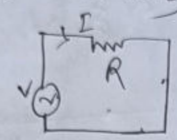
EE

3/2/22

1) 5 marks (Basics) [Electrostatics, magnetism]
2) DC N/W → 15/20 marks
3) Single phase AC
4) Rating – 230v – 50Hz
6) 1 φ AC (Rating)
7) 110v dC (train fan)

- $\boxed{V = V_m \sin\omega t}$



- $\boxed{I = I_m \sin\omega t}$

- $\boxed{P = VI\cos\phi}$ (For AC)
- $\boxed{P = VI}$ (For DC)

8) Transformer (20 marks)
9) DC machines (")
10) Induction m/C

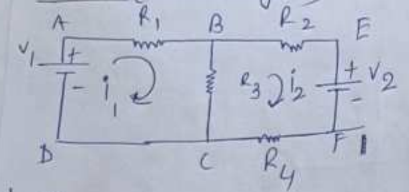
7/3/22

KVL and KCl → NODAL

V = IR

→ Loop /mesh

• KVL → (Loop analysis)



Loop 1

ABCDA

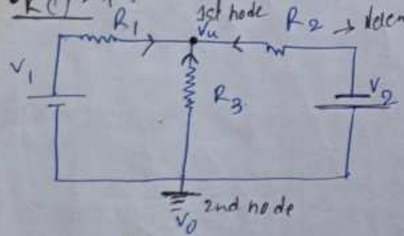
$I_1 R_1 + R_3(I_1 - I_2) - V_1 = 0$

Loop 2

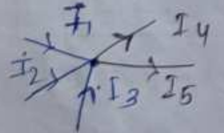
BEFCB

$I_2 R_2 + V_2 + I_2 R_4 + R_3(I_2 - I_1) = 0$

• KCl



(NODE)
↓
Junction Point
(minimum 1 element should be connected in between 2 nodes)



For nodal analysis we have to go for KCL.

$$\frac{V_u - V_1}{R_1} + \frac{V_u - V_0}{R_3} + \frac{V_u + V_2}{R_2} = 0$$ } Nodal analysis

$V_u = ?$

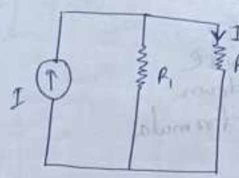
• +, + → Resultant → $V_1 - V_2$

• $V_1(+)$, $V_2(-)$ → Resultant $V_1 + V_2$

• KCl → Nodal analysis

• KVL → Loop analysis (Super mesh)

• Current division rule



~~$R_2(I_2) = ?$~~

$I_2(R_2) = ?$

~~$R_2(I_2)$~~ $I_2(R_2)$ = main current × $\frac{\text{opposite Resistance}}{\text{Total Resistance}}$

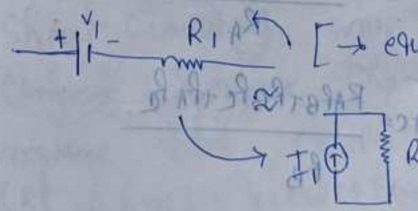
$$I_2(R_2) = I \times \frac{R_1}{R_1 + R_2}$$

$$I_1(R_1) = I \times \frac{R_2}{R_1 + R_2}$$

• Voltage division rule

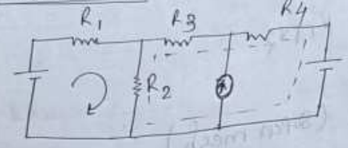
Branch vol. = main vol × $\frac{\text{Same resistance}}{\text{Total resistance}}$

• Source Transformation



[→ equivalent current source]

• Super mesh

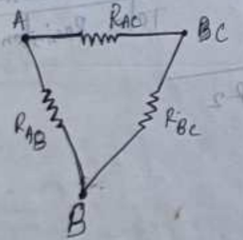


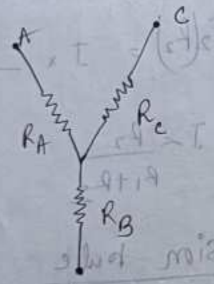
$I(R_3) = ?$

Assinment

• Star, delta connection ✓
• Series and Parallel Connection (no need) } write down the formula

• Delta, star transformation





To convert a delta to a star

$$R_A = \frac{R_{AB} R_{AC}}{R_{AB} + R_{BC} + R_{AC}}$$

$$R_B = \frac{R_{AB} R_{BC}}{R_{AB} + R_{BC} + R_{AC}}$$

$$R_C = \frac{R_{BC} R_{AC}}{R_{AB} + R_{AC} + R_{BC}}$$

To convert a ~~delta~~ star to a delta

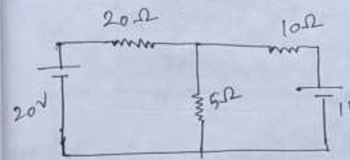
$$R_{AB} = \frac{R_A R_B + R_B R_C + R_A R_C}{R_C}$$

$$R_{BC} = \frac{R_A R_B + R_B R_C + R_A R_C}{R_A}$$

$$R_{AC} = \frac{R_A R_B + R_B R_C + R_A R_C}{R_B}$$

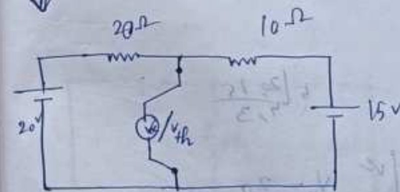
• DC Network Theorem 10/3/22

1) Thevenin's theorem
2) Norton's theorem
3) Super position theorem
4) maximum Power transformation theorem
5) [Tellegen's theorem] ×

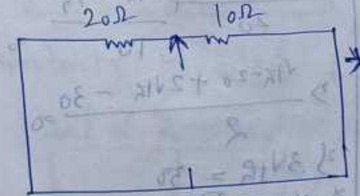


$I(5\Omega) = ?$
R_L = Load Resistance

⇓



[V_{oc} = open circuit voltage
V_{th} = Thevenin's equivalent voltage]

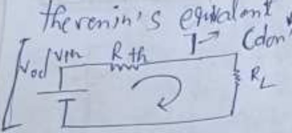


→ [this is not series, this is parallel]

[R_{th} = thevenin's equivalent resistance]

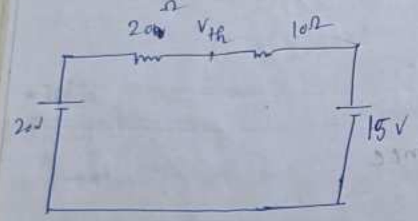
To find out Rth voltage source should be short circuited with their internal resistance. Current source should be open. measure total equivalent resistance of the ckt (Rth), viewed from the load terminal.

Thevenin's equivalent ckt (don't put R_L)



(voltage এর সাথে Resistance series এ থাকে সংযুক্ত)

$$\boxed{I_{th} = \frac{V_{th}}{R_{th}+R_L}}$$



$$\frac{V_{th}-20}{20} + \frac{V_{th}-10}{15} = 0$$

$$\Rightarrow \frac{3V_{th}-60+4V_{th}-40}{60} = 0$$

$$\Rightarrow 7V_{th} - 100 = 0$$

$$\Rightarrow V_{th} = \frac{100}{7} V$$

$$R_{th} = \frac{20\times10}{20+10} = \frac{200}{30}$$

$$I_{th} = \frac{100}{7\left(\frac{20}{3}+5\right)} = \frac{2\cancel{0}0\times3}{7\times(35)_7} = \frac{60}{49}$$

$5\,\lfloor 20,15$ / $4,3$

$$\frac{V_{th}-20}{20} + \frac{V_{th}-15}{10} = 0$$

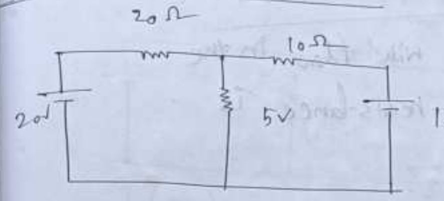
$$\boxed{\Rightarrow \frac{V_{th}-20+2V_{th}-30}{2} = 0 \qquad \Rightarrow 3V_{th} = 50}$$

$$\Rightarrow V_{th} = \frac{50}{3}$$

$$R_{th} = \frac{20}{3}$$

$$I_{th} = \frac{50}{3\left(\frac{20}{3}+5\right)} = \frac{50\times3}{3\times35} = 1.4278$$

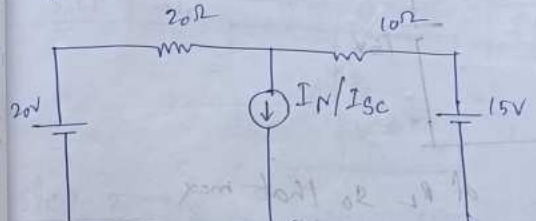
• Norton's theorem

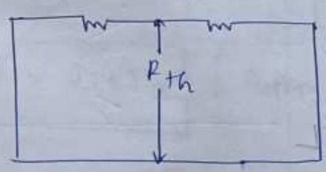


$I(5\Omega) = ?$
$\downarrow R_L$

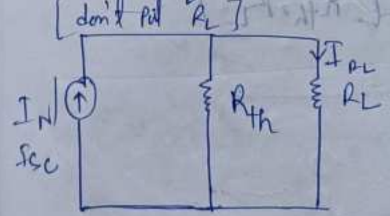
Identify R_L, then short the R_L through an ammeter, redraw the ckt diagram, then have to measure I_{sc} (short ckt current), findout R_{th}, redraw the ckt diagrame

⇓





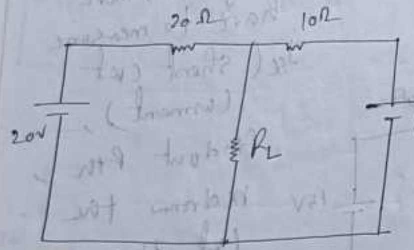
Norton's equivalent ckt
[don't put R_L]



$$I_{R_L} = \frac{I_{sc}\times R_{th}}{R_{th}+R_L}$$

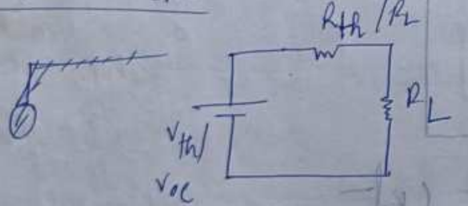
• maximum Power transformation theorem

Statement - max Power will flow in the ckt when Load resistance is equal to the R_{th}.



Find out the value of R_L so that max Power will flow in that circuit?

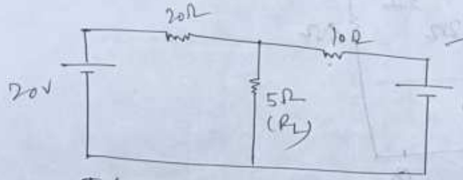
Equivalent ckt



$$I_{th} = \frac{V_{th}}{R_L+R_L} = \frac{V_{th}}{2R_L}$$ [∵ Here, $R_{th} = R_L$]

$\therefore P = I^2 R_L$

• Super position theorem



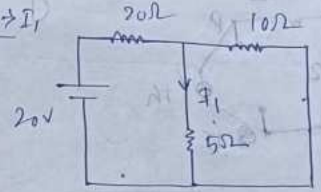
→ [more than 1 source should be present in the circuit.]

$I(5\Omega) = ?$

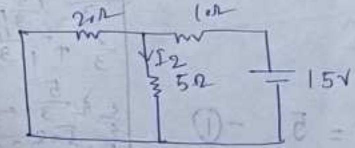
[voltage / current - more than 1]

[Only one source will act at one time]

Step-1 → I_1



Step-2 → I_2

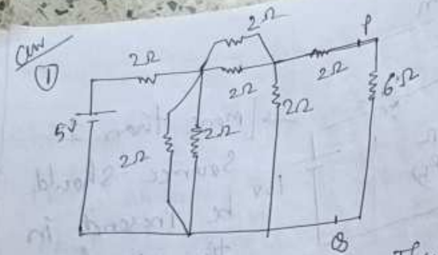


$\boxed{I = I_1 + I_2}$ [Super position theorem]

14/3/22

Qu

(1)



Determine Thevenin's theorem across terminal PQ as shown in the diagram.

~~$I_2 = 0.4545A$~~

$R_{th} = \frac{32}{11}$

ABGHA,

$2(I_1+I_2)+I_1 = 5$ — (1)

BCFGB,

$1I_2+2I_2-I_1=0$

$\Rightarrow 3I_2 = I_1$

from, (1)

$2(3I_2+I_2)+3I_2=5$

$\Rightarrow 2\times4I_2+3I_2=5$

$\Rightarrow 8I_2+3I_2=5$

$\Rightarrow I_2=\frac{5}{11}=0.4545A$

$V_{th} = 0.4545\times2 = \frac{10}{11}V$

$\frac{2\times1}{3}$ $(\frac{5}{3}+2)\frac{11}{3}$

$\frac{2}{3}+1$

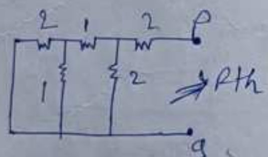
$\frac{5}{3}$ $\frac{10}{3}\cdot\frac{3}{11}$

$\frac{5\times2}{3}\times\frac{3}{11} = \frac{10}{11}$

$\frac{10}{11}+2$

$\frac{10+22}{11}$

$=\frac{32}{11}$



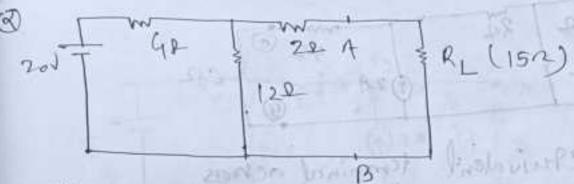
$R_{th}=2.9$

$I_{th} = \frac{10}{11\times(2.9+6)}$

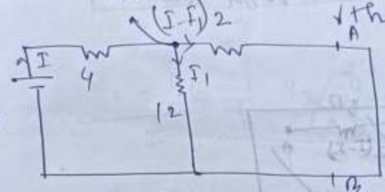
$= \frac{10\times10}{11\times8.9}$

$= \frac{100}{89\times11} = 0.102A$

(2)



⇓



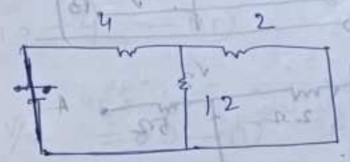
$\frac{V_{th}-20}{4}+\frac{V_{th}}{12}=0$

$\Rightarrow \frac{3V_{th}-60+V_{th}}{12}=0$

$\Rightarrow 4V_{th}=60$

$\Rightarrow V_{th}=15$

$V_{th}=15$



$\frac{4\times12}{16} = 3$

$\frac{4\times12}{14}$

$\frac{12}{7}+4$

$\frac{12+28}{7}$

$=\frac{40}{7}$

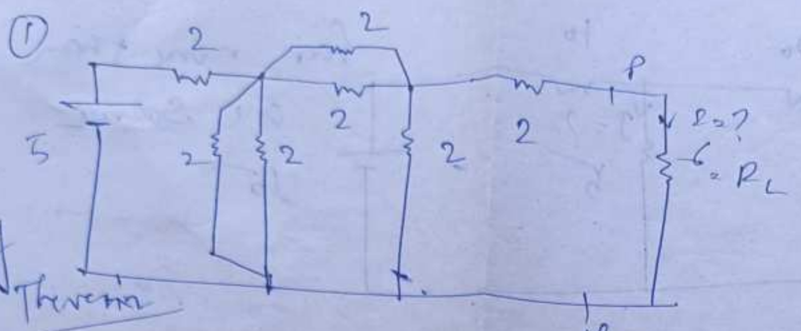
$R_{th} = \frac{40}{8} = 5$

$I_{AB} = \frac{18\times7}{40}$

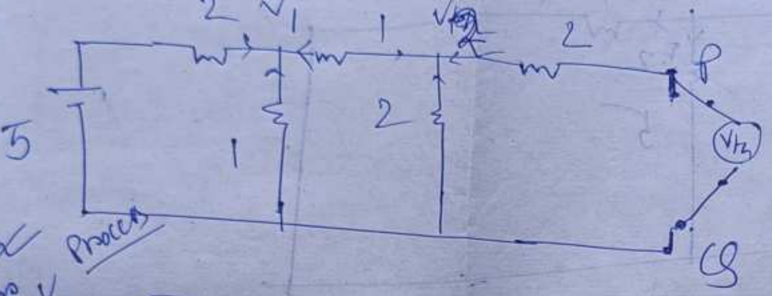
$I_{th} = \frac{15}{5+15}$

$= \frac{15}{20} = \frac{3}{4}$

①



3) Thevenin



LX other V process

$$\frac{v_1-5}{2}+\frac{v_1}{1}+\frac{v_1-v_2}{1}=0$$

$\Rightarrow v_1-5+2v_1+2v_1-2v_2=0$

$\Rightarrow 5v_1-2v_2=5$ — (I)

$$\frac{v_2-v_1}{1}+\frac{v_2}{2}=0$$

$\Rightarrow \cancel{\frac{2v_2-v_1}{2}}=$

$\Rightarrow 2v_2-2v_1+v_2=0$

$\Rightarrow -2v_1+3v_2=0$ — (II) $= V_{th}$

$\Rightarrow 3v_2=2v_1$

$\Rightarrow v_1=\frac{3v_2}{2}$

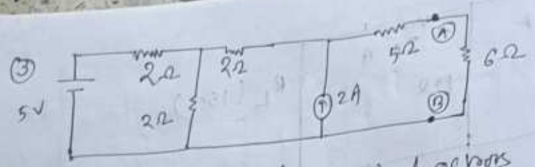
$\Rightarrow \frac{5\cdot 3v_2}{2}-2v_2=5$

$\Rightarrow 15v_2-4v_2=10$

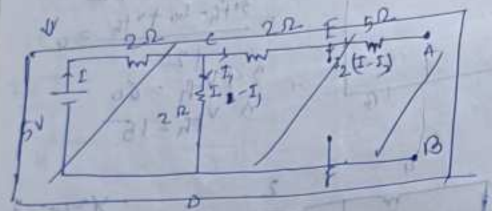
$\Rightarrow 11v_2=\frac{10}{11}$

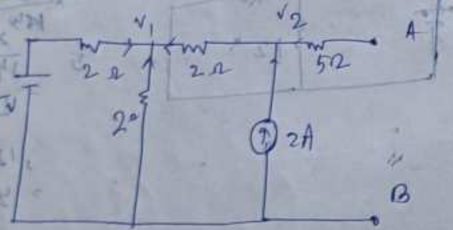
$\Rightarrow v_2=\frac{10}{11}$ V

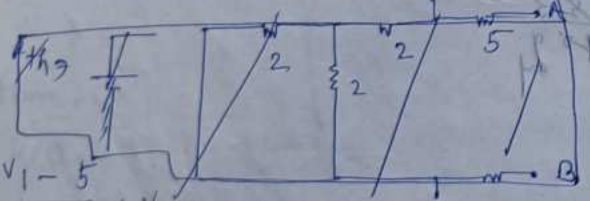
(3)



Thevenin's equivalent terminal across A and B and current through 6Ω resistance.



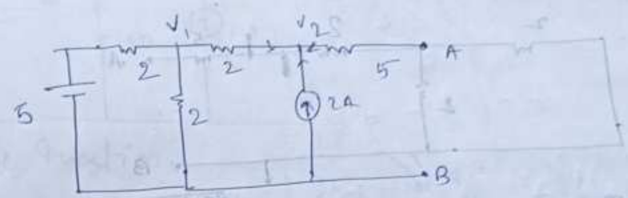




$$\frac{V_1-5}{2} + \frac{V_1-0}{2} + \frac{V_1-V_2}{2} + \cancel{2} = 0$$

$\Rightarrow V_1 - 5 + V_1 + V_1 - V_2 = 0$

$\Rightarrow 3V_1 - V_2 = 5$ — (I)



$$\frac{V_2 - V_1}{2} + \cancel{\frac{V_2 - 9}{0.5}} + 2 = 0$$

$\Rightarrow V_2 - V_1 + 4 = 0$

$\Rightarrow V_2 - V_1 = -4$ — (II)

$3V_1 - V_2 = 5$ — (I)

$V_2 - V_1 = -4$ — (II)

$\Rightarrow 2V_1 = 1$

$\Rightarrow V_1 = \frac{1}{2}$

$\Rightarrow V_2 - \frac{1}{2} = -4$

$\Rightarrow V_2 = -4 + \frac{1}{2}$

$= \frac{-8+1}{2}$

$= -\frac{7}{2}$

$= -3.5$

$V_{th} = V_2 = -3.5$ V

$3V_1 - V_2 = 5$

$-V_1 + V_2 = -4$

$\Rightarrow 2V_1 = 1$

$\Rightarrow V_1 = \frac{1}{2}$

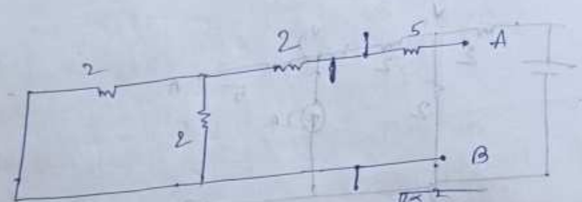
$3 \times \frac{1}{2} - V_2 = 5$

$\Rightarrow \frac{3}{2} - 5 = V_2$

$\Rightarrow \frac{3-10}{2} = V_2$

$\Rightarrow -\frac{7}{2}$

$\cancel{V_2 = -3.5}$



$\frac{2\times2}{4}$
$1+2$
$=3$

~~$R_{th} = \frac{3\times5}{8} = \frac{15}{8} = 1.9$~~

~~$I_{th} = \frac{-3.5}{3+6}$~~

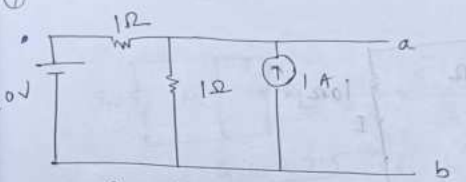
~~$= -\frac{3.5}{9}$~~

~~$= -0.38$~~

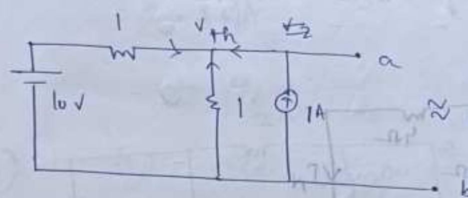
$R_{th} = 3+5 = 8$

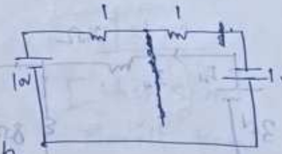
$I_{th} = \frac{-3.5}{8\cancel{+1.9}+6} = -0.25A$

(4)



same Question.





$\frac{V_{th}-10}{1} + \frac{V_{th}-0}{1} = V_2$

$\Rightarrow V_{th} - 10 + V_{th} = 0$ X

$\Rightarrow 2V_{th} = 10$

$\Rightarrow V_{th} = 5$

$R_{th} = \frac{1}{2}$

current through 1Ω resistance

$V_{th} = \frac{5}{\frac{1}{2}+1}$

$= \frac{10}{3}$

$= 3.33$

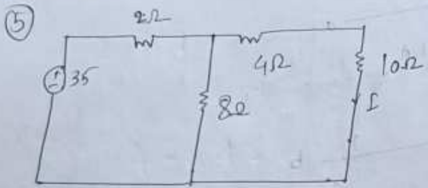
$I_{th} = \frac{10+1}{2}$

$= \frac{11}{2}$

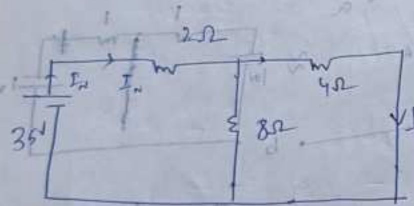
$= 5.5A$

$\boxed{\frac{1\times1}{2}}$

(5)



$I(1\Omega) = ?$ By norton's theorem



$I_N = \frac{35}{R_{eq}}$

$= \frac{35\times 3}{14 \cdot 2}$

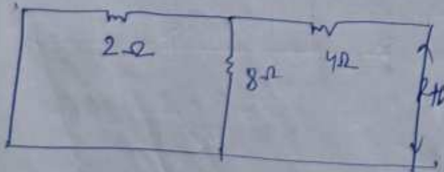
$= \frac{15}{2}$

$= 7.5\,A$

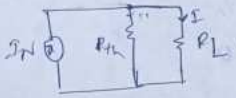
$\frac{4\times 8}{12}$

$= \frac{8}{3} + 2$

$= \frac{14}{3}$



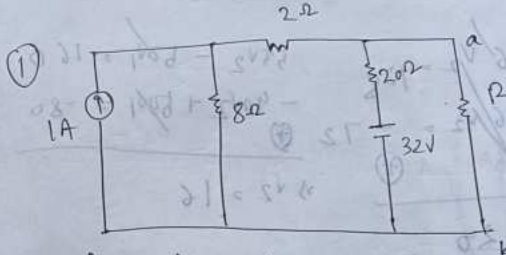
$R_{th} = 5.6\,\Omega$



$I = \frac{5.6\times 7.5}{5.6+10}$

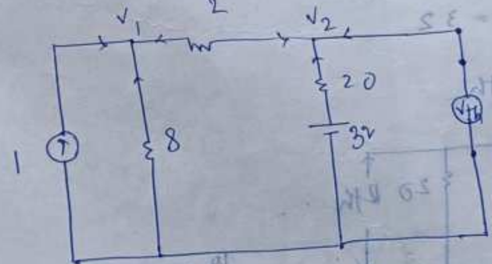
$= 2.69\,A$

(1)



[when short circuit then the total current will flow through the load ~~road~~ resistance]

Find thevenin and nortons equivalent current as shown in the figure.



$1 + \frac{V_1}{8} + \frac{V_1 - V_2}{2} = 0$

$\Rightarrow \frac{8 + V_1 + 4V_1 - 4V_2}{8} = 0$

$\Rightarrow 5V_1 - 4V_2 = -8$ — (1)

$\frac{v_2 - v_1}{2} + \frac{v_2 - 32}{20} = 0$

$\Rightarrow \frac{10v_2 - 10v_1 + v_2 - 32}{20} = 0$

$\Rightarrow 11v_2 - 10v_1 = 32$ — (ii) × 5

$5v_1 - 4v_2 = -8$ — (i) × 10

$40v_1 - 36v_2 = 128$

$55v_2 - 50v_1 = 160$

$-40v_2 + 50v_1 = -80$

$45v_1 - 36v_2 = -72$

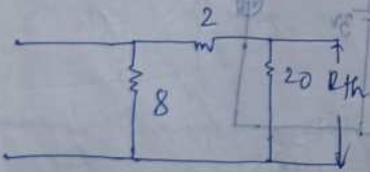
$\Rightarrow v_2 = 16$

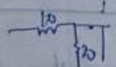
$\Rightarrow -5v_1 = 20$

$\Rightarrow v_1 = -40$

$-10 \times 40 - 9v_2 = 32$

$\Rightarrow v_2 = 16 \Rightarrow V_{th}$





$R_{th} = \frac{10 \times 20}{30}$

$= \frac{20}{3}$

$\therefore I_{th} = \frac{16}{\frac{20}{3} + \frac{20}{3}}$

$= \frac{16 \times 3}{40}$

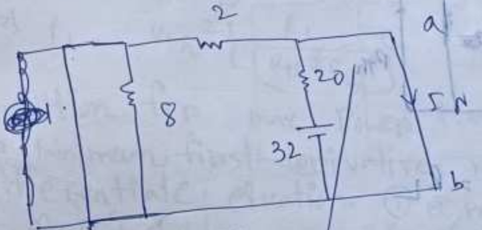
$= \frac{6}{5}$

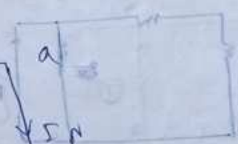
$R_L = R_{th} = \frac{20}{3}$

$I_{th} = \frac{16 \times 3}{40}$

$= \frac{6}{5} = 1.2\,A$

Norton's theorem



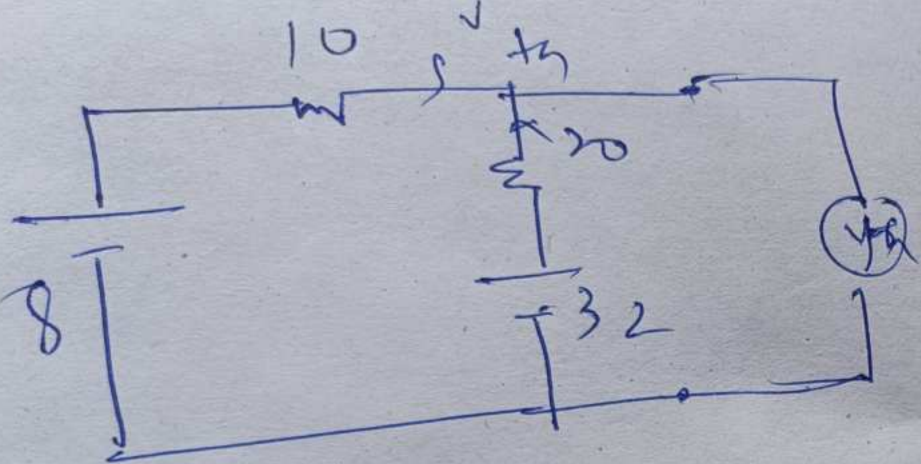


$I_N = \frac{16 \times 3}{10}$

$= 4.8\,A$

$R_{th} = \frac{20}{3}$

$\therefore$

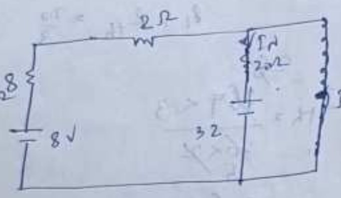


$$\frac{V_{th}-8}{10}+\frac{V_{th}-32}{20}=0$$

$$\Rightarrow \frac{2V_{th}-16+V_{th}-32}{20}=0$$

$$\Rightarrow 3V_{th}-48=0$$

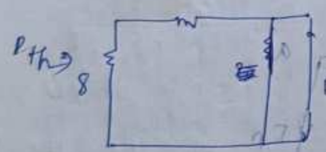
$$\Rightarrow V_{th}=16$$



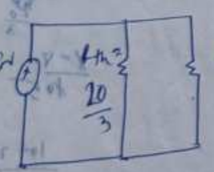
$I_N = \frac{32-8}{10}$

$= \frac{24}{10}$

$= 2.4\,A$



$R_{th} = \frac{20}{3} = R_L$

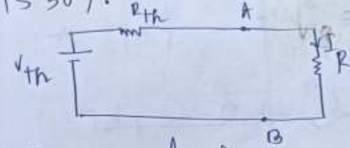


$\therefore I_L = \frac{2.4 \times \frac{20}{3} \times 3}{20 \times 2}$

$= \frac{2.4 \times 20 \times 3}{3 \times 20 \times 2}$

$= 1.2\,A$

Prove that $R_L = R_{th}$ in case of maximum power transfer theorem and also prove circuit deficiency is 50%.



The amount of power dissipated across the load resistor is $P_L = I^2 R_L$

Substitute $I = \frac{V_{th}}{R_{th}+R_L}$ in the above equation,

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

$\Rightarrow P_L = V_{th}^2 \left\{\frac{R_L}{(R_{th}+R_L)^2}\right\}$ — ①

Condition for max power transfer. For maximum or minimum, first derivative will be zero. So, differentiate equation ① w.r.t R_L and make it equal to '0'.

$\frac{dP_L}{dR_L} = V_{th}^2 \left\{\frac{(R_{th}+R_L)^2 \times 1 - R_L \times 2(R_{th}+R_L)}{(R_{th}+R_L)^4}\right\} = 0$

$\Rightarrow (R_{th}+R_L)^2 - 2R_L(R_{th}+R_L) = 0$

$\Rightarrow (R_{th}+R_L)(R_{th}+R_L-2R_L) = 0$

$\Rightarrow (R_{th}-R_L) = 0$

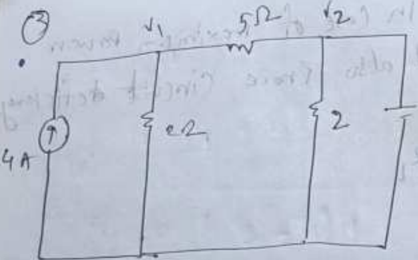
$\Rightarrow R_{th} = R_L$ or $R_L = R_{th}$ (Proved, 1st one)

The value of max power transfer, substitute $R_L = R_{th}$, $P_L = P_{L,max}$ in eqn ①

$P_{L,max} = V_{th}^2 \left\{\frac{R_{th}}{(R_{th}+R_{th})^2}\right\} = \frac{V_{th}^2}{4R_{th}} = \frac{V_{th}^2}{4R_L}$ [$\because R_L = R_{th}$]

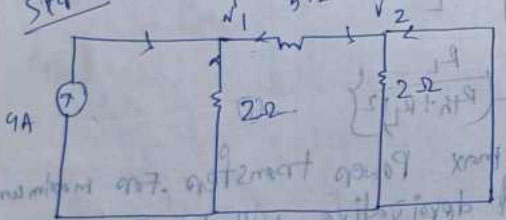
Efficiency $(\eta) = \frac{\text{output}}{\text{input}} \times 100 = I_L^2 R_L / 2I_L^2 R_L \times 100 = 50\%$.

③



For the circuit showing figure find the node voltage v_1 and v_2 using the superposition theorem.

step 1



$$4 + \frac{v_1'}{2} + \frac{v_1' - v_2'}{5} = 0$$

$$\Rightarrow \frac{40 + 5v_1' + 2v_1' - 2v_2'}{10} = 0$$

$$\Rightarrow 7v_1' - 2v_2 = -40 \quad \text{— (1)}$$

$$\frac{v_2' - v_1'}{5} + \frac{v_2'}{2} = 0$$

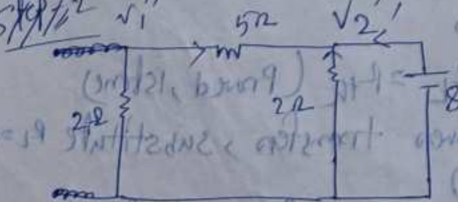
$$\Rightarrow \frac{2v_2' - 2v_1' + 5v_2'}{10} = 0$$

$$\Rightarrow 7v_2' - 2v_1 = 0$$

$v_1 = 6V$

$v_2 = 1V$

step 2



$$\frac{v_2'' - v_1''}{5} + \frac{v_2''}{2} = 8$$

$$\Rightarrow \frac{2v_2'' - 2v_1'' + 5v_2''}{10} = 0$$

$$\Rightarrow 7v_2'' - 2v_1'' = 0 \quad \text{— (ii)}$$

$7v_1 - 2v_2$ $\Rightarrow 7v_2'' = 2v_1''$ $\Rightarrow v_2'' = \frac{2}{7}v_1''$

~~from (i)~~,

$$7v_1' - 2\times\frac{2}{7}v_1' = -40 \quad \text{calculation}$$

$$\Rightarrow 7v_1' - \frac{4v_1'}{7} = -40$$

$$\Rightarrow \frac{49v_1' - 4v_1'}{7} = -40$$

$$\Rightarrow 45v_1' = -40\times 7$$

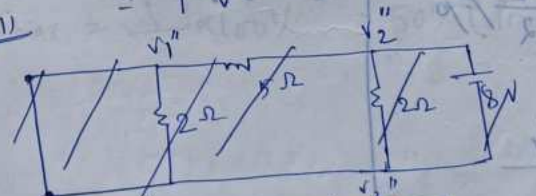
$$\Rightarrow v_1' = -\frac{40\times 7}{45} = -\frac{8\times 7}{9}$$

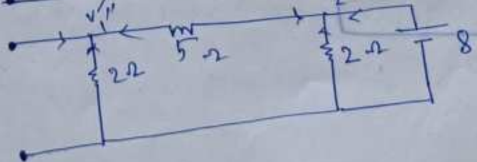
$$= -6.22\,V \approx 6\,V$$

$$v_2' = \frac{2\times 6.22}{7} \quad \text{(i)}$$

$$= 1\,V$$

step-II





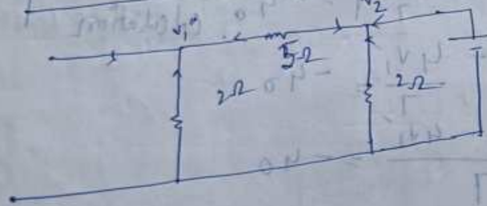
$$\cancel{\frac{v_2'' - v_1''}{5} + \frac{v_2''}{2} = 0}$$

$$\Rightarrow \frac{2v_2'' - 2v_1'' + 5v_2''}{10} = 0$$

$$\Rightarrow 7v_2'' - 2v_1'' = 0$$

$$\Rightarrow v_2'' = \frac{2}{7} v_1$$

$v_1'' = 1V$, $v_2'' = 3.5V$



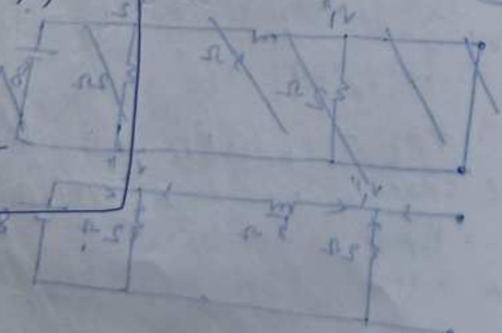
$$\frac{v_1''}{2} + \frac{v_1'' - v_2''}{5} = 0$$

$$\Rightarrow 5v_1'' - 2v_1'' - 2v_2'' = 0$$

$$3v_1'' = \frac{2}{2} v_2 \quad —(1)$$

$v_1'' = 1V$

$v_2'' = 3.5V$



(ii) assignment

(iii) $$\eta_{max} = \frac{P_{L\,max}}{P_S} \quad —(ii)$$

where,

$$P_S = I^2 R_{th} + I^2 R_L$$

$$\Rightarrow P_S = 2I^2 R_{th}, \; [\because R_L = R_{th}]$$

Substitute $I = \frac{V_{th}}{2R_{th}}$ in the above equation

$$P_S = 2\left(\frac{V_{th}}{2R_{th}}\right)^2 R_{th}$$

$$\Rightarrow P_S = 2\left(\frac{V_{th}^2}{4R_{th}^2}\right) R_{th}$$

$$= \frac{V_{th}^2}{2R_{th}}$$

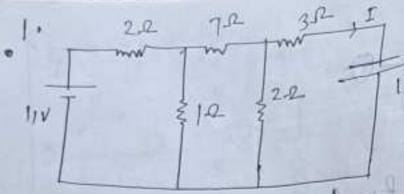
from eqn (ii)

$$\eta_{max} = \frac{\left(\frac{V_{th}^2}{4R_{th}}\right)}{\left(\frac{V_{th}^2}{2R_{th}}\right)}$$

$$\eta_{max} = \frac{1}{2}$$

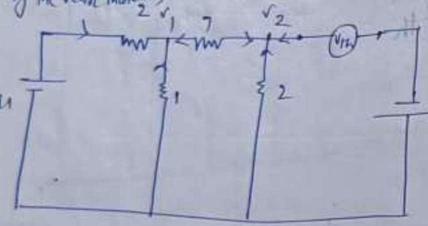
$$\%\,\eta_{max} = \frac{1}{2} \times 100\% = 50\%$$ (Proved, 2nd one)

1.



Determine the current through 3Ω resister branch as shown in the figure using a) Thevenin's b) Norton's theorem.

a) Thevenin theorem?



$$\frac{V_1-11}{2}+\frac{V_1}{1}+\frac{V_1-V_2}{7}=0$$

$$\Rightarrow \frac{7V_1-77+14V_1+2V_1-2V_2}{14}=0$$

$$\Rightarrow 23V_1-2V_2=77 \quad \text{(1)}$$

$$\frac{V_2-V_1}{7}+\frac{V_2}{2}=0$$

$$\Rightarrow \frac{2V_2-2V_1+7V_2}{14}=0$$

$$\Rightarrow 9V_2-2V_1=0$$

$$\Rightarrow V_1=\frac{9V_2}{2}$$

from (1)

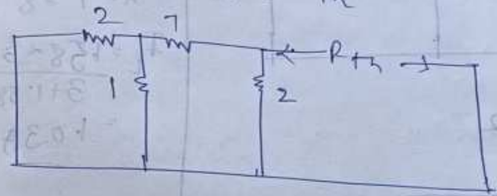
$$23\times\frac{9V_2}{2}-2V_2=77$$

$$\Rightarrow \frac{207V_2-4V_2}{2}=77$$

$$\Rightarrow 203V_2=77\times 2$$

$$\Rightarrow V_2=\frac{77\times 2}{203}$$

$$=0.75\ V = V_{th}$$



$R_{th}=1.58\,\Omega$

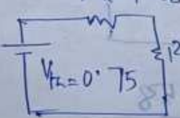
$$\frac{2}{3}+7 \quad \text{(1)}$$

$$=\frac{23}{3}\times 2$$

$$\frac{23}{3}+2$$

$$=\frac{23\times 2\times 3}{3\times 29}$$

$$=1.58$$



$$I_{th}=\frac{0.75}{1.58+3}$$

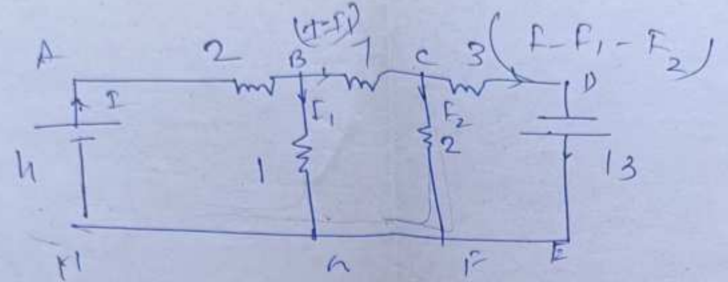
$$=0.163\ A$$

$V_{th}=9V$

$R_{th}=1.59$

$$\therefore I_{th}=\frac{9}{1.59+3}$$

$$=1.96$$



ABGHA,

$2I + I_1 = 11$ —(1)

∴ $V = 3\times3$

APEHA,

$2I + 7(I - I_1) + 3(I - I_1 - I_2) = 13 + 11$

$2I + 7I + 3I - 7I_1 - 3I_1 - 3I_2 = 24$

$\Rightarrow 12I - 10I_1 - 3I_2 = 24$

$\Rightarrow 12I - 10I_1 - \frac{3}{2}(8I_1 - 7I) = 24$

$\Rightarrow 24I - 20I_1 - 24I_1 + 21I = 48$

$\Rightarrow 45I - 44I_1 = 48$

BCFGB,

$7(I - I_1) + 2I_2 - I_1 = 0$

$7I - 7I_1 - I_1 + 2I_2 = 0$

$\Rightarrow 7I - 8I_1 + 2I_2 = 0$

$\Rightarrow 2I_2 = 8I_1 - 7I$

$\Rightarrow I_2 = \frac{(8I_1 - 7I)}{2}$

$I_2 = \frac{8\times3 - 7\times4}{2}$

$\boxed{I_2 = -2}$

$2\times4 + I_1 = 11$

$\boxed{I_1 = 3}$

$\boxed{I = 4}$

$88I + 44I_1 = 484$

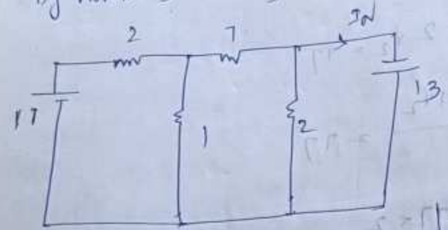
$45I - 44I_1 = 48$

$\Rightarrow 133I = 532$

$2I + I_1 = 11 \quad \times 44$

$45I - 44I_1 = 48 \quad \times 1$

By Norton's theorem,



$I_N = \frac{V}{R_{eq}} = \frac{11+13}{2+7} = 2.67\,A$

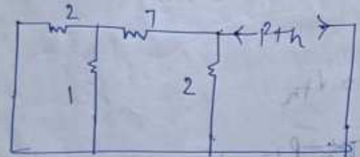
$I_N = \frac{17+13}{\frac{2}{3}+7}$

$= 3\,A$

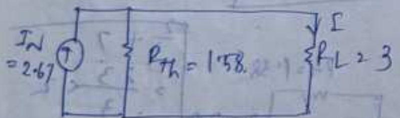
$R_{th} = 1.58$

$I_L = \frac{1.58 \times 3}{3+1.58}$

$= 1.03\,A$



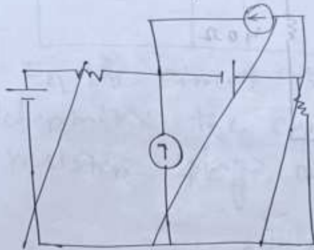
$R_{th} = 1.58\,\Omega$

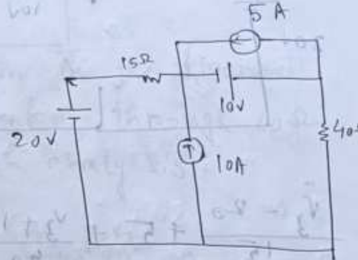


$I = \frac{2.67 \times 1.58}{(1.58+3)}$

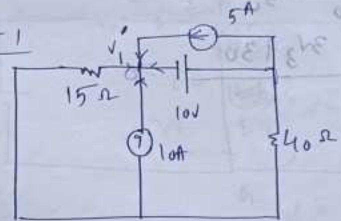
$= 0.92\,A$

② Find the voltage across through 15Ω resistor using superposition theorem.





Step-1



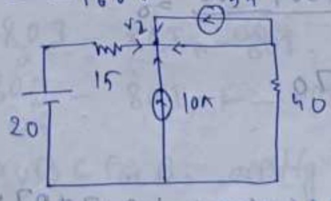
$10 + \cancel{\frac{V+10}{}}\ 5 + \frac{V_1'}{15} + \frac{V_1'+10}{40}$

$\Rightarrow \frac{1800 + 8V_1' + 3V_1' + 30}{120} = 0$

$\Rightarrow 11V_1' = -1830$

$\Rightarrow V_1' = -166\,V$

Step-2

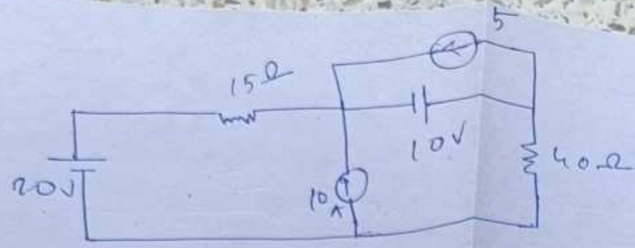


$\frac{V_2 - 20}{15} + 10 + 5 + \frac{V_2}{40} = 0$

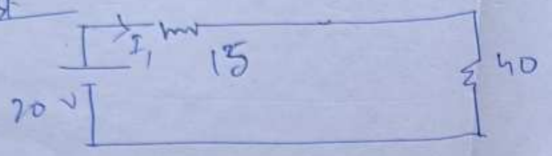
$\Rightarrow \frac{8V_2 - 160 + 1800 + 3V_2}{120} = 0$

$\Rightarrow 11V_2 = -1640$

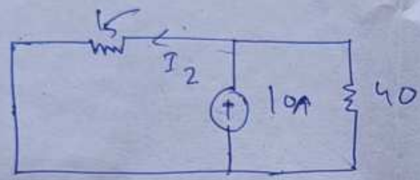
$\Rightarrow V_2 = -149\,V$



14



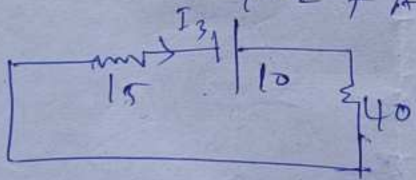
$$I_1 = \frac{20}{15+40} = 0.363\,A$$



$$I_2 = \frac{10 \times 40}{15+40}$$

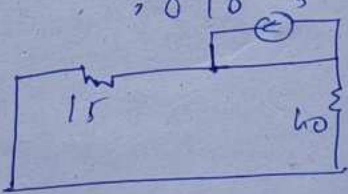
$\therefore V_{15} = 6.727 \times 15$
$= 100\,V$

$$= 7.27\,A$$



$$I_3 = \frac{10}{15+40}$$

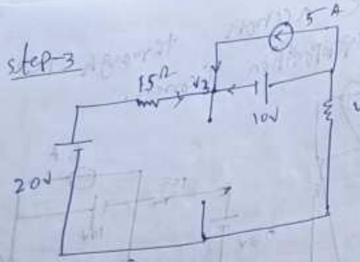
$$= 0.18$$



as it is shortcircuit current
$I_{40} = 0$

$$\therefore I = 0.363 - 7.27 + 0.18$$
$$= -6.727$$

step-3



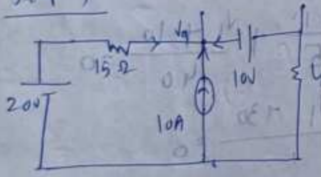
$$\frac{V_3-20}{15}+5+\frac{V_3+10}{40}=0$$

$$\Rightarrow \frac{8V_3-160+600+3V_3+30}{120}$$

$\Rightarrow 11V_3=-470$

$\Rightarrow V_3=-42.7V$

step-4



$$\frac{V_4-20}{15}+\frac{V_4+10}{40}+10=0$$

$$\Rightarrow \frac{8V_4-160+3V_4+30+1200}{120}=0$$

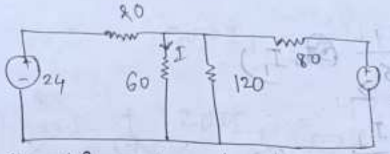
$\Rightarrow 11V_4=-1070$

$\Rightarrow V_4=-97.2V$

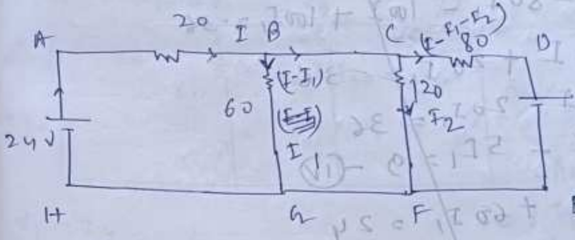
Total voltage $=166+149+42.7+97.2$
$=455V$

21/3/22

(1)



In the circuit shown in the figure determine the current through 60Ω resister using mesh analysis.



For loop ABGHA, appling mesh analysis

$20I+\cancel{60(I-I_1)}=24$
$60I_1$

$\Rightarrow 20I+60I_1=24$ —(i)

For loop, BCDEFGB appling mesh analysis.

$\cancel{120I_2}\ 80(I-I_1-I_2)-120I_2=-36$ —(ii)

$\Rightarrow 80I-80I_1-80I_2-120I_2=-36$

$\Rightarrow 80I-80I_1-200I_2=-36$ —(ii)

For loop, BCFGB, appling mesh analysis

$120I_2-60I_1)=0$

$\Rightarrow \cancel{120I_2=60(I-I_1)}$ $\Rightarrow 120I_2=60I_1$

$\Rightarrow I_2=\frac{1}{2}I_1$

$\Rightarrow I_2 = \frac{60}{120_2}(I_1)$

$= \frac{I_1}{2}$ — (iii)

from (iii)

$80I - 80I_1 - 200 \times \frac{100(I-I_1)}{2} = -36$

$\Rightarrow 80I - 80I_1 - 100I + 100I_1 = -36$

$\Rightarrow -20I + 20I_1 = -36$

$\Rightarrow 20I - 20I_1 = 36$

$\Rightarrow 5I - 5I_1 = 9$ — (iv)

$20I + 60I_1 = 24$

$\Rightarrow 5I + 15I_1 = 6$ — (v)

$5I - 5I_1 = 9$ — (iv)

$\Rightarrow 20I_1 = -3$

$\Rightarrow I_1 = -\frac{3}{20}$ A

$80I - 80I_1 - 200 \times \frac{I_1}{2} = -36$ — (ii)

$\Rightarrow 80I - 80I_1 - 100I_1 = -36$

$\Rightarrow 80I - 180I_1 = -36$ — (iv) $\times 5$

$5I + 15I_1 = 6$ — (v) $\times 80$

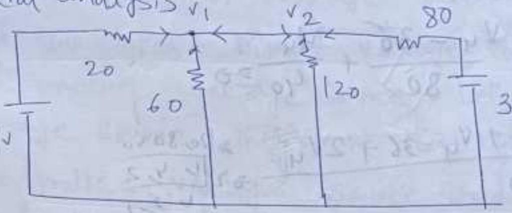
$400I - 900I_1 = -180$

$400I + 1200I_1 = 480$

$\Rightarrow -2100I_1 = -660$

$\Rightarrow I_1 = 0.314$ A

Nodal analysis



Another Process

$\frac{V_1-24}{20} + \frac{V_1}{60} + \frac{V_1-V_2}{120} = 0$

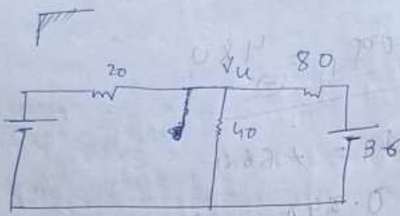
20 | 20, 60, 120
1, 3, 2

$\Rightarrow \cancel{\frac{3V_1 - 72 + V_1}{60} = 0}$

$\Rightarrow \frac{6V_1 - 144 + 2V_1 + V_1 - V_2}{120} = 0$

$\Rightarrow 9V_1 - V_2 = 144$ — (1)

$V_2 - V$



$$\frac{V_4-24}{20}+\frac{V_4-36}{80}+\frac{V_4}{40}=0$$

$$\Rightarrow \frac{4V_4-96+V_4-36+2V_4}{80}$$

$\Rightarrow 7V_4 = 132$

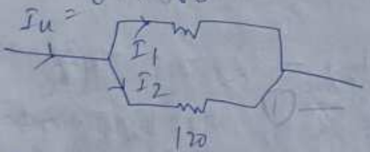
$\Rightarrow V_4 = 18.85V$

$\therefore I_4 = \frac{18.85}{40}$

$= 0.47A$

Now

$I_4 = 0.47$



$I_1 = \frac{0.47\times 120}{180}$

$= 0.314\ A$

assignment

(1) Classification of voltage and current Source.

(2) Dependent Current Source and voltage Source Independent " " " "

symbol, ckt diagram.

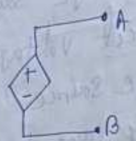
(1) classification of voltage Source :- They are of two types - Direct voltage Source and Alternating voltage Source. ~~Defentim~~ Dependent voltage Source : They are two types - Voltage Controlled voltage Source and Current Controlled Voltage Source.

classification of current Source :- Current Source is a circuit element which delivers energy with a specified current through it. If such a source maintains constant current for any voltage then it is called as an ideal current source. An ideal current source has infinite resistance (or impedance) across it.

(2) Dependent current Source :- In the theory of electrical networks, a dependent source is a voltage source or a current source whose value depends on a voltage or current elsewhere in the network. Dependent Sources are useful, for example, in modelling the behavior of amplifiers.

Symbol - Ideal dependent & voltage Sources represented by a diamond-shaped Symbols, are dependent on, and are proportional too an external controlling voltage or current. The multiplying constant, μ for a VCVS has no units, while the multiplying constant ρ for a CCVS has units of ohm's.

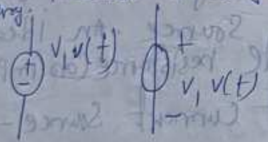
Circuit diagram -



Independent voltage source - An independent voltage source is an idealized circuit component that fixes the voltage in a branch, respectively, to a specified value.

Symbol - The middle symbol is the symbol for a specific type of independent voltage source known as a battery.

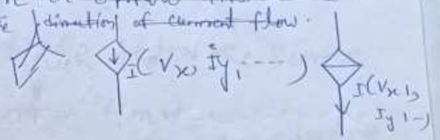
Circuit diagram -



Dependent current source - In the theory of electrical networks, a dependent source is a voltage source or a current source whose value depends on a voltage or current elsewhere in the network. Dependent Sources are useful, for example, in modelling the behavior of amplifiers.

Symbol - Ideal dependent current sources represented by a diamond-shaped symbol. ~~a circle with an arrow inside is the symbol to indicates the direction of current flow.~~

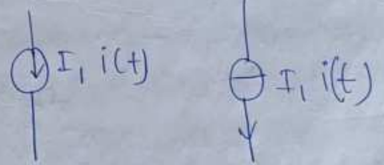
Circuit diagram -



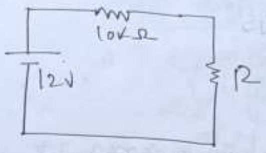
Independent current Source - An independent current source is an energy source that pushes a constant flow of electrons through an electrical circuit regardless of the load presented to it. In other words, a 1 amp current source will maintain a current flow of 1 amp through its terminals if it has an open circuit or short circuit as a load.

Symbol - A circle with an arrow inside is the symbol to indicate the direction of the flow of the current.

Circuit diagram -



(2)



For the circuit shown above
It has 3 Part—

Part A – Determine R such that the source delivers a power of 4mW.

Part B – Determine R that results in 10kΩ resister to absorb 1.6 mW of power

Part C = Replace R by a voltage source that will cause no power to be absorb by any resister.

Part-A

$P = \frac{V^2}{R}$

$\Rightarrow 4\times10^{6} = \frac{(12)^2}{R+10\times10^3}$

$\Rightarrow R + 10\times10^3 = \frac{(12)^2}{4\times10^6}$

$\Rightarrow R + 10\times10^3 = 3.6\times10^{-5}\ \Omega$

$\Rightarrow R = 9\,k\Omega$

$P = VI$

$= I^2 R$

$P = \frac{V^2}{R}$

$4mW = 4\times10^{6}\,W$

Part-B

$1.6\times10^{6} = \frac{V^2}{\cancel{10\times10^3 + R}}$

$\Rightarrow V^2 = 1.6\times10^{10}$

$\Rightarrow 1.6\times10^{10} \cancel{+ 1.6\times10^{6} R} = V^2$

$\Rightarrow V = \cancel{126.5\times10^3}\ V$

Power remains same always

Now,

~~$1.6\times10^{6} = \frac{(126.5\times10^{3})^2}{R}$~~

~~$\Rightarrow R = 10\times10^{3}\,\Omega = 10\,K\Omega$~~

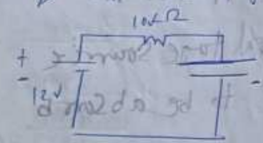
~~$1.6\times10^{6} = \frac{(12)^2}{10\times10^{3}+R}$~~

~~$\Rightarrow 1.6\times10^{10} + 1.6\times10^{6}R = 144$~~

~~$\Rightarrow R = 9.9\,K\Omega$~~

Part-C

If the diagram is



then net $V = 12 - 12 = 0$

So $P = \frac{V^2}{R} = \frac{0}{10\times10^{3}} = 0\,W$

∴ No power can be absorbed by any resistor.

Part-B

$I^2 \times 10\times10^{3} = 1.6\times10^{6}$

$\Rightarrow I = 12.64$

∴ ~~$VI = P$~~

$\Rightarrow I^2 R = P$

$\Rightarrow R = \frac{P}{I^2} = \frac{1.6\times10^{6}}{(12.64)^2} = 10\,K\Omega$

AC signal

22/3/22

- L . N Line (Line and neutral)

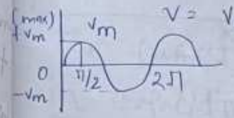
$P = VI\cos\varphi$ (AC) [angle between voltage and current $= \varphi$]

$P = VI$ (DC)

1φ, 50 Hz, 230 V (Single Phase)

- 

Pure dc



$V = V_m \sin\omega t$ (Pure sine wave)

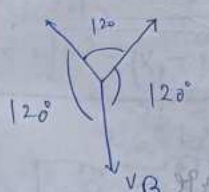
- R, Y, B, N

$V_R = V_m \sin\omega t$

$V_Y = V_m \sin(\omega t - 120°)$ → 3-Phase lines

$V_B = V_m \sin(\omega t - 240°)$

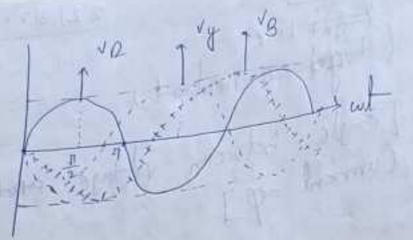
$V_N =$



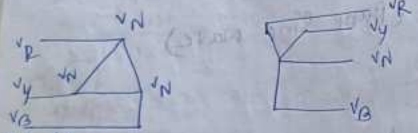
Rating = 444 V (3-Phase rating) 50 Hz, 3φ

Line voltage – If we connect a voltmeter between 2 lines, then what voltage we will get that is line voltage. (3Phase lines), V_{RY}, V_{YB}, V_{BR}

Phase voltage – V_{RN}, V_{YN}, V_{BN}, the voltage/potential difference between line and neutral is called Phase voltage.



vector sum of V_y, V_R, V_B at any particular is '0'.



• Delta,

$\boxed{LV = PV}$ (3ϕ) [ϕ = phase]

$\boxed{I_L = \sqrt{3}\, I_{ph}}$

Star, (3ϕ)

• $\boxed{LV = \sqrt{3}\, PV}$

$\boxed{I_L = I_{ph}}$

Definations:-

1) Define wareform, pic value, avarage value, frequency, time period, rms value, form factor, the relation between avarage and rms value, the relaction between rms ~~and~~, avarage value and nurmal value, phase, phase sequence (ex)

• Pure resistor,

$\boxed{I = I_m \sin \omega t}$

• Pure Inductor

$\boxed{I = I_m \sin(\omega t - \frac{\pi}{2})}$

In inductive ckt the current is always lagging, the current will stay behind the valtage.

[I ↓ → V] (phasor diagram).

Pure capacitor,

$\boxed{I = I_m \sin(\omega t + \frac{\pi}{2})}$

The current will always lead w.r.t valtage in capacitor ckt. The current will stay upper the valtage. [I ↑ → V]

(1) $L \rightarrow X_L = 2\pi f L$

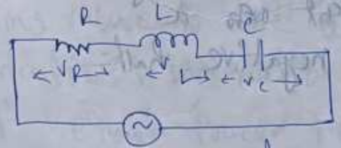
(2) $X_C = \frac{1}{2\pi f C(F)}$

RLC ckt,

$\boxed{Z = \sqrt{R^2 + (X_L - X_C)^2}}$

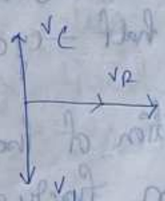
$X_L > X_C \rightarrow$ inductive ckt

$X_C > X_L \rightarrow$ capacitive resistence



$V = V_m \sin \omega t$

$V = V_R + V_L + V_C$



① Definition of waveform - a usually graphic representation of the shape of a wave that indicates its characteristics (such as frequency and amplitude) - called also wave-shape.

② Definition of PIC value - The polymorphism information content (PIC) value is often used to measure the informativeness of a genetic marker for linkage studies. The PIC value was first derived for the case of a rare dominant disease, when one of the parents is affected, and is a function of the particular mode of disease inheritance.

③ Definition of average value - The average value of alternating current is defined as the average of all values of current over a positive half-cycle or negative half-cycle.

④ Definition of frequency - In physics, the term frequency refers to the number of waves that pass a fixed point in unit time. It also describes the number of cycles or vibrations undergone during one unit of time by a body in periodic motion.

⑤ Definition of time period - The time period is the time taken by a complete cycle of the wave to pass a point.

⑥ Definition of rms value - The RMS value is the effective value of a varying voltage or current. It is the equivalent steady DC (constant) value which gives the same effect. For example, a lamp connected to a 6V RMS AC supply will shine with the same brightness when connected to a steady 6V DC supply.

⑦ Form factor - In electronics or electrical engineering, the form factor of an alternating current waveform is the ratio of the RMS value to the average value. It ~~deter~~ identifies the ratio of the direct current of equal power relative to the given alternating current.

(8) Phase – A simple description is that a phase is a region of material that is chemically uniform, physically distinct, and (often) mechanically separable.

(9) Phase sequence – phase rotation or phase sequence, is the order in which the voltage waveforms of a polyphase AC source reach their respective peaks. For three-phase system, there are only two possible phase sequences: 1-2-3 and 3-2-1, corresponding to the two possible directions of alternator ~~ro~~ rotation.

Example – Clockwise rotation phase sequence → 1-2-3, counter clockwise rotation phase sequence: 3-2-1.

(10) The RMS value is the square root of the mean (average) value of the squared function of the instantaneous values.

$e_{rms} = e_{av} \times \frac{\pi}{2\sqrt{2}}$

It is the relation between RMS and average value.

(11) The relation between RMS value and normal value – $e_{rms} = \frac{e_0}{\sqrt{2}}$

(12) The relation between average value and normal value – $e_{av} = \frac{2e_0}{\pi}$

$$\left[e_{av} = \frac{1}{\left(\frac{T}{2}\right)} \int_0^{T/2} e \, dt \right.$$

$$= \frac{2}{T} \int_0^{T/2} e_0 \sin\omega t \, dt$$

$$= \frac{2e_0}{T} \left[-\frac{\cos\omega t}{\omega} \right]_0^{T/2}$$

$$= \frac{2e_0}{T\omega} \left[-\cos\frac{\omega T}{2} + 1 \right]$$

$$= \frac{2e_0}{2\pi} \left[1 - \cos\frac{2\pi}{2} \right] \quad \left\{ T = \frac{2\pi}{\omega}, \ \omega T = 2\pi \right\}$$

$$= \frac{2e_0}{\pi} \Bigg]$$

$$\left[e_{rms} = \left[\frac{1}{T} \int_0^T e^2 \, dt \right]^{\frac{1}{2}} \right.$$

$$e^2_{rms} = \frac{1}{T} \int_0^T e_0^2 \sin^2\omega t \, dt \quad [\because e = e_0 \sin\omega t]$$

$$= \frac{e_0^2}{2T} \int_0^T 2\sin^2\omega t \, dt$$

$$= \frac{e_0^2}{2T} \int_0^T (1 - \cos 2\omega t) \, dt$$

$$= \frac{e_0^2}{2T} \left[t - \frac{\sin 2\omega t}{2\omega} \right]_0^T$$

$$= \frac{e_0^2}{2T}\left[T - \frac{\sin 2\omega T}{2\omega}\right]$$

$$= \frac{e_0^2}{2T}\left[T - \frac{\sin 4\pi}{2\omega}\right] \quad \left[\because T = \frac{2\pi}{\omega},\ \omega T = 2\pi\right]$$

$$= \frac{e_0^2}{2\cancel{T}} \times \cancel{T}$$

$$= \frac{e_0^2}{2}$$

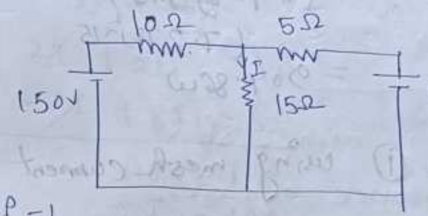
$$e_{rms} = \frac{e_0}{\sqrt{2}}$$

• ~~sinusoi~~ superposition Theorem —

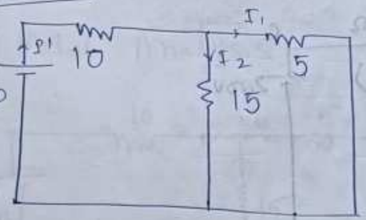
In a linear bilateral network ~~cat~~ containing more than one independent source, the voltage across or the current that flows through any branch is algebraic sum of individual voltages or current produced by each independent source acting separately with all other independent sources being replaced by their internal resistance.

Ex —

(1) using the principle of superposition, find the current through 15Ω resistor in the circuit shown in the fig. Also prove that superposition is not valid for power responses.



step-1

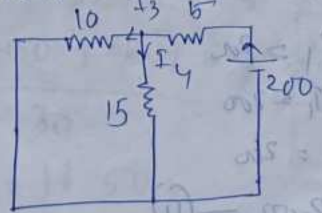


$$I'_1 = \frac{150}{13.75} = 10.91\text{ A}$$

$$\frac{5\times 15}{20} + 10 = \frac{15+40}{4} = \frac{55}{4} = 13.75$$

$$I_2 = \frac{10.91 \times 5}{20} = 2.7275\text{ A}$$

step-II



$$\frac{10\times 15}{25} = 6, \quad 6 + 5 = 11$$

$$I'' = \frac{200}{11} = 18.18\text{ A}$$

$$I_4 = \frac{18.18 \times 10}{25} = 7.272\text{ A}$$

$$I = I_2 + I_4 = 2.7275 + 7.272 = 10\text{ A}$$

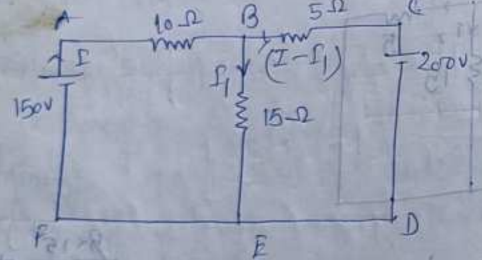
Right method - power supplied by the source - $I^2R = (10)^2 \times 15 = 1500W$,

wrong method - power supplied by the source is - $I_a^2R + I_b^2R$

$= (2.728)^2 \times 15 + (7.272)^2 \times 15$

$= 904.86W$

(2) Solve problem (1) using mesh current method.



Loop ABEFA,

$10I + 15I_1 = 150$ — (i)

Loop BCDEB,

$5(I-I_1) - 15I_1 = -200$

$\Rightarrow -5(I-I_1) + 15I_1 = 200$

$\Rightarrow 5(I_1 - I) + 15I_1 = 200$

$\Rightarrow 5I_1 - 5I + 15I_1 = 200$

$\Rightarrow -5I + 20I_1 = 200$ — (ii)

$10I + 15I_1 = 150$ — (i) $\Rightarrow 2I + 3I_1 = 30$ — (i)

$-5I + 20I_1 = 200$ — (ii) $\Rightarrow -I + 4I_1 = 40$ — (ii)

$2I + 3I_1 = 30$ — (i) $\times 1$

$-I + 4I_1 = 40$ — (ii) $\times 2$

By, (i) $\times 1$ and (ii) $\times 2$ we get

~~$8I + 12I_1 = 120$~~

~~$-3I + 12I$~~

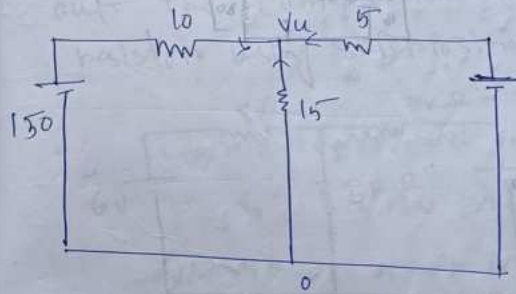
$2I + 3I_1 = 30$

$-2I + 8I_1 = 80$

$11I_1 = 110$

$\Rightarrow I_1 = 10A$

By Nodal Analysis,



$\frac{V_u - 150}{10} + \frac{V_u}{15} + \frac{V_u - 200}{5} = 0$

5 | 10, 15, 5
  2, 3, 1

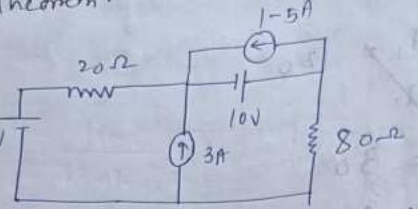
$\Rightarrow \frac{3V_u - 450 + 2V_u + 6V_u - 1200}{30} = 0$

$\Rightarrow 11V_u = 1650$

$\Rightarrow V_u = 150V$

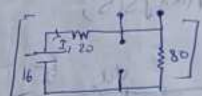
$I = \frac{150}{15} = 10A$

③ Determine the voltage across 20Ω resistance in the circuit shown in the fig, using superposition theorem.

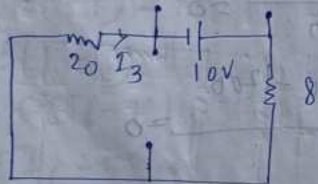


Source 16 V acting alone: short circuit the 10V source and open circuit the 3A and 1.5A sources.

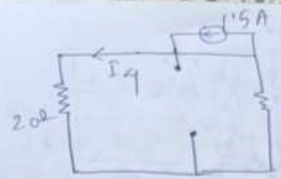
$I_1 = \frac{16}{20+80} = 0.16\,A$



$I_2 = \frac{3 \times 80}{80+20} = 2.4\,A$



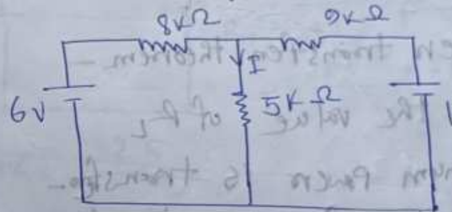
$I_3 = \frac{10}{20+80} = 0.1\,A$



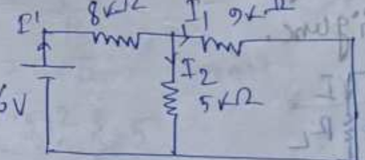
Now $I_4 = 0$, since the current source 1.5 A is short circuited. The current through 20Ω resistor is $0.16 - 2.4 + 0.1 = -2.14\,A$

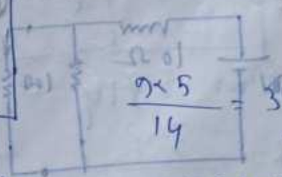
The current 2.14 A flows from right to left. The voltage across 20Ω resistance is $2.14 \times 20 = 42.8\,V$.

④ For the circuit shown in the figure, find out the current flowing through 5kΩ resistor using superposition theorem.



Step-1





$\frac{9\times5}{14} = 3.21$

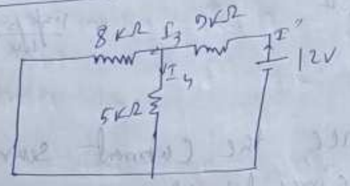
$+8$

$= 11.21\,k\Omega$

$I'_1 = \frac{6}{11.21\times10^3} = 5.35\times10^{-4}\,A$

$I_2 = \frac{9\times10^3 \times 5.35\times10^{-4}}{14\times10^3} = 3.44\times10^{-4}\,A$

Step - II



$\frac{8\times5}{13}+9$

$=12.07\times10^3$

$I'' = \frac{12}{12.07\times10^3}$

$\approx 10\times10^{-4}$ A

$I_4 = \frac{10\times10^{-4}\times8}{13}$

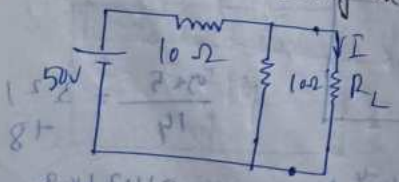
$= 6.2\times10^{-4}$ A

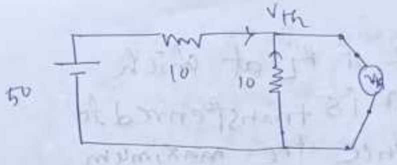
$I = I_2 + I_4 = (3.4+6.2)\times10^{-4}$

$= 9.6\times10^{-4}$ A

• maximum power transfer theorem –

Ex-1 Calculate the value of R_L so that maximum power is transferred from battery for the circuit shown in the figure.

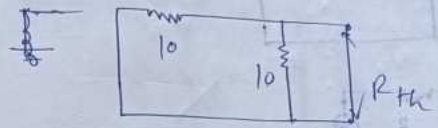




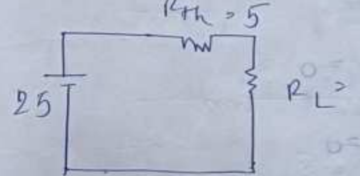
$\frac{V_{th}-50}{10}+\frac{V_{th}}{10}=0$

$\Rightarrow 2V_{th}=50$

$\Rightarrow V_{th}=25$ V



$R_{th}=\frac{10}{2}=5\,\Omega = R_L$



$I_{th}=\frac{25}{5+5}$

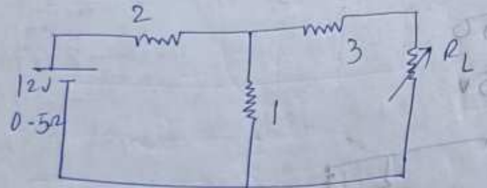
$=\frac{25}{10}$

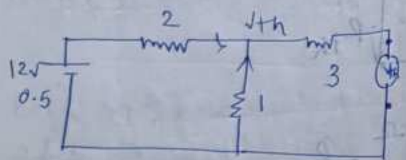
$=2.5$

$P=(2.5)^2\times5$

$=31.25$

② Find the value of R_L at which maximum power is transferred to R_L and hence the maximum power transferred to R_L in the circuit shown in fig.



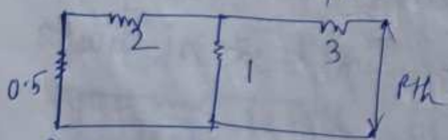


$$V_{th} = \frac{V_{th}-12}{2+0.5} + \frac{V_{th}}{1} = 0$$

$$\Rightarrow \frac{V_{th}-12+2.5V_{th}}{2.5} = 0$$

$\Rightarrow 3.5V_{th} = 12$

$\Rightarrow V_{th} = 3.4V$



$R_{th} = 3.714\,\Omega = R_L$

$$I_{th} = \frac{3.4}{3.714+3.714}$$

$= \cancel{1.04A}\ 0.457$

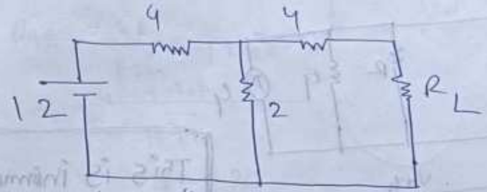
$\therefore P = (\cancel{1.0}457)^2 \times 3.714 = 0.78W$

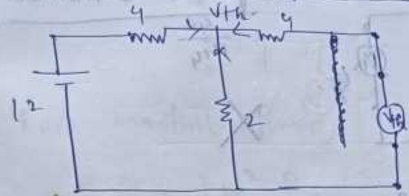
$\frac{3.4}{4}$

$0.75+2$

$\frac{2.5}{3.75}$

③ For the circuit shown in the figure ① find out (a) the value of R_L to transfer maximum power and (b) the maximum power.



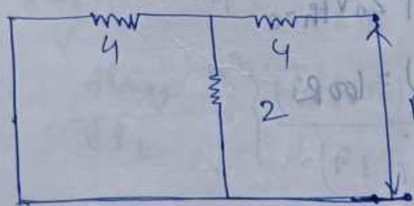


$$\frac{V_{th}-12}{4} + \frac{V_{th}}{2} = 0$$

$$\Rightarrow \frac{V_{th}-12+2V_{th}}{4} = 0$$

$\Rightarrow 3V_{th} = 12$

$\Rightarrow V_{th} = 4V$



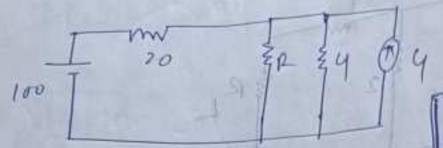
$R_{th} = 5.33\,\Omega = R_L$

$\frac{4\times\cancel{2}}{6}+4$

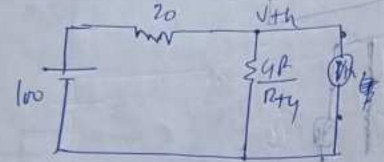
$$I_{th} = \frac{4}{5.33\times 2} = 0.375A$$

$P = (0.375)^2 \times 5.33 = 0.75W$

(9) For the circuit shown in the figure, find out the value of R for maximum power transfer and also find out the maximum value of power.



This is informat



$$\frac{V_{th}-100}{20} + \frac{V_{th} \times (R+4)}{4R} = 0$$

$$\Rightarrow \frac{R(V_{th}-100) + 5V_{th}(R+4)}{20R} = 0$$

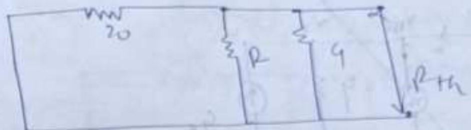
$\Rightarrow$ ~~R(Vth + 5Vth) − 100R +~~

$\Rightarrow R \times V_{th} - 100R + 5V_{th} \times R + 20V_{th} = 0$

$\Rightarrow 6V_{th}R - 100R + 20V_{th} = 0$

$\Rightarrow V_{th}(6R + 20) = 100R$

$$\Rightarrow V_{th} = \frac{100R}{6R+20} = \frac{50R}{3R+10}$$



$$R_{th} = \frac{4R}{R+4} + 20 = \frac{4R + 20R + 80}{R+4} = \frac{24R + 80}{R+4}$$

For maximum power,

$$P_{max} = I_{th}^2 R_L$$

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

$$= \frac{V_{th}^2}{4R_L} = \frac{V_{th}^2 \times R_L}{(R_L+R_{th})^2}$$

$$\frac{dP_{max}}{dR_L} = \frac{1}{4} \cdot \frac{\quad}{R_L}$$

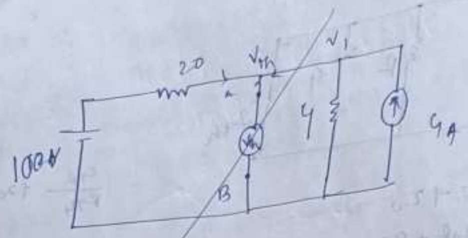
$$\frac{dP_{max}}{dR_L} = V_{th}^2 \left\{ \frac{(R_L+R_{th})^2 - R_L \cdot 2(R_L+R_{th})}{(R_L+R_{th})^4} \right\} = 0$$

$\Rightarrow (R_L+R_{th})^2 (R_L + R_{th} - 2R_L) = 0$

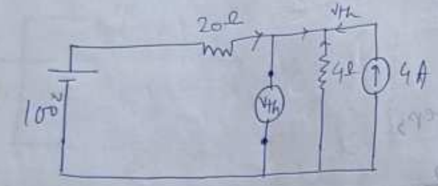
$\Rightarrow (R_L+R_{th})^2 (R_{th} - R_L) = 0$

$R_{th} = R_L$

(3) F
fi
Po



$\frac{V_{th}-100}{20} +$

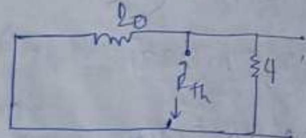


$$\frac{V_{th}-100}{20} + \frac{V_{th}}{4} + 4 = 0$$

$$\Rightarrow \frac{V_{th}-100+5V_{th}+80}{20}$$

$$\Rightarrow 6V_{th} - 20 = 0$$

$$\Rightarrow V_{th} = \frac{20}{6} = 3.33$$

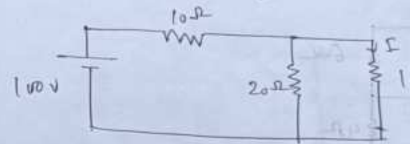


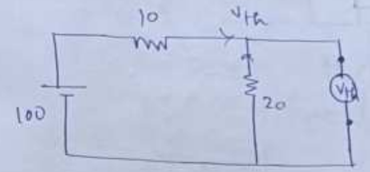
$$R_{th} = \frac{20\times 4}{24} = 3.33 = R$$

$$\therefore I_{th} = \frac{3.33}{3.33\times 2} = 0.5A$$

$$P = (0.5)^2 \times 3.33 = 0.8325\,W$$

•EX-① Using Thevenin's theorem find the current through the 15Ω resistor.



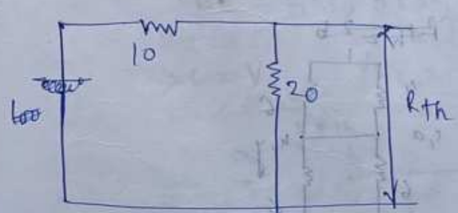


$$\frac{V_{th}-100}{10} + \frac{V_{th}}{20} = 0$$

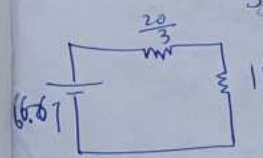
$$\Rightarrow \frac{2V_{th}-200+V_{th}}{20} = 0$$

$$\Rightarrow 3V_{th} = 200$$

$$\Rightarrow V_{th} = \frac{200}{3} = 66.67V$$

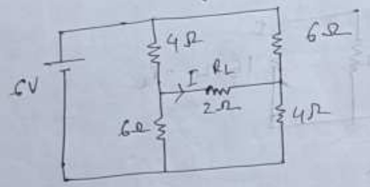


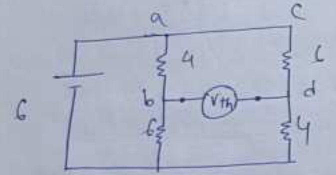
$$R_{th} = \frac{20\times 10}{30} = \frac{20}{3}\,\Omega$$



$$I_{th} = \frac{66.67}{\frac{20}{3}+15} = 3.07A$$

(2) Find the current through 2Ω resistor using Thevenin's theorem.





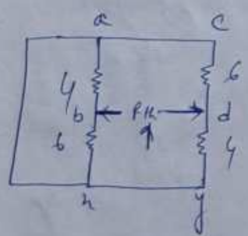
$V_{th} = V_{bd} = V_{cd} - V_{ab}$

$= 6\times\frac{6}{10} - \frac{6\times 4}{10}$ [branch vol = main vol × $\frac{\text{Same R}}{\text{total R}}$] voltage div rule

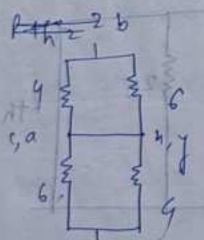
$= \frac{36-24}{10}$

$= 1.2\ V$

$\frac{4\times 6}{10} = 2.4$



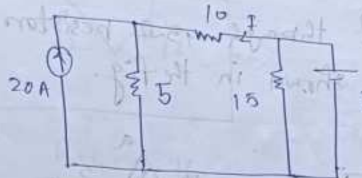
⇒



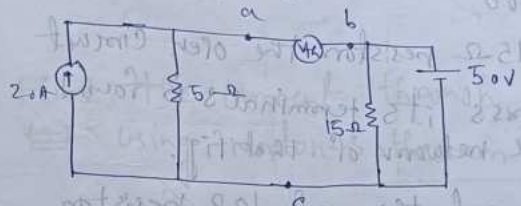
$R_{th} = 2.4 + 2.4 = 4.8$

$I_{th} = \frac{1.2}{4.8+2} = 0.176\ A$

(3) Find the current through 10Ω resistance in the fig.



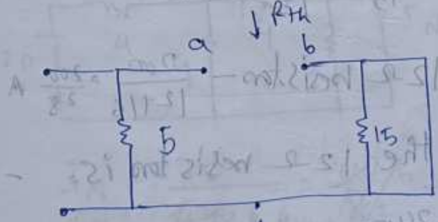
The voltage across the 15Ω resistor is due to the current supplied by the voltage source only.



∴ voltage across the 15Ω resistor is 50V

Hence $V_{bc} = 50V$, Also, $V_{ac} = 20\times 5 = 100V$

∴ $V_{ab} = V_{ac} - V_{bc} = 50V = V_{th}$

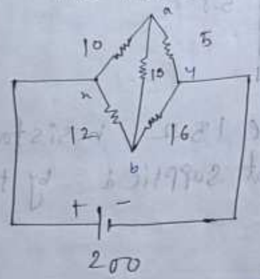


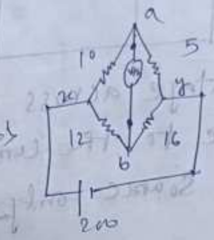
~~$R_{th} = \frac{5\times 15}{20}$~~ the internal resistance of the network as view from open circuited terminals is

$R_{th} = 5Ω$ (as 15Ω resistor is short circuit)

(3) $I_{Th} = \frac{50}{5+10} = \frac{\cancel{50}^{10}}{\cancel{15}_{3}} = 3.33\ A$

(4) Find the current through 15 Ω resistor for the network shown in the fig.





Removing 15 Ω resistor the open circuit voltage across its terminals is found out In the network of that fig.

The current through 10 Ω resistor is obtained as $\frac{200}{15}$

Voltage across the 10 Ω resistor is given by $V = 10 \times \frac{200}{15} = \frac{2000}{15} = V_{ax}$

Current through 12 Ω resistor $= \frac{200}{12+16} = \frac{200}{28}$ A

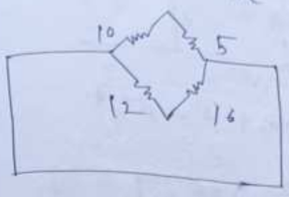
Voltage across the 12 Ω resistor is =

$\frac{200}{28} \times 12 = \frac{2400}{28} V = V_{bx}$

$V_{ab} = \cancel{V_{xb}} - V_{xa} = V_{bx}$

$= \frac{2400}{28} - \frac{2000}{15} - \cancel{V_{bx}}\ \frac{2400}{28}$

$= 47.62 = V_{th}$



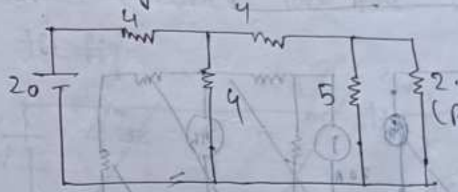
$R_{th} = 9.76$

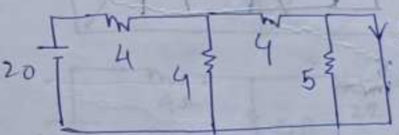
$\frac{15 \times 28}{28+15}$

$I_{Th} = \frac{47.62}{9.76+15}$

$= \cancel{34.87A} = 1.92\ A$

(5) Find the current through R_L in fig using norton's theorem.





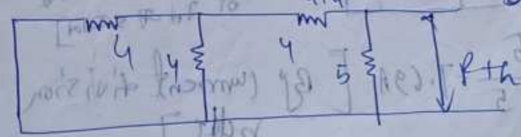
[dont consider 4Ω, 5Ω resistance]

$I_N = \frac{20}{4 + \frac{4 \times 4}{4+4}} = \cancel{2.5A} = \cancel{3.33}$

$= 3.34\ A$

$\frac{4}{2} = 2+6$

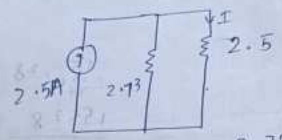
$\frac{6 \times 5}{11}$



$R_{th} = 2.73\ \Omega$

← doubt

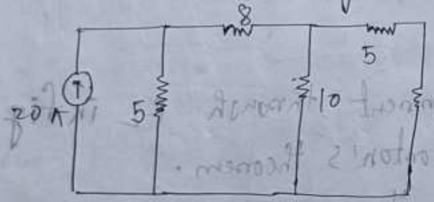
(5)

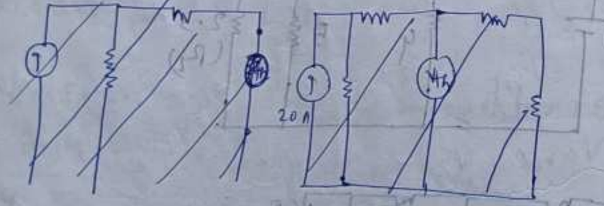


$$I = \frac{3.39 \times 2.73}{2.5 + 2.73}$$

$$= 1.7A$$

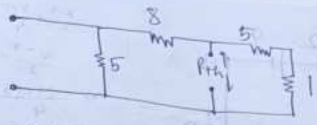
(6) Find the current through 10Ω resistor in the circuit using Norton's theorem.



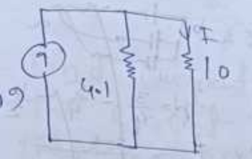


[8Ω এর মধ্যে দিয়ে যে পরিমাণ current যাচ্ছে তা I_N এর সমান]

$$I_N = \frac{20 \times 5}{8+5} = 7.69A$$ [By current division rule]



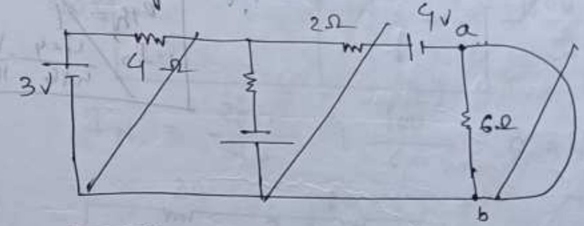
$R_{th} = 4.1\ \Omega$

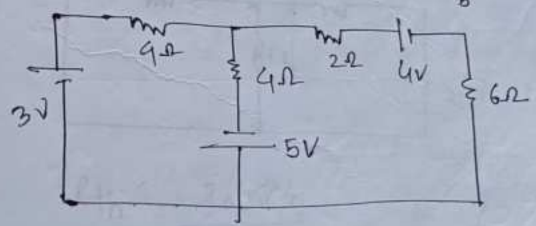


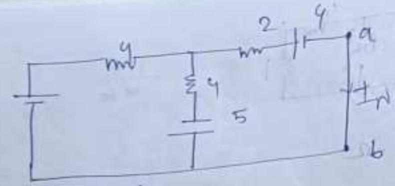
$$I = \frac{7.69 \times 4.1}{10 + 4.1}$$

$$= 2.23\ A$$

(7) Find the current in 6Ω resistor using Norton's theorem for the network shown in the fig.







$\frac{v-3}{4} + \frac{v+5}{4} + \frac{v-4}{2} = 0$

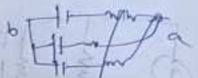
$\Rightarrow \frac{v-3+v+5+2v-8}{4}$

$\Rightarrow 4v = 6$

$\Rightarrow v = \frac{6}{4} = \frac{3}{2} = 1.5$

$I_N = \frac{3}{4} - \frac{5}{4} + \frac{4}{2} = \frac{6}{4} = \frac{3}{2}$ A

$[\because 3 - 5 + 8 = -6$ A $\therefore$ mag $= 6$ A$]$



$I_N = \frac{3}{4} - \frac{5}{4} - \frac{4}{2}$

$= \frac{3-5-8}{4}$

$[R_{eq} = \frac{4\times4}{2} = 2\|2 = 4]$

$R_{th} = 4$

$\therefore I = \frac{3\times4}{2(4+6)} = \frac{3\times4}{10\cdot5} = 0.6$ A

$I_N = \frac{3}{4} + \frac{5}{4} + \frac{4}{2}$

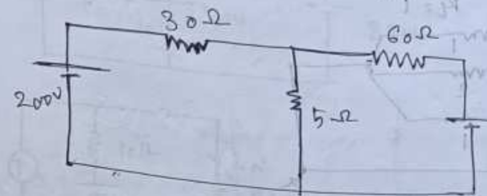
$= \frac{8+8}{4}$

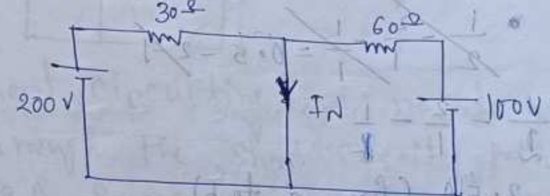
$R_{th} = 4$

$\therefore I = \frac{4\times4}{4+6} = \frac{16}{10}$

??

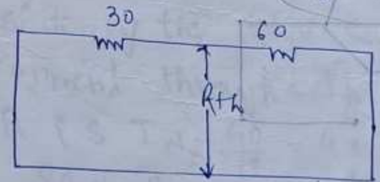
(8) Find current through 5Ω resistor in the circuit of the fig. using Norton's theorem.





$I_N = \frac{200}{30} + \frac{100}{60} = 8.33$ A

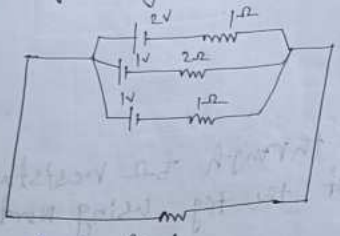
$\frac{30\times60}{90}$



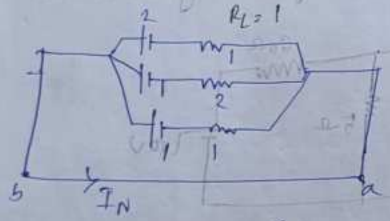
$R_{th} = \frac{30\times60}{90} = 20\Omega$

$I = \frac{8.33\times20}{25} = 6.664$ A

(9) Find the current through R_L in the fig using Norton's theorem.



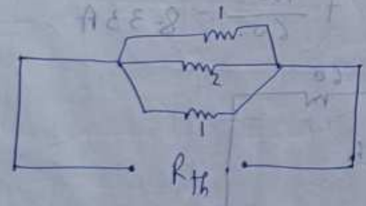
$R_L = 1$



$I_N = \cancel{\frac{1}{2} - \frac{2}{1} - \frac{1}{1} = 0.5 - 2 - 1}$

$= \frac{1}{2} - \frac{2}{1} - \frac{1}{1}$

$= 2.5 A$ (from a to b)



$\frac{1}{R_{th}} = \frac{1}{1} + \frac{1}{2} + \frac{1}{1}$

$= 2 + \frac{1}{2}$

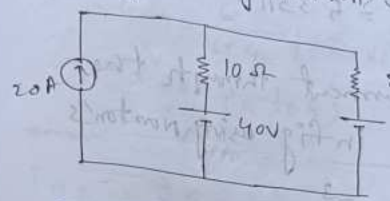
$= \frac{5}{2}$

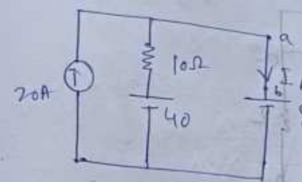
$R_{th} = \frac{2}{5} = 0.4\,\Omega$

$I = \frac{2.5 \times 0.4}{0.4 + 1}$

$= 0.714 A$

(11) Find current through the 20 Ω resistor in fig using Norton's theorem.





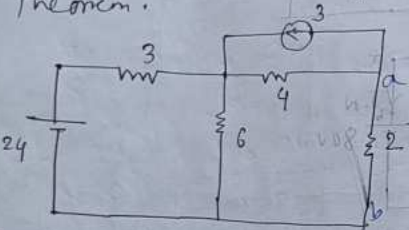
Short circuiting 20 Ω resistor the current through the short circuit path due to 20 A source acting alone is $I_{N_1} = 20 A$ from a to b.

Considering the 40 V source acting alone the current through the short circuited path is $I_{N_2} = \frac{40}{10} = 4 A$ (a to b). Considering the 80 V source acting alone the current ... the short circuited p... b to a) ... 6 (from a to b)

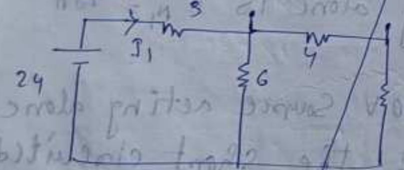
$R_{th} = 10\Omega$

$$I = \frac{10 \times 16}{10+20} = 5.33A$$

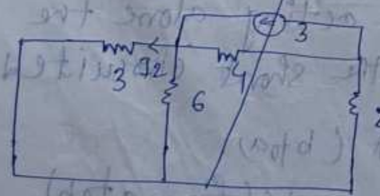
(12) Find the current through the 2Ω resistor in fig using Norton's theorem.



Source 24 acting alone: ~~short~~ open ~~circuit~~ the 3A source.

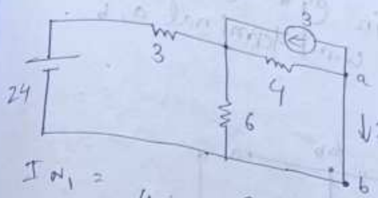


$$I_1 = \frac{24}{6} = 4A$$



$I_2 = -3A$

~~$\therefore I_N = 4-3 = 1A$~~



$$\frac{24}{3+\frac{4\times6}{10}}$$

$$I_{N_1} = 4.44 \times \frac{6}{6+4}$$ [24V Source acting alone]

$= 2.67$ (a to b)

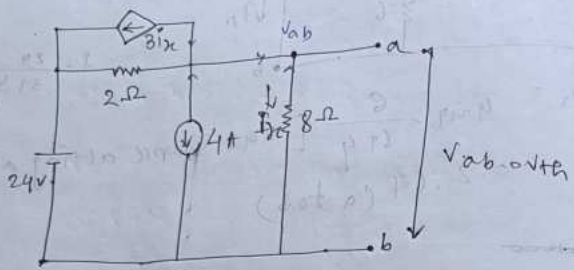
$I_{N_2} = 3A$

$$R_{th} = \frac{3\times6}{9} + 4$$

$= 6\Omega$

Ex ① Dependent Source

Find the Thevenin eq^n circuit for the following circuit w.r.t terminal a, b



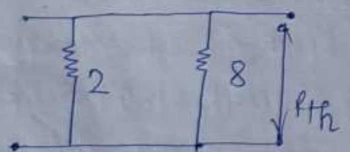
$$\frac{V_{ab}}{8} + \frac{V_{ab}-24}{2} + 3i_n + 4 = 0$$

$$\Rightarrow \frac{V_{ab}}{8} + \frac{V_{ab}-24}{2} + \frac{3\cdot V_{ab}}{8} + 4 = 0 \quad \left[I_h = \frac{V_{ab}}{8} \right]$$

$$\Rightarrow \frac{V_{ab} + 4V_{ab} - 96 + 3V_{ab} + 32}{8} = 0$$

$$\Rightarrow 8V_{ab} = 64$$

$$\Rightarrow V_{ab} = 8V = V_{th}$$

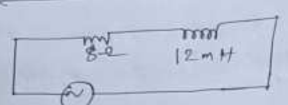


$$R_{th} = \frac{2\times 8}{10} = 1.6V$$

$$\cancel{I_N} = \frac{8}{1.6}$$

Single phase - Ac - circuit

① Find (a) the current (b) voltage drop across each element (c) power factor and (d) Power consumed



$V = 220v,\ f = 50\,Hz,\ R = 8,\ L = 12\times10^{-3}$

$Z = \sqrt{(8)^2 + (2\pi\times50\times12\times10^{-3})^2}$

$= 8.84\Omega$

a) $I = \frac{220}{8.84} = 24.8\,A$

b) $V_R = 24.8\times8 = 198.4\,V$

$V_L = 24.8\times2\pi\times50\times12\times10^{-3} = 93.49\,V$

c) $\cos\varphi = \frac{R}{Z} = \frac{8}{8.84} = 0.904$

d) Power consumed =

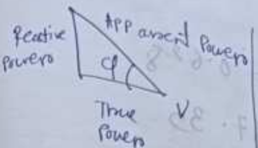
• True Power - The Power which is consumed or utilized by an Ac circuit is called true power or active power.

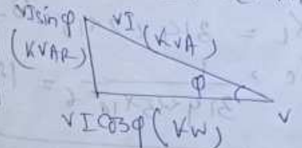
• Reactive Power - The reactive power is not useful for a circuit since it flows back and forth in the circuit. The reactive power is given by - voltage × current 90° out-of-phase with voltage = $VI\sin\varphi$ KVAR or MVAR

• Apparent Power - Apparent Power is the total Power in the circuit, which is given by - VI KVA or MVA.

Apparent Power = $\sqrt{(\text{True Power})^2 + (\text{reactive Power})^2}$

$KVA = \sqrt{(KW)^2 + (KVAR)^2}$





← Phasor diagram of voltage and current

• ~~Reactive Power - The reactive Power is not use.~~

• Active Component of Current - The current component which is in-phase with voltage is called active or wattful or in-phase component of current. It contributes or active power of the circuit.

• Reactive component of current - The current component which is in quadrature with voltage is called reactive or wattless component or current. It contributes reactive power of the circuit.

(2) A 200V, 50Hz supply is applied to an RLC circuit of 10 Ω resistance 2mH inductor and 25μF capacitor. Find the (a) input current and (b) voltage across each element.

$X_L = 314 \times 2 \times 10^{-3} = 0.628$

$X_C = \frac{1}{314 \times 25 \times 10^{-6}} = 127.39$

$\therefore Z = \sqrt{(10)^2 + (0.628 - 127.39)^2}$

$= 127.135 \Omega$

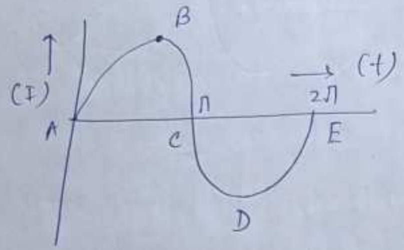
(a) $\frac{V}{Z} = \frac{200}{127.135} = 1.57A$

(b) $V_R = IR = 1.57 \times 10 = 15.7V$

$V_L = IX_L = 1.57 \times 0.628 = 0.985V$

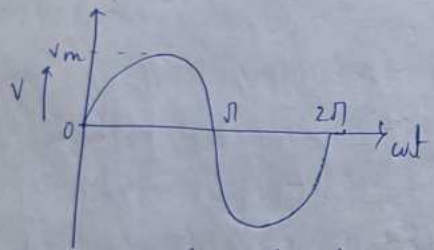
$V_C = IX_C = 1.57 \times 127.39 = 200V$

• Sinusoidal Alternating Quantity — The instantaneous value of the current is — $I = I_m \sin\theta$



Sinusoidal AC

• AC Fundamentals and Circuits—



A sinusoidal wave

The expression for AC voltage is—

$\boxed{v = V_m \sin\omega t}$ [v = Instantaneous value
V_m = max value]

The expression for alternating current is—

$\boxed{I = I_m \sin\omega t}$ [I = Instantaneous value
I_m = max value]

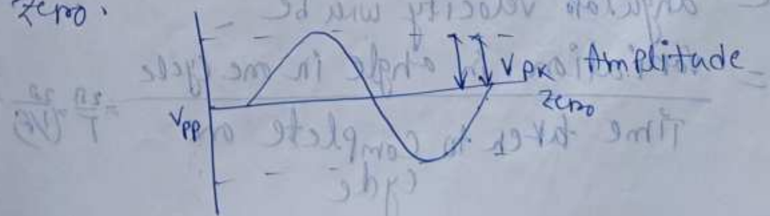
[ω = Angular velocity of the coil]

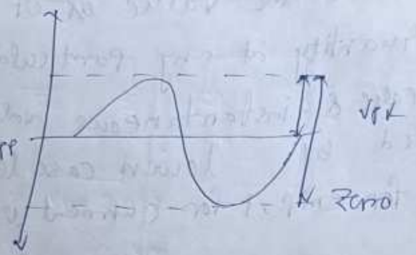
• Instantaneous value — The value ~~of~~ of alternating quantity at any particular instant is called instantaneous value. It is denoted by lower case letters such as e for emf, i for current, v for voltage.

• Amplitude — The amplitude of a sine wave is the maximum vertical distance reached in either direction from the ~~current~~ center line of the wave. As a sine wave is symmetrical about its center line, the amplitude of the wave is half of the peak to peak value.

• Peak to Peak value — The peak to peak value is the vertical distance between the top and bottom of the wave. volts for a voltage waveform.

• Peak value — The peak value of the wave is the highest value the wave reaches above a reference value. The reference value normally used is zero.





• Cycle and Alternation – when an alternating quantity completes one complete set of positive and negative values, it is called one cycle, whereas when it completes only one set of either positive or negative values, that is, half cycle, then it is called one alternation. one alternation corresponds to 180° or π rad while one cycle is 360° or 2π rad.

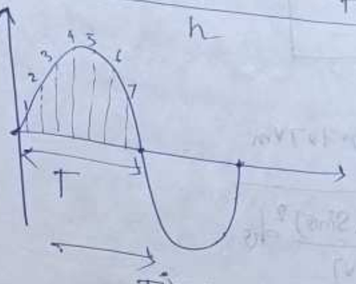
• Angular Frequency or Angular velocity – An alternating quantity completes one cycle by 2π rad. the angular velocity will be –

$$\omega = \frac{\text{Variation in angle in one cycle}}{\text{Time taken to complete one cycle}} = \frac{2\pi}{T} = \frac{2\pi}{(1/f)}$$

$= 2\pi f$ electrical rad/s

• Graphically –

$$V_{av} = \frac{v_1 + v_2 + - - - + v_n}{n}$$



• Analytically –

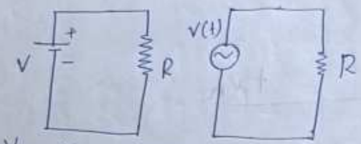
$\boxed{\text{Area of half cycle voltage wave} = 2V_m}$

V_{av} = height of the equivalent rectangle having the same base $= \frac{\text{Area}}{\text{base}}$

$$\boxed{V_{av} = \frac{2V_m}{\pi} = 0.637\,V_m}$$

$$\boxed{I_{av} = \frac{2I_m}{\pi} = 0.637\,I_m}$$

• Analytical Determination of rms —



$V = V_m \sin\theta$

$V_{rms} = \frac{V_m}{\sqrt{2}} = 0.707 V_m$

$$\left[V_{rms} = \sqrt{\frac{\int_0^{\pi} (V_m \sin\theta)^2 d\theta}{\pi}} \right.$$

$$= \sqrt{\frac{V_m^2}{\pi} \int_0^{\pi} (\sin\theta)^2 d\theta}$$

$$= \sqrt{\frac{V_m^2}{\pi} \int_0^{\pi} \left[\frac{1 - \cos 2\theta}{2}\right] d\theta}$$

$$= \sqrt{\frac{V_m^2}{2\pi} \left[\theta - \frac{\sin 2\theta}{2}\right]_0^{\pi}}$$

$$= \sqrt{\frac{V_m^2}{2\pi} \left[(\pi - 0) - \left(\frac{\sin 2\pi - \sin 0}{2}\right)\right]}$$

$$= \sqrt{\frac{V_m^2}{2\pi} \cdot \pi}$$

$$\left. = \frac{V_m}{\sqrt{2}} \right]$$

• $\boxed{\begin{array}{l} V_{rms} = 0.707 V_m \\ I_{rms} = 0.707 I_m \end{array}}$

(1) An alternating voltage of 50HZ has a peak value of 230V. write down the expression for its instantaneous value.

$V_m = 230$, $f = 50HZ$

$V = V_m \sin \omega t$

$= V_m \sin 2\pi f t \quad [\because \omega = 2\pi f]$

$= 230 \sin 2\pi \times 50 t$

$= 230 \sin 314t$

(2) An alternating current is represented by $i = 12 \sin 314t$. Find (a) frequency (b) instantaneous value at $t = 4$ ms, (c) time taken to attain a value of 10A for first time after passing through zero. Given $i = I_m \sin \omega t$, $i = 12 \sin 314t$.

(a) $\omega = 2\pi f$

$\Rightarrow 314 = 2\pi f$

$\Rightarrow f = \frac{314}{2\pi} = 50 HZ$

(b) $t = 4 ms = 4 \times 10^{-3} s$ $\left[\because I_m \sin \omega t = 12 \sin 314t,\ I_m = 12,\ \omega = 314\right]$

$I = I_m \sin \omega t$

$= 12 \sin 314 \times 4 \times 10^{-3}$

$= 0.263A$

(c) $I = I_m \sin \omega t$

$\Rightarrow 10 = 12 \sin 314 t$

$\Rightarrow t = 0.179$ s

(3) An alternating current having frequency of 50 Hz has peak value of 15.5. How much time will it require for the current to attain values of 10 A and 12 A starting from zero?

$I_m = 15.5$

$f = 50$ Hz

$10 = 15.5 \sin 2\pi \times 50 \times t$

$\Rightarrow t = 0.127$ s

$12 = 15.5 \sin 2\pi \times 50 t$

$\Rightarrow t = 0.161$ s

(4) Instantaneous current is given by the relation $I = 20 \sin 314 t$. Find rms and average value of AC.

$I_{rms} = \frac{I_m}{\sqrt{2}} = \frac{20}{\sqrt{2}} = 14.142$ A

$I_{av} = \frac{2 \times 20}{\pi \times \sqrt{2}} = 28.28$ A | $I_{av} = \frac{2 I_m}{\pi} = \frac{2 \times 20}{\pi} = 12.73$ A

(5) An AC has frequency of 50 Hz and rms current of 25 A. Write eqn of instantaneous current and find a) current at time 0.0025 s and (b) time at which current is 14.14 A.

$f = 50$, $I_{rms} = 25$ A

$I_{rms} = \frac{I_m}{\sqrt{2}}$

$\Rightarrow I_m = 25 \times \sqrt{2} = 35.35$ A

$I = 35.35 \sin 2\pi \times 50 \times 0.0025$ [$t = 0.0025$]

$= 0.484$

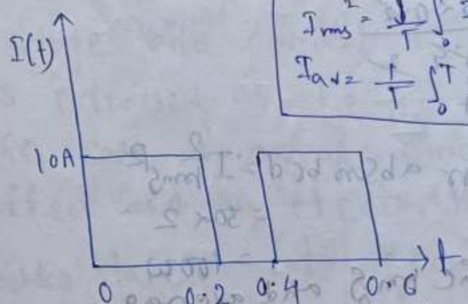
$14.14 = 35.35 \sin 2\pi \times 50 \times t$

$\Rightarrow t = 0.075$ s.

(6) Calculate the rms and average value of a square wave shown in fig. If the current is passed through 2 Ω resistor, find out average power absorbed by it.

$I_{rms}^2 = \frac{1}{T} \int_0^T I(t)^2 \, dt = \frac{1}{T} \int_0^T I_m^2(t) \, dt$

$I_{av} = \frac{1}{T} \int_0^T I(t) \, dt = \frac{1}{T} \int_0^T I_m(t) \, dt$



For the time interval $0 < t < 0.2$, $I = 10$ A and for $0.2 < t < 0.4$, $I = 0$ A. Time period of the current waveform, $T = 0.4$. The rms value is given by

$I^2_{rms} = \frac{1}{T} \int_0^T I^2(t) \, dt = \frac{1}{0.4} \left[\int_0^{0.2} 10^2 \, dt + \int_{0.2}^{0.4} 0^2 \, dt \right]$

$= \frac{1}{0.4}\left[\int_0^{0.2} 100\, dt\right]$

$= \frac{100}{0.4}[0.2-0]$

$= \frac{100\times 0.2}{0.4} = 50$

$I_{rms} = \sqrt{50} = 7.071A$

$I_{av} = \frac{1}{T}\int_0^T I(t)\,dt$

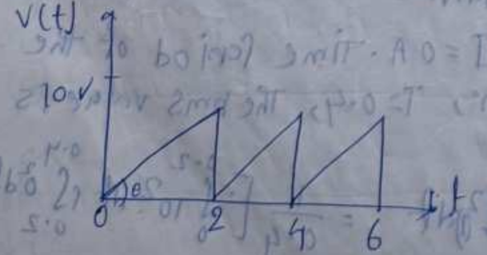
$= \frac{1}{0.4}\left[\int_0^{0.2} 10\,dt + \int_{0.2}^{0.4} 0\,dt\right]$

$= \frac{10}{0.4}\times[0.2-0]$

$= \frac{10\times 0.2}{0.4} = 5A$

Average power absorbed $= I_{rms}^2 R$
$= 50\times 2$
$= 100W$

(7) Calculate the rms and average value for the waveform shown in fig.



$V_{av} = \frac{1}{2}\int_0^2 5t\,dt$

$= \frac{5}{2}\times\frac{1}{2}[t^2]_0^2$

$= \frac{5}{4}[4]$

$= 5$

From the given triangular waveform, it is observed that $V = 5t\ V$, for $0<t<2$ and the time ~~Remp~~ period is 2. The rms value is -

[Slope $= \tan\theta = \frac{10}{2} = 5$, $V = 5t$ [$\because y = mx + c$, $c=0$]]

$V_{rms}^2 = \frac{1}{T}\int_0^T v^2(t)\,dt$

$= \frac{1}{2}\int_0^2 (5t)^2\,dt$

$= \frac{1}{2}\times\frac{25}{3}[t^3]_0^2$

$= \frac{25}{6}[8-0]$

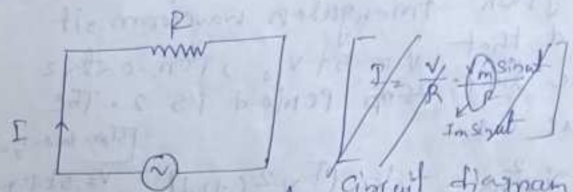
$= \frac{25\times 8}{6}$

$V_{rms} = \frac{5\times 2}{\sqrt{3}} = \frac{10}{\sqrt{3}}$

- For a DC circuit, the relationship between voltage and current is simple and is expressed as, $I = \frac{V}{R}$. However, in the case of an AC circuit, the magnetic effect and the electrostatic effect are also taken into account.

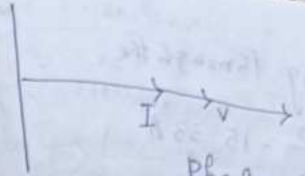
- **Pure resistance**

The circuit which contains a pure resistance, or has negligible inductance is called pure resistance circuit.



$V = V_m \sin\omega t$

Circuit diagram



Phasor diagram

for pure resistance, the current in the circuit is $= I = \frac{V}{R}$

$= \frac{V_m \sin\omega t}{R}$

$= \frac{V_m}{R} \sin\omega t$

$$\boxed{I = I_m \sin\omega t} \quad -(1)$$

$[\because$ ~~Consider~~, $I_m = \frac{V_m}{R}]$

The current will be maximum if $\omega t = \frac{\pi}{2}$ and $\sin\omega t = 1$, therefore

$I_m = \frac{V_m}{R}$

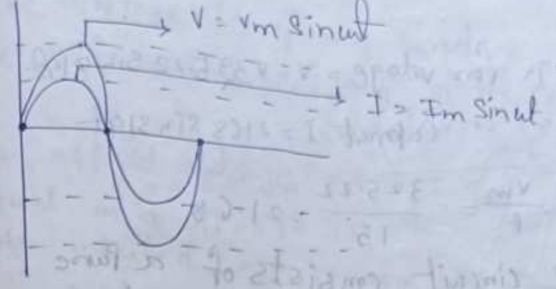
By placing I_{max} in egn (1) we get,

$$\boxed{I = I_{max} \sin\omega t}$$

The average power of a pure resistance circuit is

$$\boxed{P_{av} = \frac{V_{max} I_{max}}{2} = V_{rms} I_{rms} = VI\,W}$$

$[\because \frac{V_{max}}{\sqrt{2}} \times \frac{I_{max}}{\sqrt{2}} = V_{rms} I_{rms}]$



wave diagram

ex-(1) A 230 V (rms), 50 Hz voltage source is connected in series with a pure resistance of 15 Ω. Determine (a) the current flowing in the circuit, (b) the power absorbed by the circuit and (c) the equation for the voltage and the current.

$V_{rms} = \frac{V_m}{\sqrt{2}}$ $\quad V = V_m \sin\omega t = 325 \sin 314t$

$\therefore V_m = 230 \times \sqrt{2} = 325.22V$

$f = 50, \; R = 15$

$I_m = \frac{V_m}{R} = \frac{325}{15} = 21$

$\therefore I = 21 \sin 50 \times 2\pi t$

(a) the current flowing through the circuit $I = \frac{V}{R} = \frac{230}{15} = 15.33\,A$

(b) $P = VI = 230 \times 15.33 = 3526.67\,W$

(c) The eqn for voltage $= V = 325.22 \sin 314t$

" " current $I = 21.68 \sin 314t$

$I_m = \frac{V_m}{R} = \frac{325.22}{15} = 21.68$

(2) An AC circuit consists of a pure resistance of 20Ω and is connected across 220V, AC supply. Calculate (a) the current, (b) the power consumed and (c) the equation for the voltage and the current.

$V_{rms} = 220$, $f = 50\,Hz$

$\frac{V_m}{\sqrt{2}} = 220$

$\Rightarrow V_m = 220\sqrt{2} = 311.12\,V$

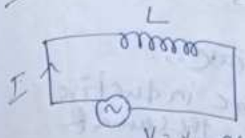
$I_m = \frac{V_m}{R} = \frac{311.12}{20} = 15.55\,A$

a) $I = \frac{V}{R} = \frac{220}{20} = 11\,A$

b) $P = VI = 11 \times 220 = 2420\,W$

c) $V = 311.12 \sin 314t$
$I = 15.55 \sin 314t$

• Pure Inductance



< circuit diagram

The voltage is, $V = V_m \sin \omega t$

The self-induced emf of the coil is, $-L\frac{dI}{dt}$

Now, applied voltage is equal and opposite to self-induced emf. Therefore,

[∵ net emf $= e - L\frac{dI}{dt}$ (induced emf)
as for pure inductance $R = 0$
∴ $IR = 0$
∴ $V = 0$
$\Rightarrow e - L\frac{dI}{dt} = 0$
$\Rightarrow e = L\frac{dI}{dt}$]

$v = V_m \sin \omega t = -\left(-L\frac{dI}{dt}\right) = L\frac{dI}{dt}$

$\Rightarrow \int dI = \int \frac{V_m}{L} \sin \omega t \, dt$

$\Rightarrow I = -\frac{V_m}{\omega L} \cos \omega t$

$\Rightarrow I = \frac{V_m}{\omega L}\left(\sin\left(\omega t - \frac{\pi}{2}\right)\right)$

$\boxed{X_L = \omega L}$

The current I will be maximum when,

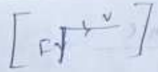
$\sin\left(\omega t - \frac{\pi}{2}\right) = 1$

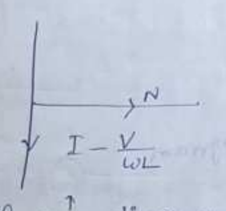
$\Rightarrow \omega t - \frac{\pi}{2} = \frac{\pi}{2}$

∴ $I_m = \frac{V_m}{\omega L}$

∴ $\boxed{I = I_m \sin\left(\omega t - \frac{\pi}{2}\right)}$

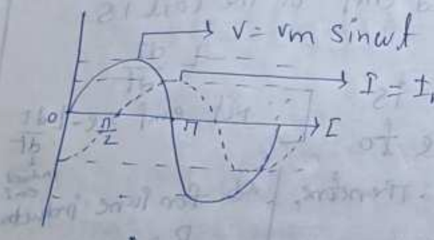
Hence, the current flowing through the inductor lags behind the applied voltage by $\frac{\pi}{2}$ or 90°.





Phasor diagram

[In this case, for pure inductive circuit the current is lagging and the voltage is leading]



wave diagram

- The inductive resistance (আবেশীয় প্রতিরোধ)

$\boxed{X_L = \omega L}$ $\left[\therefore I_m = \frac{V_m}{\omega L} = \frac{V_m}{X_L}\right]$

- The average power absorbed over a complete cycle in pure inductor is zero i.e. $\boxed{P_{av} = 0}$

Ex-(3)

The voltage $v(t) = 15\sin(50t + 45^\circ)$ is applied to a 0.3 H inductor. Find the current flowing through the inductor.

$v(t) = 15\sin(50t + 45^\circ)$, $\phi = 45^\circ$

$L = 0.3$, $\omega = 50$, $V_m = 15$

$V_{rms} = \frac{15}{\sqrt{2}} = 10.61\,V$, $X_L = \omega L = 50 \times 0.3 = 15\,\Omega$

$\therefore I_{rms} = \frac{V_{rms}}{X_L} = \frac{10.61}{15} = 0.7\,A$ (this is not ans.)

$I = \frac{V_m}{X_L} = \frac{15}{15} = 1\,A$ [As $v(t) = 15\sin(50t + 45^\circ)$ is sine wave so, we have to consider V_m not V_{rms}]

Hence, the current of 1 A will lag behind the applied voltage by 45°.

(4) An inductor of 0.5 H is connected in series with a voltage source of 220 V, 50 Hz. Find (a) the rms value of current. (b) the power and (c) the equation for voltage and current.

$V_{rms} = 220\,V$, $f = 50\,Hz$, $L = 0.5\,H$ $[I = I_{rms}, V = V_{rms}]$ $[P_{av} = P]$

a) ~~$I = 220$~~ $I_{(rms)} = \frac{V}{\omega L} = \frac{220}{50 \times 2\pi \times 0.5} = 1.40\,A$

b) ~~$P = VI = 220 \times 1.40 = 308.2\,W$~~

b) $P = 0$

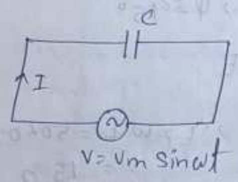
c) $V_m = V_{rms} \times \sqrt{2} = 220 \times \sqrt{2} = 311.12\,V$.

$I_m = \frac{311.12}{314 \times 0.5} = 1.98\,A$

$V = 311.12 \sin 314t$

$I = 1.98 \sin(314t - \frac{\pi}{2})$

- Pure capacitor



← circuit diagram

The applied voltage is,
$v = V_m \sin\omega t$

The charge stored in the capacitor is

$$q = Cv = CV_m \sin\omega t$$

Now $I = \frac{dq}{dt} = \frac{d}{dt}(CV_m \sin\omega t)$

$\Rightarrow I = CV_m \cos\omega t \cdot \omega$

$\Rightarrow I = \frac{V_m}{\left(\frac{1}{C\omega}\right)} \cos\omega t$

$\Rightarrow I = \frac{V_m}{(1/C\omega)} \sin\left(\omega t + \frac{\pi}{2}\right)$

Now I will be maximum, when

$$\sin\left(\omega t + \frac{\pi}{2}\right) = 1$$

$\therefore I_m = \frac{V_m}{1/C\omega}$

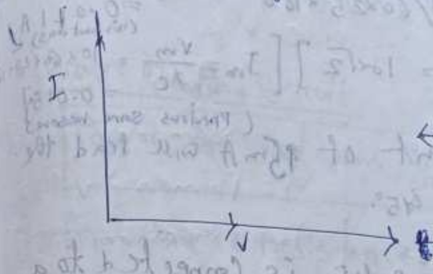
$$\therefore \boxed{I = I_m \sin\left(\omega t + \frac{\pi}{2}\right)}$$

Hence the current flowing through the capacitor leads the applied voltage by $\pi/2$. The capacitive inductance is (ধারকীয় প্রতিঘাত]

$$\boxed{X_C = \frac{1}{\omega C}\ \Omega}$$

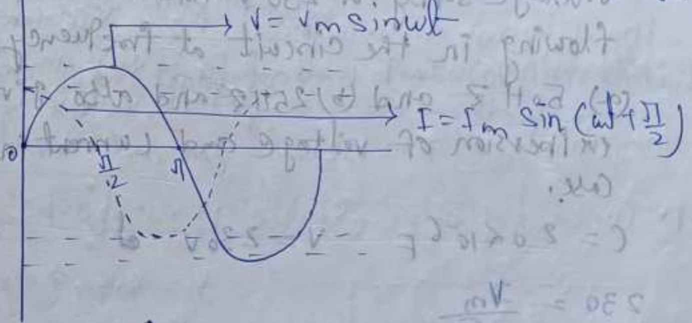
$\left[\therefore I_m = \frac{V_m}{(1/C\omega)} = \frac{V_m}{X_C}\right]$

The average power absorbed over a complete cycle is zero $\boxed{P_{av} = 0}$



← Phasor diagram

[for pure capacitance the current is leading and the voltage is lagging]



↑
wave diagram

Ex-⑤ An AC circuit consisting of a capacitor of ~~a capaci~~ of 25μF is connected in series with applied voltage $v(t) = 10\sin(60t + 45°)$. Find out the current through the capacitor.

$v(t) = 10\sin(60t + 45°)$

$C = 25\mu F = 25\times10^{-6} F$, $v_m = 10$, $\omega = 60$, $\phi = 45°$

$I = \frac{V}{X_C} = \frac{10/\sqrt{2}}{1/60\times25\times10^{-6}} = 10/\sqrt{2}\times60\times25\times10^{-6} = 0.0\cdot1A$ (this first ans)

$[V = V_{rms} = V_m/\sqrt{2} = 10/\sqrt{2}]$ $\left[I_m = \frac{V_m}{X_C} = 10\times60\times25\times10^{-6} = 0.015\right]$ (Previous same reason)

Hence, a current of 15mA will lead the applied voltage by 45°.

⑥ A capacitor of 20μF is connected to a voltage supply of 230 V. Find the current flowing in the circuit at frequency (a) 50Hz and (b) 25Hz and also give the expression of voltage and current in both case.

$C = 20\times10^{-6} F$ $V = 230V$

$230 = \frac{V_m}{\sqrt{2}}$

$\Rightarrow V_m = 230\sqrt{2} = 325.26 A$ $\therefore V = 325.26\sin 314t$

a) $f_1 = 50Hz$, $C = 20\times10^{-6}$.

$\therefore I_m = \frac{V_m}{X_C} = \frac{V_m}{1/\omega C}$

$\Rightarrow 325.26 = V_m\times314\times20\times10^{-6}$

$\Rightarrow I_m = 325.26\times314\times20\times10^{-6} = 2.04A$

$\therefore I = 2.04\sin(314t + \frac{\pi}{2})$

b) $f_2 = 25Hz$

$V_m = 325.26$

$\therefore V = 325.26\sin 157t$

$I_m = 325.26\times25\times2\pi\times20\times10^{-6}$

$= 1.02A$

$\therefore I = 1.02\sin(157t + \frac{\pi}{2})$

• Power of AC circuit

$\boxed{P_{av} = V_{rms} I_{rms}\cos\phi}$ [ϕ = Phase difference between V and I]

(i) for pure resistance circuit, $\phi = 0°$

$\boxed{P_{av} = V_{rms} I_{rms}}$

(ii) for pure inductor and pure capacitor circuit, $\phi = 90°$

$P_{av} = V_{rms} I_{rms}\sin 90°$

$\boxed{P_{av} = 0}$

$\rightarrow I_1 = 230\times50\times2\pi\times20\times10^{-6}$
$= 1.44A$

$I_2 = 230\times25\times2\pi\times20\times10^{-6}$
$= 0.722A$

কিছু বলা না থাকলে max value consider করতে হবে, বলা থাকলে rms value consider করতে হবে

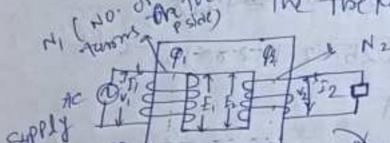
clw 28·3·22

Transformer

(static device that can transform the vol / current wi from one to another without changing the frequency)

N_1 (No. of turns on the P side)

N_2 (No. of turns on the S side)



(supply side) Primary side

Secondary side

Basic principle of transformer, Primary winding, secondary winding, derive emf eqn of single phase transformer, The relation between V_1 and V_2 and E_1 and E_2, how the transformer rated in KVL

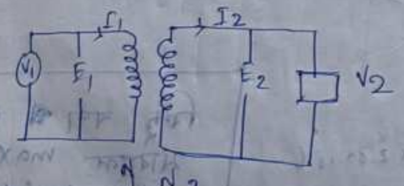
[I_1 = Primary current
I_2 = secondary current]

[V_1 = Primary voltage
V_2 = Secondary voltage]

[E_1 = Primary emf
E_2 = Secondary emf]

[E_1 = self inductance
E_2 = mutual inductance]

• Representation of single phase AC transformer -

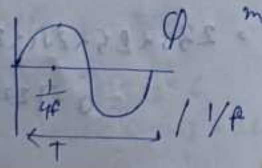


$V_1 = 4.44 f \phi_m N_1$

$V_2 = 4.44 f \phi_m N_2$

$E_1 = 4.44 f \phi_m N_1$

$E_2 = 4.44 f \phi_m N_2$ [ϕ_m = max flux]



• Trans ratio -

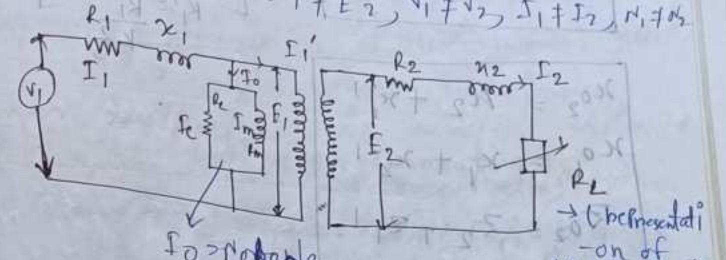
$$\boxed{\frac{E_2}{E_1} = \frac{V_2}{V_1} = \frac{I_1}{I_2} = \frac{N_2}{N_1} = K}$$

$$\boxed{V_1 I_1 = V_2 I_2 \Rightarrow V_1 = \frac{V_2 I_2}{I_1}}$$

• If we supply DC then the winding get heated as the same current will surrounding in primary side and the primary side will get heated.

• In ideal case, $E_1 = E_2$, $V_1 = V_2$, $I_1 = I_2$, $N_1 = N_2$

In real case $E_1 \neq E_2$, $V_1 \neq V_2$, $I_1 \neq I_2$, $N_1 \neq N_2$



$\rightarrow$ (Representation of the transformer)

I_0 = No load current

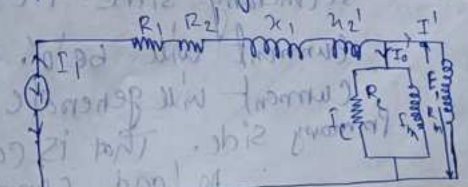
vector sum of I_c and I_m

I_c = coreloss component of the current

I_m = magnetic component of the current

$$\boxed{I_0 = \sqrt{I_c^2 + I_m^2} \qquad I_1 = I_0 + I_1'}$$

If we want to shift the parameters of ~~prima~~ secondary side to primary side



R_{o_2} (Total eq. resistance referred to secondary) $\boxed{R_{o_2} = R_2 + R_1'}$

$\boxed{R_{o_1} = R_1 + R_2'}$ $\left[R_2' = K^2 R_2, \quad R_1' = \frac{R_1}{K^2} \right]$

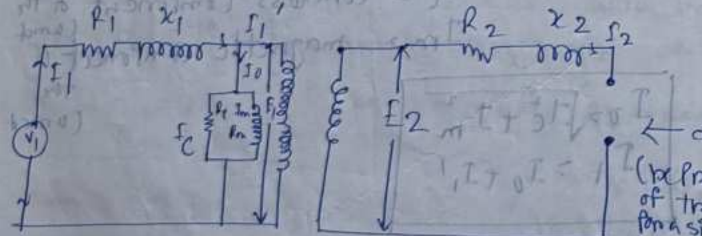
$x_{o_2} = x_2 + x_1'$

$x_{o_1} = x_1 + x_2'$

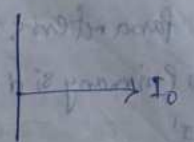
$Z_{o_2} = Z_2 + Z_1'$

$Z_{o_1} = Z_1 + Z_2'$

• No load operation for a single phase transformer



← diagram (representation of transformer for a single phase transformer)



As there is no load in secondary side the secondary current will be 0. So, a current will generate in Primary side. That is called no load current.

3/3/22

• On load operation for a single phase transformer –

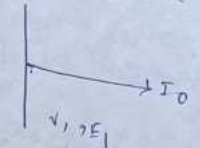
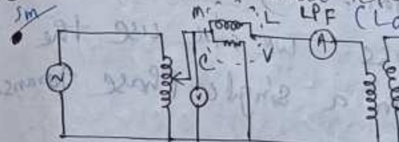


Diagram (representation of transformers for a single phase transformer)

① What is the wattmeter connection?



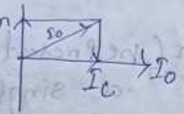
[MC is always short for wattmeter]

K = K is wattmeter constant [V = rated voltage]

$K = \frac{V_S I_S}{\text{Full scale deflection}}$ [V_S = voltage selected, I_S = current selected]

• Open circuit phase for single phase transformer (details)

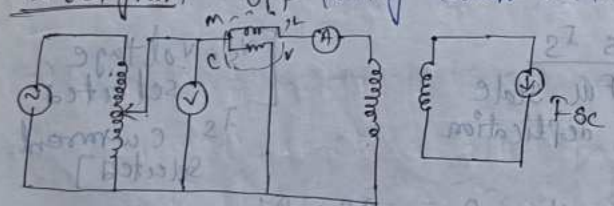
Here we will get a small amount of current that is called no load current (I_0) when we will give a rated voltage (230V) and as the secondary side is disconnected ($I_2 = 0$) so the I_0 current will appear in Primary side.

• No load Component — 

• onlode operation for single phase transformer (short circuit operation :- ....)

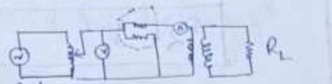
To perform cuper loss we will use the short circuit test for a single phase transformer.

crt diagram UPF (unity power factor)



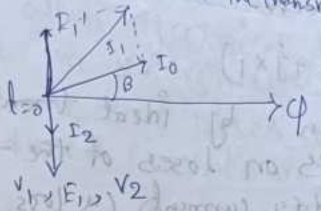
Here we will give rated current and the value of rated current is 45A.

• Phasor diagrams



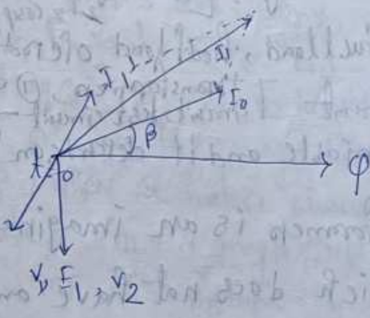
[β = histerisis angle] (loding is 3 types, capacitive, inductive, resistive loading)

[at time t=0, V_1 and E_1 are max negetive] [Let the transratio 1:1 here]

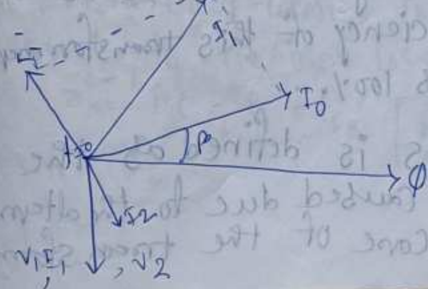


[For ideal case phasor diagram]

R



L



C

• Dimagnatising effect – $\boxed{I_2 = I_1'}$ [I_1' is just opposite direction of I_2]

$$\boxed{\begin{array}{l} I_1' = I_0 + I_1' \\ I_2 = I_1' \end{array}}$$

assingment

(1) Some phasor diagrame for non-ideal case. ideal type transformer.

Hint $E_1 = V_1 + I_1 (R_1 + jX_1)$

(2) What to you mean by ideal transformer,

(3) write short notes on loses of the transformer. (Iron loss, eddy current, cu loss)

(4) At what condition transformer wher give maximum efficieny? [$\eta = \frac{V_2 I_2 \cos\phi_2}{V_2 I_2 \cos\phi + P_i + R_{cu} n^2}$]

(5) Derive it. (6) fullload, half load operation for transformer, (7) short circuit, test circuit → transformer

[Iron loss is constant]

[Cupper loss is variable and it depends on 'n']

(2) An ideal transformer is an imaginary transformer which does not have any loss in it, means no core losses, copper losses and any other losses in transformer. Efficiency of this transformer is considered as 100%.

(3) Iron loss – This is defined as the loss that is caused due to the alternating flux in the core of the transformer. As the loss occurs in the core, therefore the iron loss is also known as core loss. There are two types of iron losses, and they are eddy current loss and hysteresis loss.

cu loss – It is the term often given to heat produced by electrical currents in the conductors of transformer windings or other electrical devices. Copper losses are an undesirable transfer of energy, as are core losses, which result from induced currents in adjacent components.

Eddy current losses – Eddy current losses are the result of Faraday's law, which states that, "Any change in the environment of a coil of wire will cause a voltage to be induced in the coils regardless of how the magnetic change is produced. Thus, when a motor ~~change is~~ core is rotated in a magnetic field, a voltage, or EMF, is ~~included~~ induced in the coils.

(4) The transformer will give the maximum efficiency when their copper loss is equal to the iron loss.

$$P_C = P_i = P_{cu} \quad \left[\begin{array}{l} P_i = \text{iron loss} \\ P_{cu} = \text{copper loss} \end{array}\right]$$

(5) $$\eta = \frac{V_2 I_2 \cos\phi_2}{V_2 I_2 \cos\phi_2 + P_i + P_{cu}}$$

$$\eta = \frac{V_2 I_2 \cos\phi_2}{V_2 I_2 \cos\phi_2 + P_i + (I_1^2 R_1 + I_2^2 R_2)}$$

$$\eta = \frac{V_2 I_2 \cos\phi_2}{V_2 I_2 \cos\phi_2 + P_i + I_2^2 R_{02}}$$

or

$$\eta = \frac{V_2 I_2 \cos\phi_2}{V_2 I_2 \cos\phi_2 + P_i + I_1^2 R_{01}}$$

$d\eta / dI_2 = 0$

Now, $\eta = (V_2 I_2 \cos\phi_2) / (V_2 I_2 \cos\phi_2 + P_i + I_2^2 R_{02})$

$$\therefore \frac{d\eta}{dI_2} = \frac{d}{dI_2}\left[\frac{V_2 I_2 \cos\phi_2}{V_2 I_2 \cos\phi_2 + P_i + I_2^2 R_{02}}\right] = 0$$

$$\therefore (V_2 I_2 \cos\phi_2 + P_i + I_2^2 R_{02}) \frac{d}{dI_2}(V_2 I_2 \cos\phi_2) - (V_2 I_2 \cos\phi_2) \frac{d}{dI_2}(V_2 I_2 \cos\phi_2 + P_i + I_2^2 R_{02}) = 0$$

$$\Rightarrow (V_2 I_2 \cos\phi_2 + P_i + I_2^2 R_{02})(V_2 \cos\phi_2) - (V_2 I_2 \cos\phi_2)(V_2 \cos\phi_2 + 2 I_2 R_{02}) = 0$$

Cancelling $(V_2 \cos\phi_2)$ from both the terms we get,

$$V_2 I_2 \cos\phi_2 + P_i + I_2^2 R_{02} - V_2 I_2 \phi_2 - 2 I_2^2 R_{02} = 0$$

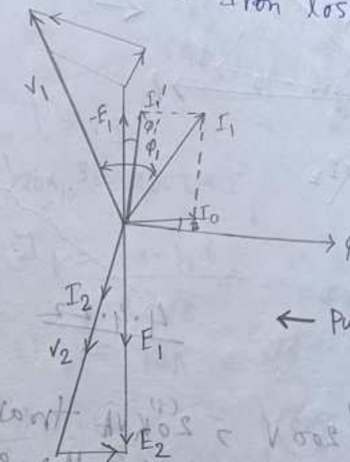
$$\therefore P_i - I_2^2 R_{02} = 0$$

$$\Rightarrow P_i = I_2^2 R_{02} = P_{cu}$$

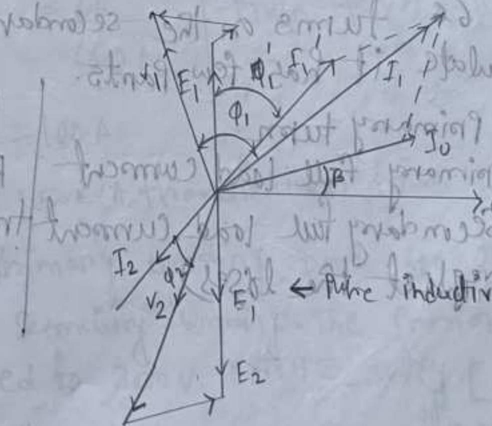
So condition to achieve maximum efficiancy is that,

Copper losses = Iron losses

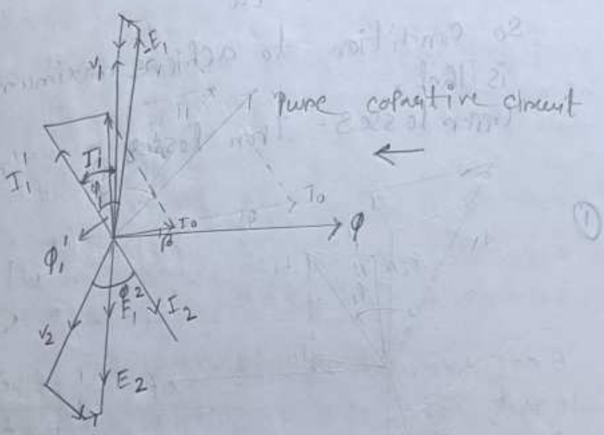
(1)



← Pure resistive circuit



← Pure inductive circuit



4.4.22

cw

① Solve A 2000/200 V, 20 KVA transformer (Kilo volt Ampere) has 66 turns on the secondary winding. Calculate it has few parts.

(a) Primary turn
(b) Primary full load current
(c) Secondary full load current (neglect the losses)

KVA means Rating of a transformer

$N_2 = 66$, $E_2 = 200$, $E_1 = 2000$

(a) $\frac{E_2}{E_1} = \frac{N_2}{N_1}$

$\Rightarrow \frac{200}{2000} = \frac{66}{N_1}$

$\Rightarrow N_1 = \frac{2000 \times 66}{200} = 660$

(b) $P = VI$

$\Rightarrow 20 \times 10^3 = 2000 \times I_1$

$\Rightarrow I_1 = \frac{20 \times 10^3}{2000} = 10A$

$\frac{V_2}{V_1} = \frac{I_1}{I_2} = \frac{N_2}{N_1} = \frac{E_2}{E_1}$

VI volt ampere Power

(c) $\frac{I_1}{I_2} = \frac{N_2}{N_1}$

$\Rightarrow \frac{10}{I_2} = \frac{66}{660}$

$\Rightarrow I_2 = 100A$

or $I_2 = \frac{V_1 I_1}{V_2}$ from this eqn (i)

2) A Ideal 25 KVA transformer has 500 turns on the primary winding and 40 turns on the secondary winding. The primary is connected to 3000 V, 50 HZ supply. Calculate

i) Primary and secondary currents on full

load
(ii) secondary EMF.
(iii) The minimum core flux

$P = 25 \times 10^3$, $N_1 = 500$, $N_2 = 40$, $V_1 = 3000$

(i) $25 \times 10^3 = 3000 \times I_1$

$\Rightarrow I_1 = \frac{25 \times 10^3}{3000}$

$= 83.33$ A

$\frac{I_1}{I_2} = \frac{N_2}{N_1}$

$\Rightarrow \frac{83.33}{I_2} = \frac{40}{500}$

$\Rightarrow I_2 = \frac{83.33 \times 50}{4}$

$= 1041.A$

(ii) $\frac{N_1}{N_2} = \frac{V_1}{V_2}$

$\Rightarrow \frac{N_2}{N_1} = \frac{V_2}{V_1}$

$\Rightarrow \frac{40}{500} = \frac{V_2}{3000}$

$\Rightarrow V_2 = \frac{40 \times 30}{5}$

$= 240$ V

(iii) $E_1 = 4.44 f \phi_m N_1$ $\Rightarrow E_1 = 4.44 \times 50 \times \phi_m N_1$

$\Rightarrow 3000 = 4.44 \phi_m \times 500 \times 50$

$\Rightarrow \phi_m = \frac{30}{5 \times 4.44 \times 50}$

$= \cancel{1.35}\ 0.027$

(3) A 230/2300 volt transformer takes no load current of 5 amp, of 0.25 power factor lagging. Find (i) Iron loss (I_c)
(ii) magnetising loss component of current (I_m)

$V_1 = 230$ V, $V_2 = 2300$ V, $I_0 = 5$ amp, $\cos\phi_0 = 0.25$

$I = I_c + I_m$

(i) Iron loss component of the current is $\boxed{I_c = I_0 \cos\phi_0}$

$I_c = I_0 \cos\phi_0$

$= 5 \times 0.25$

$= 1.25$

(ii) $\boxed{I_m = I_0 \sin\phi_0}$

$\cos\phi_0 = \frac{0.25}{1}$

$\sqrt{1 - 0.25^2}$

0.25

$I_m = I_0 \sin\phi_0$

$= 5 \times 0.96$

$= 4.84$

(4) A 10KVA, single phase transformer has 200 turns in one winding and 100 turns in the other winding, 50HZ, If the induced EMF in a primary side is 250V find the value of -

(i) max flux density if the core area is 64×10^{-4}

$P = 10 \times 10^3$, $N_1 = 200$, $N_2 = 100$, $f = 50$,

$E_1 = 250$

$\frac{100}{200} = \frac{E_2}{250}$

$\Rightarrow E_2 = 125$

$E_2 = 4.44 f \phi_m N_2$

$\Rightarrow 125 = 4.44 \times 50 \phi_m \times 100$

$\Rightarrow \phi_m = 5.6 \times 10^{-3}$

flux density $= \boxed{\frac{\phi}{A} = \frac{\phi_m}{A}}$

$= \frac{5.6 \times 10^{-3}}{64 \times 10^{-4}}$

$= 0.875$

(5) A 20 KVA, 2000/200 V transformer at full load, the iron and Cu loss are found to be 400W and 450W respectively. Calculate the efficiency at (i) full load, (ii) Half load

In case of full load, $x = 1$

$P = 20 \times 10^3$, $V_1 = 2000$, $V_2 = 200$

$P_i = 400W$, $x^2 P_{cu} = 450$

(i) $\eta_1 = \frac{O/P}{O/P + P_i + x^2 P_{cu}}$

$\eta = \frac{x V_2 I_2 \cos\phi}{V_2 I_2 \cos\phi + P_i + P_{cu}}$

$= \frac{20 \times 10^3 \times 1}{20 \times 10^3 \times 1 + 400 + (1)^2 \times 450}$

$= 0.96$

At half load, KVA will be $\frac{1}{2} \times 20 = 10$ KVA. Iron loss remain same. but $P_{cu} = \frac{1}{4} \times 450 = 112.5$

In case of half load $x = \frac{1}{2}$

(ii) $\eta_2 = \frac{O/P}{O/P + P_i + x^2 P_{cu}}$

$= \frac{20 \times 10^3 \times \frac{1}{2}}{\frac{1}{2} \times 20 \times 10^3 + 400 + (\frac{1}{2})^2 \times 450}$

$= 0.9512$

(6) A single-phase 2200/250V, 50HZ transformer has a net core area of $36\,cm^2$ and a maximum flux density of $6\,Wb/m^2$. Calculate the numbers of turns of (a) the primary and (b) the secondary.

$V_1 = 2200\,V$, $V_2 = 250\,V$, $f = 50\,Hz$

$$\frac{36\times10^{-4}}{6} = \frac{\phi_m}{36\times10^{-4}}$$

$\Rightarrow \phi_m = 6\times36\times10^{-4}$

$E_1 = 4.44 f \phi_m N_1$

$\Rightarrow 2200 = 4.44\times50\times6\times36\times10^{-4} N_1$

$\Rightarrow N_1 = 459$ turns

$E_2 = 4.44 f \phi_m N_2$

$\Rightarrow 250 = 4.44\times50\times36\times6\times10^{-4} N_2$

$\Rightarrow N_2 = 52$ turns

(or) $$\frac{E_2}{E_1} = \frac{N_2}{N_1}$$

$$\Rightarrow \frac{250}{2200} = \frac{N_2}{459}$$

$\Rightarrow N_2 = 52$ turns

(7) A 230/2300 V transformer takes no-load current of 5 A of 0.25 power factor lagging. Find (a) iron loss and (b) magnetizing loss component of current.

$V_1 = 230$, $V_2 = 2300$, $I_0 = 5$, $P = 0.25$

done

Q. The emf per turn of 3300/300, 50 Hz single-phase core type transformer is 6V. The maximum flux density is 1.2T. Find the number of turns in the primary and secondary windings. Also find the net core-sectional area of the core.

$V_1 = 3300$, $V_2 = 300$, $f = 50$

$\frac{E_1}{N_1} = 6$

$\Rightarrow \frac{3300}{6} = N_1 = 550$ turns

$\frac{E_2}{N_2} = 6$

$\Rightarrow \frac{300}{6} = N_2 = 50$ turns

$\frac{\phi_m}{A} = 1.2$

$\Rightarrow \phi_m = 1.2A$

$\Rightarrow 300 = 4.44 \times 50 \times 1.2 \times A \times 50$

$\Rightarrow A = 225.2\ cm^2$

Q. A 1kVA, 200/400 turns, single-phase transformer is fed with a 220V, 50 Hz supply at the low-voltage end. Assuming ideal conditions, calculate the maximum flux density if the area of cross-section of the core is $5\ cm^2$.

$N_1 = 200$, $N_2 = 400$, $P = 10^3 \times 1$

$V_1 = 220$, $f = 50$, $A = 2 \times 10^{-4} m^2$

$10^3 = 200 \times E_1$

$\Rightarrow E_1 = \frac{10^3}{200} = 5$

$5 = 4.44 \times 50 \times \phi_m \times 200$

$\Rightarrow \phi_m = 1.126 \times 10^{-4}$

$\therefore$ flux density (max) $= \frac{\phi_m}{A}$

$= \frac{1.126 \times 10^{-4}}{2 \times 10^{-4}}$

$= 0.56$

$220 = 4.44 \times 50 \times \phi_m \times 200$

$\Rightarrow \phi_m = 0.00405$ Wb

$A = 5 \times 10^{-4}$

max flux density $= \frac{0.00495}{5 \times 10^{-4}} = 9.9\ Wb/m^2$

(10) A 50 kVA, 5000/500 V, 50 Hz, single-phase transformer is given as grow. Find the efficiency of the transformer at full load and 0.8 power factor lagging. It has the high and low-voltage winding resistance of 8 Ω and 0.04 Ω respectively. The no-load loss of the transformer. $\left[\eta = \frac{\text{output}}{\text{output} + \text{loss}}\right]$

$P = 50 \times 10^3$, $V_1 = 5000$, $V_2 = 500$, $f = 50$

The no-load loss is same as the core loss or iron loss $= P_i = 900\,W$. Full load loss is the copper loss which equals $P_{cu} = I_2^2 R_{02}$

Now, for $K = 1/10$ $[R_1' = K^2 R_1]$

$R_{02} = R_2 + K^2 R_1 = R_2 + \left(\frac{V_2}{V_1}\right)^2 R_1$

$= R_2 + \left(\frac{500}{5000}\right)^2 \times R_1$

$= 0.04 + \left(\frac{1}{10}\right)^2 \times 8$

$= 0.12\,\Omega$

The current is

$I_2 = \frac{50 \times 10^3}{500} = 100\,A$

$P_{cu} = (100)^2 \times 0.12 = 1200\,W$

So, total loss at full load $= P_i + P_{cu} = 1200 + 900 = 2100\,W$

At 0.8 power factor the full-load output P is $50 \times 0.8 = 40\,kW$. So, efficiency, $\eta = \frac{40}{42.1} \times 100 = 95\%$.

(11) Determine the minimum of rating of a circuit breaker for single-phase transformer with 3% impedance operated from 400 V, 50 Hz source.

Normal full-load current is—

$I_L = \frac{VA}{V_L} = \frac{10,000}{400} = 25\,A$

max. Short-circuit ampere is given by — $\boxed{\frac{\text{Full-load ampere}}{\text{\% Impedance}}} =$

$\frac{\text{Full-load ampere}}{\text{\% Impedance}} = \frac{25}{0.03}$

$= 833.3\,A$

So the breaker used would have minimum interrupting rating of 833.3 A.

[NOTE — The secondary side voltage is not used in the calculation because in a transformer the primary circuit is the only winding to be interrupted

$\boxed{\text{\% Impedance}} =$

$= 225.2 \text{ cm}^2$

$P = 50 \times 10^3$, $E_1 = 5000$, $E_2 = 500$

$f = 50$, $R_1 = 8$, $R_2 = 0.04$ $P_i = 900$,

$\cos\phi = 0.8$

$\eta = \frac{out}{in} = \frac{out}{out + losses}$

$P_i = 900$

$P_{cu} = I_2^2 R_{02}$

$R_{02} = R_2 + R_1' = R_2 + K^2 R_1$

$= 0.04 + \left(\frac{500}{5000}\right)^2 \times 8$

$= 0.12$

$I_2 = \frac{50 \times 10^3}{500} = 100$

$P_{cu} = I_2^2 R_{02} = (100)^2 \times 0.12$

output $= 50 \times 10^3 \times 1 \times 0.8$

$= 40\ \text{kW}$

total $= 2100\ \text{W}$

$= 2.1\ \text{kW}$

$$\eta = \frac{40}{42.1} \times 100$$

$= 96\%$

(12) A 50 KVA, 6000/250 V transformer has 52 turns on the secondary winding. Determine the primary number of turns. Also calculate primary and secondary currents.

$P = 50 \times 10^3$ $V_1 = 6000$, $V_2 = 250$

$N_2 = 52$

$$\frac{250}{6000} = \frac{52}{N_1}$$

$$\Rightarrow \boxed{N_1 = 1248}$$

$50 \times 10^3 = 6000 \times I_1$

$\Rightarrow I_1 = 8.33$

$$\frac{250}{6000} = \frac{8.33}{I_2}$$

$\Rightarrow I_2 = 200$

(13) A single-phase, 50 Hz transformer has 350 turns on the primary and 800 turns on the secondary windings. The primary voltage is 400 and the cross-sectional area of the core is 750 mm². Determine (a) the emf induced in the secondary and (b) the maximum value of flux density.

$f = 50$, $N_1 = 350$, $N_2 = 800$, $V_1 = 400$,
$A = 750 \times 10^{-6} = 7.5 \times 10^{-4}$

a)
$$\frac{E_2}{400} = \frac{800}{350}$$

$E_2 = 914.2$ V

(b)
$400 = 4.44 \times 50 \times \phi_m \times 350$

$\Rightarrow \phi_m = 5.1 \times 10^{-3}$ Wb

$$\text{max flux density} = \frac{5.1 \times 10^{-3}}{7.50 \times 10^{-4}}$$

$= 6.86$ Wb/m²

or T

(14) A 440/200 V. transformer takes a current of 0.2 A open circuit at a power factor of 0.18. Find the magnetizing and iron loss component of current.

$V_1 = 440$; $V_2 = 200$; $I_0 = 0.2$; $\cos\phi_0 = 0.18$

$I_c = I_0 \cos\phi_0$
$= 0.2 \times 0.18$
$= 0.036$ A

$I_m = I_0 \sin\phi_0$
$= 0.2 \times \sqrt{1-(0.18)^2}$
$= 0.1967$ A

(15) Determine the % efficiency of single-phase 20 kVA, 2200/120 transformer at full load 0.8 pf and half full load 0.4 pf. Given: Full-load copper loss = 400 W, iron loss = 350 W

$P = 20 \times 10^3$ $V_1 = 2200$ $V_2 = 20$

Rated kVA = 20, iron loss = 350 W, full-load copper loss = 400 W.

To find % efficiency at full load 0.8 pf:

Fraction of the load (x) = 1, therefore,

output = Rated kVA × 1000 × pf × x
$= 20 \times 10^3 \times 0.8 \times 1$
$= 16000$ W

Total loss = (Iron loss) + x^2 (copper loss)
$= 350 + (1)^2 \times 400$
$= 750$ W

Input = output + total loss
$= 16000 + 750 = 16750$ W

$\% \eta = \frac{\text{output}}{\text{input}} \times 100$
$= \frac{16000}{16750} \times 100$
$= 95.52\%$

To find % efficiency at half load 0.4 pf :

(12) $x = \frac{1}{2}$

$\therefore$ output $= 20 \times 10^3 \times \frac{1}{2} \times 0.4 = 4000 W$

total loss $= 350 + (0.5)^2 \times 400 = 450$

Input $= 4000 + 450 = 4450 W$

$\% \eta = \frac{4000}{4450} \times 100 = 89.88\%$.

(16) In a 25 KVA, 2000/200V transformer the iron and copper losses are 350 and 400W, respectively. Calculate the percent efficiency on unity pf at (a) full load, (b) half load and (c) determine the load for maximum efficiency and the iron and copper loss in this case.

$P = 25 \times 10^3$ $\quad V_1 = 2000, V_2 = 200$

$P_i = 350, P_{cu} = 400$

(a) $x = 1$, $pf = 1$

$\therefore$ output $= 25 \times 10^3 \times 1 \times 1$

$= 25 \times 10^3$

Total loss $= 350 + 400 \times (1)^2$

$= 750$

Input $= 750 + 25 \times 10^3 = 25750$

$\% \eta = \frac{25 \times 10^3}{25750} \times 100 = 97.08\%$.

(b) $pf = 1, x = \frac{1}{2}$

$$\% \eta = \frac{25 \times 10^3 \times \frac{1}{2} \times 1}{25 \times 10^3 \times \frac{1}{2} + 350 + 400 \times (\frac{1}{2})^2} \times 100$$

$= 96.52\%$

(c) The load at which maximum efficiency will occur is -

$\sqrt{\frac{350}{400}} \times 25 = 23.38$ KVA

and the losses are each 350W

The load at which max. efficiency will occur - $\sqrt{\frac{P_i}{P_{cu}}} \times P$
losses are each $= P_i$

2

11/4/22

(1) A resistance of 10Ω is connected in series with a 50 mH inductance across 230V 50 Hz supply. Calculate i) current flowing in the circuit. ii) The phase angle (φ) of the current.

$R = 10\,\Omega$, $V = 230\,V$, $f = 50\,Hz$, $L = 50\times10^{-3}\,H$

(i) $I = \frac{V}{R} = \frac{230}{10} = 23\,A$

(ii) $I_m = \frac{V_m}{X_L} = \frac{V_m}{\omega L}$

$V_R = IR$
$V_L = IX_L$

$V_{rms} = \frac{V_m}{\sqrt{2}}$

$\Rightarrow V_m = 230\times\sqrt{2}$
$= 325.2\,V$

$Z = \sqrt{R^2 + X_L^2}$
$= \sqrt{(10)^2 + (50\times10^{-3}\times2\pi)^2}$
$= 18\,\Omega$

$\therefore I_m = \frac{325.2}{2\pi\times50\times50\times10^{-3}}$
$= 20.7\,A$

$\tan\varphi = \frac{X_L}{R}$
$= \frac{2\pi\times50\times50\times10^{-3}}{10}$

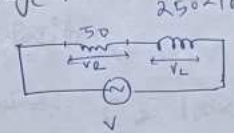
$\therefore I = I_m \sin(\omega t - \frac{\pi}{2})$
$= 20.7 \sin(2\pi\times50t - \frac{\pi}{2})$
$= 20.7 \sin(314t - \frac{\pi}{2})$

$\varphi = \cancel{26}\ 57.51^\circ$

$I = \frac{230}{7} = 12\,A$

$\therefore$ The phase angle is $\frac{\pi}{2}$ and the current is lagging.

(2) The resistance of 50Ω is connected in series with a pure inductor of 250 mH. The circuit is connected to a 50 Hz sinusoidal supply and the voltage across the resistance is 150 V. i) Calculate the supply voltage.



$R = 50\,\Omega$, $L = 250\times10^{-3}\,H$, $f = 50\,Hz$
$V_R = 150$

$I = \frac{V_R}{R} = \frac{150}{50} = 3\,A$

$V_L = IX_L = 3\times2\pi\times50\times250\times10^{-3}$
$= 235.6\,V$

$\therefore$ supply voltage $= V_R + V_L = 150 + 235.6$
$= 385.6\,V$

③ A 10 Ω resistor is connected in series with ~~100~~ 100 μF capacitor to a 230 V 50 Hz supply. Find i) Impedance ii) current iii) Power factor (iv) phase angle (v) voltage across resistor and the capacitor.

$R = 10\Omega$, $C = 100 \times 10^{-6}$ F, $V = 230$, $f = 50$

$X_C = \cancel{2 \times \pi \times 50 \times} \quad \frac{1}{\omega C} = \frac{1}{2\pi f C} = \frac{1}{2\pi \times 100 \times 10^{-6} \times 50}$

$= 31.8 \cancel{\times 10^{3}\,\Omega}$

(i) $Z = \sqrt{(X_C)^2 + R^2}$ | $\boxed{Z_C = R - jX_C}$ $= 10 - j \times 31.83$

$= \sqrt{(31.8 \cancel{\times 10^3})^2 + (10)^2}$

$= \cancel{1600\,\Omega}$ $33.38\,\Omega$

(ii) $I = \frac{V}{Z} = \frac{230}{\cancel{1600}\ 33.38} = \cancel{0.14\,A}$ 6.89 A

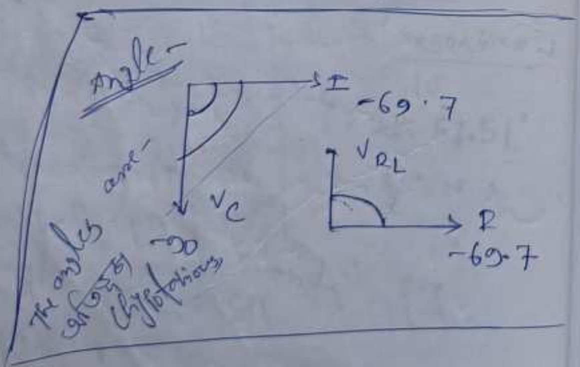
(iii) $\phi = \tan^{-1}\left(\frac{X_C}{R}\right)$

$= \tan^{-1}\left(\frac{\cancel{2 \times \pi \times 50 \times 100 \times 10^{-6}}\ 33.38}{10}\right) = \cancel{0}\ 72.9$

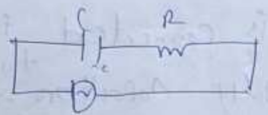
$\therefore \cos\phi = 0.29 = \frac{R}{Z}$

[or 1st get the angle from $\cos\phi$, then calculate $\tan\phi$]

(iv) Phase angle $\phi = \cancel{0}\ 72.9$



(v)



$C = 100 \times 10^{-6} F$

$I = 6.89$

∴ The voltage across capacitor $= 6.89 \times 31.8$

$= 219.1 V$

The voltage across the resistance $=$

6.89×10

$= 68.9 V$

④ A choke coil of resistance 8Ω and inductance of 0.15 H is connected in series with a capacitor of capacitance 125 μF across 230V, 50 Hz supply. Calculate i) the inductive reactance ii) capacitive reactance (iii) Impedance (iv) current (v) voltage across the coil and the capacitor respectively. (vi) Phase difference between the current and the supply voltage.

$R = 8\Omega$, $L = 0.15 H$, $C = 125 \times 10^{-6} F$
$f = 50$, $V = 230V$

(i) $X_L = 2\pi \times 50 \times 0.15 = 47.12 \Omega$

(ii) $X_C = \frac{1}{\omega C} = \frac{1}{2\pi \times 50 \times 125 \times 10^{-6}} = 25.46 \Omega$

(iii) $Z = \sqrt{(X_L - X_C)^2 + R^2}$

$= \sqrt{(47.12 - 25.46)^2 + (8)^2}$

$Z = 23.09 \Omega$

(iv) $I = \frac{V}{Z} = \frac{230}{23.09} = 9.96 A$ at an angle $= -69.7°$

(v)

The voltage across coil $= I \times (X_L)$

$= 9.96 \times 47.12$

$= 469.3$ V, angle $= 10.6°$

" " capacitor $= I \times X_C$

$= 9.96 \times 25.46$

$= 253.58 V$, angle $= -159.7$

(vi) $\tan\varphi = \left(\frac{X_L - X_C}{R}\right)$

$= \frac{47.12 - 25.46}{8}$

$\varphi = 69.72°$

The phase diff. is $69.72°$. (we consider Z making the angle with V_R) [∴ V_R এর সাথে $69.72°$]

The value of impedance is 23.09 at an angle of 69.72°.

13/4/22

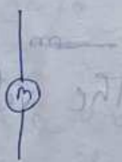
cw

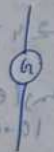
DC MACHINES

DC MACHINES → Definations, (Working Principle) Construction Parts)

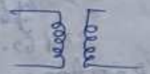
Dc Generators (Electrical energy ↑ mechanical energy)

DC motor (Electrical energy → mechanical energy)





single phase ac ~~Transf~~ representation

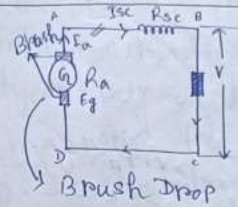


Series Shunt Compound

- The EMF eqn of DC Generators.

$E_g = \frac{P \phi N Z}{60A}$ [P = no of poles, A = no of parallel path, N = speed, Z = No. of conductors, ϕ = flux]

- The winding of conductors → LAP, A=P ; WAVE A=2
- Series Generator



[R_{sc} = Series field resistance, R_a = armature resistance] [I_a = Armature current] [I_{sc} = Series field current] [V = Terminal voltage drop]

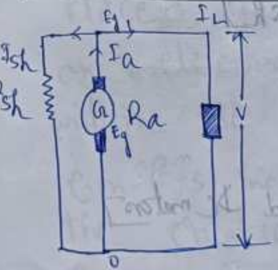
ABCDA LOOP,

$BCD + I_aR_a + I_{sc}R_{sc} = E_g - V$

$\Rightarrow V + BCD + I_a(R_a + R_{sc}) = E_g$ [BCD = Brush Contact drop]

$\Rightarrow \boxed{E_g = V + I_a(R_a + R_{sc}) + BCD}$

- Shunt motors



[R_{sh} = Shunt field resistance, R_a = armature resistance] [I_L = Load/line current]

$I_a = I_L + I_{sh}$

$\frac{E_g}{R_{sh}} + \frac{E_g}{R_a} + (E_g - V) = 0$

$\Rightarrow E_g R_a R_{sh} + E_g R_{sh} + (E_g - V) R_a R_{sh} = 0$

$\Rightarrow E_g \cancel{(R_a + R_{sh})} + E_g = R_a R_{sh} - V R_a R_{sh} \rightarrow$

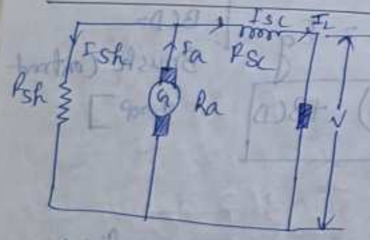
$\Rightarrow E_g \cancel{(R_a + R_{sh}}$

$$\boxed{E_g = V + I_a R_a + BCD}$$

$$\boxed{R_{sh} = \frac{V}{I_{sh}}}$$

H/W

• Compound Generator



[When it is Compound then R_a and R_{sc} are in Series and this will Parallel to R_{sh}]

[Graphs I_a v/s Φ
N v/s I_a]

[DC Generator characteristics]

[Principle of DC Generator and DC motor]

[Numericals]

Defination of

① DC motor – A DC motor is any of a class of rotary electrical motors that converts direct current electrical energy into mechanical energy. The most common types rely on the forces produced by magnetic fields.

Defination

② DC generator – A direct-current (DC) generator is a rotating machine that supplies an electrical output with unidirectional voltage and current. The basic principle of operation are the same as those for synchronous generators.

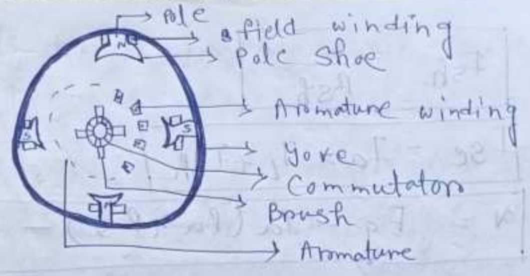
③ DC generator operates on the principle of the dynamically induced electromagnetic force. When a conductor is placed in a varying magnetic field, an electromotive force gets induced within the conductor. This induced e.m.f's magnitude is measured using the equation of the electromotive force of a generator. This is the working principle of dc generator.

④ Working Principle of DC motor –

When kept in a magnetic field, a current-carrying conductor gains torque and develops a tendency to move. In short, when electric fields and magnetic fields interact, a mechanical force arises. This is the Principle on which the DC motors work.

⑤ Construction of DC motor –

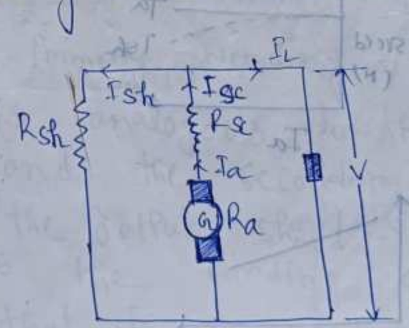
There are two main parts of DC motor. The rotating part is the armature and the stator is their stationary part. The armature coil is connected to the DC supply. The armature coil consists the commutators and brushes.



⑥ Compound Generator – In a compound generator there are two sets of the field winding on each pole. One of them is connected in series having few turns of thick wire, and the other is connected in parallel having many turns of fine wire with the armature windings. This is divided into 2 types –

1) Long Shunt Compound Generator
2) Short " "

1) Long shunt Compound generator –

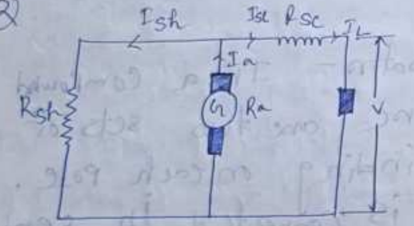


(1) $\boxed{I_{sh} = \frac{V}{R_{sh}}}$

$\boxed{I_{se} = I_a = I_L + I_{sh}}$

$\boxed{V = E_g - I_a(R_a + R_{se}) - BSD}$

(2)

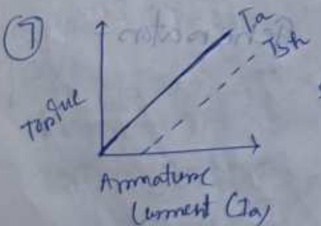


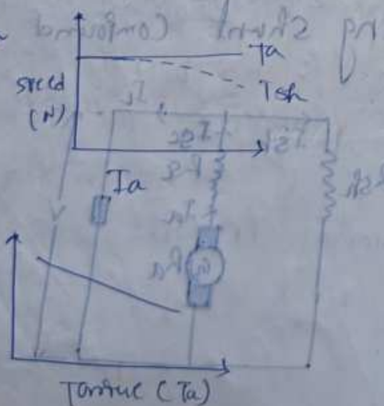
$\boxed{I_{se} = I_L}$

$\boxed{I_{sh} = \frac{V + I_L R_{se}}{R_{sh}} = \frac{E_g - I_a R_a}{R_{sh}}}$

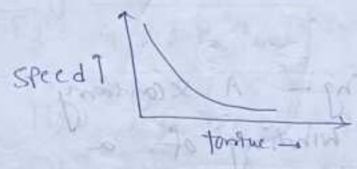
$\boxed{E_g = V + I_a R_a + I_L R_{se} + BSD}$

(7)





(8) Speed v/s torque graph



(9) Characteristics of DC generator –

(i) open circuit characteristic (o.c.c)

(ii) Internal or total characteristic

(iii) External characteristic

(10) Basic principle of transformer – The transformer works on the principle of Faraday's law of electromagnetic induction and mutual induction. There are usually two coils primary coil and secondary coil on the transformer core. The core laminations are joined in the form of strips.

(11) Primary winding – The primary winding is analogous to the input shaft and the secondary winding to the output shaft. A primary winding is the winding of a transformer that is connected to and receives

energy from an external source of electrons.

(12) Secondary winding – A secondary winding is the winding of a transformer that receives its energy by electromagnetic induction from the Primary winding.

(13) Emf eqn of single phase AC transformer–

we know that –
in the Primary winding

$E_1 = -N \frac{d\phi}{dt}$

Maximum value of induced emf, Equation.

$E_1 (max) = N_1 \omega \phi_m$

$E_1 (max) = 2\pi f N_1 \phi_m$, [where $\omega = 2\pi f$]

Rms value is given by, $E_1 = \frac{E_1(max)}{\sqrt{2}}$

Putting the value of $E_{1(max)}$ in above equation, we get,

$E_1 = \sqrt{2}\pi f N_1 \phi_m$

$\boxed{E_1 = 4.44 f N_1 \phi_m}$

similarly, we get,

$\boxed{E_2 = 4.44 f N_2 \phi_m}$

(14) How the transformer is rated in

KVA – Transformers are rated in KVA because the losses occurring in the transformers are independent of Power factor. KVA is the unit of apparent power. It is a combination of real power and reactive power.

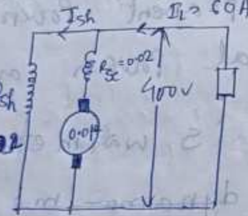
(15) What is wattmeter connection –

~~The dynamo-me~~ the current coil is connected in series with the load hence it carries the circuit current. The potential coil is connected across the load so it carries current proportional to the voltage.

21/4/22

Pole cone

(1) A ~~G~~ long shunt generator supplies 60 A at a terminal voltage of 400 ~~V. star~~ the armature resistance is 0.01 Ω the series field resistance is 0.02 Ω and the shunt field resistance is 100 Ω. Find the generated emf taking the BSD at 1 V per brush. Neglect the armature reaction drop



$V = \cancel{60A}\ 400\ V$

$R_a = 0.01\ \Omega$

$R_{SC} = 0.02$

$R_{sh} = 100\ \Omega$

$BSD = 1V$

$I_L = 60A$

It is a long shunt generator (given)

$E_g = \cancel{V + I_a(R_a + R_{sc}) + BSD}$

$\cancel{\Rightarrow E_g = V + I_aR_a + BSD}$

$= 400 + 60 \times 0.01 + 1$

$= 401.6$

$I_a = I_{sh} + I_L$ $\left[I_{sh} = \frac{V}{R_{sh}} = \frac{400}{100} = 4 \right]$

$= 4 + 60$

$= 64A$

$E_g = V + I_aR_a + BSD$

$= 400 + 64 \times 0.01 + 1 = 401$

$E_g = V + I_a(R_{se} + R_a) + BCD$

$= 400 + 64 \times (0.02 + 0.01) + 1$

$= 403$

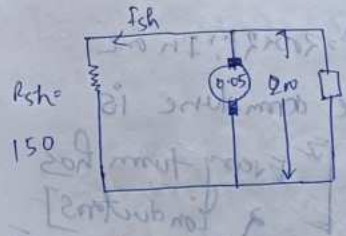
(2) A 20 kW, 200 V dc shunt generator has armature and field resistance of 0.05 Ω and 150 Ω respectively. Determine the total armature power developed when the machine works as a generator delivering 20 kW output.

$V = 200V$

$R_a = 0.05$

$R_{sh} = 150\ \Omega$

$P = 20 \times 10^3\ W$



$I_a = I_{sh} + I_L$ $\left[I_{sh} = \frac{V}{R_{sh}} = \frac{200}{150} = 1.33A \right]$

$= 1.33 + 100$

$= 101.33A$

$E_g = V + I_a(R_a + \cancel{R_{sh}})$ $\left[P = V \cdot I_L \Rightarrow I_L = \frac{20 \times 10^3}{200} = 100A \right]$

$= 200 + 101.33 \times 0.05$

$= 205.06\ V$

12

$\therefore P_a = 205.06 \times 101.33$ $\boxed{P_a = E_g I_a}$

$= 20.78 \times 10^3 W$

A = P (Lap wound)
A = 2 (Wave wound)

H/W

③ A 4 pole lap wound dc shunt generator has useful flux per pole of 0.08 wb. The armature winding consist of 200 turns ~~each~~ with total resistance of 0.8Ω. Calculate the terminal voltage when running at 1000 rpm. If the armature current is 50A.

P = 4
A = P = 4
$\phi = 0.08$ wb
N = 1000 rpm

$I_a = 50A$
number of turns (n) = 200
$R_a = 0.8 \Omega$

The total no. of turns Z = 200×2 [∵ In one complete rotation the armature is rotating for 2 times] [Every turn has 2 conductors]

$E_g = \frac{P \phi N Z}{60 A}$

$= \frac{4 \times 0.08 \times 1000 \times 400}{60 \times 4}$

$= 533.33V$

~~Req~~ $R_{eq} = 0.8 \Omega$

Since there are four parallel paths, each path has the resistance of 0.8/4 = 0.2Ω

The equivalent resistance of the four parallel paths of 0.2Ω in each parallel path will be 0.2/4 = 0.05Ω

$\therefore V = E_g - I_a R_a$

$= 533.33 - 50 \times 0.05$

$= 530.83V$

Q A 4 Pole wave wound dc generator has 50 slots and 24 conductors per slot. The flux per pole is 10 mWb. Determine the induced emf in the armature if it is rotating at speed of 600 rpm.

$P = 4$

$Z = 24 \times 50 = 1200$

$\phi = 10 \times 10^{-3}$ Wb

$N = 600$ rpm

$A = 2$ (∵ it is a wave wounded generator)

$$E_g = \frac{P\phi N Z}{60A}$$

$$= \frac{4 \times 10 \times 10^{-3} \times 600 \times 1200}{60 \times 2}$$

$= 240$ V

Q A 6 Pole wave wound armature has 780 Conductors and a flux of 12 mWb. Find the speed of the armature when generated emf is 400 V. What will be the speed when it is lap wound.

wave wound $E_g = 400$ $\phi = 12 \times 10^{-3}$

$P = 6$

$A = 2$

$Z = 780$

i) $$400 = \frac{6 \times 12 \times 10^{-3} \times N_1 \times 780}{60 \times 2}$$

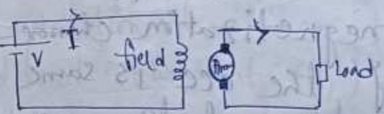
$\Rightarrow N_1 = 8.54 \times 10^{+4}$ rpm

ii) $$400 = \frac{\cancel{6} \times 12 \times 10^{-3} \times N_2 \times 780}{60 \times \cancel{6}}$$

$\Rightarrow N_2 = 2.56 \times 10^{+3}$ rpm

- Types of generator

1) Separately excited generator – In this type of generators, the field magnets are energized from an external DC source.



2) Self excited generator – In these generators the field is excited by the current induced in the generator itself. These are classified into 3 types of generator –

a) Shunt – wound generator

b) Series – wound generator

c) Compound wound generator

i) Long-Shunt Compound "

ii) Short-Shunt Compound "

• The Armature magnetic field has two effects-

1. It demagnetizes or weakens the main flux. 2. It cross-magnetizes or distorts the main flux.

• DC generator's characteristics

1) Open circuit characteristic - The curve between the no-load generated emf (E_g) and the field current (I_f) at constant speed is known as open-circuit characteristics (OCC) of a DC generator. It is otherwise known as no-load saturation curve or megnetization characteristic. Practically the OCC is same for all the generator whether separately or self-excited. The data for OCC curve are obtained experimentally by varying the field current at a constant speed and recording the change in terminal voltage for the corresponding field current.

2) Internal or total characteristic (E/I_a): It gives the relation between the generated emf on load (E) and the armature current (I_a). The Emf E is the emf generated after deducting the voltage drop due to the demagnetizing effect of armature reaction. Therefore, this curve lies below the OCC curve. The internal characteristic can be obtained from external characteristic if winding resistances are known.

$E = E_g$ - Armature reaction drop

3) External characteristic (V/I_L) - It gives the relation between the terminal voltage (V) and load current (I_L). The terminal voltage V becomes avialable across the external circuit after deducting the voltage drop due to the armature reaction drop, due to the armature resistance and voltage drop from the total emf generated (E_0). Therefore this curve lies below the internal characteristic. This characteristic is very important in determining the suitability of a generator for a given purpose.

$V = E_g$ - Armature reaction drop - I_aR_a

$V = E - I_aR_a$

where I_a is the armature current and R_a is the armature resistance.

4) Voltage regulation- The voltage regulation of a generator generally refers to the change in output voltage for any change in load. It is usually expressed as the change in voltage from a no-load condition to a full-load condition and is expressed as a percentage of full load. It is expressed mathematically in the following way-

$$\% \text{ regulation} = \frac{E_{no\,load} - E_{full\,load}}{E_{full\,load}} \times 100$$

where E_{noload} is the no-load terminal voltage which is same as E_g and $E_{full\,load}$ is the full-load terminal voltage of the generator which is same as V.

• Applications of DC generators -

1) DC Shunt generator- Because of its slightly drooping characteristics, the shunt generator is suited for charging batteries and also for parallel operation. It is also used for lighting and power supply purpose.

2) DC series generator- Because of its raising characteristics, it is widely used as boosters (railway service). It is also used for supplying the field current for regenerative breaking of DC locomotives.

3) DC Compound generator- They are used to supply power to railway circuits, elevator motors, incandescent lamps, etc. Differentially compound generator is used as an arc welding generator.

(6) A DC long shunt compound generator delivers a load current of 200A at 500V. The resistance of the armature, series field and shunt field are 0.03Ω, 0.015Ω and 150Ω. Calculate the emf induced in the armature. Allow a brush contact drop of 1 V/brush

$I_L = 200A$, $V = 500V$, $R_a = 0.03\Omega$,

$R_{se} = 0.015\Omega$, $R_{sh} = 150\Omega$, $BSD = 2V$ [1×2 = 2V]

$I_{se} = I_a = I_{sh} + I_L$

$I_{sh} = \frac{V}{R_{sh}} = \frac{500}{150} = 3.33A$

$I_a = 3.33 + 200$
$= 203.33A$

$E_g = V + I_a(R_a + R_{se}) + BSD$
$= 500 + 203.33(0.03 + 0.015) + 2$
$= 511.15V$

(7) An 8-pole lap wound DC generator has 450 armature turns. It operates at 0.02 wb flux per pole and runs at 1000 rpm at no load. Find the emf induced by it.

$A = P = 8$

$Z = 450 \times 2$ [∵ every turn has 2 conductors]

~~1 pole → $\phi = 0.02$~~
~~8 → 0.02 × 8~~

$N = 1000$

$E_g = \frac{0.02 \times 8 \times 450 \times 2 \times 1000}{60 \times 8}$
$= 3000V$

(8) A separately excited DC generator develops an induced emf of 220V while running at 900 rpm and with a flux of 0.05 wb/pole. What would be the required speed if the emf of 200V is to be generated with a flux of 0.045 wb?

$E_{g_1} = 220V$, $N_1 = 900$, $\phi_1 = 0.05$

$E_{g_2} = 200$, $N_2 = ?$ $\phi_2 = 0.045$

$\frac{220}{200} = \frac{900 \times 0.05}{N_2 \times 0.045}$ ⇒ $N_2 = 909$ rpm

(9) A 6-pole lap wound DC generator has 720 conductors. A flux of 80m wb/pole is driven at 1000 rpm. Find the generated emf.

$A = P = 6$, $Z = 720$, $\phi = 80 \times 10^{-3}$

$N = 1000$

$$E_g = \frac{\cancel{6} \times 1000 \times 720 \times 80 \times 10^{-3}}{60 \times \cancel{6}}$$

$= 9600$

(10) A ~~8~~4-pole DC generator has 500 armature conductors and a useful of 0.05 wb. What will be the emf generated if it is lap connected and runs 1200 rpm? What must be the speed at which it is to be driven to produce the same emf if it is wave wound?

a) $A = P = \cancel{8}4$, $\phi = 0.05$, $Z = 500 \cancel{\times 2}$

$N = 1200$ $\cancel{4000}$

$$\therefore E_g = \frac{\cancel{4}\times 0.05 \times 500 \times 1200}{60 \times \cancel{4}}$$

$= 500$ V

b) $A = 2$, $P = 8$, $\phi = 0.05$, $E_g = 500$

$Z = 500$, $N' = ?$

$$~~E_g~~ \quad 500 = \frac{4 \times 0.05 \times N' \times 500}{60 \times 2}$$

$$N' = \frac{120}{4 \times 0.05}$$

$= 600$ rpm

- **Principle of DC motor** –

motor change electrical energy to mechanical energy. whenever a current carrying conductor is placed in a magnetic field, a force (F) will act on the conductor whose magnitude is given by

$$F = BIl \sin\theta \text{ newton}$$

[B = flux density (wb/m²)
l = length (m)
I = current (A)
θ = Angle between conductor and field]

[* Direction of the force is given by Fleming's left-hand rule.]

(3)

Sem-II (Last year) EENUGE 301

1) a) Distinguish between mesh and loop of a network.

Loop (⊛ is encountered more than once.)	mesh
1) loop is any closed path through a circuit where no node more than one is encountered ⊛ 2) to find a loop, start at a node in the ckt, from this node, move back to the same node along a path to ensure that no node ⊛	1) A mesh is a closed path in a circuit with no other paths inside it. 2) In other terms, a loop with no other loops inside it.

b) An electric iron is rated power 240 V. Find the current drawn and resistance of the heating element.

$P = 1000W, V = 240 V$

$P = VI$

$\Rightarrow 1000 = 240 \times I$

$\Rightarrow I = \frac{1000}{240} = 4.16 A$

$R = \frac{V}{I} = \frac{240}{4.16}$

$= 57.6 \Omega$

c) Define i) charge ii) electric current (iii) power (iv) network.

(i) Charge - Electric charge is the physical property of matter that causes it to experience a force when placed in an electromagnetic field. / The fundamental electrical property to which mutual attractions or repulsions between electrons or protons is attributed.

(ii) Electric current - An electric current is a flow of electrical charge, electric charge flows when there is voltage present across a conductor.

(iii) Power - The rate of doing work or the rate of using energy is called power.

(iv) network - A network is a collection of points or nodes, joined by lines or edges.

d) Write some applications of maximum power transfer theorem.

Radio communications, audio systems.

e) why is a single phase induction motor does not self start?

As - The produced stator flux is alternating in nature and at the starting, the two components of this flux cancel each other and hence there is no net torque.

f) Give two basic speed control scheme of DC shunt motor?

Flux control - To control the flux, a rheostat is added in series with the field winding.

Armature control - speed control of a dc motor is directly proportional to the back emf E_b and $E_b = V - I_a R_a$. That means, when supply voltage V and the armature resistance R_a are kept constant, then the speed is directly proportional to armature current I_a.

g) Define Power factor. State the conditions under which it is (i) maximum (ii) minimum.

~~In electronics and electrical~~ It will be max when $\phi = 0°$ and will be min when $\phi = \pi$ | 180°

Power factor is the ratio of ACTIVE POWER to the TOTAL POWER (apparent power)

$$\text{Power factor} = \frac{\text{Active power}}{\text{Total power}} = \frac{P}{S}$$

S = total power of generator (or used)

P = Power consumed in the load (active power)

Q = Reactive power stored in magnetic field or wasted power.

(i) Power factor will be max when either the a.c. circuit is pure resistive circuit or is in resonance condition. (ii) min when a.c circuit is either pure inductive or pure capacitive or a combination of two.

h) Can DC be applied to transformers?

No. If we supply DC then same current will move round in primary side, so the winding side (primary side) will get heated. So we cannot use DC to transformers.

i) Give some application of D.C motor?

Elevators, steel mills, rolling mills, locomotives, and excavators, like auto ~~roati~~ rotating machines. DC motors result from the interaction of two magnets.

1) Determine the power factor of a RLC series circuit with $R = 50\,\Omega$, $X_L = 80\,\Omega$, $X_C = 12\,\Omega$.

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

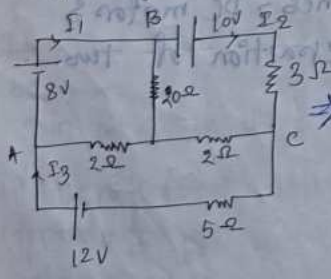
$$= \sqrt{(50)^2 + (80-12)^2}$$

$$= 84.40\,\Omega$$

$$\therefore \cos\phi = \frac{R}{Z} = \frac{50}{84.40} = 0.59$$

$\therefore$ The power factor is $\cos\phi = 0.59$.

2) a) Determine current in 5 Ω resistor by any one method.



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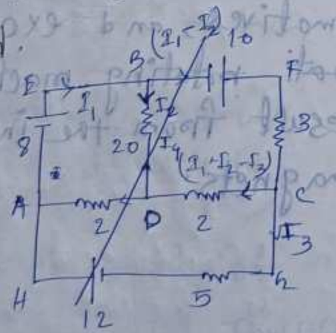
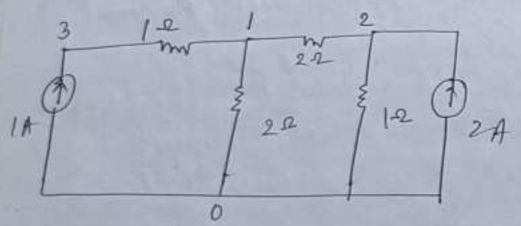


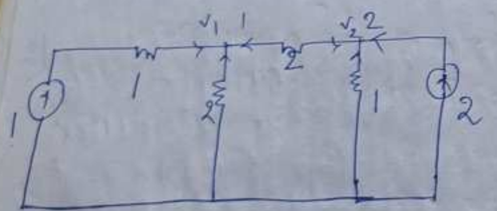
ACWAA,

−RI

(b) Determine the voltages 1 and 2 of the network by nodal analysis.



For 1 and 2



$$1 + \frac{v_1}{2} + \frac{v_1 - v_2}{2} = 0$$

$$\Rightarrow 2 + v_1 + v_1 - v_2 = 0$$

$$\Rightarrow 2v_1 - v_2 = -2 \quad (I)$$

$$\frac{v_2 - v_1}{2} + \frac{v_2}{1} + 2 = 0$$

$$\Rightarrow v_2 - v_1 + 2v_2 + 4 = 0$$

$$\Rightarrow -v_1 + 3v_2 = -4 \quad (II)$$

$$2v_1 - v_2 = -2 \quad (I) \times 1$$
$$-v_1 + 3v_2 = -4 \quad (II) \times 2$$

$$2v_1 - v_2 = -2$$
$$-2v_1 + 6v_2 = -8$$

$$\Rightarrow 5v_2 = -10$$
$$\Rightarrow v_2 = -2$$

mag $v_2 = 2V$

$$2v_1 - v_2 = -2 \quad (I) \times 3$$
$$-v_1 + 3v_2 = -4 \quad (II) \times 1$$

$$6v_1 - \cancel{3v_2} = -6$$
$$-v_1 + \cancel{3v_2} = -4$$

$$5v_1 = -10$$
$$\Rightarrow v_1 = -2$$

mag $v_1 = 2V$

3) a) Derive the emf eqn of a single phase transformer.

$\phi = \phi_m \sin \omega t$

By faraday's law of electromagnetic induction emf induced is, for a single turn:

$$e = -\frac{d\phi}{dt}$$

For N no of turns.

$$e = -N\frac{d\phi}{dt}$$

$$e = N\left\{-\frac{d}{dt}(\phi_m \sin \omega t)\right\}$$

$$= -N\omega \cos \omega t \cdot \phi_m$$

12

$e = -\phi_m N \omega \cos(\omega t)$

$= \phi_m N \cdot 2\pi f \cdot \sin(\omega t - \frac{\pi}{2})$

e_{max} when $\omega t - \frac{\pi}{2} = \frac{\pi}{2}$, i.e $\sin(\omega t - \frac{\pi}{2}) = 1$

$\therefore e_{max} = \phi_m \cdot N \cdot 2\pi f$

$E_{rms} = \frac{e_{max}}{\sqrt{2}} = 4.44 N \phi_m f$

Primary induced emf,

$E_1 = 4.44 f \phi_m N_1$

$E_2 = 4.44 f \phi_m N_2$

b) A 200/50 V, 50 Hz single phase transformer is connected to a 200V, 50 Hz supply with secondary winding open. (i) what is the value of max flux through the core, if the primary winding has 400 turns? (ii) what is the peak value of flux if the primary voltage is 200 V, 25 Hz and what happens to no load current? [Data missing =?]

$V_1 = 200$, $f = 50$ Hz

$N_1 = 400$

$E_1 = 4.44 f \phi_m N_1$

(i) $\phi_m = \frac{200}{4.44 \times 50 \times 400}$

$= 2.25 \times 10^{-3}$ Wb

ii) $E_1 = 200$ V, $f = 25$ Hz

$\phi_m = \frac{200}{4.44 \times 25 \times 400}$

$= 4.5 \times 10^{-3}$ Wb

$I_0 = I_e + I_m$

$= I_0 \cos\phi + I_0 \sin\phi$

no load current is independent of flux or max flux. i.e. there is no relation between flux and no load current. So it will remain unchange.

4) a) sketch the o.c.c of DC generator
done (Previous)

b) A series RLC circuit has 30Ω resistance, 2mH inductance and 25.1μF capacitance and is connected to 220V, 60HZ supply. Find (i) the current, (ii) the Power factor, (iii) the voltage drop across each element.

$R = 30,\ L = 2\times10^{-3}H,\ C = 25.1\times10^{-6}F$

$V = 220V,\ f = 60$

$X_L = 2\pi\times60\times2\times10^{-3},\ X_C = \frac{1}{2\pi\times60\times25.1\times10^{-6}}$

$= 0.75\ \Omega \qquad\qquad = 105.68$

$Z = \sqrt{(30)^2 + (0.75 - 105.68)^2}$

$= 109.13\ \Omega$

(i) $I = \frac{220}{109.13} = 2.01A$

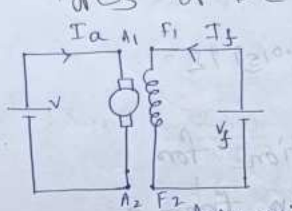
(ii) $\cos\phi = \frac{R}{Z} = \frac{30}{109.13} = 0.27$

(iii) $V_R = IR = 2.01\times30 = 60.3V$

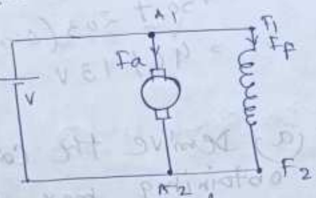
$V_L = IX_L = 2.01\times0.75 = \cancel{1.507V}\ 1.50V$

$V_C = IX_C = 2.01\times105.68 = 212.41V$

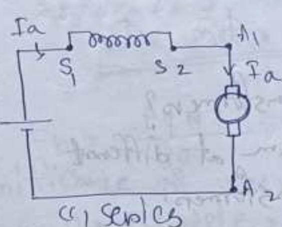
5) (a) Draw the circuit for various types of DC motor.



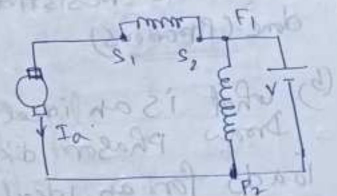
(a) separately excited



(b) shunt



(c) series



b) A DC long shunt compound generator delivers a load current of 200A at 450V. The resistance of the armature series field and shunt field are 0.03Ω, 0.015Ω and 150Ω. Calculate the emf induced in the armature. Allow a brush drop of 1V/brush.

$I_L = 200A,\ V = 450,\ R_a = 0.03\Omega,\ R_{se} = 0.015\Omega$

$R_{sh} = 150\ \Omega,\ BSD = 2V$

$I_{sh} = \frac{450}{150} = 3A$

$I_a = I_{se} = I_L + I_{sh} = 200 + 3 = 203A$

$E_g = V + I_a(R_a + R_{se}) + BSD$

$= 450 + 203(0.03 + 0.015) + 2$

$= 461.13\ V$

6) (a) Derive the condition for obtaining max power from a source to resistive load.

done (Previous)

(b) What is an ideal transformer? Draw phasor diagram at different loads for an ideal transformer.

done.

7) (a) write short notes on Rms values of AC waveforms.

done

(b) An alternating voltage is given by $v = 230 \sin 314t$. Calculate (i) frequency, (ii) maximum value, (iii) average value (iv) Rms value.

$\omega = 314$

$2\pi f = 314$

(i) $\therefore f = \frac{314}{2\pi} = 50\ Hz$

(ii) $V_m = 230\ V$

(iii) $V_{av} = \frac{2 \times 230}{\pi} = 146.42\ V$

(iv) $V_{rms} = \frac{230}{\sqrt{2}}$

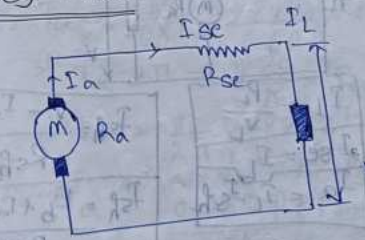
$= 162.63\ V$

13/5/22

DC motor

$E_b = \frac{P \phi N Z}{60 A}$ [P = Pole, ϕ = flux, N = speed, Z = no. of conductor, A = no. of Parallel path]

- significance of back emf, working principle, definations, classification, characteristics, torque eqn, speed control.
- If I_a is changed what will be the effect over back emf (E_b)?
- series motor



[I_a = Armature current, I_{se} = series field current, BCD = Brush contact drop, V = terminal voltage, R_a = Armature resistance, R_{se} = series field resistance]

$\boxed{E_b = V + I_a(R_a + R_{se}) + BCD}$

$I_a = I_{se} = I_L = \frac{P_L}{V_L}$

$E_b = I_L(R_a + R_{se}) + V + BCD$

$$\boxed{E_b = V - BCD - I_a(R_a + R_{se})}$$

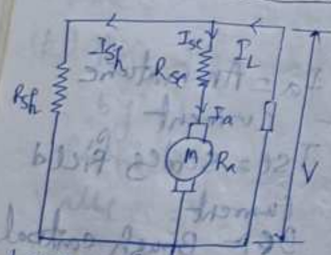
- DC shunt motors

[R_{sh} = Shunt field Resistance, I_{sh} = shunt field current]

$$\therefore \boxed{I_{sh} = \frac{V}{R_{sh}}}$$

$$\boxed{\begin{aligned} E_b &= V - I_aR_a - BCD \\ I_a &= \cancel{I_{sh}} + I_L - \cancel{I_{sh}} \end{aligned}}$$

- Compound motors

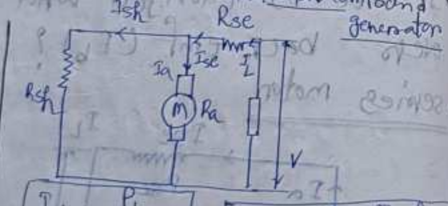


Long Shunt Compound motors

$$\boxed{I_L = \frac{P_L}{V_L}} \quad \boxed{I_{sh} = \frac{V}{R_{sh}}}$$

$$\boxed{\begin{aligned} I_a &= I_L - I_{sh} \\ I_{se} &= I_a \end{aligned}} \quad \boxed{\begin{aligned} E_b &= V - I_aR_a - I_{se}R_{se} - BCD \\ &= V - I_a(R_a + R_{se}) - BCD \end{aligned}}$$

Short shunt Compound generator



$$\boxed{\begin{aligned} I_L &= \frac{P_L}{V_L} \\ I_{se} &= I_L \\ I_a &= I_L + I_{sh} \end{aligned}} \quad \boxed{\begin{aligned} I_{sh} &= \frac{V - I_{se}R_{se}}{R_{sh}} \\ I_{sh} &= \frac{E_b + I_aR_a}{R_{sh}} \end{aligned}}$$

$$\boxed{E_b = V - I_aR_a - I_LR_{se} - BCD}$$

- Derive the torque eqn for dc motors. (PTO)
- Armature torque

Torque = force × distance = $F \times R$ Nm

Work done/sec $= F \times (2\pi R) \times \frac{N}{60}$

$\therefore$ W/sec or Power developed is given by

$P_m = \omega T_a$

$\Rightarrow P_m = T_a \times \frac{2\pi N}{60}$ J/s or W

Also, the electrical equivalent of mechanical

- Speed control of dc motors

Power developed in the armature is E_bI_a watts

$\therefore T_a \times \frac{2\pi N}{60} = E_bI_a$

where, $E_b = \frac{\phi ZNP}{60A}$ V

$\therefore T_a \times \frac{2\pi N}{60} = \frac{Z\phi NP}{60A} \times I_a$

$\Rightarrow T_a \times 2\pi = \frac{\phi ZP}{A} \times I_a$

$\Rightarrow T_a = \frac{1}{2\pi} \times \frac{\phi ZPI_a}{A}$

$\therefore T_a = \frac{0.159\phi ZPI_a}{A} = \left(\frac{0.159ZP}{A}\right)\phi I_a$

This implies that, $T_a \propto \phi I_a \Rightarrow T_a \propto I_a$

For a series motor, before saturation, as the field winding carries armature current we have $\phi \propto I_a$

$\therefore T_a \propto I_a^2$

• Speed control of DC motors - The speed of a motor is given by

$$N = \frac{E_b(60A)}{P\phi Z} = \frac{V - I_a R_a}{\phi Z}\left(\frac{60A}{PZ}\right) = K\frac{V - I_a R_a}{\phi}$$

where K is a constant, V is the supply voltage, I_a is the armature current, R_a is the armature resistance and ϕ is the flux per pole. We can control the speed of motor by varying:

1. Flux per pole ϕ (flux control)
2. Armature resistance control
3. Voltage control

• Characteristics of dc motor

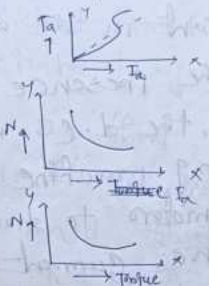
A motor has both electrical and mechanical characteristics. There are three important characteristics worth noting:

1. Armature torque versus armature current is T_a/I_a. This is also called electrical characteristic.
2. Speed versus armature current (N/I_a).
3. Speed versus armature torque (N/T_a). This is also called mechanical characteristic.

This following relation are to be recalled while discussing the characteristics of motors:

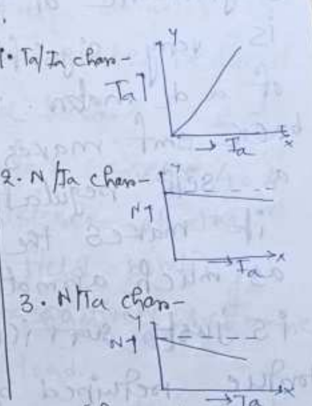
1. $T_a \propto \phi I_a$
2. $N \propto \frac{E_b}{\phi}$
3. 'ϕ' is constant for shunt motor.
4. ϕ is proportional to "I_a" for a series motor, before saturation.

1. T_a/I_a char-
2. N/I_a char-
3. N/T_a char-



(for series motor)

1. T_a/I_a char-
2. N/I_a char-
3. N/T_a char-



(for series motor)

• Applications of dc motor

i) Shunt motor application - Since shunt motor has approximately constant speed, it can be used for lathes line - shaft drives, pumps, machine tools, fans, wood working machines etc.

ii) Series motor applications - Since series motor has high starting torque, it can be used for electric traction, tram cars, railway cars, elevators etc.

iii) Cumulative compound motor application - Since this motor has high starting torque, it can be used for rolling mills, elevators, gears, power fans etc.

① Significance of back emf – Back emf is very significant in the working of a dc motor. The presence of back emf makes the d.c. motor a self regulating machine i.e, it makes the motor to draw as much armature current as is just sufficient to develop the torque required by the load.

② classification of dc motor –

i) series motor

ii) shunt motor

iii) Compound motor → Cumulative compound motor / → differential "

Compound motor → long shunt compound motor (cumulative/differential), short shunt compound motor (cumulative/differential)

③ If Ia changed what will be the effect upon Eb?

As the armature speed increases, the back emf Eb also increases and causes the armature current Ia to decrease. The motor will stop accelerating when the armature current is just sufficient to produce the reduced torque required by the load.

Ex.

① A 250 V DC shunt motor takes 40 A at full load. The resistance of the armature and shunt field winding are 0.5 Ω and 250 Ω respectively. Determine the back emf at full load.

$V = 250V,\ I_L = 40A,\ R_a = 0.5\Omega,$

$R_{sh} = 250\Omega$

$I_a = I_L - I_{sh}$ $\left[I_{sh} = \frac{V}{R_{sh}} = \frac{250}{250} = 1 \right]$

$= 40 - 1$

$= 39A$

$\therefore E_b = 250 - 39 \times 0.5$

$= 230.5V$

② A 250 V DC series motor has an armature resistance of 0.05 Ω and series field resistance of 0.02 Ω. It is running at a speed of 900 rpm taking a current of 30 A. Determine its speed when it takes current of 25 A.

$V = 250V,\ R_a = 0.05,\ R_{se} = 0.02,\ I_L = 30A$

$\therefore I_{sh} = \frac{250}{0.02} = 12500A$

$I_a = 30 = I_{sc} = I_L$

$E_{b_1} = 250 - 30(0.02 + 0.05)$

$= 247.9 = E_1$

When, $I_a = 25 = I_{sc} = I_L$

$E_{b_2} = 250 - 25 \times 0.07$

$= 248.25 = E_2$

$\frac{E_{b_1}}{E_{b_2}} = \frac{N_1}{N_2} \times \frac{I_2}{I_1} \quad \left[\because E_b = \frac{P\phi N Z}{60A}\right]$

$\Rightarrow \frac{247.9}{248.25} = \frac{900}{N_2} \times \frac{25}{30}$

$\Rightarrow N_2 = \frac{900 \times 25 \times 248.25}{30 \times 247.9}$

$= 751.05$ rpm

We have

$\frac{N_2}{N_1} = \frac{E_2}{E_1} \times \frac{I_1}{I_2}$

$\Rightarrow N_2 = \frac{E_2 \times I_1 \times N_1}{E_1 \times I_2}$

$= \frac{248.25 \times 30 \times 900}{247.9 \times 25}$

$= 1081$ rpm

- emf eqn of for dc generator

ϕ = flux per pole, P = Pole no.
N = speed
Z = no. of conductors
A = No. of Parallel Paths
(where $A = 2$ (wave wound)
$A = P$ (lap wound))

E_g = generated emf

We know, $d\phi = P \times \phi$ Wb

Time taken to complete one revolution –

$dt = \frac{60}{N}$ sec

We know that, emf generated per conductor [according to the law of electro-magnetic induction]

E_g / per conductor, $= \frac{d\phi}{dt}$

$= \frac{P\phi}{(N/60)} = \frac{P\phi}{60/N}$

$= \frac{P\phi N}{60}$

No. of conductors / parallel path $= \frac{Z}{A}$

$\therefore$ generated emf (E_g) = (E_g / per conductor) $\times$ (No. of conductors / Parallel Path)

$$\boxed{E_g = \frac{P\phi Z N}{60A}}$$