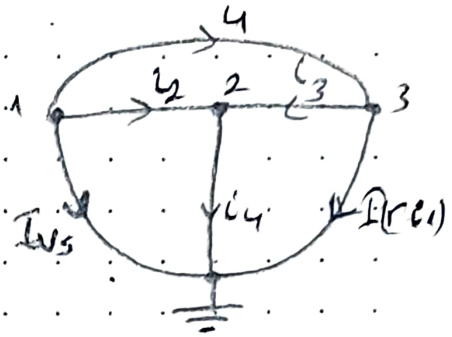
$i_1 + i_2 + I_{VS} = 0$ (1)

$i_2 + i_3 - i_4 = 0$ (2)

$i_3 + I_{ri4} - i_1 = 0$ (3)

$V_1 = V_S$ ext de (4)

$V_3 = r \cdot i_1$ ext de (5)



$i_4 = \frac{V_1 - V_3}{R_1}$

$$\frac{V_1 - V_3}{R_1} + \frac{V_1 - V_2}{R_2} + I_{VS} = 0$$

$$\frac{V_1 - V_2}{R_2} + \frac{V_3 - V_2}{R_3} - \frac{V_2}{R_4} = 0$$

$$\frac{V_3 - V_2}{R_3} - \frac{V_1 - V_3}{R_1} + I_{ri4} = 0$$

$$\begin{bmatrix} \frac{1}{R_1} + \frac{1}{R_2} & -\frac{1}{R_2} & -\frac{1}{R_1} & 1 & 0 \\ 1/R_2 & -(1/R_2 + 1/R_3 + 1/R_4) & 1/R_3 & 0 & 0 \\ -1/R_1 & -1/R_3 & 1/R_1 + 1/R_3 & 0 & 1 \\ 1 & 0 & 0 & 0 & 0 \\ r/R_1 & 0 & -(r/R_1 + 1) & 0 & 0 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \\ I_{VS} \\ I_{ri4} \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ V_S \\ 0 \end{bmatrix}$$

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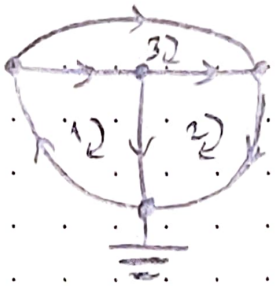


$$V_2 + V_4 + V_{Is} = 0$$

$$V_3 + V_{gv1} - V_4 = 0$$

$$V_1 - V_3 - V_2 = 0$$

$$I_{m2} = g V_1 = g R_1 I_{m3}$$

$$I_{m1} = I_s$$

$$R_2(I_{m1} - I_{m3}) + R_4(I_{m1} - I_{m2}) + V_{Is} = 0$$

$$R_3(I_{m2} - I_{m3}) + V_{gv1} - R_4(I_{m2} - I_{m1}) = 0$$

$$R_1 I_{m3} - R_3(I_{m3} - I_{m2}) - R_2(I_{m3} - I_{m1}) = 0$$

$$(R_2 + R_4) I_{m1} - R_4 I_{m2} = R_2 I_{m3} + V_{Is} = 0$$

$$R_4 I_{m1} + (R_3 - R_4) I_{m2} - R_3 I_{m3} + V_{gv1} = 0$$

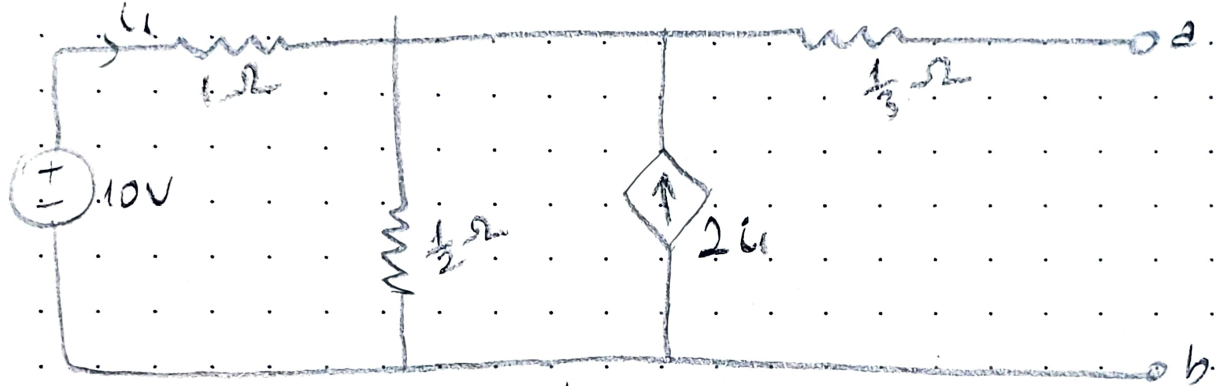
$$R_2 I_{m1} + R_3 I_{m2} + (R_1 - R_2 - R_3) I_{m3} = 0$$

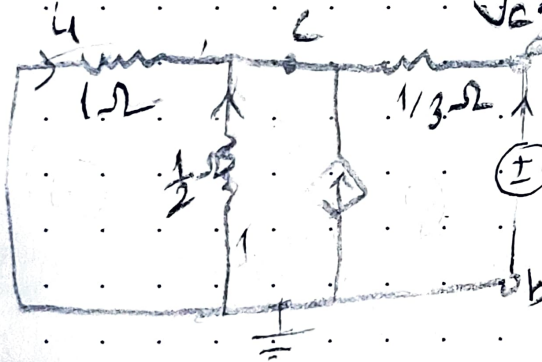
$$I_{m2} - g R_1 I_{m3} = 0$$

$$I_{m1} = I_s$$

$$\begin{bmatrix} R_2+R_4 & -R_4 & -R_2 & 1 & 0 \\ R_4 & R_3-R_4 & -R_3 & 0 & 1 \\ R_2 & R_3 & (R_1-R_2-R_3) & 0 & 0 \\ 0 & 1 & -gR_1 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} I_{m1} \\ I_{m2} \\ I_{m3} \\ V_{Is} \\ V_{gv1} \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ I_s \end{bmatrix}$$

Find Thevenin equivalent of the 2-terminal a-b.





$V_c = \frac{1}{3}$

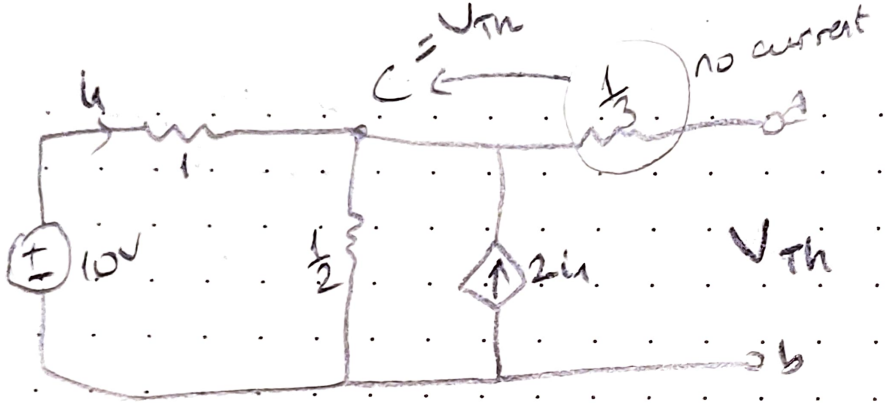
KCL at node c:

$$\frac{V_c - 1}{1/3} + 2 \cdot \frac{V_c}{1} + \frac{V_c}{1} + \frac{2V_c}{1/2} = 0$$

$$8V_c = 3 \qquad V_c = \frac{3}{8}$$

$$i_{test} = \frac{5/8}{1/3} = 15/8 \qquad 1 - 3/8$$

$$R_{th} = \frac{1}{15/8} = 8/15\,\Omega$$



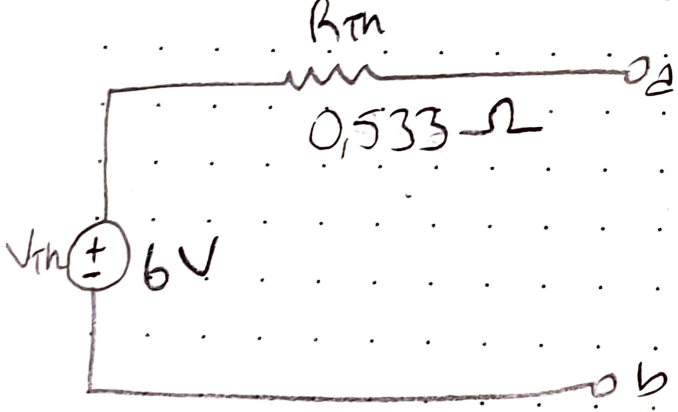
KCL at nod C:

$$\frac{V_c - 10}{1} + \frac{V_c}{\frac{1}{2}} + 2\frac{V_c - 10}{1} = 0$$

$$V_c - 10 + 2V_c + 2V_c - 20 = 0$$

$$5V_c = 30$$

$$V_{TH} = V_c = 6$$



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