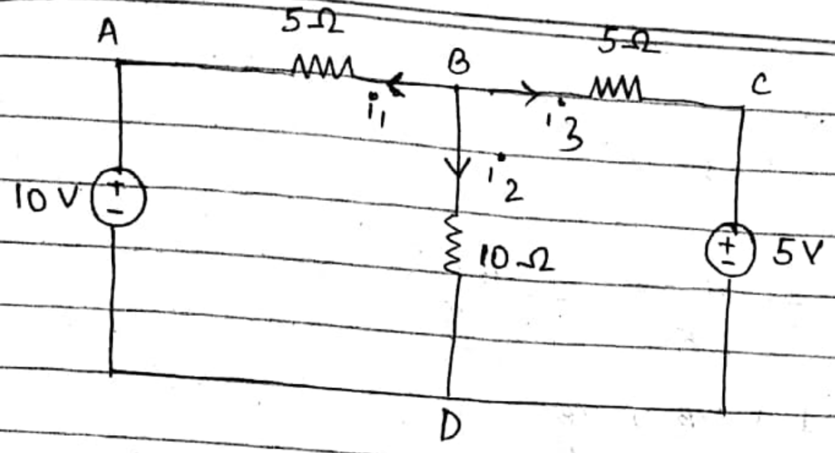
$$5I_1 + 10I_1 + 10I_2 = 10$$
$$5I_2 + 10I_1 + 10I_2 = 5$$

$$3I_1 + 2I_2 = 2$$
$$2I_1 + 3I_2 = 1$$

$$-5I_2 = 1$$

$$I_2 = \frac{-1}{5}\,A \qquad I_1 = \frac{4}{5}\,A$$

KCL



From KCL,

$$i_1 + i_2 + i_3 = 0$$

$$\frac{V_B - 10}{5} + \frac{V_B - 0}{10} + \frac{V_B - 5}{5} = 0.$$

$$\Rightarrow \frac{V_B}{5} - 2 + \frac{V_B}{10} + \frac{V_B}{5} - 1 = 0$$

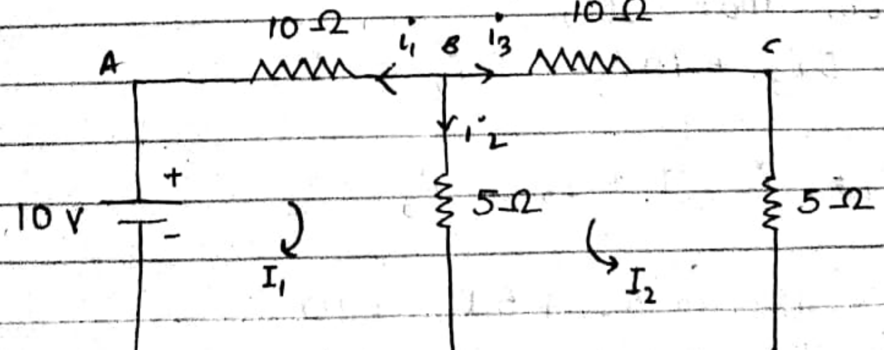
$$\Rightarrow \frac{2V_B}{5} + \frac{V_B}{10} = 3$$

$$\Rightarrow \frac{4V_B + V_B}{10} = 3 \Rightarrow \frac{5V_B}{10} = 3$$

$$\Rightarrow V_B = 6.$$

$$i_1 = \frac{V_B - 10}{5} = -\frac{4}{5} \quad i_2 = \frac{3}{5} \quad i_3 = \frac{1}{5}$$

2. Find the branch currents using both KCL and KVL in the following circuit :



i) KCL

From KCL,

$$i_1 + i_2 + i_3 = 0$$

$$\frac{V_B - 10}{10} + \frac{V_B - 0}{5} + \frac{V_B - 0}{15} = 0$$

$$\frac{V_B}{10} - 1 + \frac{V_B}{5} + \frac{V_B}{15} = 0$$

$$\boxed{\begin{gathered} \cancel{\frac{2V_B}{10}} + \cancel{\frac{V_B}{5}} = \cancel{1} \Rightarrow \cancel{\frac{2V_B}{5}} = \cancel{1} \\ \cancel{V_B} = \cancel{\frac{5}{2}} \\ \cancel{\frac{V_B}{5}} \left(\cancel{\frac{V_B}{2}} + \cancel{V_B} \right. \end{gathered}}$$

$$\frac{V_B}{5}\left(\frac{1}{2} + 1 + \frac{1}{3}\right) = 1 \Rightarrow \frac{V_B}{5} \times \frac{11}{6} = 1$$

$$\Rightarrow V_B = \frac{30}{11}$$

$$i_1 = \frac{\frac{30}{11} - 10}{10} \quad \boxed{= \cancel{\frac{\frac{30-110}{11}}{10}} = \cancel{\frac{80 \times 10}{11}} = 0.7272}$$

$$= 0.7272$$

ii) KVL

From loop I,

$$10 i_1 + 5 i_2 = 10$$

From loop II,

$$5 i_3 + 10 i_3 + 5 i_2 = 0.$$

$$i_1 = I_1 ; \quad i_2 = I_1 + I_2 \qquad i_3 = I_2$$

$$10 I_1 + 5 I_1 + 5 I_2 = 10$$

$$5 I_2 + 10 I_2 + 5 I_1 + 5 I_2 = 0$$

$$\Rightarrow 15 I_1 + 5 I_2 = 10$$

$$5 I_1 + 20 I_2 = 0$$

$3I_1 + I_2 = 2 \quad \times 1$

$I_1 + 4I_2 = 0 \quad \times 3$

$3I_1 + I_2 = 2$

$3I_1 + 12I_2 = 0$

$(-) \quad (-) \quad (-)$

$-11 I_2 = 2$

$I_2 = \frac{-2}{11}$

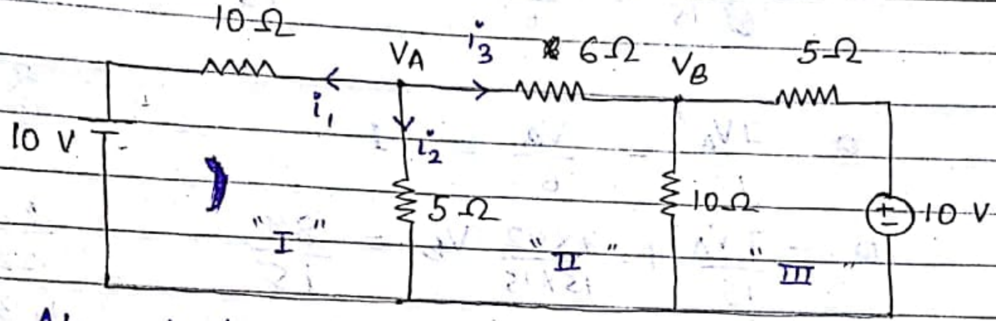
$I_1 = -4I_2$

$= \frac{4\times 2}{11} = \frac{8}{11}$

$i_1 = \frac{8}{11} = 0.727272$

Assign

2.



At node A,

$i_1 + i_2 + i_3 = 0$

$$\frac{V_A - 10}{10} + \frac{V_A - 0}{5} + \frac{V_A - V_B}{6} = 0 \quad \text{— (I)}$$

At node B,

$$\frac{V_B - V_A}{6} + \frac{V_B - 0}{10} + \frac{V_B - 10}{5} = 0 \quad \text{— (II)}$$

From (I),

$$\frac{V_A}{10} - 1 + \frac{V_A}{5} + \frac{V_A}{6} - \frac{V_B}{6} = 0$$

$$\Rightarrow \frac{V_A}{5} \times \frac{3}{2} + \frac{V_A}{6} - \frac{V_B}{6} = 1$$

$$\Rightarrow \frac{3V_A}{10} + \frac{V_A}{6} - \frac{V_B}{6} = 1 \Rightarrow \frac{7V_A}{15} - \frac{V_B}{6} = 1$$

$$\Rightarrow \frac{7V_A}{15} - \frac{V_B}{6} = 1 \quad \text{— (III)}$$

$$\frac{V_B}{6} - \frac{V_A}{6} + \frac{V_B}{10} + \frac{V_B}{5} - 2 = 0$$

$$\frac{7}{15}V_B - \frac{V_A}{6} = 2 \quad \text{—— (IV)}$$

$$\frac{7V_A}{15} - \frac{V_B}{6} = 1 \quad \times 1$$

$$\frac{7}{15}\times\frac{6}{6}$$

$$\frac{7}{15}V_B - \frac{V_A}{6} = 2 \quad \times \frac{42}{15}$$

$$\frac{48}{} \quad \frac{42}{15}$$

$$\frac{7V_A}{15} - \frac{V_B}{6} = 1$$

$$\frac{7}{15}\times\frac{42}{15}$$

$$-\frac{7V_A}{15} + \frac{7\times42}{15\times15}V_B = \frac{84}{15}$$

$$\frac{294}{225}$$

1.306

0.166

$$1.14\,V_B = 6.6$$

$$V_B = 5.78$$

$$\frac{7}{15}\times 5.78 - 2 = \frac{V_A}{6}$$

$$V_A = 4.184$$

$$i_2 = \frac{V_A}{5} = 0.83$$

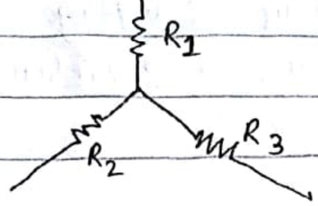
Scanned by CamScanner

Superposition

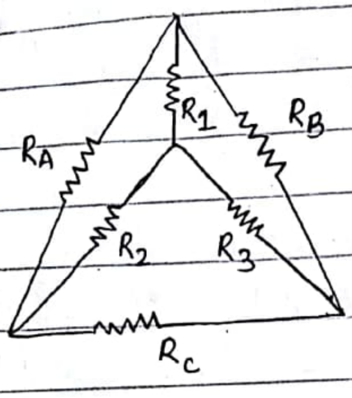
Active source : Voltage and current source

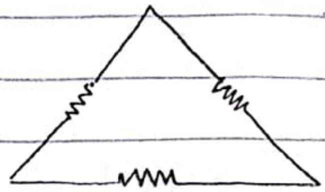
Passive " : Resistance , inductance.

Star and Delta



Star





Delta

1. Delta → Star

R_A, R_B and R_C are Known

$$R_1 = \frac{R_A \cdot R_B}{R_A + R_B + R_C}$$

$$R_2 = \frac{R_B \cdot R_C}{R_A + R_B + R_C}$$

$$R_3 = \frac{R_A \cdot R_C}{R_A + R_B + R_C}$$

2. Star → Delta

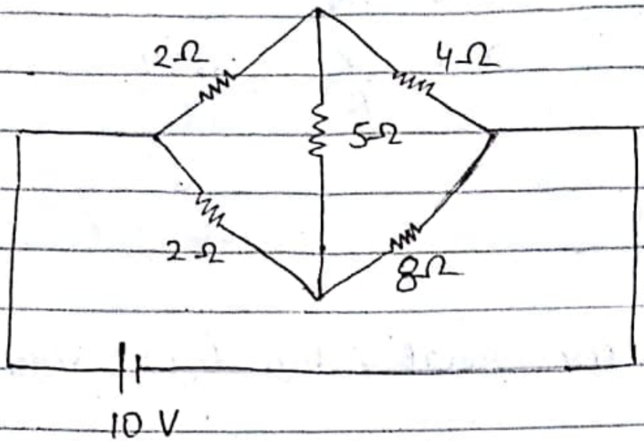
R_1, R_2 and R_3 are Known

$$R_A = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_2}$$

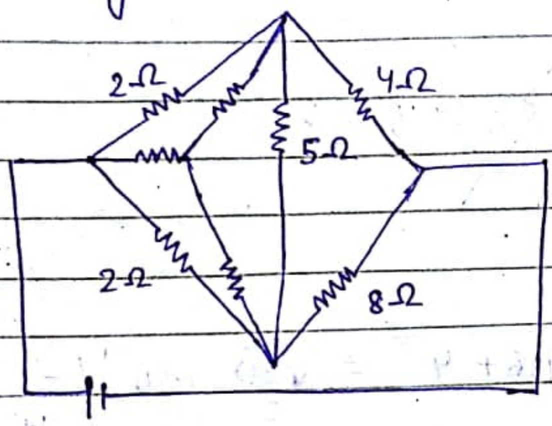
$$R_B = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_3}$$

$$R_C = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_1}$$

3. Find out the total current in the circuit



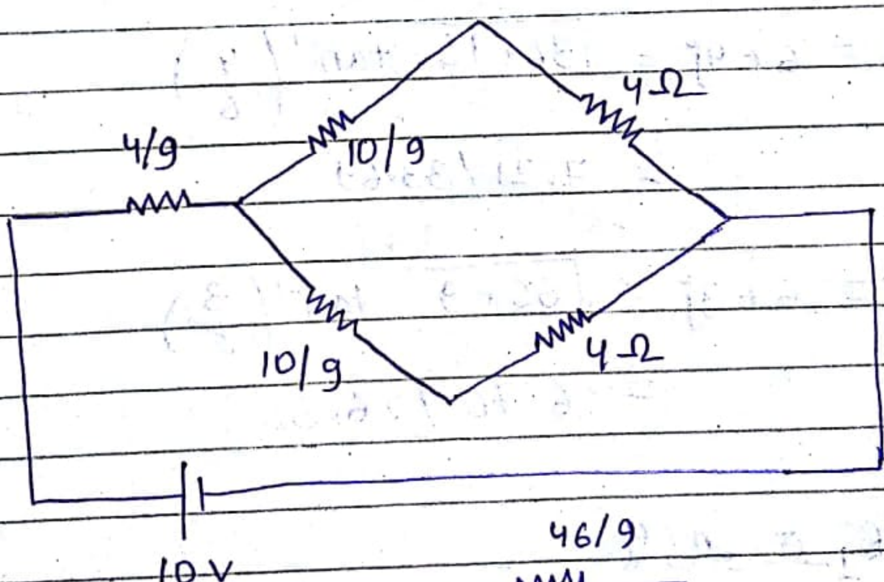
Assuming star,

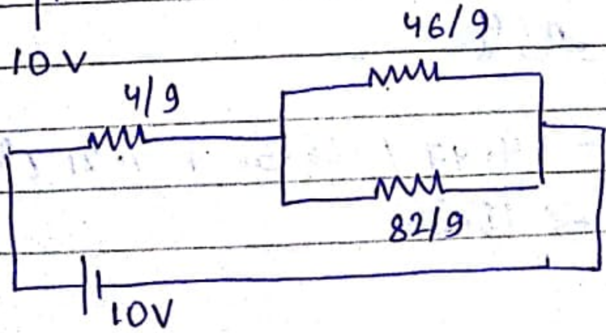


$\frac{10}{9}$

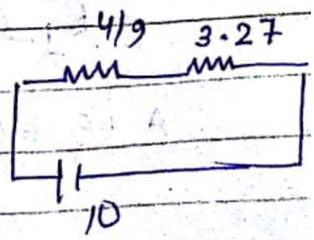
After rearranging it,

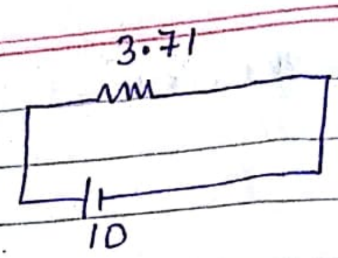
$$\frac{\frac{10}{9} \times 4}{\frac{10}{9} + 4} = \frac{40}{9}$$





⇒





$V = IR$

$\Rightarrow I = \frac{V}{R} = \frac{3.71}{10}$

$= 2.695$

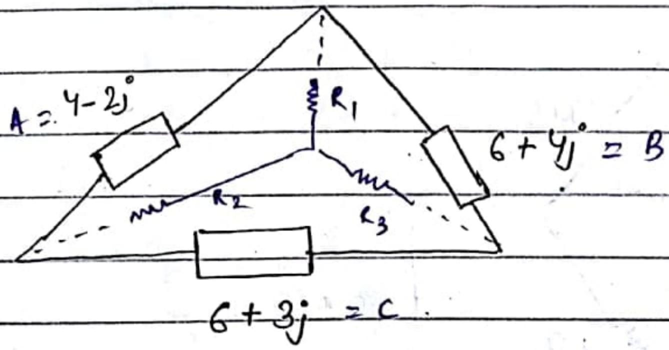
$\simeq 2.7$

Assign

3. Derive the inter relationship b/w star and delta.

Assign

4.



$A = 4-2j = \sqrt{16+4} = \sqrt{20}\ \tan^{-1}\left(\frac{-2}{4}\right)$

$= 4.47 \angle -26.56$

$B = 6+4j = \sqrt{36+16}\ \tan^{-1}\left(\frac{4}{6}\right)$

$= 7.21 \angle 33.69$

$C = 6+3j = \sqrt{36+9}\ \tan^{-1}\left(\frac{3}{6}\right)$

$= 6.70 \angle 26.56$

~~Req of ΔB~~

$A + B + C = 4.47 \angle -26.56 + 7.21 \angle 33.69 + 6.70 \angle 26.56$

~~= 18.38~~

$a(\cos\theta + i\sin\theta)$

253.1281

24.9001

$= 4.47(0.89 - j0.44) + 7.21(0.83 + j0.55) + 6.70(0.89 + j0.447)$

$= 3.97 - 1.96j + 5.98 + 3.96j + 5.96 + 2.99j$

$= 15.91 + 4.99j \simeq 16 + 5j = 16.76\angle 17.35$

$\cancel{= \sqrt{278.0282}\ \tan^{-1}\left(\frac{4.99}{15.91}\right) = 16.67\angle 17.41}$

$R_1 = \frac{(4-2j)(6+4j)}{16.67\angle 17.41} = \frac{24+16j-12j+8}{16.67\angle 17.41}$

$= \frac{32+4j}{16.76\angle 17.35}$

$= \frac{32.24\angle 7.12}{16.76\angle 17.35}$

$= 1.92\angle -10.23$

$= 1.88 + j(-0.33)$

$\cancel{= \frac{32+4j}{16.67\angle 17.41}}$

$\cancel{= \frac{4(8+j)}{16.67\angle 17.41}}$

$\cancel{= \frac{4\times 8.06\angle 7.12}{16.67\angle 17.41}}$

$\cancel{= 1.93\angle -10.29}$

$\cancel{= 1.89 + j(-0.34)}$

$R_2 = \frac{A\cdot C}{A+B+C} = \frac{(4-2j)(6+3j)}{16.76}$

$= \frac{24+12j-12j+6}{16.76}$

$= \frac{30}{16.76\angle 17.35}$

$= 1.78\angle -17.35$

$= 1.7 + j(-0.53)$

Scanned by CamScanner

$$R_3 = \frac{(6+4j)(6+3j)}{16.76\angle 17.35}$$

$$= \frac{36+18j+24j-12}{16.76\angle 17.35}$$

$$= \frac{24+42j}{16.76\angle 17.35} = \frac{48.37\angle 60.25}{16.76\angle 17.35}$$

$$= 2.88\angle 42.9$$

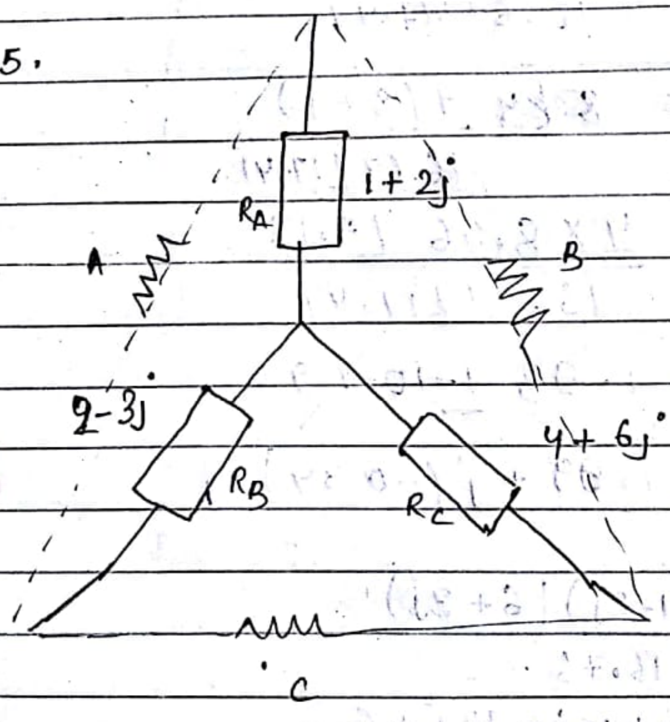
$$= 2.10 + j(1.96)$$

$R_1 = 1.88 + j(-0.33)$

$R_2 = 1.7 + j(-0.53)$

$R_3 = 2.10 + j(1.96)$

5.



$R_A = 1+2j$

$= 2.23\angle 63.43$

$R_B = 2-3j$

$= 3.6\angle -56.30$

$R_C = 4+6j$

$= 7.21\angle 56.30$

$$D = R_A R_B + R_B R_C + R_C R_1$$

$$= (1+2j)(2-3j) + (2-3j)(4+6j) + (4+6j)(1+2j)$$

$$= 2-3j+4j+6+8+12j-12j+18+4+8j+6j-12$$

$$= 26+15j$$

$$= 30.01\angle 29.98 \simeq 30.01\angle 30$$

$$A = \frac{D}{2-3j} = \frac{30.01\angle 30}{3.6\angle -56.30} = 8.33\angle 86.3$$

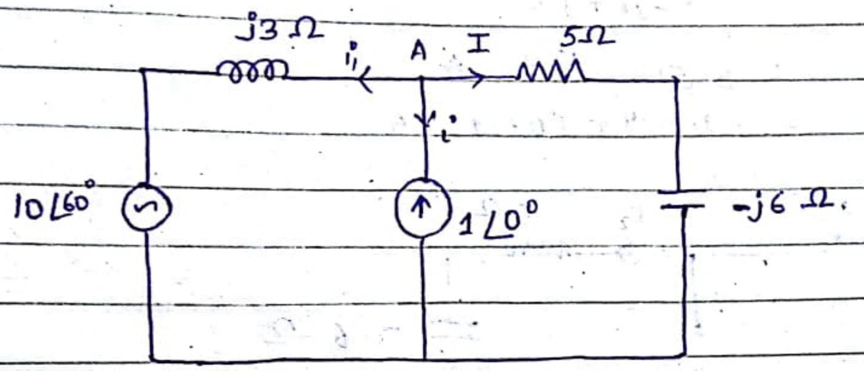
$$= 0.53 + j(8.31)$$

Scanned by CamScanner

$$B = \frac{D}{4+6j} = \frac{30.01\angle 30}{7.21\angle 56.30} = 4.16\angle -26.3$$
$$= 3.72 + j(-1.84)$$

$$C = \frac{30.01\angle 30}{1+2j} = \frac{30.01\angle 30}{2.23\angle 63.43} = 13.45\angle -33.43$$

—x—



$$X_L = j3 = 3\angle 90^\circ$$
$$X_C = -j6 = 6\angle 90^\circ$$

~~At Node A,~~

$$\cancel{\frac{V_A - 10\angle 60^\circ}{3\angle 71.56}} + \cancel{\frac{V_A - 6\angle 80.53}{5}} + \cancel{V_A -}$$

$$i_1 + I + i = 0$$

$$\frac{V_A - 10\angle 60^\circ}{3\angle 90^\circ}$$

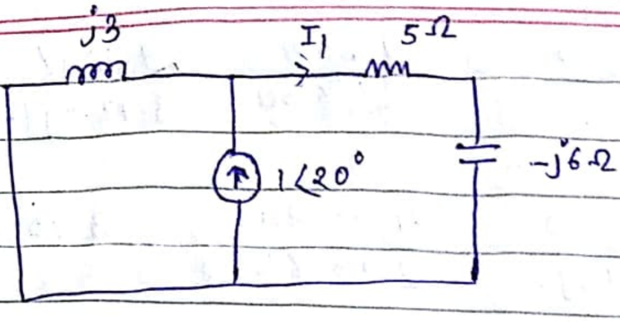
$1+2j)$

12

d:

lto

$$I_1 = \frac{j3}{j3+5-j6} \times 1\angle 20^\circ$$

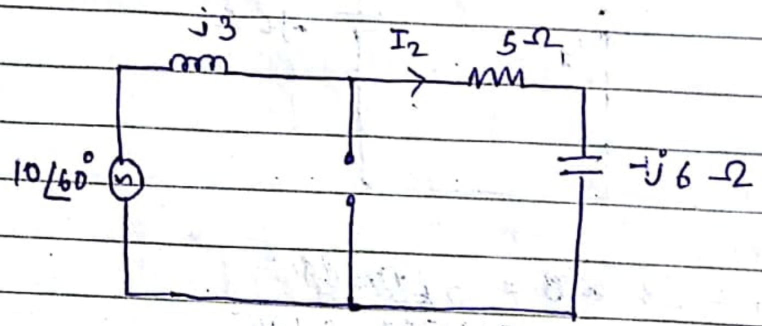


$$I_2 = \frac{5-j6}{j3+5-j6} \times 1\angle 20^\circ$$

$$I_1 = \frac{j3}{5-j6+j3} \times 1\angle 20^\circ$$

$$= 0.515 \angle 120^\circ \text{ A}$$

$$= -0.264 + j0.442 \text{ A}$$



$$I_2 = \frac{10\angle 60^\circ}{5-j3} = 1.71 \angle 90.9^\circ$$

$$= -0.026 + j1.715 \text{A}$$

$$I = I_1 + I_2$$

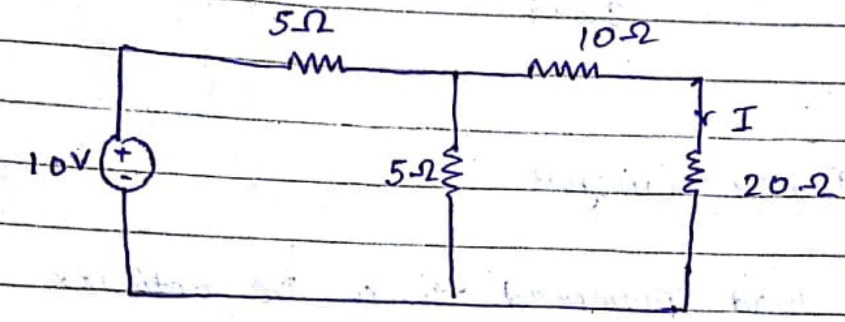
$$= -0.29 + j2.157.$$

Thevenin's th

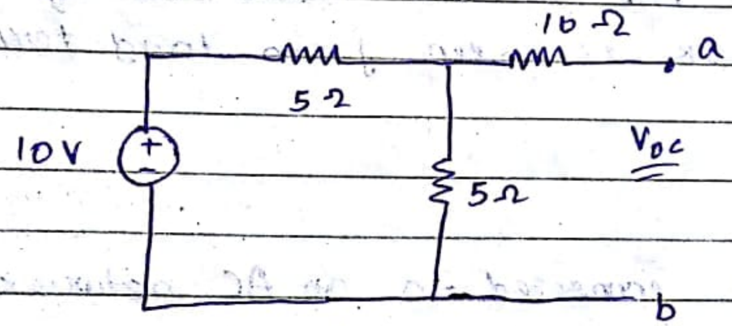
Any linear active network consisting of dependent/ independent sources and linear bilateral network elements (resistances, conductance, inductance) can be replaced by an equivalent circuit consisting of a voltage source in a series with a resistance. The voltage source being a open circuited voltage across the open-circuited load resistance

Scanned by CamScanner

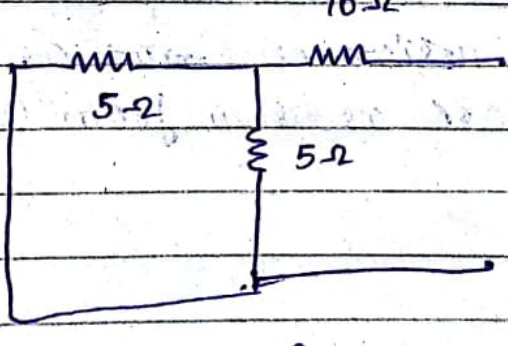
and the resistance being the internal resistance of load ~~source terminals~~ source network looking through open circuited load terminal. With All the active sources either replaced by their internal resistances (if any) or short-circuited (in case of voltage source) or open circuited (in case of current source).



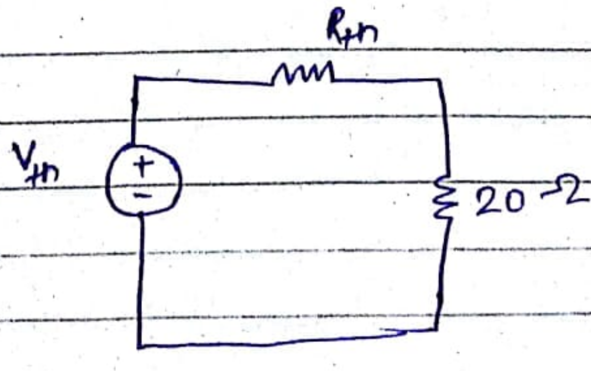
$R_L = 20\,\Omega$



$V_{oc} = V_{th} = 5V$



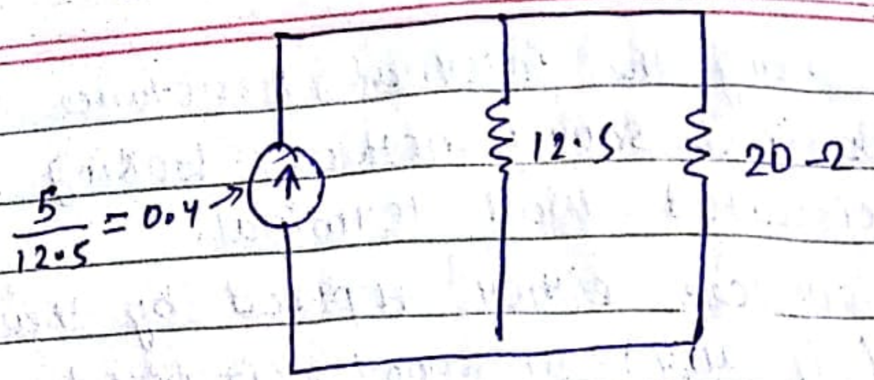
$R^{th} = 5 \| 5 + 10$
$= 12.5$



$I_{th} = \frac{5}{12.5 + 20}$
$= 0.153A$

Scanned by CamScanner

Norton.

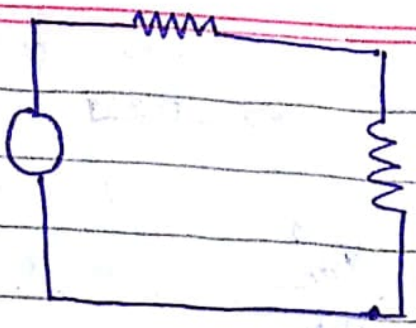


$$I_N = \frac{12.5}{32.5} \times 0.4$$

Maximum Power transfer

A resistive load connected to a DC network recieves maximum power when the load resistance is equal to the internal resistance of source network as seen from load terminal.

An impedence connected to an AC network recieves maximum power when the load impedence is equal to the complex conjugate of the internal resistance ~~same as above~~ of source network as seen from load terminal.



$$P_L = I_L^2 R_L$$

$$= \left(\frac{V_{Th}}{R_{Th}+R_L}\right)^2 \cdot R_L$$

$\frac{dP_L}{dR_L} = 0$, then power will be maximum.

$$\cancel{2\left(\frac{V_{Th}}{R_{Th}+R_L}\right)\frac{1}{R_{Th}+R_L}}$$

$$\frac{V_{Th}^2}{(R_{Th}+R_L)^2} \cdot R_L$$

$$\Rightarrow V_{Th}^2 \left[2(R_{Th}+R_L)^4 - (R_{Th}+R_L)^2 \cdot 2V_{Th}\right]$$

$$\Rightarrow R_{Th} = R_L$$

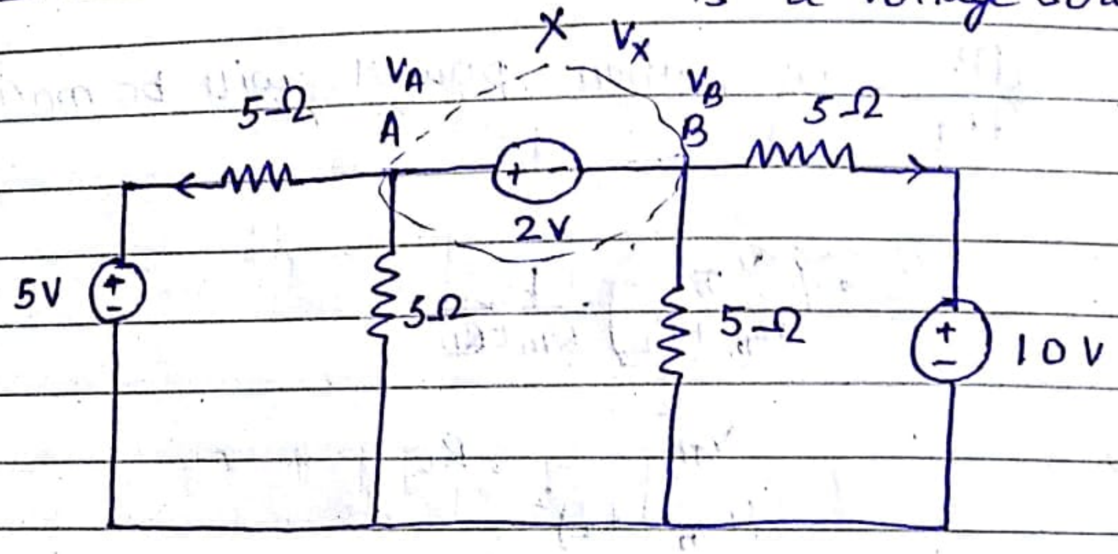
Proof the Maximum power transfer theorem for AC circuit.

$$P_L = \frac{2 V_{Th}^2 \cdot R_L}{4 R_L^2} \longrightarrow$$ Power consumed Load.

$$= \frac{2 V_{Th}^2}{4 R_L} = \frac{V_{Th}^2}{2 R_L}$$

50 % : Maximum Efficiency

Super Node Analysis (In b/w two Node there is a voltage source)



At Node X,

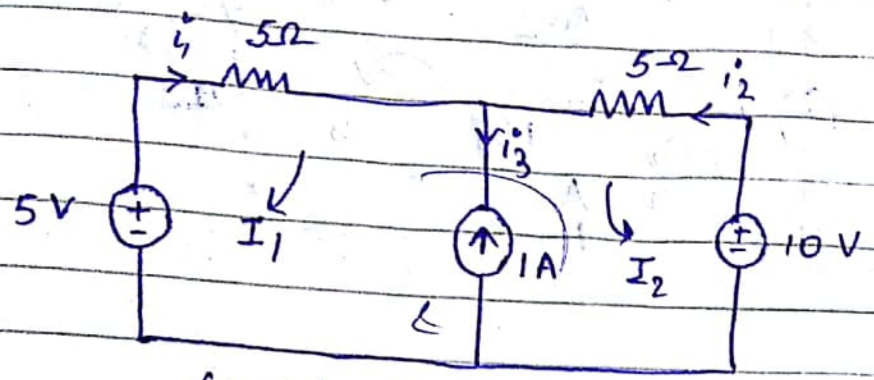
$$\frac{V_A - 5}{5} + \frac{V_A}{5} + \frac{V_B - 10}{5} + \frac{V_B}{5} = 0 \quad \text{—(I)}$$

$$V_A - V_B = 2 \quad \text{—(II)}$$

$V_A =$

$V_B =$

Super Mesh. (b/w two mesh a current source)



Considered as 1 mesh.

$$5I_2 + 5 = 5I_1 + 10 \quad — (1)$$

Voltage rises = Voltage ~~down~~ drops.

$$I_1 + I_2 = -1 \quad — (2)$$

$$I_1 = -1 - I_2$$

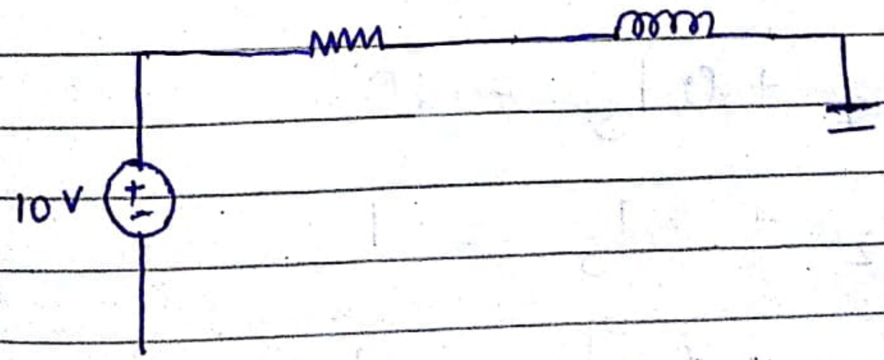
$$5I_2 + 5 = 5(-1 - I_2) + 10$$

$$\Rightarrow 5I_2 + 5 = -5 - 5I_2 + 10$$

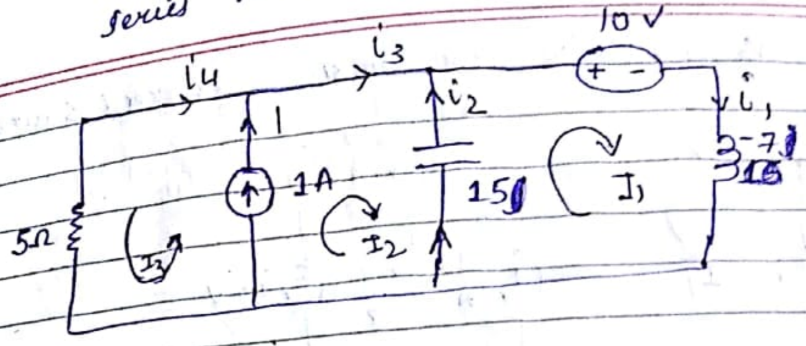
$$\Rightarrow 10I_2 = 0$$

$$\Rightarrow I_2 = 0$$

$$I_1 = -1.$$



Parallel resistance + voltage source = super node
Series resistance + current source = super mesh



$$I_3 - I_2 = 1.$$

$$\cancel{-10 + 7I_1 - 15(I_2 - I_2) = 0.}$$

$$\cancel{7I_1 = 15(I_1 - I_2) + 10}$$

$$-10 + 7I_1 + 5I_3 = 0. \quad — (1).$$

$$7I_1 = 15(I_1 - I_2) + 10 \quad — (2).$$

$$I_3 - I_2 = 1.$$

$$7I_1 = 15I_1 - 15I_2 + 10.$$

$$-8I_1 + 15I_2 + 0I_3 = 10.$$

$$0 I_1 - 1I_2 + I_3 = 1$$

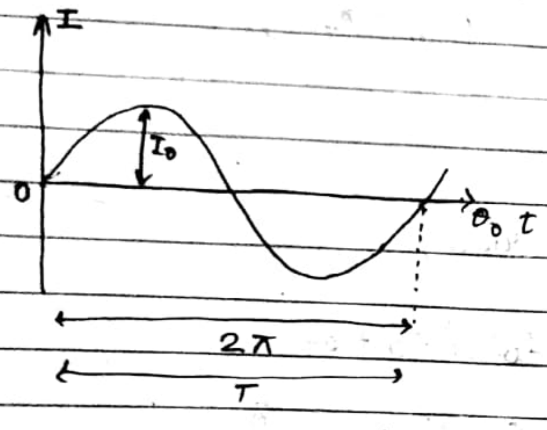
$$7I_1 + 0I_2 + 5I_3 = 10.$$

$I_1 = 0.1724$ A
$I_2 = 0.7586$ A
$I_3 = 1.7586$ A

Rms : value of AC = value of DC flowing in a circuit producing same amount of heat as of AC circuit

Avg value.

value of DC charge flowing in a circuit same amount of charge as of AC circuit.



Symmetrical electric signal :

In a symmetrical electrical signal : average value half ~~of~~ over a half period.
In a unsymmetrical electrical signal : average value over a complete period

$$I_{av} = \frac{1}{T/2}\int_0^{T/2} i\,dt = \frac{1}{\pi}\int_0^{\pi} i\,d\theta$$

$i = I_0 \sin \omega t$

$$I_{avg} = \frac{1}{\pi}\int_0^{\pi} I_0 \sin \omega t \, dt$$

$$= \frac{I_0}{\pi}\left[\frac{-\cos \omega t}{\omega}\right]_0^{\pi}$$

$$= \frac{I_0}{\pi}\cdot\left[-1-1\right]$$

$$= -\left(\frac{-2I_0}{\pi}\right) = \frac{2I_0}{\pi}$$

Form fa

=

Peak fact

$$I_{rms}^2 = \frac{1}{2\pi}\int_0^{2\pi} i^2 \, d\theta \qquad \text{mean} = 2\pi$$

$$= \frac{1}{2\pi}\int_0^{2\pi} I_0^2 \sin^2 \omega t \, dt$$

=

I_a

For half period,

$$= \frac{1}{\pi}\int_0^{\pi} I_0^2 \sin^2 \omega t \, dt$$

$$= \frac{I_0^2}{\pi}\left[\sin^2 t \, dt\right]_0^{\pi}$$

$$= \frac{I_0^2}{2\pi}\left[\frac{1-\cos 2\theta}{2}\right]_0^{\pi}$$

$$= \frac{I_0^2}{4\pi}\int_0^{2\pi} \theta - \frac{\sin 2\theta}{2}$$

Form factor : Ratio of rms value ~~of~~ by Vavg

$$= \frac{I_{rms}}{I_{avg}}$$

$$= \frac{I_0}{\sqrt{2}} \times \frac{\pi}{2I_0}$$

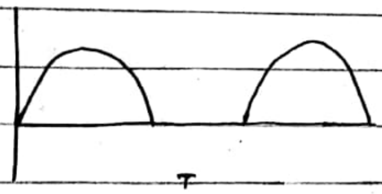
$$= \frac{\pi}{2\sqrt{2}} = 1.11.$$

Peak factor: Ratio of peak value by rms value

$$= \frac{I_{peak\ value}}{I_{rms}}$$

$$= I_0 \times \frac{\sqrt{2}}{I_0}$$

$$= \sqrt{2} = 1.414$$



For full ~~value~~ period.

$$I_{avg} = \frac{1}{T}\int_0^T i\,dt$$

$$= \frac{1}{T}\int_0^{T/2} i\,dt + \frac{1}{T}\int_{T/2}^{T} i\,dt$$

$$= \frac{1}{T}\int_0^{T/2} i\,dt$$

$T/2 = \pi$

$T = 2\pi$

$$= \frac{1}{2\pi}\int_0^{\pi} i\,dt$$

$$= \frac{I_0}{\pi} A$$

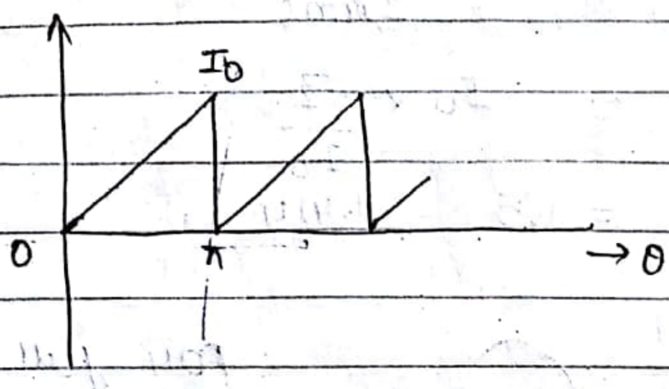
$$I_{rms}^2 = \frac{1}{2\pi}\int_0^{2\pi} i^2\,d\theta = \frac{1}{2\pi}\int_0^{\pi} i^2\,d\theta + \frac{1}{2\pi}\int_{\pi}^{2\pi} i^2\,d\theta.$$

$$= \frac{1}{2\pi}\int_0^{\pi} i^2\,d\theta = \frac{I_0}{2} A$$

$$\text{Form factor} = \frac{I_0}{2} \times \frac{\pi}{I_0}$$
$$= \frac{\pi}{2} = 1.57$$

$$\text{Peak factor} = I_0 \times \frac{2}{I_0}$$
$$= 2.$$

1. Find form factor and peak factor of :



$y = \cancel{mx + c}$

$y = \left\{\frac{y_1 - y_2}{x_1 - x_2}\right\} x$

$$I_{av} = \frac{1}{T/2} \int_0^{T/2} i \, dt$$

$$= \frac{1}{\pi} \int_0^{\pi} i \, d\theta \qquad i = \frac{I_0}{\pi} \cdot \theta$$

$$= \frac{1}{\pi} \int_0^{\pi} \frac{I_0}{\pi} t \, dt$$

$$= \frac{I_0}{\pi^2} \left[\frac{t^2}{2}\right]_0^{\pi}$$

$$= \frac{I_0}{2\pi^2} \left[\pi^2\right]$$

$$= \frac{I_0}{2}$$

$$I_{rms}^2 = \frac{1}{2\pi}\int_0^{2\pi} i^2\,d\theta$$

$$= \frac{1}{2\pi}\int_0^{2\pi} \frac{I_0^2}{\pi^2}\,t^2\,dt$$

$$= \frac{I_0^2}{2\pi^3}\left[\frac{t^3}{3}\right]_0^{2\pi}$$

$$= \frac{I_0^2}{3\pi^3}\left[t^3\right]_0^{2\pi}$$

$$= \frac{I_0^2}{3\pi^3}\left[8\pi^3\right]$$

$$= \frac{I_0^2}{3}, \quad I_{rms} = \frac{I_0}{\sqrt{3}}$$

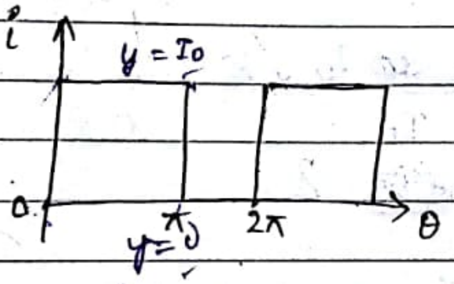
Form factor $= \frac{I_0}{\sqrt{3}} \times \frac{2}{I_0}$

$= 1.15$

Peak factor $= I_0 \times \frac{\sqrt{3}}{I_0}$ $\quad i = v \cdot t$

$= 1.73$

2.



$i = \frac{I_0 - I_0}{\pi - 0}\theta$

$$I_{av} = \frac{1}{T}\int_0^T i\,dt$$

$$= \frac{1}{T}\int_0^{T/2} i\,dt + \frac{1}{T}\int_{T/2}^{T} 0\,dt$$

$$= \frac{1}{T}\int_0^{T/2} i\,dt + 0$$

$$I_{av} = \frac{1}{2\pi}\int_0^{\pi} I_0\,dt = \frac{I_0}{2\pi}\times\pi = \frac{I_0}{2}$$

Form factor > 1 Always.
Minimum value form factor have = 1.

$$= \cancel{\frac{1}{2\pi}\int_0^{\pi} \frac{I_0}{2\pi} t\, dt}$$

$$= \cancel{\frac{I_0}{2\times 4\pi^2}\left[t^2\right]_0^{\pi}} = \cancel{\frac{I_0}{8\pi^2} \times \pi^2}$$

$$= \cancel{\frac{I_0}{8}}$$

$$I_{rms}^2 = \frac{1}{\pi}\int_0^{2\pi} i^2 d\theta \qquad i = I_0$$

$$= \frac{1}{\pi}\int_0^{2\pi} I_0^2\, dt$$

$$= \cancel{\frac{I_0^2}{8\pi^3}\left[\frac{t^3}{3}\right]_0^{2\pi}}$$

$$= \cancel{\frac{I_0^2}{12\pi^3} \times 8\pi^3} \qquad = \frac{I_0^2}{\pi} \times \pi$$

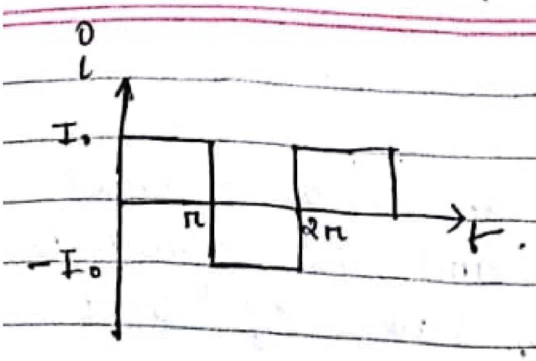
$$I_{rms} = I_0$$

$$= \cancel{I_0^2 \frac{8}{12}} \quad = \cancel{\frac{2I_0^2}{3}} \quad = \cancel{\sqrt{\frac{2}{3}} I_0}$$

$$= \cancel{0.81 I_0}$$

Form factor $= \frac{I_0}{I_0} = 2$

Peak factor $= \frac{I_0}{I_0} = 1$



$i = I_0 , -I_0$

$$i = \begin{cases} I_0 & 0 < t < \pi \\ -I_0 & \pi < t < 2\pi \end{cases}$$

$$I^2_{rms} = \frac{1}{T} \int_0^{T/2} i^2 \, dt$$

$$= \cancel{\frac{1}{T/2} \int_0^{T/2} I_0 \, dt + \frac{1}{T/2} \int_0^{T/2} -I_0 \, dt}$$

$$= \frac{1}{2\pi} \left[\int_0^{\pi} I_0^2 \, dt + \int_{\pi}^{2\pi} (-I_0)^2 \, dt \right]$$

$$= \frac{1}{2\pi} \left[I_0^2 (t)_0^{\pi} + I_0^2 (t)_{\pi}^{2\pi} \right]$$

$$= \frac{I_0^2}{2\pi} (\pi + \pi) = \frac{I_0^2}{2\pi} \times 2\pi = I_0^2$$

$$I_{rms} = I_0$$

$$I_{avg} = \frac{1}{T/2} \int_0^{T/2} i \, dt = \frac{1}{\pi} \int_0^{\pi} I_0 \, dt$$

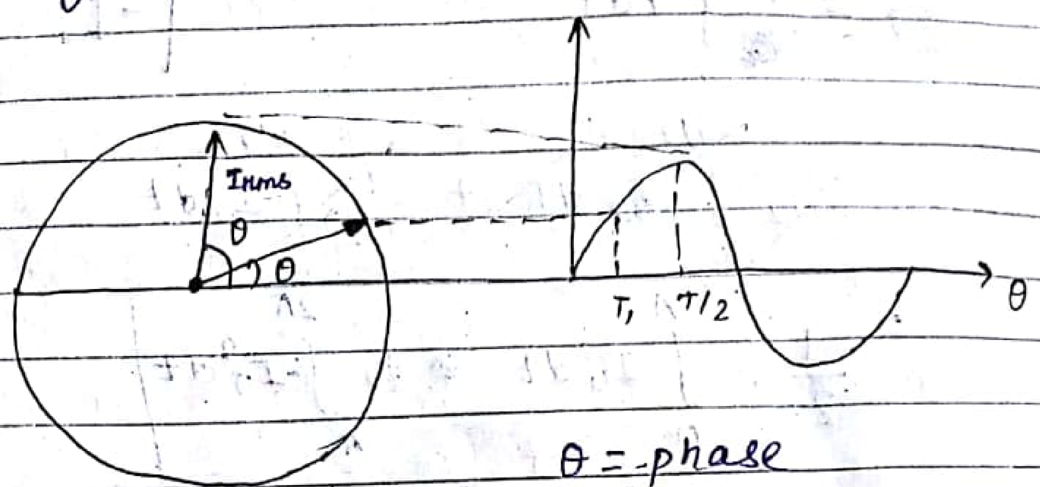
$$= \frac{I_0}{\pi} \times \pi = I_0 .$$

Form factor = 1

Peak factor $= \frac{I_0}{I_0} = 1$

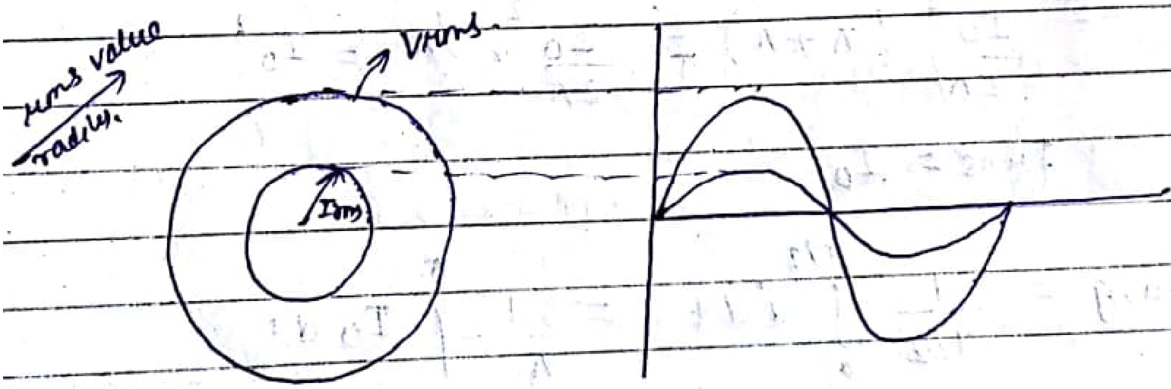
Phasor quantity

Only sunisoidal quantity can be represented as a phasor diagram and the magnitude of that phasor is rms value of that quantity.



θ = phase

V = IR

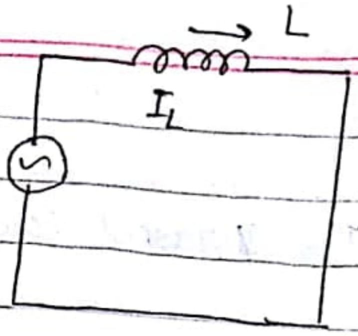


In a resistive ckt, current and voltage are in same phase.

$$E = E_0 \sin \omega t$$

$$I = \frac{E_0}{R} \sin \omega t$$

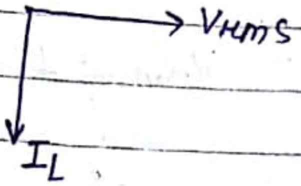
$$= I_0 \sin \omega t$$



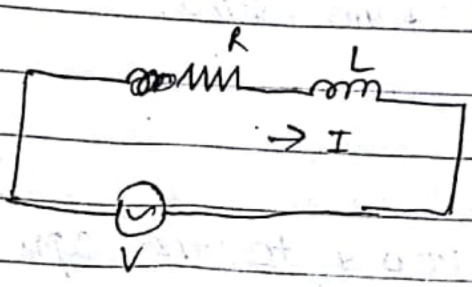
$V = V_0 \sin \omega t$

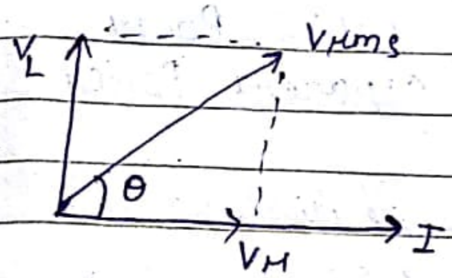
$I_L = \dfrac{V}{jX_L}$ $\sin \omega t$

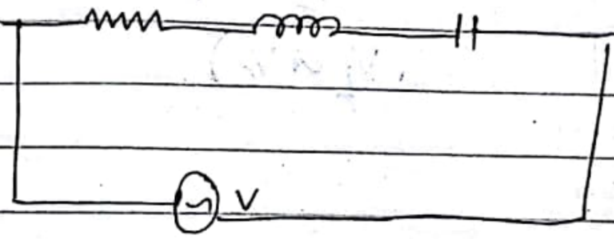
$= \dfrac{V}{X_L} \sin(\omega t - 90^\circ)$

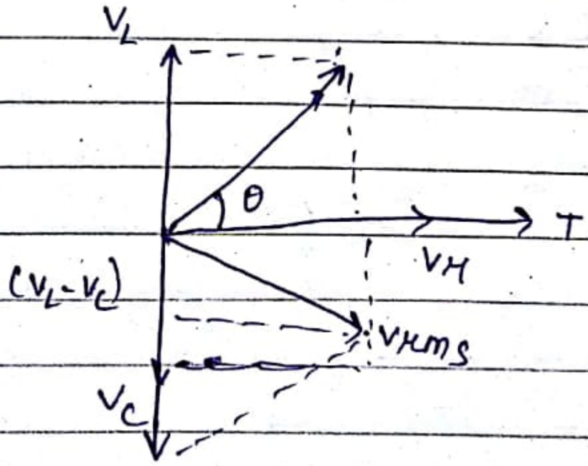


V is reference.









Power factor angle

$P = V_{rms} I_{rms}$ $\quad$ P = apparent Power

Unit of P = VA = Volt-Ampere.

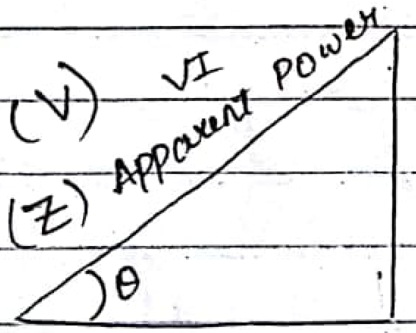
Active / Available Power $= V_{rms} \cdot I_{rms} \cos\theta$

Reactive Power $= V_{rms} \cdot I_{rms} \sin\theta$.

Power factor

The ratio of active power to the apparent Power.

$$= \frac{\text{Active Power}}{\text{apparent Power}}$$



Reactive power

$V I \sin\theta$

$(X_L \sim X_C)$

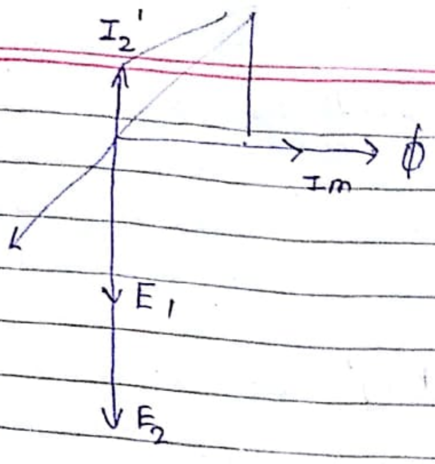
$(V_L \sim V_C)$

Active Power

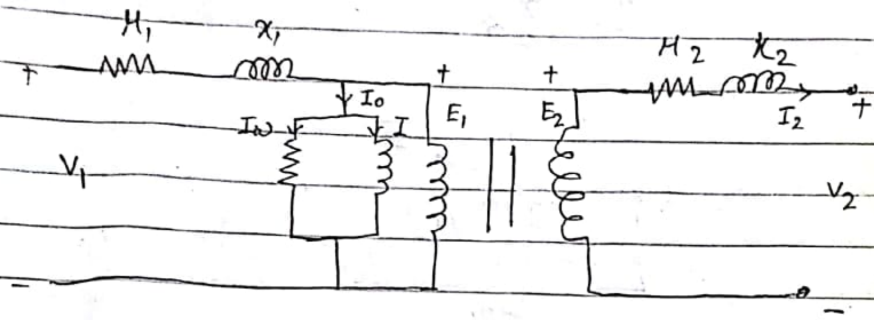
$V I \cos\theta$

(R)

V_R

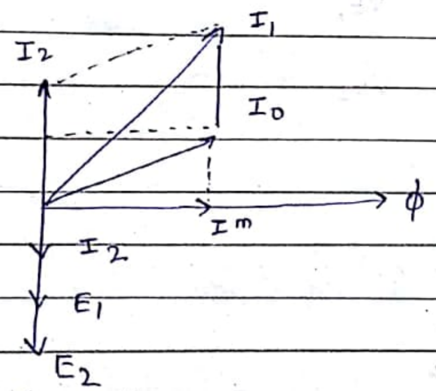


— X —

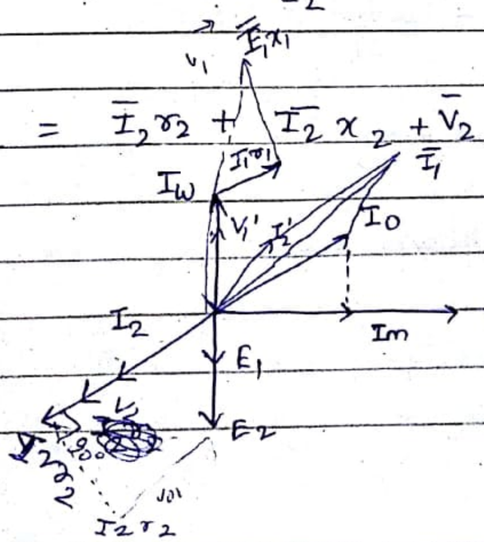


Applying KVL at Primary, phasor eq^n

$$V_1 = \bar{I}_1 r_1 + \bar{I}_1 x_1 + \bar{E}_1 \quad (1)$$



$$E_2 = \bar{I}_2 r_2 + \bar{I}_2 x_2 + \bar{V}_2$$



unity power factor load.

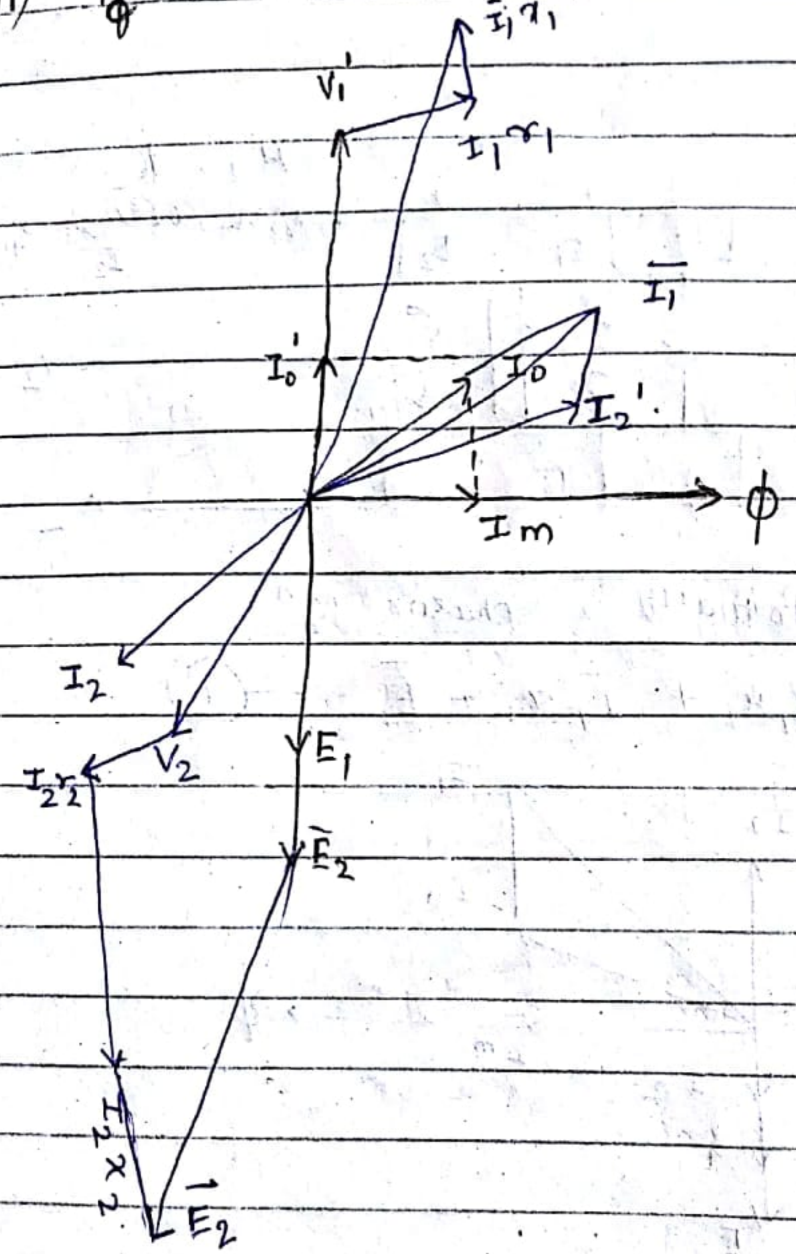
J.P gupta electrical machines

$E_1 = -\bar{V_1}'$ [(–) to indicate direction not magnitude.]

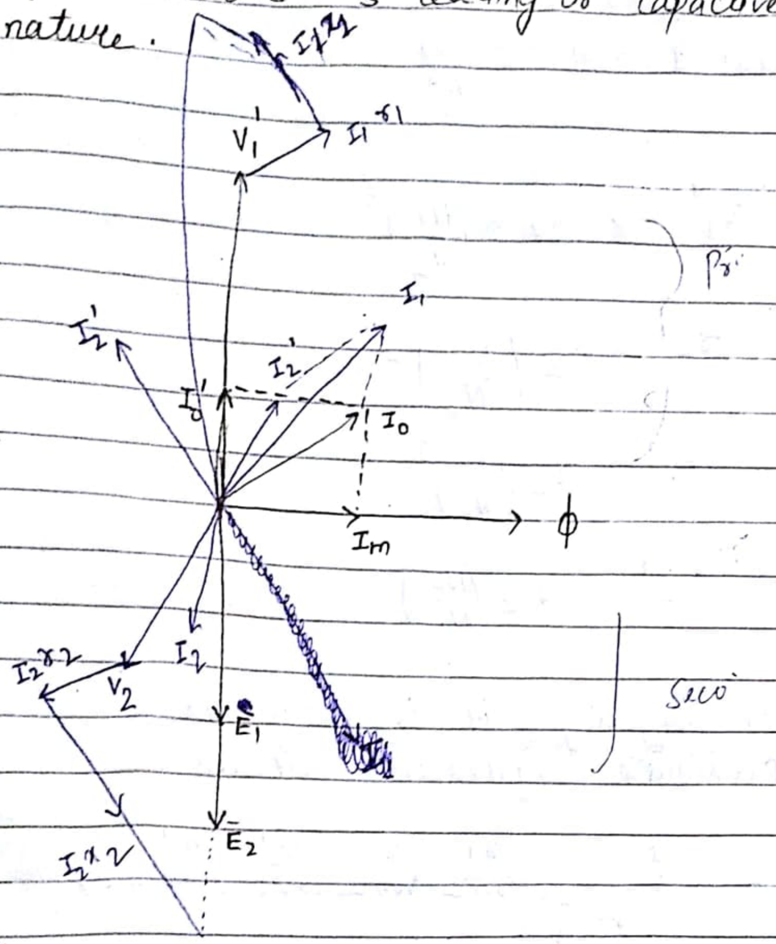
From ①,

$$\bar{V_1} = \bar{I_1} r_1 + \bar{I_1} x_1 + \bar{E_1}$$
$$= \bar{I_1} r_1 + \bar{I_1} x_1 + V_1'$$

ii) If the Load connected is lagging

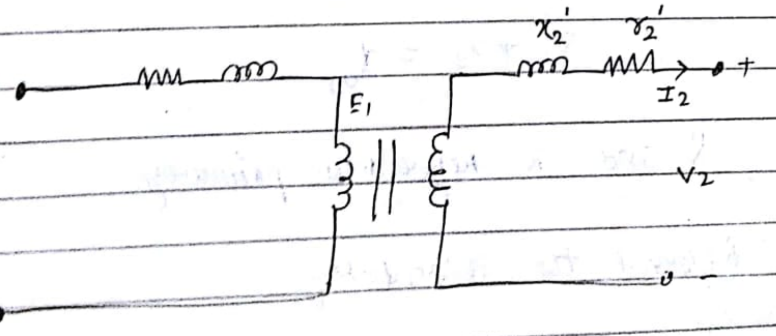


iii) If the Load is leading or capactive in nature.



i) Reffered to primary

$$\frac{E_1}{N_1} = \frac{E_2}{N_2} \Rightarrow E_2 = \frac{N_2}{N_1} E_1$$



Value of E_2 is reffered to primary $= E_2'$

$N_2 \rightarrow r_2$
$N_1 \rightarrow r_2 \left(\frac{N_1}{N_2}\right)^2$

$$\frac{E_2'}{E_2} = \frac{N_1}{N_2}$$

$$E_2' = \frac{N_1}{N_2} E_2$$

Scanned by CamScanner

$N_2 \rightarrow r_2$

For 1 turn $\rightarrow \frac{r_2}{N_2^2}$

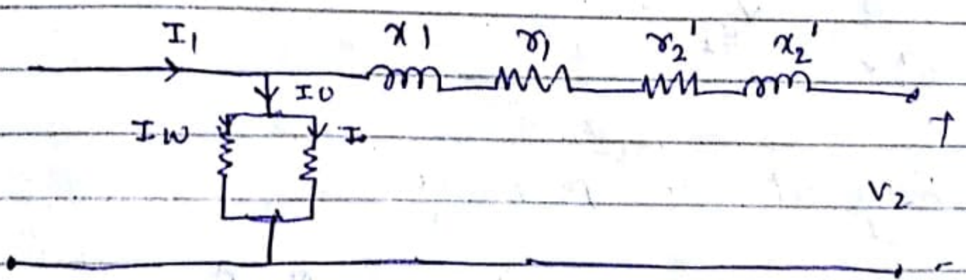
$$N_1' \rightarrow r_2 \times \left(\frac{N_1}{N_2}\right)^2$$

$$r_2' = r_2 \left(\frac{N_1}{N_2}\right)^2$$

$$x_2' = x_2 \left(\frac{N_1}{N_2}\right)^2$$

$$I_2' = I_2 \left(\frac{N_2}{N_1}\right)$$

After reffering, it is known as approximate equivalent circuit



I_0 is very small

$$r_1 + r_2' = R_{01}$$

$$x_1 + x_2' = X_{01}$$

R and x reffered to primary.

ii) Reffered to secondary

value of E_1' is reffered to secondary $= E_1'$

$$\frac{E_1'}{E_1} = \frac{N_2}{N_1}$$

$$E_1' = \left(\frac{N_2}{N_1}\right) E_1 \qquad x_1' = \left(\frac{N_2}{N_1}\right)^2 x_1$$

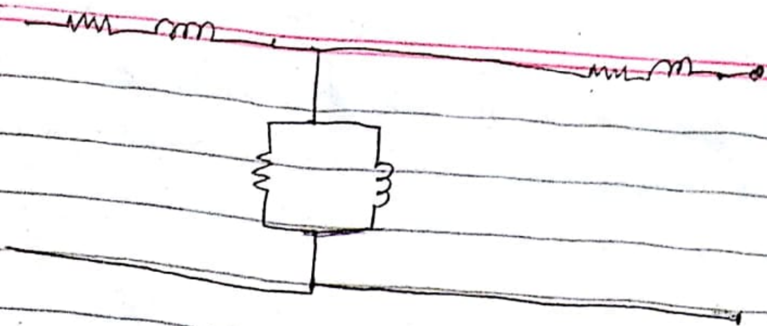
$$r_1' = \left(\frac{N_2}{N_1}\right)^2 r_1 \qquad I_1' = \frac{N_1}{N_2} I_1$$

$$I_w' = \frac{N_1}{N_2} I_w \qquad I_m' = \frac{N_1}{N_2} I_m$$

$$R_w' = \left(\frac{N_2}{N_1}\right)^2 R_w \qquad X_m' = \left(\frac{N_2}{N_1}\right)^2 X_m$$

$$r_1' + r_2 = R_{02}$$
$$x_1' + x_2 = x_{02}$$

R_{02} and x_{02} are reffered to secondary



$E_2' = \frac{N_1}{N_2} E_2$ $\quad r_2' = \left(\frac{N_1}{N_2}\right)^2 r_2$

$x_2' = \left(\frac{N_1}{N_2}\right)^2 x_2$ $\quad V_2' = \frac{N_1}{N_2} V_2$

$I_2' = \frac{N_2}{N_1} I_2$

Exact equivalent ckt reffered to primary.

$r_1 + r_2' = R_{01}$

$x_1 + x_2' = x_{01}$

$E_1' = \frac{N_2}{N_1} E_1$ $\quad I_w' = \frac{N_1}{N_2} I_w$ $\quad X_m' = \left(\frac{N_2}{N_1}\right)^2 X_m$

$V_1' = \frac{N_2}{N_1} V_1$ $\quad I_m' = \frac{N_1}{N_2} I_m$ $\quad I_0' = \frac{N_1}{N_2} I_0$

$I_1' = \frac{N_1}{N_2} I_1$ $\quad R_w' = \left(\frac{N_2}{N_1}\right)^2 R_w$ $\quad r_1' = \left(\frac{N_2}{N_1}\right)^2 r_1$

$x_1' = \left(\frac{N_2}{N_1}\right)^2 x_1$

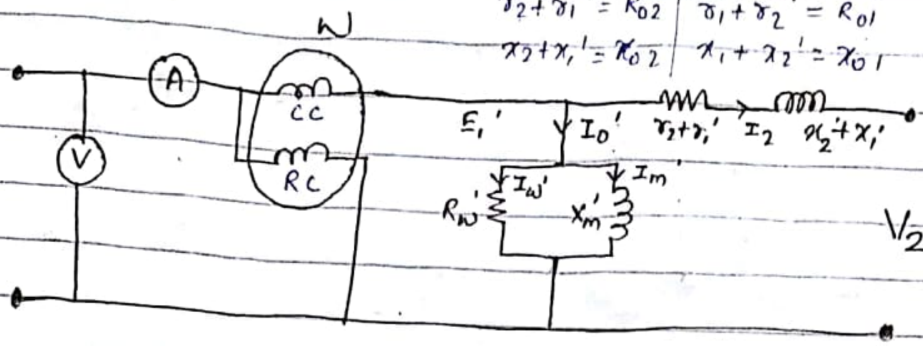
(core rolled grain oriented steel) with little bit of
CRGOS silicon.
↓
Histeri's loss reduce
laminated sheet : Reduce eddy current

wattmeter :
No-load losses are fixed losses in txH i.e they remain const → Histersis loss
→ Edd current loss

Open - ckt test

As the name suggest, we will open the circuit. Apply rated voltage. Open-ckt test perform on low voltage side

$r_2 + r_1' = R_{02}$ | $r_1 + r_2' = R_{01}$
$x_2 + x_1' = X_{02}$ | $x_1 + x_2' = X_{01}$



1 KVA, 100 V / 400 V

I_0 ↑ V ↑

OC test : 100 V, 1A, 50 W (Readings)

$I_m = I_0 \sin\phi$
$I_w = I_0 \cos\phi$

$V I_0 \cos\phi = 50$

$\cos\phi = \dfrac{50}{1 \times 100}$

$= \dfrac{1}{2}$

$\cos\phi = 0.5$
$\sin\phi = 0.867$
$I_m = 0.867$ A
$I_w = 0.5$

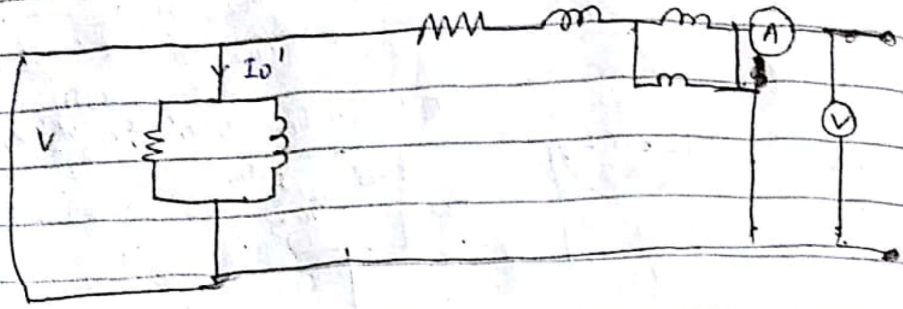
$X_m = \dfrac{100}{0.867}$ $\qquad R_w = \dfrac{100}{0.5} = 200\,\Omega$

$= 115.34\,\Omega$

why low voltage Not high voltage.

1) very high voltage needed i.e 400 V.
2) Dangerous

SC perform on high voltage side. LV side is sort circuited.



1 KVA, 1000 V/400 V

OC test : 100V, 1A, 50W

SC test : 40V, 2.3A, 80W → Ohmic or Variable loss or I^2R loss

$$I^2 R_{02} = 80$$

$$R_{02} = \frac{80}{(2.5)^2} \quad \therefore R_{02} = 12.8\,\Omega$$

$$Z_{02} = \frac{40}{2.5} = 16\,\Omega$$

$$X_{02} = \sqrt{Z_{02}^2 - R_{02}^2}$$

$$= \sqrt{16^2 - (12.8)^2} = \sqrt{256 - 163.84}$$

$$= 9.6\,\Omega$$

$$R_{01} = 12.8 \times \left(\frac{100}{400}\right)^2$$

$$= \frac{12.8}{16}$$

$$X_{01} = 9.6 \times \left(\frac{100}{400}\right)^2 \Omega$$

$$X_m' = X_m \times \left(\frac{400}{100}\right)^2$$

$$R_w' = R_w \times \left(\frac{400}{100}\right)^2$$

Primary

OC test $\rightarrow$ Low voltage side.
Convert high voltage side parameters to low voltage side.

secon

SC test $\rightarrow$ high voltage side
convert low voltage side parameters to high voltage side.

Find parameters for primary and secondary res

5 KVA, 500 V / 200 V

OC test : $\overset{\text{Rated voltage} \rightarrow V}{200\ V}$, $\overset{I_0}{1.5\ A}$, $\overset{VI_0\cos\phi}{80\,W}$ $\rightarrow$ No load losses

SC test : 50 V, 10 A, 200W.

Primary :

$I_m = I_0 \sin\phi$

$I_w = I_0 \cos\phi$

$V I_0 \cos\phi = 80$ $\qquad$ $V = 200$

$\cos\phi = \dfrac{80}{200 \times 25}$

$= \dfrac{8}{25 \times 20} = \dfrac{8}{500} = 0.016$

$\cos\phi = \dfrac{80}{200 \times 1.5} = 0.26$

$\sin\phi = 0.965$

$I_m = 1.5 \times 0.965 = 1.44$

$I_w = 1.5 \times 0.26 = 0.40$

$X_m = \dfrac{200}{1.44} = 138.88$ $\qquad$ $R_w = \dfrac{200}{0.40} = 500$

Scanned by CamScanner

$R_{01} \to$ when perform in primary
$R_{02} \to$ when perform in secondary

Secondary :

$$I^2 R_{01} = 200$$

$$R_{01} = \frac{200}{10 \times 10} = 2$$

$$Z_{01} = \frac{50}{10} = 5$$

$$X_{01} = \sqrt{25 - 4} = \sqrt{21} = 4.58$$

$$R_{02} = R_{01} \times \left(\frac{200}{500}\right)^2$$

$$= \frac{2 \times 2 \times 2}{5 \times 5} = \frac{8}{25} = 0.32$$

$$X_{02} = X_{01} \times \left(\frac{200}{500}\right)^2$$

$$X_m' = X_m \times \left(\frac{500}{200}\right)^2$$

$$R_w' = R_w \times \left(\frac{500}{200}\right)^2$$

2. 10 KVA, 1000 V/500 V

OC test → 500V, 2A, 100 W
SC test → 50 V, 10 A, 300 W

Find the eq. ckt parameters i) OC
ii) SC.

Voltage regulation.

Fractional change of txr from No load to Full load.

V_{NL} = No load Voltage = E_2

Full load voltage = V_2

Voltage Regulation $= \dfrac{E_2 - V_2}{E_2}$

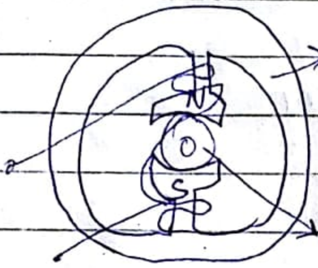
DC Machine

→ Rotating Machine

Mechi part
→ Stator : Stationary part
→ Rotator : Rotating part

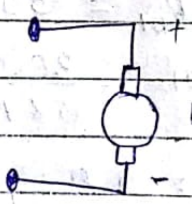
→ Electrical part : Field and Ammerature.

→ Field placed on ~~Ammertue~~ Stator and Rotator in ~~B.~~ Ammeron



→ Stater

→ Rotated



+

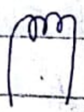
Eq / E_b

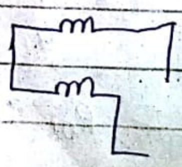
−

Series

Parallel

Separetly exited





compound