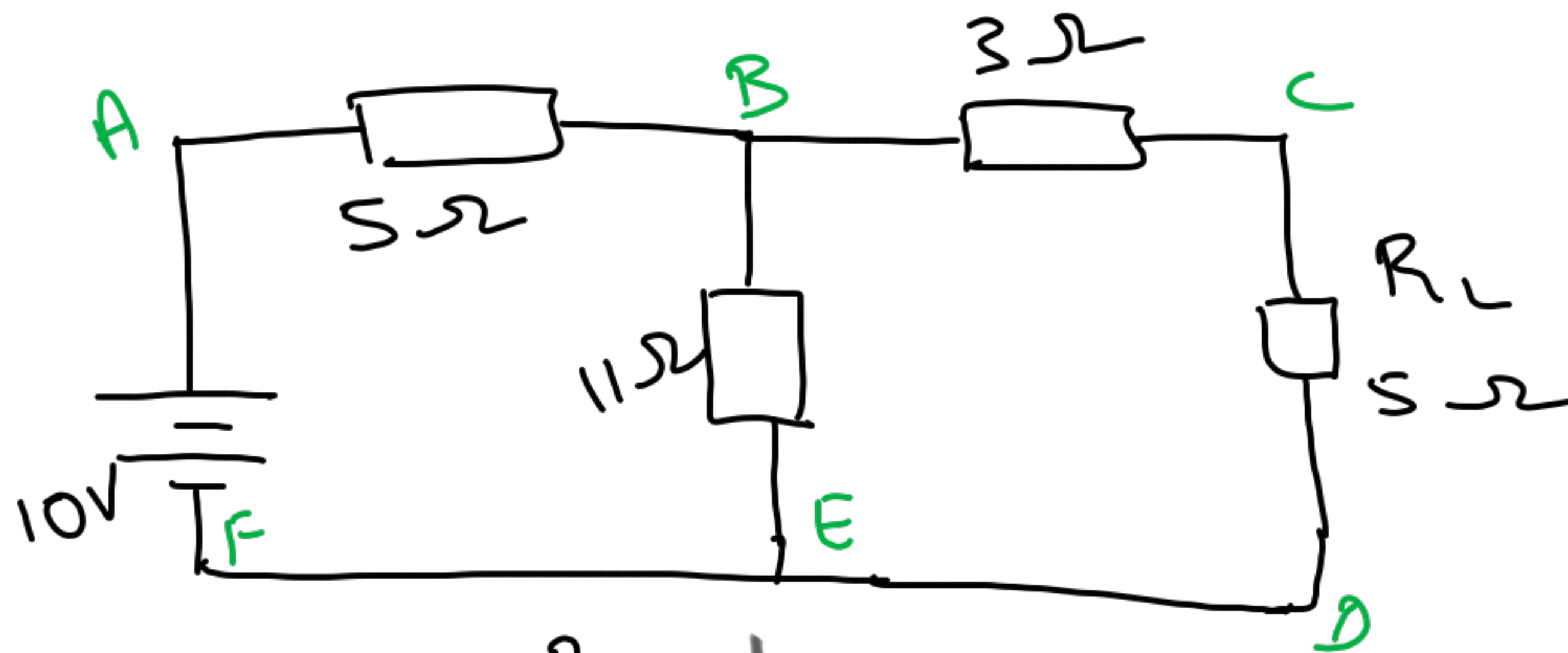


1) Determine the Thevenin's equivalent circuit and the current across the load from the following circuit.

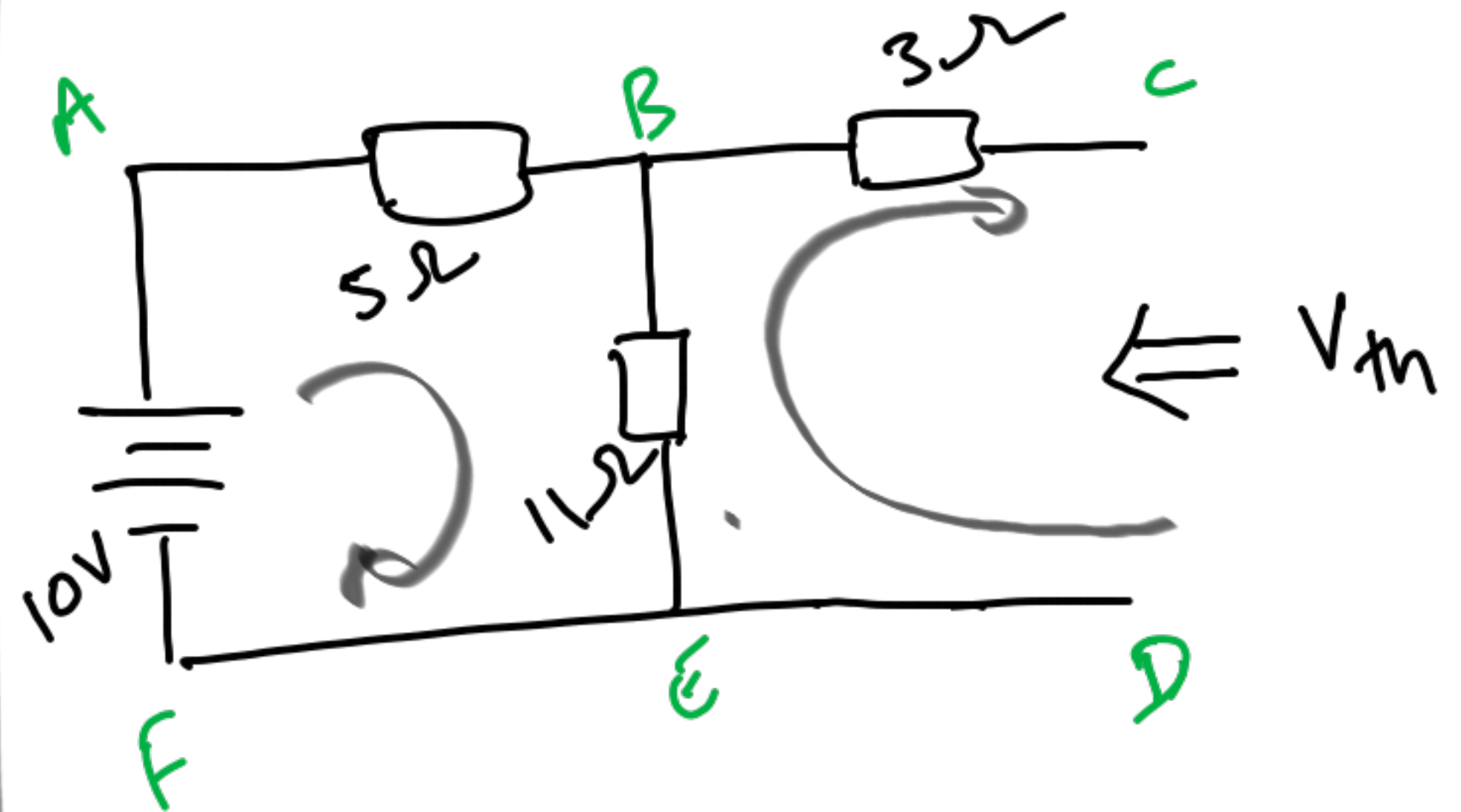


$$V_{th} = V_{oc} \quad - ?$$

$$R_{th} = \quad - ?$$

$$I_L \quad - ?$$

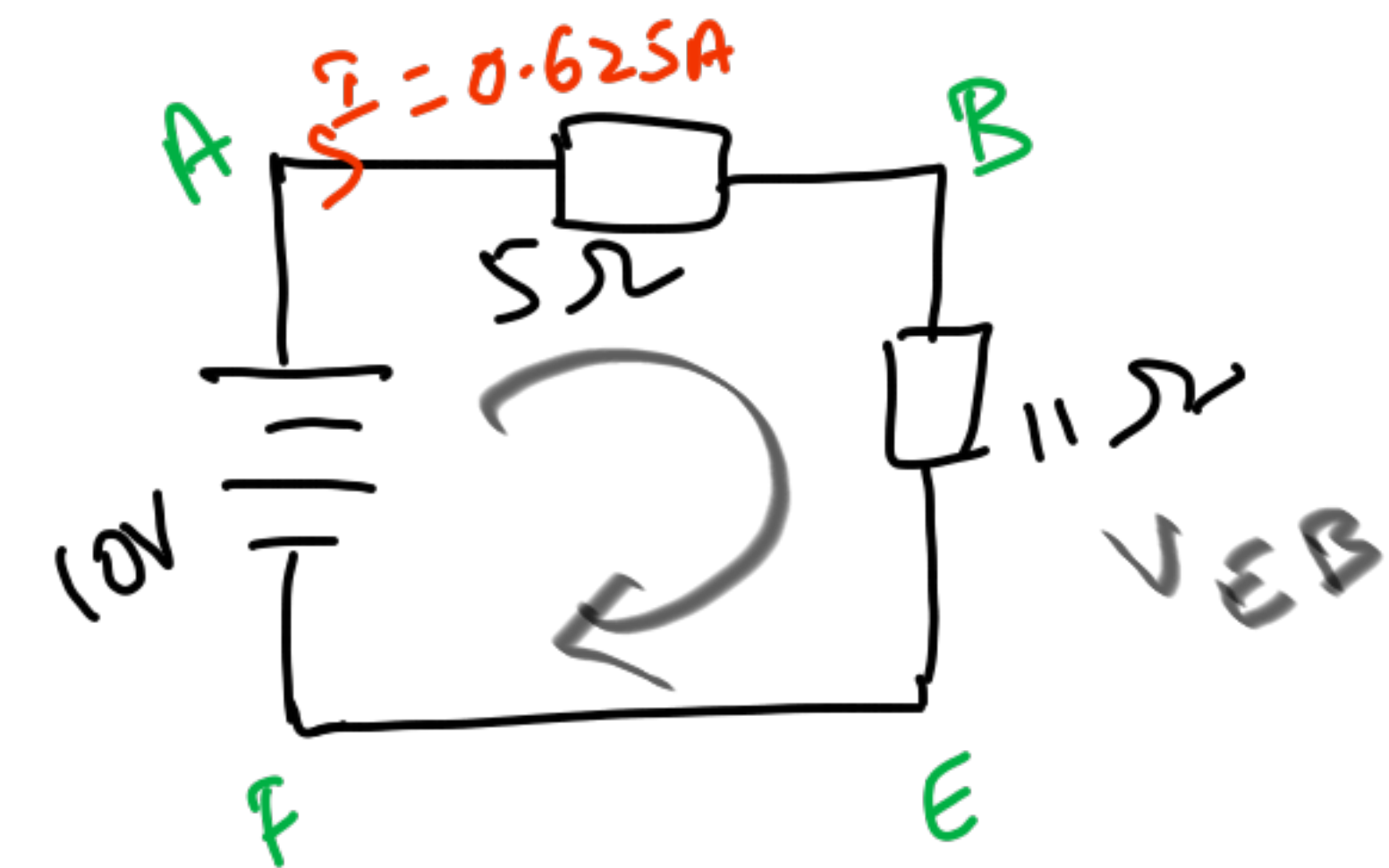
To find V_{th} .



$$V_{th} = V_{DC} = V_{DE} + V_{EB} + V_{BC}$$

$$V_{th} = 0 + V_{EB} + 0$$

$$V_{th} = V_{EB}$$



$$I = \frac{V}{R} = \frac{10}{5+11}$$

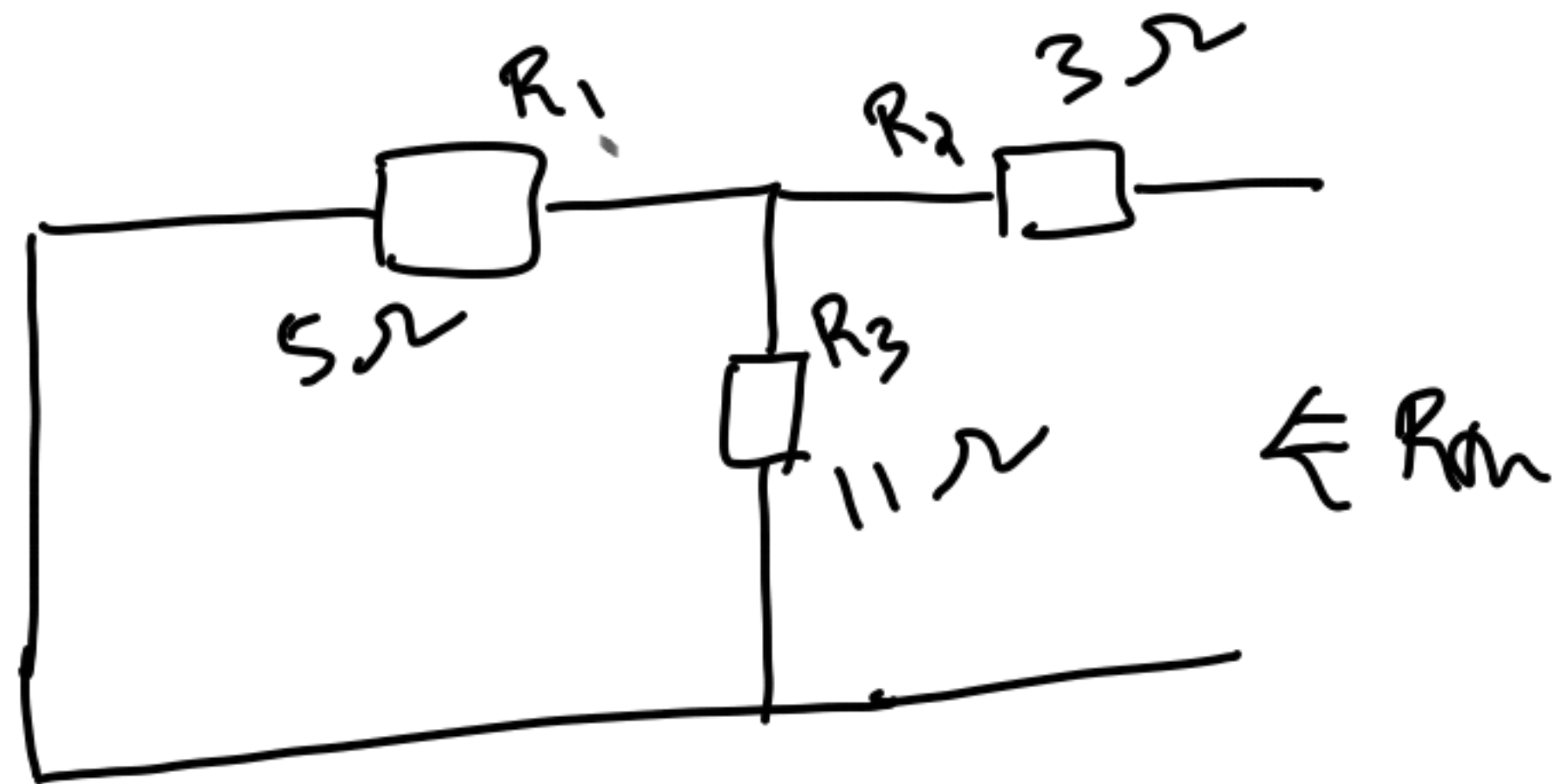
$$I = \frac{10}{5+11} = 0.625A$$

$$V_{EB} = I R_{11} = 0.625 \times 11$$

$$V_{EB} = 6.875V$$

$$V_{th} = V_{EB} = 6.875V$$

To find R_{th} !

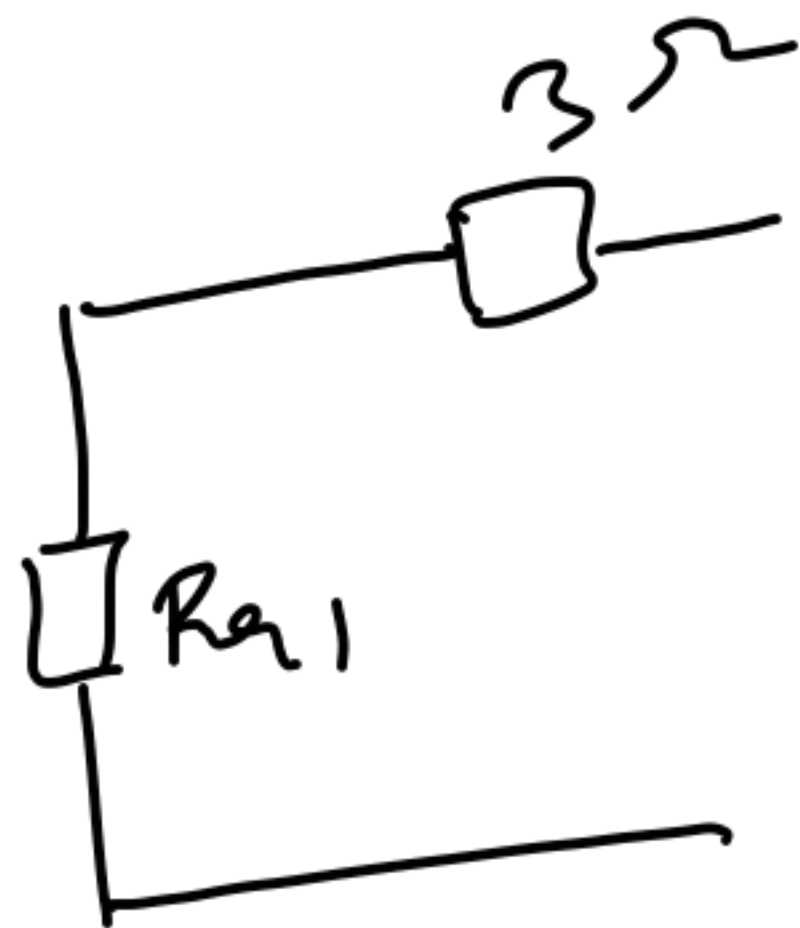


R_1 and R_3 in parallel.

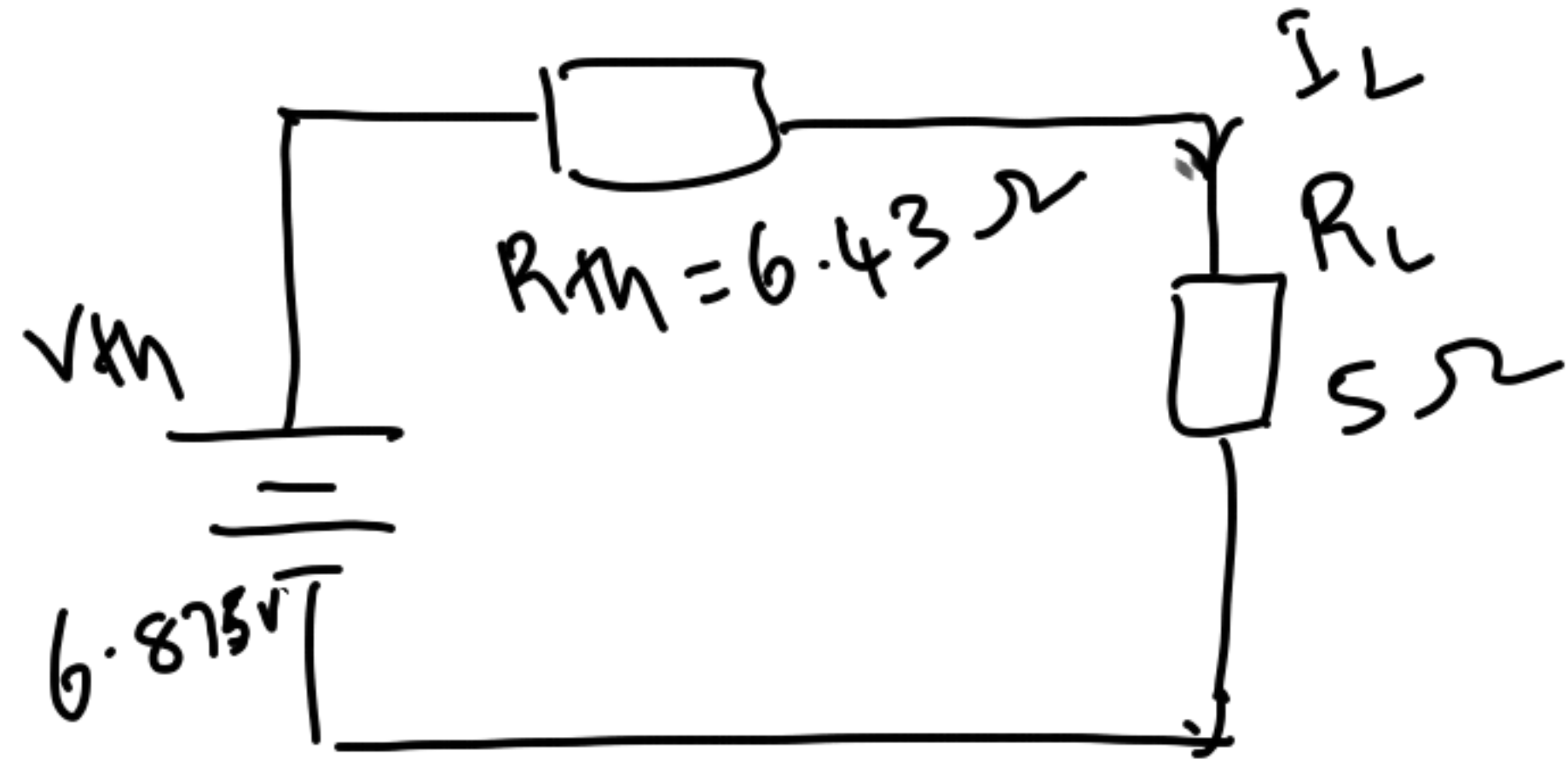
$$R_{th1} = \frac{1}{\left(\frac{1}{5} + \frac{1}{11}\right)} = 3.43\Omega$$

$$R_{th} = 3.43 + R_2 = 3.43 + 3 = 6.43\Omega$$

$$R_{th} = 6.43\Omega$$

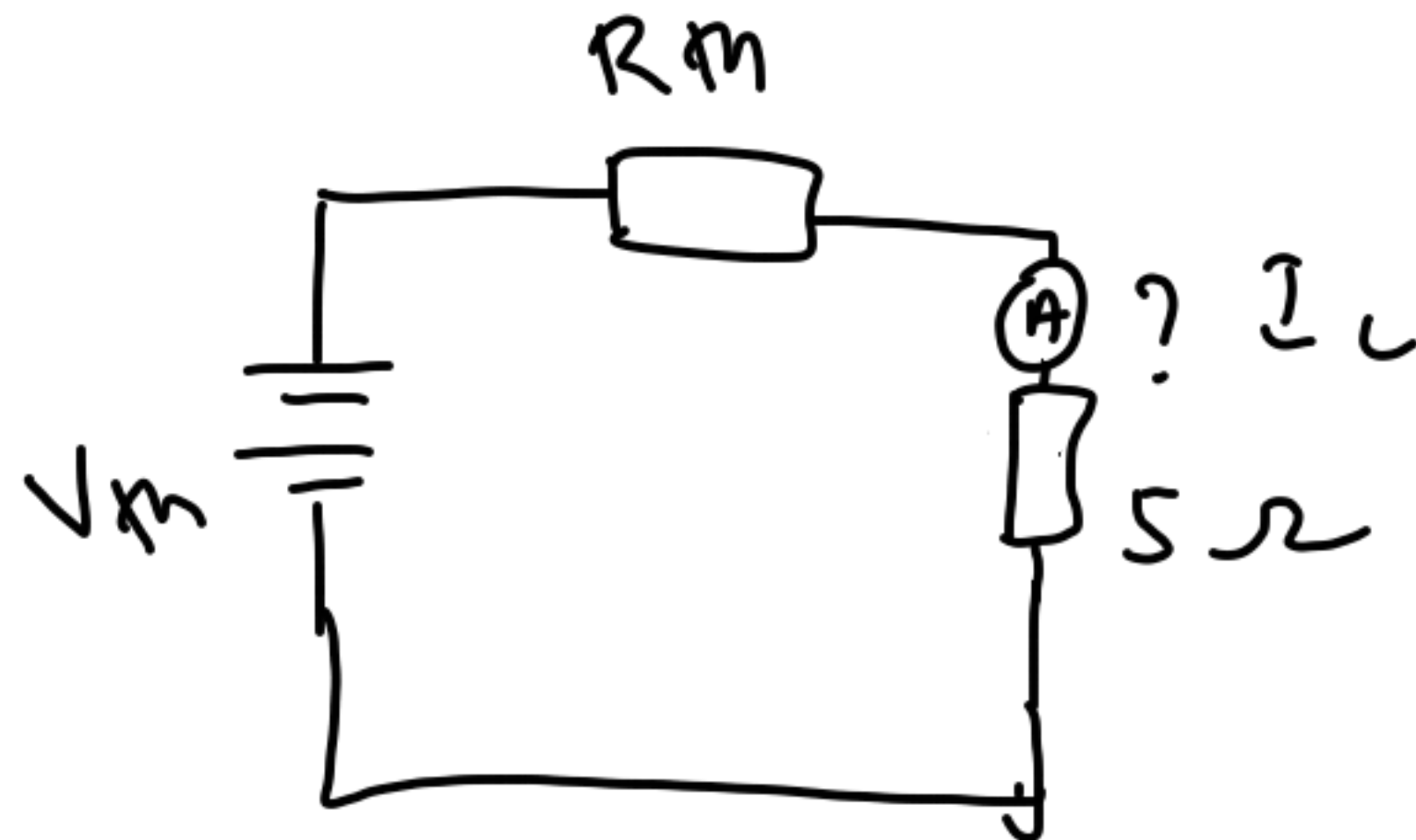
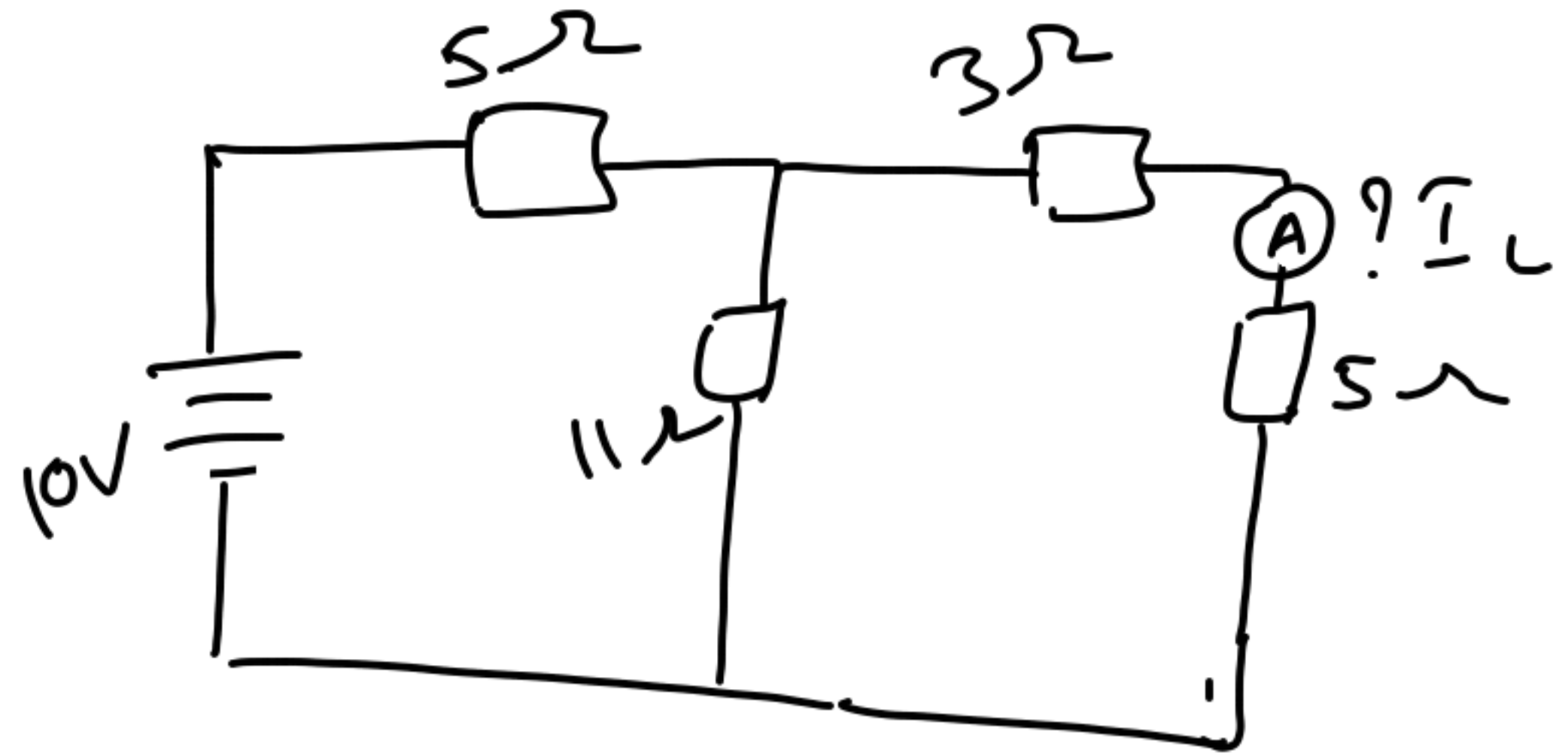


Thevenin's Equivalent Circuit.

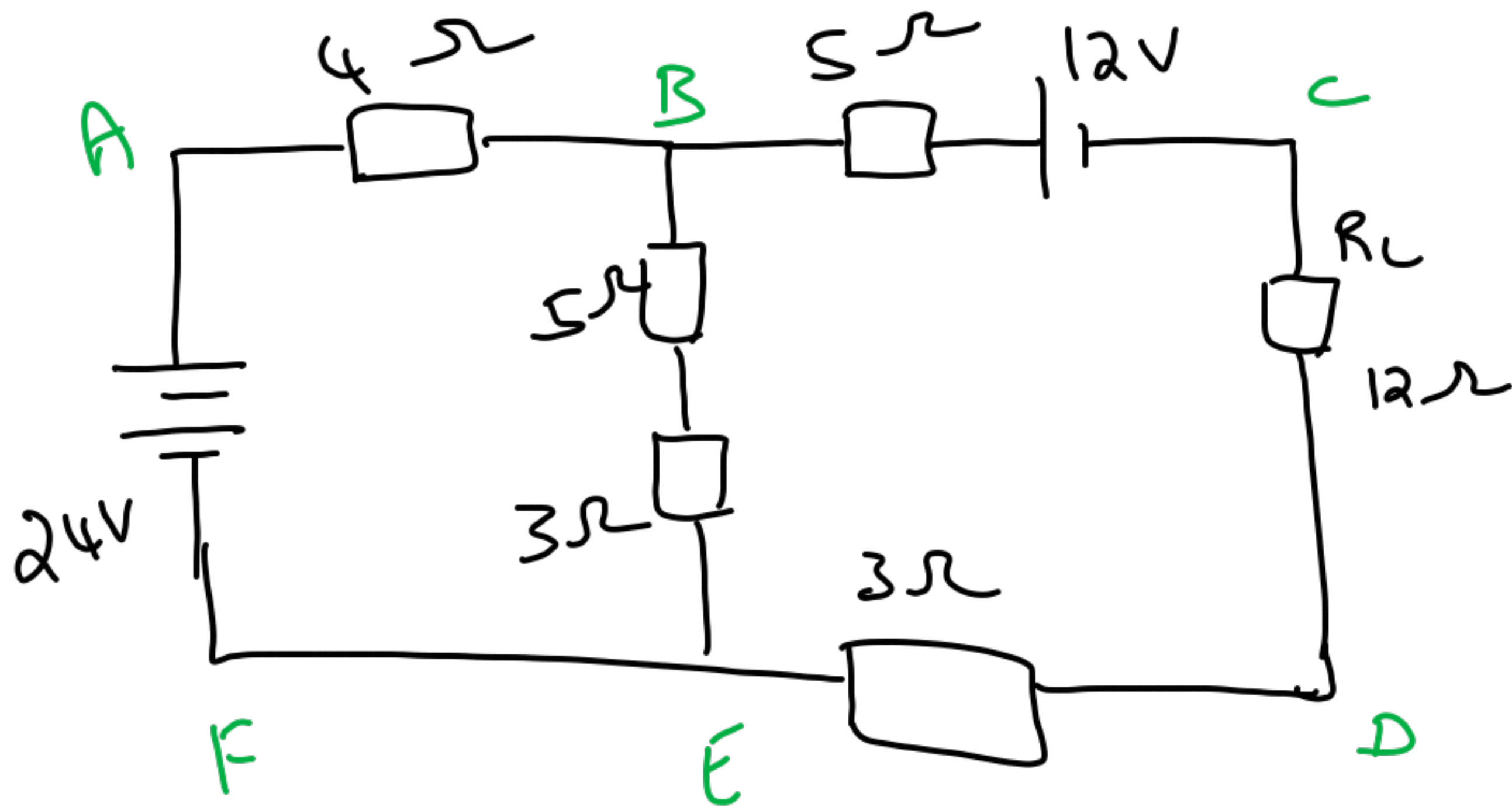


$$I_L = \frac{V_{th}}{R_{th} + R_L}$$
$$= \frac{6.875}{6.43 + 5}$$

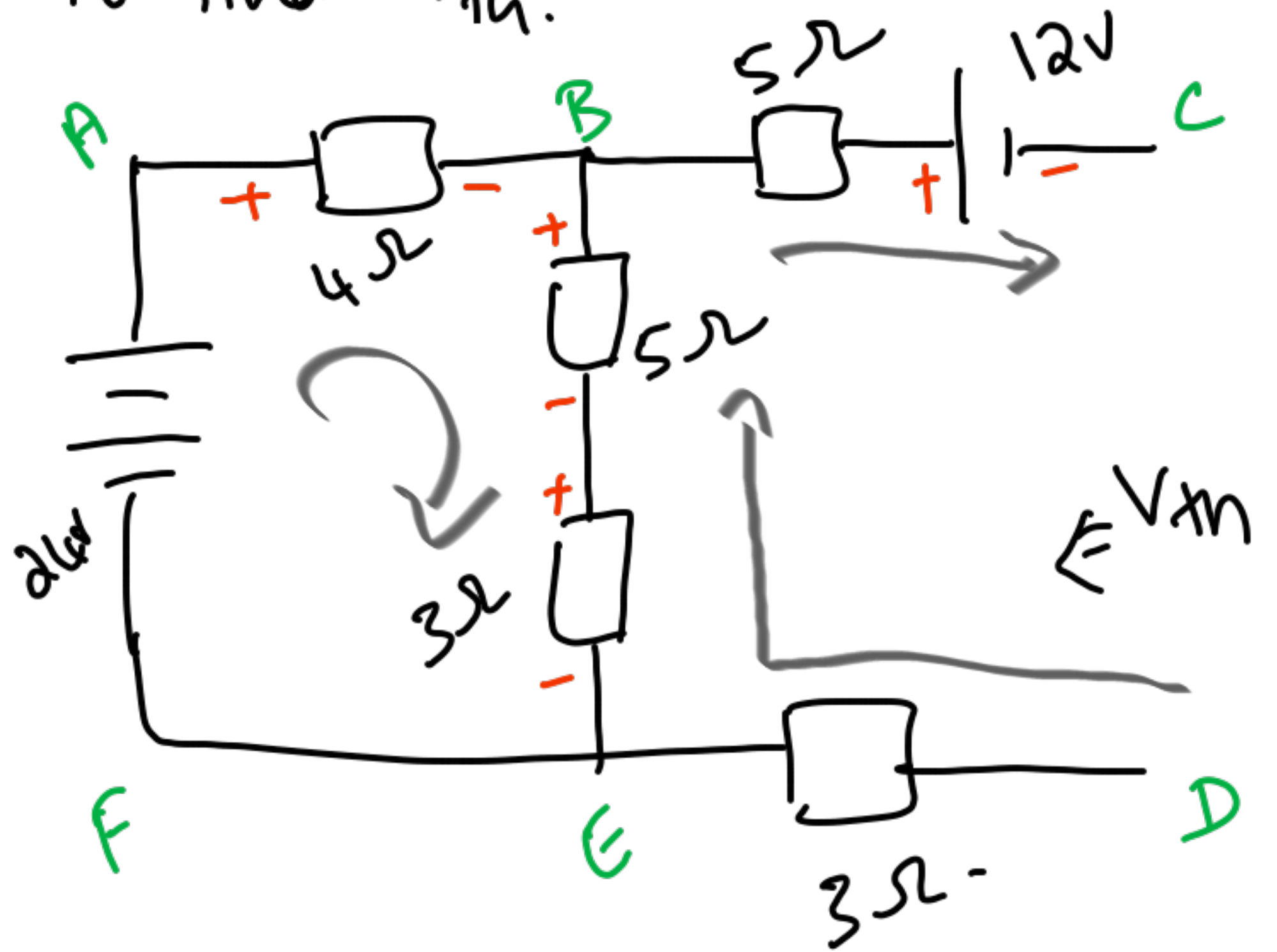
$$I_L = 0.6A$$



2) Determine the load current in the following circuit using Thevenin's theorem.



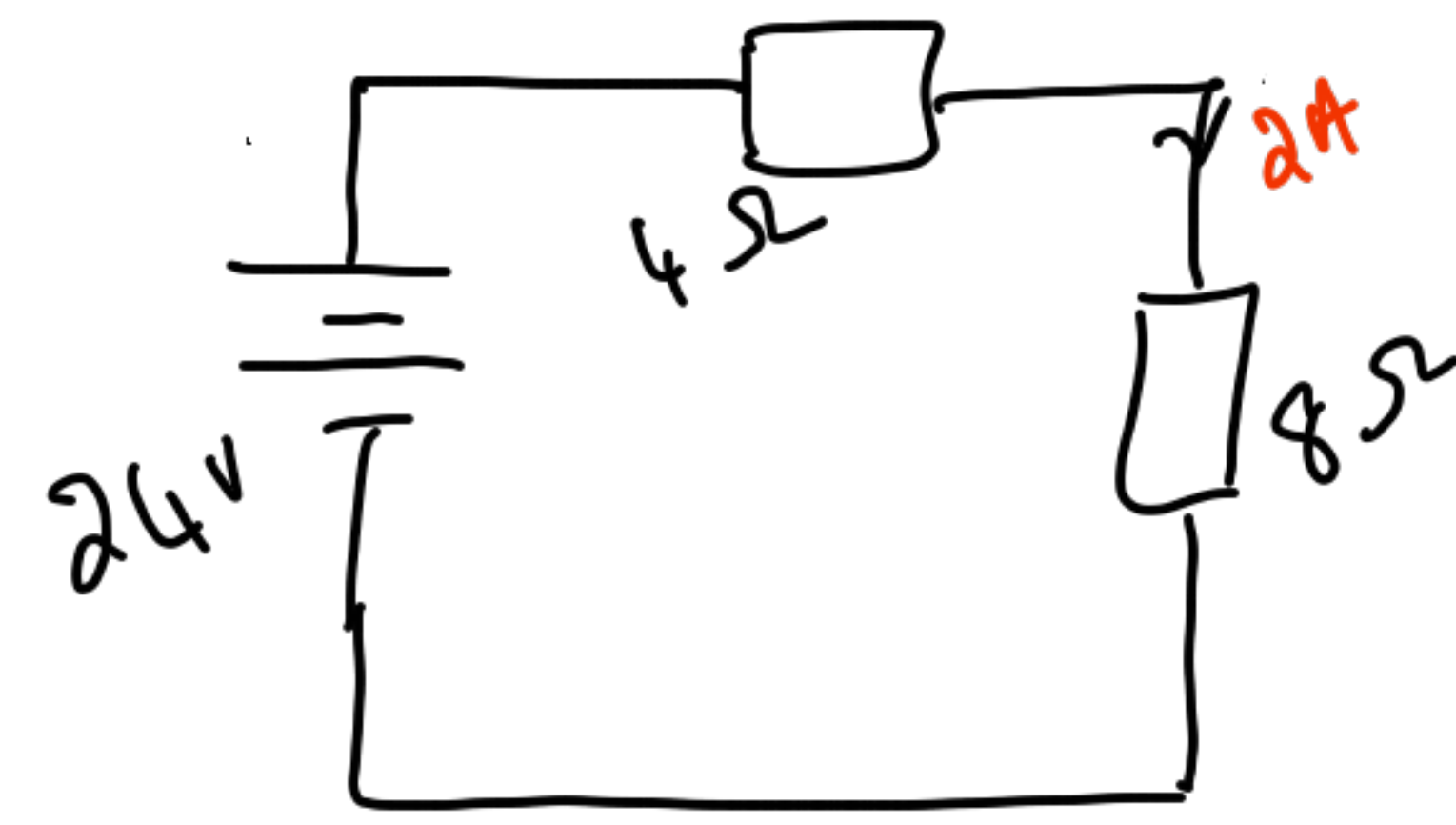
To find V_{th} .



$$V_{th} = V_{DC} = V_{DE} + V_{EB} + V_{BC}$$

$$V_{th} = 0 + V_{EB} + V_{BC}$$

To find V_{EB}



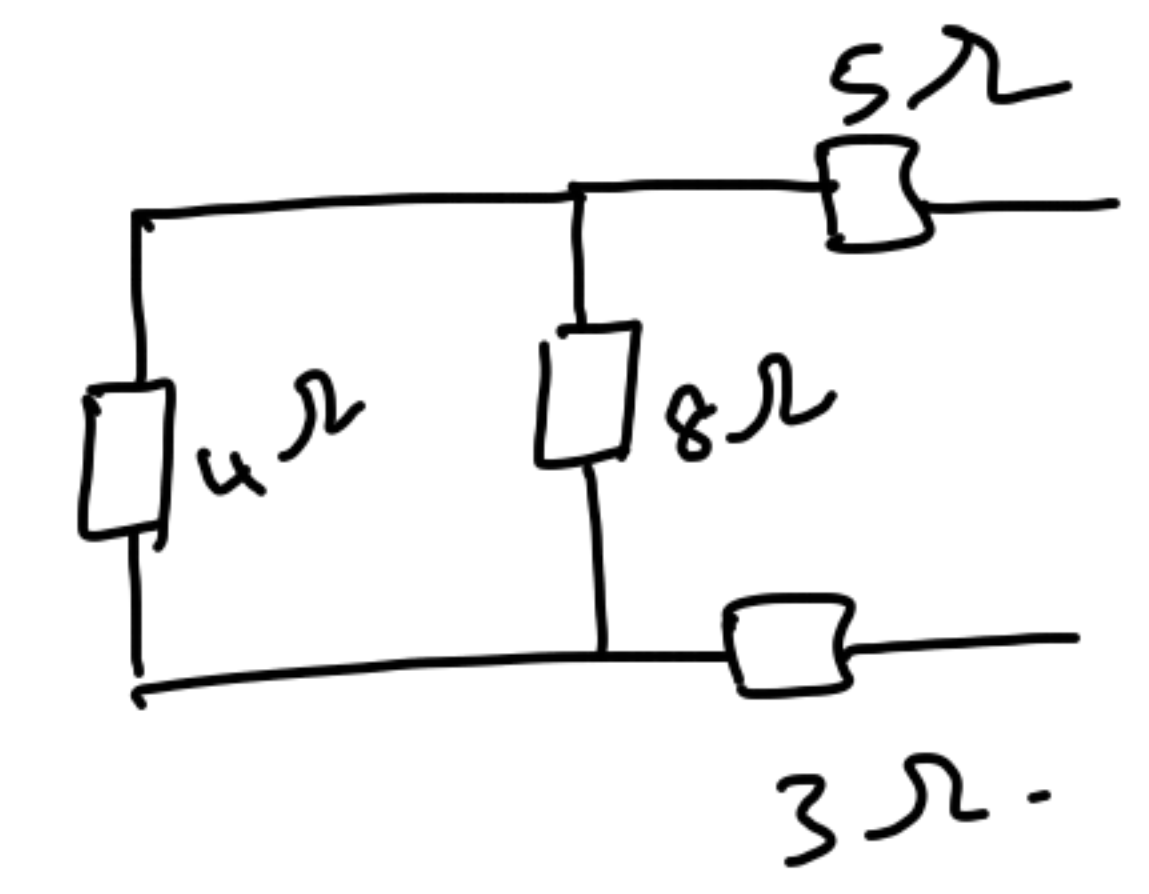
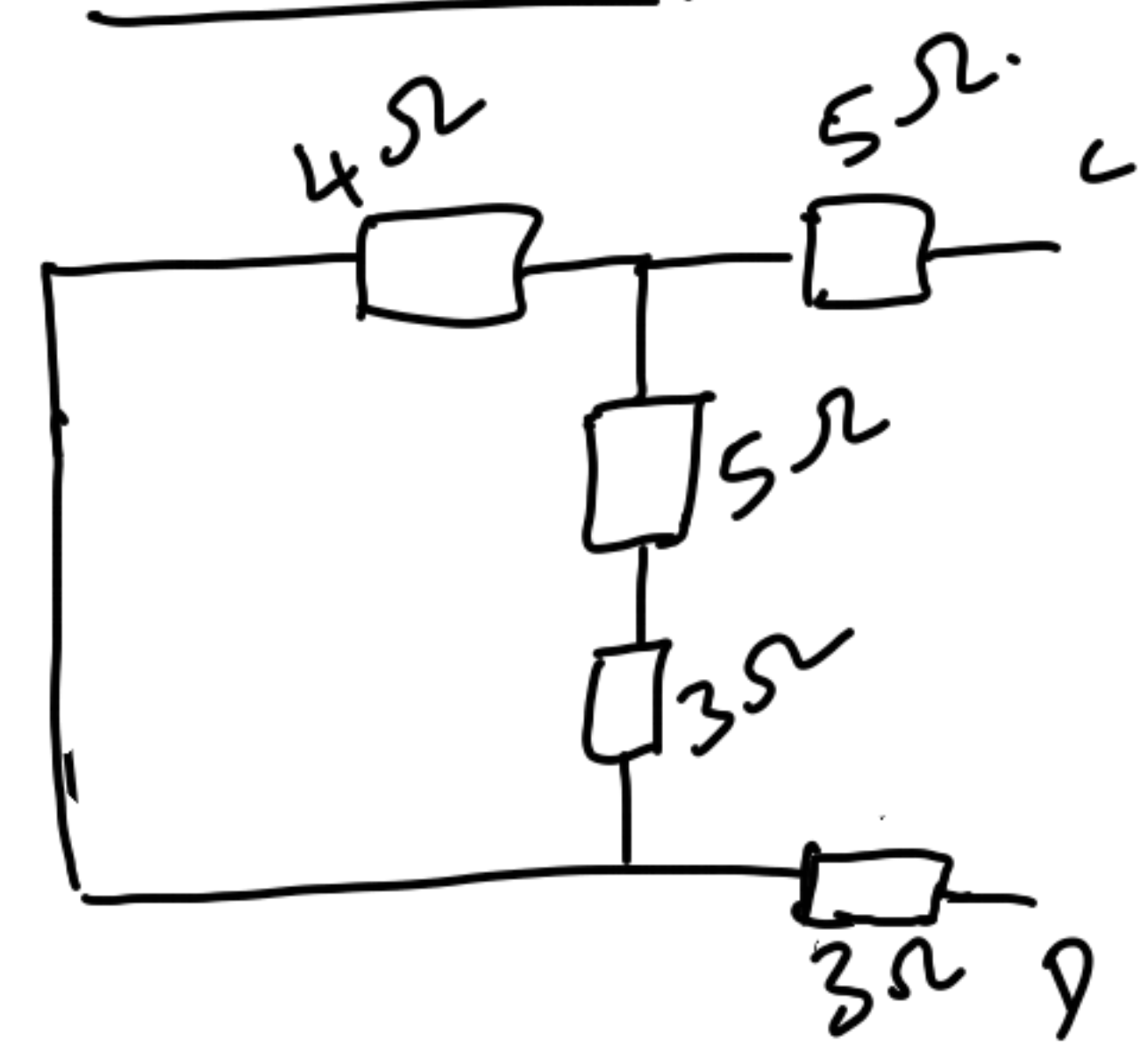
$$I = \frac{V}{R} = \frac{24}{12} = 2A$$

$$V_{EB} = 2 \times 8 = 16V$$

$$V_{th} = 16 - 12$$

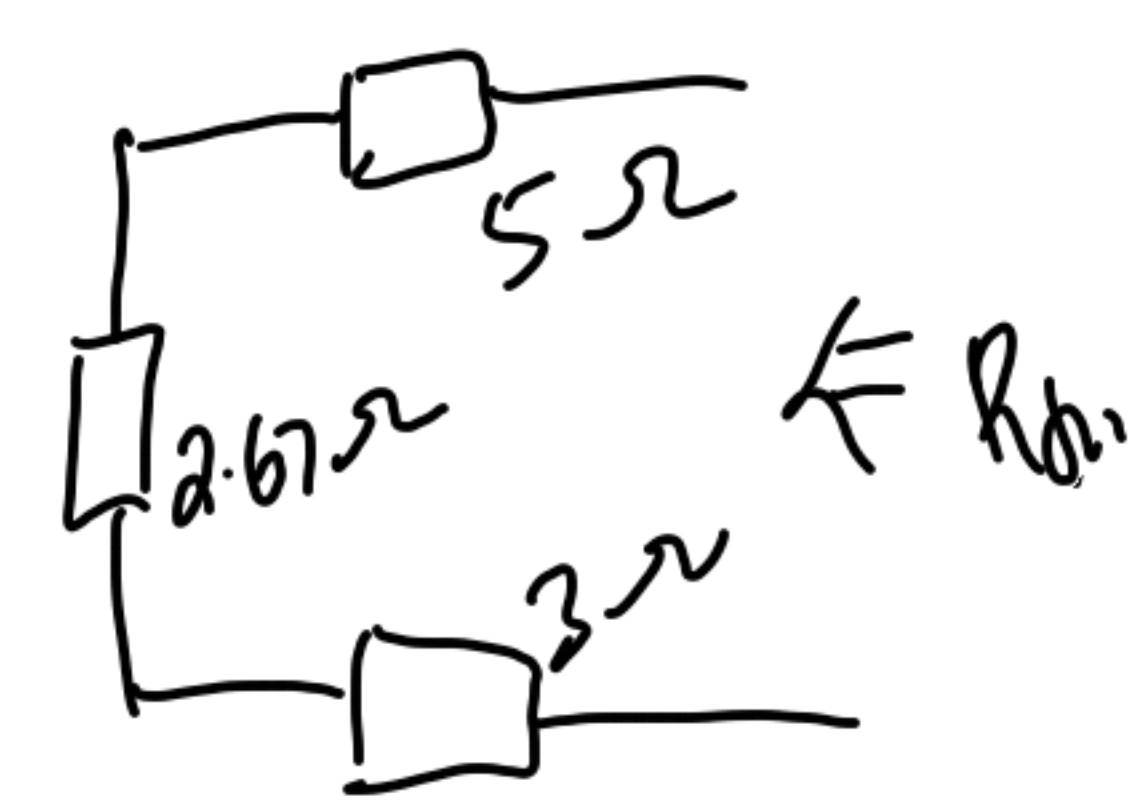
$$V_{th} = 4V$$

To find R_{th} :



4Ω and 8Ω parallel.

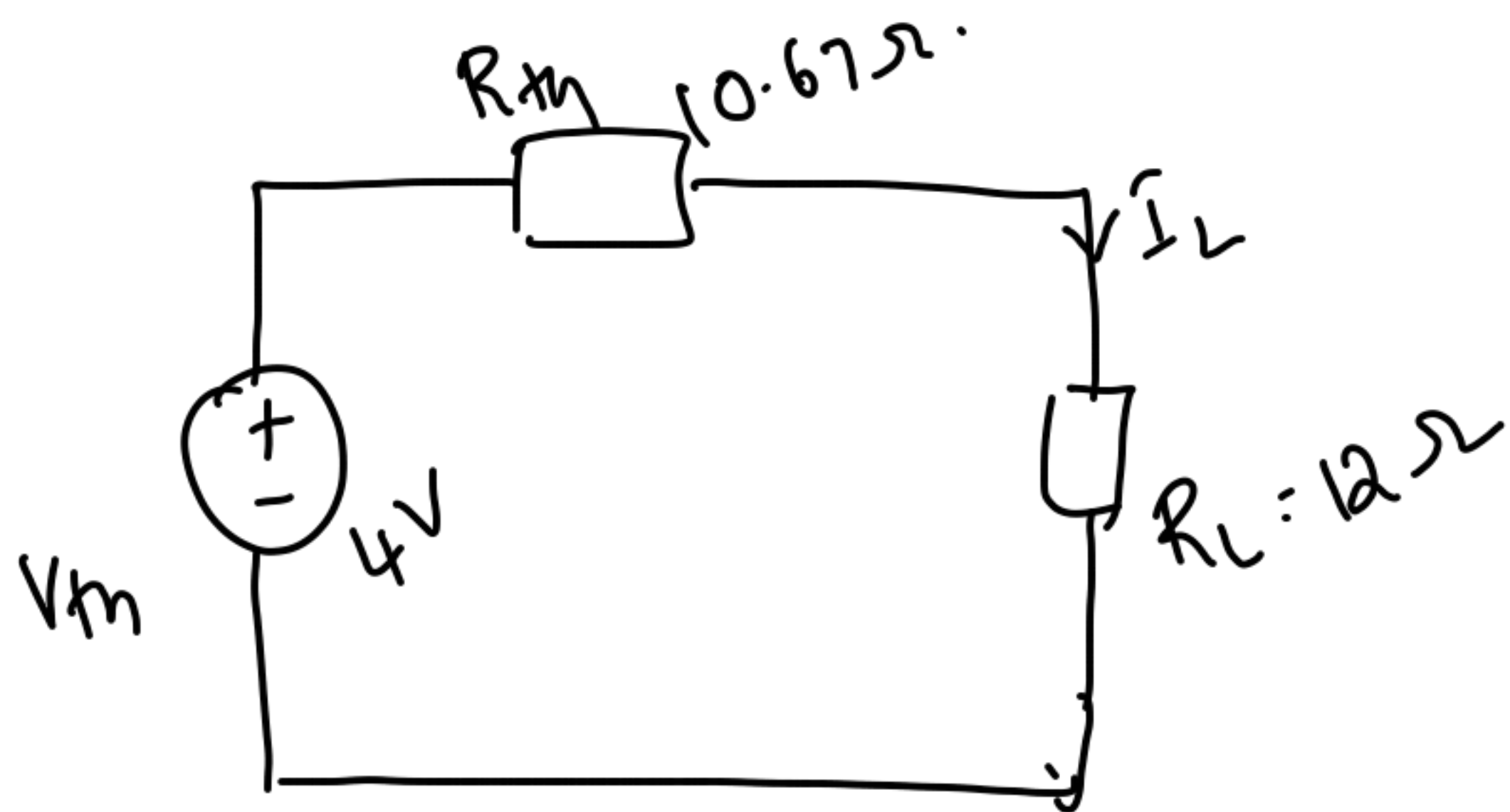
$$R_{eq1} = \frac{1}{\frac{1}{4} + \frac{1}{8}} = 2.67\Omega$$



$$R_{th} = 5 + 2.67 + 3$$

$$R_{th} = 10.67 \Omega$$

Thevenin's Equivalent Circuit

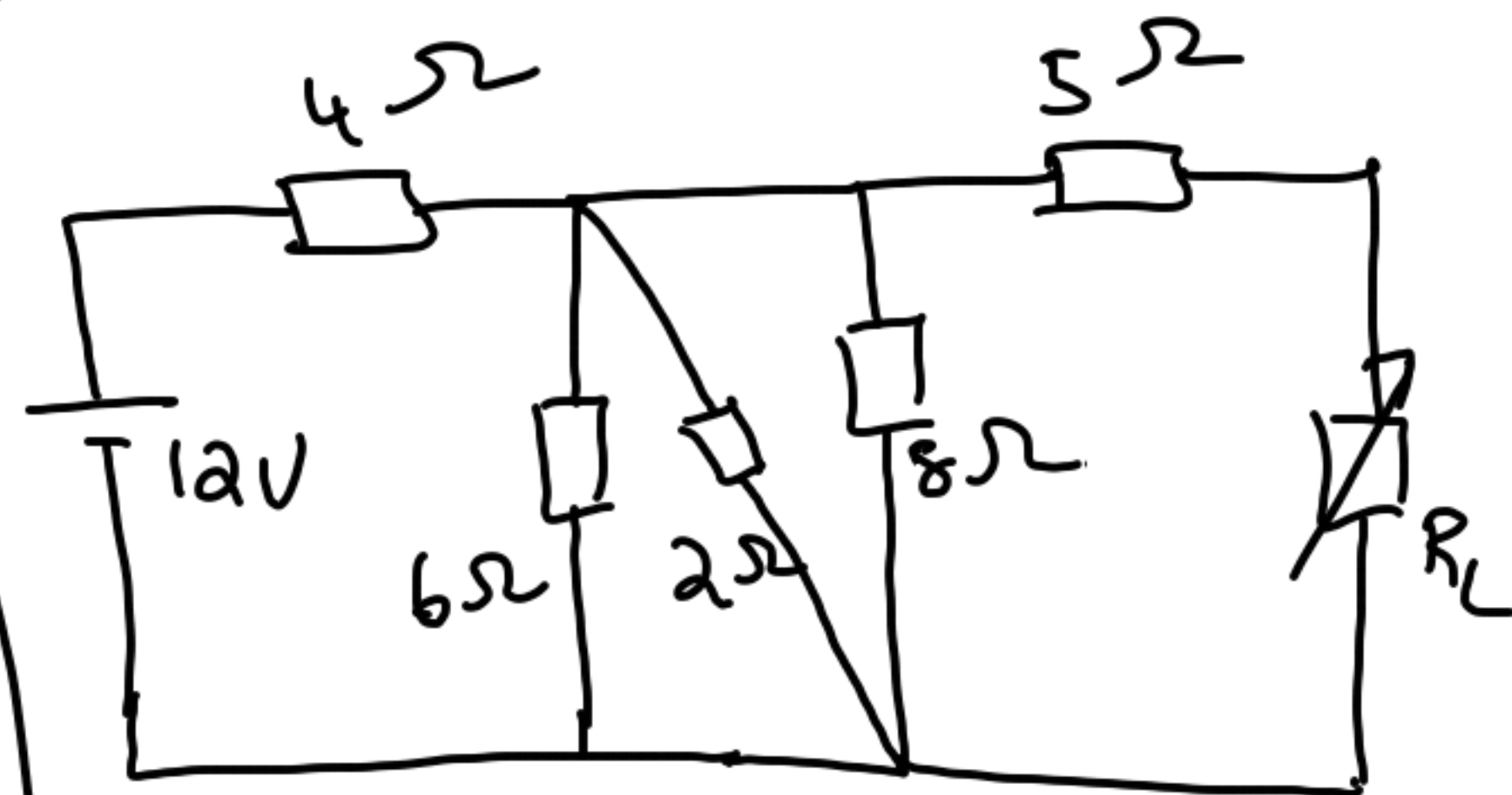


$$I_L = \frac{V_{th}}{R_{th} + R_L} = \frac{4}{10.6 + 12} = 0.18 A$$

3) A 12V DC power supply is used in an electronic control system to power a small DC motor acting as a variable load. The circuit consists of combination variable and fixed resistor. Determine the following.

- Thevenin's equivalent circuit
- Value of load Resistor for maximum power transfer
- load current under maximum power transfer

- Maximum power transfer to the load
- power transfer efficiency at maximum power transfer condition.



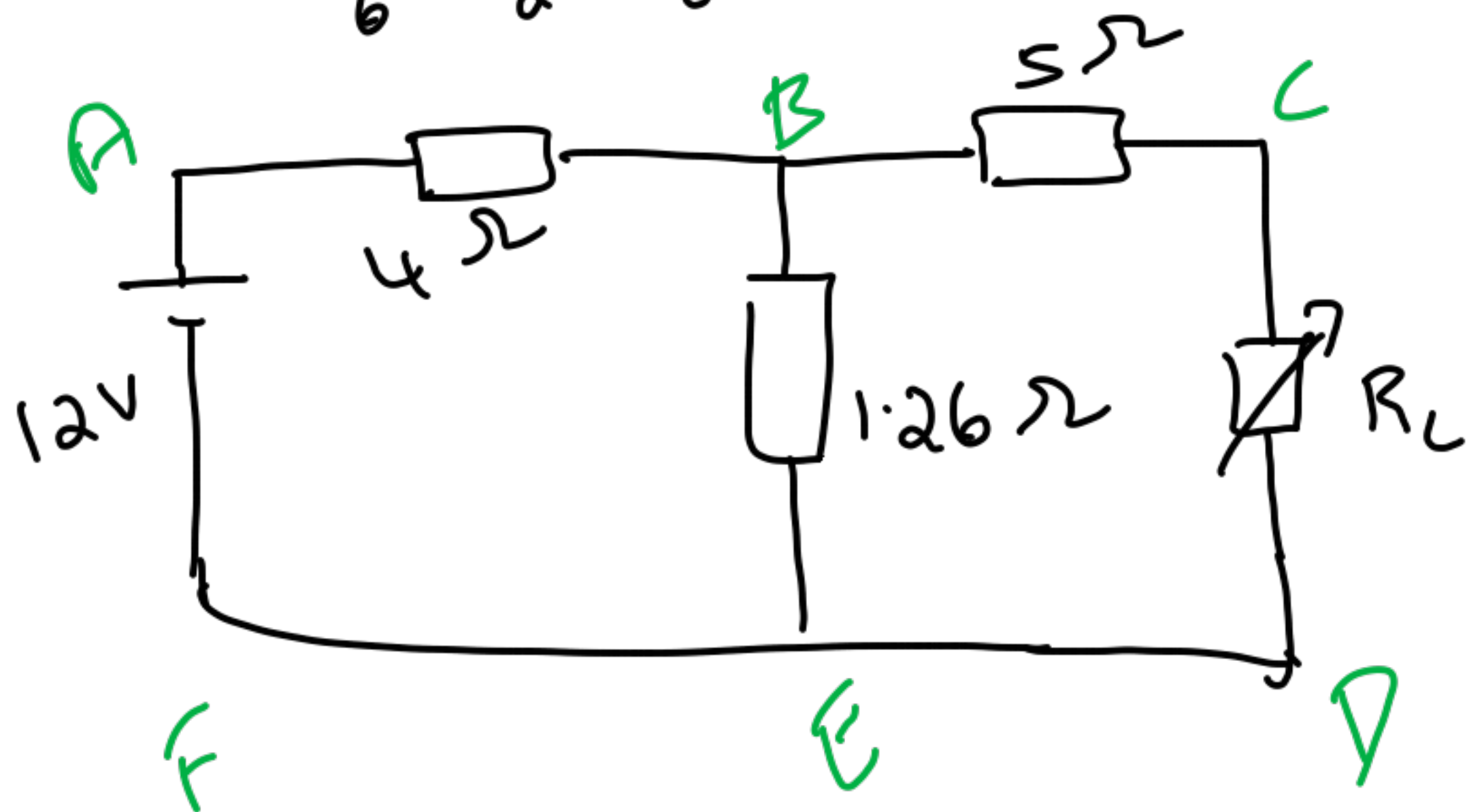
V_{th} , R_{th} , R_L , P_L , η

↑ ↑ ↑ ↑

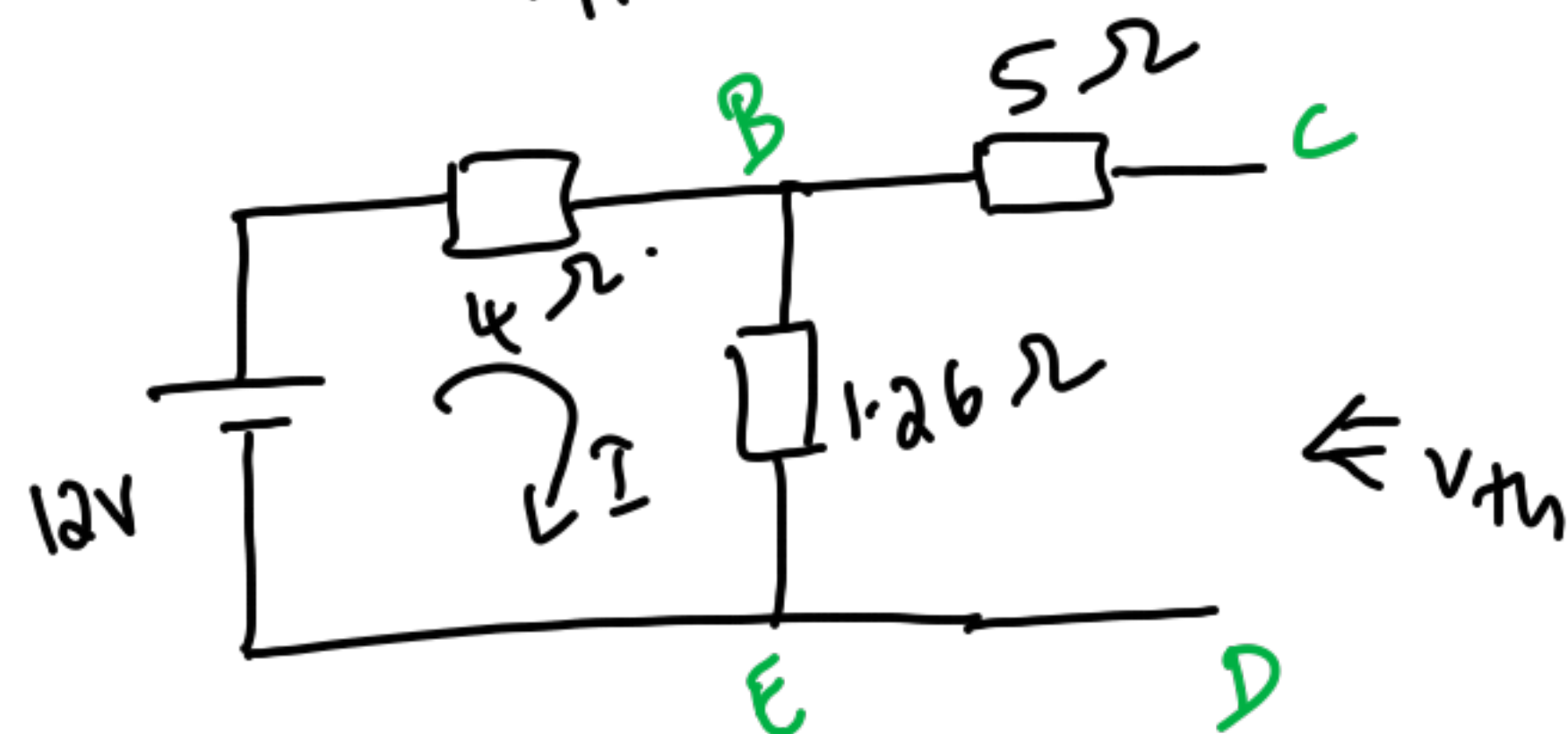
Soln.
we know that;

6Ω , 2Ω and 8Ω are in parallel.

$$R_{eq1} = \frac{1}{\frac{1}{6} + \frac{1}{2} + \frac{1}{8}} = 1.26\Omega.$$



To find V_{th} .



$$V_{th} = V_{DC} = V_{DE} + V_{EB} + V_{BC}$$

$$V_{th} = 0 + V_{EB} + 0$$

$$V_{th} = V_{EB}$$

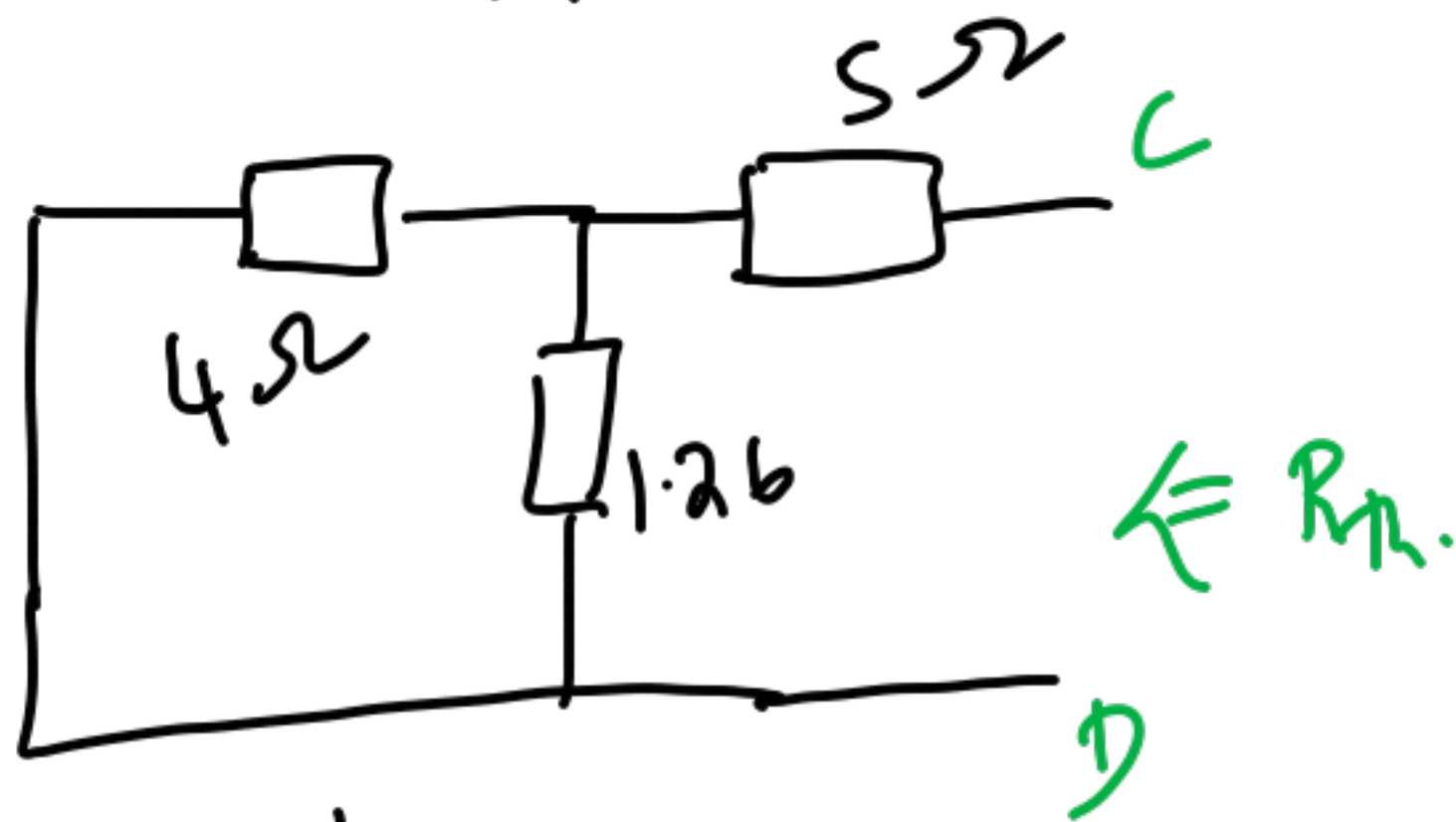
$$I = \frac{V}{R} = \frac{12}{4 + 1.26} = 2.28A$$

$$V_{1.26} = V_{EB} = I \times R = 1.26 \times 2.28$$

$$V_{EB} = 2.87V$$

$$V_{th} = V_{EB} = 2.87V$$

To find R_{th} .

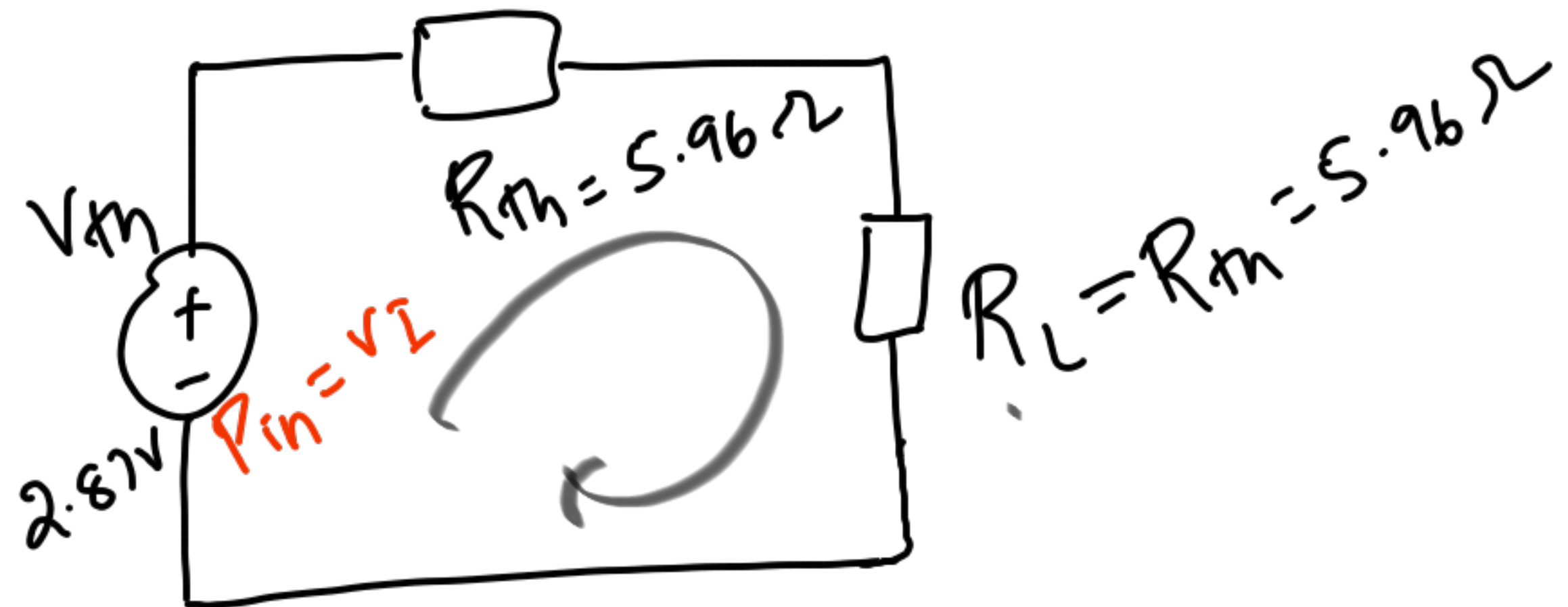


$$R_{eq} = \frac{1}{\frac{1}{4} + \frac{1}{1.26}} = 0.96\Omega$$

$$R_{th} = 0.96 + 5$$

$$R_{th} = 5.96\Omega$$

Thevenins Equivalent circuit.



$$R_L = R_{th} = 5.96\Omega$$

[maximum power transfer]

Load current: [Max. Power]

$$I_L = \frac{V_{th}}{R_{th} + R_L}$$
$$= \frac{2.87}{5.96 + 5.96}$$

$$I_L = 0.24 \text{ A}$$

Power at the load - maximum power tx.

$$P_L = I_L^2 R_L$$
$$= (0.24)^2 \times 5.96$$

$$P_L = 0.34 \text{ W}$$

Power efficiency [Max]

$$\eta = \frac{P_L}{P_{in}}$$
$$= \frac{0.34}{2.87 \times 0.24}$$

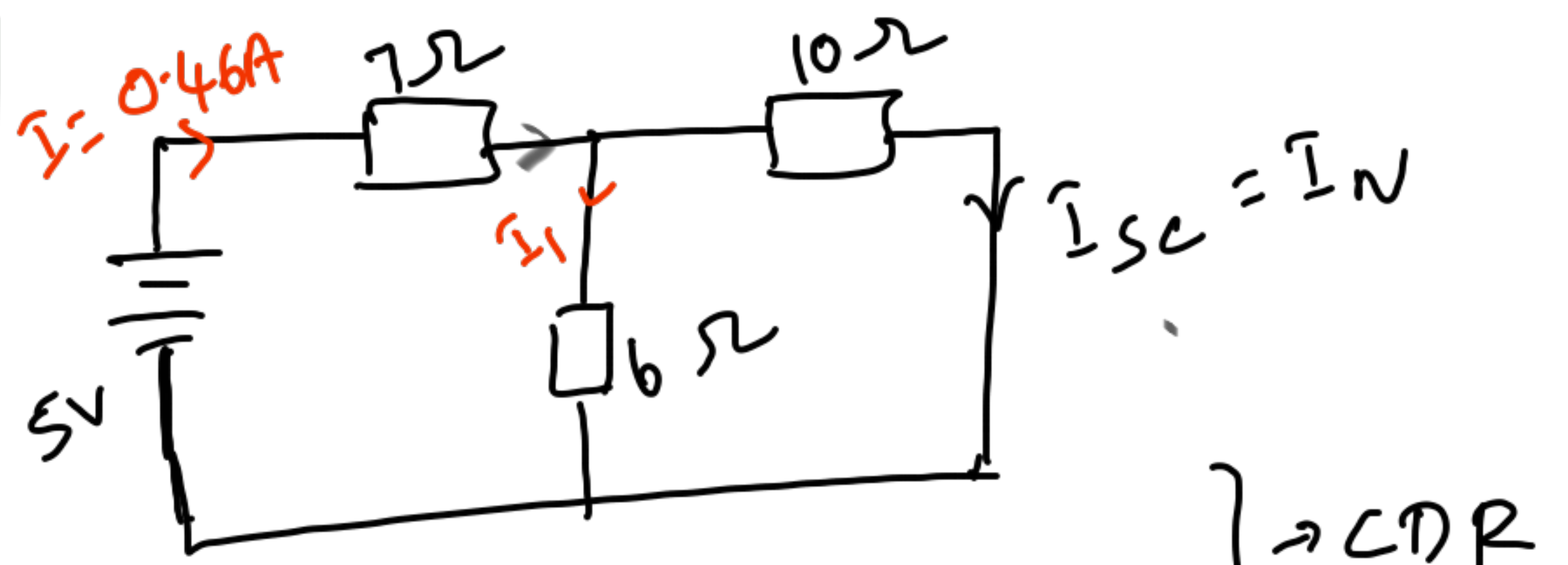
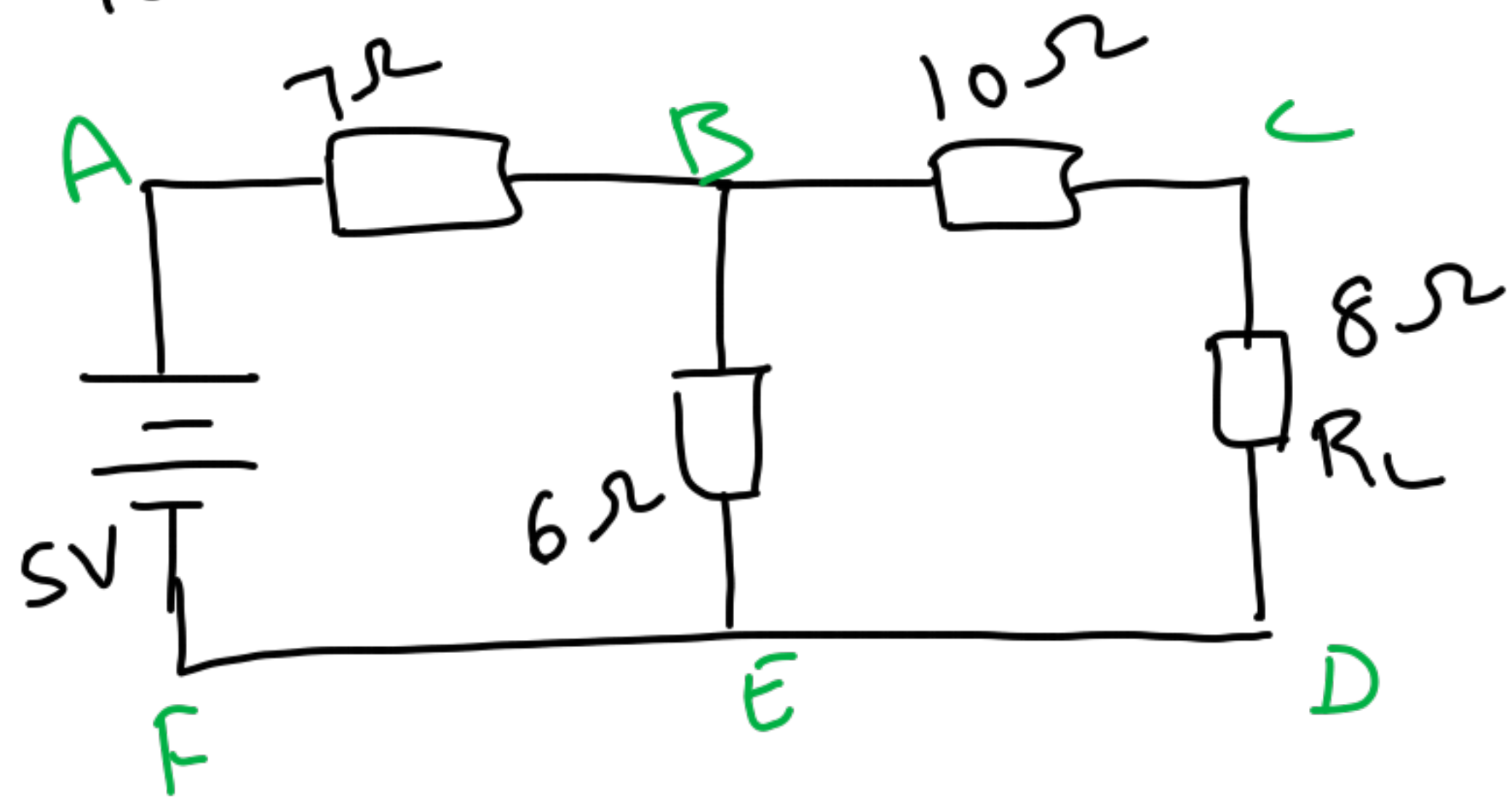
$$\eta = 0.49$$

$$\boxed{\% \eta = 49\%}$$

$$P = VI$$

$$P_{in} = 2.87 \times 0.24$$

4) For the following Circuit
Determine the Norton's
equivalent circuit and the
load current.

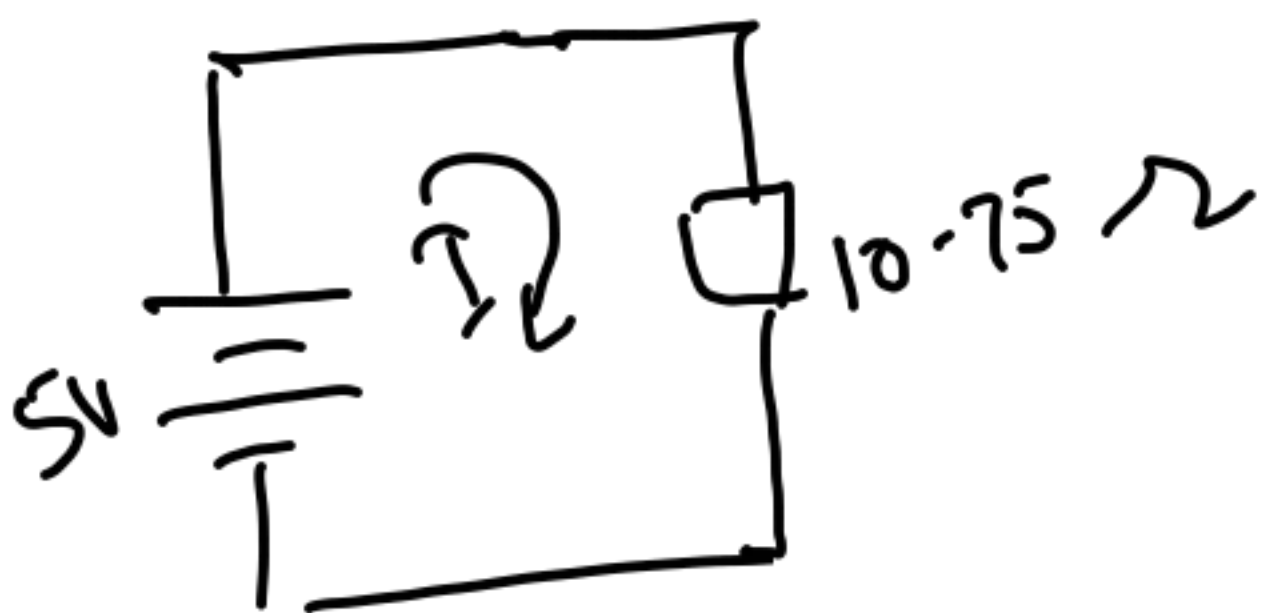


10Ω and 6Ω are in parallel. $\rightarrow$ CDR
 $\rightarrow$ Mesh

$$R_{q1} = \frac{1}{\frac{1}{6} + \frac{1}{10}} = 3.75\Omega.$$

3.75Ω is Series with 7Ω

$$R_{eq} = 3.75 + 7 = 10.75\Omega$$



$$I = \frac{V}{R} = \frac{5}{10.75}$$

$$I = 0.46 \text{ A}$$

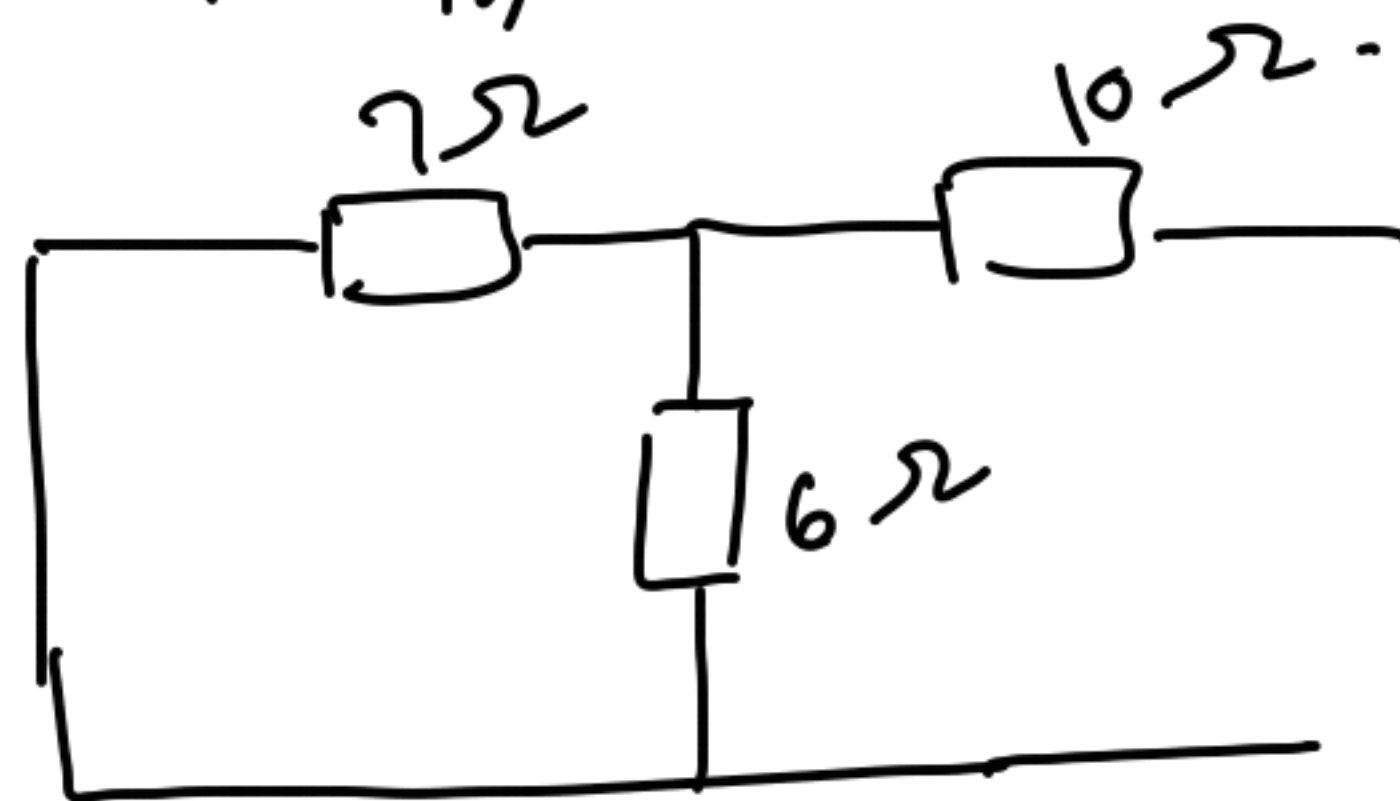
To find I_{sc} - Current divider Rule

$$I_{sc} = \frac{I}{10} \left(\frac{1}{\frac{1}{6} + \frac{1}{10}} \right)$$

$$I_{sc} = \frac{0.46}{10} \left(\frac{1}{\frac{1}{6} + \frac{1}{10}} \right) = 0.175 \text{ A}$$

$$I_{sc} = 0.175 \text{ A}$$

To find R_{th}

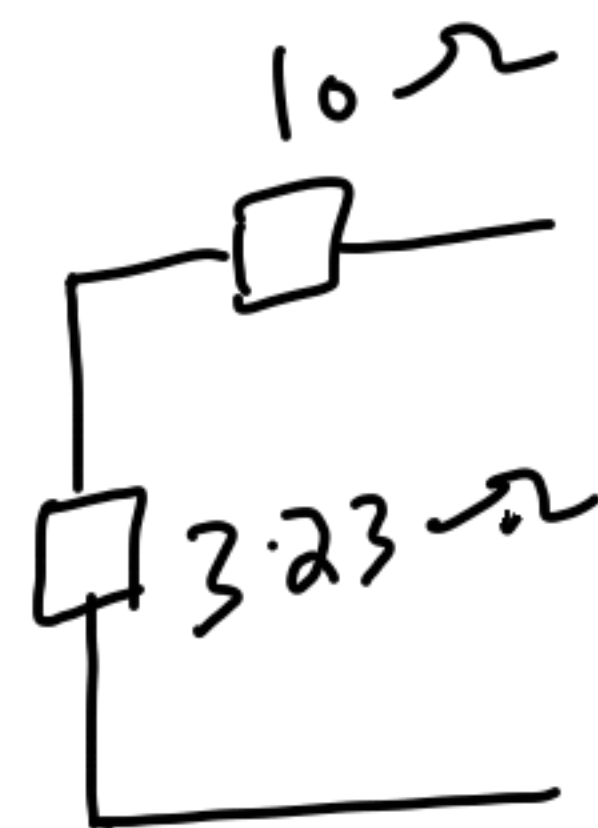


7 ohm and 6 ohm in parallel.

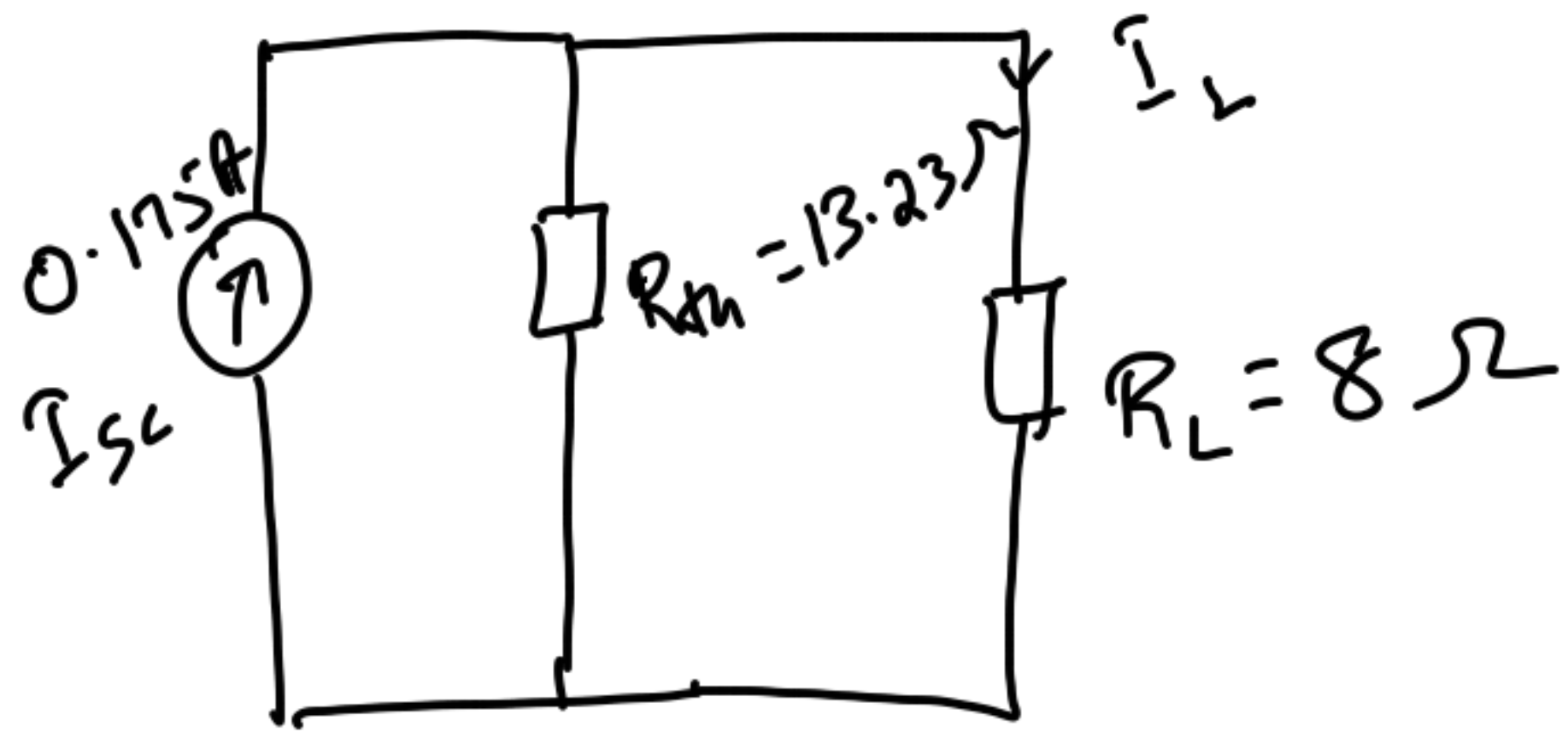
$$R_{eq1} = \frac{1}{\left(\frac{1}{7} + \frac{1}{6} \right)} = 3.23 \text{ ohm}$$

$$R_{th} = 3.23 + 10 \text{ ohm}$$

$$R_{th} = 13.23 \text{ ohm}$$



Norton's Equivalent circuit

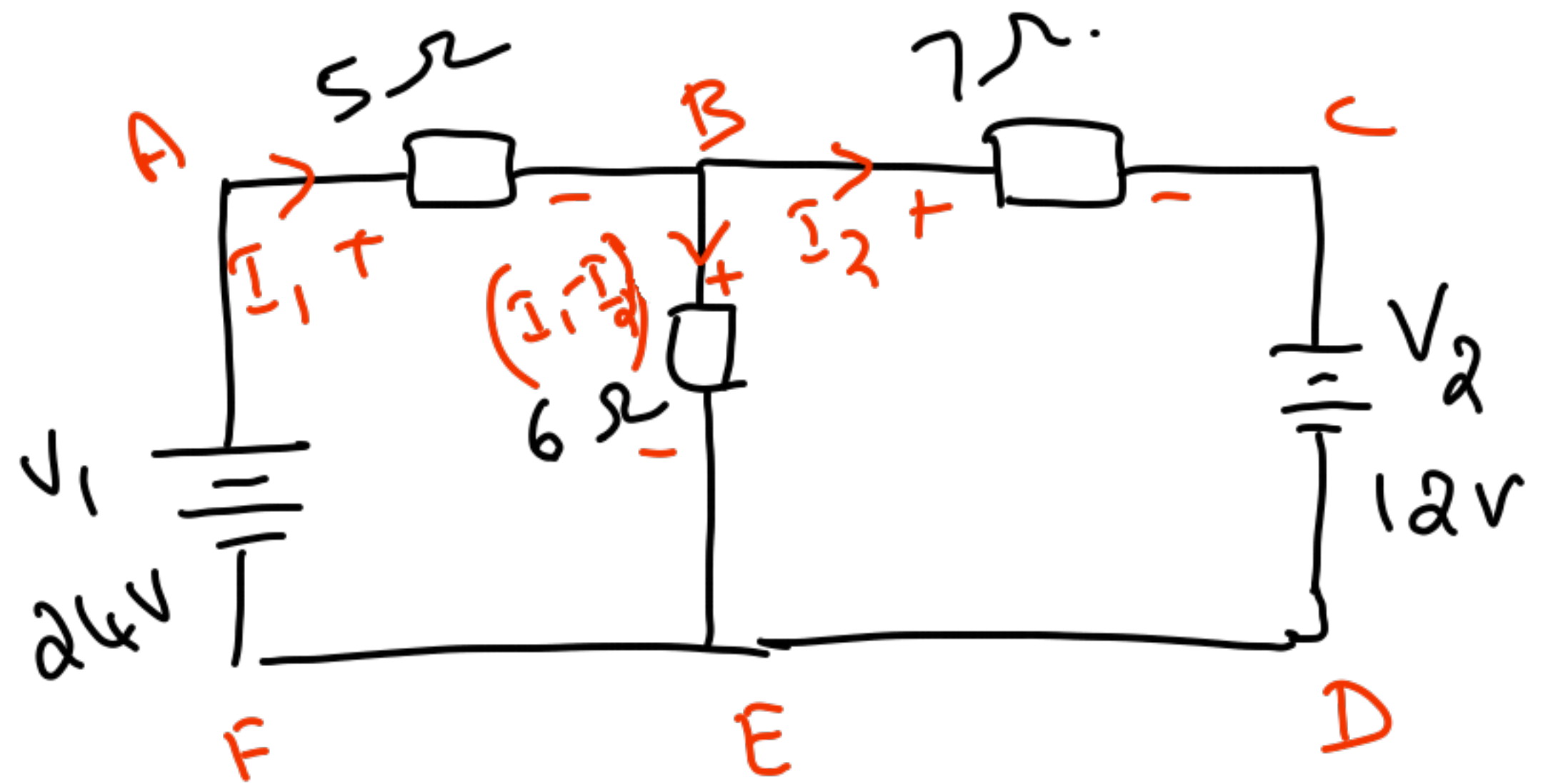


$$I_L = \frac{I_{sc} \cdot R_{th}}{R_{th} + R_L}$$

$$= \frac{0.175 \times 13.23}{13.23 + 8} = 0.11 \text{ A}$$

$$I_L = 0.11 \text{ A}$$

5) Verify if the following circuit obeys superposition theorem.



Apply KVL in ABFEA

$$-5I_1 - 6(I_1 - I_2) + 24 = 0$$

$$-11I_1 + 6I_2 = -24 \quad \text{--- (1)}$$

Apply KVL in BCDE

$$-7\hat{I}_2 - 12 + 6(\hat{I}_1 - \hat{I}_2) = 0$$

$$6\hat{I}_1 - 13\hat{I}_2 = 12 \quad \text{--- (2)}$$

Simplify (1) & (2)

$$\textcircled{1} \Rightarrow -11\hat{I}_1 + 6\hat{I}_2 = -24$$

$$\textcircled{2} \Rightarrow 6\hat{I}_1 - 13\hat{I}_2 = 12$$

$$\textcircled{1} \times 6 \rightarrow -66\hat{I}_1 + 36\hat{I}_2 = -144$$

$$\textcircled{2} \times 11 \rightarrow 66\hat{I}_1 - 143\hat{I}_2 = 132$$

$$\begin{aligned} -107\hat{I}_2 &= -12 \\ \hat{I}_2 &= 0.11 \text{ A} \end{aligned}$$

Sub. $\hat{I}_2$ in eq (1)

$$-11\hat{I}_1 + 6(0.11) = -24$$

$$\hat{I}_1 = 2.24 \text{ A}$$

$$\hat{I}_1 - \hat{I}_2 = 2.24 - 0.11$$

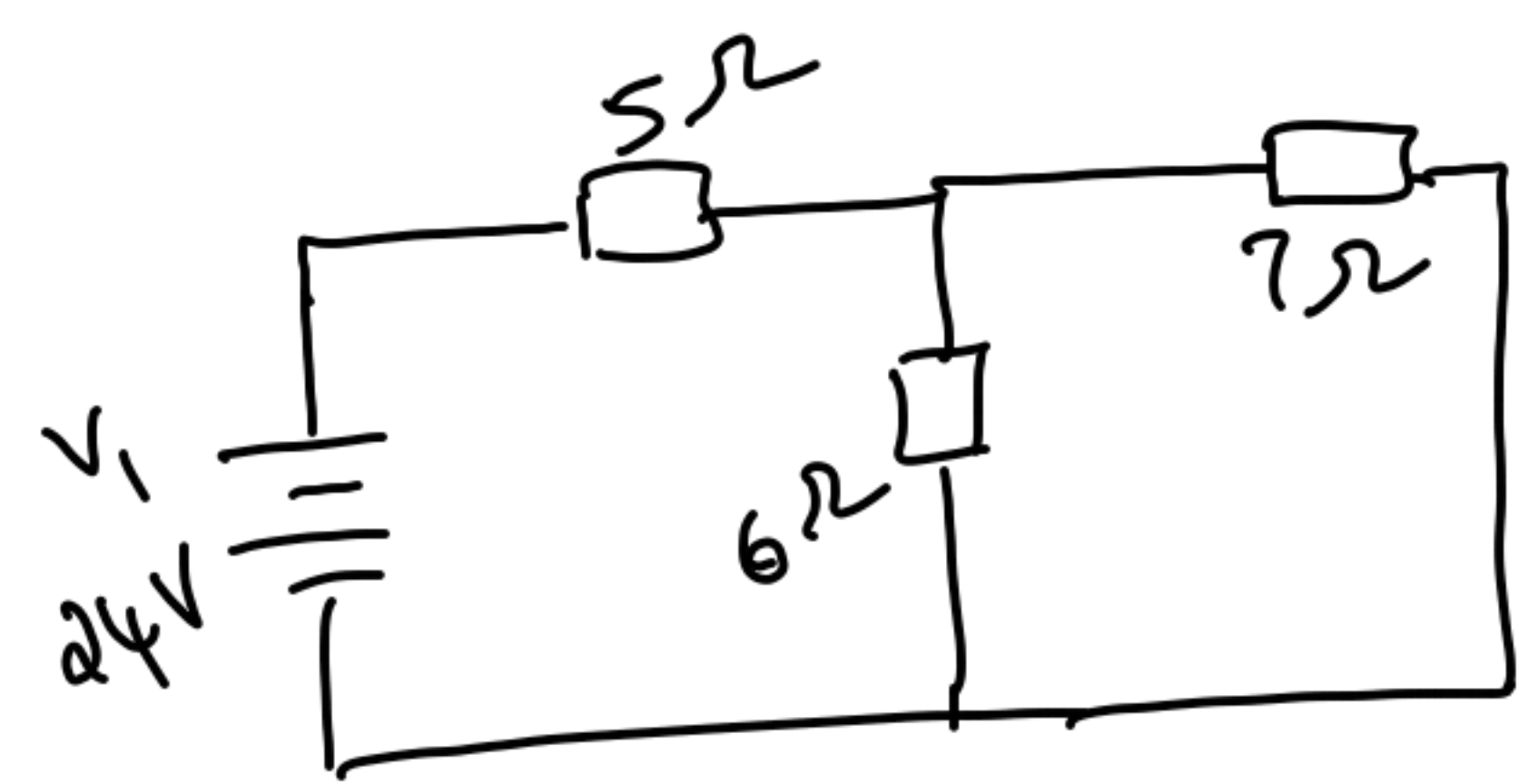
$$\hat{I}_1 - \hat{I}_2 = 2.13 \text{ A}$$

$$\hat{I}_{A_1} = 2.24 \text{ A}$$

$$\hat{I}_{A_2} = 0.11 \text{ A}$$

$$\hat{I}_{A_3} = 2.13 \text{ A}$$

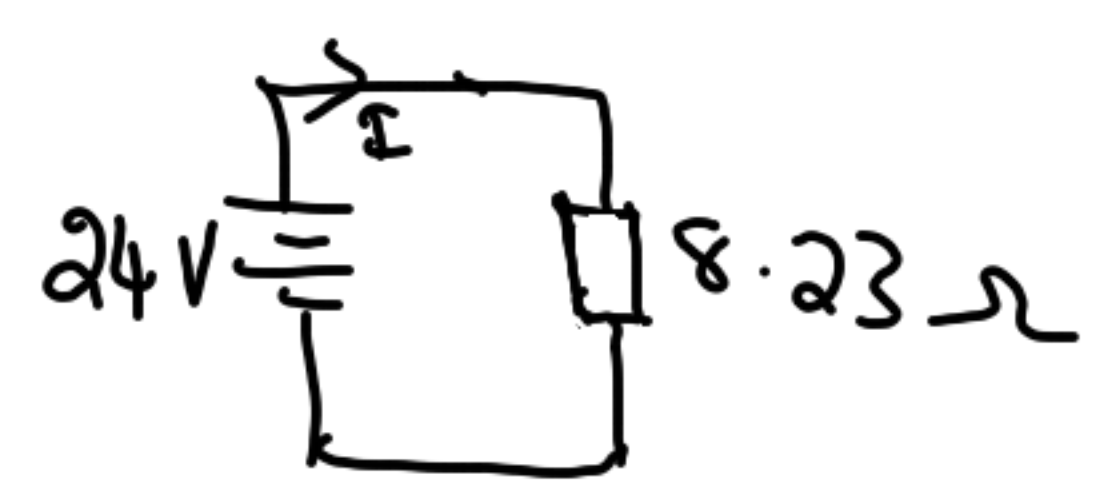
Circuit with V_1



6Ω and 7Ω are in parallel.

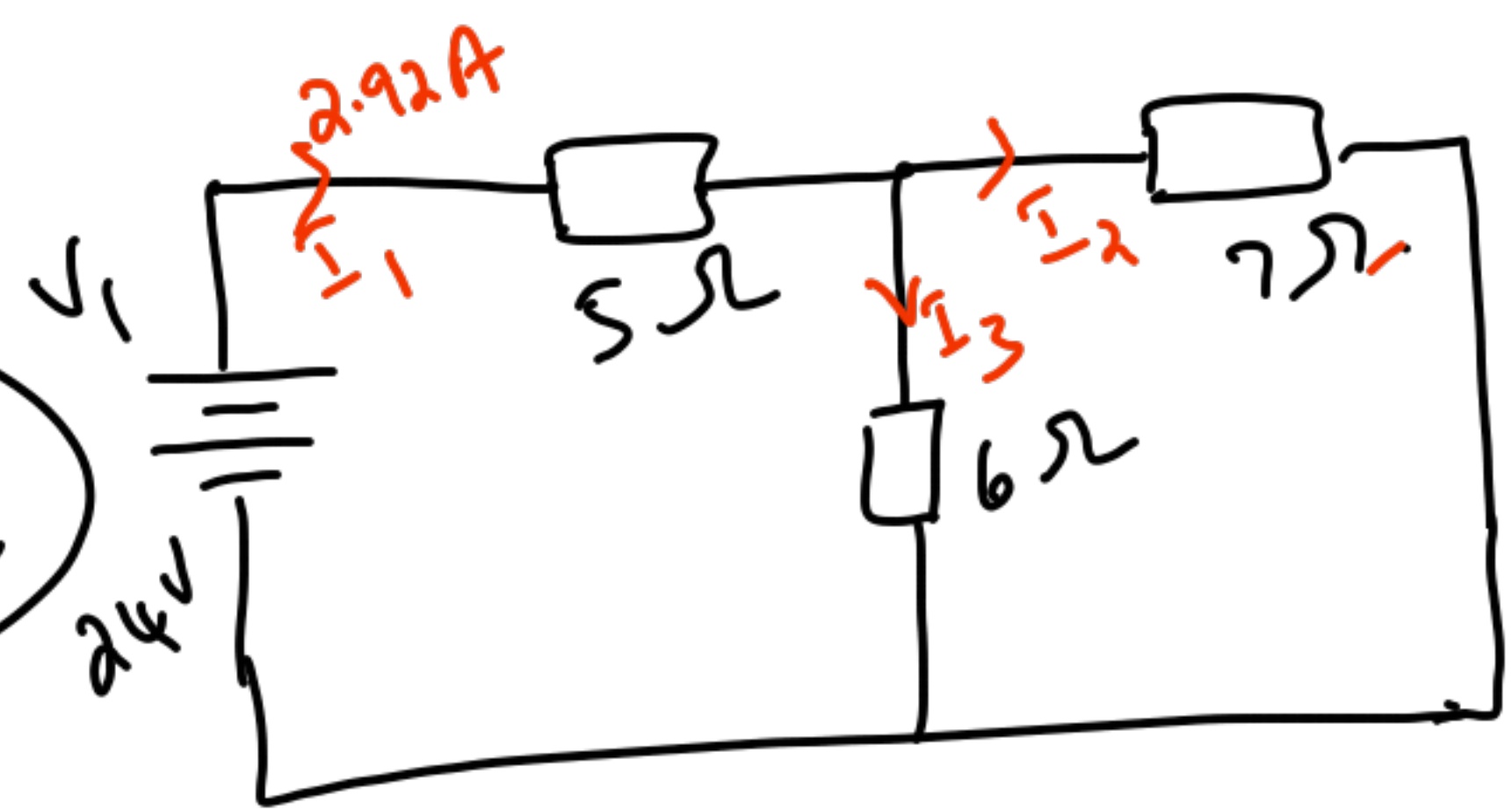
$$R_{eq1} = \frac{1}{\frac{1}{6} + \frac{1}{7}} = 3.23\Omega$$

$$R_{eq} = 5 + 3.23 = 8.23\Omega$$



$$\hat{I} = \frac{V}{R} = \frac{24}{8.23}$$

$$\hat{I} = 2.92\text{ A}$$



$$I_2 = \frac{\text{Total current}}{\text{Own Resistor}} \left(\text{equivalent Resistor} \right)$$

$$I_2 = \frac{2.92}{7} \left(\frac{1}{\frac{1}{6} + \frac{1}{7}} \right) = 1.35\text{ A}$$

$$I_3 = \frac{2.92}{6} \left(\frac{1}{\frac{1}{6} + \frac{1}{7}} \right)$$

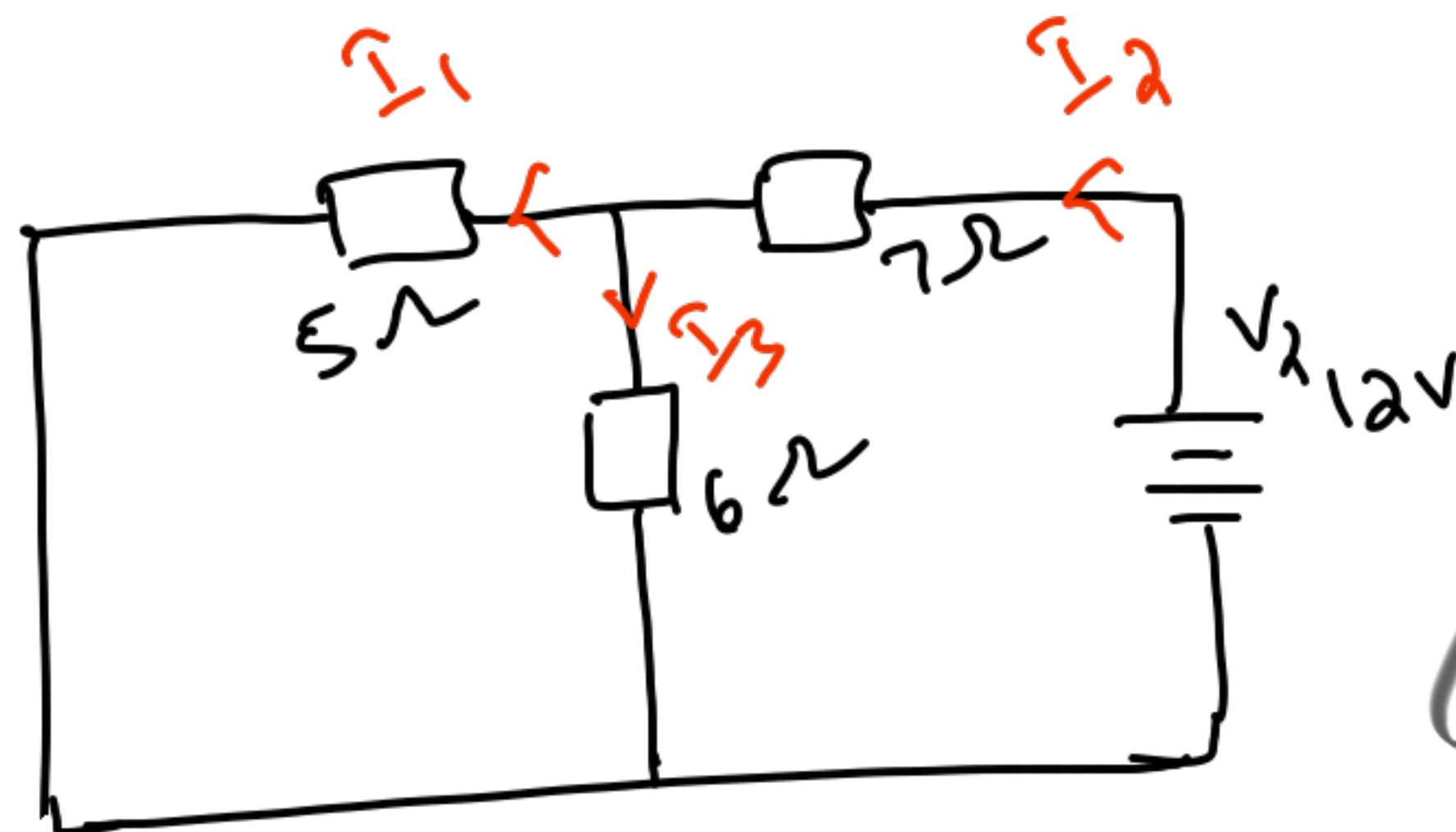
$$I_3 = 1.57 \text{ A}$$

$$I_{B1} = 2.92 \text{ A}$$

$$I_{B2} = 1.35 \text{ A}$$

$$I_{B3} = 1.57 \text{ A}$$

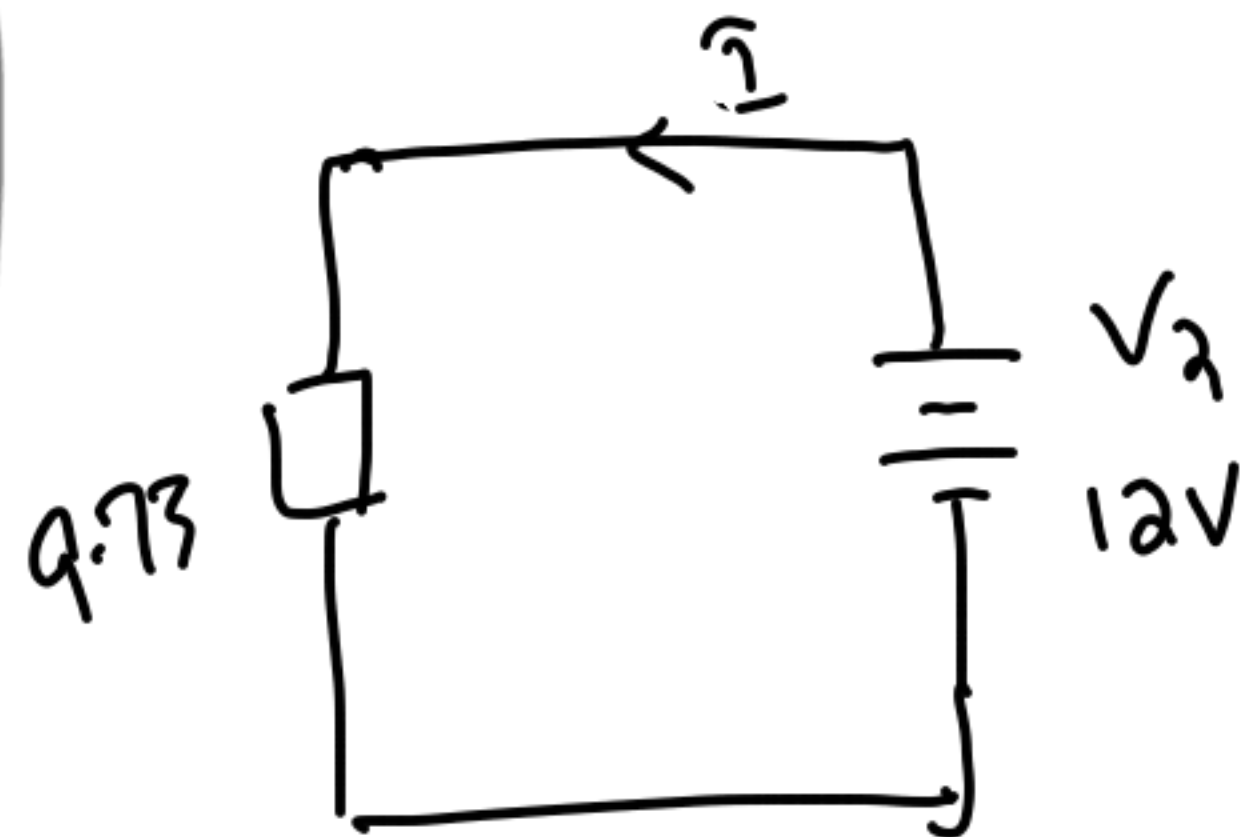
Circuit with V_2



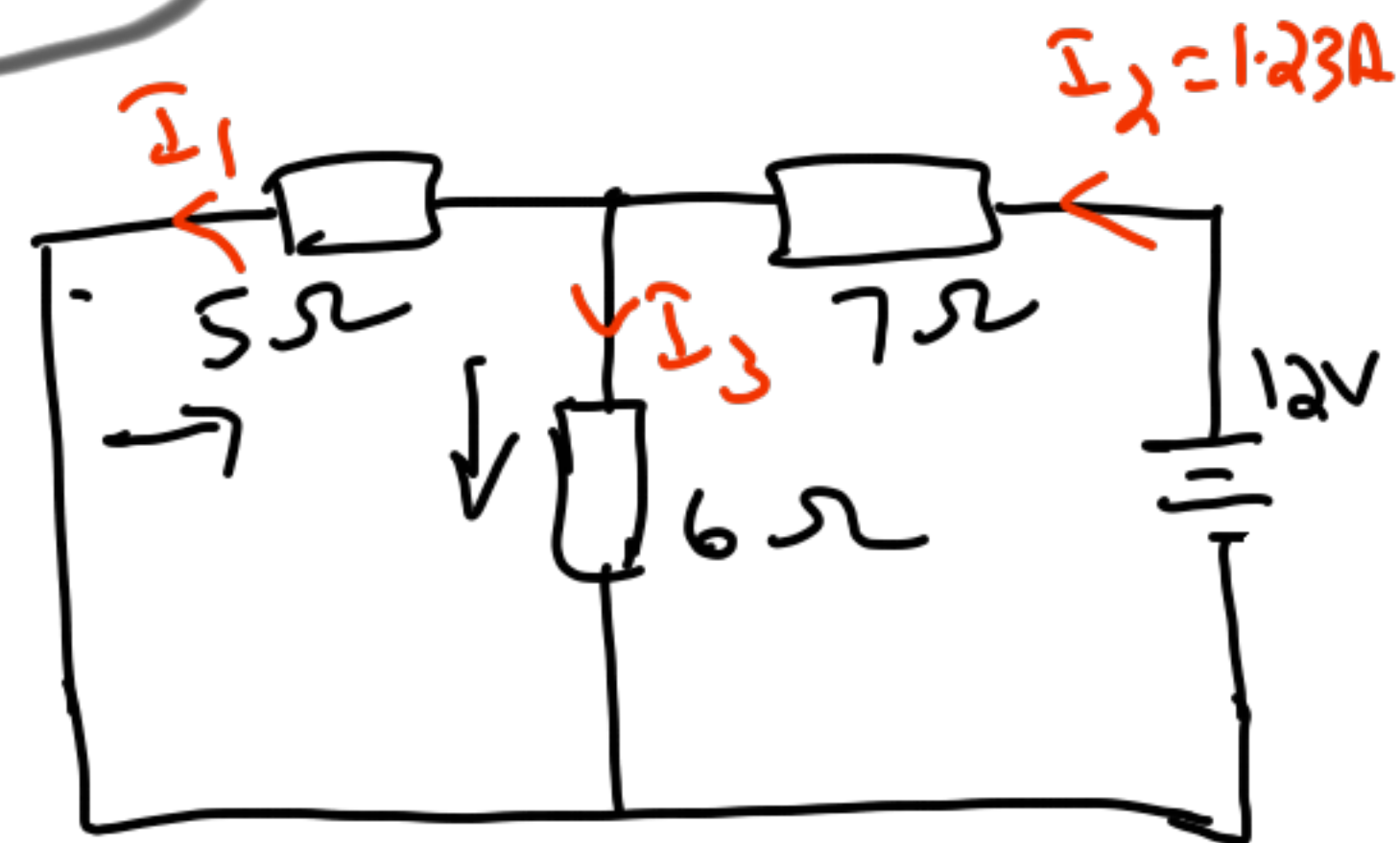
5Ω and 6Ω are parallel.

$$R_{eq1} = \frac{1}{\left(\frac{1}{5} + \frac{1}{6}\right)} = 2.73\Omega$$

$$R_{eq} = 7 + 2.73 = 9.73\Omega$$



$$I = \frac{12}{9.73} = 1.23 \text{ A}$$



$$\hat{I}_1 = \frac{1.23}{5} \left(\frac{1}{\left(\frac{1}{6} + \frac{1}{5}\right)} \right)$$

$$\hat{I}_1 = 0.67 \text{ A}$$

$$\hat{I}_3 = \frac{1.23}{6} \left(\frac{1}{\frac{1}{6} + \frac{1}{5}} \right)$$

$$\hat{I}_3 = 0.56 \text{ A}$$

$$\hat{I}_{C1} = 0.67 \text{ A}$$

$$\hat{I}_{C2} = 1.23 \text{ A}$$

$$\hat{I}_{C3} = 0.56 \text{ A}$$

$$\hat{I}_{A1} = \hat{I}_{B1} + \hat{I}_{C1} \Rightarrow 2.24 = 2.92 + (-0.67)$$

$$2.24 = 2.25 \text{ A} \quad \checkmark$$

$$\hat{I}_{A2} = \hat{I}_{B2} + \hat{I}_{C2} \Rightarrow 0.11 = 1.35 + (-1.23)$$

$$0.11 \approx 0.12 \text{ A} \quad \checkmark$$

$$\hat{I}_{A3} = \hat{I}_{B3} + \hat{I}_{C3} \Rightarrow 2.13 = 1.57 + 0.56$$

$$2.13 = 2.13 \text{ A} \quad \checkmark$$

Superposition theorem verified

Reciprocity theorem.

