Paper 1, TDC Part-1
Chapter– 3, Mesh and Node Analysis
Nodal Analysis - 4

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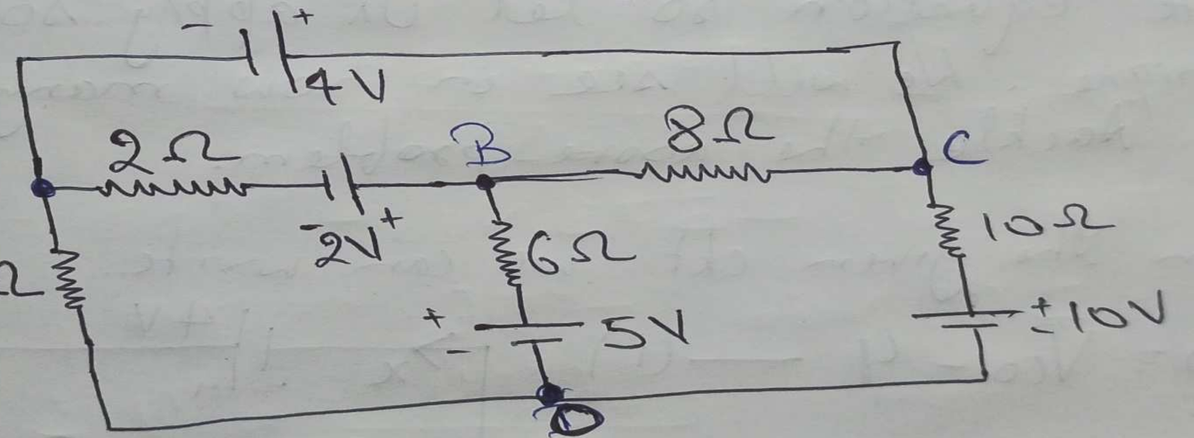
Mesh and Nodal Analysis in Passive Circuits

Nodal Analysis

Lecture 4

Let us discuss one more problem on Nodal Analysis.

Problem :- Solve the below shown network using Nodal Analysis method. The 4V voltage source is the ideal voltage source.



Soln :- Note that it is given "4V" source is ideal voltage source this means internal resistance of the voltage source is '0'.

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voltage source this means internal resistance of the voltage source is '0'.

Now let us proceed further, to solve the problem using Nodal Analysis.

So first let us identify the nodes and name them A, B, C & D. Also consider the voltage at A, B & C are V_A, V_B & V_C, while the voltage at node D is $V_D = 0V$ because it is grounded.

Now let us see what happen if we consider D as reference node.

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Writing KCL at node A,

$$V_{AO}\left(\frac{1}{2}+\frac{1}{4}+\frac{1}{0}\right) - V_{BO}\left(\frac{1}{2}\right) - V_{CO}\left(\frac{1}{0}\right) = \frac{-2}{2} - \frac{4}{0} + $$

So dividing any thing with ~~respect to~~ 0 results in ∞ (infinite). This means we can't solve the above equation so let us apply some other technique. We will see in how many ways we can tackle the above problem.

From the given ckt. we can write

$V_{AO} - V$ ... (i) 4V

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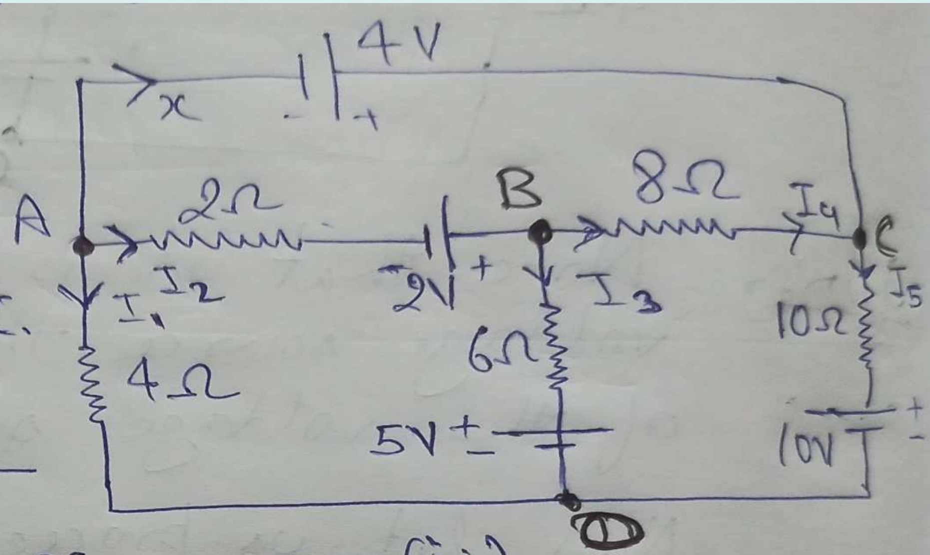
$V_{AO} = V_{CO} - 4$ —— (i)



Let the current x flows in the branch AC. from node A to node C.

At node A, writing KCL,

$$-I_1 - I_2 - x = 0$$

$$V_{AO}\left(\frac{1}{4} + \frac{1}{2}\right) - V_{BO} \times \frac{1}{2} = -\frac{2}{2} - x \quad \text{—— (ii)}$$

where $I_1 = \frac{V_{AO}}{4}$, $I_2 = \frac{V_{AO} - (V_{BO} - 2)}{2} = \frac{V_{AO}}{2} - \frac{V_{BO}}{2} + \frac{2}{2}$

Now writing KCL at node B, we get

$$I_2 - I_3 - I_4 = 0$$

$$\frac{V_{AO} - (V_{BO} - 2)}{2} - \frac{V_{BO} + 5}{6} - \frac{V_{BO} - V_{CO}}{8} = 0$$

or, $-\frac{1}{2} V_{AO} + V_{BO}\left(\frac{1}{2} + \frac{1}{6} + \frac{1}{8}\right) - \frac{1}{8} V_{CO} = \frac{2}{2} + \frac{5}{6}$ —(iii)

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Now writing KCL at node C

$$I_4 + x - I_5 = 0$$

$$\frac{V_{BO} - V_{CO}}{8} + x - \frac{V_{CO} - 10}{10} = 0$$

$$-\frac{V_{BO}}{8} + V_{CO}\left(\frac{1}{8} + \frac{1}{10}\right) = \frac{10}{10} + x \quad \text{--- (iv)}$$

Now to solve, putting value of $V_{AO} = V_{CO} - 4$ from eqn (i) in eqn. (iii) we get,

$$-\frac{1}{2}(V_{CO} - 4) + V_{BO}\left(\frac{12 + 4 + 3}{24}\right) - \frac{1}{8}V_{CO} = \frac{11}{6}$$

or, $$\frac{19 V_{BO}}{24} - \left(\frac{1}{2} + \frac{1}{8}\right)V_{CO} = \frac{11}{6} - 2$$

or, $$\frac{19 V_{BO} - 15 V_{CO}}{\cancel{24}\ 4} = \frac{-1}{\cancel{6}}$$

or, $$19 V_{BO} - 15 V_{CO} = -4 \quad \text{--- (v)}$$

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or, $19V_{BO} - 15V_{CO} = -4$ —— (v)

putting value of V_{AO} from eqn. (i) into eqn. (ii)

$$(V_{CO} - 4)\left(\frac{3}{4}\right) - \frac{V_{BO}}{2} = -1 - x$$

or, $$\frac{-2V_{BO} + 3V_{CO}}{4} = -1 - x + 3$$

or, $-2V_{BO} + 3V_{CO} = 8 - 4x$ —— (vi)

Solving eqn. (iv) yields.

$$\frac{-5V_{BO} + 9V_{CO}}{40} = 1 + x$$

or, $-5V_{BO} + 9V_{CO} = 40 + 40x$ —— (vii)

Multiplying eqn. (vi) by 10 and adding with eqn. (vii)

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$$-20V_{BO} + 30V_{CO} = 80 \; \cancel{- 40x}$$

$$-5V_{BO} + 9V_{CO} = 40 \; \cancel{+ 40x}$$

$$-25V_{BO} + 39V_{CO} = 120 \quad \text{———} ~~(viii)~~$$

or, $$V_{CO} = \frac{120 + 25V_{BO}}{39}$$

Now putting value of V_{CO} in eqn. (v) we get

$$19V_{BO} - \frac{15(120 + 25V_{BO})}{39} = -4$$

or, $$741V_{BO} - 375V_{BO} - 1800 = -4 \times 39$$

or, $$366V_{BO} = -156 + 1800$$

or, $$V_{BO} = \frac{1644}{366} \approx 4.5\,V$$

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$$V_{CO} = \frac{120 + 25 \times 4.5}{39} = \frac{120 + 112.5}{39} \approx 6V$$

$$V_{AO} = V_{CO} - 4V$$
$$= 6V - 4V = 2V$$

So different branch currents are,

$$I_1 = \frac{V_{AO}}{4} = \frac{2V}{4\Omega} = 0.5\,A$$

$$I_2 = \frac{2 - (4.5 - 2)}{2} = \frac{2 - 2.5}{2} = \frac{-0.5}{2}\,A = -0.25\,A$$

This means direction I_2 is from B to A.

$$I_3 = \frac{4.5 - 5}{6} = \frac{-0.5}{6}\,A = -0.083\,A = -83\,mA$$

$$I_4 = \frac{4.5 - 6}{8} = \frac{-1.5}{8}\,A \approx -0.19\,A$$

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$$I_5 = \frac{6-10}{10} A = \frac{-4}{10} A = -0.4 A$$

By KCL at node A we have,

$$-I_1 - I_2 - x = 0$$

$$I_1 + I_2 + x = 0$$

$$0.5A - 0.25A + x = 0$$

or, $x = -0.25 A$ so the direction of current x is from C to A.

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For any query contact- 9771474020

Thank You