Paper 1, TDC Part-1
Chapter– 3, Mesh and Node Analysis
Nodal Analysis -5

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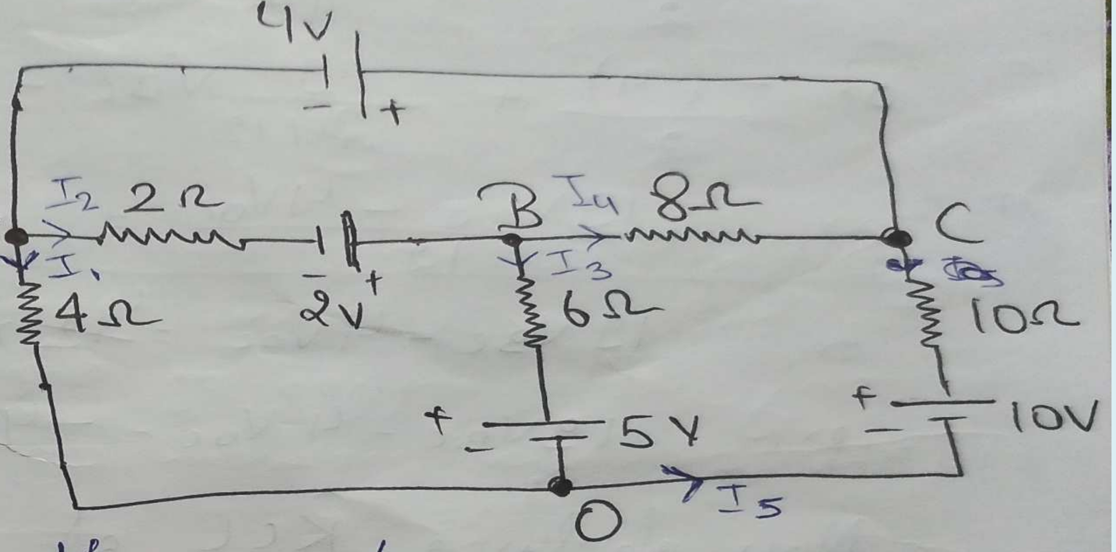
Mesh and Nodal Analysis in Passive Circuits

Question

We solve this problem by another method. In this method we take node C as reference node.



first name all the nodes A, B, C & O. Let the voltages of this nodes are V_A, V_B, V_C & V_O respectively. Also let the currents I_1, I_2, I_3, I_4 & I_5

Now let us consider 'C' as reference node then we have to find V_{AC}, V_{BC} & V_{OC}.

and $V_{AC} = -4V$

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So we get V_{AC} so there is no need to write KCL at node A.

Now we have to apply KCL at node B we get

$$I_2 - I_3 - I_4 = 0$$

$$\frac{V_{AB} + 2}{2} - \frac{V_{BO} - 5}{6} - \frac{V_{BC}}{8} = 0$$

$$\frac{V_{AC} - V_{BC} + 2}{2} - \frac{V_{BC} - V_{OC} - 5}{6} - \frac{V_{BC}}{8} = 0$$

$$-\frac{V_{AC}}{2} + V_{BC}\left(\frac{1}{2} + \frac{1}{6} + \frac{1}{8}\right) - \frac{V_{OC}}{6} = \frac{5}{6} + 1 = \frac{11}{6}$$

or, $-\frac{(-4)}{2} + \frac{19}{24\ 12} V_{BC} - \frac{V_{OC}}{6\ 3} = \frac{11}{6\ 3}$

or, $\frac{19 V_{BC} - 4V_{OC}}{12} = \frac{11}{3} - 4$

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or, $\frac{19V_{BC} - 4V_{OC}}{12} = \frac{11}{3} - 4$

or, $19V_{BC} - 4V_{OC} = 12 \times -\frac{1}{3} = -4$

or, $19V_{BC} - 4V_{OC} = -4 \Rightarrow V_{BC} = \frac{-4 + 4V_{OC}}{19}$

Now applying KCL at node O, we get

$I_1 + I_3 - I_5 = 0$

$\frac{V_{AO}}{4} + \frac{V_{BO} - 5}{6} - \frac{V_{OC} + 10}{10} = 0$

~~or, $-\frac{V_{AO}}{4} - \frac{V_{BO}}{6} - \frac{5}{6} - \frac{V_{OC}}{10} + 1 = 0$~~

or, $-\frac{V_{AO}}{4} - \frac{V_{BO}}{6} + \frac{V_{OC}}{10} = -1 - \frac{5}{6} = -\frac{11}{6}$

or, $-\frac{V_{AC}}{4} - \frac{V_{BC}}{6} + V_{OC}\left(\frac{1}{4} + \frac{1}{6} + \frac{1}{10}\right) = -\frac{11}{6}$

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Putting $V_{AC} = -4$ we get

$$-\frac{(-4)}{4} - \frac{V_{BC}}{6} + V_{oc}\left(\frac{15+10+6}{60}\right) = \frac{-11}{6}$$

$$\frac{-V_{BC}\times 10 + 31V_{oc}}{60} = -\frac{11}{6} - 1$$

or, $-10V_{BC} + 31V_{oc} = 10 \times \frac{-17}{6} = -170$

or, $\frac{-10(-4+4V_{oc})}{19} + 31V_{oc} = -170$

or, $40 - 40V_{oc} + 31\times 19 V_{oc} = -170\times 19$

or, $(589-40)V_{oc} = -3230 - 40 = -3270$

or $V_{oc} = \frac{-3270}{549}$ = $\frac{-3270}{549}$

$$V_{oc} \approx -6\text{ V}$$

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$\approx -6V$

$V_o - V_c = -6V$

$\Rightarrow 0 - V_c = -6V \Rightarrow V_c = 6V$

$V_{AC} = -4 \Rightarrow V_A - V_c = -4$

$V_A = -4 + V_c = -4 + 6 = 2V$

$V_{BC} = \frac{-4 + 4 \times \bar{6}}{19} = \frac{-28}{19} \approx -1.5$

$V_B - V_c \approx -1.5\ V \Rightarrow V_B \approx -1.5 + V_c$

$\approx -1.5 + 6 = 4.5V$

from this we get.

$I_1 = \frac{V_{AO}}{4} = \frac{2}{4} = 0.5\ A.$

$I_2 = \frac{V_{AB} + 2}{2} = \frac{V_A - V_B + 2}{2} = \frac{2 - 4.5 + 2}{2} = -0.25$

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$$I_3 = \frac{V_{BO} - 5}{6} = \frac{V_B - V_0 - 5}{6} = \frac{4.5 - 0 - 5}{6} = \frac{-0.5}{6}$$

$$= -83\,mA$$

$$I_4 = \frac{V_{BC}}{8} = \frac{V_B - V_C}{8} = \frac{4.5 - 6}{8} \approx 0.19\,A$$

$$I_5 = \frac{V_{OC} + 10}{10} = \frac{V_0 - V_C + 10}{10} = \frac{0 - 6 + 10}{10}$$

$$= 0.4\,A$$

Current in Branch AC is let I then

$$I + I_1 + I_2 = 0$$

$$I = -I_1 - I_2 = -0.5 - (-0.25)$$

$$I = -0.25\,A$$ i.e. direction of current ~~is~~ into the node A.

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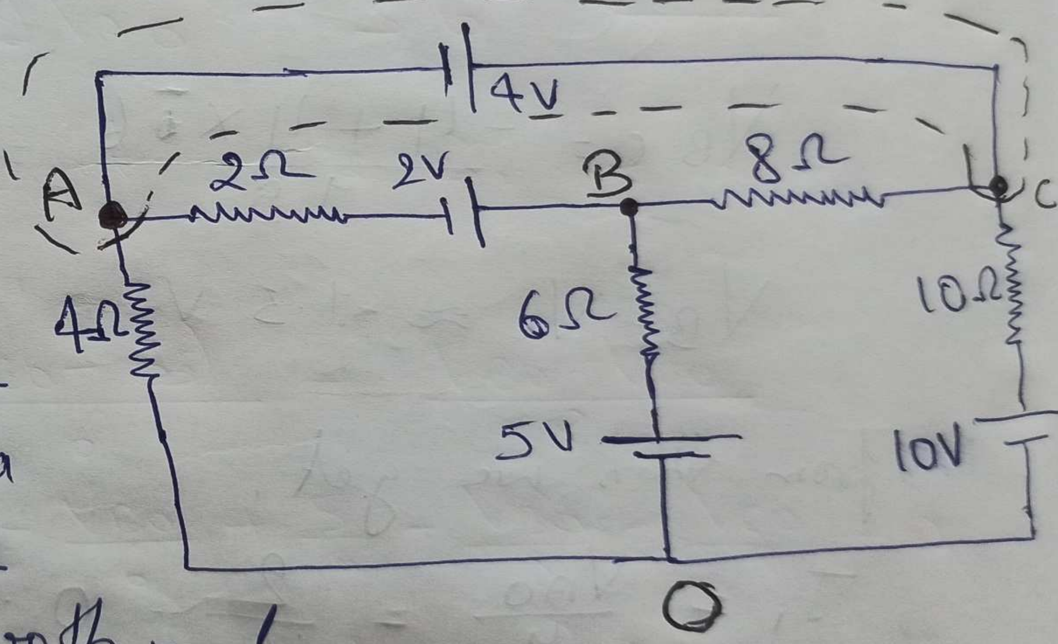
Supernode method of Nodal Analysis

The problem discussed earlier can also be solve using nodal analysis by super node. Let us consider the previous problem once more.



In Supernode method we treat node A, node B and voltage source together as a sort of super node and apply KCL to both nodes at the same time. The super node is indicated by the dotted line in the ckt. shown above

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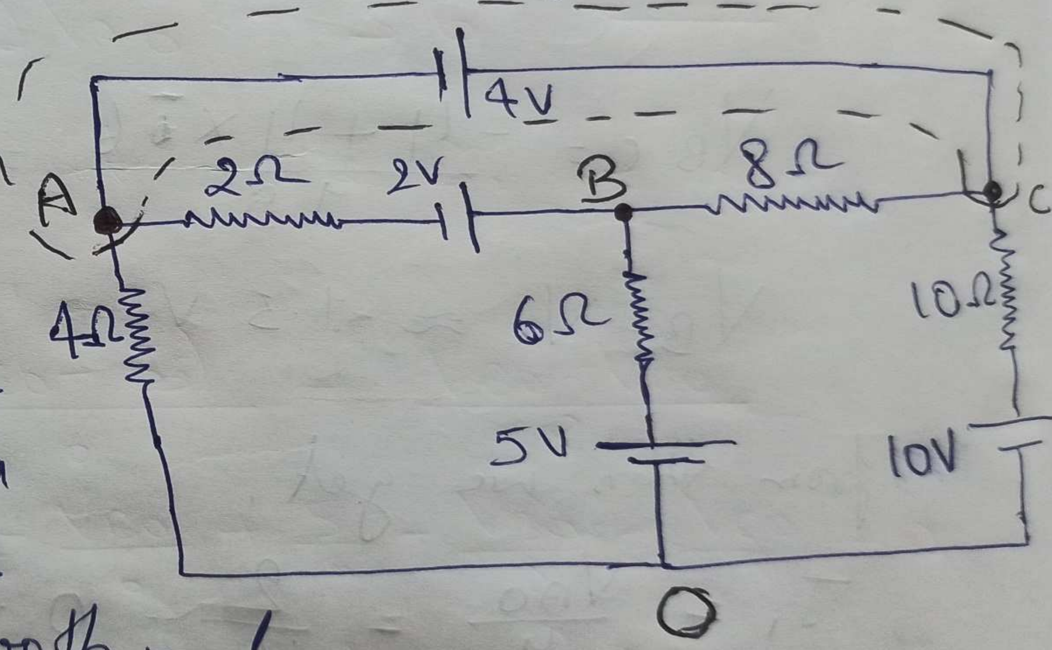

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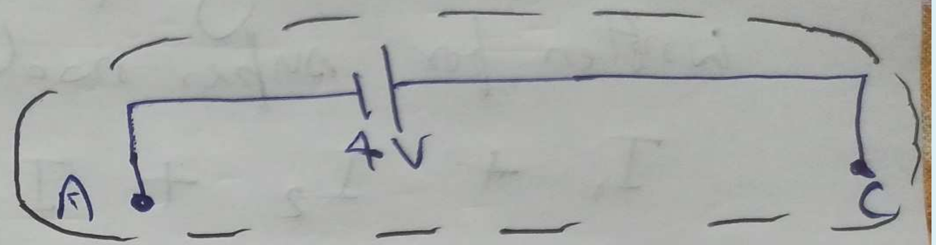
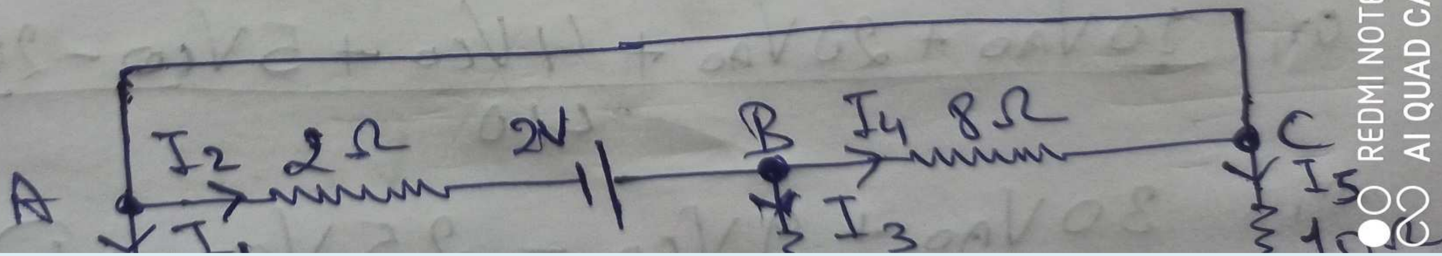
or, it has been shown seperatly below also.

As we have treated node A, node C and the voltage source together



as a sort of supernode so the voltage $V_A = V_C$ and hence there will be no current flow in branch AC and also the both nodes A and C will be consider together for writing KCL. The ckt is redrawn ~~once~~ again ~~by~~ according to supernode



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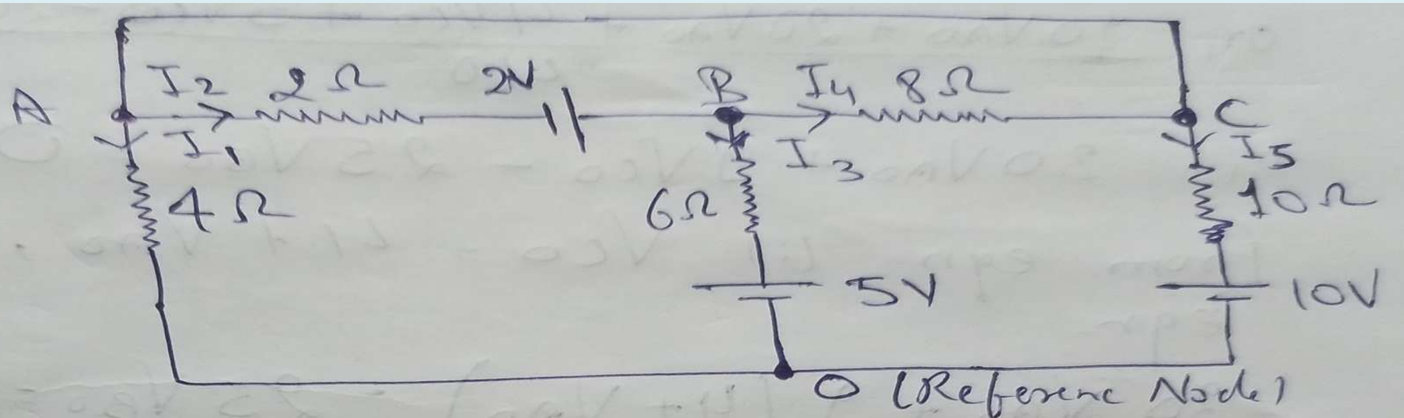

In above ckt. A-C is super node, for this ckt we will assume current direction as shown in the ckt above. For supernode A-C, current I_1; I_2 leaving for node A and current I_5 leaving node C while there is only one entering current i.e. I_4 at node C so KCL for supernode A-C is written,

$$I_1 + I_2 + I_5 = I_4$$

Also for branch AC there is 4V voltage source between nodes A and C so we have.

$$V_{AO} - V_{CO} = -4V \Rightarrow \boxed{V_{CO} = V_{AO} + 4V} \quad \text{—(i)}$$

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Now substituting eqn. for, I_1, I_2, I_4 & I_5 ~~for~~ in KCL written for super node A-C. i.e.

$$I_1 + I_2 + I_5 = I_4$$

$$\frac{V_{AO}}{4} + \frac{V_{AO} - (V_{BO} - 2)}{2} + \frac{V_{CO} - 10}{10} = \frac{V_{BO} - V_{CO}}{8}$$

or, $\frac{V_{AO}}{4} + \frac{V_{AO}}{2} - \frac{V_{BO}}{2} + \frac{2}{2} + \frac{V_{CO}}{10} - \frac{10}{10} = \frac{V_{BO}}{8} - \frac{V_{CO}}{8}$

or, $\frac{V_{AO}}{4} + \frac{V_{AO}}{2} + \frac{V_{CO}}{10} + \frac{V_{CO}}{8} - \frac{V_{BO}}{2} - \frac{V_{BO}}{8} = 0$

or, $\frac{10 V_{AO} + 20 V_{AO} + 4 V_{CO} + 5 V_{CO} - 20 V_{BO} - 5 V_{BO}}{40} = 0$

or, $30 V_{AO} + 9 V_{CO} - 25 V_{BO} = 0$

From eqn. (i) $V_{CO} = 4 + V_{AO}$, putting in above

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From eqn. (i) $V_{CO} = 4 + V_{AO}$, putting in above eqn.

$$30 V_{AO} + 9(4 + V_{AO}) - 25 V_{BO} = 0$$

or $$25 V_{BO} - 39 V_{AO} = 36 \quad \text{——— (ii)}$$

Now writing KCL at node B, we have:

$$I_2 = I_3 + I_4$$

$$\frac{V_{AO} - (V_{BO} - 2)}{2} = \frac{(V_{BO} - 5)}{6} + \frac{V_{BO} - V_{CO}}{8}$$

or $$\frac{V_{AO}}{2} - \frac{V_{BO}}{2} + \frac{\cancel{2}}{\cancel{2}}1 - \frac{V_{BO}}{6} + \frac{5}{6} - \frac{V_{BO}}{8} + \frac{V_{CO}}{8} = 0$$

or $$-\frac{V_{AO}}{2} + \frac{V_{BO}}{2} + \frac{V_{BO}}{6} + \frac{V_{BO}}{8} - \frac{V_{CO}}{8} = 1 + \frac{5}{6} = \frac{11}{6}$$

or $$\frac{-12 V_{AO} + 19 V_{BO} - 3 V_{CO}}{\cancel{24}\ 4} = \frac{11}{\cancel{6}}$$

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again putting $V_{CO} = 4 + V_{AO}$

$$-12 V_{AO} + 19 V_{BO} - 3(4 + V_{AO}) = 44$$

$$\Rightarrow 19 V_{BO} - 15 V_{AO} = 44 + 12 = 56$$

or $V_{BO} = \dfrac{56 + 15 V_{AO}}{19}$

putting this in eqn. (ii) we get,

$$25 \times \left(\frac{56 + 15 V_{AO}}{19}\right) - 39 V_{AO} = 36$$

On solving it gives, $V_{AO} \approx 2.0V$

So, $V_{CO} = 4 + V_{AO} \approx 6.0V$

$V_{BO} \approx 4.5V$

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All currents I_1, I_2, I_3, I_4 & I_5 can be obtained putting values of V_{AO}, V_{BO} & V_{CO} in their respective eqn.

We observe that out of 3 methods that we discuss for this problem, the super node method is more easier method comparasion to other two methods. Applying super node method reduces to write 1 eqn. here, so it is more convenient.

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For any query contact- 9771474020

Thank You