Department of Electrical Engi

Final Assignment

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course Details

Course Title: Linear circuit Analysis.

Module : 2

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Student Detail

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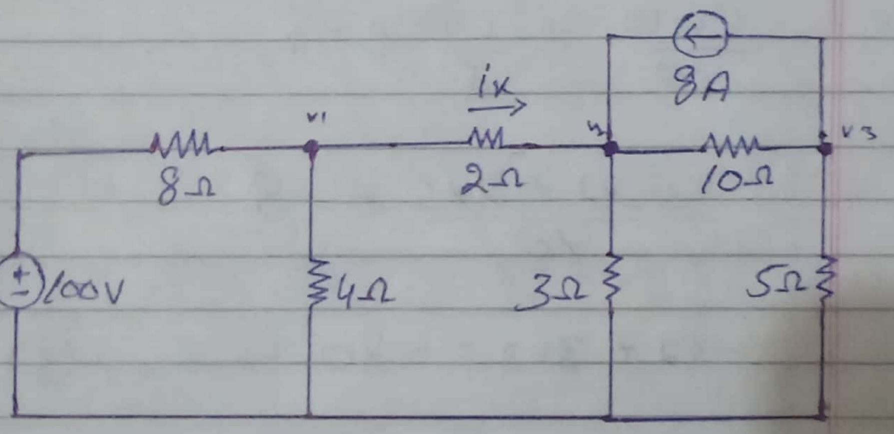
Question 1.

Find the value of Ix.
For the circuit using.

(1) Nodal Analysis
(2) Mesh Analysis
(3) Superposition theorm
(4) Compare the number of steps and degree of easiness of all the three methods with each other.



Solution: (i) Nodal Analysis

Applying KCL on node 1

$$\frac{V-100}{8} + \frac{V1}{4} + \frac{V1-V2}{2} = 0$$

$$\frac{\cancel{7}V1-100+2V1+4V1-4V2}{8} = 0$$

$$7V1 - 4V2 = 100 \quad \text{------} \quad (1)$$

(2)

Applying KCL on node 2:

$$\frac{v_2 - v_1}{2} + \frac{v_2}{3} + \frac{v_2 - v_3}{10} = 8$$

$$\frac{30v_2 - 30v_1 + 20v_2 + 3v_2 - 3v_3}{\cancel{60}\ 30} = 8$$

$$-30v_1 + 53v_2 - 3v_3 = \overset{240}{\cancel{480}} \quad \text{—— (2)}$$

Applying KCL on node 3:

$$\frac{v_3 - v_2}{10} + \frac{v_3}{5} = -8$$

$$\frac{v_3 - v_2 + 2v_3}{10} = -8$$

$$-v_2 + 3v_3 = -80 \quad \text{—— (3)}$$

~~Applying KCL on node 4~~

Taking eq (1)

$$7v_1 - 4v_2 = 100$$

$$v_1 = \frac{4v_2 + 100}{7} \quad \text{—— (A)}$$

Taking eq (2)

$$-v2 + 3v3 = -80$$

$$v3 = \frac{v2 - 80}{3} \text{ ——— } (B)$$

Putting eq (a) and (b)

in eq (2)

$$-30(0.57v2 + 14.28) + 53v2 - 3(0.33v2 - 26.67)$$
$$= \cancel{480}\ 240$$

$$-17.1v2 - 428.4 + 53v2 - 0.99v2 + 80.01 = \cancel{480}\ 240$$

$$34.91v2 = 828.39$$

$$v2 = \frac{828.39}{34.91}$$

$$\boxed{v2 = 20.31}$$

putting in eq (a)

$$v1 = \frac{4(20.31) + 100}{7}$$

$$v1 = 25.89$$

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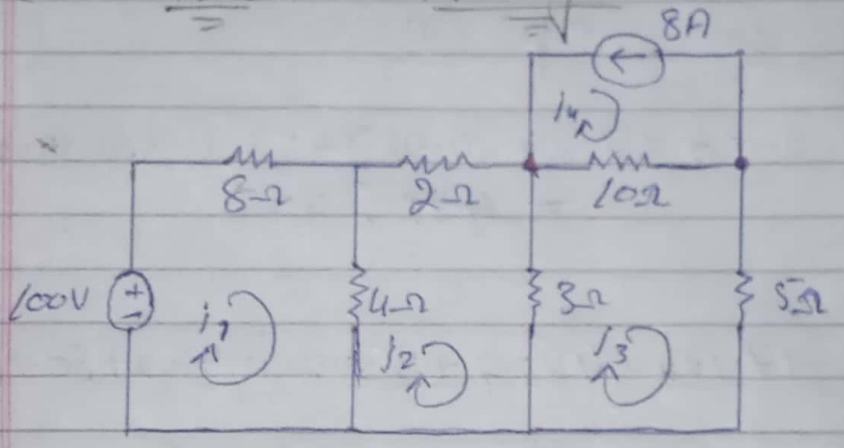
$$ix = \frac{v1 - v2}{2}$$

$$= \frac{25.89 - 20.31}{2}$$

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

(ii) Mesh Analysis



Applying KVL on Loop 1:

$$8i_1 + 4(i_1 - i_2) = 100$$

$$8i_1 + 4i_1 - 4i_2 = 100$$

$$12i - 4i_2 = 100 \quad \text{—— (1)}$$

Applying KVL on Loop 2:

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

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

$-4i_2 + 9i_2 - 3i_3 = 0$ ——— (2)

Applying KCL on loo 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 $i_4 = 8$

$-3i_2 + 18i_3 = -80$ ——— (3)

Taking eq (1)

$i_1 = \frac{4i_2 - 100}{12}$ ——— (a)

Taking eq (3)

$-3i_2 + 18i_3 = -80$

$i_3 = \frac{3i_2 + 80}{18}$ ——— (b)

putting eq (a) and (b) in eq (2)

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

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

$$7.2 i_2 = +20$$

$$i_2 = 20/7.2$$

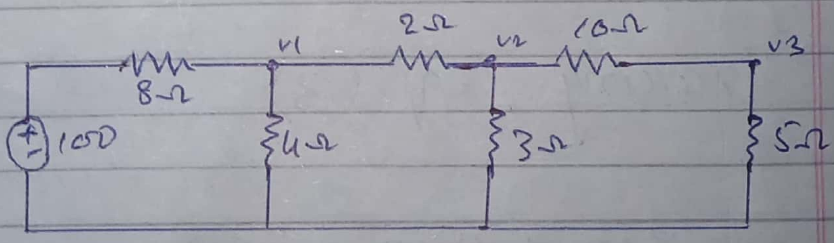
$$i_2 = 2.79\ A$$

$$i_2 = i_x$$

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

(iii) Superposition Theorem

First removing the current source and making at and open circuit Re drawing the circuit.



Apply KCL on node 1:

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

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

$$7V_1 - 4V_2 = 100 \text{ —— } (1)$$

7

Applying KCL on node 2

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

$$-30V_1 + 53V_2 - 3V_3 = 0$$

Applying KCL on node 3:

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

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

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

Now taking eq (1) and (3)

$$7V_1 - 4V_2 = 100$$

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

Now

$$-V_2 + 3V_3 = 0$$

$$V_3 = \frac{1V_1}{3} \quad \text{—— (b)}$$

Putt eq (a) and (b) in eq (2)

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

$-17.1v_2 - 428.4 - 4v_2 + 0.66v_2 = 0$

$20.44v_2 = 428.4$

$v_2 = -20.95$

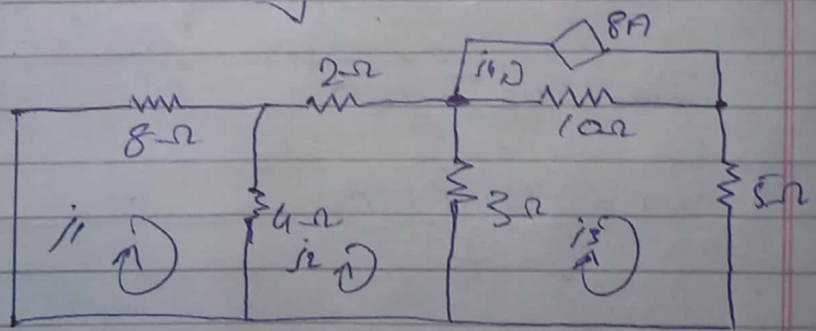
putt in eq a

$v_1 = 2.31$

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

$\boxed{i_1 = 11.63}$

Now Removing voltage source and making it short circuit Re drawing circuit.



$i_4 = 8A$

Apply KVL on loop 1

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

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

(9)

$$12i_1 - 4i_2 = 0$$

$$3i_1 - i_2 = 0 \quad \text{——— (1)}$$

Applying KVL on Loop 2

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

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

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

Applying KVL on Loop 3

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

$$-3i_2 + 18_3 = -80 \quad \text{——— (3)}$$

Taking eq (1)

$$3i_1 - i_2 = 0$$

$$i_1 = 0.33i_2 \quad \text{——— (a)}$$

Taking eq (3)

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

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

(iii)

$$-4(0.33i_1) + 9i_2 - 3(0.16i_2 - 4.44) = 0$$

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

$$i_2 = 1.354$$

Now $i_x = i_1 + i_2$

$$i_x = 1.44 + 1.35$$

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

(iv) Compare the number of step and degree of easiness of all the three method with each other.

Solution

The number of steps in nodal and mesh analysis are almost equal but in superposition the number of steps are almost of mesh and nodal analysis.

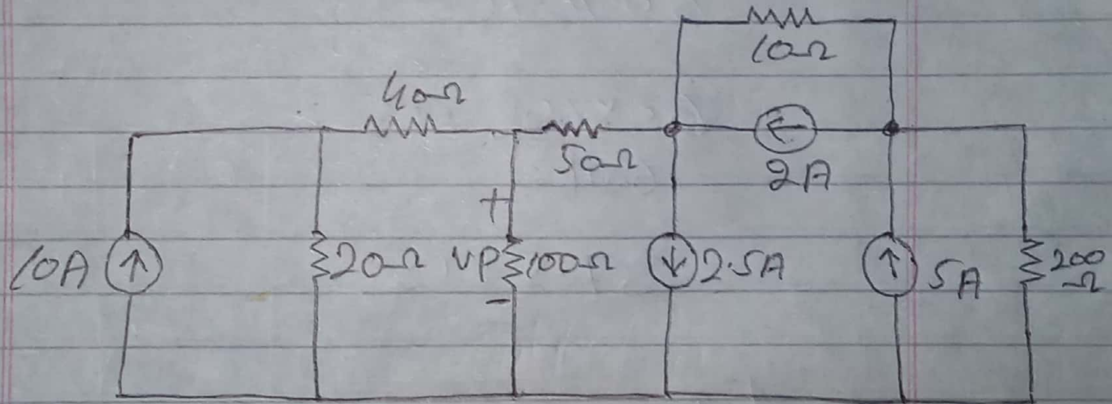
Degree of easinessn:

According to opioion mesh analysis is easyer Then nodal anlysis and superposition Theorem.

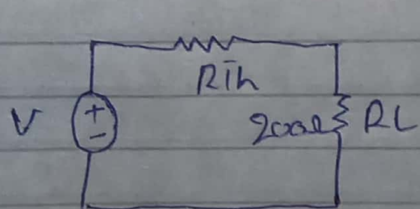
Question 2:

Consider the 200 ohm's resistor in Figure as load resistor and develop.

(i) Thevinin equivalent circuit.
(ii) Norton equivalent circuit.
(iii) Find out what value of thevinin resistor should be used to deliver maximum power to the load.



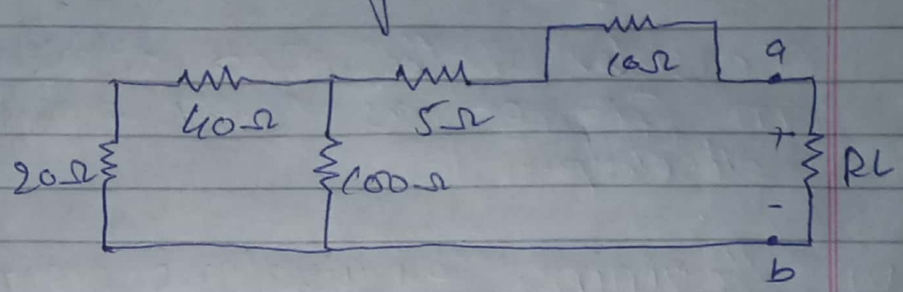
Solution: ① Solving for Thevinen.



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

(12)

Redrawing the circuit



adding all resistor

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

$60 \parallel 100+15$

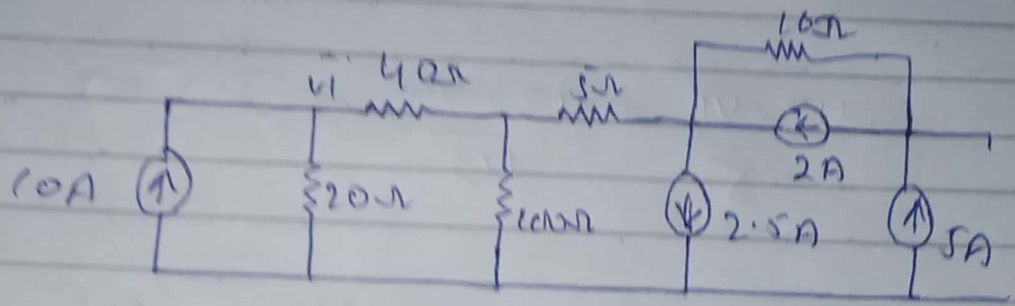
$\frac{60\times100}{60+100}+15$

$37.5+15$

$\boxed{R_{Th} = 52.5}$

(13)

For finding Vth applying nodal analysis.



Apply KCL on V1

$$\frac{V1-V2}{40} + \frac{V1}{20} = 10$$

$$\frac{V1-V2+2V2}{40} = 10 \quad \text{——} \quad (1)$$

Apply KCL on node 2

$$\frac{V2-V1}{40} + \frac{V2}{100} + \frac{V2-V3}{5}$$

$$\frac{50V2 - 5V1 + 20V2 + 400V3 - 400V3}{2000}$$

$$\frac{-50V1 + 70V2 - 400V3 = 0}{2000}$$

$$-0.05V_1 + 0.035V_2 - 0.2V_3 = 0 \quad \text{—} \quad (2)$$

Apply KCL on node (3)

$$\frac{V_3 - V_1}{5} + \frac{V_3 - V_4}{10} = 2.5 + 2$$

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

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

Apply KCL on node (4)

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

$$V_4 - V_3 = 30 \quad \text{—} \quad (4)$$

Solving by using calculator

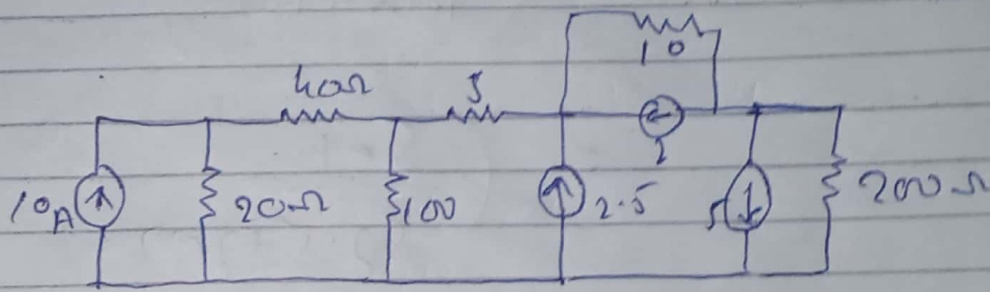
$V_1 = 275$
$V_2 = -124.9$
$V_3 = -87.5$
$V_4 = -57.5$

(15)

$$I_{th} = \frac{5-1}{52.5+200}$$

$$I_{th} = 0.02$$

(ii) For Norton theorem



For RN will be the same

$RN = Rth$
$RN = 52.5$

Find $In = \frac{Vth}{RN}$

$In = 0.09$

As the circuit are same so we find it directly

Using Theinen for finding power.

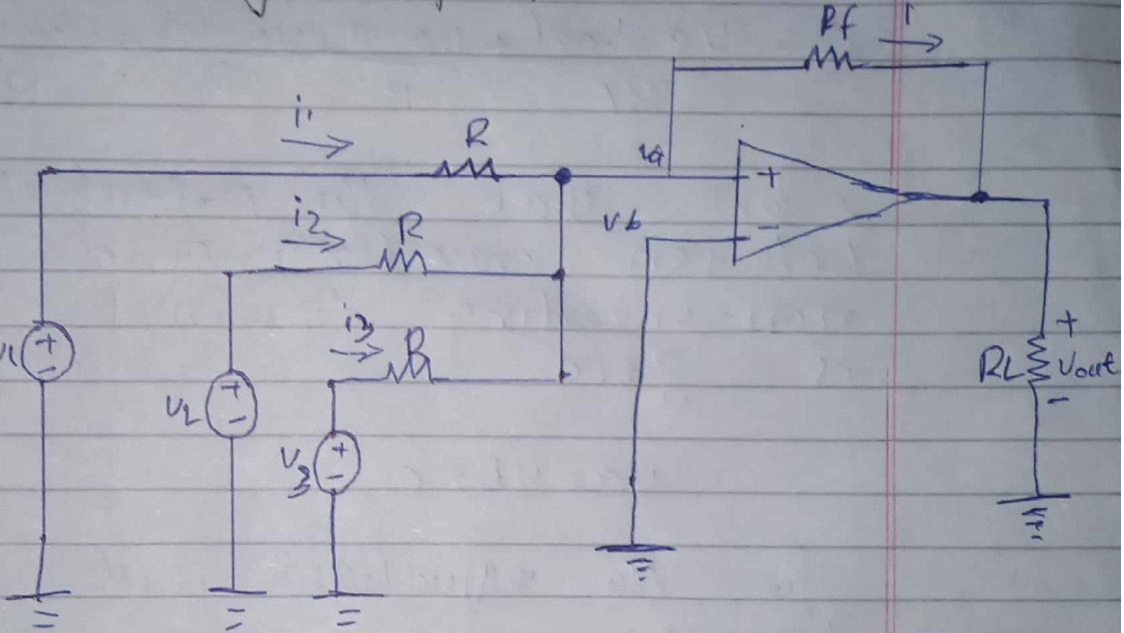
We know that

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

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

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

Q3: obtain an expression for V_{out} in terms of v_1, v_2 and v_3 for the op amp circuit in figure, also known as a summing amplifier.



Solution:

We know that all the current is entering to the inverting terminal or we know that the current enter to inverting or non-inverting are vertually zero

Now $i = i_1 + i_2 + i_3$

Therefore we are taking node v_a as mantain on the circuit above

As current I is flowing from va to Vout as Va will be at high potential writing equation.

$$0 = \frac{Va - Vout}{RF} + \frac{Va - V1}{R} + \frac{Va - V2}{R} + \frac{Va - V3}{R}$$

Now that the potential between inverting and non-inverting terminal is zero.

$$va = vb = 0$$

So the equation will become:

$$0 = \frac{Vout}{Rf} + \frac{V1}{R} + \frac{V2}{R} + \frac{V3}{R}$$

$$\frac{-Vout}{RF} = \frac{V1}{R} + \frac{V2}{R} + \frac{V3}{R}$$

$$-Vout = Rf\left(\frac{V1}{R} + \frac{V2}{R} + \frac{V3}{R}\right)$$

$$\boxed{Vout = -\frac{RF}{R}\left(V1 + V_2 + V_3\right)}$$

In This Case where

$v_2 = v_3 = 0$

we see that our rules Agress.