EEE1241 | 06.01.2019

Course Title: Basic Electrical Engineering
Course Teacher: Ayman Uddin Mahin.

Total Que: 8
Have to answer: 6

Voltage: Potential difference between points at a circuit is known as voltage.

If a total of 1 joule (J) of energy is used to move a charge at 1 Coloumb (C), Here is a difference at 1 volt (V) between the two points.

Current: The rate at charge flow is known as current.

$$I = \frac{dQ}{dt} \quad \text{or,} \quad I = \frac{Q}{t}$$

Unit: Ampere (A)

Power: Power is the energy per unit at time.

$$\text{power} = \frac{\text{energy}}{\text{time}}$$

$$\text{power} = \text{voltage} \times \text{current}$$

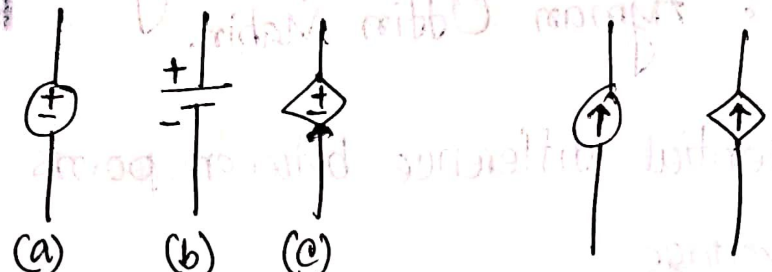
$$\Rightarrow P = VI$$

Unit: Js^{-1} or Watt (W).

Direct Current: DC is the unidirectional current of constant magnitude.

$\Diamond$ = Dependent source
others shape = independent

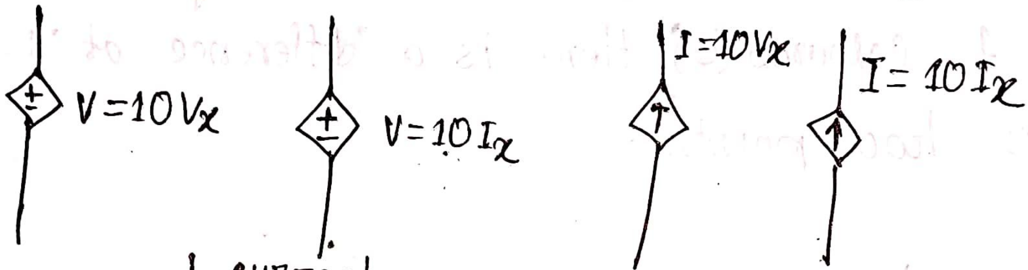
Sources:



(a) (b) (c) (d) (e)

Voltage source
(voltage constant)

Current source.
(current constant)



voltage controlled voltage source | current controlled v. source

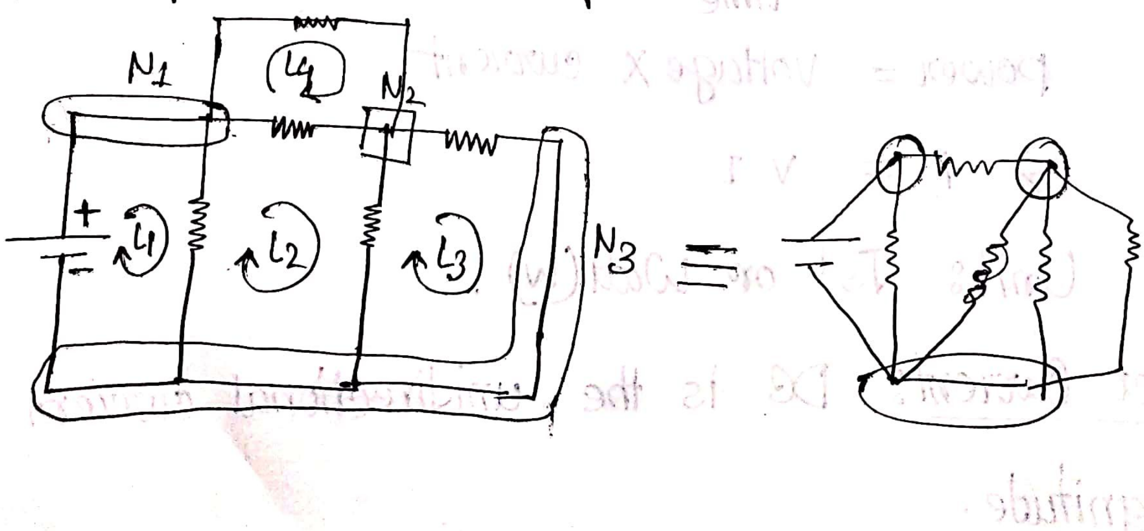
Voltage Controlled current source

current controlled current source

N.B: a, b, d $\rightarrow$ independent
c, e $\rightarrow$ dependent

Node: Node is a junction of a circuit, where two or more circuit elements are together.

Loop: Loop is a closed path



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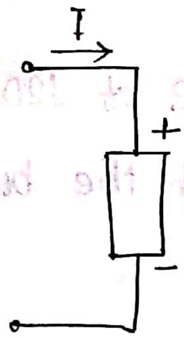
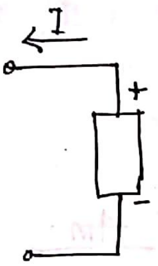
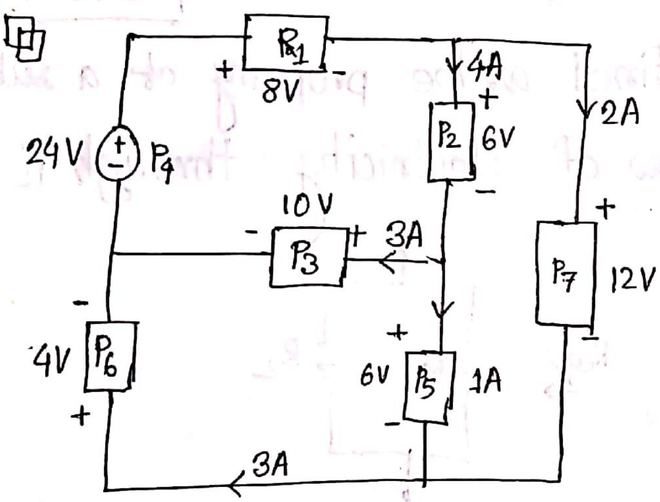
Power



Power absorbed by an element,
$P = VI$



Power absorbed by an element,
$P = -VI$



$P_1 = 6 \times 8 = 48W$

$P_2 = 6 \times 4 = 24W$

$P_3 = 10 \times 3 = 30W$

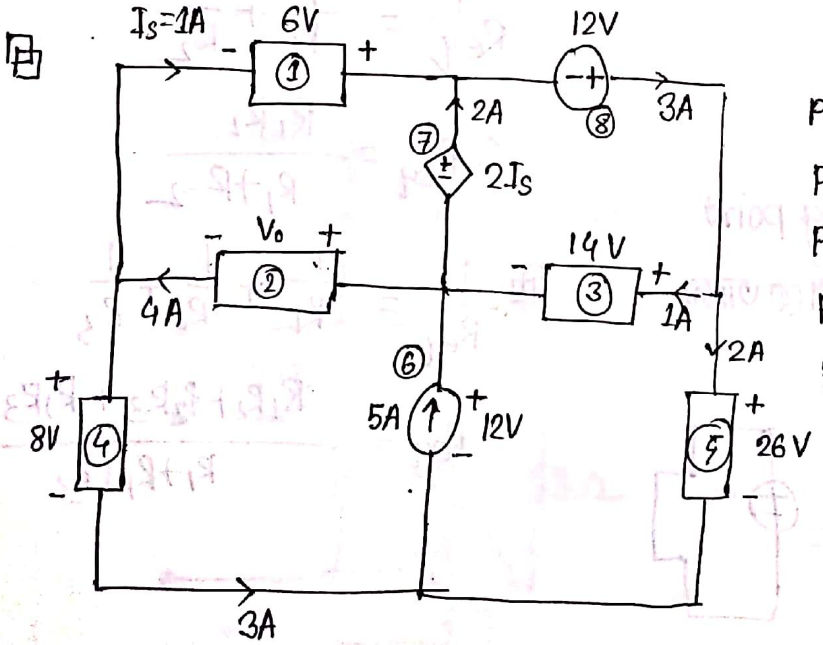
$P_4 = -6 \times 24 = -144W$

$P_5 = 6 \times 1 = 6W$

$P_6 = 4 \times 3 = 12W$

$P_7 = 12 \times 2 = 24W$

* $\boxed{\text{1 Que}}$
$\boxed{\text{Marks } 18 = \cancel{8}6}$



$P_1 = -6 \times 1 = 6W$

$P_2 = V_o \times 4$

$P_3 = 14 \times 1 = 14W$

$P_4 = 8 \times 3 = 24W$

$P_5 = 2 \times 26 = 52W$

$P_6 = -12 \times 5 = -60W$

$P_7 = -(2 \times 1) \times 2 = -4W$

$P_8 = -12 \times 3 = -36W$

Now, $-6 + 4V_o + 14 + 24 + 52 - 60 - 4 - 36 = 0$

$\Rightarrow V_o = \cancel{16}\ 4$ Volt.

~~$-6+4V_0+14+24+52$~~

A bulb consumes 75W at a rated voltage of 120 V. Find the current through the bulb and resistance of the bulb.

Here,

$P = 75\,W$

$V = 120$

$$I = \frac{P}{V} = \frac{75}{120} = 0.625\ A$$

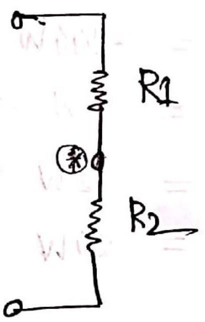
Ans.

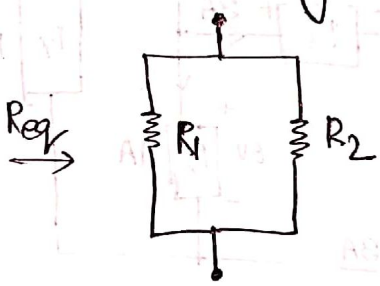
$$R = \frac{V}{I} = \frac{120}{0.625} = 192\ \Omega$$

Ans.

13.01.19

Resistance: Resistence is defined as the property of a substance due to which it opposes flow of electricity through it.





$$R_{eq} = R_1 + R_2$$

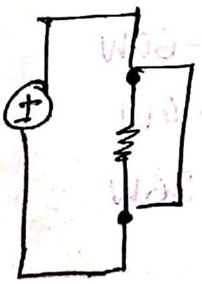
$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\therefore R_{eq} = \frac{R_1 R_2}{R_1 + R_2}$$

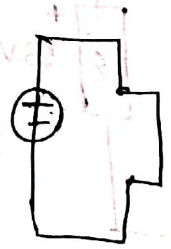
$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

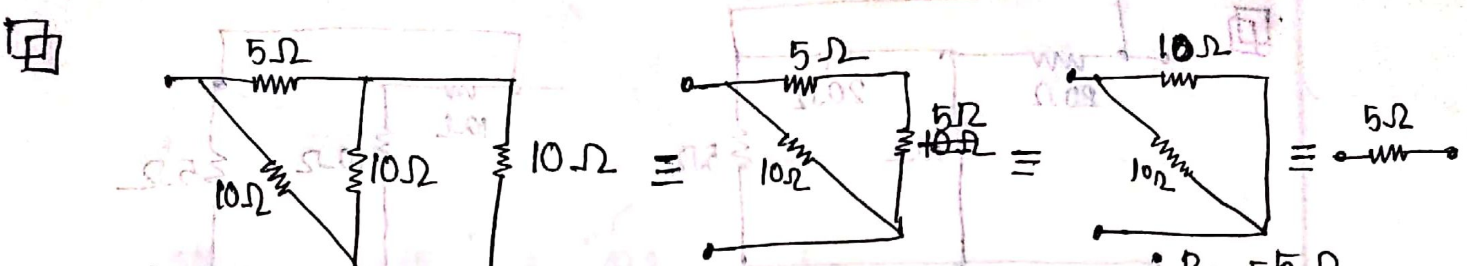
$$\therefore R_{eq} = \frac{R_1R_2 + R_2R_3 + R_1R_3}{R_1 + R_1 + R_3}.$$

যদি ~~connectio~~ connecting point থেকে কোন wire/Resistor থাকে তাহলে সেটা series থাকবে না



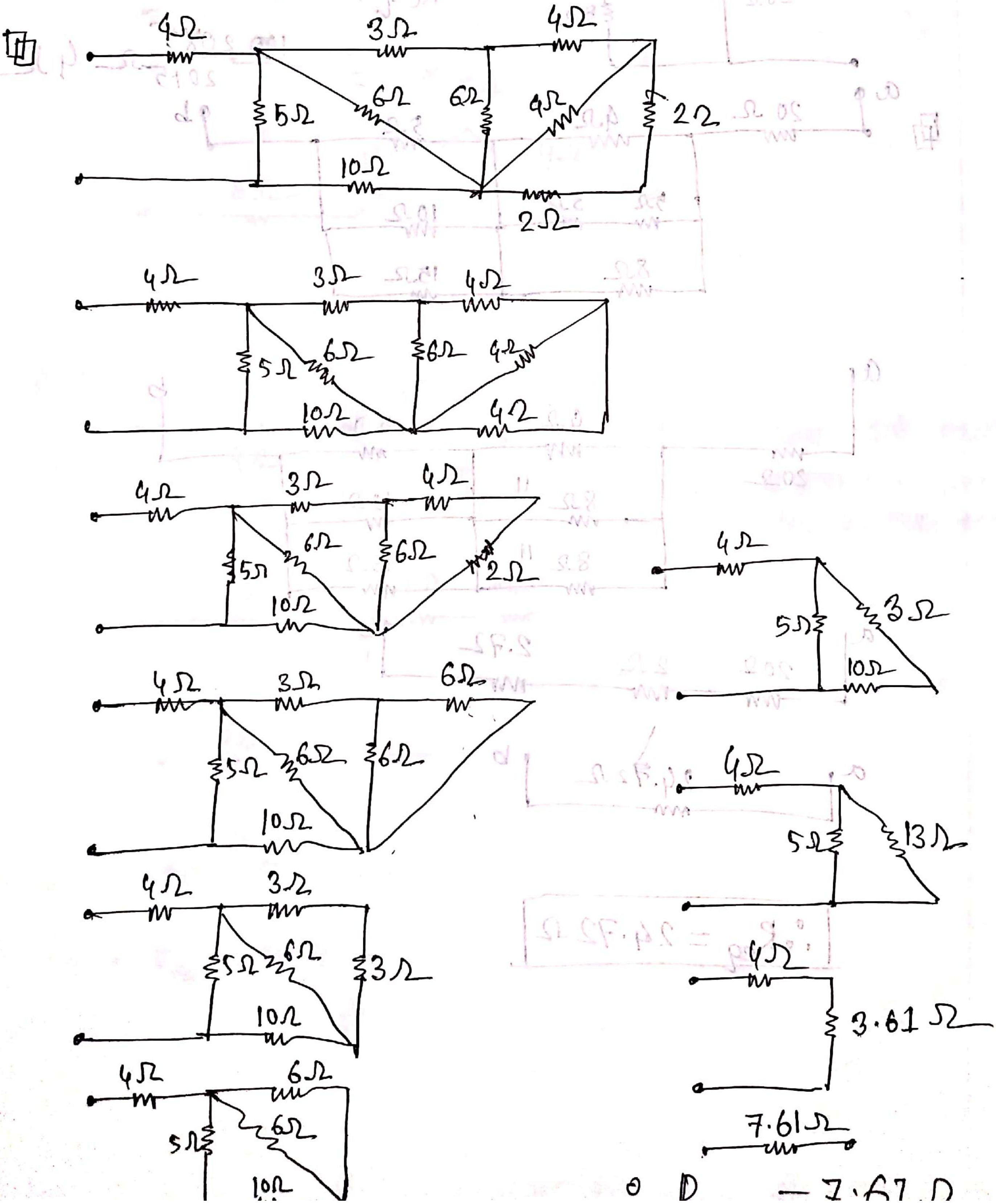
short resistor =

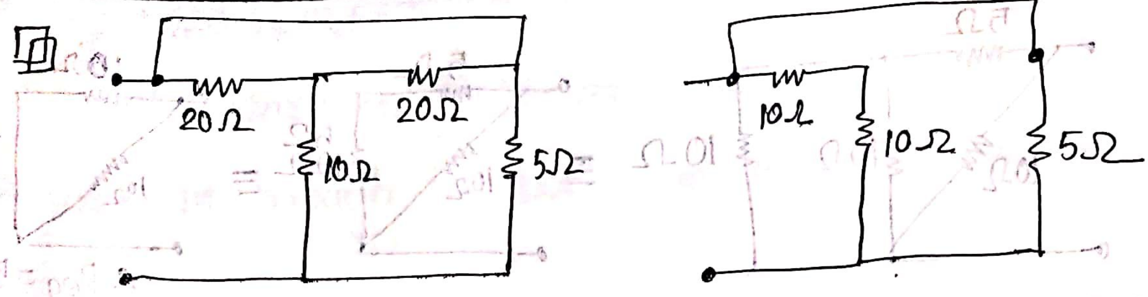


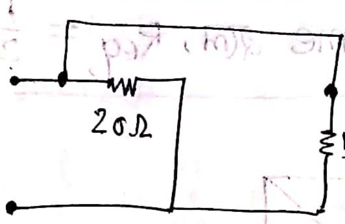


∴ $R_{eq} = 5\,\Omega$.

দুটি parallel resistor এর value same হলে, $R_{eq} = \frac{1}{2}$ (one resistor).

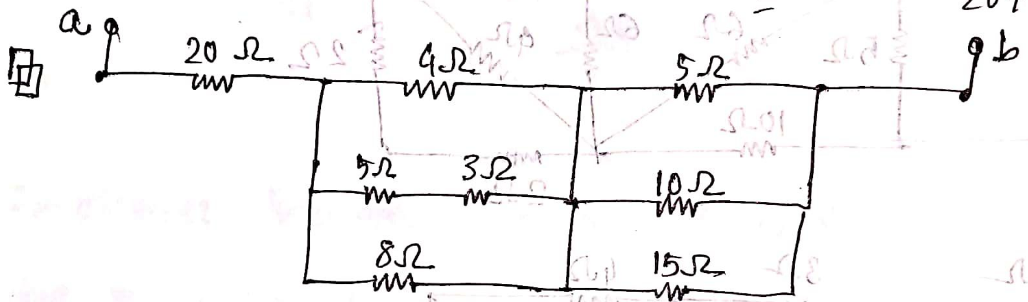


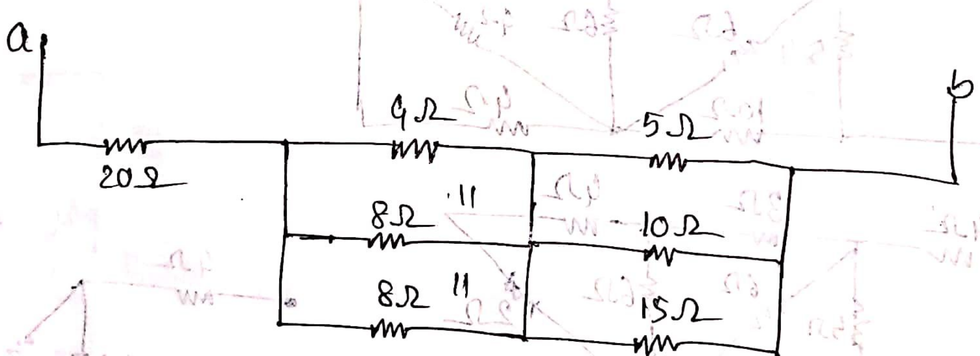


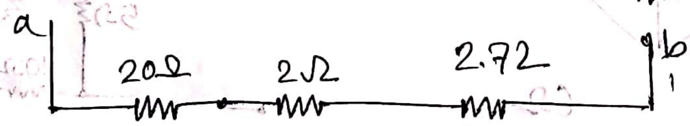


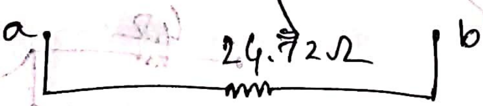
$$Req = 20 \parallel 5\ \Omega$$

$$= \frac{20 \times 5}{20+5}\ \Omega = 4\ \Omega$$

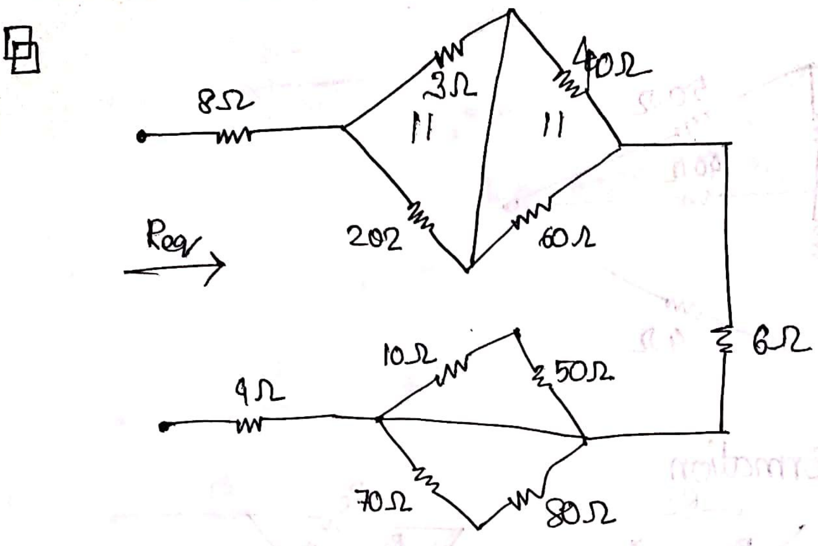


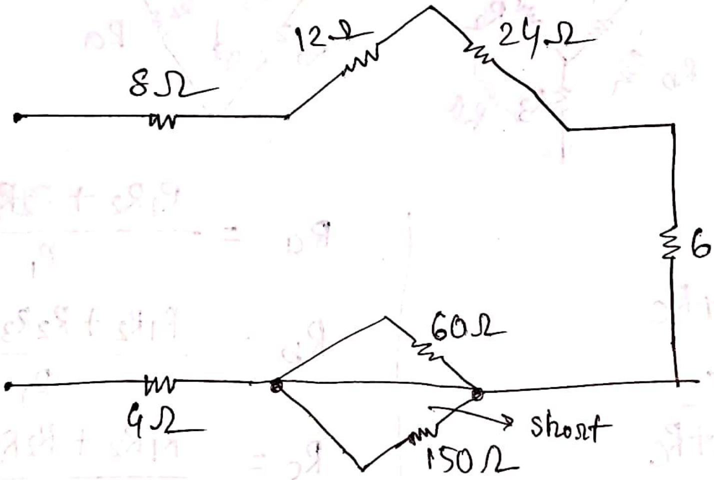




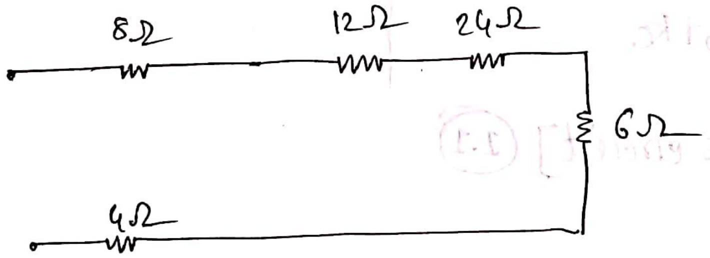


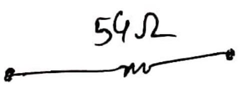
$$\boxed{\therefore R_{eq} = 24.72\,\Omega}$$





Short: একটি resistor এর দুই প্রান্তে wire connected থাকলে short হয়, তখন resistence 0.

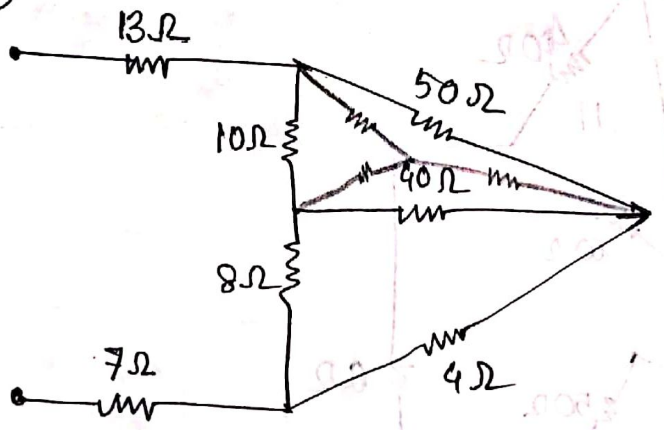




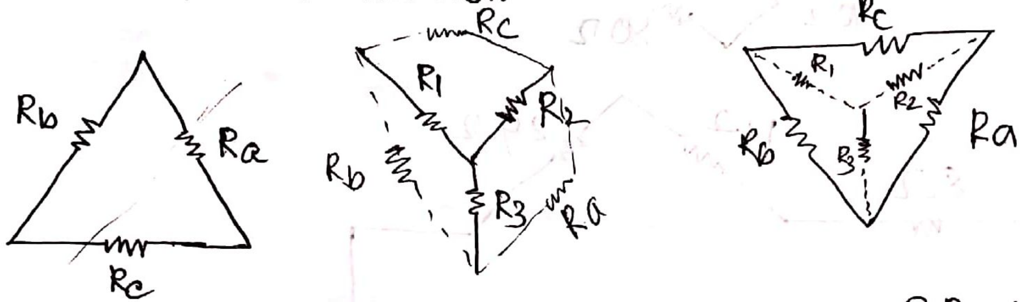
$\therefore R_{eq} = 54\Omega$

A

□ (1.1)



□ Y−Δ−Y tranformation



$$R_1 = \frac{R_b R_c}{R_a + R_b + R_c}$$

$$R_2 = \frac{R_a R_c}{R_a + R_b + R_c}$$

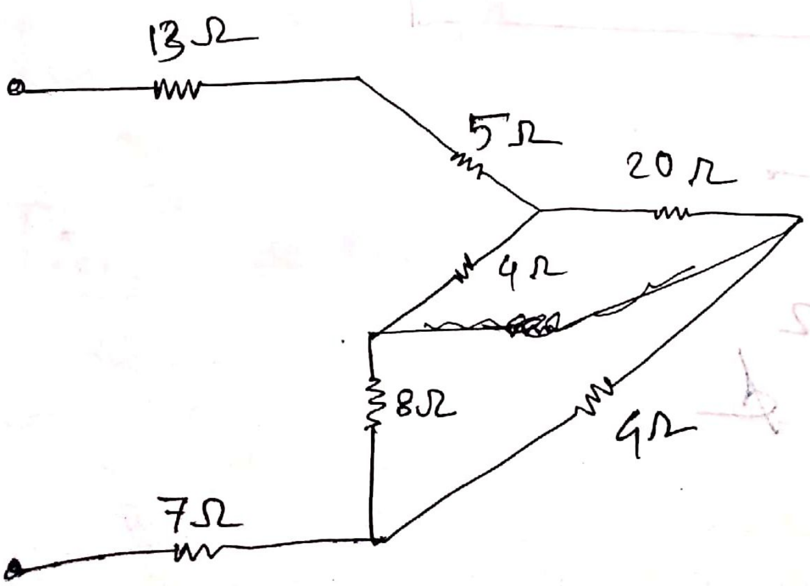
$$R_3 = \frac{R_a R_b}{R_a + R_b + R_c}$$

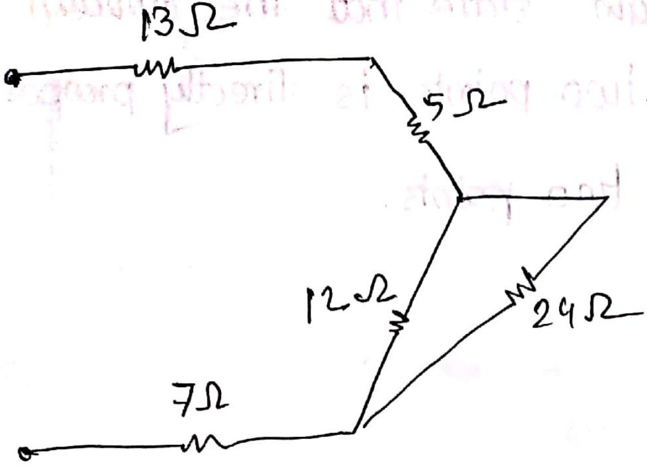
$$R_a = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_1}$$

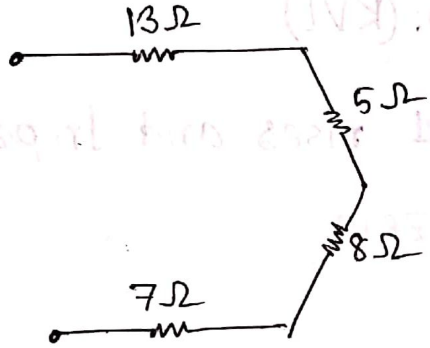
$$R_b = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_2}$$

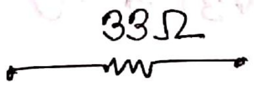
$$R_c = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_3}$$

⊛ Solve [previous circuit] (1.1)

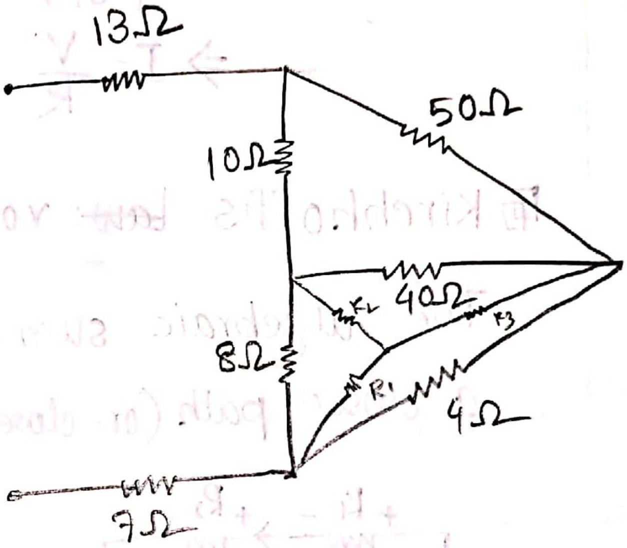


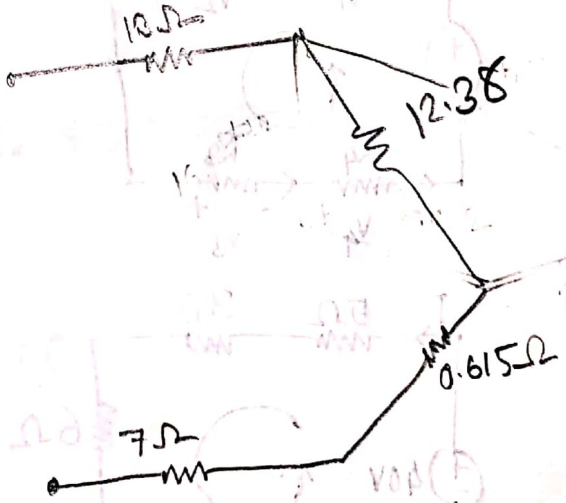






$\boxed{\therefore R_{eq} = 33\Omega}$





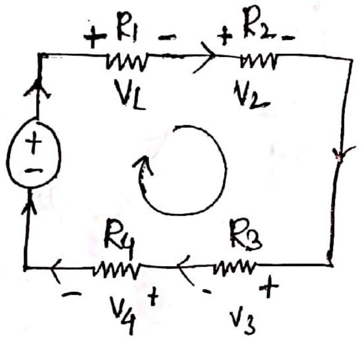
$R_{eq} = 33\Omega$

Ohm's Law: Ohm's Law state that the current through a conductor between two points is directly proportional to the voltage across the two points.

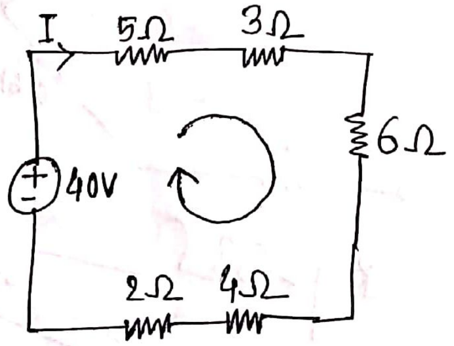
$$I \propto V$$
$$\Rightarrow I = \frac{V}{R}$$

Kirchhoff's ~~Law~~: voltage law: (KVL)

The algebraic sum of potential rises and drops around a closed path (or closed loop) is zero.

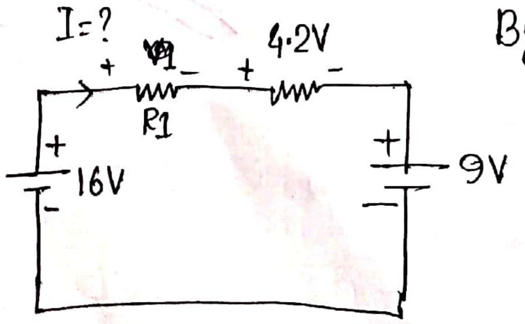


$$-E + V_1 + V_2 + V_3 + V_4 = 0$$



$$-40 + (5\times I) + (3\times I) + (6\times I) + (4\times I) + (2\times I) = 0$$
$$\Rightarrow -40 + I \times 20 = 0$$
$$\Rightarrow I = 2\text{ A}$$

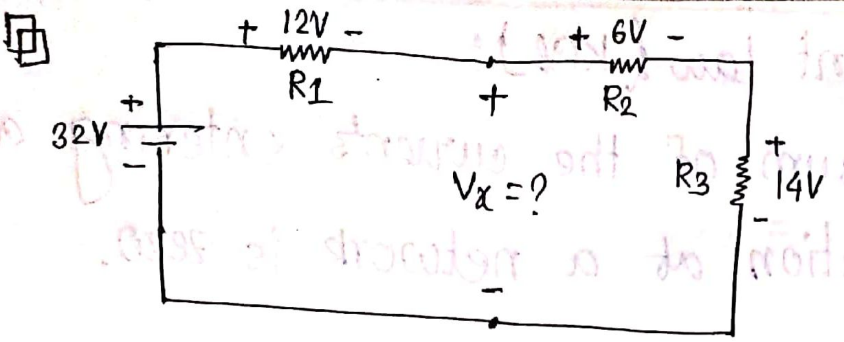
Am



By applying (KVL),

$$-16 + V_1 + 4.2 + 9V = 0$$
$$\Rightarrow V_1 = 2.8\text{ V}$$

A

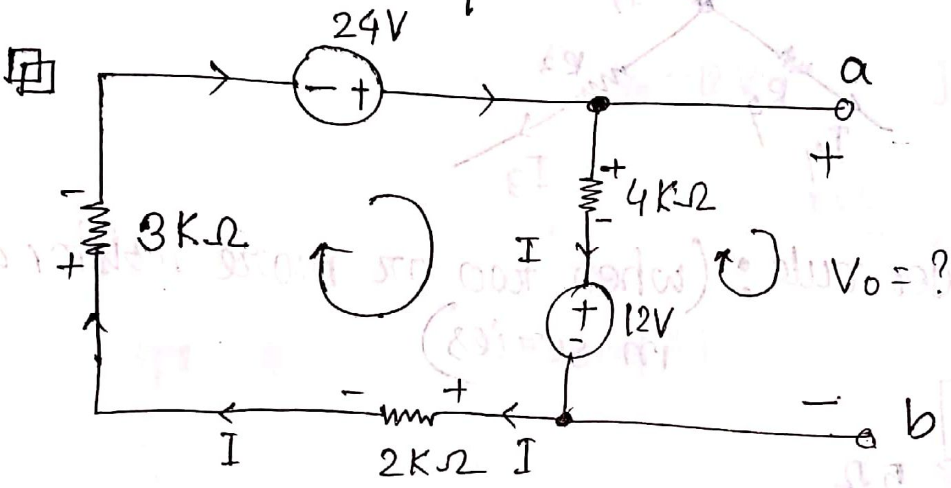


$V_x - 32 + 12 = 0$

$\Rightarrow V_x = 20\text{ V}$

$-V_x + 6 + 14 = 0$

$\therefore V_x = 20\text{V}$



$V_{ab} = ? \equiv V_0 = ?$

[* V_{ba} হলে b(+) & a(-)]

$(3\times10^3)\times I - 24 + (4\times10^3)I - 12 + (2\times10^3)I = 0$

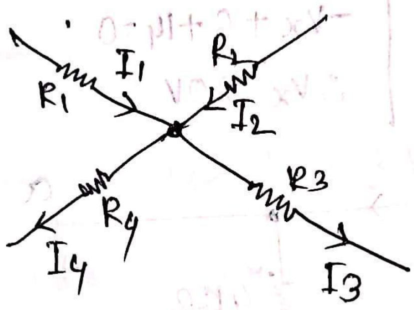
$\Rightarrow \quad I = 4\times10^{-3}\text{ A}$

$12 - (4\times10^3)\times(4\times10^{-3}) + V_0 = 0$

$\Rightarrow V_0 = 4\text{ V.}$ A

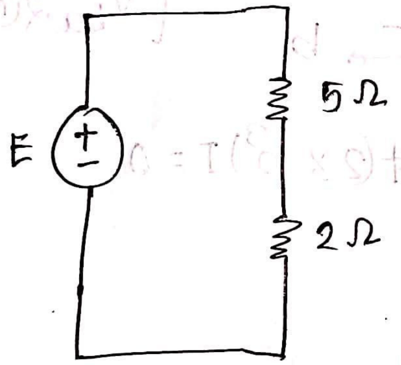
Kirchhoff's Current Law (KCL):

The algebraic sum of the currents entering and leaving a junction at a network is zero.



$I_1 + I_2 - I_3 - I_4 = 0$

Voltage divider rule: (when two or more resistor are in series)



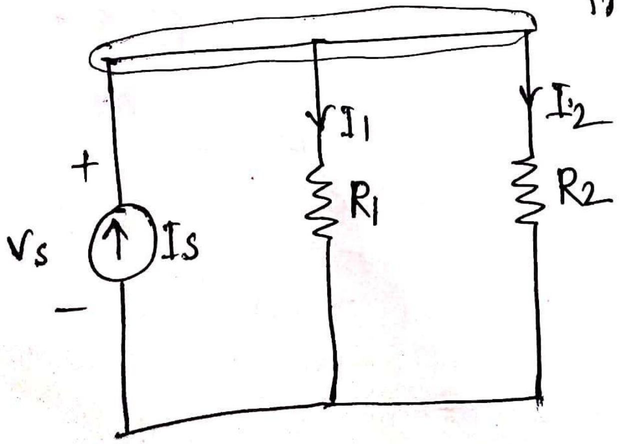
$R_T = R_1 + R_2$

$I = \frac{E}{R_T}$

$V_1 = IR_1 = \frac{E}{R_T} R_1 = \frac{R_1}{R_1+R_2} E$

$V_2 = IR_2 = \frac{R_2}{R_1+R_2} E$

Current Divider Rule: (when two or more resistor are in parallel)



$I_s - I_1 - I_2 = 0$

$\Rightarrow I_s = I_1 + I_2$

$\Rightarrow I_s = \frac{V}{R_1} + \frac{V}{R_L}$

$\Rightarrow I_s = V\left(\frac{R_1+R_2}{R_1 R_2}\right)$

$\therefore V = \frac{R_1 R_2}{\ldots} \times I_s$

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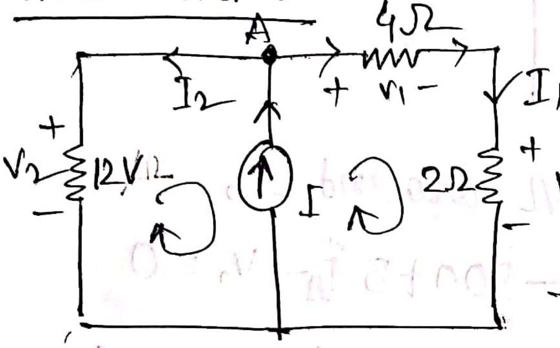
$$I_1 = \frac{V}{R_1}\left(\frac{R_1R_2}{R_1+R_2}\right) \times I_s \qquad I_2 = \frac{V}{R_2} = \left(\frac{1}{R_2} \times \frac{R_1R_2}{R_1+R_2}\right) I_s$$

$$\therefore I_1 = \frac{R_2}{R_1+R_2} I_s \qquad \therefore I_2 = \frac{R_1}{R_1+R_2} I_s$$

KVL & KCL:



$I = ?$

KVL $-V + V_1 + V_0 = 0$

$\Rightarrow V = V_1 + V_0$

$= 24 + 12 = 36V$

$12 ~~+ IR_1~~ \qquad ~~IR_1 + 4 \times I~~$

$I_1 = \frac{12}{2} = 6A$

$V_1 = 4 \times I_1 = 4 \times 6 = 24V$

$> V_2 = V = 36V$

$\therefore I_2 = \frac{V_2}{R_2} = \frac{36}{12} = 3A$

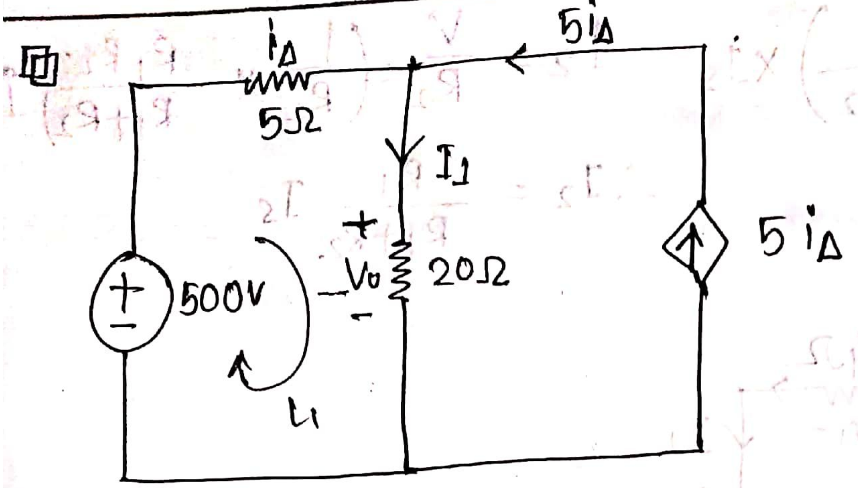
KCL at node A,

$I - I_1 - I_2 = 0$

$\Rightarrow I = I_1 + I_2$

$= (6+3)A$

$= 9A.$



$V_0 = ?$

$i_\Delta + 5i_\Delta - I_0 = 0$

$\Rightarrow I_0 = 6i_\Delta$

$\therefore I_0 = (6 \times \cancel{5}\,4)\text{ A}$

$= \cancel{20\text{ A}}\ 24\text{A}$

KVL around L_1,

$-500 + 5i_\Delta + V_0 = 0$

$\Rightarrow -500 + 5i_\Delta + 20I_0 = 0$

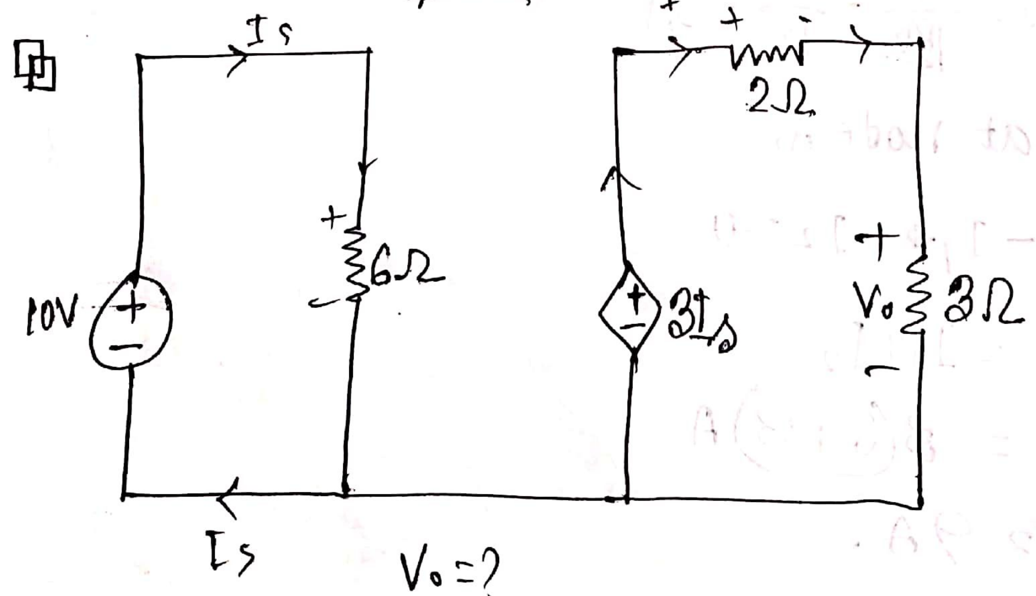
$\Rightarrow -500 + 5i_\Delta + 120i_\Delta = 0 \quad [\because I_0 = 6i_\Delta]$

$\Rightarrow i_\Delta = \cancel{5A}\ 4\text{A}$

$V_0 = 20 \times I_0$

$= (20 \times 24)\text{ V}$

$= 480\text{V}.$ A



$V_0 = ?$

$-10 + 6I_s = 0$

$\Rightarrow I_s = \frac{10}{6} = 1.67\text{ A}$

$-(3\times 1.67) + 2I + 3I = 0$

$\Rightarrow I = \frac{3\times 1.67}{5}$

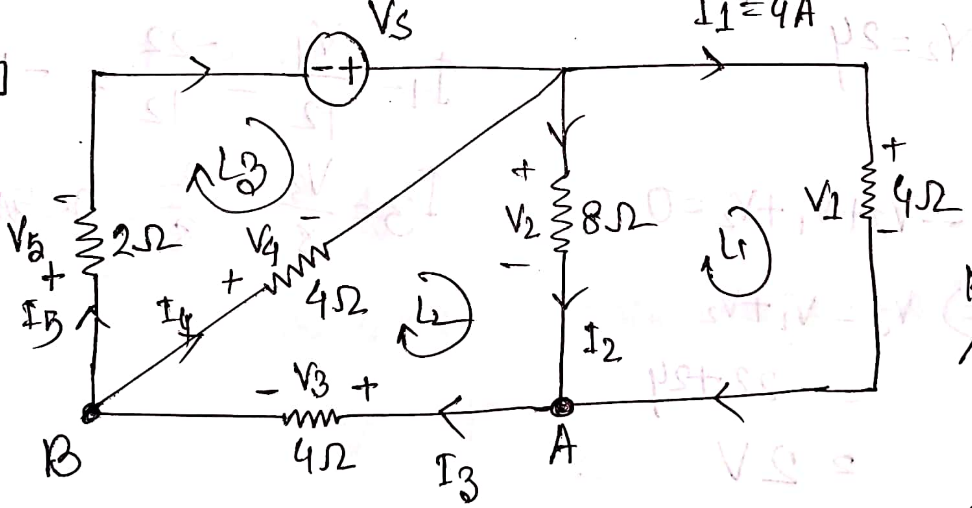
$= 1\text{A}$ A

$V_0 = I\times 3$

$= 3\times 1$

$= 3\text{V}$ A

*//



$V_S = ?$

KVL at loop 3,

$32 - V_S + 40 = 0$

$V_S = 72\text{ V}$ A

$V_1 = 4\times 4 = 16\text{ V}$

$-V_2 + V_1 = 0$

$\Rightarrow V_2 = 16\text{ V}$

$I_2 = \frac{V_2}{8} = \frac{16}{8} = 2\text{A}$

KCL at node A,

$I_1 + I_2 - I_3 = 0$

$\Rightarrow I_3 = 4+2 = 6\text{A}$

$V_3 = I_3\times 4$

$= 6\times 4$

$= 24\text{V}$

KVL at L_2,

$V_3 + V_4 + V_2 = 0$

$\Rightarrow V_4 = -(V_3 + V_2)$

$= -40\text{V}$

$I_4 = \frac{V_4}{4} = -10$

$V_5 = I_5 \times 2$

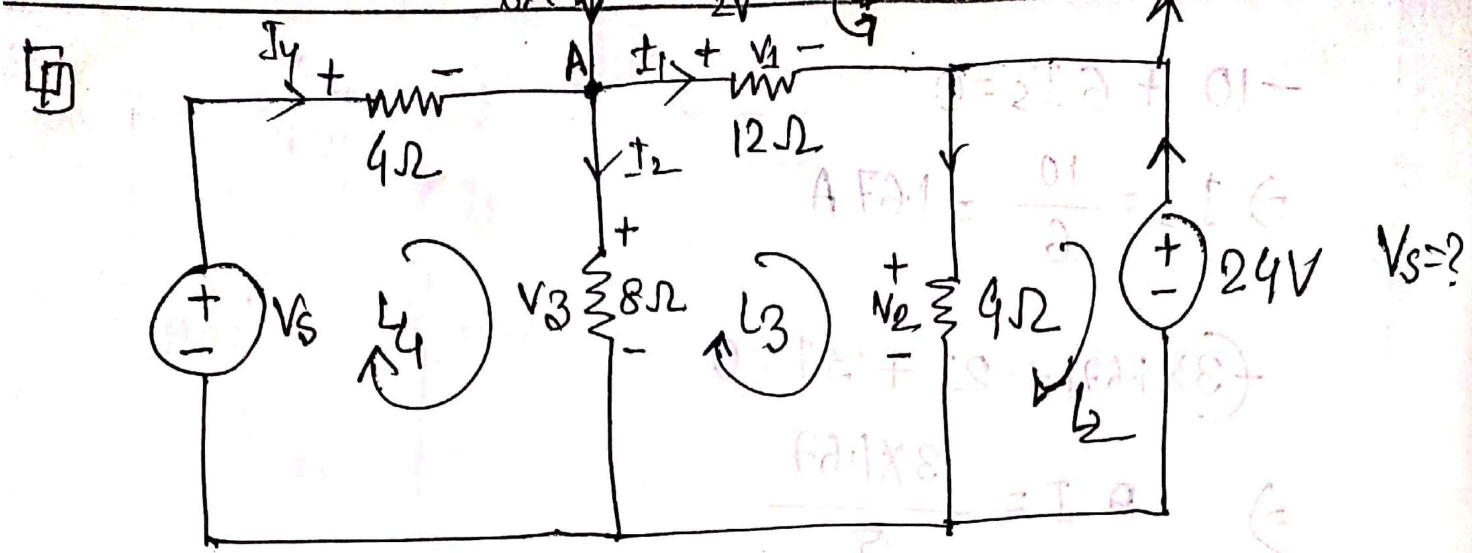
$= 16\times 2$

$= 32\text{ V}$

KCL at node B,

~~$I_3 = I_4 + I_5$~~ $I_5 = I_3 - I_4$

$\Rightarrow I_5 = 16\text{A}$



In L_1,

$$V_1 + (4\times6) - 2 = 0$$

$$\Rightarrow V_1 = -22V$$

In L_2,

$$-V_2 + 24 = 0$$

$$\Rightarrow V_2 = 24$$

In L_3,

$$-V_3 + V_1 + V_2 = 0$$

$$\Rightarrow V_3 = V_1 + V_2$$

$$= -22 + 24$$

$$= 2V$$

$$I_1 = \frac{V_1}{12} = \frac{-22}{12} = -1.83A$$

$$I_3 = \frac{V_3}{8} = \frac{2}{8} = 0.25A$$

at Node A;

$$I_1 + I_3 = 6 + I_4$$

$$I_4 = (-1.83 + 0.25) - 6$$

$$\therefore I_4 = -7.58A$$

In L_4,

$$-V_S + V_4 + V_3 = 0$$

$$\Rightarrow V_s = V_4 + V_3 = (4 \times I_4) + 2 = -32.32V.$$

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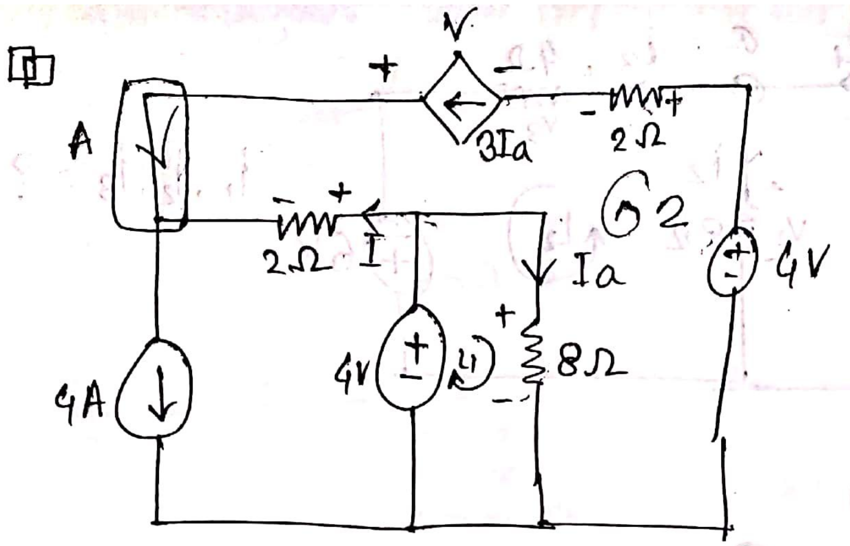


I = ?

V = ?

$8I_a - 4 + 8I_a$

$14 I_a = 4$

$I_a = \frac{4}{14}$

In L1,

$$-4 + 8I_a = 0$$

$$\Rightarrow I_a = 0.5A$$

In node A, (KCL+

$$I + 3I_a - 4 = 0$$

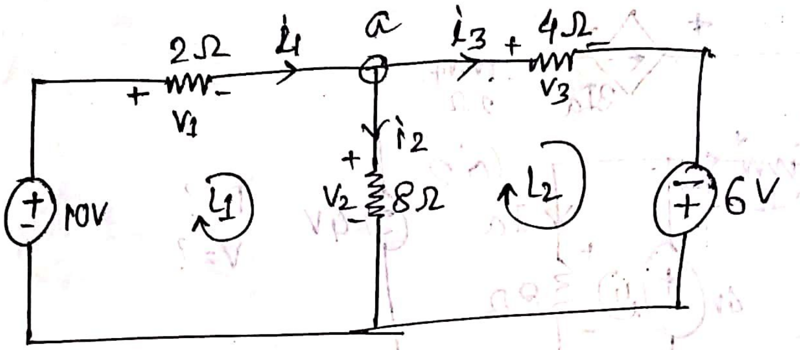
$$\Rightarrow I = 4 - (3 \times 0.5)$$

$$= 2.5A \quad \underline{A}$$

In loop 2 KVL,

$$2I + V - (2 \times 3I_a) + 4 - (8 \times I_a) = 0$$

$$\Rightarrow V = -2V \quad \underline{A}$$



$i_1, i_2, i_3 = ?$

L_1, $-10 + V_1 + V_2 = 0$

$\Rightarrow V_1 = 10 - V_2$ —— (I)

L_2, $-V_2 + V_3 - 6 = 0$

$\Rightarrow V_3 = V_2 + 6$ —— (II)

KCL at a,

$i_1 - i_2 - i_3 = 0$

$\Rightarrow \frac{V_1}{2} - \frac{V_2}{8} - \frac{V_3}{4} = 0$

$\Rightarrow \frac{10 - V_2}{2} - \frac{V_2}{8} - \frac{V_2 + 6}{4} = 0$

$\Rightarrow$ ~~——~~ $V_2 = 4V$

V_2 এর value (I) ও (II) এ বসাই,

$V_1 = 6V$
$V_3 = 10V$

$\therefore i_1 = \frac{V_1}{2} = 3A$

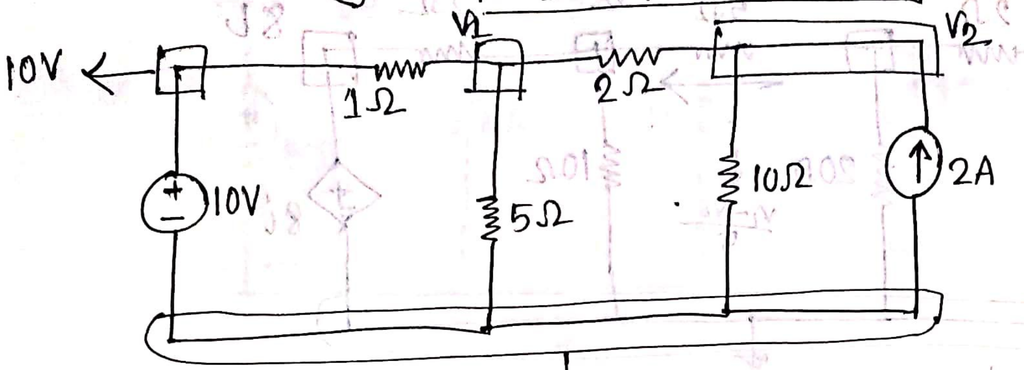
$i_2 = V = 0.5A$

$i_3 = V = 2.5A$

Quiz-01 [Equivalent Resistance KVL & KCL
Next Monday (28.01.19)]

27.01.19

Nodal Analysis: $\boxed{\text{Very important topic}}$



reference node (যেখানে maximum num element connected)
Voltage (0V)

For V_1,

$$\frac{V_1-10}{1}+\frac{V_1-V_2}{2}+\frac{V_1-0}{5}=0$$

$$\Rightarrow V_1\left(1+\frac{1}{2}+\frac{1}{5}\right)+V_2\left(-\frac{1}{2}\right)-\frac{10}{1}=0$$

$$\Rightarrow 1.7V_1-0.5V_2=10 \quad \text{--- (1)}$$

For V_2,

direction opposite

$$\frac{V_2-V_1}{2}+\frac{V_2-0}{10}-2A=0$$

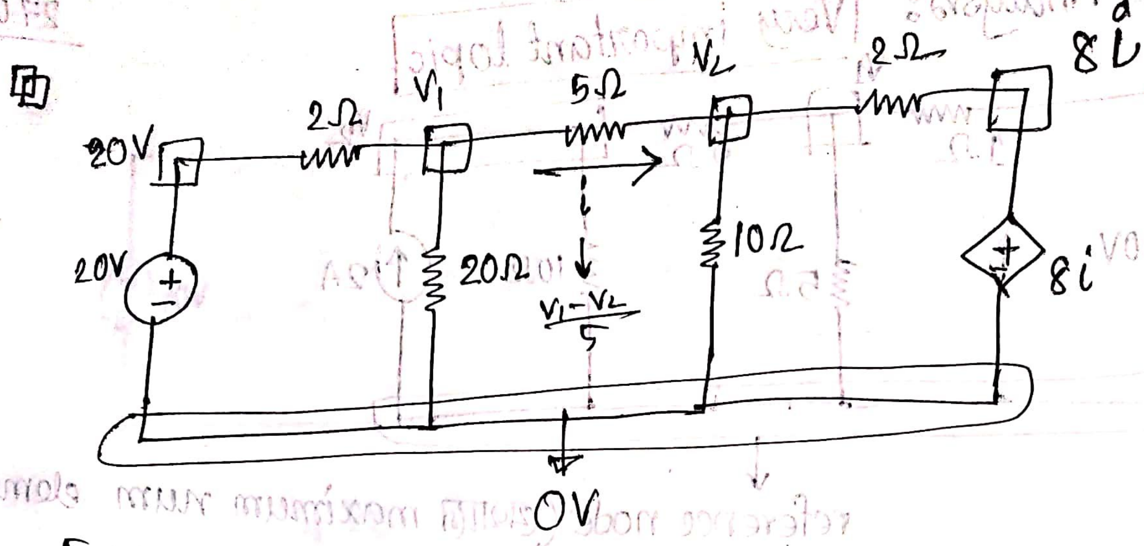
$$\Rightarrow V_2\left(\frac{1}{2}+\frac{1}{10}\right)+V_1\left(-\frac{1}{2}\right)=2$$

$$\Rightarrow -0.5V_1+0.6V_2=2 \quad \text{--- (11)}$$

Solving (1) and (2),

$V_1 = 9.09V$

$V_2 = 10.9V.$



For V_1,

$$\frac{V_1-20}{2} + \frac{V_1-200}{20} + \frac{V_1-V_2}{5} = 0$$

$$\Rightarrow V_1\left(\frac{1}{2}+\frac{1}{20}+\frac{1}{5}\right) - \frac{1}{5}V_2 - 10 = 0$$

$$\Rightarrow 0.75\,V_1 - 0.2V_2 = 10 = 0 \text{ —— (I)}$$

For V_2,

$$\frac{V_2-V_1}{5} + \frac{V_2-0}{10} + \frac{V_2-8i}{2} = 0$$

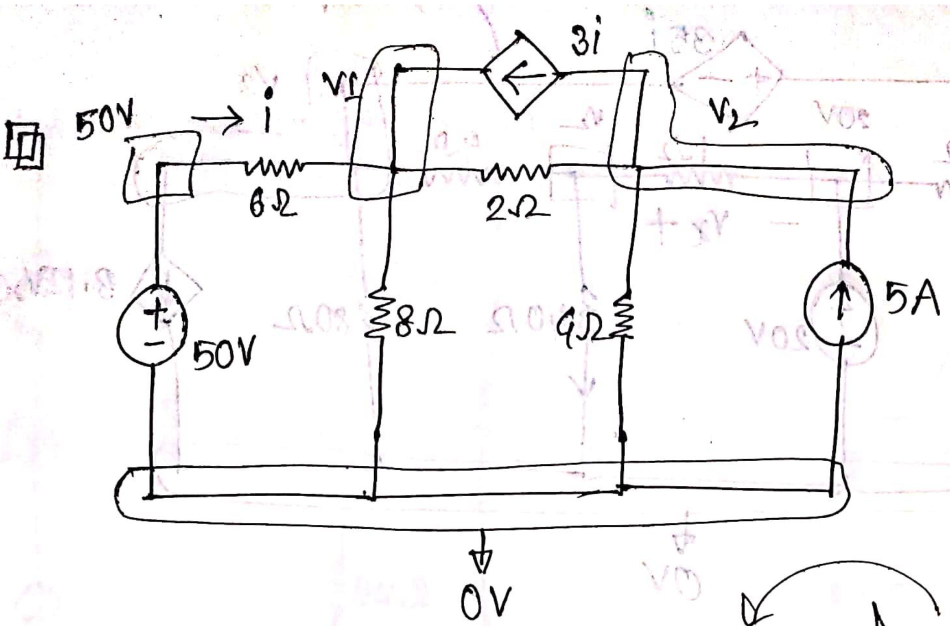
$$i = \frac{V_1-V_2}{5}$$

$$\Rightarrow -V_1 + 1.6\,V_2 = 0 \text{ —— (II)}$$

Solving (I) and (II),

$V_1 = 16\,V$,

$V_2 = 10\,V$. (A



For V_1, $\frac{V_1-50}{6}+\frac{V_1-0}{8}+\frac{V_1-V_2}{2}-3i=0$ | $i=\frac{50-V_1}{6}$

$\Rightarrow 1.29V_1-0.5V_2=33.33$ — (I)

For V_2,

$3i+\frac{V_2-V_1}{2}+\frac{V_2-0}{4}-5=0$

$\Rightarrow -V_1+0.75V_2=-20$ — (II)

By solving (I) and (II),

$V_1 = 32.08V$

$V_2 = 16.1V$

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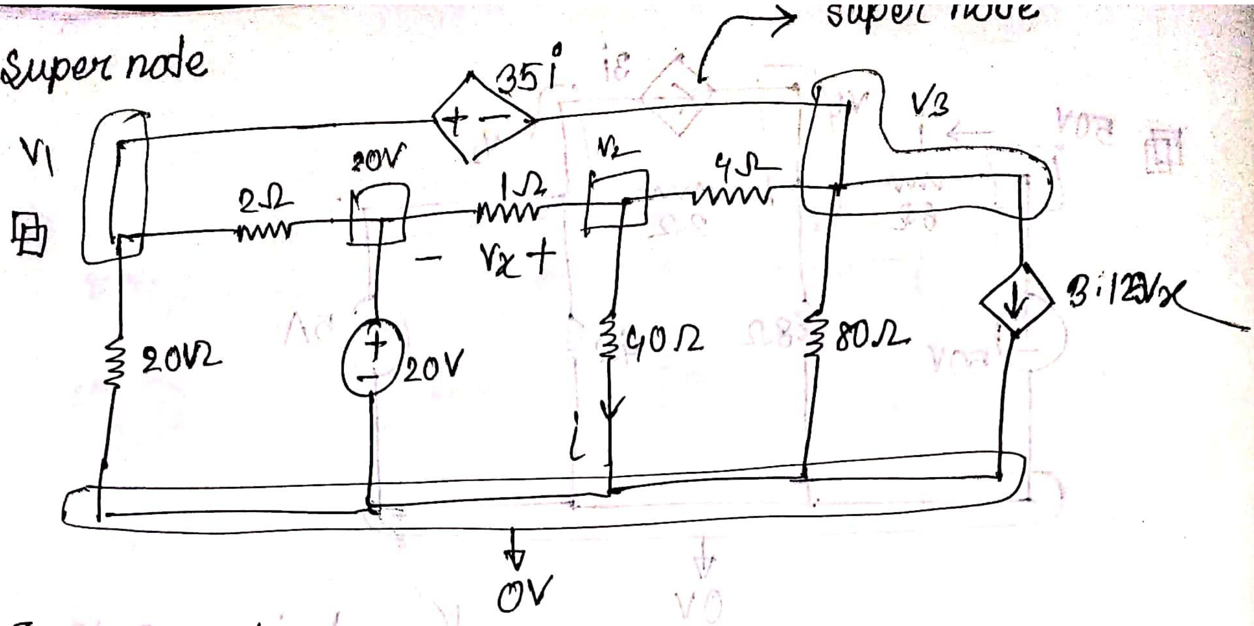
super node



For supernode,

$$\frac{V_1-20}{2}+\frac{V_1-0}{20}+\frac{V_3-V_2}{4}+\frac{V_3-0}{80}+3.125V_x=0$$

$V_x = V_2 - 20$

$\Rightarrow 0.55V_1 + 2.875V_2 + 0.2625V_3 = 72.5$ —— (I)

For V_2,

$$\frac{V_2-20}{1}+\frac{V_2-0}{40}+\frac{V_2-V_3}{4}=0$$

$\Rightarrow 1.275V_2 - 0.25V_3 = 20$ —— (II)

$V_1 - V_3 = 35i$

$i = \frac{V_2-0}{40}$

$\Rightarrow V_1 - 0.875V_2 - V_3 = 0$ —— (III)

By solving (I), (II), (III)

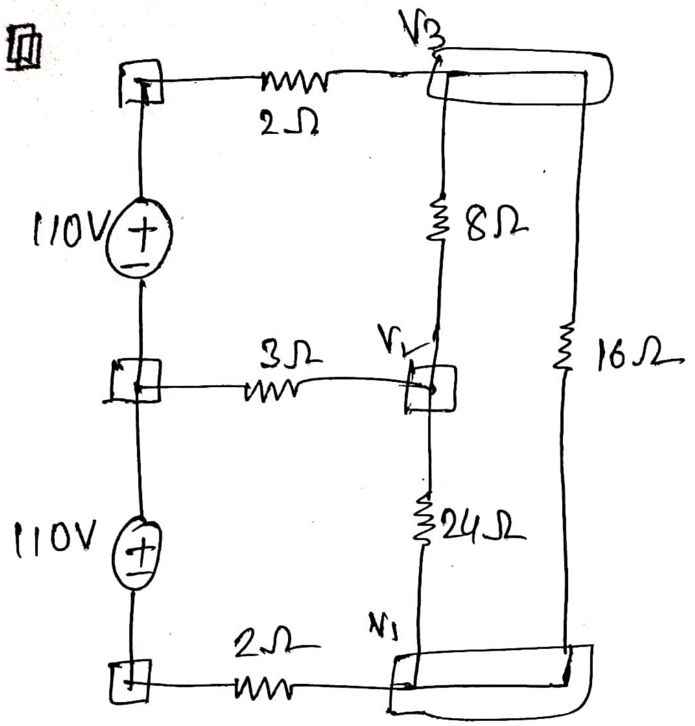
$V_1 = 29.54V$

$V_2 = 18.33V$

$V_3 = 13.5V$

A

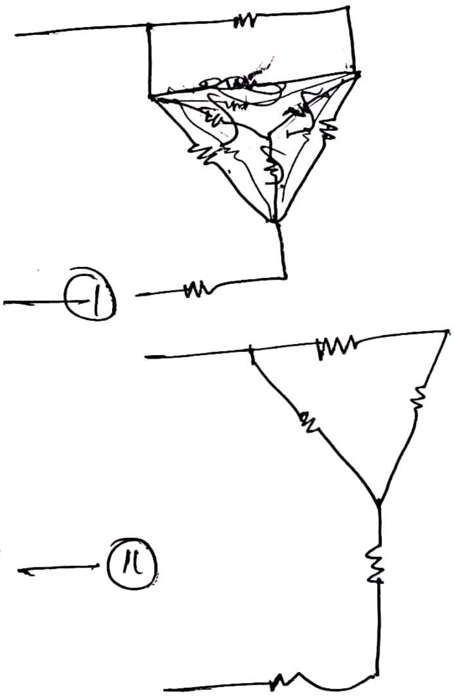
Super node: দুটি node এর মাঝে একটি voltage source দেওয়া থাকলে, but current source থাকলে তা super node হবে না.



A set

I=5.07

Req = 11.025



For, V1, $\frac{V_1}{2} + \frac{V_1 - V_2}{24} + \frac{V_1 - V_3}{16} = 0$

$\Rightarrow 0.604 V_1 - 0.042 V_2 - 0.0625 V_3 = 0$ —— (I)

For, V2, $\frac{V_2 - V_1}{24} + \frac{V_2 - 110}{3} + \frac{V_2 - V_3}{8} = 0$

$\Rightarrow -0.042 V_1 + 0.5 V_2 - 0.125 V_3 = 36.67$ —— (II)

For V3, $\frac{V_3 - 220}{2} + \frac{V_3 - V_2}{8} + \frac{V_3 - V_1}{16} = 0$

$\Rightarrow -0.0625 V_1 - 0.125 V_1 + 0.6875 V_3 = 110$ —— (III)

Solving (I), (II) and (III),

$V_1 = 27.579V$

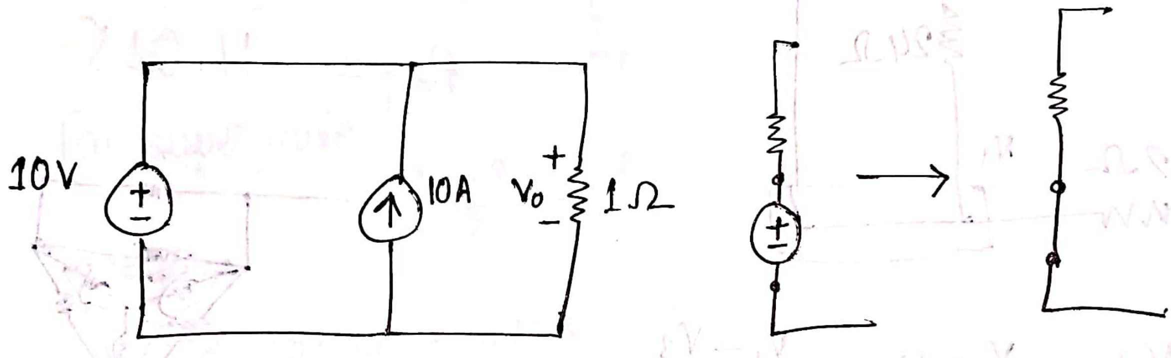
$V_2 = 121.82V$

$V_3 = 184.66V$

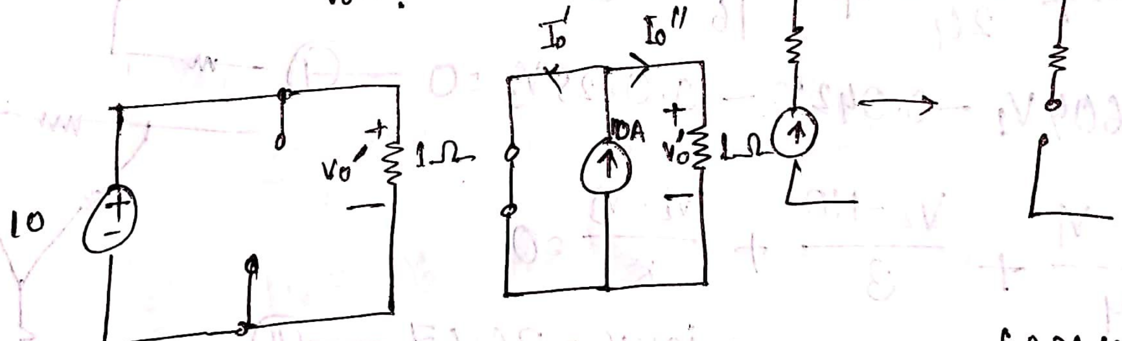
03.02.2019

Super position theorem:

The current through or voltage across any element of a network is equal to the algebraic sum of the currents and voltages produced independently by each source.



$V_o = ?$



$-10 + V_o' = 0$

$\Rightarrow I = \frac{10}{1}$

$= 10A$

$\therefore V_o' = I \times R$

$= 10 \times 1$

$= 10V$

~~$V_o'' = 10 \times 1$~~

~~$= 10V$~~

$\therefore V_o = V_o' + V_o''$

$= 10 + 0$

$= 10V$

$I_o'' = \frac{0 \times 10A}{0+1}$

$= 0A$

$\therefore V_o'' = (0 \times I)$

$= 0$

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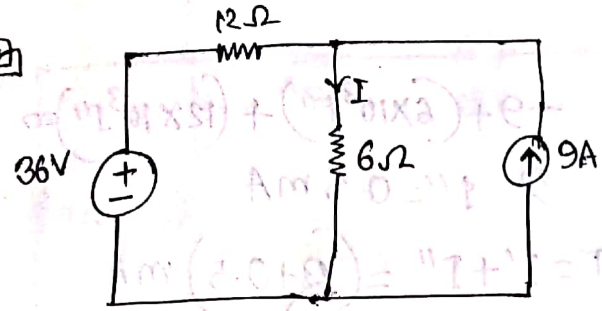
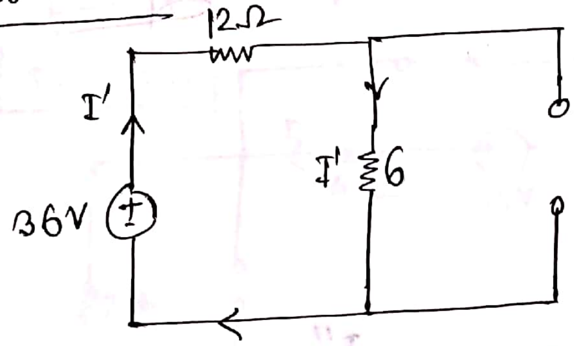
Q

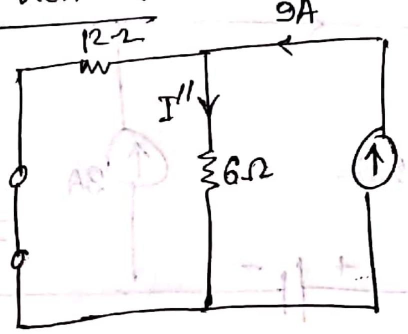


I = ?

36 v active:



9A active:



$$I' = \frac{36}{12+6}$$

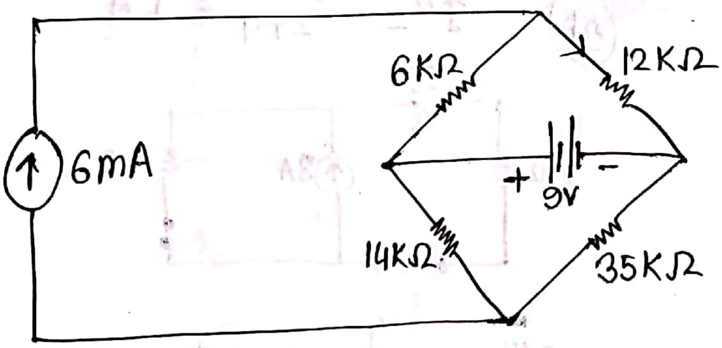
$$= 2A$$

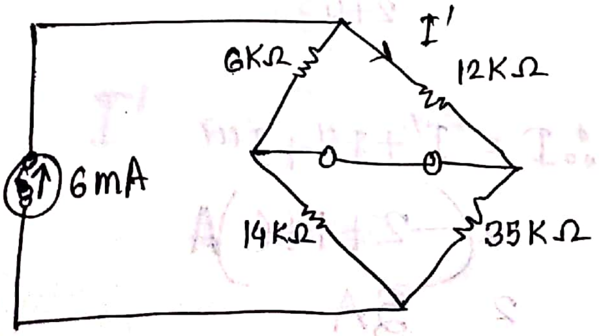
$$I'' = \frac{12}{6+12} \times 9$$

$$= 6A$$

$$\therefore I = I' + I'' = (2+6) = 8A.$$

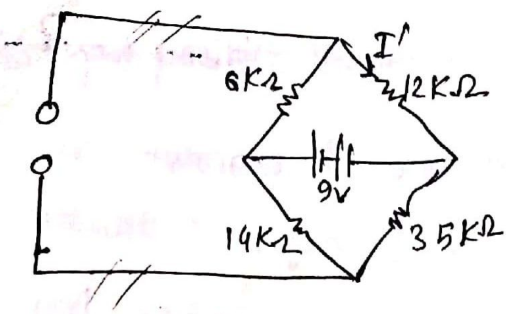
Q





$$I' = \frac{6K\Omega}{(12+6)K\Omega} \times 6mA$$

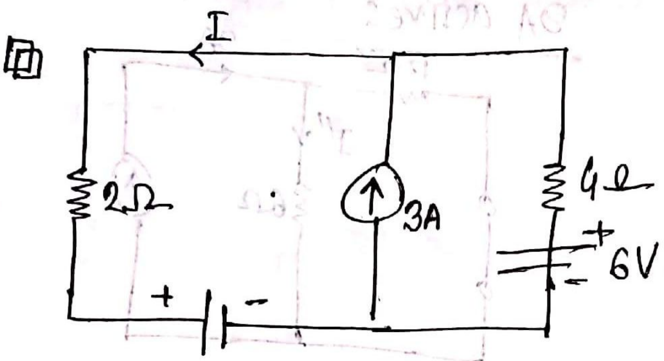
$$= 2mA$$



$$-9+(6\times10^{3} I'')+(12\times10^{3} I'')=0$$

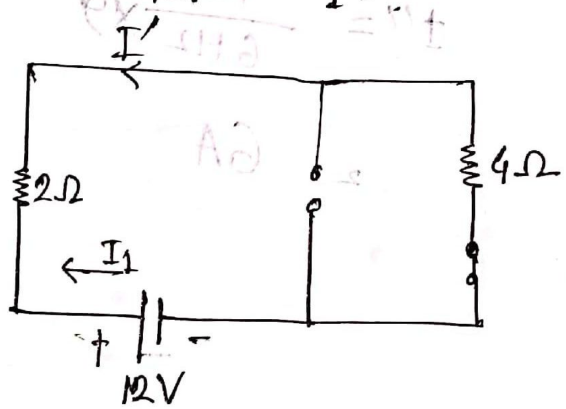
$\Rightarrow I''=0.5\,mA$

$$I=I'+I''=(2+0.5)\,mA$$
$$=2.05\,mA$$



$I=?$

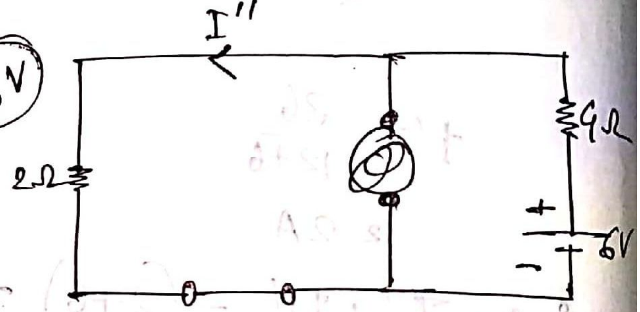
12V



$$I_1=\frac{12}{2+4}\,A$$
$$=2\,A$$

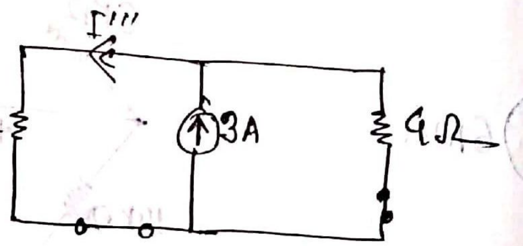
$\therefore I'=-2A$

6V



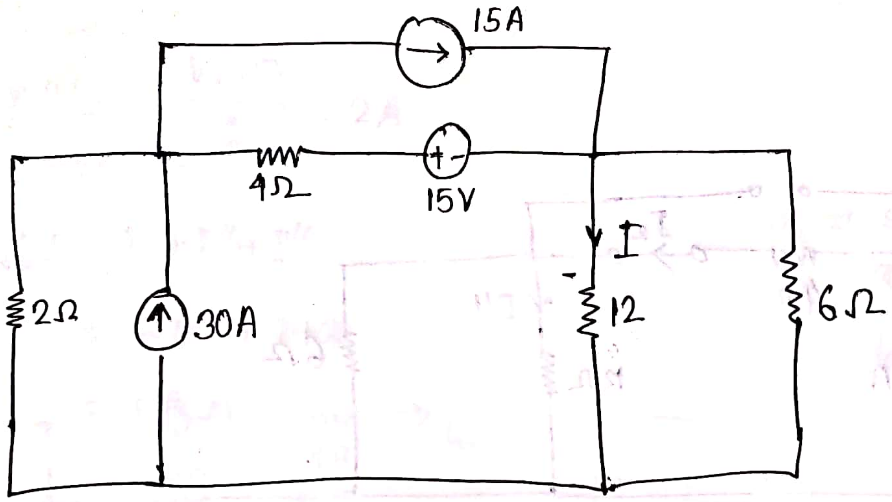
$$I''=\frac{6}{2+4}=1\,A$$

3A



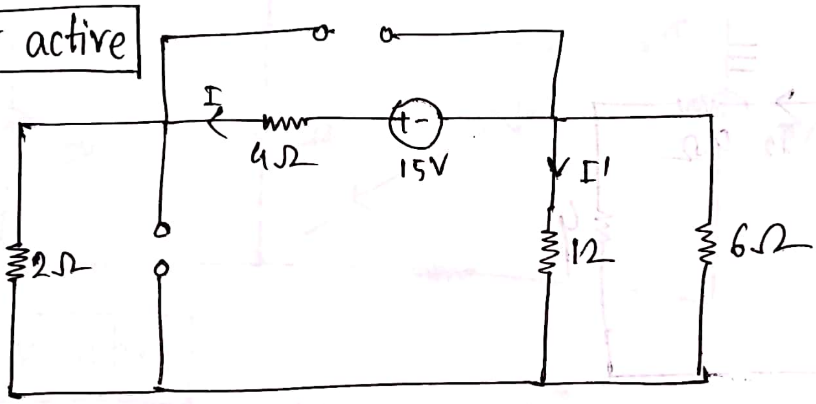
$$I'''=\frac{4}{2+4}\times3=6A$$

$$\therefore I=I'+I''+I'''$$
$$=(-2+1+6)A$$
$$=5A$$

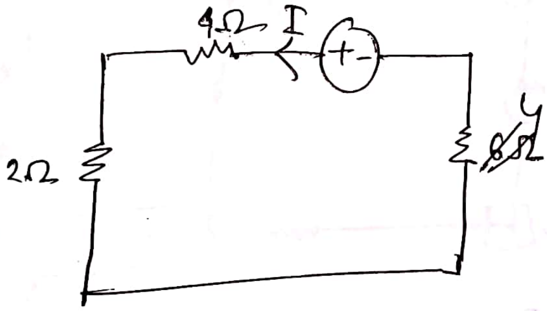


$I' = -0.5\,A$

$\boxed{\text{15V active}}$



$\equiv$



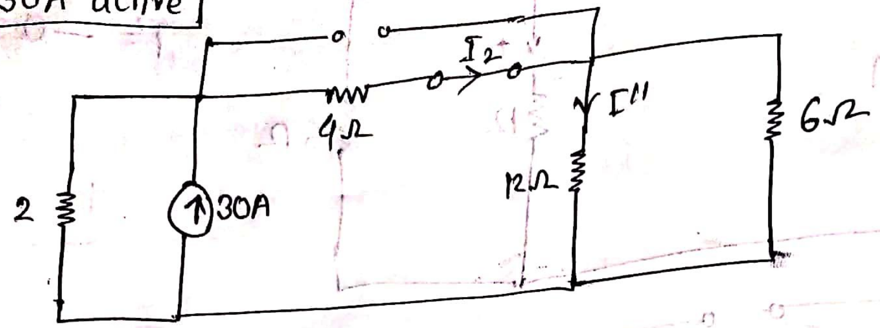
$$I = \frac{15V}{4+2+4}$$

$$= 1.5A$$

$$I' = -\frac{6}{12+6} \times 1.5$$

$$= -0.5A$$

$\boxed{\text{30A active}}$



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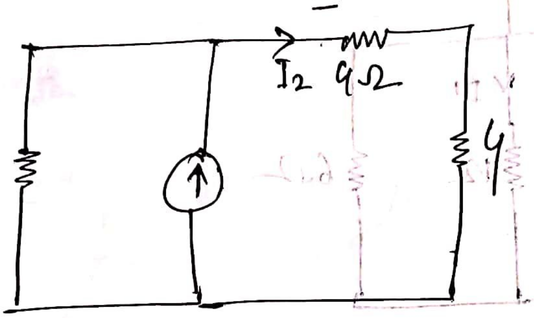


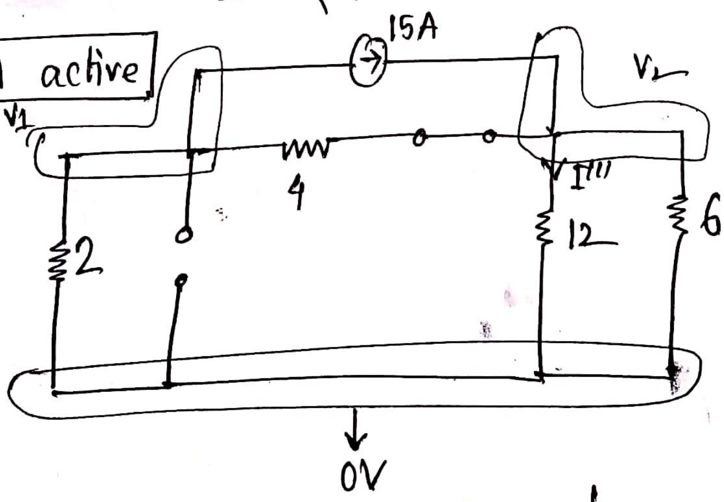
$$I_2 = \frac{2}{2+8} \times 30$$

$$= 6A$$

$$I'' = \frac{6}{12+6} \times 6$$

$$= 2A$$

$\boxed{\text{15A active}}$



$$\frac{V_1 - 0}{2} + \frac{V_1 - V_2}{4} + 15 = 0 \quad \text{— (1)}$$

$$\frac{V_2 - 0}{12} + \frac{V_2 - 0}{6} + \frac{V_2 - V_1}{4} - 15 = 0 \quad \text{— (2)}$$

$V_1 = (\ )$ $\quad$ $V_2 = (\ )$

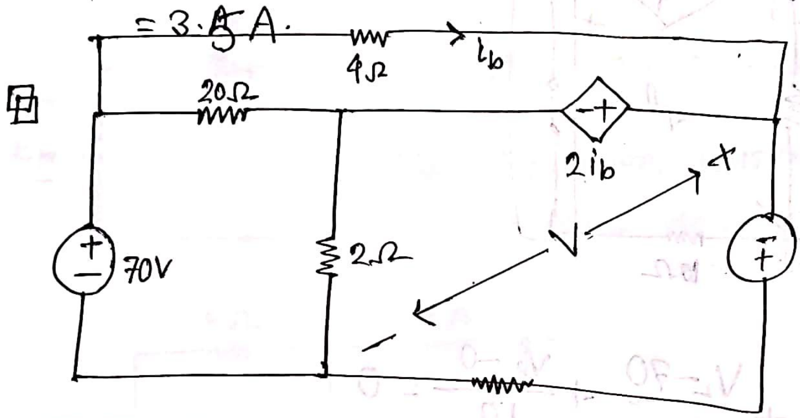
$I''' = \dfrac{V_2 - 0}{1} = 2A$

$\therefore I = I' + I'' + I'''$

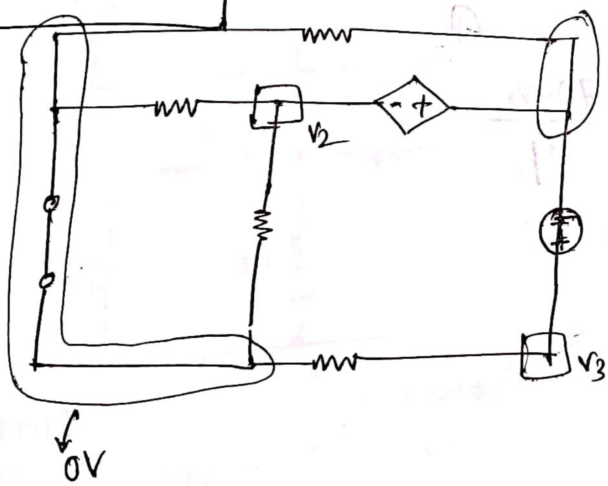
$= -0.5 + 2 + 2$

$= 3.5A$

\# superposition করার সময় কোন dependent source কে deactive করা যায় না।



50V active



$$\underbrace{\frac{V_1 - 0}{4}}_{V_1} + \underbrace{\frac{V_2 - 0}{20} + \frac{V_2 - 0}{2}}_{V_2} + \underbrace{\frac{V_3 - 0}{10}}_{V_3} = 0$$

$\Rightarrow 0.25V_1 + 0.55V_2 + 0.1V_3 = 0$ — (i)

$V_1 - V_2 = 2i_b$ | $i_b = \dfrac{0 - V_1}{4}$

$\Rightarrow 1.5V_1 - V_2 = 0$ — (ii)

$V_3 - V_1 = 50$ — (iii)

~~$V_1 = (\ ); V_2 = (\ ); V_3 = (\ )$~~

$V_1 = -4.255V$

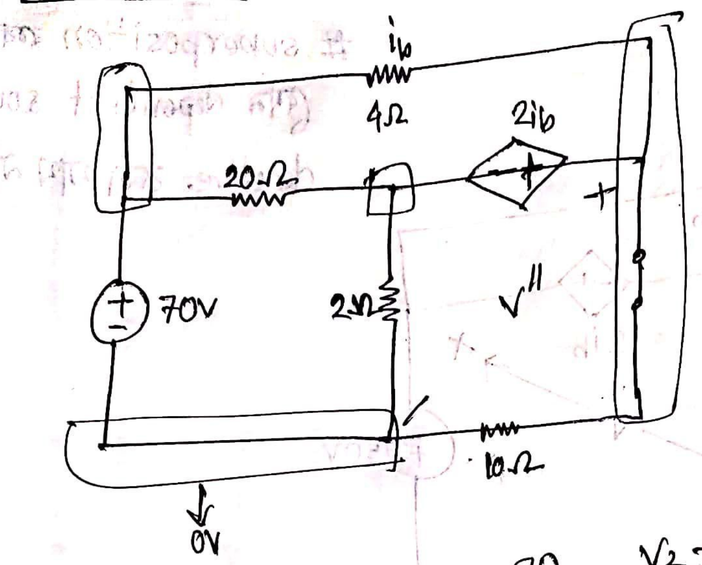
$V_2 = -6.38V$

$V_3 = 45.74V$

$\therefore V' = V_1 - 0$

$= -4.255V$

$\boxed{\text{70V active}}$



$$\frac{V_1-70}{20}+\frac{V_1-0}{2}+\frac{V_2-70}{4}+\frac{V_2-0}{10}=0$$

$\Rightarrow \; 0.55V_1 + 0.55V_2 = 21$ —— (I)

$V_2 - V_1 = 2i_b$ $\qquad i_b = \dfrac{70-V_2}{4}$

$\Rightarrow -V_1 + 1.5V_2 = 35$ —— (II)

Solving (I) and (II) $\Rightarrow$

$V_1 = 16.38V$

$V_2 = 34.255V$

$V'' = V_2 - 0$

$= 34.255V$

$V = V' + V''$

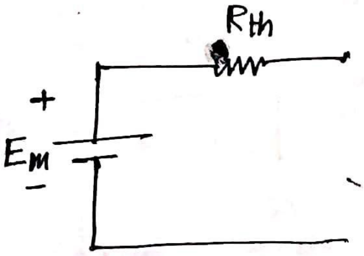
$= (-4.255 + 34.255)\ V$

$= 30\ V$

04.02.19

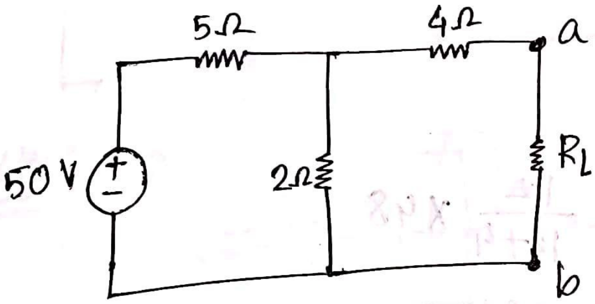
Thevenin's theorem

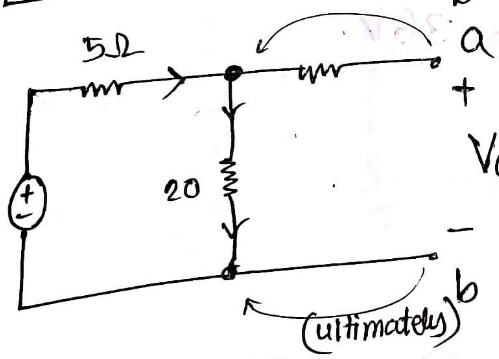
Any two terminal dc netwok can be replaced by an equivalent circuit consisting solely of a voltage source and a series resistor.



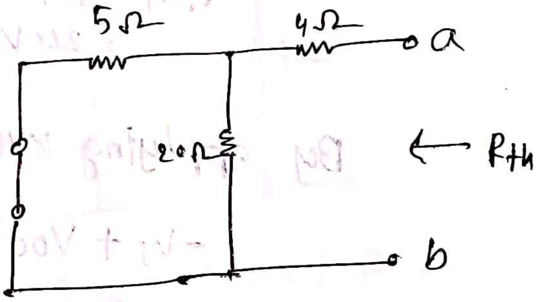
E_{th} = Open Circuit voltage $\cancel{= E_{oc}}$ at the two terminal ab. ($= V_{oc}$)

R_{th} = Equivalent resistance with all the independent sources deactivated.





$V_{oc} = E_{th}$



$$R_{th} = \frac{5 \times 20}{5+20} + 4$$

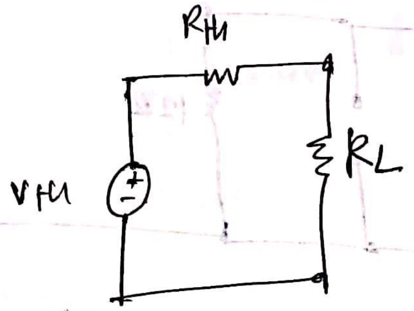
$= 8\Omega$

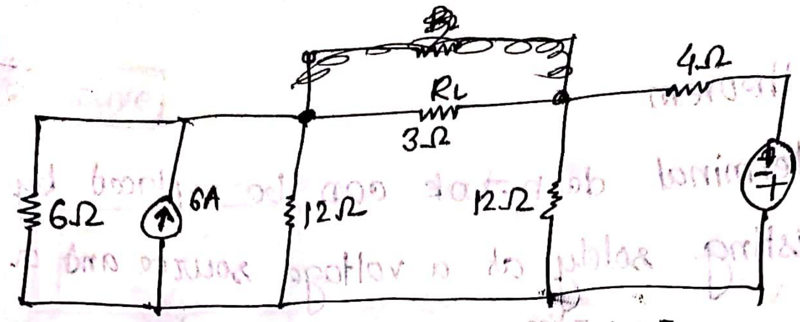
V_{th}:

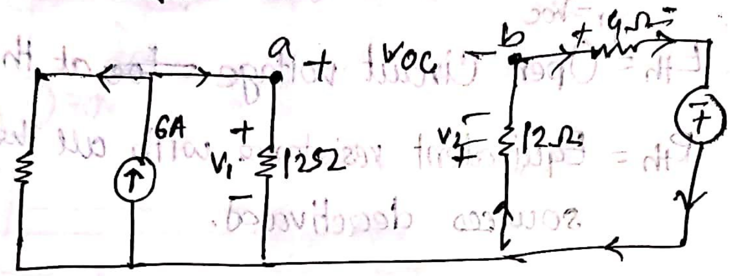
$$V_{OC} = \frac{20}{20+5} \times 50$$

$= 40V$

$R_{th} =$







V_{th}:

$$I_1 = \frac{6}{6+12} \times 6$$

$$I_1 = 2A$$

$$\therefore V_1 = 12 \times 2 = 24V$$

$$V_2 = \frac{12}{12+4} \times 48 = 36V$$

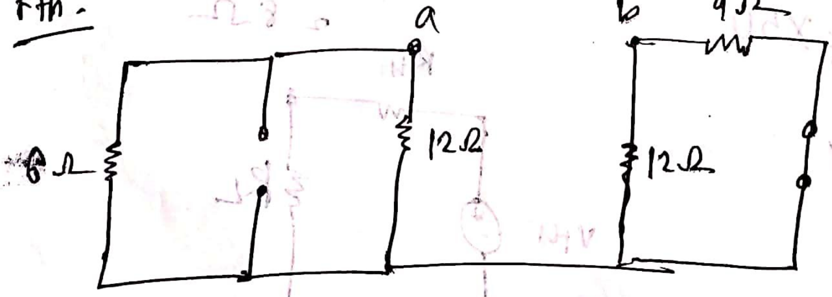
By applying KVL,

$$-V_1 + V_{oc} - V_2 = 0$$

$$\Rightarrow V_{oc} = 24+36$$

$$\Rightarrow V_{th} = 60\,V$$

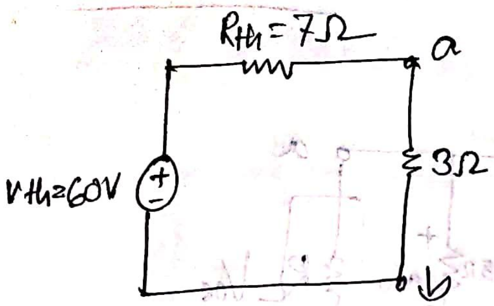
R_{th}:

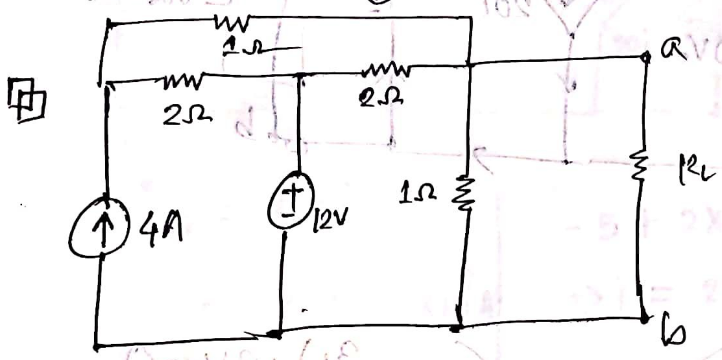


$$R_{th} = \frac{6 \times 12}{6+12} + \frac{4 \times 12}{4+12}$$

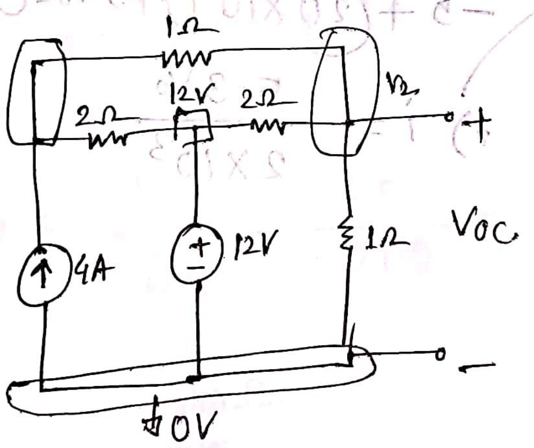
$$= 4+3$$

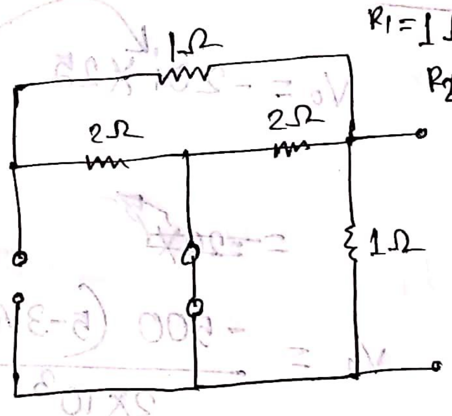
$$= 7\Omega$$





Vth:





$R_1 = 1\Omega \parallel 2\Omega$

$R_2 = R_1 \parallel 2\Omega$

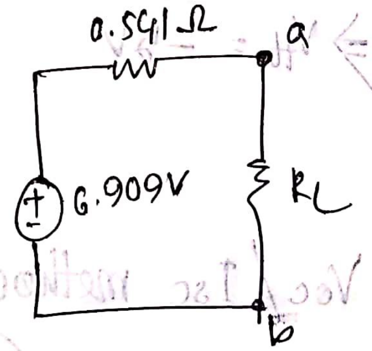
$R_3 = R_2 \parallel 1\Omega$

$R_{th} = 0.541\ \Omega$

For, V_1,

$$\frac{V_1 - V_2}{1} + \frac{V_1 - 12}{2} - 4 = 0$$

$$\Rightarrow 1.5V_1 - V_2 = 10 \quad \text{--- (I)}$$



For V_2,

$$\frac{V_2 - 12}{2} + \frac{V_2 - V_1}{1} + \frac{V_2 - 0}{1} = 0$$

$$\Rightarrow -V_1 + 2.5V_2 = 6 \quad \text{--- (II)}$$

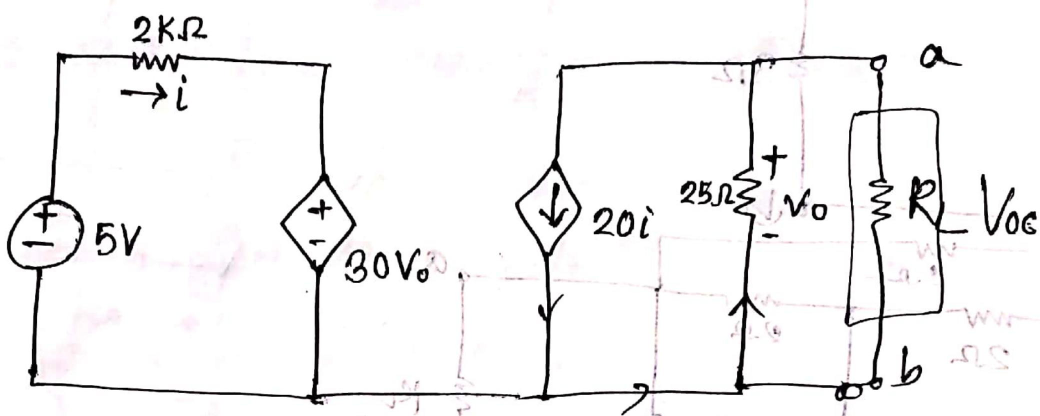
$V_1 = 11.27\text{V}$

$V_2 = 6.909\text{V}$

$\therefore V_{oc} = V_2 - 0 = 6.909\text{V}$

17.02.19

Thevenins theorem:



V_{th}:

$V_o = -20i \times 25$

$= \cancel{-20 \times 5}$

$-5 + (20 \times 10^3 i) + 3V_o = 0$

$\Rightarrow i = \dfrac{5 - 3V_o}{2 \times 10^3}$

$V_o = \dfrac{-500\,(5-3V_o)}{2 \times 10^3}$

$\Rightarrow V_o = -5V.$

$\Rightarrow V_{th} = -5V$

R_{th}:

1. V_{oc}/I_{sc} method
2. V_T/I_T method (Test Voltage Method)

$\rightarrow R_{Th} = \dfrac{V_T}{I_T}$

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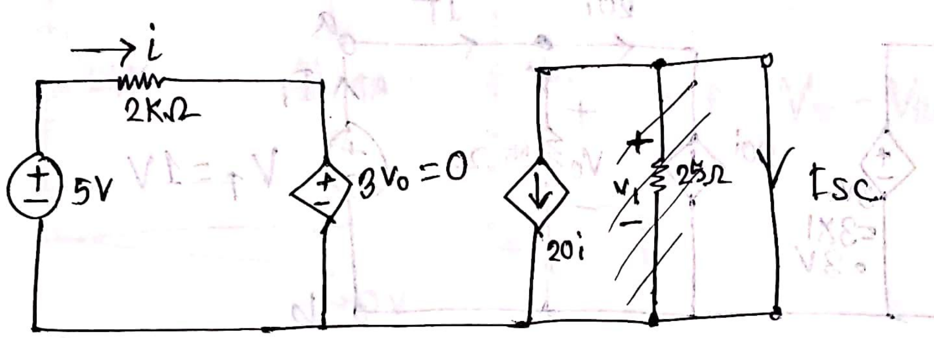
Method : 1: Voc / Isc



$I_{sc} = -20i$

$= -20 \times 2.5 \times 10^{-3} A$

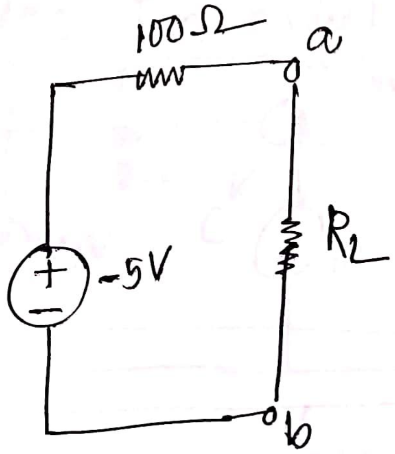
$= -50 \times 10^{-3} A$

$= -0.05 A$

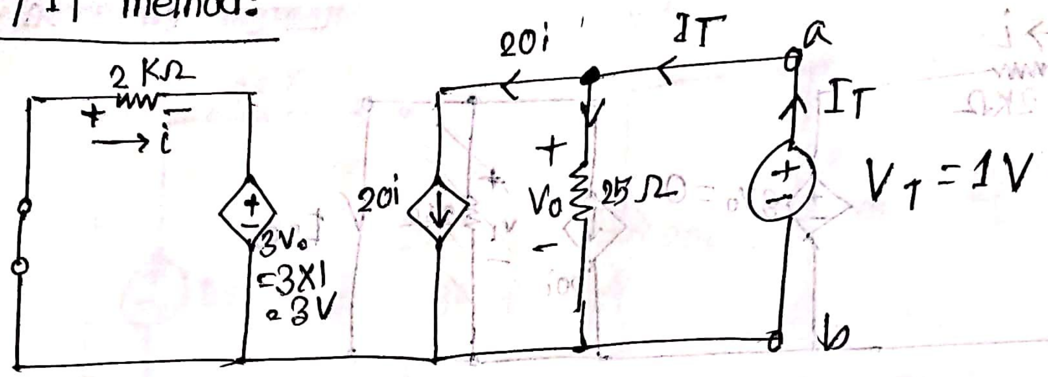
$-5 + 2 \times 10^{3} i + 0 = 0$

$\Rightarrow i = 2.5 \times 10^{-3} A$

$$R_{th} = \frac{V_{oc}}{I_{sc}} = \frac{-5}{-0.05} = 100\Omega$$



② V_T/I_T method:



$$I_T = -\frac{1}{25} - 20i = 0$$

$$2\times10^3\, i + 3 = 0$$

$$\Rightarrow i = -\frac{3}{2\times10^3}$$

$$= -1.5\times10^{-3} A$$

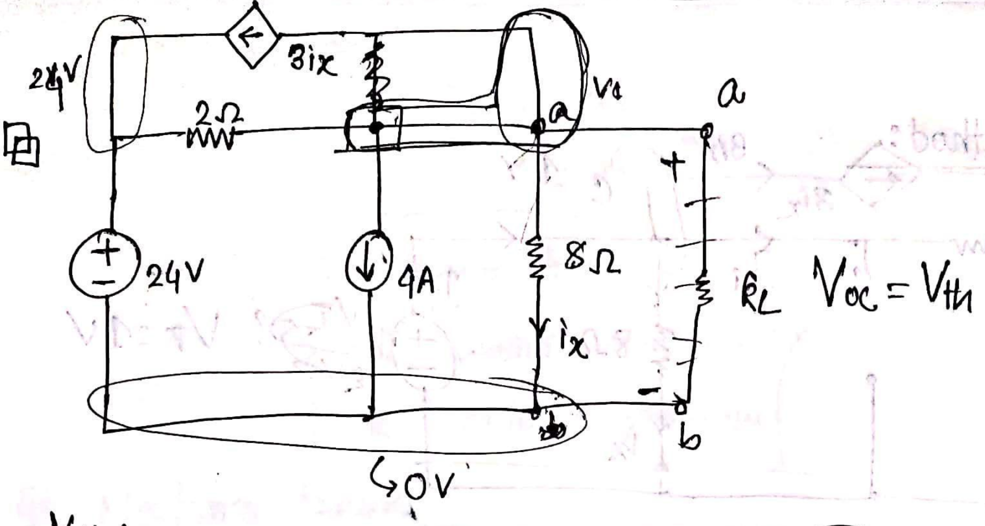
$\Rightarrow$ ~~$i = 1.5\times10^{-3} A$~~

$\Rightarrow I_T = 0.01A$

$$R_{th} = \frac{V_T}{I_T}$$

$$= \frac{1V}{0.01A}$$

$$= 100\Omega$$



$V_{oc} = V_{th}$

V_{th}:

$$\frac{V_1 - 24}{2} + 4 + \frac{V_1}{8} + 3i_x = 0 \quad \Bigg| \quad i_x = \frac{V_1 - 0}{8}$$

$\Rightarrow V_1 = 8V$

$\Rightarrow V_{oc} = V_1 - 0$

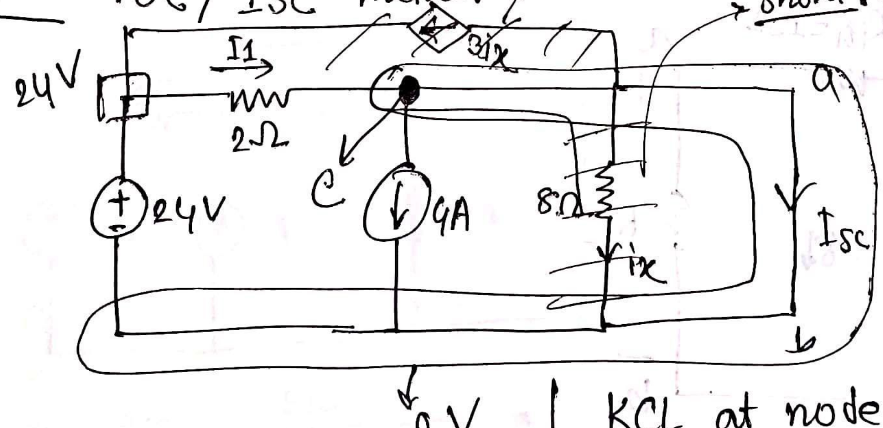
$= 8V - 0$

$= 8V$

R_{th}: Voc/Isc method

$3 \times 0 = 0$

short: $i_x = 0$



$\therefore I_1 = \frac{24 - 0}{2}$

$= 12A$

KCL at node c,

$I_1 - 4 - I_{sc} = 0$

$\Rightarrow 12 - 4 - I_{sc} = 0$

$\Rightarrow I_{sc} = 8A$

$\therefore R_{th} = \frac{V_{oc}}{I_{sc}} = \frac{8}{8} = 1\Omega$

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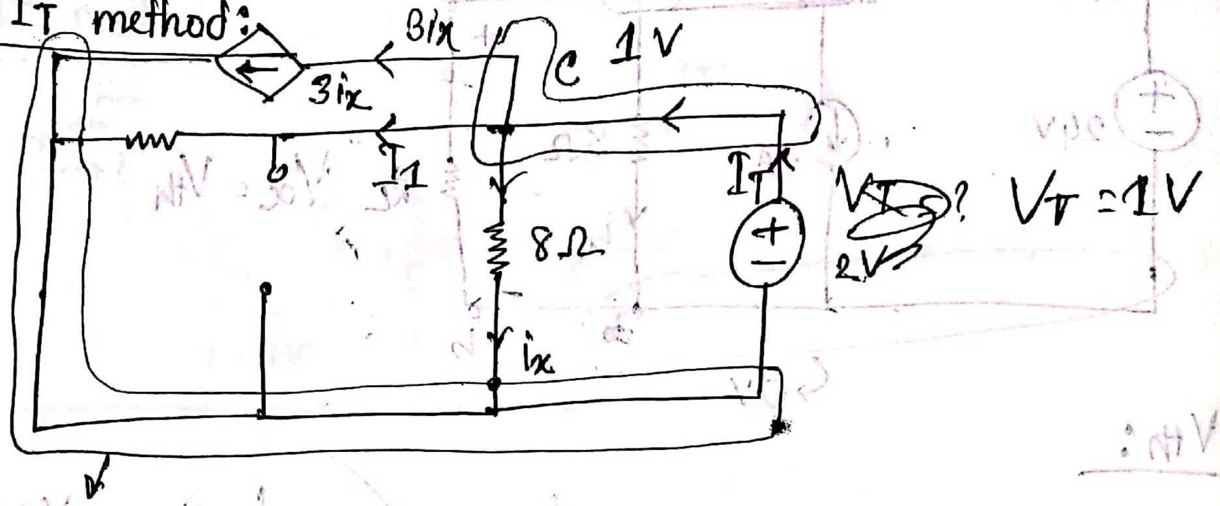
V_T / I_T method:



KCL at node C,

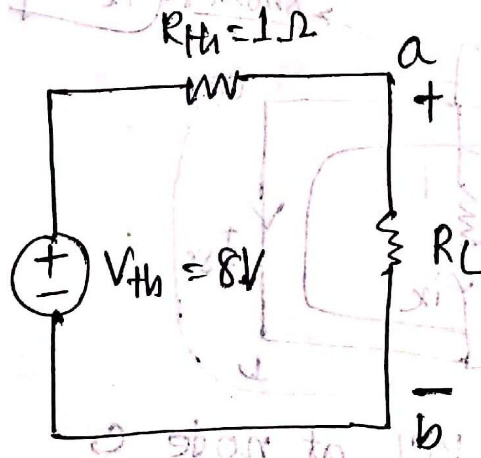
$$\boxed{i_x = \frac{1}{8}}$$

$$I_T - i_x - I_1 - 3i_x = 0$$

$$\Rightarrow I_T - \frac{1}{8} - \frac{1-0}{2} - 3\frac{1}{8} = 0$$

$$\Rightarrow I_T = 1A$$

$$R_{th} = \frac{V_T}{I_T} = \frac{1}{1} = 1\Omega$$



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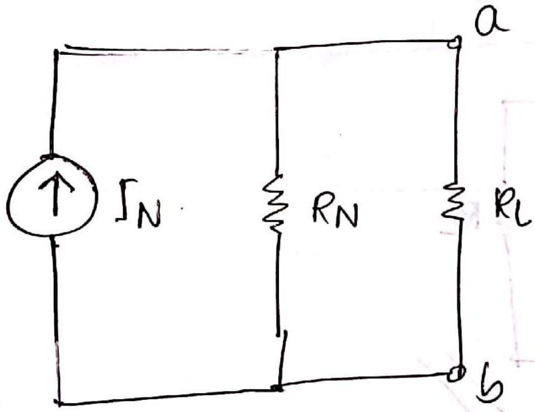
Quiz - 02

4/03/2019

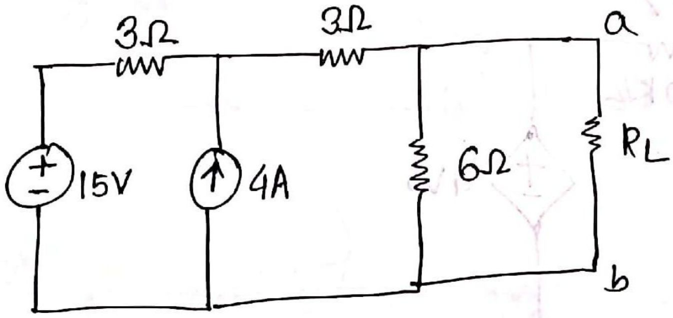
- Nodal Analysis
- Thevenins theorem
- Norton's theorem

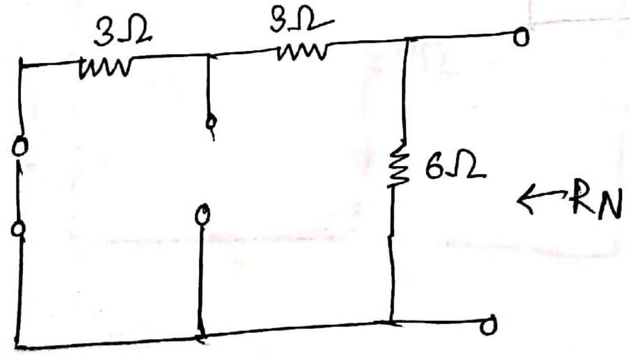
Norton's theorem:

Any two terminal dc-network can be replaced by an equivalent circuit consisting of a current source and a parallel resistor.



$R_N \equiv R_{TH}$





$R_N = 3\Omega$

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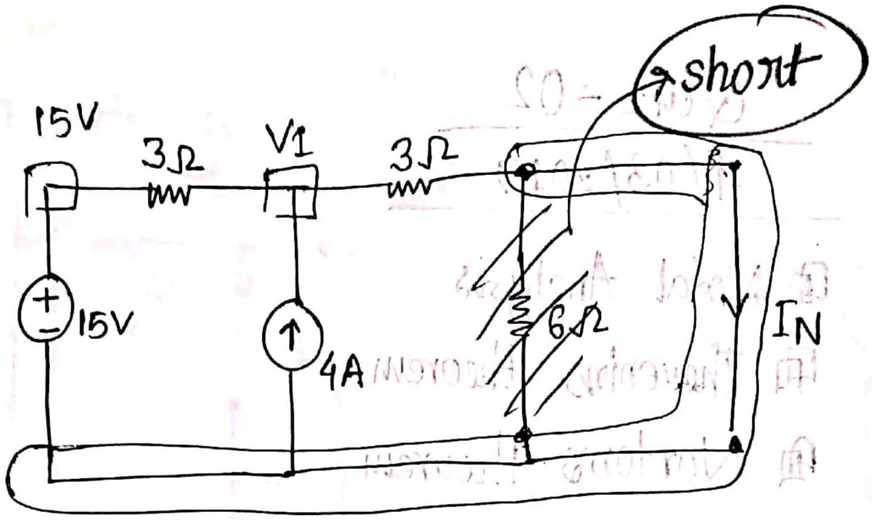
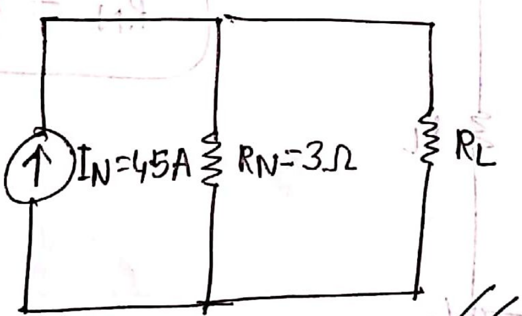


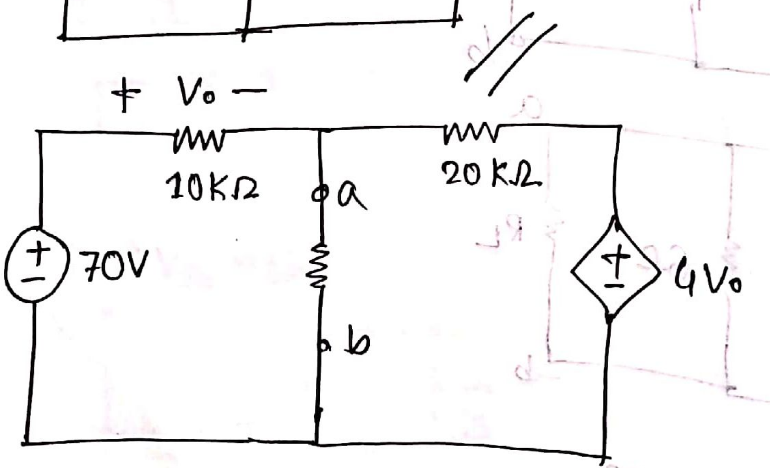
$$\frac{V_1 - 15}{3} + \frac{V_1}{3} - 4 = 0$$

$\Rightarrow V_1 = 13.63$

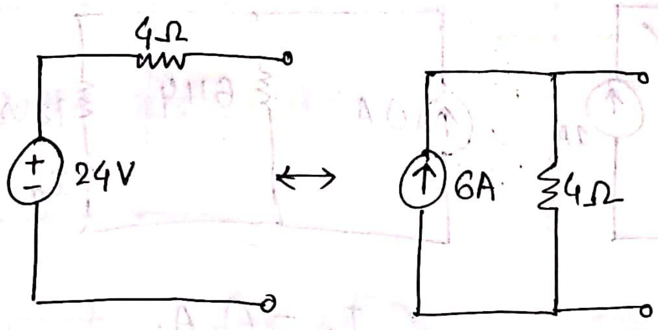
$$I_N = \frac{V_1 - 0}{3} = \cancel{4.31}\ 4.5\,A$$



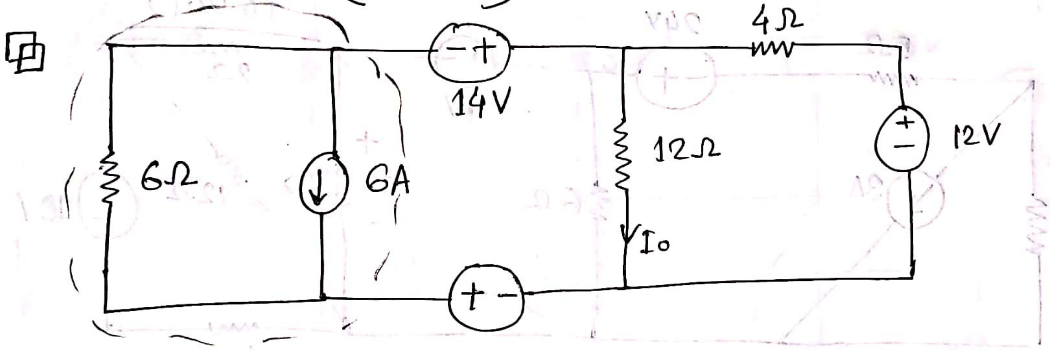
H.W.

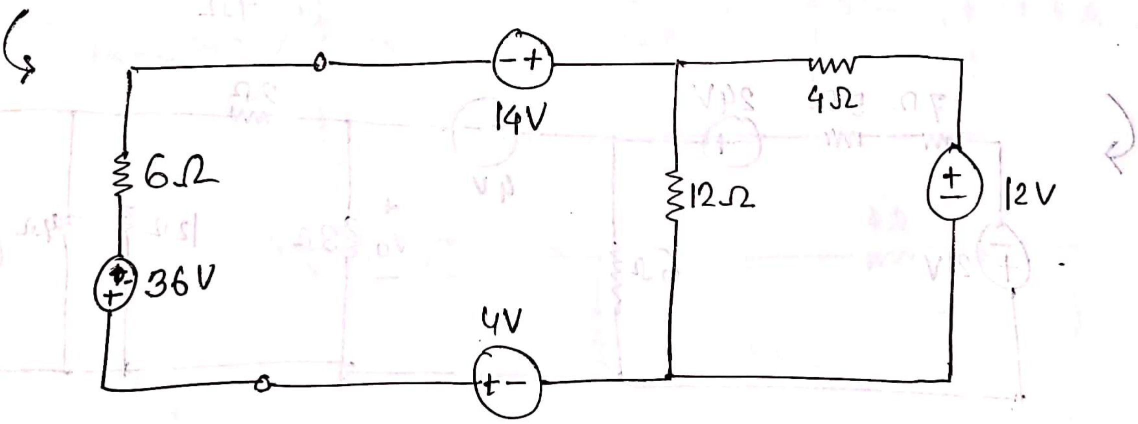


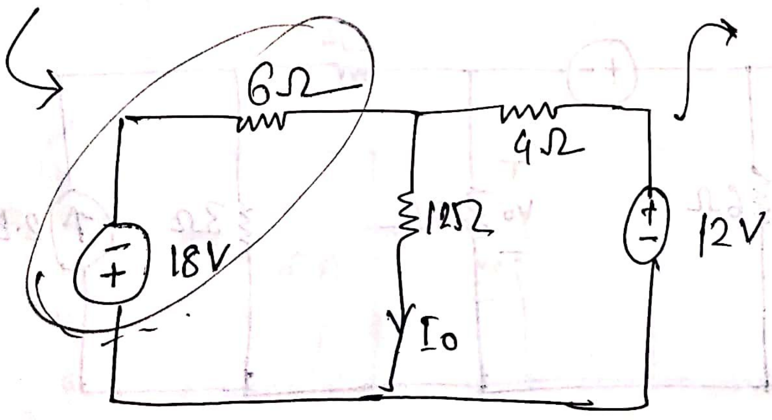
Source Transformation:

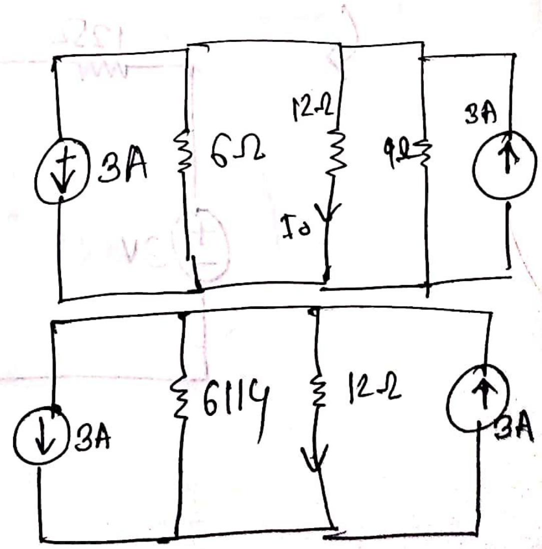


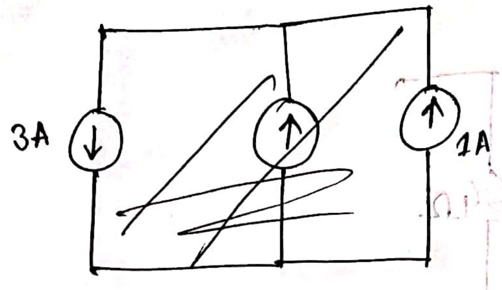
(vice versa)

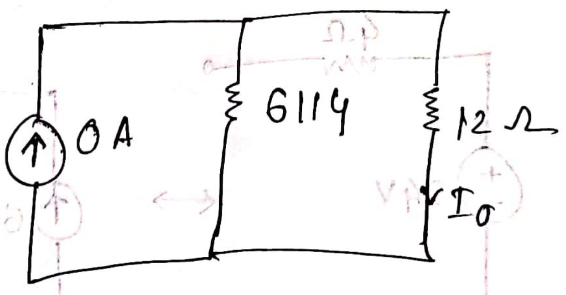






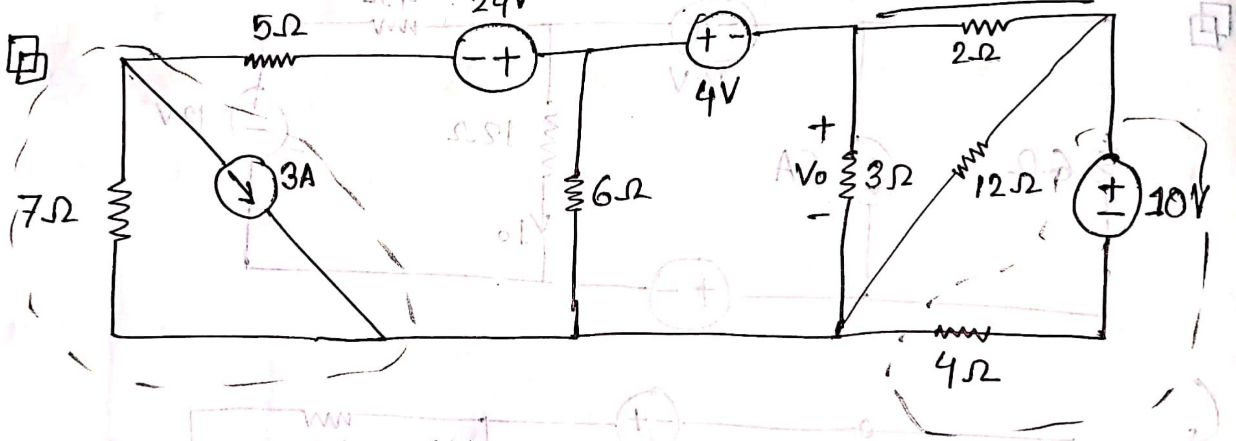


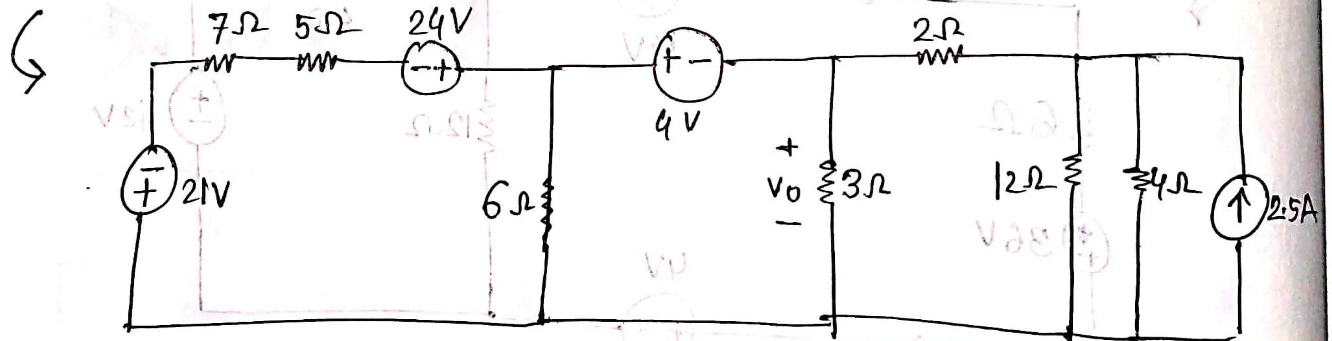


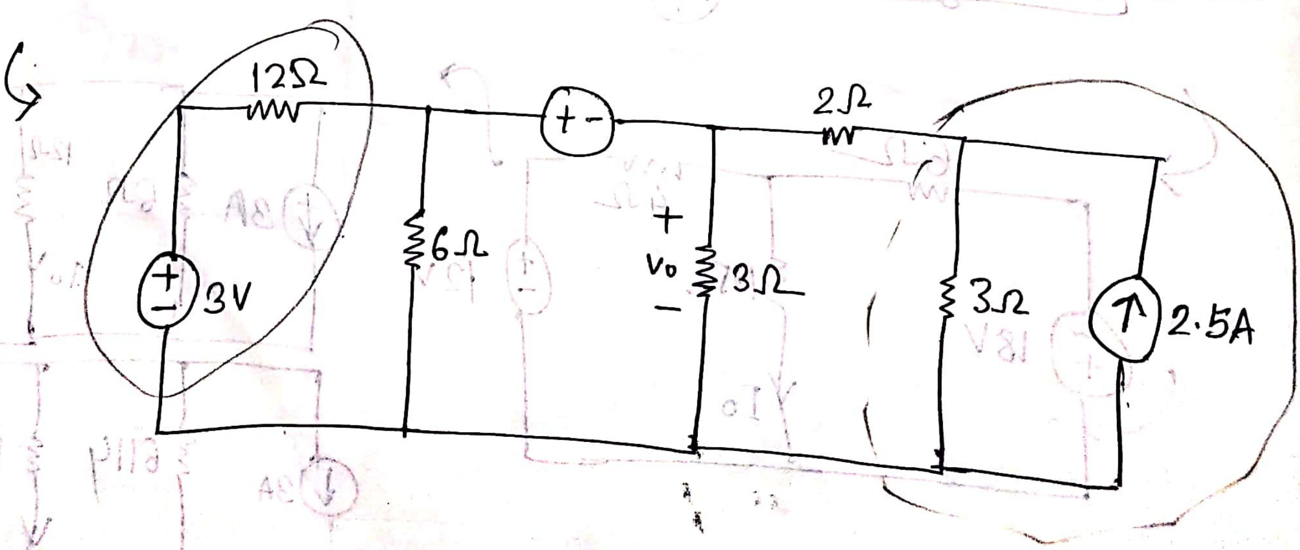


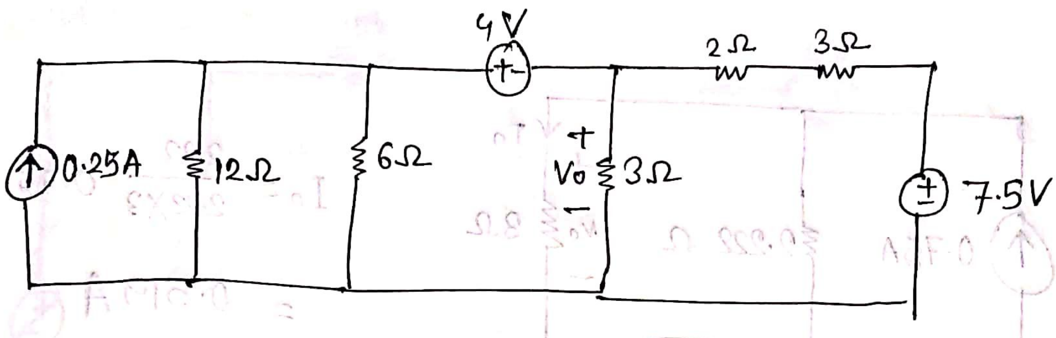
$\therefore I_0 = 0\ A.$

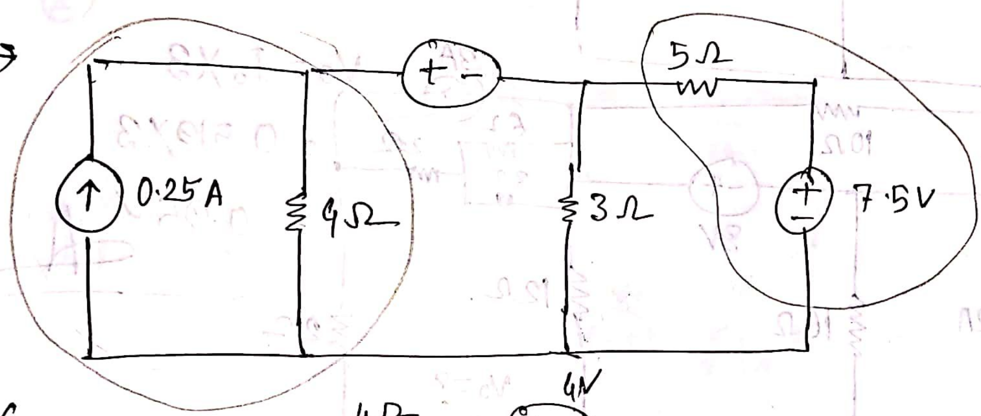
18.02.19

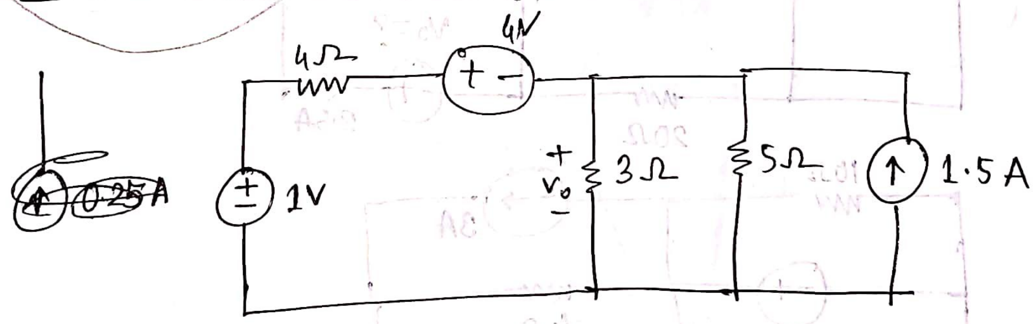


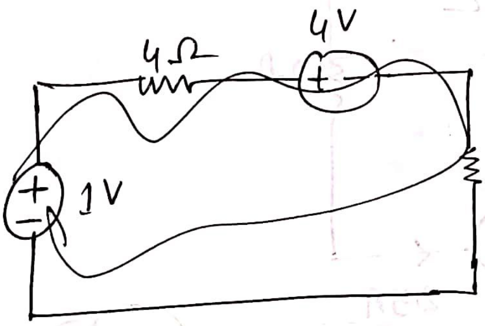


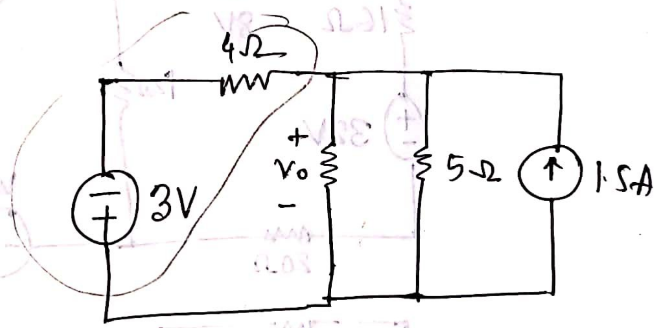


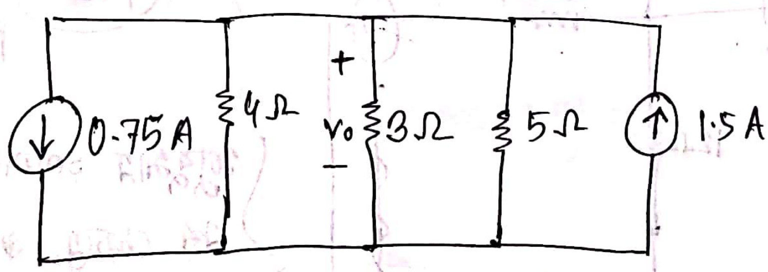

4V
2Ω
3Ω
0.25A
12Ω
6Ω
Vo
3Ω
7.5V

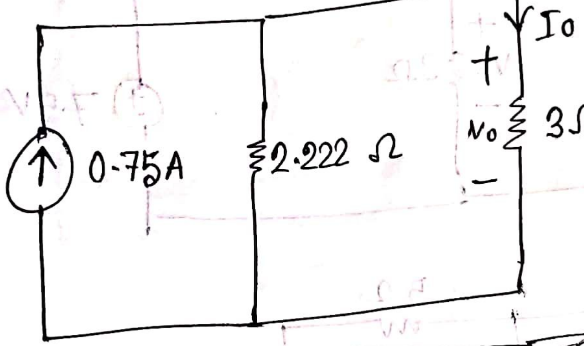

5Ω
0.25A
4Ω
3Ω
7.5V


4Ω
4V
0.25A
1V
Vo
3Ω
5Ω
1.5A


4Ω
4V
1V


4Ω
3V
Vo
5Ω
1.5A


0.75A
4Ω
Vo
3Ω
5Ω
1.5A



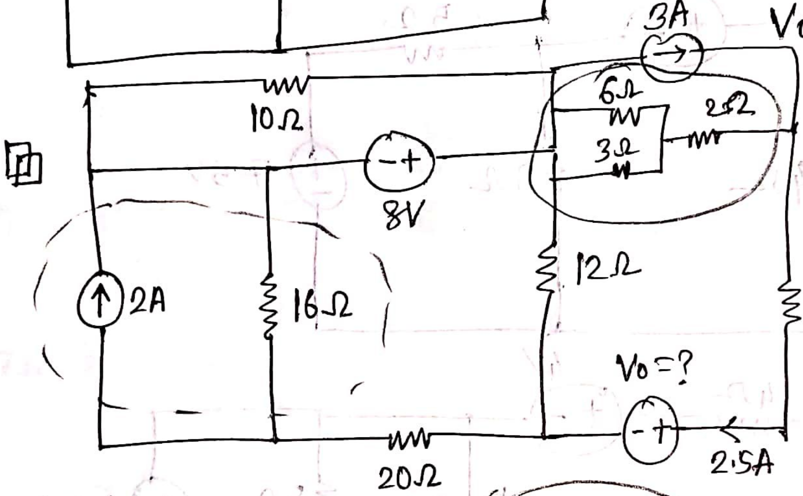
$$I_o = \frac{2.22}{2.22 \times 3} \, 0.75$$

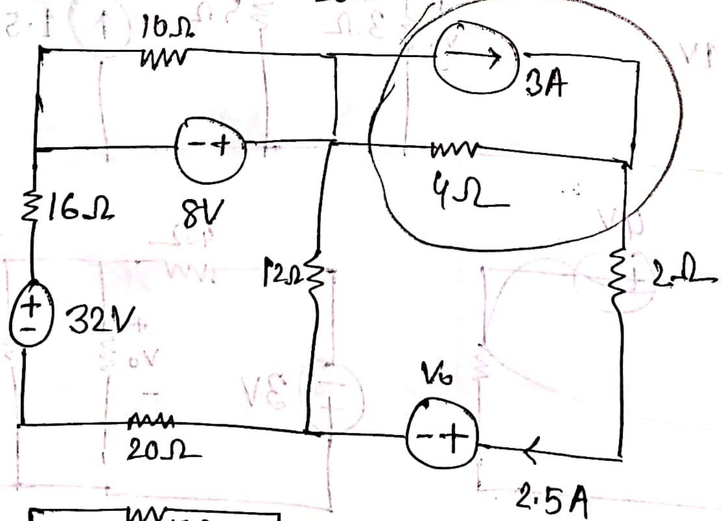
$$= 0.519\,A$$

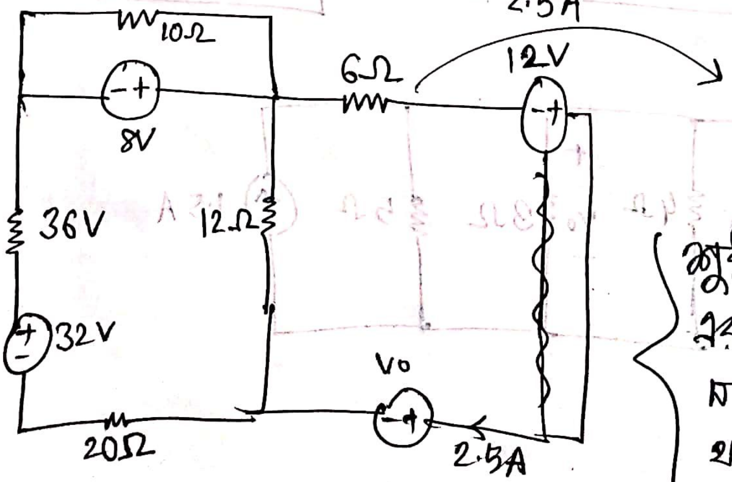
$$V_o = I_o \times 3$$

$$= 0.519 \times 3$$

$$= 0.96\,V$$







4+2 যোগ করে নিতে হবে

শুধুমাত্র source transformation এর ক্ষেত্রে, ও voltage এর সাথে resistor parallel থাকলে, ঐ resistor skip করা যায়।

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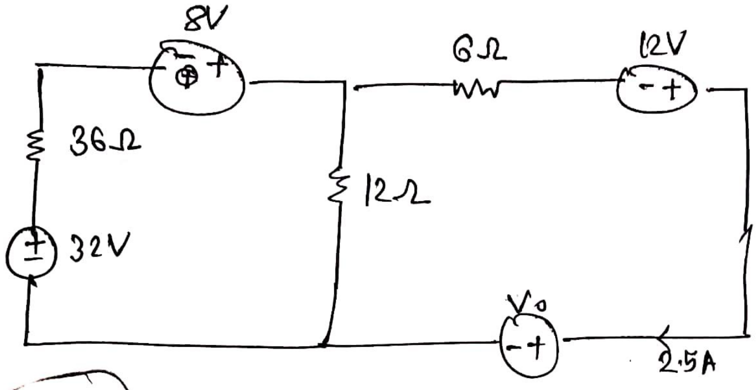
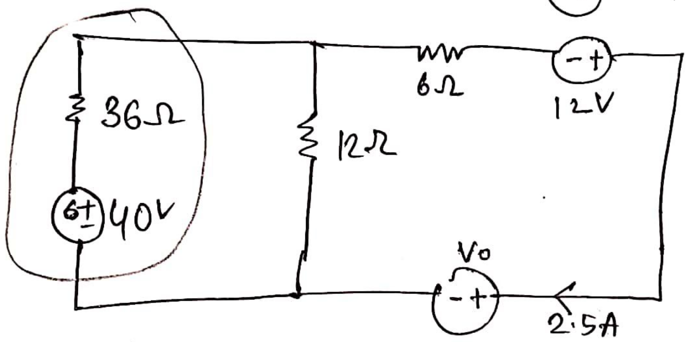
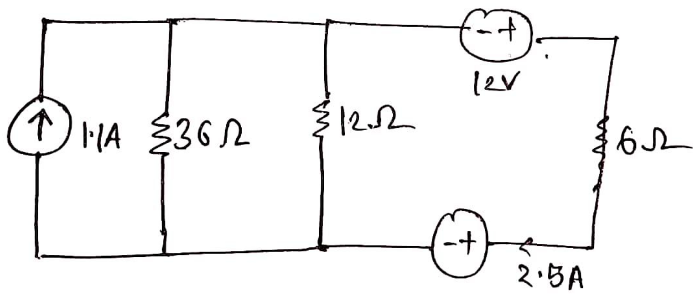
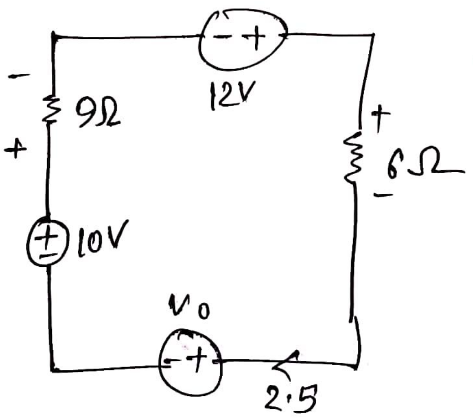








$$V_o - 10 + (9 \times 2.5) - 12 + (6 \times 2.5) = 0$$

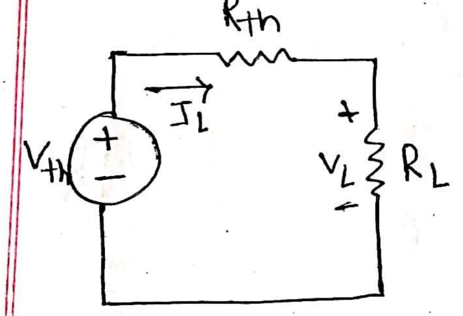
$\Rightarrow \quad V_o = -15.5V$

A

Date: 03/03/2019

Maximum Power Transfer Theorem

A load will receive maximum power from a a network when it's' resistance is exactly equal to the Thevinin's resistance of the network applied to the load.



$$I_L = \frac{V_{th}}{R_{th} + R_L} \quad \text{—— (i)}$$

$$\text{Now, } V_L = I_L R_L = \frac{V_{th}}{R_{th} + R_L} \cdot R_L \quad \text{—— (ii)}$$

$$P_L = V_L I_L$$

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

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

$$\text{Now, } \frac{dP_L}{dR_L} = V_{th}^2 \, \frac{(R_{th} + R_L)^2 - 2R_L(R_L + R_{th})}{(R_L + R_{th})^4}$$

For maximum Power,

$$\frac{dP_L}{dR_L} = 0$$

$$\Rightarrow V_{th}^2 \frac{(R_{th}+R_L)^2 - 2R_L(R_{th}+R_L)}{(R_L+R_{th})^4} = 0$$

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

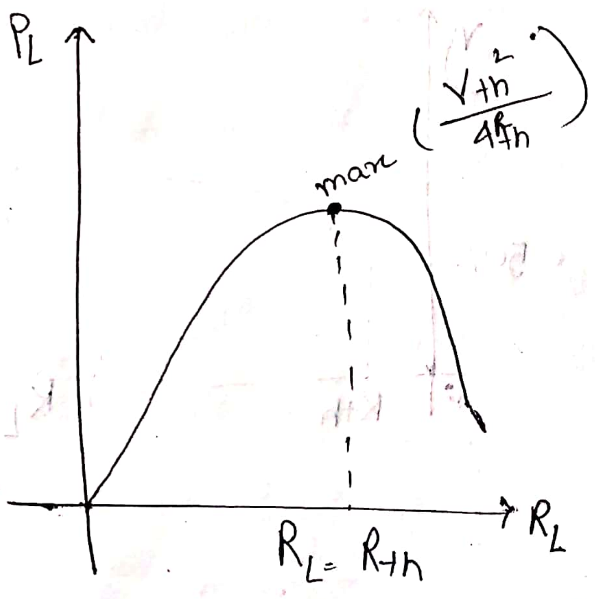
$$\Rightarrow (R_{th}+R_L)(R_{th}+R_L-2R_L) = 0$$

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

Here, $R_{th}+R_L \neq 0$

$$\therefore R_{th} - R_L = 0$$

$$\Rightarrow \boxed{R_L = R_{th}}$$



when, $R_L = R_{th}$

$$I_L = \frac{V_{th}}{R_{th}+R_L}$$

$$= \frac{V_{th}}{R_{th}+R_L} = \frac{V_{th}}{2R_{th}}$$

$$P_{L\,max} = I_L^2 R_L$$

$$= \frac{V_{th}^2}{4R_{th}^2} \times R_{th} = \frac{V_{th}^2}{4R_{th}}$$

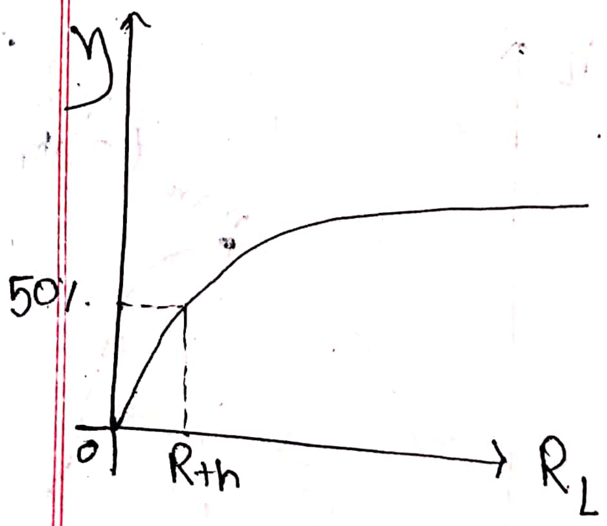
Efficiency

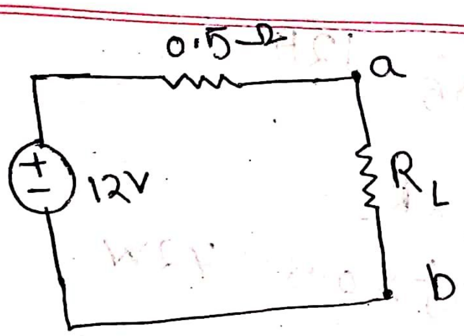
$$\eta = \frac{P_L}{P_S} \times 100\%$$

$$\eta = \frac{I_L^2 R_L}{I_L^2 (R_L + R_{th})} \times 100$$

When $R_L = R_{th}$

$$\eta = \frac{I_L^2 R_{th}}{I_L^2 (R_{th} + R_{th})} = \frac{1}{2} \times 100 = 50\%$$





(a) Determine R_L for maximum power transfer.

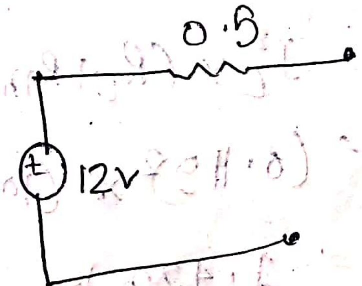
(b) Under maximum power conditions what are the current level and the power to the load?

(c) What is the efficiency of the system.

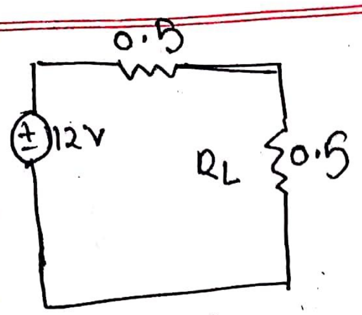
(d) If a load of 100Ω is connected to the terminals, what will be the efficiecncy and transferred power to the load?

(e) Determine R_L for obtaining efficiency of 75%?

(a) $R_L = 0.5\Omega = R_{th}$



(b)



$I_L = \frac{12}{0.5+0.5} = 12A$

$P_L = I_L^2 \times R_L$

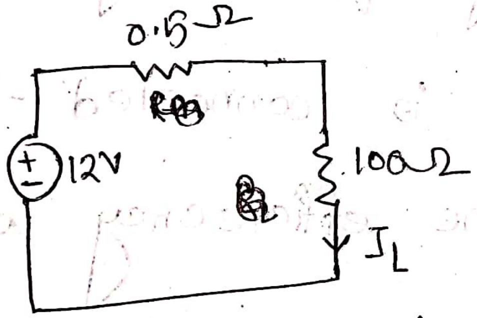
$= (12)^2 \times 0.5 = 72W$

$P_{Lmax} = \frac{V_{th}^2}{4R_{th}}$

$= \frac{(12)^2}{4 \times 0.5} = 72\ W$

(c) $\eta = 50\%$.

(d)



$P_L = I_L^2 \times R_L$

$= (0.119)^2 \times 100$

$= 1.4161\ W$

$I_2 = \frac{12}{0.5 + 100}$

$= 0.119\ A$

$P_g = I_L^2 \times (R_L + R_{th})$

$= (0.119)^2 \times (100+0.5)$

$= 1.423\ W.$

$$\eta = \frac{P_L}{P_S} \times 100 = \frac{1.4161}{1.423} \times 100 = 99.51\%.$$

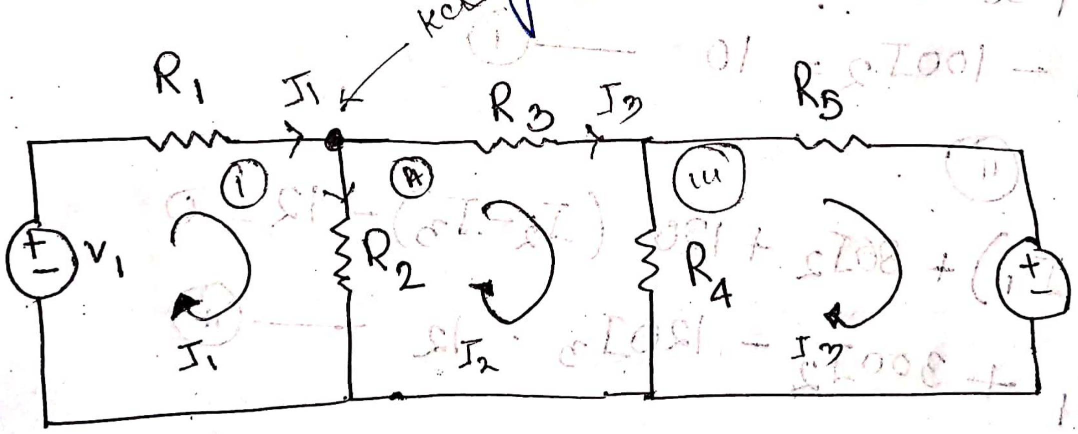
(e)

$$\eta = \frac{P_L}{P_S} \times 100$$

$$\Rightarrow \frac{I_L^2 R_L \times 100}{I_L^2 (R_L + R_{12})} = 75$$

$$\Rightarrow R_L = \frac{0.75 \times 0.5}{(1 - 0.75)} = 1.5\Omega$$

Mesh current analysis



At mesh (i),

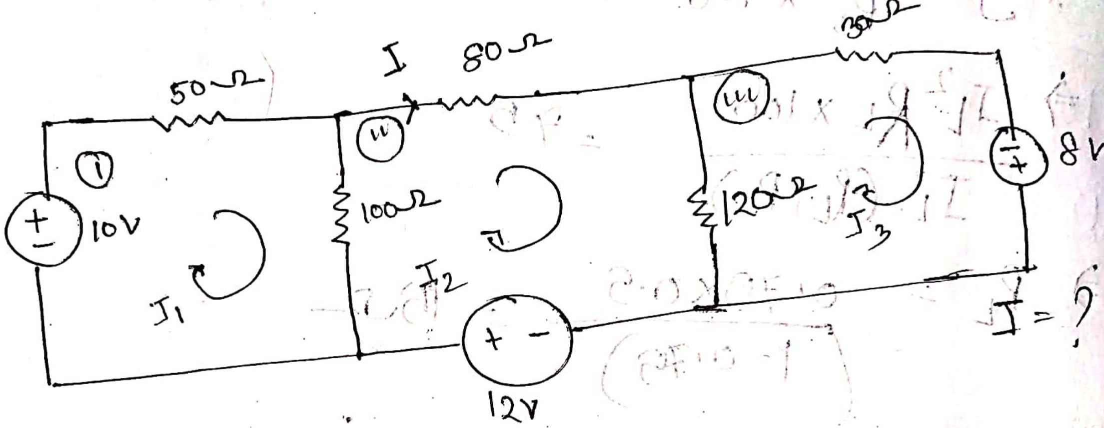
$$-V_1 + I_1 R_1 + (I_1 - I_2) R_2 = 0 \quad \text{——— (i)}$$

At mesh (ii)

$$(I_2 - I_1) R_2 + R_3 I_2 + R_4 (I_2 - I_3) = 0 \quad \text{——— (ii)}$$

At mesh (II)

$R_4(I_3 - I_2) + R_3 I_3 + V_2 = 0$ —— (III)



At mesh (I)

$-10 + I_1 50 + 100(I_1 - I_2) = 0$

$\Rightarrow 150 I_1 - 100 I_2 = 10$ —— (I)

At mesh (II)

$100(I_2 - I_1) + 80 I_2 + 120(I_2 - I_3) - 12 = 0$

$\Rightarrow -100 I_1 + 300 I_2 - 120 I_3 = 12$ —— (II)

At mesh (III)

$30 I_3 + 120(I_3 - I_2) - 8 = 0$

$\Rightarrow -120 I_2 + 150 I_3 = 8$ —— (III)

Solving 1, 11 & 111

$I_1 = 0.188\,A$

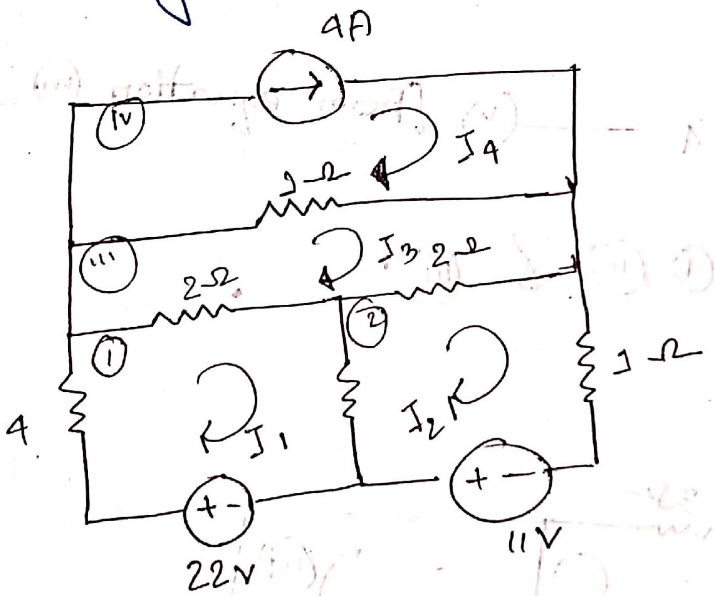
$I_2 = 0.1825\,A$

$I_3 = 0.1993\,A$

$I = I_2 = 0.1825\,A$

Date: 10/03/2019

Mesh Analysis



At mesh 1

$$-22 + 4I_1 + 2(I_1 - I_3) + 2(I_1 - I_2) = 0$$

$$\Rightarrow 8I_1 - 2I_2 - 2I_3 = 22 \quad \text{—— (1)}$$

At mesh (II)

$$-11 + 2(I_2 - I_1) + 2(I_2 - I_3) + 1(I_2) = 0$$

$$\Rightarrow -2I_1 + 5I_2 - 3I_3 = 11 \quad \text{—— (II)}$$

At mesh (III)

$$2(I_3 - I_1) + 1(I_3 - I_4) + 2(I_3 - I_2) = 0 \quad \text{—— (III)}$$

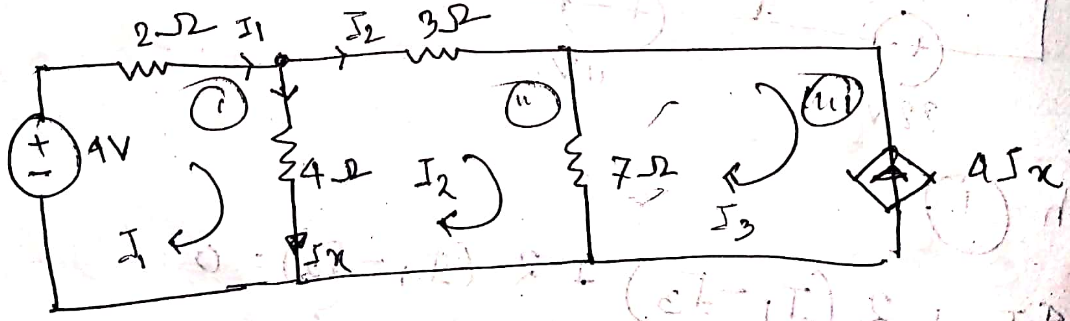
At mesh (IV)

$$I_4 = 4 \quad \text{—— (IV)}$$

$$I_4 = 4 \quad \text{—— (III)} \Rightarrow$$

$$-2I - 2I_2 + 5I_3 = 4 \quad \text{—— (V)} \quad \text{[From equation (III)]}$$

$$\left.\begin{array}{l} I_1 = 6\,A \\ I_2 = 7\,A \\ I_3 = 6\,A \end{array}\right\} \text{Solving (I) (II) \& (III)}$$



At mesh (I)

$$-4 + 2I_1 + 4(I_1 - I_2) = 0$$

$$\Rightarrow 6I_1 - 4I_2 = 4 \quad \text{—— (I)}$$

At mesh (II)

$$4(I_2 - I_1) + 3I_2 + 7(I_2 - I_3) = 0$$

$$\Rightarrow -4I_1 + 14I_2 - 7I_3 = 0 \longrightarrow \text{(ii)}$$

At mesh (III)

$$I_3 = -4 I_x \qquad I_1 - I_2 - I_x = 0$$

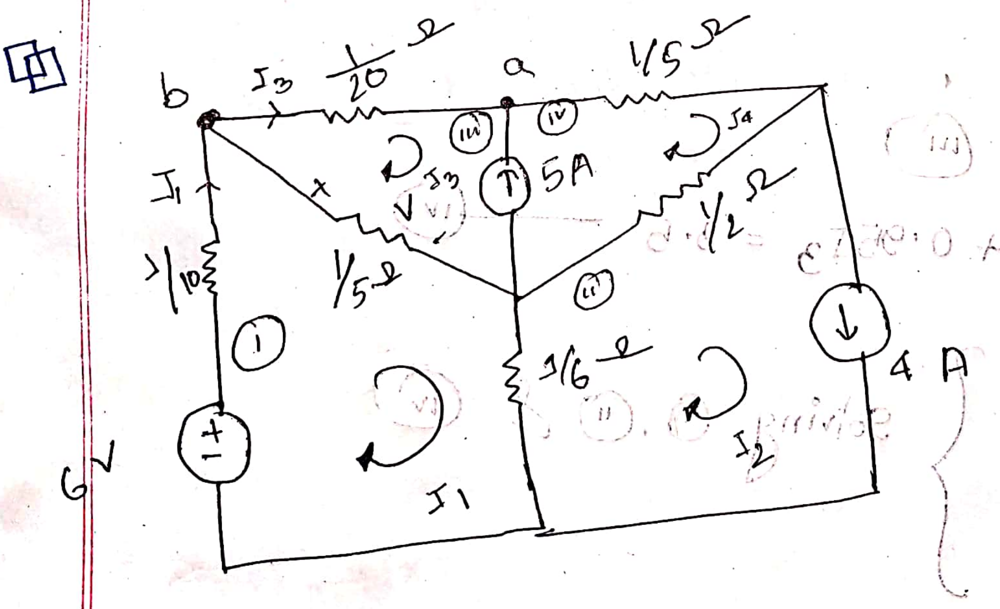
$$\Rightarrow I_x = I_1 - I_2$$

$$\Rightarrow 4I_1 - 4I_2 + I_3 = 0 \longrightarrow \text{(iii)}$$

$I_1 = -4.67$ A

$I_2 = -8$ A

$I_3 = -13.33$ A



At mesh (I)

$-6+\frac{1}{10}I_1+\frac{1}{5}(I_1-I_3)+\frac{1}{6}(I_1-I_2)=0$

$\Rightarrow 0.47 I_1 - 0.167 I_2 - 0.2 I_3 = 6$ —— (ii)

At mesh (ii)

$I_2 = 40$

At super mesh, $\frac{1}{5}(I_3-I_1)+\frac{1}{20}I_3+\frac{1}{5}I_4+\frac{1}{2}(I_4-I_2)=0$ —— (iii)

KCL at node a,

$I_3+5-I_4=0$

$\Rightarrow I_4 = I_3+5$

From equation (iii)

$-0.2I_1-0.5I_2+0.95I_3 = 3.5$ —— (iv)

$I_1 = 37.375\text{ A}$

$I_2 = 40\text{ A}$

$I_3 = 25.316\text{ A}$

$I_4 = 30.316\text{ A}$

Solving (I), (II) & (iv)

KCL at node (b)

$I_1 - I - I_3 = 0$

$\Rightarrow I = I_1 - I_3$

$V = \frac{1}{5} \times I$

$= \frac{1}{5}(I_1 - I_3) = \frac{1}{5}(37.75 - 25.316) = 2.4868\ V$

Magnetic Circuits

$$\text{Effect} = \frac{\text{Cause}}{\text{Opposition}}$$

(emf)

$$\text{current} = \frac{\text{Votage}}{\text{Resistance}}$$

$$\text{Flux} = \frac{\text{Magnetomotive force (mmf)}}{\text{Reductance}}$$

$$\varphi = \frac{F}{R}$$

Unit: $\frac{At}{At/Wb} =$ Wb (weber)

$mmf = N \times I$

Magnetizing force / Magnetic field strength / Magnetic field intensity

The mmf per unit length is called magnetizing force.

$$H = \frac{F}{l}$$

Units: At/m

$$H = \frac{F}{l} = \frac{NI}{l}$$

Flux density

$$B = \frac{\varphi}{A} \quad [\text{Flux per unit area}]$$

We know,

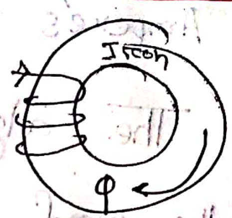
$$H = \frac{NI}{l} \; ; \quad R = \frac{l}{\mu A}$$

Now, $B = \dfrac{F/R}{A} = \dfrac{F/\frac{l}{\mu A}}{A}$

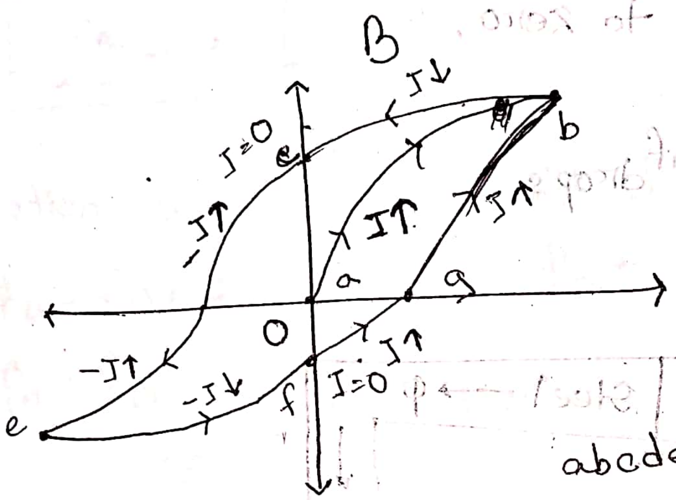
$$= \frac{F}{A \cdot \frac{l}{\mu A}} = \frac{F\mu}{l} = \frac{NI\mu}{l} = \mu H$$

Unit: Wb/m^2 (Tesla) (T)

Magnetic Circuit এ flux produce হয়

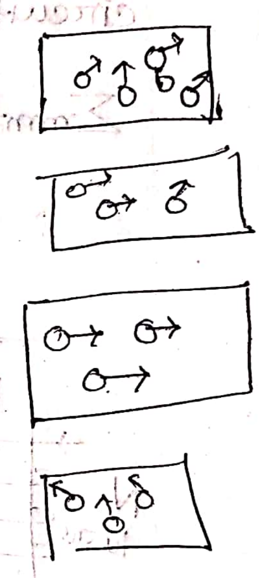


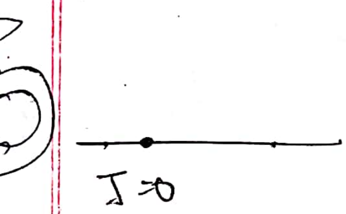
Hysteresis

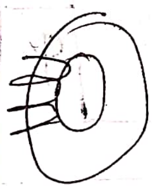


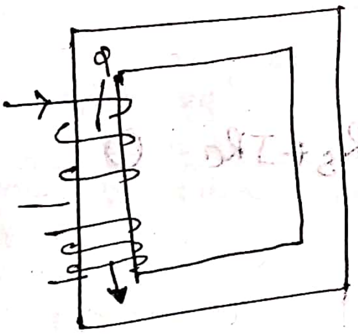
$H \rightarrow \frac{NI}{R}$

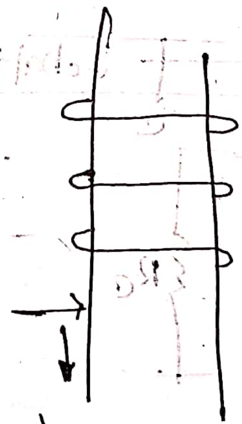
abcdefg b

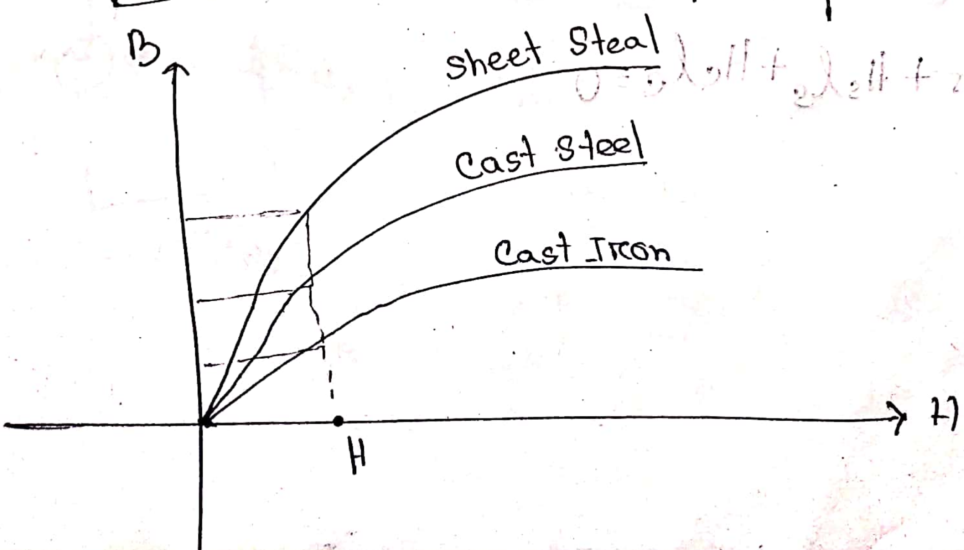








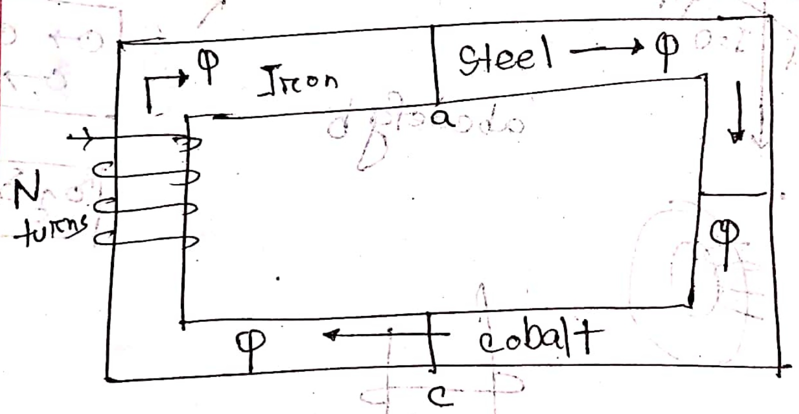


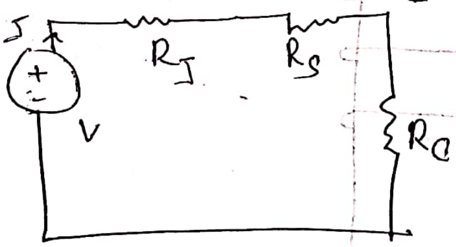


Ampere's Circuital Law

The algebraic sum of the rises and drops of the mmf around a closed loop of a magnetic circuit is equal to zero.

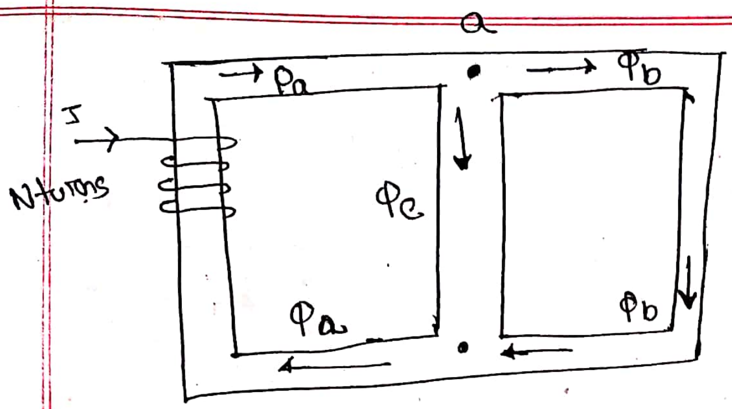
$\Sigma mmf_{rises} = \Sigma mmf_{drops}$





$-V + IR_1 + IR_S + IR_C = 0$

$-NI + H_I l_I + H_S l_S + H_C l_C = 0$



At junction a,

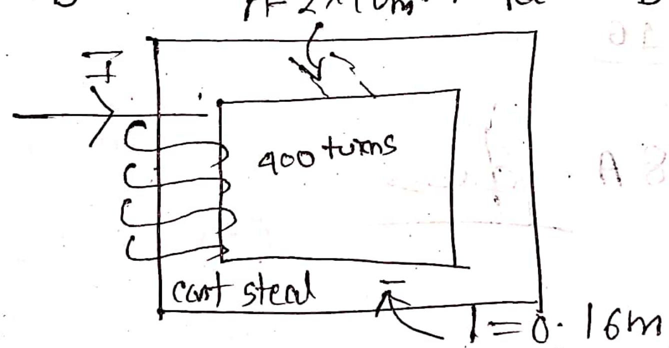
$\phi_a - \phi_b - \phi_c = 0$

$\Rightarrow \phi_a = \phi_b + \phi_b$

At junction b,

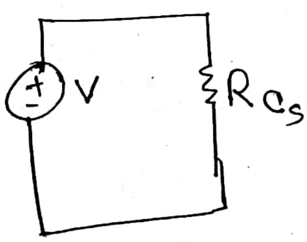
$\phi_c + \phi_b - \phi_a = 0$

$\Rightarrow \phi_a = \phi_b + \phi_c$



Find the value of I required to develop a magnetic flux of $\phi = 4\times10^{-4}$ Wb

$\Rightarrow$



$-V + IR_{cs} = 0$

By applying Ampere's curcuital law,

$-NI + H_{cs} l_{cs} = 0$

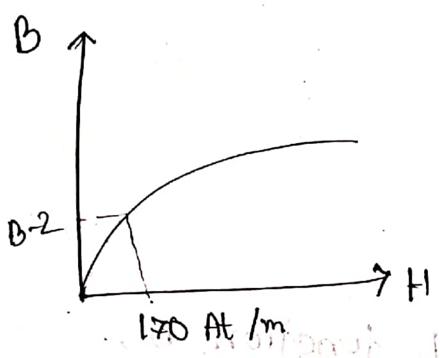
$\Rightarrow I = \dfrac{H_{cs} l_{cs}}{N}$

$B = \dfrac{\phi}{A}$

$= \dfrac{4\times10^{-4}}{2\times10^{-3}}$

$= 0.2\ T$

From B-H curve



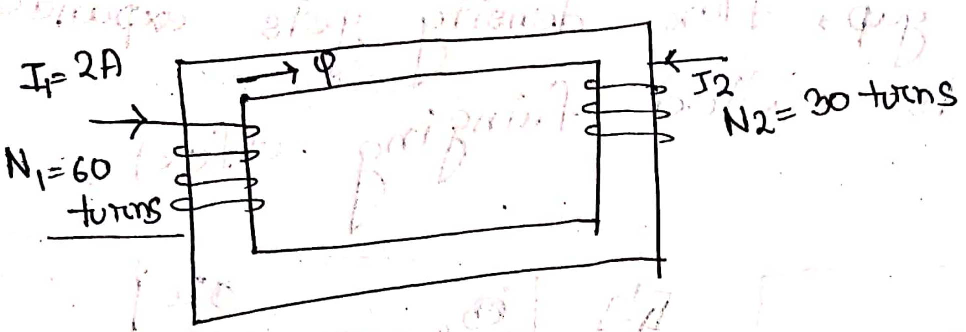
From B-H curve

$$H_{cs} \simeq 170 \, At/m$$

$$I = \frac{170 \times 0.16}{400}$$

$$= 0.068 \, A$$

Date: 11/03/2019

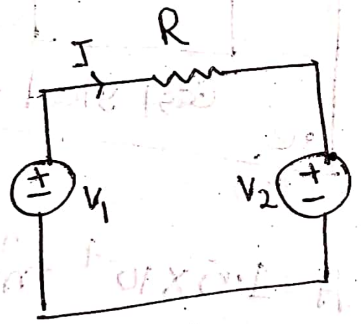


$\phi = 1.5 \times 10^{-5}$ Wb

$A = 0.15 \times 10^{-3}\ m^2$

$l = 0.16$ m $\quad I_2 = ?$

$\Rightarrow$



$-V_1 + IR + V_2 = 0$

By applying Ampere's Circuital law

$-N_1 I_1 + Hl + N_2 I_2 = 0$

$\Rightarrow N_2 I_2 = N_1 I_1 - Hl$

$\Rightarrow I_2 = \dfrac{N_1 I_1 - Hl}{N_2}$

$= 3.89$ A

$B = \dfrac{\phi}{A} = \dfrac{1.5 \times 10^{-5}}{0.15 \times 10^{-3}}$

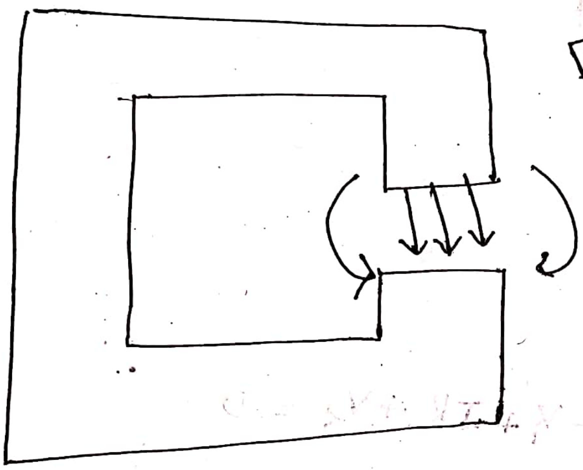
$= 0.1$ T

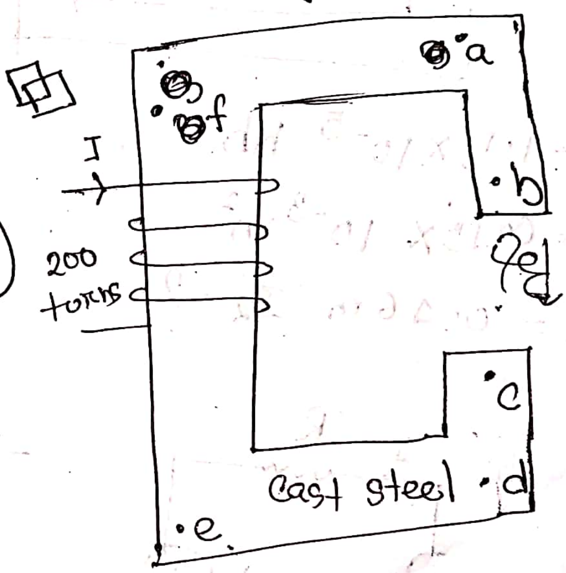
From B-H curve,

$H \cong 20$ At/m

Fringing Effect :

In air gap, flux density gets expanded. This effect is called fringing effect.





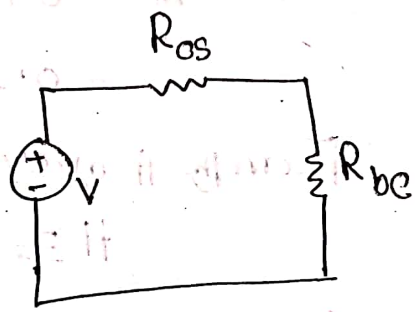
$A = 1.5 \times 10^{-4} \ m^2$

$\phi = 0.75 \times 10^{-4} \ Wb$

$l_{cdefab} = 100 \times 10^{-3} \ m$

$l_{bc} = 2 \times 10^{-3} \ m$

$\Rightarrow$



$-V + IR_{cs} + IR_{bc} = 0$

$\Rightarrow -NI + H_{cs} l_{cs} + H_{bc} l_{bc} = 0$

$$B = \frac{\phi}{A} = \frac{0.75\times10^{-4}}{1.5\times10^{-4}} = 0.5\,T$$

From B-H curve, $H_{es} \cong 6280$ At/m

For air, $B = \mu H$

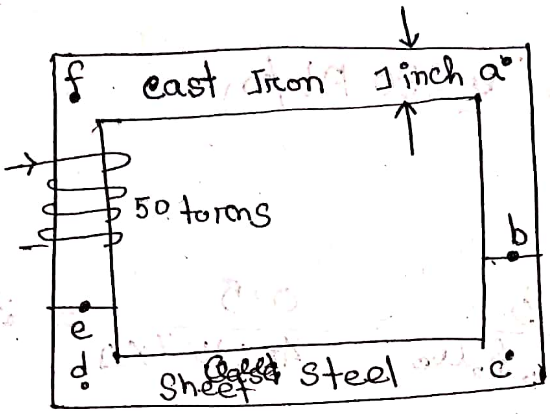
$$\mu_{bc} = \frac{B}{\mu} = \frac{B}{\mu_0 \mu_r} = \frac{0.5}{4\pi\times10^{-7}\times1} = 397886.43 \text{ At/m}$$

$$\therefore NI = H_{es} l_{es} + H_{bc} l_{bc}$$

$$\Rightarrow I = \frac{H_{es} l_{es} + H_{bc} l_{bc}}{N}$$

$$= 4.119\,A$$

Date: 18/03/2019



$I = ?$

$A = 1 \text{ inch}^2$

$l_{ab} = l_{cd} = l_{fe} = l_{fa} = 4 \text{ inch}$

$l_{bc} = l_{de} = 0.5 \text{ inch}$

$\phi = 3.5 \times 10^{-4} \text{ Wb}$

$A = 1 \text{ inch}^2$

$= (2.54 \times 10^{-2})^2$

$= 6.4516 \times 10^{-4} \text{ m}^2$

Now $B = \dfrac{\phi}{A} = \dfrac{3.5 \times 10^{-4}}{6.4516 \times 10^{-4}} = 0.53 \text{ T}$

From B-H curve

$H_{st} \cong 70 \text{ At/m}$; $H_{ci} = 1550 \text{ At/m}$

Now,

$$l_{st} = l_{bc} + l_{cd} + l_{de} = 0.5 + 4 + 0.5$$
$$= 5 \text{ inch}$$
$$= 5 \times 2.54 \times 10^{-2} = 0.127 \text{ m}$$

$$l_{ci} = l_{ef} + l_{fa} + l_{ab}$$
$$= 4 + 4 + 4$$
$$= 12 \text{ inch}$$
$$= 0.3048 \text{ m}$$

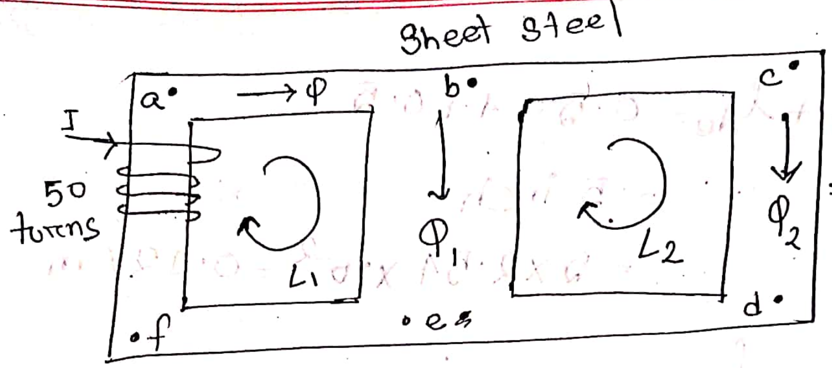
By applying Ampere's circuital law,

$$NI - H_{st} l_{st} - H_{ci} l_{ci} = 0$$

$$\Rightarrow I = \frac{H_{st} l_{st} + H_{ci} l_{ci}}{N}$$

$$= \frac{(70 \times 0.127) + (1550 \times 0.3048)}{50}$$

$$= 9.627 \text{ A}$$



$\varphi_2 = 1.5 \times 10^{-4}$ Wb

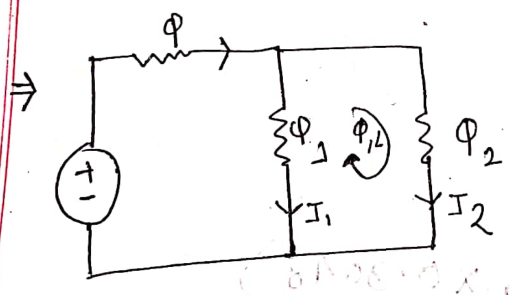
$l_{bcde} = l_{efab} = 0.2\,m$

$A = 6 \times 10^{-4}\,m^2$

$l_{bc} = 0.05\,m$

Find I, u, u_r in each section.

$\Rightarrow$



$B_2 = \dfrac{\varphi_2}{A}$

$= \dfrac{1.5 \times 10^{-4}}{(6 \times 10^{-4})}$

$= 0.25\,T$

From B-H curve

$H_{bcde} \cong 40$ At/m

$-V_1 + V_2 = 0$

By applying Ampere's circuital law around L_2

$-H_{bc} l_{bc} + H_{bcde} l_{bcde} = 0$

$\Rightarrow H_{bc} = \dfrac{H_{bcde}\, l_{bcde}}{l_{be}}$

$= \dfrac{40 \times 0.2}{0.05}$

$= 160$ At/m

From B-H curve

$B_1 \cong 0.97\ T$

$B_1 = \frac{\phi_1}{A}$

$\Rightarrow \phi_1 = B_1 \times A = 0.97 \times 6 \times 10^{-4}$
$= 5.82 \times 10^{-4}\ Wb$

$\phi = \phi_1 + \phi_2 = 5.82 \times 10^{-4} + 1.5 \times 10^{-4}$
$= 7.32 \times 10^{-4}\ Wb$

$B = \frac{\phi}{A} = \frac{7.32 \times 10^{-4}}{6 \times 10^{-4}} = 1.22\ T$

From B-H curve,

$H_{efab} \cong 400\ At/m$

Ampere's circuital law around L_1,

$-NI + H_{efab} l_{efab} + H_{be} l_{be} = 0$

$\Rightarrow I = \frac{400 \times 0.2 + 160 \times 0.05}{50}$

$= 1.76\ A$

From section bcde

$$B = \mu H$$

$$\Rightarrow \mu = \frac{B}{H} = \frac{0.25}{40} = 6.25 \times 10^{-3} \text{ wb/Am}$$

$$\mu = \mu_0 \mu_r$$

$$\Rightarrow \mu_r = \frac{\mu}{\mu_0} = \frac{6.25 \times 10^{-3}}{4\pi \times 10^{-7}} = 4972.2$$

For section bc,

$$\mu = \frac{B}{H}$$

$$= \frac{0.97}{160}$$

$$= 6.06 \times 10^{-3} \text{ wb/A.m}$$

$$\mu_r = \frac{\mu}{\mu_0} = \frac{6.06 \times 10^{-3}}{4\pi \times 10^{-7}} = 4821$$

For section efab

$$\mu = \frac{B}{H} = \frac{1.22}{400} = 3.05 \times 10^{-3} \text{ wb/Am}$$

$$\mu_r = \frac{\mu}{\mu_0} = \frac{3.05 \times 10^{-3}}{4\pi \times 10^{-2}} = 2426.41$$

Alternating Current

24/03/2019

An alternating current is such type of signal that goes through a series of different values both positive and negative in a period of time, after which it repeats the same series of values in cyclic manner.

Instanterous value:

The magnitude of a wave form at any instant of time.

Amplitude / Peak value:

The maximum value of a wave form.

$\boxed{V_{p-p} = 2V_p}$

Peak to peak value:

Full voltage between positive and negative peaks of the waveform

Period (T):

The time needed for one complete cycle of vibration to pass in a given point.

Cycle:

The portion of a waveform continued in one period of time.

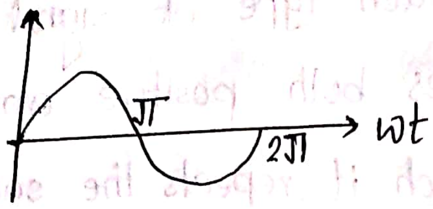
Frequency:

The number of cycles that occurs in 1 sec.

$$f = \frac{1}{T}$$

Unit: Cycle per second or ~~Hz~~ Hertz (Hz)

Angular velocity:

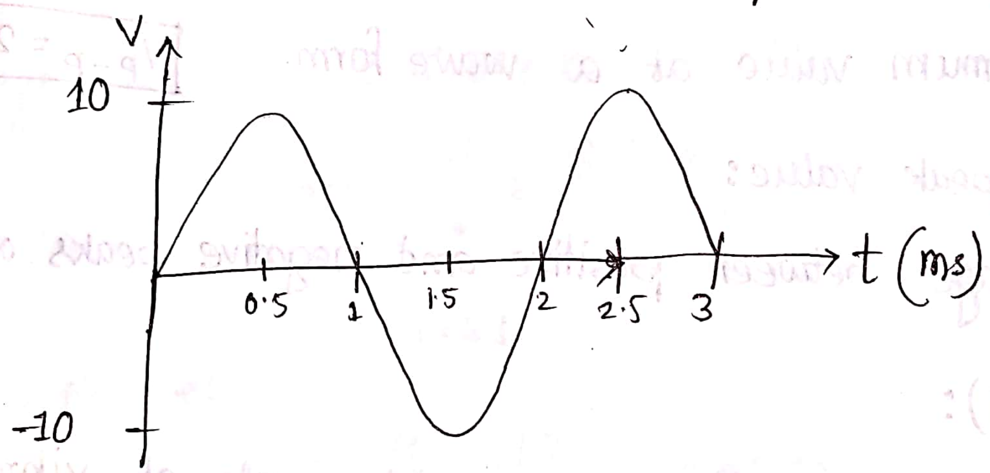


complete cycle $= 2\pi$

Time for a complete cycle $= T$

Angular velocity $= \frac{2\pi}{T}$ rad/s

$= 2\pi f$ rad/s.



$v = V_m \sin\theta$

$= V_m \sin\omega t$

$= V_m \sin 2\pi f t$

$= 10 \sin(2\pi \times 500t)$

$= 10 \sin(180000t)$

$=$

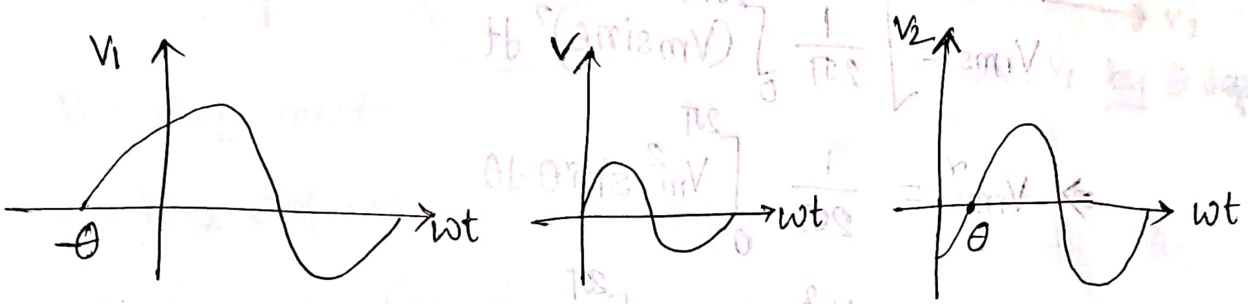
$f = \frac{1}{T} = \frac{1}{2\times10^{-3}}$ s

$= 500$ Hz

Scanned by CamScanner

Phase:

Phase is the fractional part of a period through which time or associated time angle ωt has advanced from an arbitrary reference.



$$V_1 = V_m\{\sin \omega t - (-\theta)\}$$
$$= V_m \sin(\omega t + \theta)$$

$\boxed{\text{Phase angle} = -\theta}$

$$V_2 = V_m \sin(\omega t - \theta)$$

$\boxed{\text{Phase angle} = \theta}$

Average value:

$$\text{Average value} = \frac{\text{Area under the curve}}{\text{Period}}$$

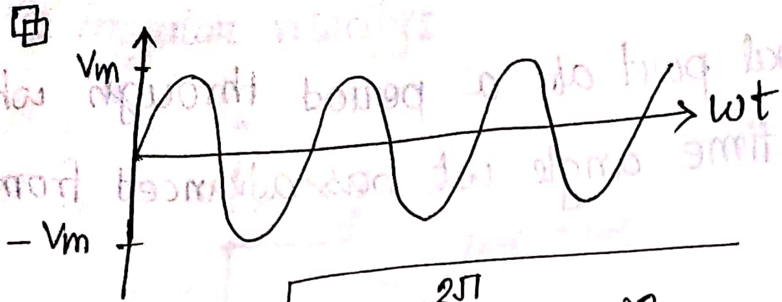
$$V_{avg} = \frac{1}{T}\int_0^T v\,dt$$

Effective value / Root mean square (rms) value

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

$$\text{Form factor} = \frac{V_{rms}}{V_{avg}}$$

$$\text{peak factor} = \frac{V_{avg}}{V_{rms}}$$



$$V_{rms} = \sqrt{\frac{1}{2\pi}\int_0^{2\pi} (V_m \sin\theta)^2\, dt}$$

$$\Rightarrow V_{rms}^2 = \frac{1}{2\pi}\int_0^{2\pi} V_m^2 \sin^2\theta\, d\theta$$

$$= \frac{V_m^2}{2\pi}\cdot\frac{1}{2}\int_0^{2\pi} 2\sin^2\theta\, d\theta$$

$$= \frac{V_m^2}{4\pi}\int_0^{2\pi} (1-\cos 2\theta)\, d\theta$$

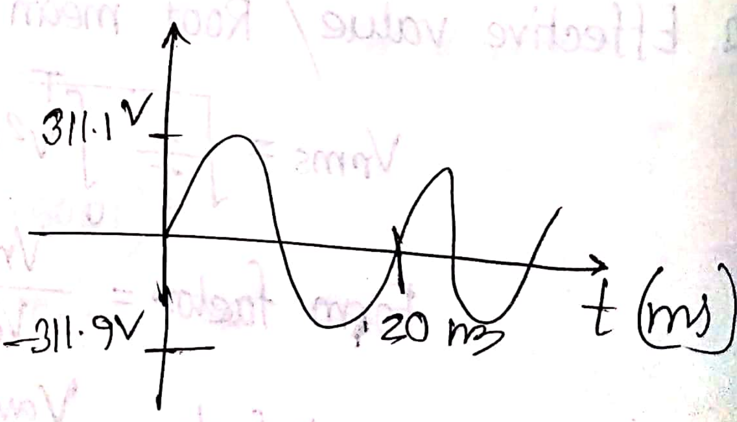
$$\Rightarrow V_{rms}^2 = \frac{V_m^2}{4\pi}\left[\theta - \frac{1}{2}\sin\theta\right]_0^{2\pi}$$

$$\Rightarrow V_{rms}^2 = \frac{V_m^2}{4\pi}\left[2\pi - 0 + 0 + 0\right]$$

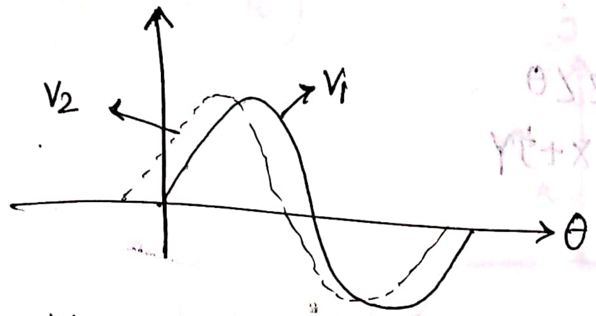
$$\Rightarrow V_{rms}^2 = \frac{V_m^2}{2}$$

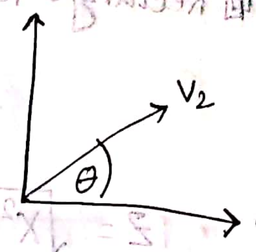
$$\Rightarrow V_{rms} = \frac{V_m}{\sqrt{2}}$$

$$\Rightarrow V_m = \sqrt{2}\, V_{rms}$$



Phase relation:





V_2 leads V_1 by θ degree.

$V_1 = V_{m1} \sin\omega t$

$V_2 = V_{m2} \sin(\omega t - (-\theta))$

$= V_{m2} \sin(\omega t + \theta)$

$\cos\alpha = \sin(\alpha + 90^\circ)$

$\sin\alpha = \cos(\alpha - 90^\circ)$

$-\sin\alpha = \sin(\alpha \pm 180^\circ)$

$-\cos\alpha = \sin(\alpha + 270^\circ) = \sin(\alpha - 90^\circ)$

$V = V_m \sin(\omega t + \theta)$

$V = V_{rms} \angle\theta$ — Polar form

$V = A + jB$ — Rectangular form

Example: $V = 10(\sin\omega t + 10^\circ)$

$v = \frac{10}{\sqrt{2}} \angle 10^\circ$

Conversion:

Rectangle to polar,

$$C = Z\angle\theta$$
$$C = X + jY$$

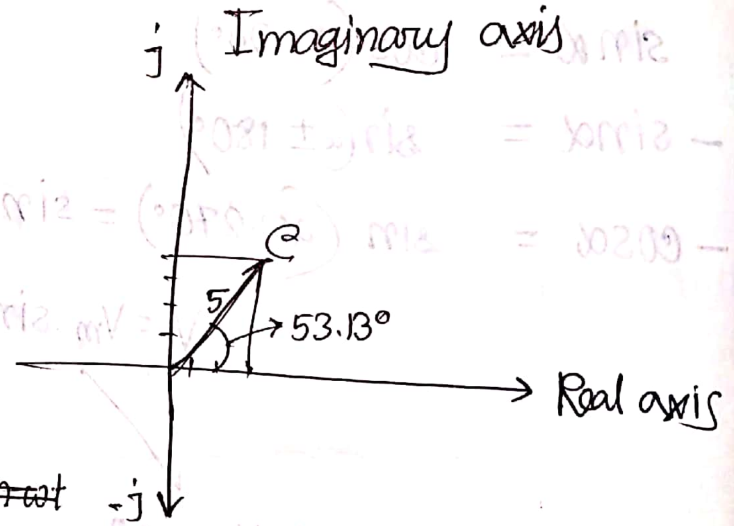
$$Z = \sqrt{X^2+Y^2}$$

$$\theta = \tan^{-1}\frac{Y}{X} \quad \Big| \quad C = Z\angle\theta$$

Polar to rectangle:

$$X = Z\cos\theta$$
$$Y = Z\sin\theta$$
$$C = X + jY$$

$$C = 3 + j4$$
$$Z = \sqrt{3^2+4^2} = 5$$
$$\theta = \tan^{-1}\frac{4}{3} = 53.13$$
$$C = 5\angle 53.13^\circ$$



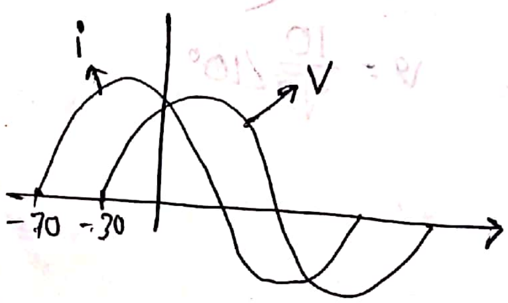
Complex plane

$$V = 10\sin(\omega t + 30^\circ) \cancel{= 10\sin\omega t}$$
$$i = 5\sin(\omega t + 70^\circ)$$

Find out the relationship between v & i.

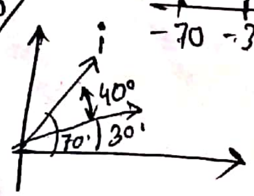
Soln:

$$V = 10\sin(\omega t - (-30^\circ))$$
$$i = 5\sin(\omega t - (-70^\circ))$$



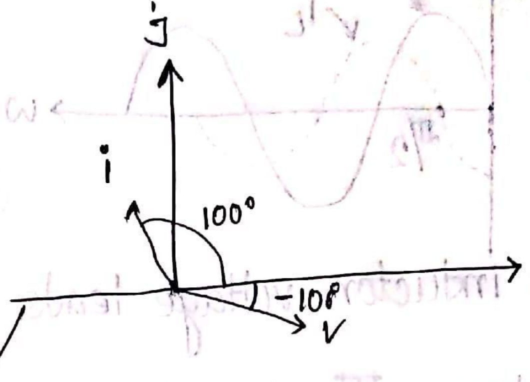
~~i Leads V by 40°~~

V lack i by 40°



$$i = 2\cos(\omega t + 10^\circ) = 2\sin(\omega t + 10^\circ + 90^\circ) = 2\sin(\omega t + 100^\circ)$$

$$v = 3\sin(\omega t - 10^\circ)$$

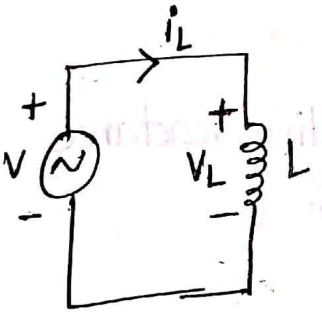


i leads v by 110°

V lacks i by 110°

31/03/2019

Inductor



The term L represents inductance. It opposses the rate of change of current and for this reason it is called electric inertia.

$$V_L = L\frac{di_L}{dt}$$

$$i_L = \frac{1}{L}\int V_L\,dt$$

Let, $v = V_m \sin\omega t$

Here, $v = V_L$

$$\Rightarrow V_m \sin\omega t = L\frac{di_L}{dt}$$

$$\Rightarrow \frac{di_L}{dt} = \frac{V_m}{L}\sin\omega t$$

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

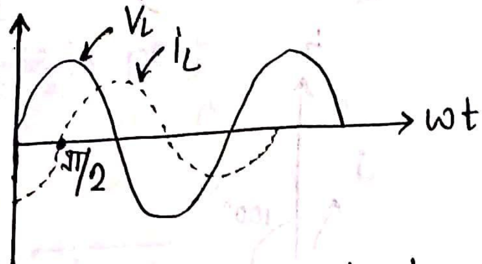
$$\Rightarrow i_L = -\frac{V_m}{\omega L}\cos\omega t$$

$$\Rightarrow i_L = \frac{V_m}{\omega L}(\sin\omega t - 90^\circ)$$

$$\Rightarrow i_L = I_m \sin(\omega t - 90^\circ)$$ Where, $I_m = \frac{V_m}{\omega L}$

$$V_L = V_{rms}\angle 0^\circ$$

$$i_L = I_{rms}\angle -90^\circ$$



∴ For inductor, voltage leads current by 90°.

Impedance: The impedence at the L branch is

$$Z_L = \frac{V_L}{i_L} = \frac{V_{rms}\angle 0^\circ}{I_{rms}\angle -90^\circ} = \frac{\sqrt{2}\,V_m\angle 0^\circ}{\sqrt{2}\,I_m\angle -90^\circ} = \frac{V_m}{I_m}\angle 90^\circ = \omega L\angle 90^\circ$$

$$= j\omega L = j2\pi f L$$

$\therefore Z_L = \omega L \angle 90^\circ$
$= jX_L$ ~~$\angle 90^\circ$~~

$X_L = \omega L$ = Inductive reactance
$= 2\pi f L$

Unit of Inductance: Henry (H)

Unit of reactance & impedance: Ohm (Ω).

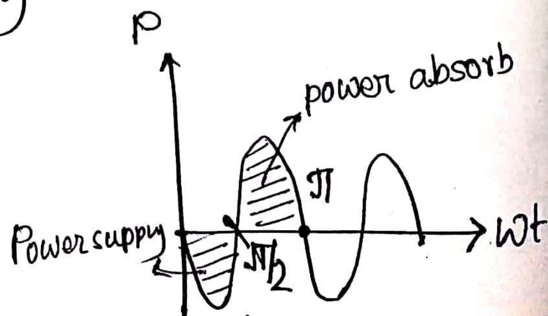
Power:

$$P = V_L i_L$$

$$= V_m \sin\omega t \times I_m \sin(\omega t - 90^\circ)$$

$$= -\frac{V_m I_m}{2} \times 2\sin\omega t \cdot \cos\omega t$$

$$= -\frac{V_m I_m}{2} \sin 2\omega t$$



Energy delivered to the inductor during a quarter of a cycle:

P.T.O

$$W_L = \int_{\pi/4}^{\pi/2} -\frac{V_m I_m}{2} \sin 2\omega t \, dt$$

$$= \frac{V_m I_m}{2(2\omega)} \left[\cos 2\omega t\right]_{\pi/4}^{\pi/2}$$

$$= \frac{V_m I_m}{4\frac{2\pi}{T}} \left[\cos \frac{4\pi}{T} t\right]_{\pi/4}^{\pi/2}$$

$$= \frac{V_m I_m}{8\pi/T} \left[\cos 2\pi - \cos \pi\right]_{\pi/4}^{\pi/2}$$

$$= \frac{V_m I_m}{8\pi/T} \left[1-(-1)\right]$$

$$= \frac{V_m I_m}{8\pi/T} 2$$

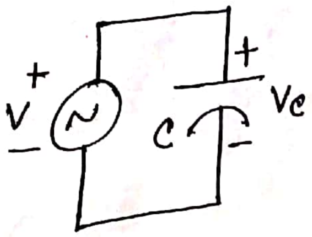
$$= \frac{V_m I_m}{2\omega}$$

$$= \frac{(\omega L I_m) I_m}{2\omega}$$

$$\therefore W_L = \frac{1}{2} L I_m^2$$

Capacitor:

Capacitor:



C = capacitor

$$i_c = C\frac{dV_c}{dt}$$

$$V_c = \frac{1}{C}\int i_c\,dt$$

Let, $V = V_m \sin\omega t$

Here, $V = V_c$

Now, $i_c = C\frac{dV_c}{dt}$

$= C\frac{dV}{dt}$

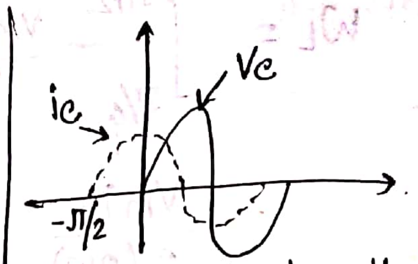
$= C\frac{d}{dt}(V_m \sin\omega t)$

$= C V_m \omega \cos\omega t$

$= \frac{V_m}{1/\omega C}\sin(\omega t + 90^\circ)$

$= I_m \sin(\omega t + 90^\circ)$

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



∴ current leads voltage by 90°.

Impedance:

$$Z_c = \frac{V}{i_c} = \frac{V_{rms}\angle 0^\circ}{I_{rms}\angle 90^\circ}$$

$$= \frac{\sqrt{2}\,V_m \angle 0^\circ}{\sqrt{2}\,I_m \angle 90^\circ}$$

$$= \frac{V_m}{I_m}\angle -90^\circ$$

$$= \frac{1}{\omega C}\angle -90^\circ$$

$$\therefore Z_c = \frac{1}{\omega C}\angle -90^\circ$$

$$= -j X_c$$

X_c = Capacitive reactance.

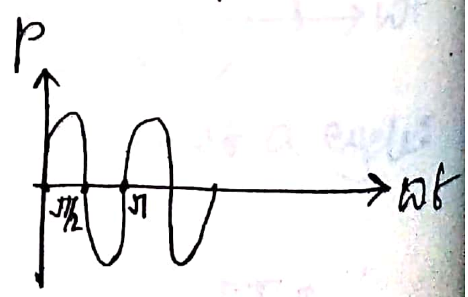
Instantenous power:

$$P = V_c i_c$$

$$= V_m \sin\omega t \cdot I_m \sin(\omega t + 90^\circ)$$

$$= \frac{V_m I_m}{2}\, 2\sin\omega t \cdot \cos\omega t$$

$$= \frac{V_m I_m}{2}\sin 2\omega t$$



Energy received by a capacitor during a quarter cycle:

$$W_C = \int_0^{\pi/4} \frac{V_m I_m}{2} \cancel{\sin \omega t} \sin 2\omega t \, dt$$

$$= \frac{V_m I_m}{2} \left[- \frac{\cos 2\omega t}{2\omega} \right]_0^{\pi/4}$$

$$= \frac{V_m I_m}{2 \times 2\omega} \left[-\cos \frac{4\pi t}{T} \right]_0^{\pi/4}$$

$$= \frac{V_m I_m}{4\omega} \left[-\cos \pi + \cos 0 \right]$$

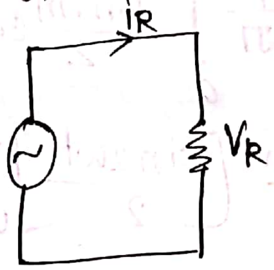
$$= \frac{V_m I_m}{2\omega}$$

$$= \frac{V_m (\omega C V_m)}{2\omega}$$

$$= \frac{1}{2} V_m^2 C$$

$$\therefore W_C = \frac{1}{2} V_m^2 C$$

⊞ The R branch



$$V = V_m \sin \omega t$$

$$i_R = \frac{V_R}{R} = \frac{V}{R}$$

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

$$= I_m \sin \omega t \quad \because I_m = \frac{V_m}{R}$$

Impedance:

$$Z_R = \frac{\frac{V_m}{\sqrt{2}} \angle 0^\circ}{\frac{I_m}{\sqrt{2}} \angle 0^\circ}$$

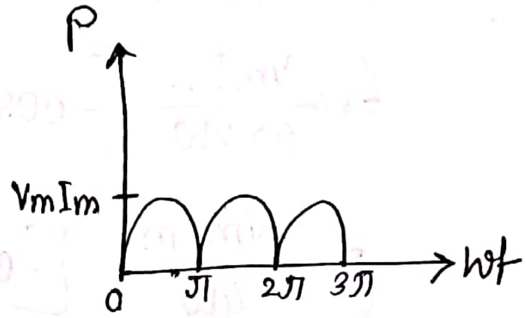
$$= R \angle 0^\circ$$

$$\therefore Z_R = R$$

Power: $p = v_R i_R$

$$= V_m \sin\omega t \cdot I_m \sin\omega t$$

$$= V_m I_m \sin^2\omega t$$



Average power:

$$P_{avg} = \frac{1}{2\pi}\int_0^{2\pi} P \, d\omega t$$

$$= \frac{1}{2\pi}\int_0^{2\pi} V_m I_m \sin^2\omega t \, d\omega t$$

$$= \frac{1}{2\pi}\int_0^{2\pi} \frac{V_m I_m}{2}(1-\cos 2\omega t)\, d\omega t$$

$$= \frac{1}{2\pi}\int_0^{2\pi} \frac{V_m I_m}{2} d\omega t - \frac{1}{2\pi}\int_0^{2\pi} \frac{V_m I_m}{2} \cos 2\omega t \cdot d\omega t$$

$$= \frac{V_m I_m}{4\pi}\left[\omega t\right]_0^{2\pi} - \frac{V_m I_m}{4\pi}\left[\frac{\sin 2\omega t}{2}\right]_0^{2\pi}$$

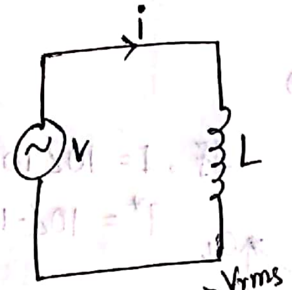
$$= \frac{V_m I_m}{4\pi} \times 2\pi$$

$$= \frac{V_m I_m}{2}$$

$$\therefore P_{avg} = \frac{V_m I_m}{2} = \frac{V_m I_m}{\sqrt{2} \cdot \sqrt{2}} = V_{rms} I_{rms}.$$

01.04.2019

If $L = 10\,mH$, $f = 60\,Hz$ and applied voltage is $V = 100\sin\omega t$. Find X_L & i for the following circuit.



$$X_L = \omega L$$
$$= 2\pi f L$$
$$= 2\pi \times 60 \times 10 \times 10^{-3}$$
$$= 3.77\,\Omega$$

$$V = \frac{100}{\sqrt{2}} \angle 0^\circ \quad (\rightarrow V_{rms})$$

$$Z_L = jX_L$$
$$= 3.77j = 3.77\angle 90^\circ$$

$$i = \frac{V}{Z_L} = \frac{\frac{100}{\sqrt{2}}\angle 0^\circ}{3.77\angle 90^\circ}$$

$$= -18.75j \;/\; 18.75\angle -90^\circ$$

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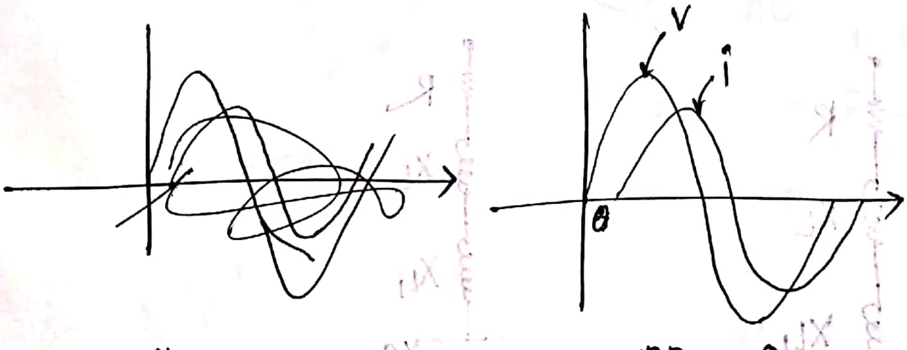
Power factor:



$PF = \cos\theta$

cosine of the $\angle$

Phase difference between voltage and current is power factor.

$$P_{avg} = V_{rms} I_{rms} \cos\theta.$$

Scanned by CamScanner

Power triangle

Real/Average power $\rightarrow P = \cancel{VI}\ V_{rms} I_{rms} \cos\theta$

Reactive power $\rightarrow Q = V_{rms} I_{rms} \sin\theta$

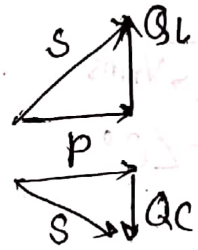
If, $I = 10\angle 10°$

$I^* = 10\angle -10°$

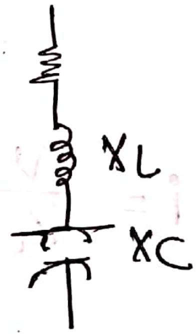
Apparent power $\rightarrow S = VI^*$

$S = P + jQ_L$ [For inductive load]

$S = P - jQ_C$ [For capacitive load]

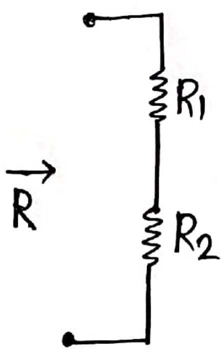


$\boxed{\begin{array}{l} X_L > X_C \text{ the circuit is inductive,} \\ X_C > X_L \text{ the " " capacitive} \end{array}}$

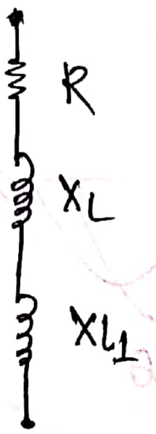


$\therefore |S| = \sqrt{Q^2 + P^2}$

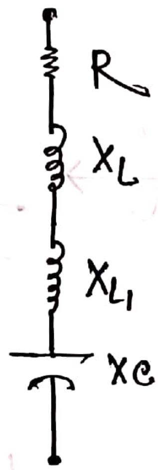
$\boxed{\begin{array}{l} \text{Inductor consumes } Q \\ \text{Capacitor supplies } Q \end{array}}$



$R = R_1 + R_2$

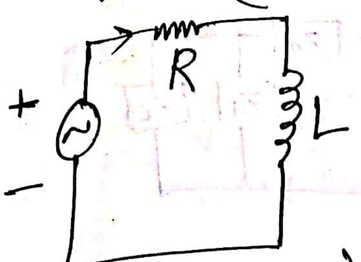


$Z = R + jX_L + jX_{L_1}$



$Z = R + jX_L + jX_{L_1} + (-jX_C)$

$i = 5\sin(314t + 120^\circ)$



$V = 15\sin(314t + 150^\circ)$

a) What is the value at the impedance at the circuit?

c ~~b)~~ What is the value at resistance?

d ~~c)~~ What is the value at the inductance?

*b) Find the power factor

Answer:

a) $Z = \frac{V}{i}$

$$= \frac{\frac{15}{\sqrt{2}}\angle 150^\circ}{\frac{5}{\sqrt{2}}\angle 120^\circ}$$

$= 3\angle 30^\circ$ impe

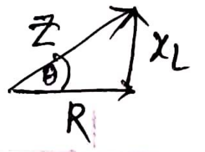
Ans

b) $PF = \cos(150^\circ - 120^\circ)$

$= 0.86$ (Lagging) → If the circuit is inductive

* capacitive হলে (leading)

c)



$\cos\theta = \frac{R}{|Z|}$

$\Rightarrow R = |Z|\cos\theta$

$= 3 \times 0.86$

$= 2.59\Omega$

d) $\sin\theta = \frac{X_L}{|Z|}$

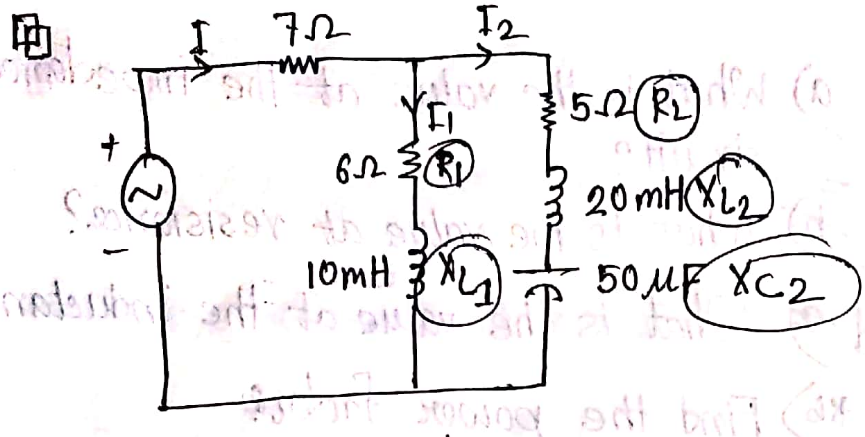
$\Rightarrow X_L = |Z|\sin\theta$

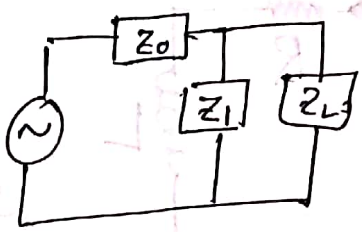
$= 3 \times \sin 30^\circ$

$= 1.5\Omega$

$X_L = \omega L$

$\Rightarrow L = \frac{X_L}{\omega} = \frac{1.5}{314} = 4.7 \times 10^{-3}$ H





$v = 141.4 \sin 100\pi t$

Find the current through each branch and the equivalent impedance connected to the source Also find the power factor.

$Z_0 = 7\Omega$

$Z_1 = R_1 + j X_{L1}$

$= 6 + j \omega L_1$

$= 6 + j(100\pi \times 10 \times 10^{-3})$

$= 6 + 3.14 j$

$= 6.77 \angle 27.62^\circ \Omega$

$Z_2 = R_2 + j X_{L2} - j X_{C2}$

$= 5 + j \omega L_2 - j \frac{1}{\omega C_2}$

$= 5 + j(100\pi \times 20 \times 10^{-3}) - j \frac{1}{(100\pi \times 50 \times 10^{-6})}$

$= 57.59 \angle -85.02^\circ \Omega$

$Z = Z_0 + (Z_1 \parallel Z_2)$

$= Z_0 + \frac{Z_1 Z_2}{Z_1 + Z_2}$

$= 7 + \frac{(6.77\angle 27.62^\circ) \times (57.59 \angle -85.02^\circ)}{(6.77 \angle 27.62^\circ) + (57.59 \angle -85.02^\circ)}$

$= 13.81 \angle 10.6^\circ \Omega$ A

> equivalent impedence

$$I = \frac{V}{Z}$$

$$= \frac{\frac{141.4}{\sqrt{2}} \angle 0^\circ}{13.81 \angle 10.6^\circ}$$

$$= 7.24 \angle -10.6^\circ \text{ A}$$

$$I_1 = I \times \frac{Z_2}{Z_1 + Z_2}$$

$$= 7.5 \angle -17.1^\circ \text{ A}$$

$$I_2 = I \times \frac{Z_1}{Z_1 + Z_2}$$

$$= 0.886 \angle 95.6^\circ \text{ A}$$

$$\therefore PF = \cos\{0 - \cancel{10}(-10.6^\circ)\}$$

$$= 0.98 \text{ lagging}$$