Paper 1, TDC Part-1
Chapter– 3, Mesh and Node Analysis
Nodal Analysis -2

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Mesh and Nodal Analysis in Passive Circuits

Now to solve for V_{A0}, V_{B0} & V_{C0} we will write KCL at nodes A, B, & C respectively,

KCL at Node A can be written as,

$$I_1 - I_2 - I_3 = 0 \quad \text{[A/c to KCL } \Sigma I = 0 \text{ at any node]}$$

or, $I_1 = I_2 + I_3$

or, $\frac{E_1 - V_{A0}}{R_1} = \frac{V_{A0} - V_{B0} + E_2}{R_2} + \frac{V_{A0} - V_{C0} + E_4}{R_3}$

[from eqn (i), (v) & (vi)]

or, $V_{A0}\left[\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right] - V_{B0}\left[\frac{1}{R_2}\right] - V_{C0}\left[\frac{1}{R_3}\right] = \frac{E_1}{R_1} - \frac{E_2}{R_2} - \frac{E_4}{R_3}$ ——— (vii)

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Now writing KCL at node B,

$$I_2 - I_4 - I_6 = 0$$

or, $$\frac{V_{AO} - V_{BO} + E_2}{R_2} - \frac{V_{BO} - V_{CO}}{R_4} - \frac{V_{BO} - E_2}{R_2} = 0$$

[from eqn. i, ii & iii]

or, $$\frac{V_{AO}}{R_2} - V_{BO}\left(\frac{1}{R_2} + \frac{1}{R_4} + \frac{1}{R_2}\right) + \frac{V_{CO}}{R_4} = -\frac{E_2}{R_2} - \frac{E_2}{R_2}$$

or, $$-\frac{V_{AO}}{R_2} - V_B\left(\frac{1}{R_2} + \frac{1}{R_4} + \frac{1}{R_2}\right) - \frac{V_{CO}}{R_4} = \frac{2E_2}{R_2} \quad \text{(viii)}$$

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Now writing KCL at node C,

$$I_3 + I_4 - I_5 = 0$$

[I_3 & I_4 are incoming current & I_5 is outgoing

$$\text{or, } \frac{V_{AO} - V_{CO} + E_4}{R_3} + \frac{V_{BO} - V_{CO}}{R_4} - \frac{V_{CO} + E_3}{R_5} = 0$$

$$\text{or, } -\frac{V_{AO}}{R_3} - \frac{V_{BO}}{R_4} + V_{CO}\left(\frac{1}{R_3} + \frac{1}{R_4} + \frac{1}{R_5}\right) = \frac{E_4}{R_3} - \frac{E_3}{R_5}$$

—— (ix)

As we have three eqn^{n}. (vii), (viii) & (ix) and three unknowns V_{AO}, V_{BO}, & V_{CO}. So on solving we can find the value of V_{AO}, V_{BO} & V_{CO}

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Once we obtained the value of V_{20}, V_{30} & V_{40} we can find the different branch currents.

Q. If we solve the same the same problem using 3 mesh analysis there there will be 4 unknowns and hence we need 4 equations to solve to obtain all the values

1) Find the currents in various branches of the circuit shown in figure.

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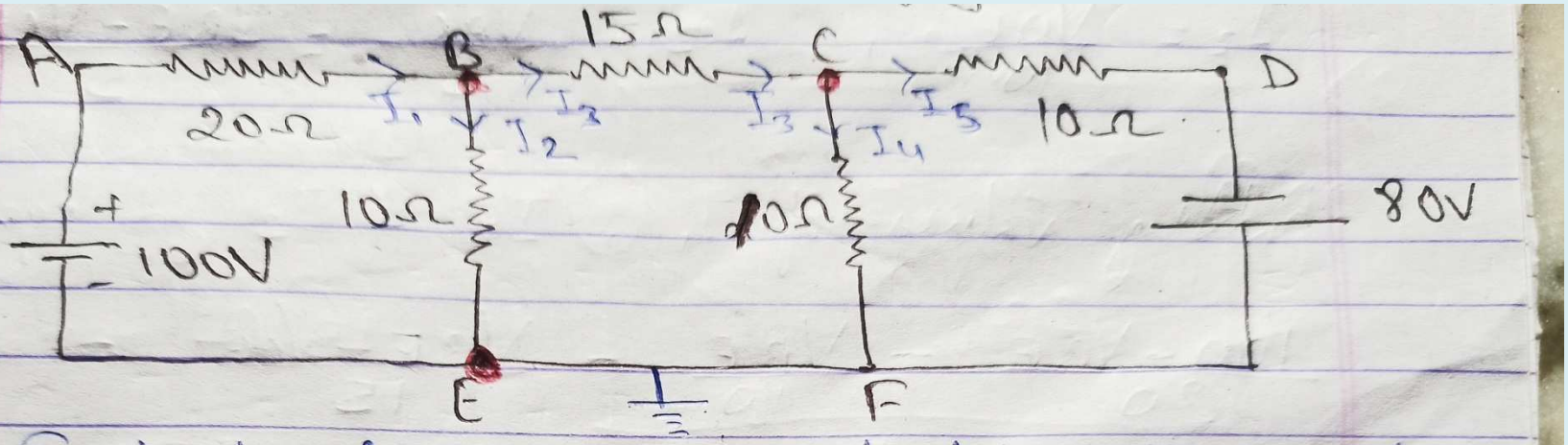

Soln:- First of all let us identify the nodes and the nodes are B, C and E/F

$n = 3$ where reference node is E i.e. $V_E = 0$

Now let us assign the current at the nodes B & C,

Let I_1 is incoming current and I_2 & I_3 are out-

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going current at node B. I_3 is incoming current and I_4 & I_5 are outgoing current at node C.

Now writing KCL at node B.

$$I_1 = I_2 - I_3 = 0 \quad \text{——— (i)}$$

where $I_1 = \frac{V_{AB}}{20} = \frac{V_{AE} - V_{BE}}{20} = \frac{100 - V_{BE}}{20}$

$(\because V_{AE} = 100V)$

$$I_2 = \frac{V_{BE}}{10}, \quad I_3 = \frac{V_{BC}}{15} = \frac{V_{BE} - V_{CE}}{15}$$

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putting values of I_1, I_2 & I_3 in eqn. (i)

$$\frac{100 - V_{BE}}{20} - \frac{V_{BE}}{10} - \frac{V_{BE} - V_{CE}}{15} = 0$$

$$5 = V_{BE}\left(\frac{1}{20} + \frac{1}{10} + \frac{1}{15}\right) - \frac{V_{CE}}{15}$$

$$\Rightarrow \frac{13 V_{BE} - 4 V_{CE}}{60} = 5$$

$$\Rightarrow 13 V_{BE} - 4 V_{CE} = 300 \quad \text{——— (ii)}$$

Writing KCL at node C,

$$I_3 - I_4 - I_5 = 0 \quad \text{——— (iii)}$$

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$$I_3 = \frac{V_{BE} - V_{CE}}{15}, \quad I_4 = \frac{V_{CE}}{10},$$

$$I_5 = \frac{V_{CE} - V_{DE}}{10} = \frac{V_{CE} - (-80)}{10}$$

$$\text{or } I_5 = \frac{V_{CE} + 80}{10} \qquad V_{DE} = -80$$

putting values of I_3, I_4 & I_5 in eqn (i) we get

$$\frac{V_{BE} - V_{CE}}{15} - \frac{V_{CE}}{20} - \frac{V_{CE} + 80}{10} = 0$$

$$\Rightarrow V_{BE}\left(\frac{1}{15}\right) - V_{CE}\left(\frac{1}{15} + \frac{1}{10} + \frac{1}{10}\right) = +\frac{80}{10} \times 8$$

$$\Rightarrow \frac{2V_{BE} - 8V_{CE}}{30} = 8$$

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$$\Rightarrow V_{BE} + 4V_{CE} = 120 \quad \text{---------- (iv)}$$

Subtracting eqn. (iv) from (iii) we get.

$$13V_{BE} - 4V_{CE} = 300$$
$$-V_{BE} + 4V_{CE} = -120$$
$$12V_{BE} = 180$$
$$V_{BE} = \frac{180}{12} = 15\,V = V_B$$

$$V_{CE} = V_C = -26.25\,V$$

$$I_1 = \frac{100 - V_B}{20} = \frac{100 - 15}{20} = 4.25\,A$$

Hardly $I_2 = \frac{V_{BE}}{10} = \frac{V_B}{10} = 1.5\,A$

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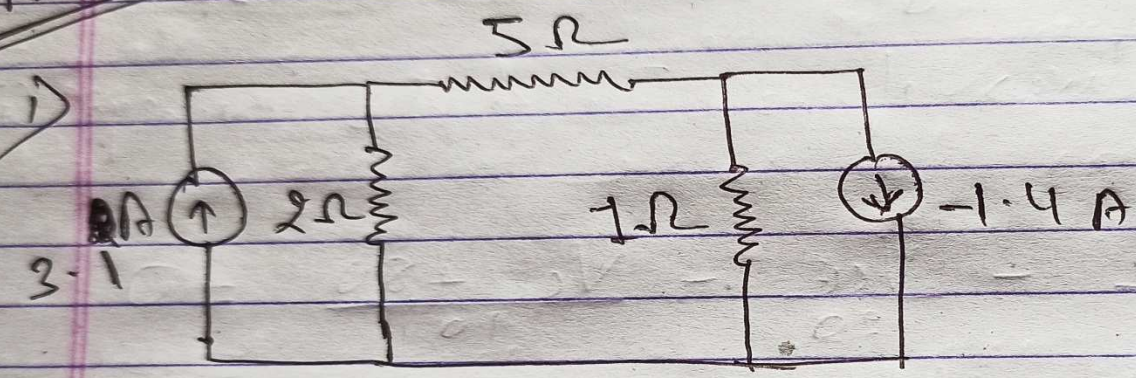
$I_3 = 2.75\ A$, $I_4 = -2.625\ A$

$I_5 = 5.375\ A$

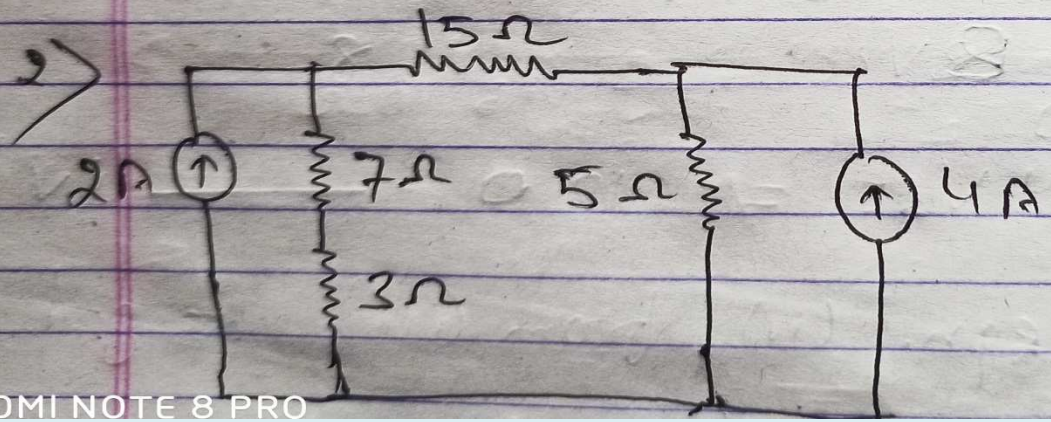
Assignment

1)



Find the current in 1Ω resistor

2)



Determine the current flowing left to right through the 15Ω resistor.

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For any query contact- 9771474020

Thank You