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COURSE TITLE :- LINEAR CIRCUT ANALYSIS

INSRTUCTOR :- "SIR SOHAIL IMRAN"

MODULE :- 3

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FINAL PAPER

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DEPARTMENT OF ELECTRICAL ENGINEERING

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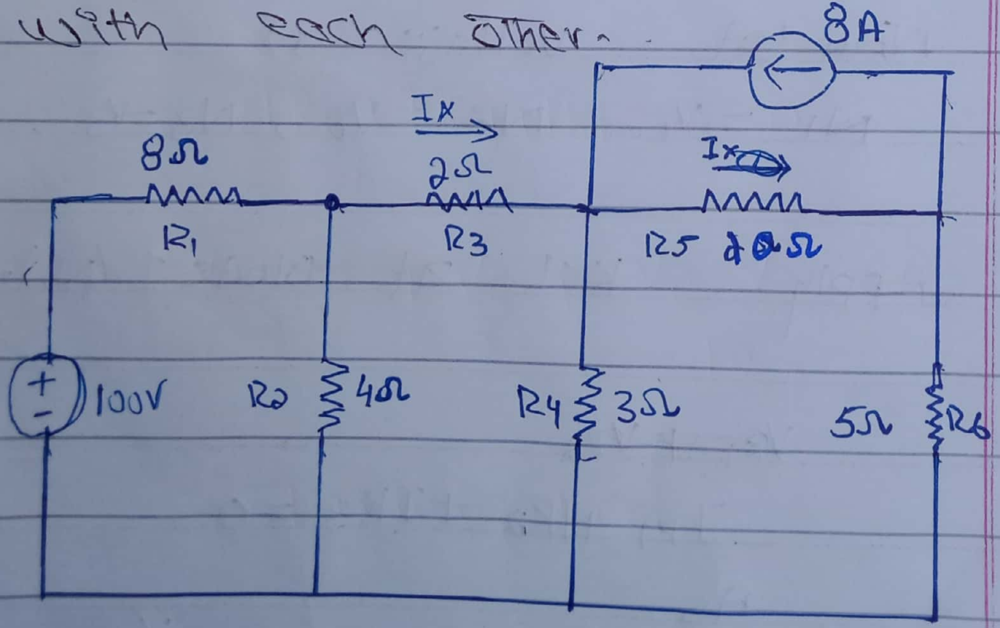
Q No 1:-

Find value of I_x using.

* Nodal Analysis
* Mesh Analysis
* Super possition theorem
* Com pair number of steps and ~~degree~~ of ~~easi~~ ensiness of all ~~the~~ Three method with each other.



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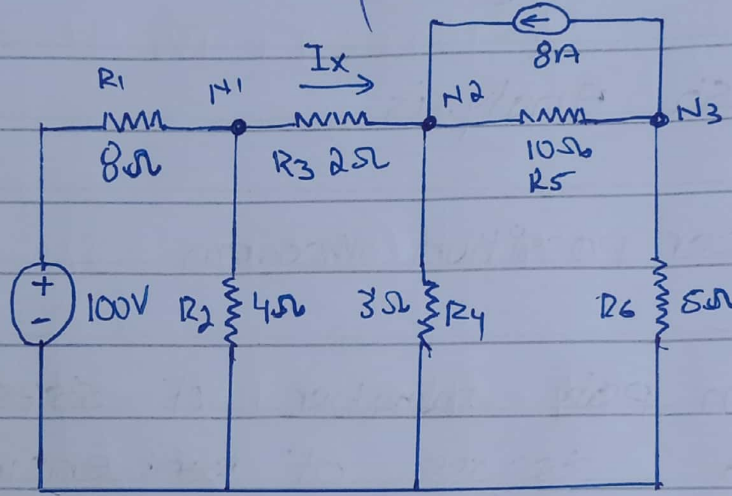
Solution:-

(1) By Nodal Analysis:-

Re draw the circuit and Identify Nodes.



~~Now~~ let voltage at

$N_1 = V_1$ $N_2 = V_2$, $N_3 = V_3$

Apply KCL at Node 1 (N_1).

~~$V_{R_1} + V_{R_2}$~~

$$I_{R_1} + I_{R_2} + I_{R_3} = 0$$

As

$$V = IR \Rightarrow I = V/R$$

$$\frac{V_1 - 100}{8} + \frac{V_1}{4}.$$

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(3)

$$\frac{V_1-100}{8}+\frac{V_1}{4}+\frac{V_1-V_2}{2}=0$$

Taking L.C.M.

$$\frac{V_1-100+2V_1+4(V_1-V_2)}{8}=0$$

$$\frac{V_1-100+2V_1+4V_1-4V_2}{8}=0$$

$$7V_1-4V_2-100=8\times0$$

$$7V_1-4V_2=100 \rightarrow (1)$$

Apply KCL at N2:-

$$I_{R2}+I_{R4}+I_{R5}-8=0$$

$$\Rightarrow \frac{V_2-V_1}{2}+\frac{V_2}{3}+\frac{V_2-V_3}{10}=8$$

Taking Lcm.

$$\frac{30V_2-30V_1+20V_2+6V_2-6V_3}{60}=8$$

(4)

$$\frac{30V_2 - 30V_1 + 20V_2 + 6V_2 - 6V_3}{60} = 8$$

$$-30V_1 + 56V_2 - 6V_3 = 8 \times 60$$

$$-30V_1 + 56V_2 - 6V_3 = 480 \rightarrow (2)$$

~~Ata~~ at N3:-

$$IR_5 + IR_6 + 8 = 0$$

$$\Rightarrow \frac{V_3 - V_2}{10} + \frac{V_3}{5} = -8$$

Take lcm

$$\frac{V_3 - V_2 + 2V_3}{10} = -8$$

$$\frac{-V_2 + 3V_3}{10} = -8$$

$$-V_2 + 3V_3 = -80 \rightarrow (3)$$

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From eq ①

$$7V_1 - 4V_2 = 100$$

$$7V_1 = 100 + 4V_2$$

$$V_1 = \frac{100 + 4V_2}{7}$$

$$\boxed{V_1 = \frac{100 + 4V_2}{7}} \rightarrow (4)$$

From equation (3)

$$-V_2 + 3V_3 = -80$$

$$3V_3 = -80 + V_2$$

$$V_3 = \frac{-80 + V_2}{3}$$

$$\boxed{V_3 = \frac{V_2 - 80}{3}} \rightarrow (5)$$

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NOW put equation (5) & (4) in eq (2)

2 =>

$$-30V_1 + 56V_2 - 6V_3 = 480$$

$$-30\left(\frac{100+4V_2}{7}\right) + 56V_2 - 6\left(\frac{V_2-80}{3}\right) = 480$$

$$-30\left(\frac{100}{7} + \frac{4V_2}{7}\right) + 56V_2 - 6\left(\frac{V_2}{3} - \frac{80}{3}\right) = 480$$

$$\Rightarrow -30(14.28 + 0.57V_2) + 56V_2 - 6(0.33V_2 - 26.6) = 480$$

$$-428.4 - 17.1V_2 + 56V_2 - 1.98V_2 + 159.6 = 480$$

$$36.98V_2 - 268 = 480$$

$$36.98V_2 = 480 + 268$$

$$36.98 V_2 = 748$$

$$V_2 = 748/36.98$$

$$\boxed{V_2 = 20.22 \text{ volt}}$$

put value of V_2 in eq (H)

$H \Rightarrow$

$$V_1 = \frac{100 + 4V_2}{7}$$

$$V_1 = \frac{100 + (4 \times 20.22)}{7}$$

$$= \frac{100 + 80.90}{7}$$

$$\boxed{V_1 = 25.8 \text{ volt}}$$

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NOW For I_x

From ohm law

$V = IR$

$I = V/R$ —

but here

$V = V_1 - V_2$

$R_3 = 2\,\Omega$

$$I_x = \frac{V_1 - V_2}{R_3}$$

$$= \frac{25.8 - 20.22}{2}$$

$$I_x = \frac{5.624}{2}$$

$I_x = 2.79$

$I_x = 2.8\,A$

$\boxed{I_x = 2.79 \text{ OR } I_x = 2.8\,A}$ → ANS

x —— x —— x —— x —— x.

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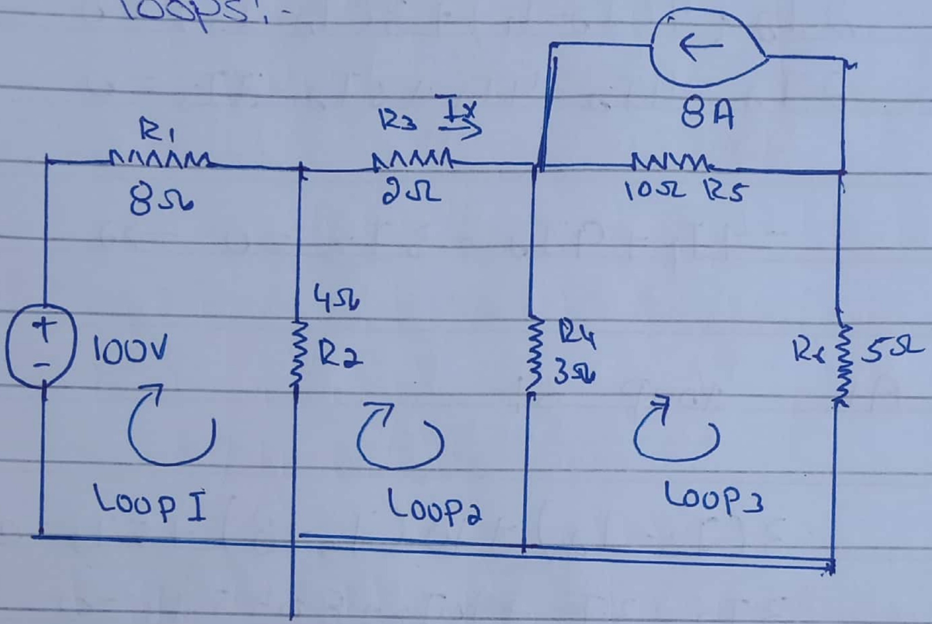
(2) MESH analysis :-

Ree draw circuit & identify loops :-



Current in loop1 = I_1

Loop2 = I_2 & loop3 = I_3

Apply KVL at loop 1

$V_{R_1} + V_{R_2} = 100$ $\quad$ ∴ $V = IR$

$8I_1 + 4(I_1 - I_2) = 100$

$8I_1 + 4I_1 - 4I_2 = 100$

$12I_1 - 4I_2 = 100 \rightarrow (1)$

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At loop 2:-

$$V_{R2} + V_{R3} + V_{R4} = 0$$

$$2I_2 + 4(I_2 - I_1) + 3(I_2 - I_3) = 0$$

$$2I_2 - 4I_2 - 4I_1 + 3I_2 - 3I_3 = 0$$

$$-4I_1 + 9I_2 - 3I_3 = 0 \rightarrow 2$$

At loop 3:-

$$3(I_3 - I_2) + 10(I_3 + 8) + 5I_3 = 0$$

$$3I_3 - 3I_2 + 10I_3 + 80 + 5I_3 = 0$$

$$-3I_2 + 18I_3 = -80 \rightarrow 3$$

From eq 1

$$12I_1 - 4I_2 = 100$$

$$I_1 = \frac{100 + 4I_2}{12}$$

$$\boxed{I_1 = \frac{4I_2 + 100}{12}} \rightarrow (N)$$

From eq (3)

$$-3I_2 + 18I_3 = -80$$

$$\boxed{I_3 = \frac{3I_2 - 80}{18}} \rightarrow K$$

put N & K in (2)

(1) ⇒

$$-4I_1 + 9I_2 - 3I_3 = 0$$

$$-4\left[\frac{4I_2 + 100}{12}\right] - 3\left[\frac{3I_2 - 80}{18}\right] + 9I_2$$

$$-4(0.33I_2 + 8.3) - 3(0.16I_2 - 4.44) + 9I_2 = 0$$

$$-1.32I_2 - 33.23 - 0.58I_2 + 13.2 + 9I_2 = 0$$

$$7.18I_2 - 20.13 = 0$$

~~$7.5I_2$~~

$$I_2 = \frac{20.13}{7.18}$$

$$I_2 = 2.79$$

$$I_2 = 2.8$$

Here $I_2 = I_x$ ⇒ $\boxed{I_x = 2.79 \text{ OR } I_x = 2.8A}$ → ANS

Super possition Theorm.

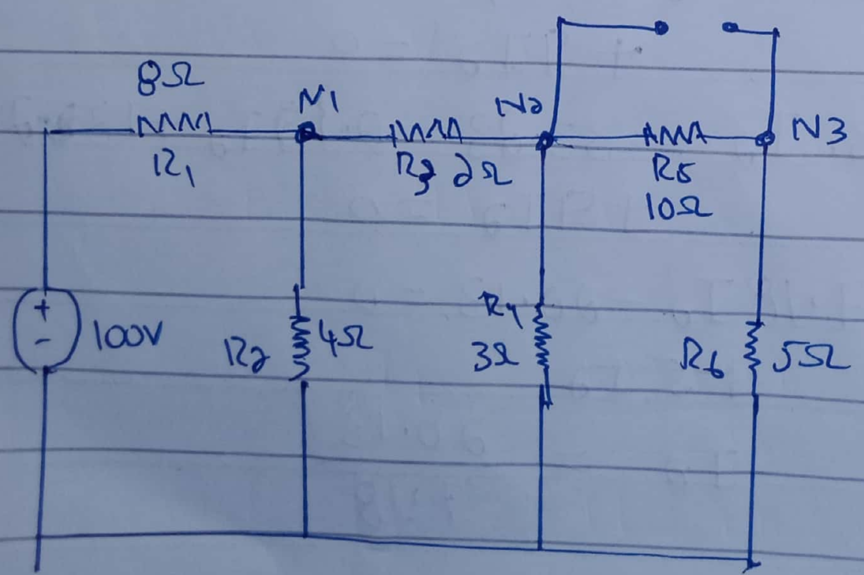
we can Find Ix by Supper possition

1st Remove The current source by open circuit and calculat I_1

2nd vremove The voltage source by short circuit & calculat I_2 Then For Ix Add I_1 & I_2

$$I_x = I_1 + I_2.$$

Draw circuit by removing current souce by open circuit also identify nodes.



at Node 2

$$\frac{V_1 - 100}{8} + \frac{V_1}{4} + \frac{V_1 - V_2}{2} = 0$$

$$\frac{V_1 - 100 + 2V_2 + 2V_1 - 2V_2}{8} = 0$$

$$7V_1 - 4V_2 = 100 \rightarrow ①$$

at Node 2:-

$$\frac{V_2 - V_1}{2} + \frac{V_2}{3} + \frac{V_2 - V_3}{10} = 0$$

$$\frac{30V_2 - 30V_1 + 20V_2 + 6V_2 - 6V_3}{60} = 0$$

$$-30V_1 - 30V_2$$

$$-30V_1 + 56V_2 - 6V_3 = 0 \rightarrow (ii)$$

at Node 3

$$\frac{V_3 - V_2}{10} + \frac{V_3}{5} = 0$$

$$\frac{V_3 - V_2 + 2V_3}{10} = 0$$

$$-V_2 + 3V_3 = 0 \rightarrow (iii)$$

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From equation 1

$$7V_1 - 4V_2 = 100$$

$$\boxed{V_1 = \frac{100 + 4V_2}{7}} \rightarrow (5)$$

From equation (3):

$$-V_2 + 3V_3 = 0$$

$$\boxed{V_3 = \frac{1}{3} V_2}$$

put value of V_1 & V_3 in equation (ii)

(ii) $\Rightarrow$

$$-30V_1 + 56V_2 - 6V_3 = 0$$

$$-30\left(\frac{100 + 4V_2}{7}\right) + 56V_2 - 6\left(\frac{1}{3}V_2\right) = 0$$

$$-30(14.28 + 0.57V_2) + 56V_2 - 2V_2 = 0$$

$$-428.4 - 17.1V_2 + 56V_2 - 2V_2 = 0$$

$$-428.4 + 36.9V_2 = 0$$

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(25)

$V_2 = 428.4 / 36.9$

$\boxed{V_2 = 11.6 \text{ volt}}$

put $V_2 = 11.6$ in eq(5)

(5) $\Rightarrow$

$$V_1 = \frac{100 + \cancel{56}4V_2}{7}$$

$$V_1 = \frac{100 + (4 \times 11.6)}{7}$$

$\boxed{V_1 = 20.91 \text{ V}}$

From ohm law

$I = V/R$

Here $V = \cancel{V_2} \; V_1 - V_2$

$R = 2\,\Omega$

$$I_1 = \frac{20.91 - 11.6}{2}$$

$\boxed{I_1 = 4.65 A}$

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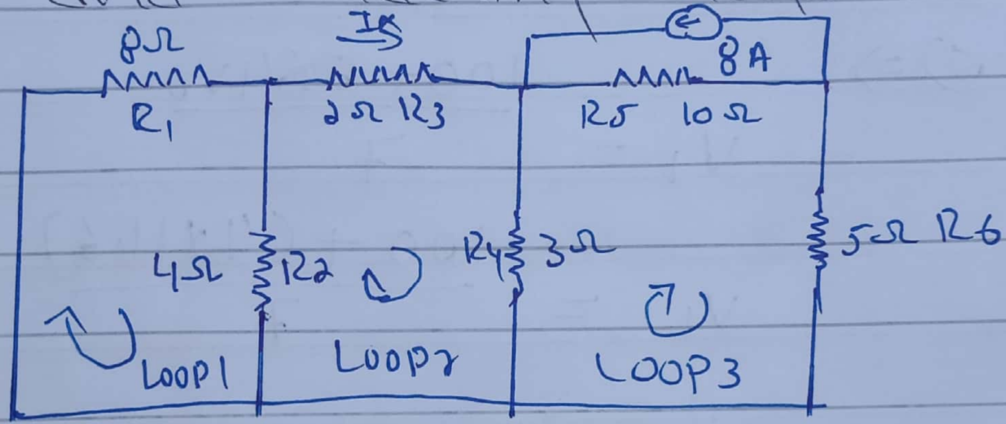
Now remove volt source ~~and~~ as short circuit-
Re-draw circuit by removing voltage source and identify loops.



Curren in loop 1 $= I_1$, loop 2 $= I_2$ & loop 3 $= I_3$.

Apply KVL to loop 1 :-

$$8I_1 + 4(I_1 - I_2) = 0$$

$$8I_1 + 4I_1 - 4I_2 = 0$$

$$12I_1 - 4I_2 = 0$$

$$4(3I_1 - I_2) = 0$$

$$3I_1 - I_2 = 0 \rightarrow (1)$$

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at loop 2):-

$$2I_2 + 4(I_2 - I_1) + 3(I_2 - I_3) = 0$$
$$2I_2 + 4I_2 - 4I_1 + 3I_2 - 3I_3$$

$$-4I_1 + 9I_2 - 3I_3 = 0 \rightarrow (ii)$$

at loop 3):-

$$3(I_3 - I_2) + 10(I_3 + 8) + 5I_3 = 0$$
$$3I_3 - 3I_2 + 10I_3 + 80 + 5I_3 = 0$$

$$-3I_2 + 18I_3 = -80 \rightarrow (3)$$

From eq (1):-

$$3I_1 - I_2 = 0$$

$$I = 1/3\, I_2 \rightarrow (k)$$

From eq (3)

$$-3I_2 + 18I_3 = -80$$

$$\cancel{-3I_2 = 80 - 18T}$$

$$I_3 = \frac{-80 + 3I_2}{18} \rightarrow (M)$$

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Put eq 18 m
in eq (2)

(2) =>

$-4I_1 + 9I_2 - 3I_3 = 0$

$$-4\left(\tfrac{1}{3}I_2\right) + 9I_2 - \left(3\left(\frac{3I_2 - 80}{18}\right)\right) = 0$$

$\cancel{-1.3 I_2 + 9 I_2 - 3}$

$-1.3I_2 + 9I_2 - 0.5I_2 + 13.3 = 0$

$7.2I_2 + 13.2 = 0$

$7.2I_2 = -13.2$

$\boxed{I_2 = -1.83A} \rightarrow *$

Now From super position Theorem

$I_x = I_1 + I_2$

put vale of I_1 & I_2

$I_x = 4.65 - 1.83$

$I_x = 2.79$

$\boxed{I_x = 2.8}$

$\boxed{\begin{array}{l} I_x = 2.79 \\ \text{or} \quad I_x = 2.8 \end{array}}$

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(iv) **Comparism:-**

* From Nodal Analysis we get $I_x = 2.8A$

* From mesh Analysis we get $I_x = 2.8A$

* From super possition Theorem we get $I_x = \cancel{2.0}\ 2.8A$.

by ~~aa~~ sto solving the circuit different method we get same result which $I_x = 2.8A$.

but superpossition theorm is quit easir that nodal & mesh analysis. because it very deficult to identify nodes & loops in complex circuit having current & voltage source at a time. In super position we ~~can~~ take one source at a time which makes circuit easy. ~~I think super possition is quit~~

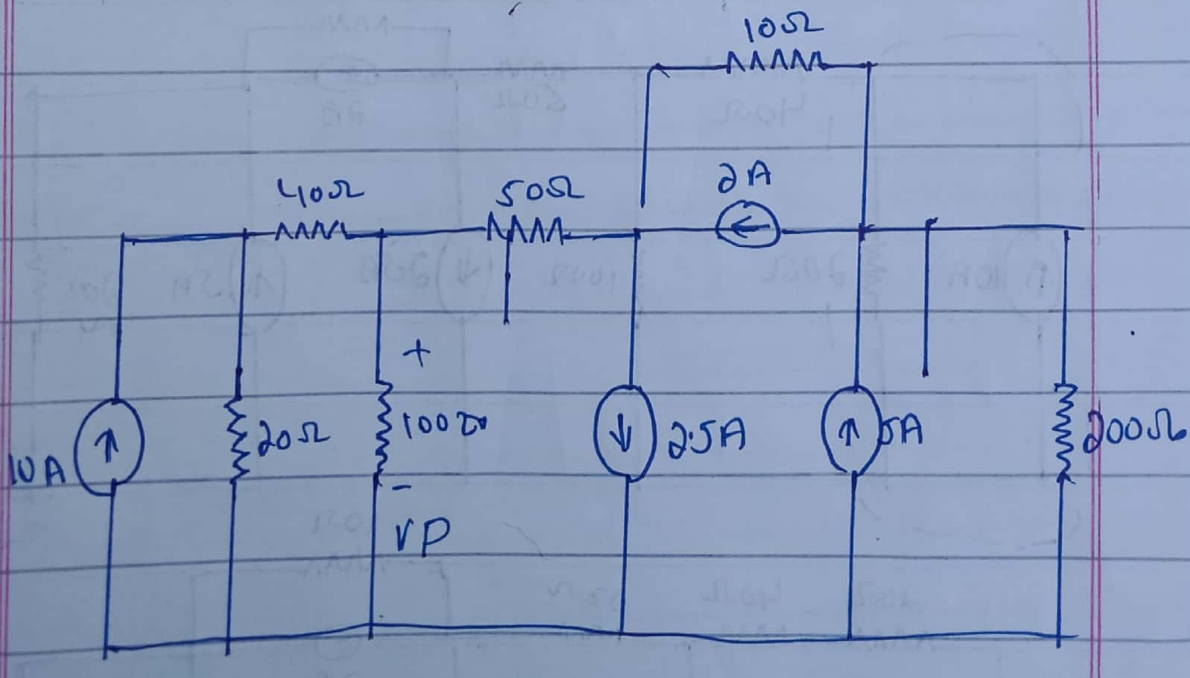
Due to removal of one source i.e current or voltage it became to easy and the equation became also easy.
that why I Think that super possition method is quit easy than Nodal & mesh analysis.

x —x —x —x —x—x

QNo2:-

Consider The 200 ohm ~~resistor~~ as a load resistor and ~~devo~~ develop

* Thevinin equivalent circuit
* Northen equivalent circuit
* Find out value of Thevinin resistance should be used to delever max-power to the load.

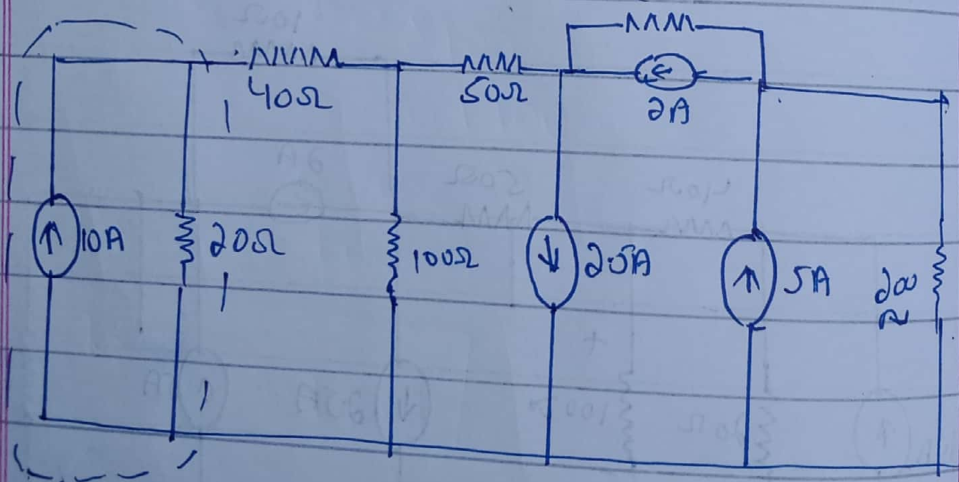


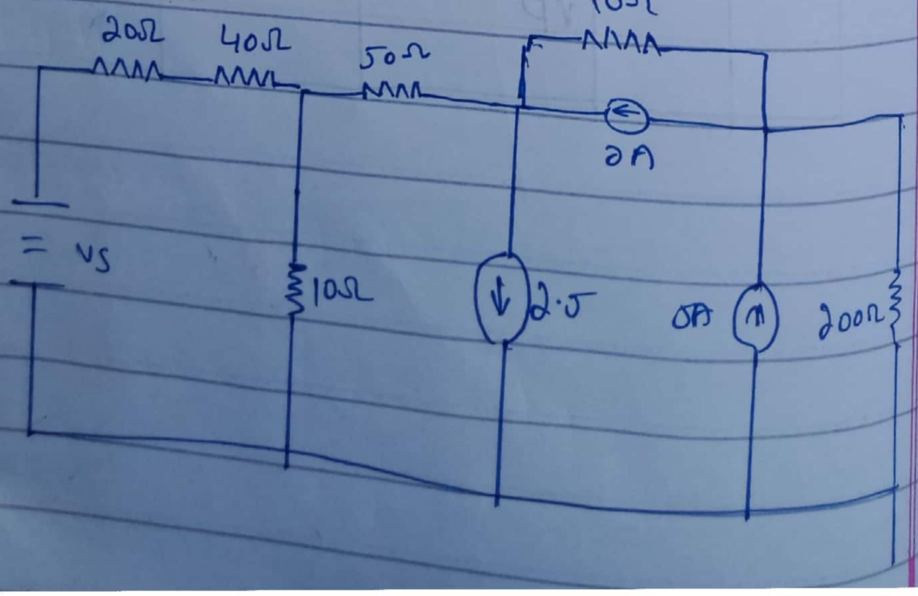
Solution:

THEVENIN'S THEOREM:-

In oxder to solve the question /circuit in THEVENIN'S Theorim we need a votage soure. ~~which~~

So Frist covert 10 A current source to votage soure and re draw circuit.





(23)

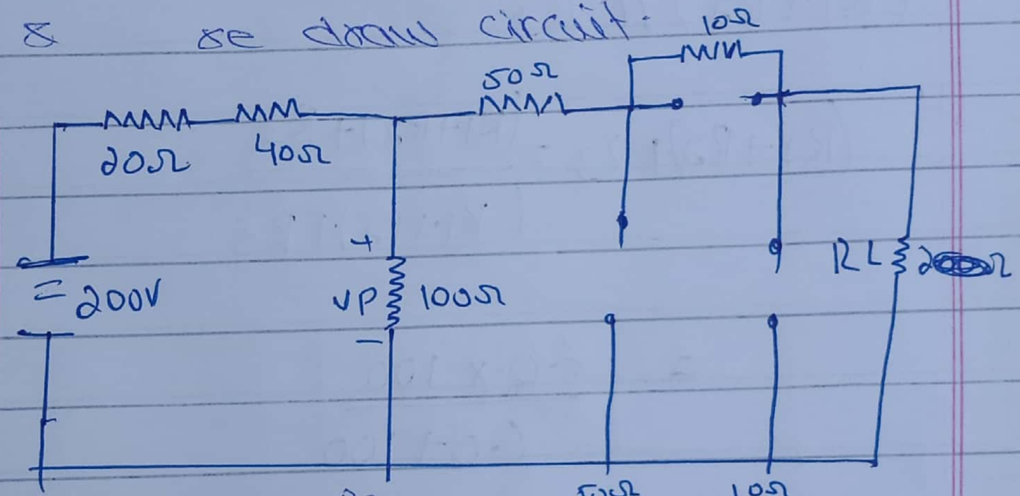
Now

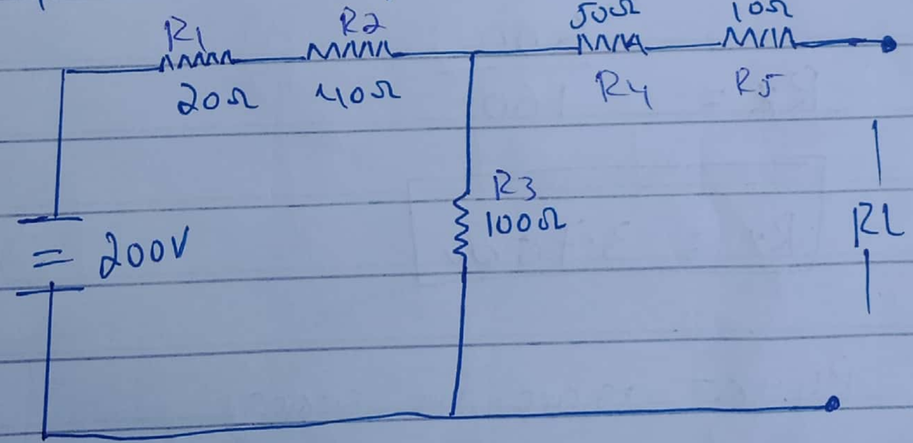
$$V_S = I R$$

$$V_S = 10 \times 20$$

$$V_S = 200 \text{ Volt.}$$

For Thevinin equilant resistance "RTH" remove all current source & re draw circuit.





In above Fig:-

R1 & R2 are in series but parral to R3

$\Rightarrow R_1 + R_2 \parallel R_3$

& Also R_4 & R_5 in series but $\parallel R_3$

$R_1 + R_2 = 20 + 40$

$R_1 + R_2 = 60\Omega \parallel R_3$

$(R_1 + R_2) \parallel R_3$

$$(R_1 + R_2) + R_3 = \frac{(R_1 + R_2) + R_3}{(R_1 + R_2) + R_3}$$

$$= \frac{60 \times 100}{60 + 100}$$

$$R_x = \frac{600}{160}$$

$$\boxed{R_x = 3.75\Omega}$$

$R_4 + R_5$ ~~is~~ are in series.

$R_4 + R_5 = 5\cancel{0} + 10$

$R_4 + R_5 = 60 = R_y$

$$\boxed{R_y = 60}$$

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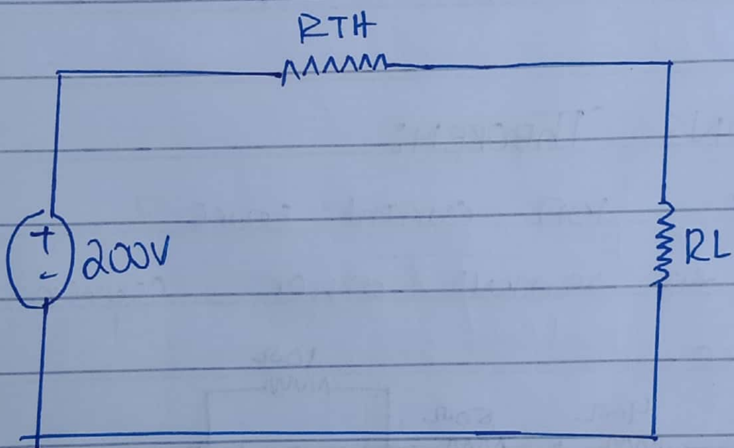
~~(22)~~ (25)

Ry & Rx are 11

$$R_{TH} = \frac{3.75 \times 60}{3.75 + 60}$$

$$R_{TH} = \frac{225}{63.7}$$

$$\boxed{R_{TH} = 3.53\,\Omega}$$



Now by voltage divider rule.

$$V_{TH} = \left(\frac{10}{20+40+10}\right) 200$$

$$V_{TH} = \left(\frac{10}{70}\right) 200$$

$$\boxed{V_{TH} = 28.5 \text{ Volt}}$$

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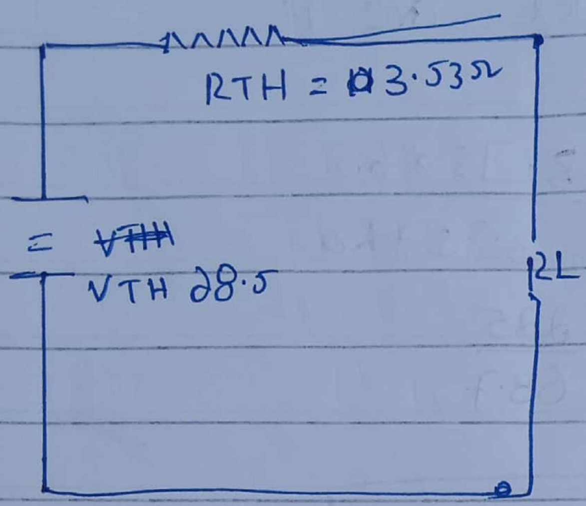
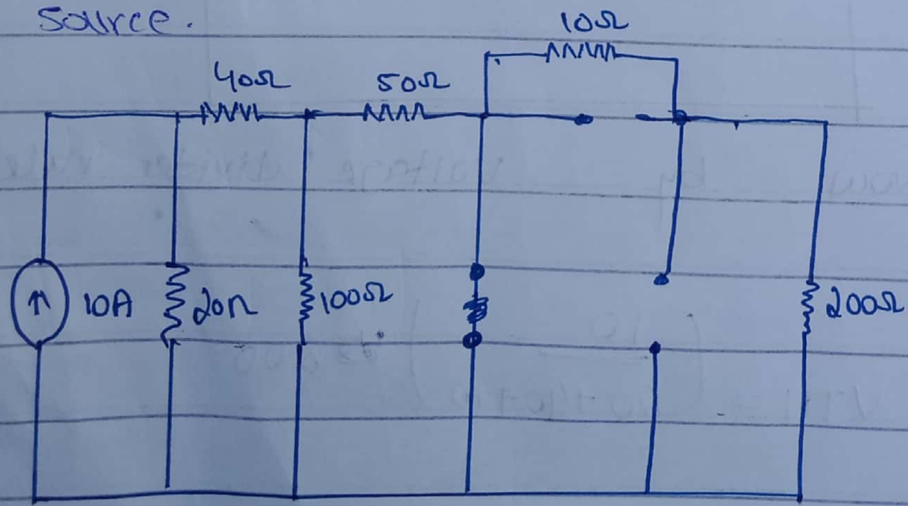


X — X — X — X — X

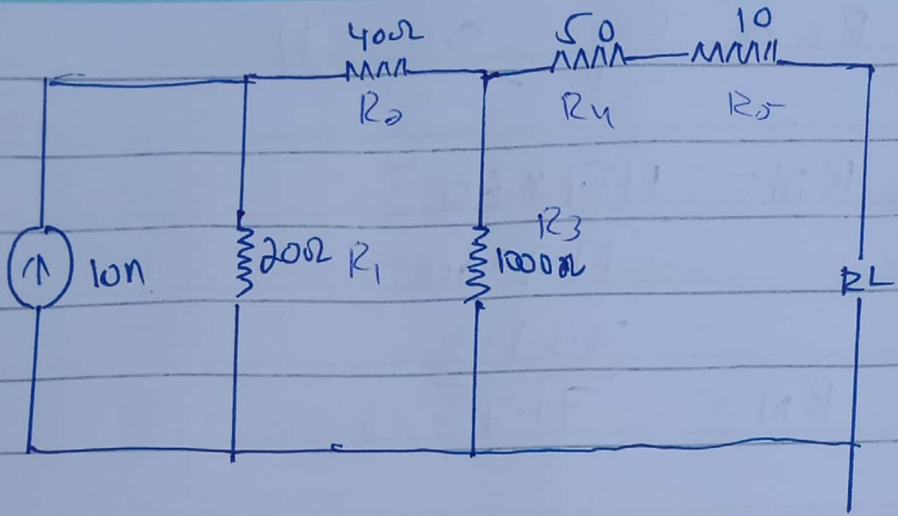
NORTONS THEOREM:

Take 10A current soure & ~~&~~ remove other current source.



Consider 200 Ω as Rl And FIND RN & IN.

(24) (27)



R4 & R5 series || R3

& R1 & R2 are parallel.

$$R_1 + R_2 = \frac{20 \times 40}{20 + 40} = \frac{800}{60}$$

$R_x = 13.3\,\Omega$

$R_x \parallel R_3$

$$R_x + R_3 = \frac{13.3 \times 100}{13.3 + 100}$$

$$= \frac{1330}{113.3}$$

$R_y = 11.7\,\Omega$

Now $R_4 + R_5$ in series.

$R_4 + R_5 = 50 + 10$

$R_z = 60\,\Omega$

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(28) (28)

R_2 & R_4 are ||

$$R_N = \frac{11.7 \times 60}{11.7 + 60}$$

$$R_N = \frac{704.3}{71.7}$$

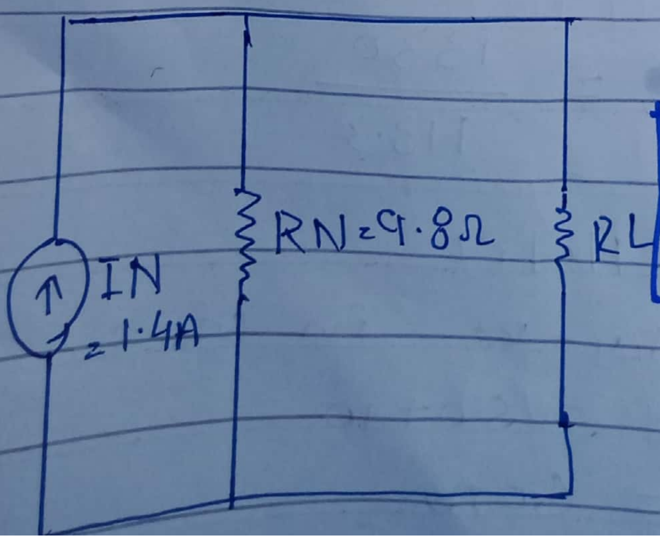
$$R_N = 9.8\,\Omega$$

For I_N: we use current devider.

$$I_N = \left(\frac{10}{10+60}\right) \times 10$$

$$I_N \; \frac{10}{70} \times 10$$

$$\boxed{I_N = 1.4A}$$



$$\boxed{\begin{array}{l} I_N = 1.4 \\ R_N = 9.8 \end{array}}$$

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(c)

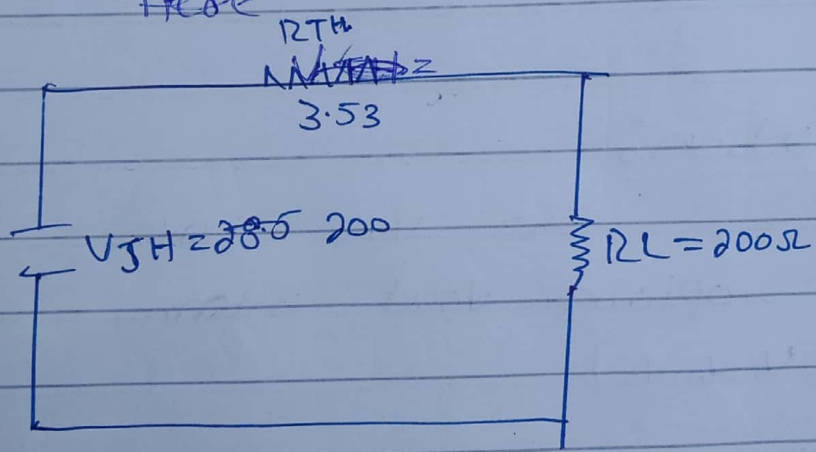
I value of Thevinin resistance For deliver maximum power-

We know that

~~$P_L = I_L^2 R_L =$~~

$$P_L = I^2 R_L = \frac{V_S^2 \, R_L}{(R_S + R_L)^2}$$

~~Here~~



$$P_L = \frac{(28.5)^2 \cdot 200}{(200 + 3.53)^2}$$

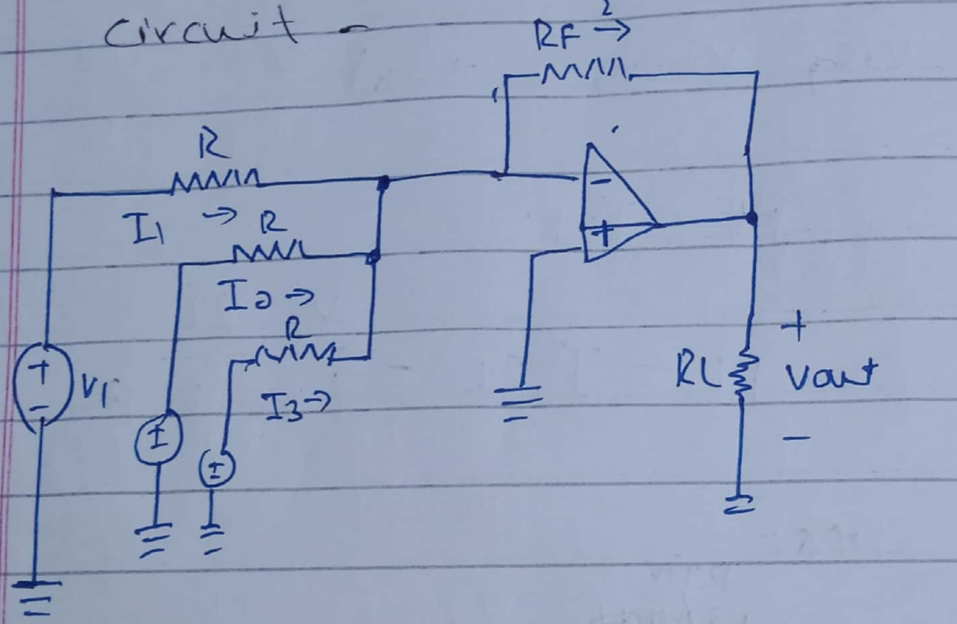
$$P_L = \frac{11400}{203.5}$$

$P_L = 56.1$ Watt

maximum power is transfer when RL = RTH -

x —— x —— x —— x —— x

Obtain an expression For Vout in term of V_1, V_2, V_3 For op amp circuit -



Solution:

~~The~~ we have to optain Vout interm (V_1, V_2, V_3)

No current can Flow into the inverting input terminal

$$i = I_1 + I_2 + I_3$$

we use both value when analysis an op amp

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Thus

$$Va = Vb = 0$$

So we can write

$$0 = \frac{Vout}{RF} + \frac{V_1}{R} + \frac{V_2}{R_3} + \frac{V_3}{R}$$

by Re-arranging.

$$Vout = -\frac{RF}{R}(V_1 + V_2 + V_3)$$

Here $V_2 = V_3 = 0$
we see that our result agrees, which was desired for essentially the same current.
So we write follow equation at Va.

$$0 = \frac{Va - Vout}{RF} + \frac{Va - V_1}{R} + \frac{Va - V_2}{R} + \frac{Va - V_3}{R}$$

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This equation contain both both vout & input voltage, to remove this unknow we need an equation. remember that we havn't used op amp rule 2. that we will certainly used. when analyzing op amp circuit.

Thus

$$V_a = V_b = 0$$

$$0 = \frac{V_{out}}{R_F} + \frac{V_1}{R} + \frac{V_2}{R} + \frac{V_3}{R}$$

~~by r~~

$\Rightarrow$

$$V_{out} = -\frac{R_F}{R}(V_1 + V_2 + V_3)$$

X ——— X ——— X ——— X ———

The END

X