NAME = HASNAT KHAN

ID = 16631

SEMESTER = 2^{ND}

Deptt : = ELECTRICAL ENG.

SUBJECT = Linear Circuit Analysis

TEACHER = Sir SOHAIL IMRAN

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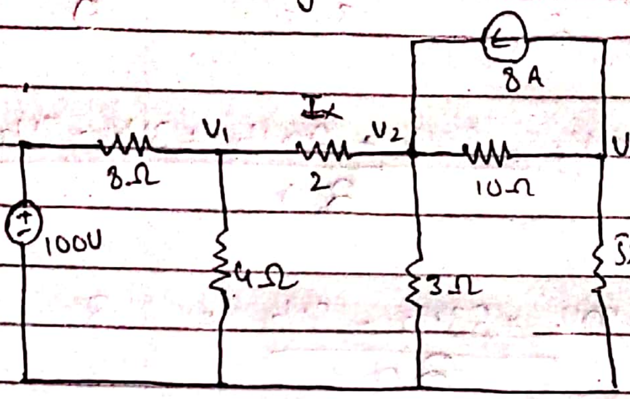
Q1) Find the value of i_x
i) Nodal Analysis:



Solution:-

Applying KCL on node 1n:

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

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

$$\frac{7V_1 - 4V_2 - 100}{8} = 0$$

xing 8 on b.s

$$\cancel{8} \times \frac{7V_1 - 4V_2 - 100}{\cancel{8}} = 0 \times 8$$

$$7V_1 - 4V_2 - 100 = 0$$

$$7V_1 - 4V_2 = 100 \quad \text{——} \quad (1)$$

Now

Applying KCL on node 2n :

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

$$\frac{30V_2 - 30V_1 + 20V_2 + 3V_2 - 3V_3}{30} = 8$$

$$\frac{-30V_1 + 53V_2 - 3V_3}{30} = 8$$

xing 60 on b.s

$$30 \times \frac{-30V_1 + 53V_2 - 3V_3}{30} = 8 \times 30$$

$$-30V_1 + 53V_2 - 3V_3 = 240 \quad \text{— (2)}$$

Now

Applying KCL on node 3n :-

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

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

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

xing 10 on b.s

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

$$-V_2 + 3V_3 = -80 \quad \text{— (3)}$$

Now taking eq ①
We get

$7V_1 - 4V_2 = 100$

$$V_1 = \frac{4V_2 + 100}{7} \quad \text{—— (a)}$$

Now taking eq ②

$-V_2 + 3V_3 = -80$

$$V_3 = \frac{V_2 - 80}{3} \quad \text{—— (b)}$$

Putting eq (a) & (b) in eq ②
we get

$$-30(0.57V_2 + 14.28) + 53V_2 - 3(0.33V_2 - 26.67) = 480$$

$$-17.1V_2 - 428.4 + 53V_2 - 0.99V_2 + 80.01 = 480$$

$$34.91V_2 = 828.39$$

$$V_2 = \frac{828.39}{34.91}$$

$$V_2 = 20.31$$

putting V_2 in eq (a)

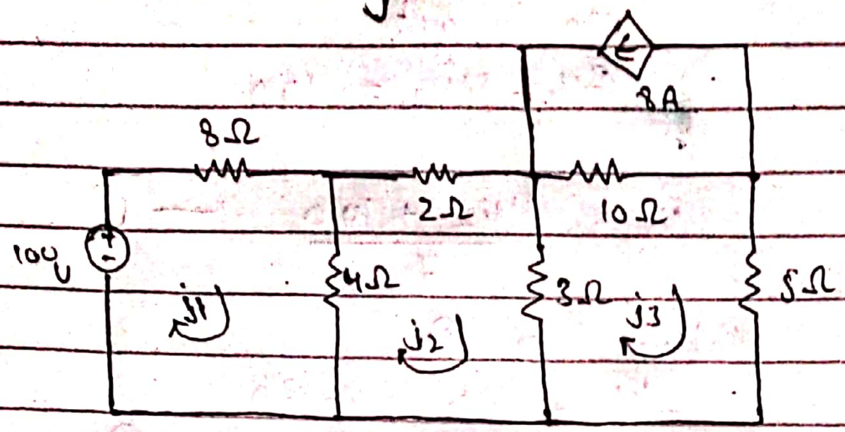
$$V_1 = \frac{4(20.31) + 100}{7}$$

$$V_1 = 25.89$$

$$i_x = \frac{V_1 - V_2}{2} = \frac{25.89 - 20.31}{2}$$

$$\boxed{i_x = 2.79\text{A}}$$

ii.) Mesh analysis:-



Applying KVL on Loop 1.

$$8j_1 + 4(j_1 - j_2) = 100$$

$$8j_1 + 4j_1 - 4j_2 = 100$$

$$12j_1 - 4j_2 = 100 \quad \text{——} \quad (1)$$

Now

Applying KVL on loop 2:

$$2i_2 + 4(j_2 - j_1) + 3(j_3 - j_2) = 0$$

$$2i_2 + 4i_2 - 4i_1 + 3i_3 - 3i_2 = 0$$

$$-4i_2 + 9i_1 - 3i_3 = 0 \quad \text{——} \quad (2)$$

Again

Applying KVL on loop 3:

$$3(i_3 - i_2) + 10(i_3 - i_4) + 5i_3 = 0$$

$$3i_3 - 3i_2 + 10i_3 - 10i_4 + 5i_3 = 0$$

As $i_4 = 8$

$$-3i_2 + 18i_3 = -80 \quad \text{——} \quad (3)$$

Taking eq (1)

$$i_1 = \frac{4i_2 - 100}{12} \quad \text{——} \quad (a)$$

taking eq (3)

$$-3i_2 + 18i_3 = -80$$

$$i_3 = \frac{-3i_2 + 80}{18} \quad \text{——} \quad (b)$$

Putting eq (a) & (b) in eq (2)

$$-4(0.33i_2 - 8.33) + 9i_2 - 3(0.16i_2 + 4.44) = 0$$

$$-1.32i_2 + 33.32 + 9i_2 - 0.48i_2 - 13.32 = 0$$

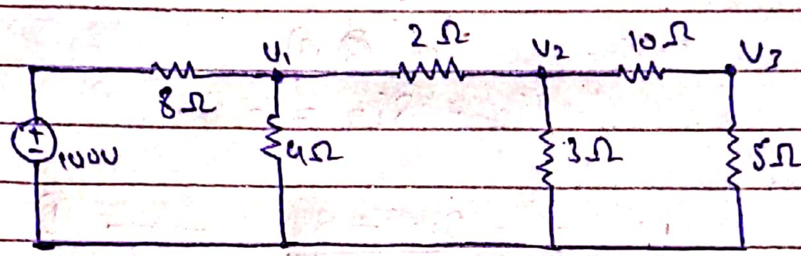
$$7.2i_2 = 20$$

$$i_2 = \frac{20}{7.2}$$

$$i_2 = 2.79A \Rightarrow \boxed{i_x = 2.79A}$$

iii.) Superposition Theorem :-

First removing the current source & making it an open circuit. Re-drawing the circuit.



Applying KCL on node 1n:

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

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

$$7V_1 - 4V_2 = 100 \quad \text{—— (1)}$$

Now

Applying KCL on node 2n:

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

So,

$$-30V_1 + 53V_2 - 3V_3 = 0 \quad \text{—— (2)}$$

Again

Applying KCL on node 3n.

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

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

$$-V_2 + 2V_3 = 0 \quad \text{——} \quad (3)$$

Now taking eq (1) & (2)

$$7V_1 - 4V_2 = 100$$

$$7V_1 = 100 + 4V_2$$

or

$$7V_1 = 4V_2 + 100$$

$$V_1 = \frac{4V_2 + 100}{7} \quad \text{——} \quad (a)$$

Eq.

$$-V_2 + 3V_3 = 0$$

$$V_3 = \frac{1}{3}V_2 \quad \text{——} \quad (b)$$

Putting in eq (2)

$$-30(0.57V_2 + 14.28) - 4V_2 + 2(0.33V_2) = 0$$

$$-17.1V_2 - 428.4 - 4V_2 + 0.60V_2 = 0$$

$$20.44V_2 = 428.4$$

or

$$V_2 = \frac{428.4}{20.44}$$

$$\boxed{V_2 = 20.95}$$

Put v_2 in eq (a)

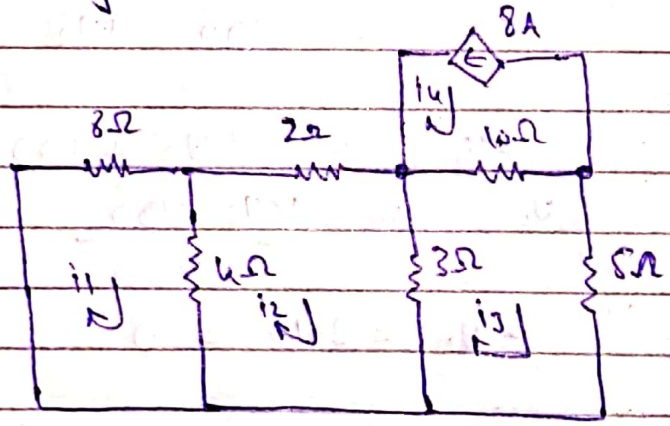
$v_1 = 2.31$

Or $i_1 = \frac{2.31 + 20.95}{2}$

$i_1 = \frac{23.26}{2}$

$\boxed{i_1 = 11.63A}$

Now removing voltage source &
making it short circuit.
Re-drawing circuit.



$i_4 = 8A$

Apply KVL on Loop 1

$8i_1 + 4(i_1 - i_2) = 0$

$8i_1 + 4i_1 - 4i_2 = 0$

$12i_1 - 4i_2 = 0$

$3i_1 - i_2 = 0$ —— ①

Applying KVL on Loop 2

$2i_2 + 3(i_2 - i_3) + 4(i_2 - i_1) = 0$

$$2i_2 + 3i_2 - 3i_3 + 4i_2 - 4i_1 = 0$$

$$-4i_1 + 4i_2 - 3i_3 = 0$$

$$-4i_1 + 4i_2 - 3i_3 = 0 \quad \text{—— (3)}$$

Now

Applying KVL on loop 3

$$10i_3 + 5i_3 + 3i_3 - 3i_2 + 8(10) = 0$$

$$-3i_2 + 18i_3 = -80 \quad \text{—— (3)}$$

taking eq (1)

$$3i_1 - i_2 = 0$$

$$i_1 = 0.33i_2 \quad \text{—— (4)}$$

taking eq (3)

$$-3i_2 + 18i_3 = -80$$

$$i_3 = \frac{3i_2 - 80}{18} \quad \text{—— (5)}$$

$$-4(0.33i_2) + 9i_2 - 3(0.16i_2 - 4.44) = 0$$

$$1.32i_2 + 9i_2 - 0.48i_2 + 13.32 = 0$$

$$i_2 = 1.354$$

Now

$$i_x = i_1 + i_2$$

$$i_x = 1.44 + 1.35$$

$$\boxed{i_x = 2.79A}$$

iv.) Compare the no of ~~stee~~ step & degree of easiness of all the three method with each other.

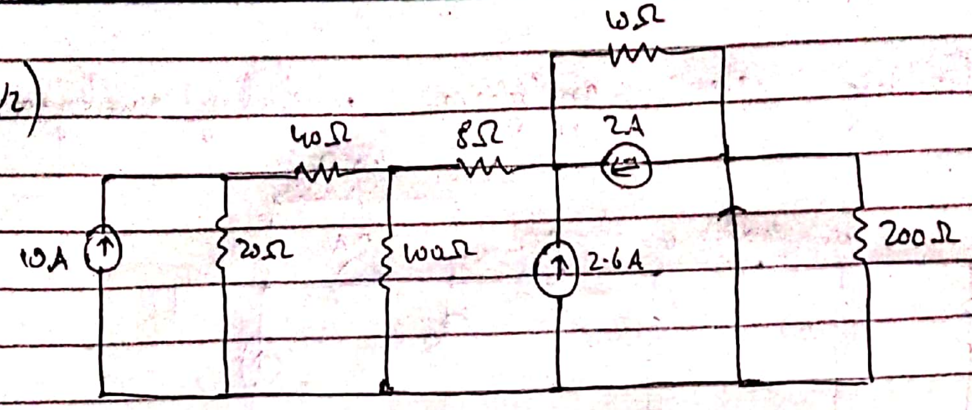
Sol:-

The no of steps in nodal & mesh analysis are almost equal but in superposition the no of steps are almost of mesh & nodal analysis.

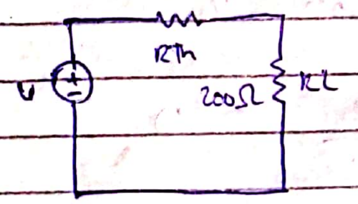
Degree of easinessn:-

According to opinion mesh analysis is eaiyer. then nodal analysis & superposition theorem.

(Q2)

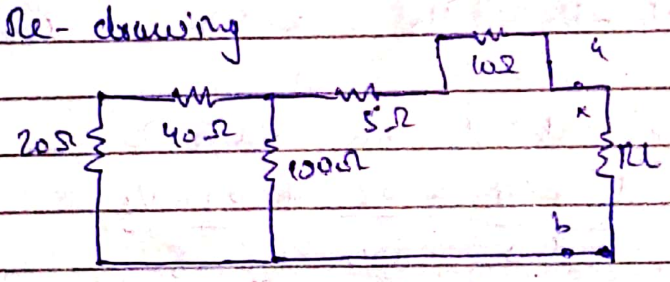


i) Solving for thevinen:-



We will find RTh for which we will remove all the current source by short circuit the load resistor.

Re-drawing



adding all the resistor

$20 + 40 \parallel 100 + 5 + 10$

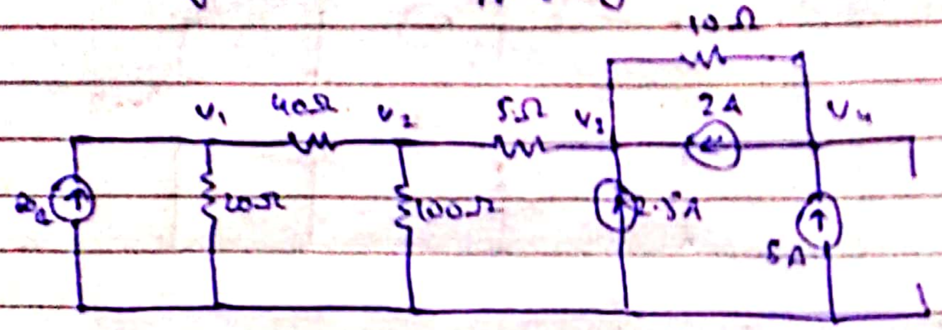
$60 \parallel 100 + 15$

$\frac{60 \times 100}{60 + 100} + 15$

$37.5 + 15$

$R_{Th} = 52.5$

Finding V_{th} applying nodal analysis



applying KCL on V_1

$$\frac{V_1 - V_2}{40} + \frac{V_1}{20} = 10$$

$$\frac{V_1 - V_2 + 2V_2}{40} = 10$$

$$V_1 - V_2 + 2V_2 = 40 \quad \text{—— (1)}$$

applying KCL on node 2

$$\frac{V_2 - V_1}{40} + \frac{V_2}{100} + \frac{V_2 - V_3}{5}$$

$$\frac{80V_2 - 50V_1 + 20V_2 + 400V_2 - 400V_3}{2000}$$

$$\frac{-80V_1 + 70V_2 - 400V_3}{2000} = 0$$

$$-0.05V_1 + 0.03V_2 \cdot 0.2V_3 = 0 \quad \text{—— (2)}$$

Applying KCL on node 3

$$\frac{V_3 - V_2}{5} + \frac{V_3 - V_4}{10} = 2.5 + 2$$

$$\frac{2V_3 - 2V_2 + V_3 - V_4}{10} = 4.5$$

$$-2V_2 + 3V_3 - V_4 = 45 \quad — (3)$$

Applying KCL on node 4

$$\frac{V_4 - V_3}{10} = 5 - 2$$

$$V_4 - V_3 = 30 \quad — (4)$$

Solving

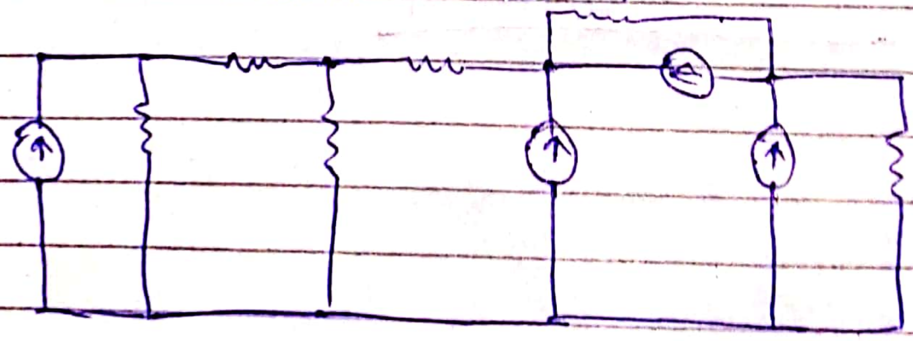
$V_1 = 275$

$V_2 = -124.9$

$V_3 = -87.5$

$V_4 = -57.5$

ii) For Norton Theorem:-



For RN will be the same

$R_N = R_{Th}$

$R_N = 52.5$

Rthed

$I_n = \frac{V_{Th}}{R_N}$

$I_n = 0.09$

if the circuit are same

so then find it directly

iii) Using thevinen for finding

we know that

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

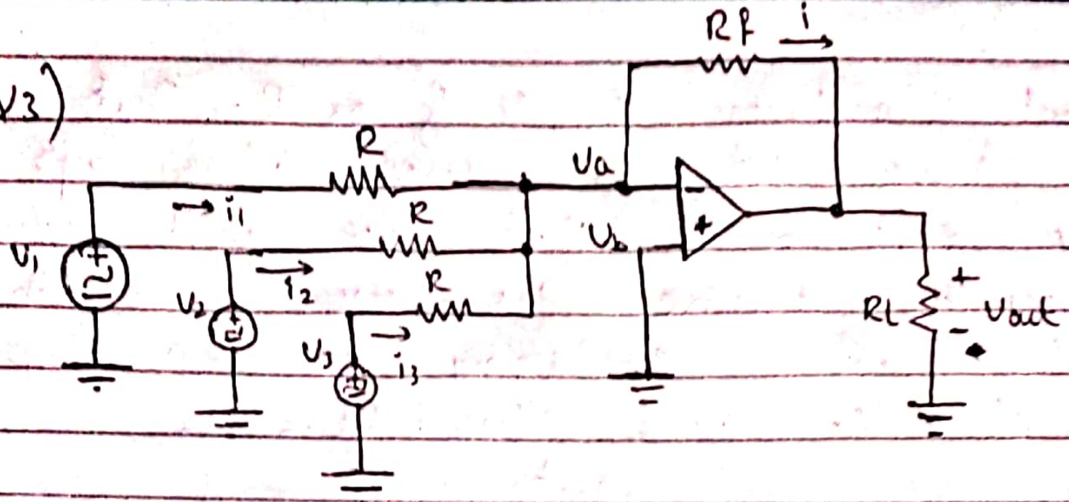
$$= \left(\frac{5.1}{52.5+200}\right)^2 200$$

$$\boxed{P = 0.08\,W}$$

iii) To find Thevenin's Equivalent Circuit

If the circuit contains resistor & independent source	you should do 1) Connect open circuit b/w a & b. 2) Find the voltage across the open circuit which is Voc. $V_{oc} = V_{th}$. 3) Deactivate the independent sources Voltage source I open circuit Current source I short 4) Find Rth by circuit resistance reduction
Resistor & dependent sources or independent sources	o) If there are both dependent & independent sources so, then, 1) Connect a short circuit b/w a & b. 2) Determine the current b/w a & b. 3) $R_{th} = V_{oc} / I_{ab}$ If there are only dependent sources. 4) Connect 1 ampere current source flowing from terminal b to a. $I_t = 1$ [A] 5) Then $R_{th} = V_{oc}/I_t = V_{oc}/1$

(Q3)



Sol:-

Again the goal is to obtain an expression from Vout (which in this case appears across a load resistor RL) in term of the input (v_1, v_2 & v_3).

Since no current can flow into the inverting input terminal,

So,

$$i = i_1 + i_2 + i_3$$

Therefore we can write the following equation at the nodel as Va.

$$0 = \frac{V_a - V_{out}}{R_f} + \frac{V_a - V_f}{R} + \frac{V_a - V_2}{R} + \frac{V_a - V_3}{R}$$

This equation contains both Vout & the input voltages but it also contains the ~~notte~~ nodal voltage Va. To remove this unknown quantity from out expression, we need to write an additional equation that relates Va to Vout the input voltages Rf & R or R. That we have not yet used ideal op amp rule 2 & that we will almost certainly require the use of both rule when analyzing an op amp circuit & since $va = Vb = 0$, So we can write

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

Rearranging the following expression as:

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

In this equation where $V_2 = V_3 = 0$. We see that this equation derived for essentially the same circuit.

finish

x———x———x———x