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Subject: Linear Circuit Analysis

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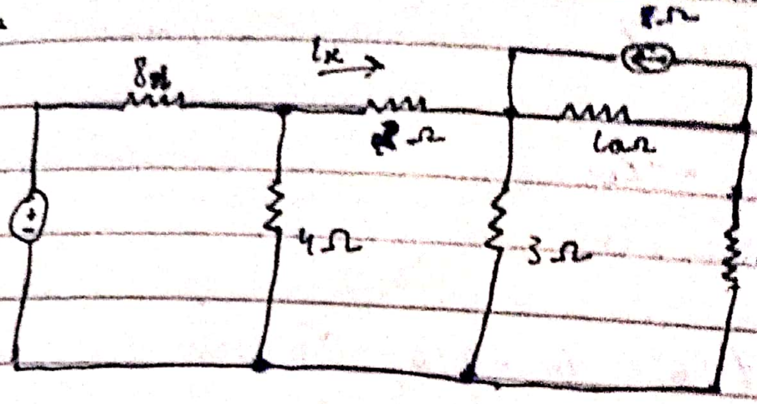
Question no: 1

Find the value of i_x for the circuit using
1) Nodal Analysis
2) Mesh Analysis
3) Superposition Analysis
4) Compare the number of steps and degree of easiness of all the three methods with each other



Solution:

Applying KCL on node 1

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

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

$7V_1 - 4V_2 = 100 \rightarrow ①$

Applying KCL on node 2:

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

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

$-30V_1 + 53V_2 - 3V_3 = \cancel{880}\ 240 \rightarrow (2)$

Applying KCL on node 3

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

$$\frac{V_3 - V_2 - 12V_3}{10} = -8$$

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

Taking eq ①

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

Taking eq (2)

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

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

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

$$-30(0.51V_2 + 14.28) + 53V_2 - 3(0.33V_2 - 26.67) = 480$$

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

$$34.94V_1 = 828.39$$

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

$$\boxed{V_2 = 20.31}$$

Putting in eq (a)

$$V_2 = \frac{4(20.31) + 100}{7}$$

$$V_2 = 25.89$$

$$I_x = \frac{V_1 - V_2}{2}$$

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

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

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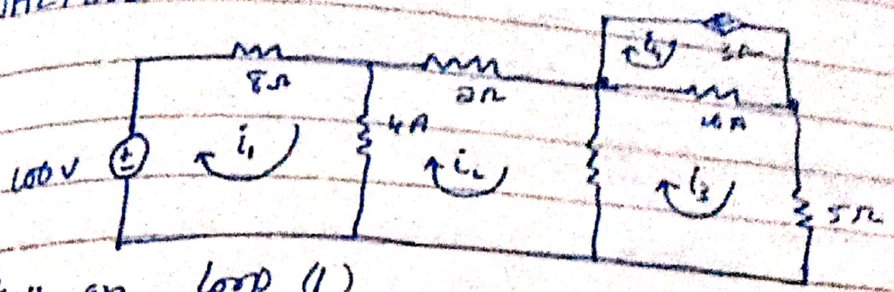
Mesh Analysis



Applying KVL on loop (1)

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

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

$12i_2 - 4i_2 = 100 \rightarrow (1)$

Applying KVL on loop(2)

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

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

$-4i_2 + 9i_2 - 3i_3 = 0 \rightarrow (2)$

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 $i_4 = 8$

$= 3i + 18i_3 = -80 \; (3)$

Taking eq (1)

$i_1 = \dfrac{4i_2 - 100}{12} \; (a)$

Taking eq (3)

$-3i_2 + 18i_3 = -80$

$i_3 = -\dfrac{3i_2 + 80}{18} \rightarrow (b)$

Putting eq (a) and (b) on eq (2)

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

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

$7.2 i_2 = 20$

$\Rightarrow i_2 = 20/7.2$

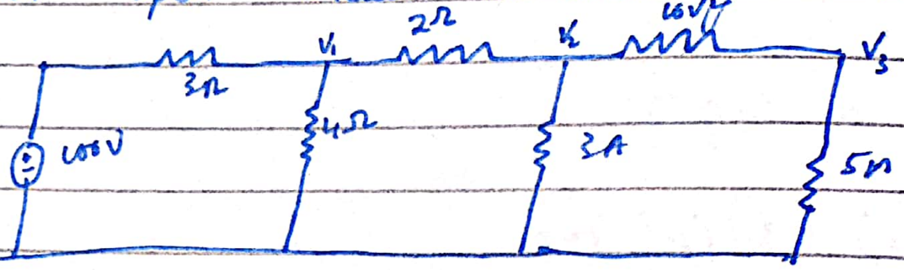
$\Rightarrow i_2 = i_x$

$\Rightarrow i_2 = 2.78A$

$\boxed{\Rightarrow i_x = 2.78A}$

iii) SUPERPOSITION THEOREM:

first we remove the current and then making it on open circuit Re-drawing the circuit



Applying KCL on node 1

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

$$\frac{V_1 - 100 + 4V_1 - 4V_2 + 2V_3 = 0}{8}$$

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

Apply KCL on node 2

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

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

Apply KCL on node 3

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

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

$-V_2 + 2V_3 = 0 \rightarrow (3)$

Now taking eq (1) and (2)

$7V_1 - 4V_2 = 100$

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

Now $-V_2 + 3V_3 = 0$

$$V_3 = \frac{1}{3} V_2 \rightarrow (b)$$

putting on eq ⓐ

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

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

$$V_2 = -20.95$$

putting in eq (a)

$$V_2 = 2.31$$

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

$$\boxed{i_2 = 11.63}$$

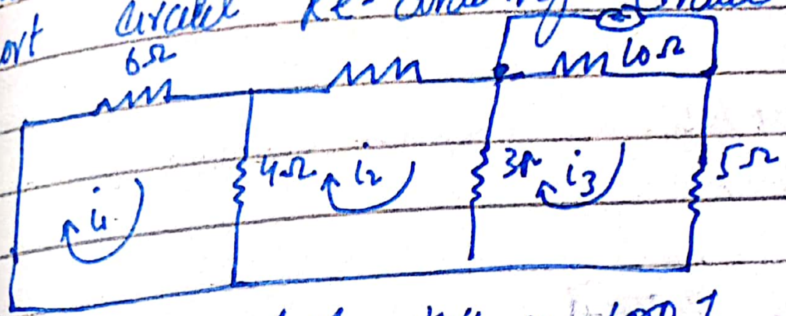
putting in eq (a)

$$V_2 = 2.31$$

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

$$i_1 = 11.63$$

Now removing voltage source and making it short circuit Re-drawing circuit



$i_4 = 8A \Rightarrow$ Apply KVL on loop 1

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

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

$$12i_1 - 4i_2 = 0$$

$$3i_1 - i_2 = 0 \rightarrow (1)$$

Applying KVL on loop 2

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

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

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

Apply KVL on loop 3

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

$$-3i_2 + 18i_3 = -80 \rightarrow (3)$$

Taking eq (1)

$$3i_1 - i_2 = 0$$

$$i_1 = 0.33 i_2 \rightarrow (a)$$

Taking eq (3)

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

$$i_3 = \frac{3i_2 - 80}{18} \rightarrow (6)$$

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

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

$$i_2 = 1.354$$

Now $i_x = i_1 + i_2$

$$i_x = 1.44 + 1.35$$

$$i_x = 2.79\,A$$

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

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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 easiness:

According to opinion mesh analysis is easyer then nodal analysis and superposition theorem.

Question # 2

Consider the 200 ohms resister in figure as load resistor and develop

i) Thevinin equivalent circuit
ii) Norton equivalent circuit
iii) Find out what value of Thevinin resistence should be used to deliver maximum powe to the load

Thevenin's and Norton's Equivalent Circuit Tutorial :-

Thevenin's Theorem states that we can replace entire network by an equivalent circuit that contains only an independent voltage source in series with an impedance (resistor) such that the current-voltage relationship at the load is unchanged.

Norton's Theorem is identical to Thevenin's Theorem except that the equivalent circuit is an independent current source in parallel with an impedance (resistor)
Therefore, the Norton's equivalent is a source transformation of the Thevenin equivalent circuit.

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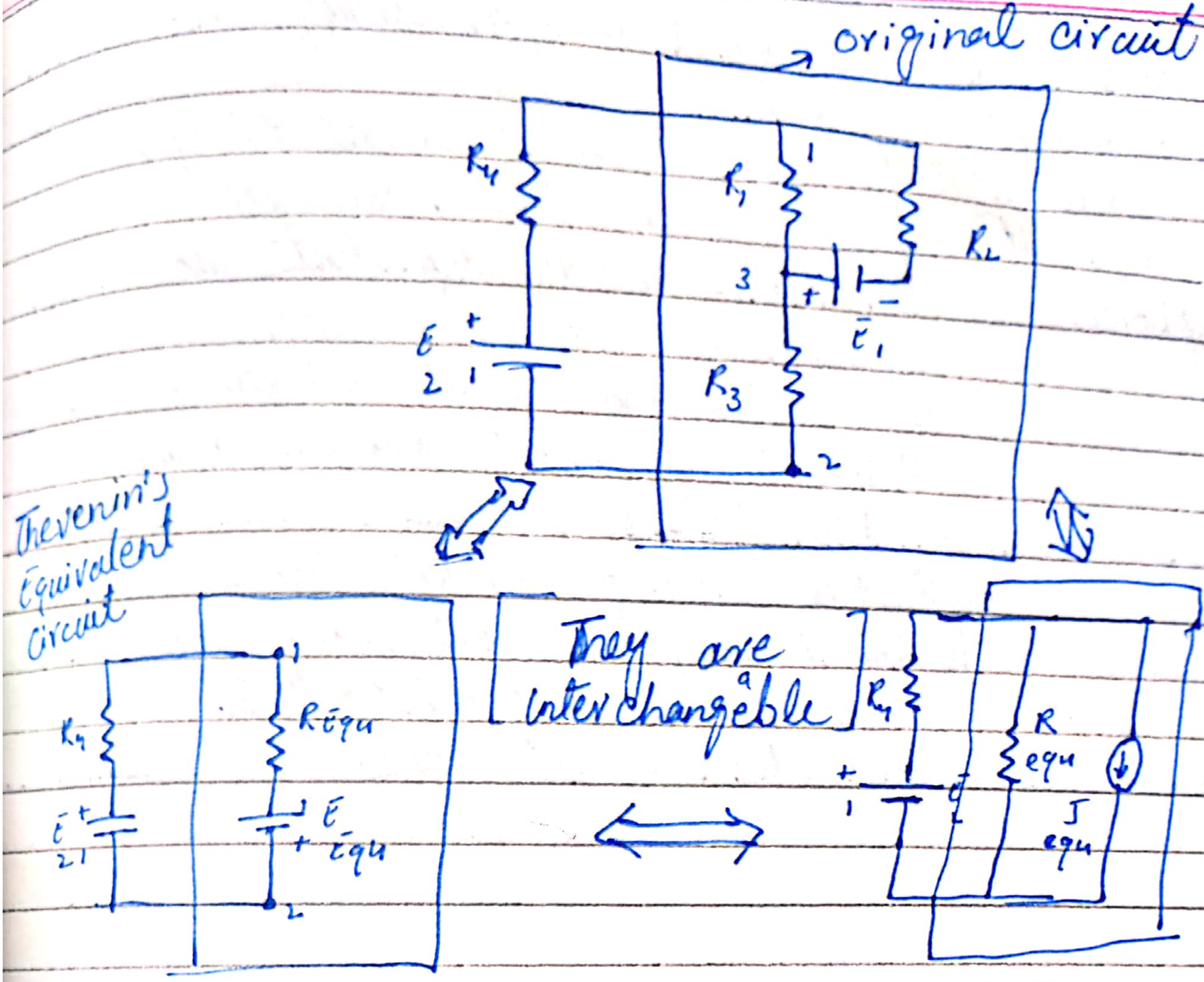


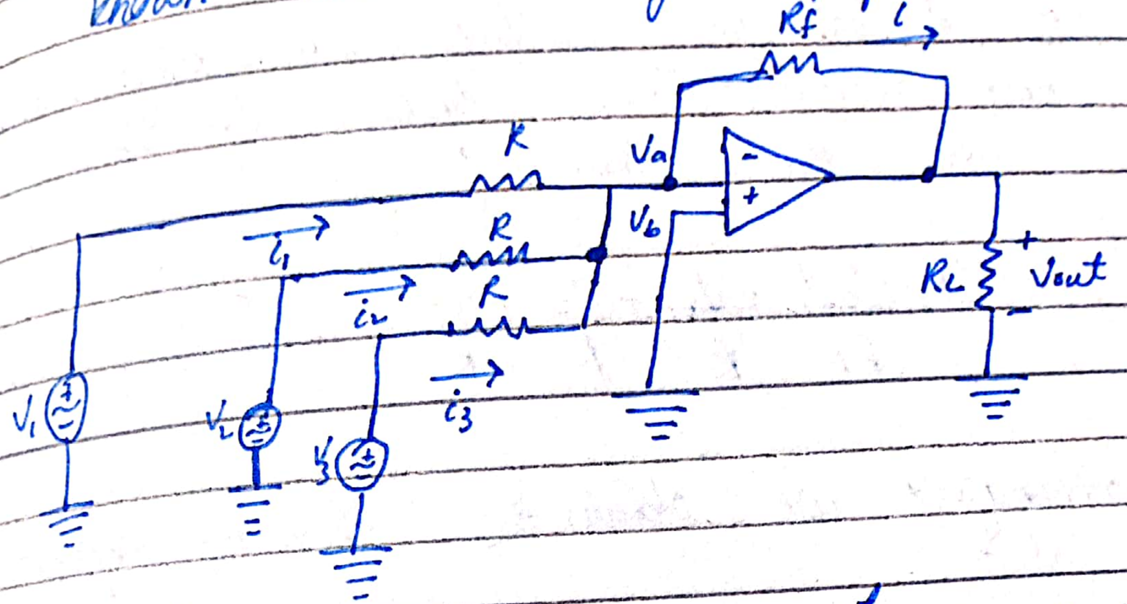
Norton's Equivalent Circuit

How to find Thevenin's Equivalent Circuit:

If the Circuit	You should do
Resistors and independent sources	1) Connect an open circuit b/w a and b 2) Find the voltage across the open circuit which is Voc. $V_{oc} = V_{th}$ 3) Deactive the independent sources voltage source Î open circuit 4) Find R_{Th} by circuit resistance reduction.

Resistors and dependent sources or independent shorces	1) Connect an open circuit between a and b. 2) Find the voltage across the open circuit which is Voc. $V_{oc} = V_{th}$ If there are both dependent and independent sources. 3) Connect a short circuit between a and b 4) Determine the current between a and b 5) $R_{th} = V_{oc}/I_{ab}$ If there are only dependent sources. 3) Connect 1 Amphere current source flowing from terminal b to a. $I_t = [A]$ 4) Then $R_{th} = V_{oc}/I_t = V_{oc}/1$

Q#3 Obtain an expression for ~~Vo~~ Vout of V_1, V_2, and V_3 for the op amp circuit in figure also known as summing amplifier.



We first note that this circuit is similar to the inverting amplifier circuit. & again, the goal is to obtain ~~an~~ an expression for Vout (which in this case appears across a load resistor R_1) in terms of the inputs (V_1, V_2 and V_3)

Since no current can flow into the inverting input terminal we, can write

$$i = i_1 + i_2 + i_3$$

Therefore we can write the following equation at the node labeled Va:

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

This equation contains both Vout and the input voltages but unfortunately it also contains the nodal voltage Va. To remove this unknown quantity from our expression, we need to write an additional equation that relates

Va to Vout the input voltages Rf and/or R. At this point we remember that we have not yet used ideal op amp rule 2 and that we will almost certainly require the use of both rule when analyzing an op amp circuit. Thus since $V_a = V_b = 0$, we can write the following

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

Re-arranging, we obtain the following expression for Vout

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

In the special case where $V_2 = V_3 = 0$ we see that our result agrees with eq(8). which was derived for essentially the same circuit