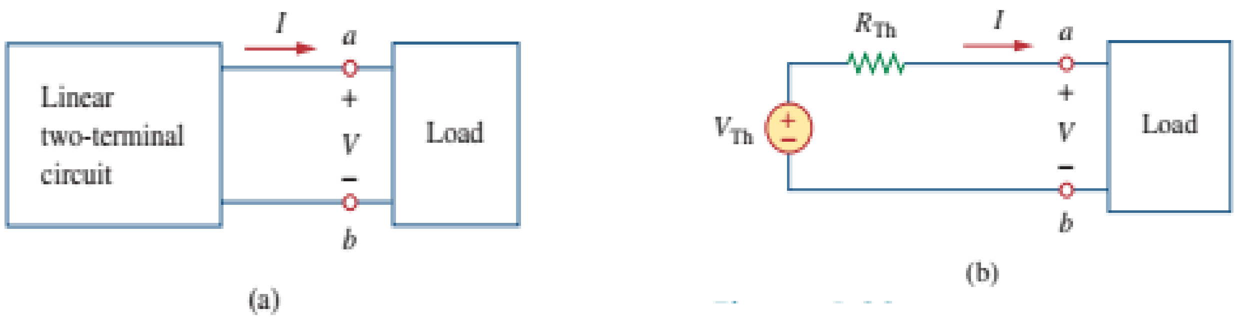
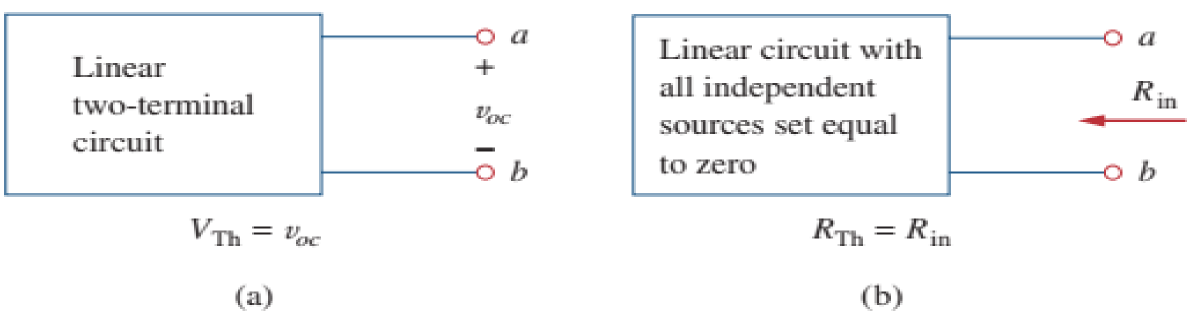
Thevenin’s Theorem

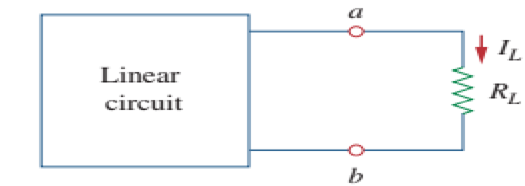


Thevenin's theorem states that a linear two-terminal circuit can be replaced by an equivalent circuit consisting of a voltage source V_{Th} in series with a resistor R_{Th}, where V_{Th} is the open-circuit voltage at the terminals and R_{Th} is the input or equivalent resistance at the terminals when the independent sources are turned off.

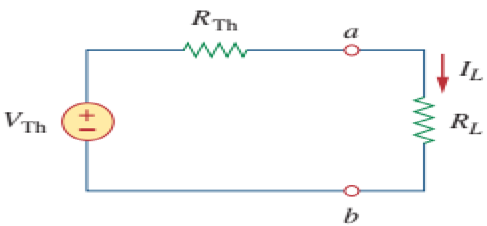
$$V_{Th} = v_{oc}$$



- For example



(a)



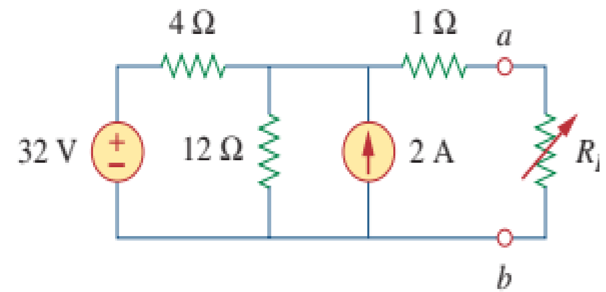
(b)

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

$$V_L = R_L I_L = \frac{R_L}{R_{Th} + R_L} V_{Th}$$

Example(1):

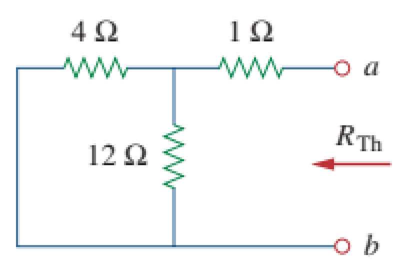
Find the equivalent circuit of the circuit shown in the figure below, to the left of the terminals (a-b), then find the current through R_L =6Ω.



Solution:

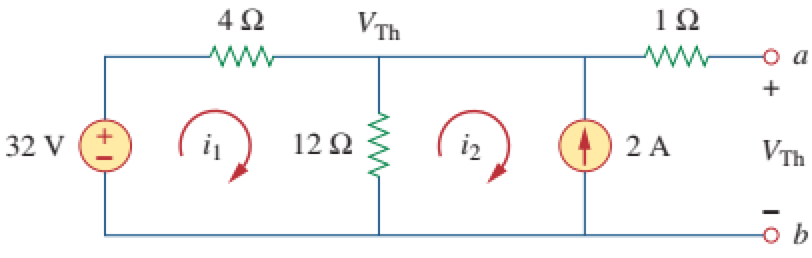
We find R_{Th} by turning off the 32-V voltage source (replacing it with a short circuit) and the 2-A current source (replacing it with an open circuit). The circuit becomes what is shown in Fig.

$$R_{Th} = 4 \parallel 12 + 1 = \frac{4 \times 12}{16} + 1 = 4\ \Omega$$

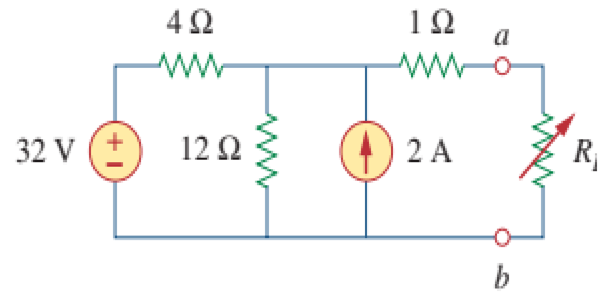


(a)

- To find V_{th},consider the circuit in figure below, Applying mesh analysis to the two loops, we obtain:



(b)



$$-32 + 4i_1 + 12(i_1 - i_2) = 0, \qquad i_2 = -2 \text{ A}$$

Solving for i_1, we get $i_1 = 0.5$ A. Thus,

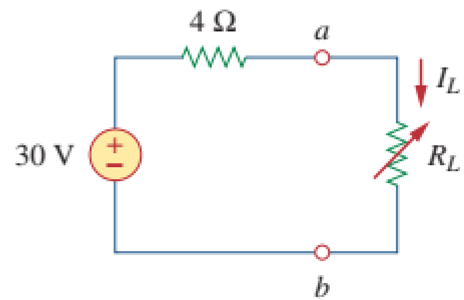
$$V_{\text{Th}} = 12(i_1 - i_2) = 12(0.5 + 2.0) = 30 \text{ V}$$

- The thevenins equivalent circuit is shown below, and the current (I_L) through the R_L is :

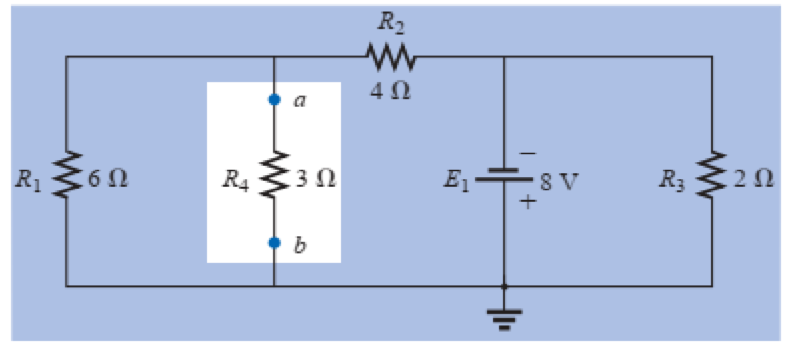
$$I_L = \frac{V_{\text{Th}}}{R_{\text{Th}} + R_L} = \frac{30}{4 + R_L}$$

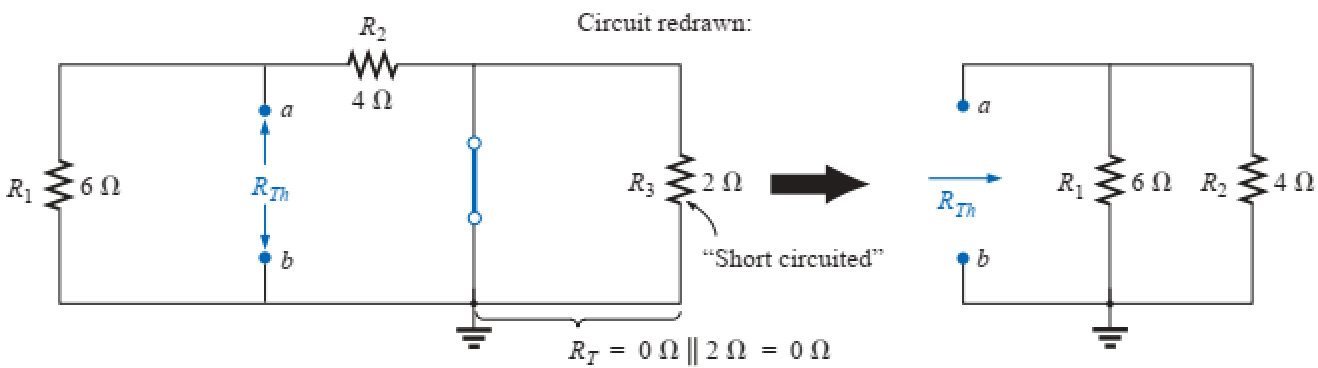
When $R_L = 6$,

$$I_L = \frac{30}{10} = 3 \text{ A}$$



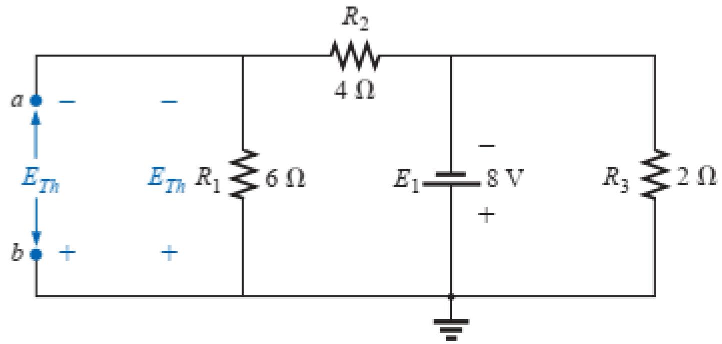
Example(2): Find the Thevenin's equivalent circuit for the network in the shaded area of the network of figure below.



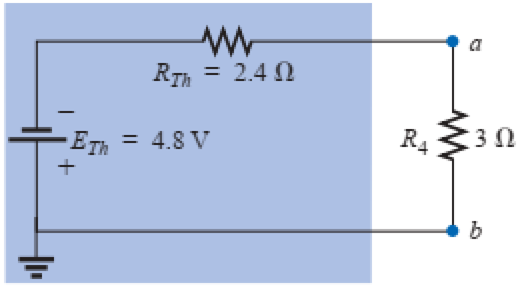


$$R_{Th} = R_1 \parallel R_2 = \frac{(6\ \Omega)(4\ \Omega)}{6\ \Omega + 4\ \Omega} = \frac{24\ \Omega}{10} = \mathbf{2.4\ \Omega}$$

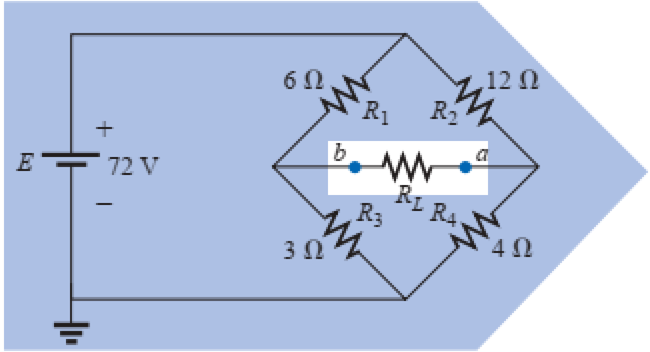
$$E_{Th} = \frac{R_1 E_1}{R_1 + R_2} = \frac{(6\,\Omega)(8\,\text{V})}{6\,\Omega + 4\,\Omega} = \frac{48\,\text{V}}{10} = \mathbf{4.8\,V}$$



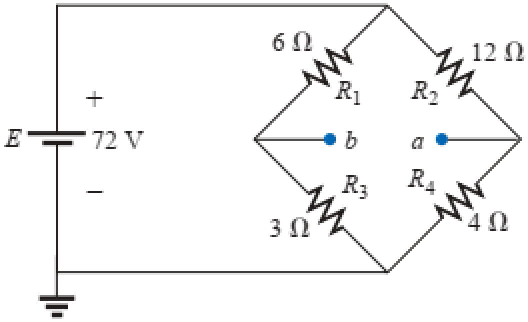
$$I = \frac{E_{TH}}{(R_{TH} + R_4)} = \frac{4.8}{2.4 + 3} = 0.89A$$



Example (3): For the circuit shown in the figure below, find the Thevenin's equivalent circuit

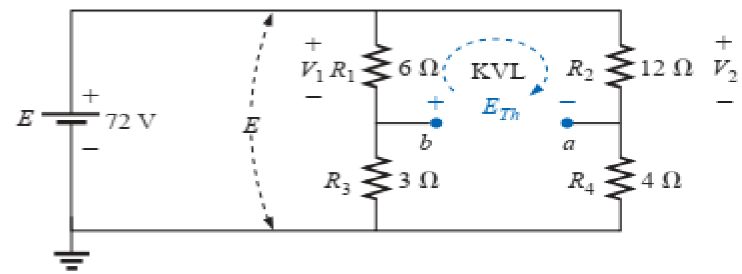


$$R_{Th} = R_{a\text{-}b} = R_1 \parallel R_3 + R_2 \parallel R_4$$
$$= 6\,\Omega \parallel 3\,\Omega + 4\,\Omega \parallel 12\,\Omega$$
$$= 2\,\Omega + 3\,\Omega = \mathbf{5\,\Omega}$$



$$V_1 = \frac{R_1 E}{R_1 + R_3} = \frac{(6\ \Omega)(72\ \text{V})}{6\ \Omega + 3\ \Omega} = \frac{432\ \text{V}}{9} = 48\ \text{V}$$

$$V_2 = \frac{R_2 E}{R_2 + R_4} = \frac{(12\ \Omega)(72\ \text{V})}{12\ \Omega + 4\ \Omega} = \frac{864\ \text{V}}{16} = 54\ \text{V}$$



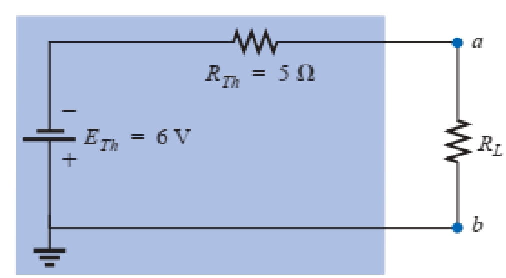
Assuming the polarity shown for E_{Th} and applying Kirchhoff's voltage law to the top loop in the clockwise direction will result in

$$\Sigma_C\ V = +E_{Th} + V_1 - V_2 = 0$$

and
$$E_{Th} = V_2 - V_1 = 54\ \text{V} - 48\ \text{V} = \mathbf{6\ V}$$

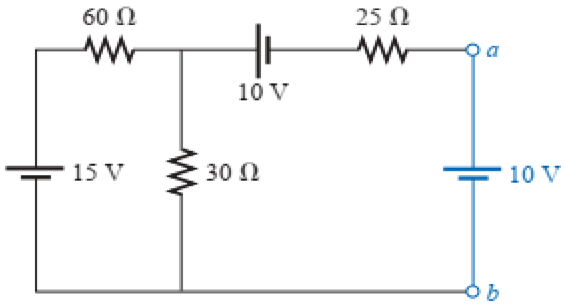
When $R_L = 7\Omega$,

$$I = \frac{E_{TH}}{R_{Tj} + R_L} = \frac{6}{5+7} = 0.5A$$

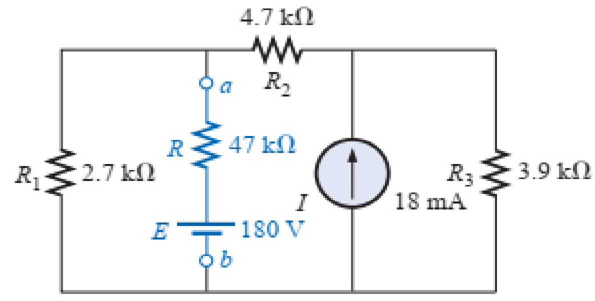


HW

- 1- Find the Thevenin's equivalent circuit for the portions of the networks of figure below at points a and b.

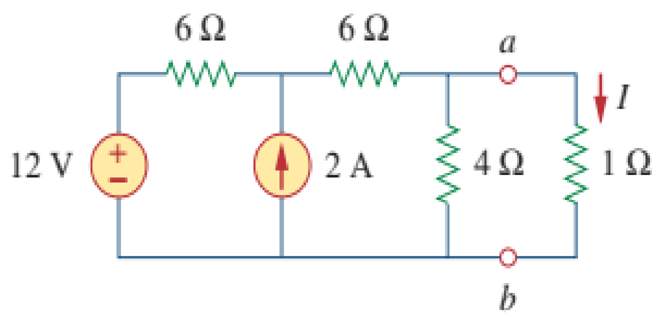


(I)

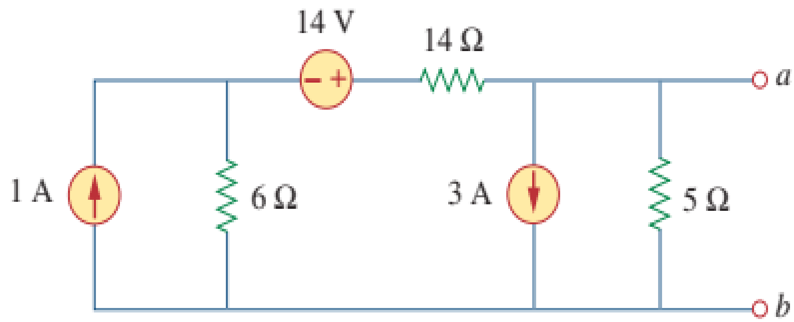


(II)

- 2- ind the current I using Thevenin's Theorem.



- 3- Find the Thevenin's equivalent



- 4- Find the Thevenin's equivalent circuit for the network within the shaded area of Figure below:.