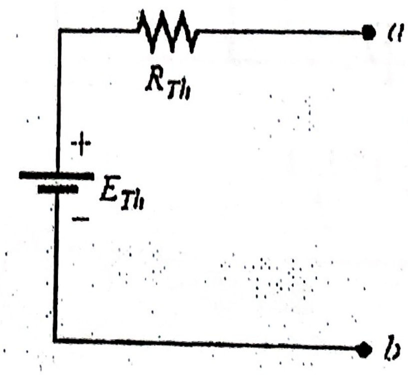
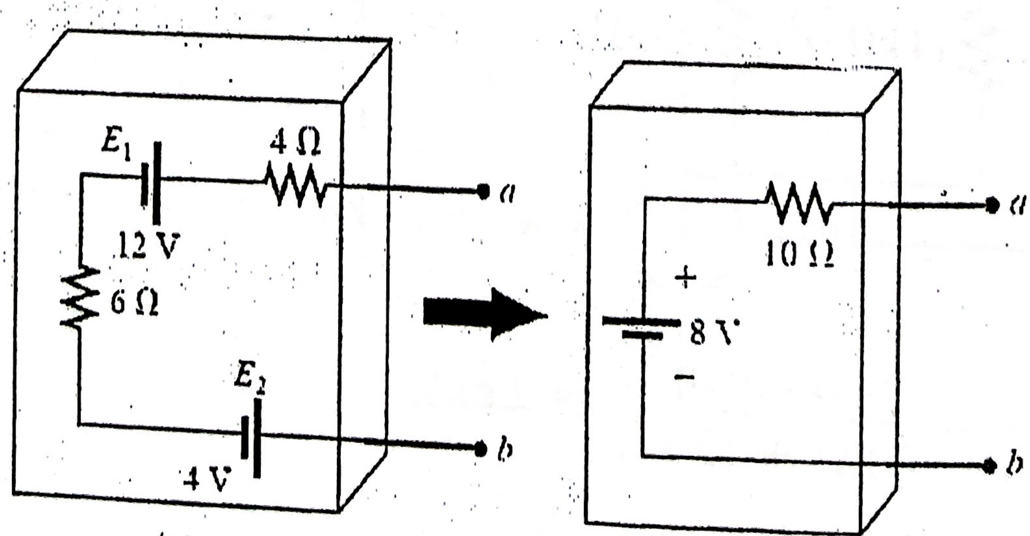
Thevenin's Theorem

Any two-terminal, linear bilateral dc network can be replaced by an equivalent circuit consisting of a voltage source and a series resistor,





(a) (b)

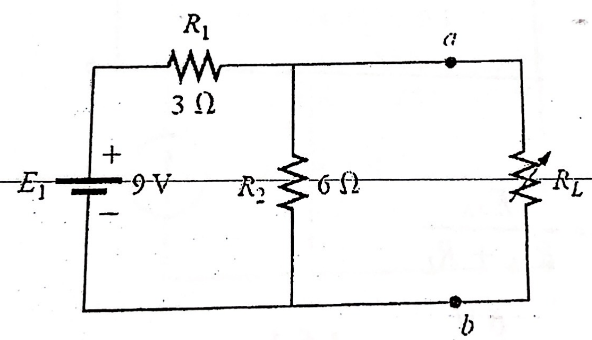
The following sequence of steps will lead to the proper value of *RTh* and *ETh*.

1) Remove that portion of the network across which the Thévenin equivalent circuit is to be found.
2) Mark the terminals of the remaining two-terminal network.
3) Calculate RTh by first setting all sources to zero (voltage sources are replaced by short circuits and current sources by open circuits) and then finding the resultant resistance between the two marked terminals.
4) Calculate ETh by first returning all sources to their original position and finding the open-circuit voltage between the marked terminals.
5) Draw the Thévenin equivalent circuit with the portion of the circuit previously removed replaced between the terminals of the equivalent circuit.

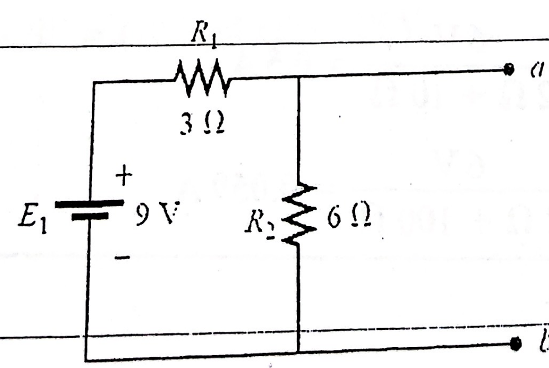
So the load current will be equal to

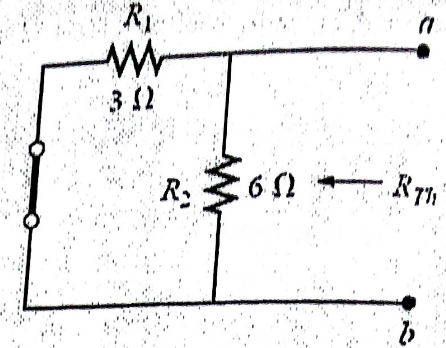
$$I_L = \frac{E_{th}}{R_{th} + R_L}$$

EXAMPLE: Find the Thévenin equivalent circuit for the network in the shaded area of the network. Then find the current through *RL* for values of 2Ω, 10Ω, and 100Ω.

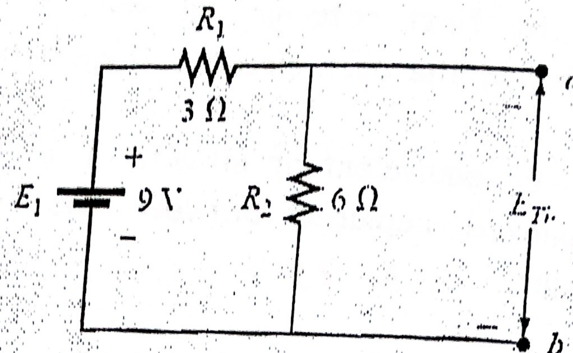


Solution:

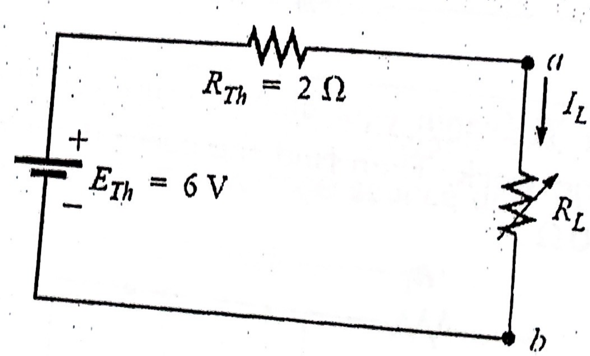




$$R_{Th} = R_1 \parallel R_2 = \frac{(3\ \Omega)(6\ \Omega)}{3\ \Omega + 6\ \Omega} = 2\ \Omega$$



$$E_{Th} = \frac{R_2 E_1}{R_2 + R_1} = \frac{(6\ \Omega)(9\ \text{V})}{6\ \Omega + 3\ \Omega} = \frac{54\ \text{V}}{9} = 6\ \text{V}$$



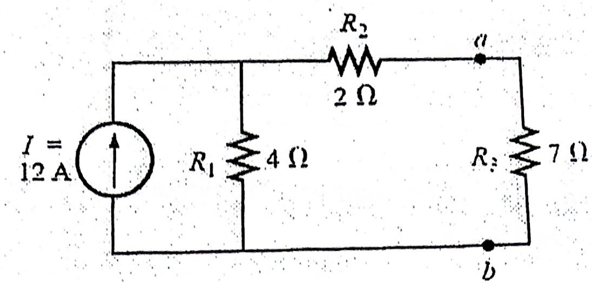
$$I_L = \frac{E_{Th}}{R_{Th} + R_L}$$

$R_L = 2\ \Omega$: $$I_L = \frac{6\ \text{V}}{2\ \Omega + 2\ \Omega} = 1.5\ \text{A}$$

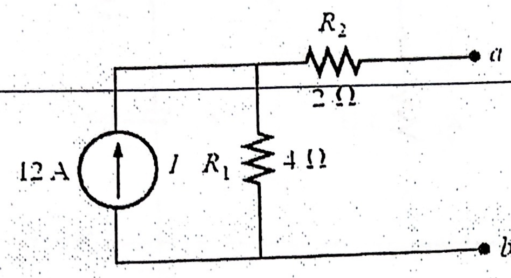
$R_L = 10\ \Omega$: $$I_L = \frac{6\ \text{V}}{2\ \Omega + 10\ \Omega} = 0.5\ \text{A}$$

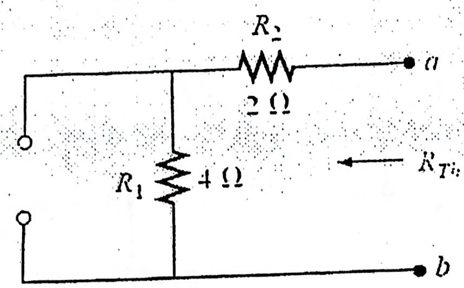
$R_L = 100\ \Omega$: $$I_L = \frac{6\ \text{V}}{2\ \Omega + 100\ \Omega} = 0.059\ \text{A}$$

EXAMPLE: Find the Thévenin equivalent circuit for the network in the shaded area of the network

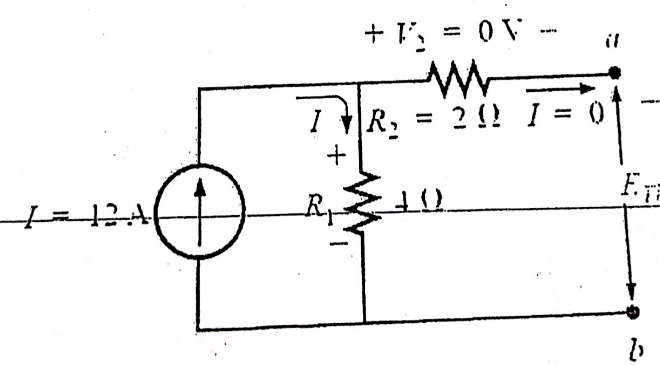


Solution:



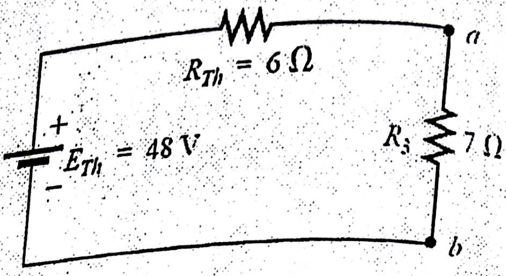


$$R_{Th} = R_1 + R_2 = 4\ \Omega + 2\ \Omega = 6\ \Omega$$

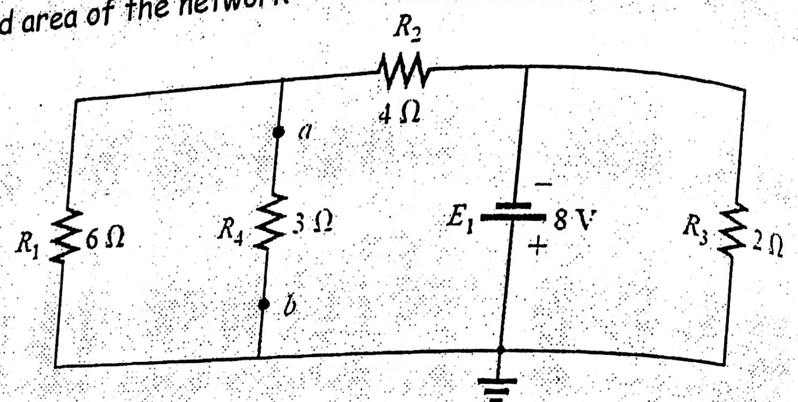


$$V_2 = I_2R_2 = (0)R_2 = 0\ V$$

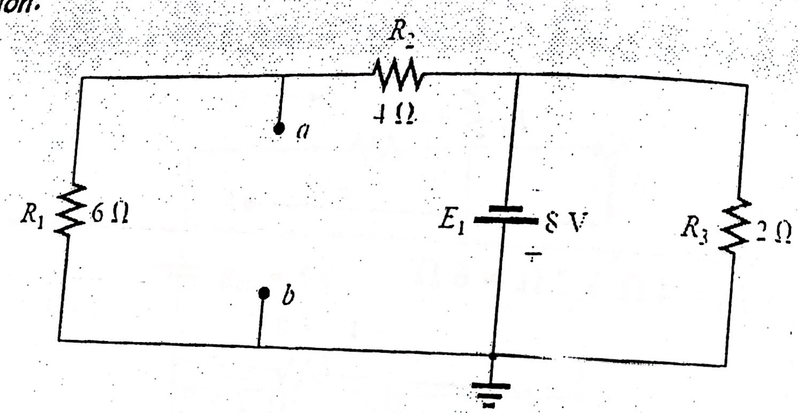
$$E_{Th} = V_1 = I_1R_1 = IR_1 = (12\ A)(4\ \Omega) = 48\ V$$



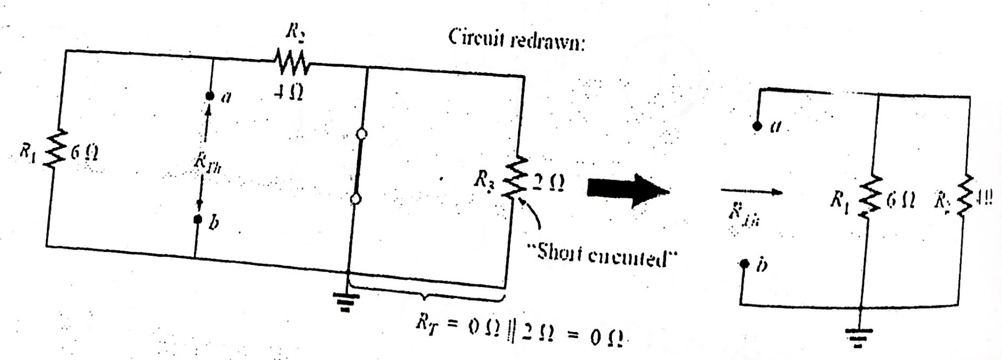
EXAMPLE: Find the Thévenin equivalent circuit for the network in the shaded area of the network



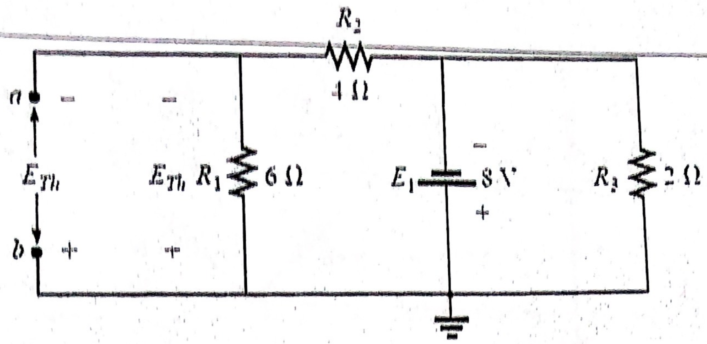
Solution:

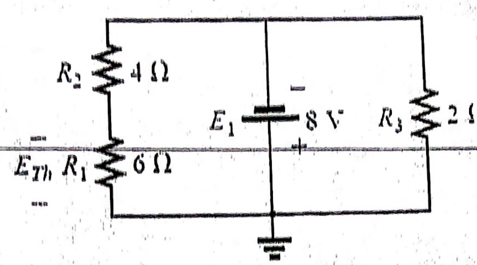


Circuit redrawn:

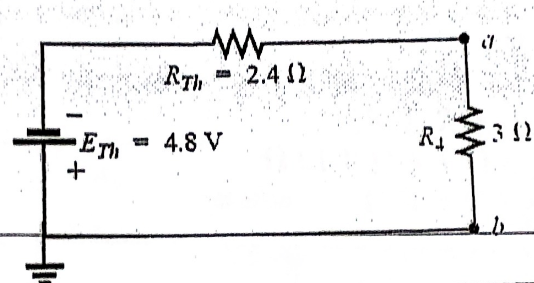


$$R_{Th} = R_1 \parallel R_2 = \frac{(6\ \Omega)(4\ \Omega)}{6\ \Omega + 4\ \Omega} = \frac{24\ \Omega}{10} = \mathbf{2.4\ \Omega}$$





$$E_{Th} = \frac{R_1E_1}{R_1 + R_2} = \frac{(6\ \Omega)(8\ \text{V})}{6\ \Omega + 4\ \Omega} = \frac{48\ \text{V}}{10} = 4.8\ \text{V}$$



EXAMPLE: Find the Thévenin equivalent circuit for the network in the shaded area of the bridge network