

First Class/ Lecture four

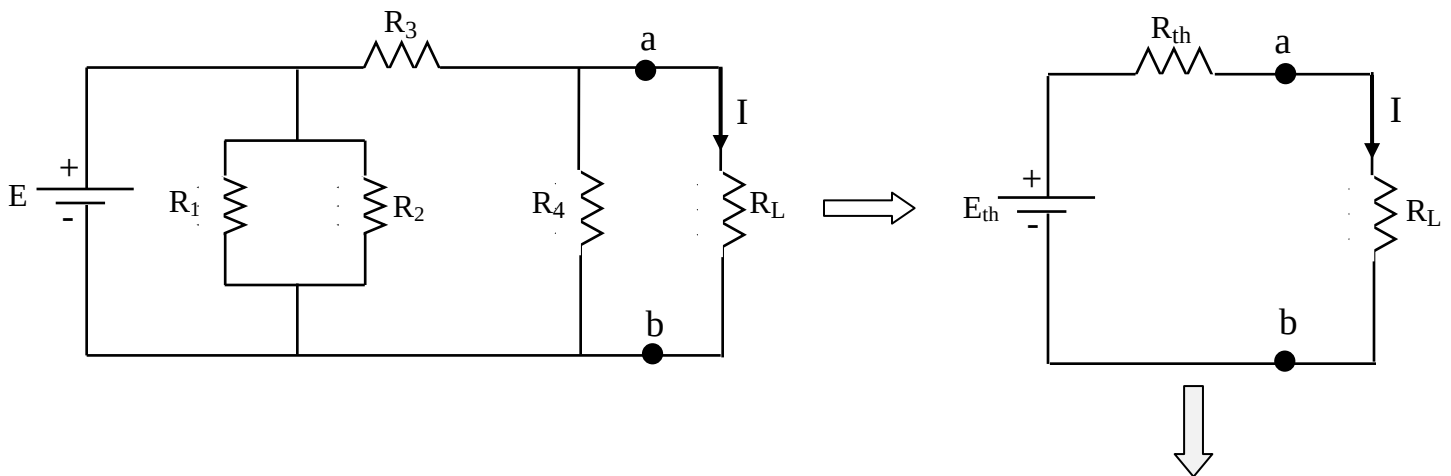
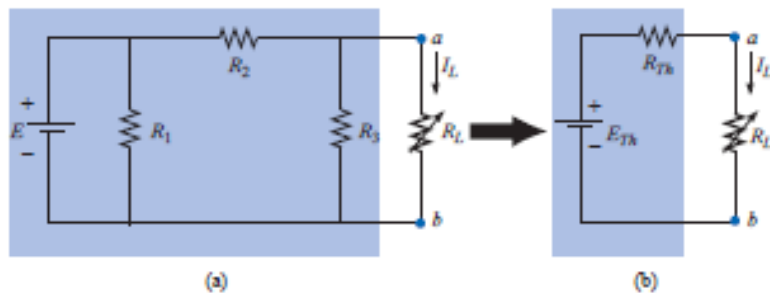
Circuit Theorems

Thevenin's Theorem

Introduction

The Thevenin's theorem states that: Any two-terminal, linear bilateral dc network can be replaced by an equivalent circuit consisting of a voltage source and a series resistor,”.

Consider the network shown, it can be placed by the voltage source E_{th} and the series resistor R_{th} .

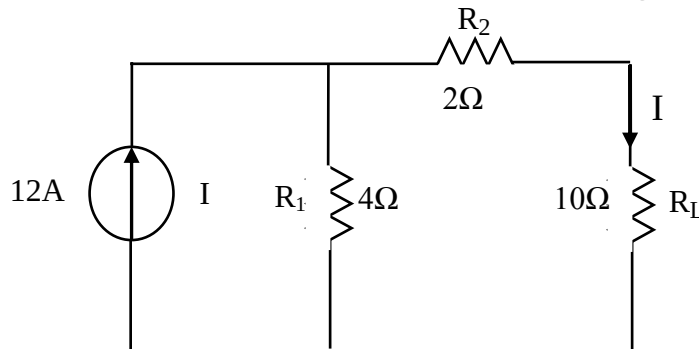


To find I through the resistor $R_L \Rightarrow I = \frac{E_{th}}{R_{th} + R_L}$

Steps to find E_{th} and R_{th} :

- 1) Remove the portion of the network across which the Thevenin's equivalent circuit is to be found (Remove R_L).
- 2) Mark the terminals of the remaining two-terminal network.
- 3) R_{th} : Calculate (R_{th}) by first setting all sources to zero (voltage sources are replaced by short circuit and current sources by open circuit) and finding the resulting resistance between the two marked terminals (Mark R_L (a-b)).
- 4) E_{th} : Calculate E_{th} by first returning all sources to their original positions and finding the open circuit voltage between the marked terminals.
- 5) Draw the **Thevenin's equivalent circuit** with the portion of the circuit previously removed replaced between the terminals of the equivalent circuit.

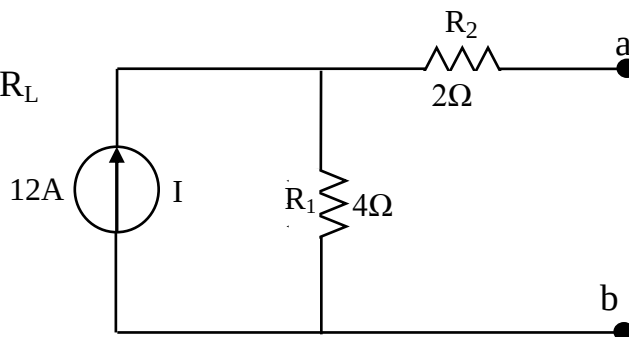
Example1: Using Thevenin's theorem, find the current through $R_L = 10\Omega$ of the circuit shown.



Solution:

Step 1 and 2

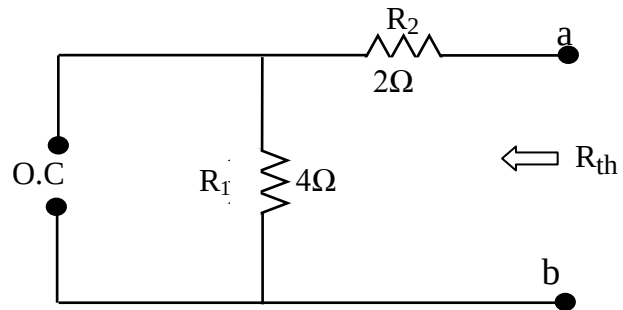
Remove and Mark R_L



Step3: R_{th} ?

Remove the current source I , and then calculate R_{th} between the terminals (a) and (b).

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



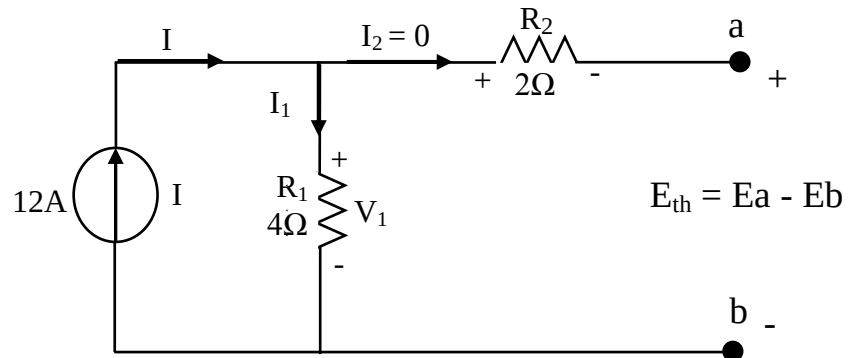
Step4: E_{th} ?

Return the current source to its original position then determine E_{th} across the open circuit terminals (a) and (b)

$$I_2 = 0 \Rightarrow I_2 R_2 = 0$$

$$\text{Then: } E_{th} = I_1 R_1 - I_2 R_2 = I_1 R_1$$

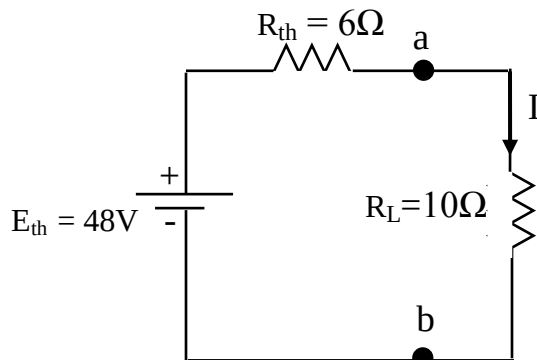
$$I_1 R_1 = (12)(4) = 48V$$



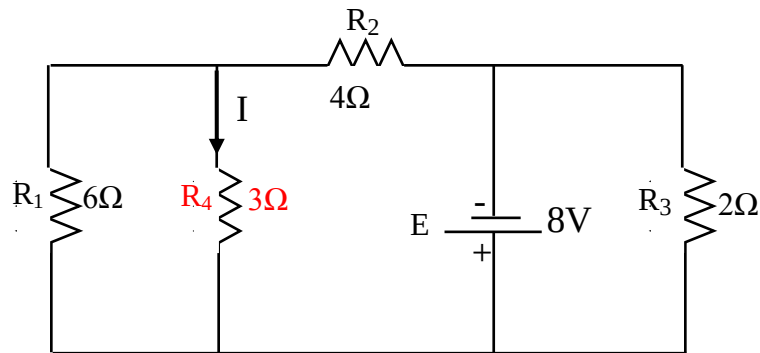
Step5:

Draw the **Thevenin's equivalent circuit** representing the network between points a and b with R_L added.

$$I_L = \frac{E_{th}}{R_{th} + R_L} = \frac{48}{6 + 10} = 3A$$

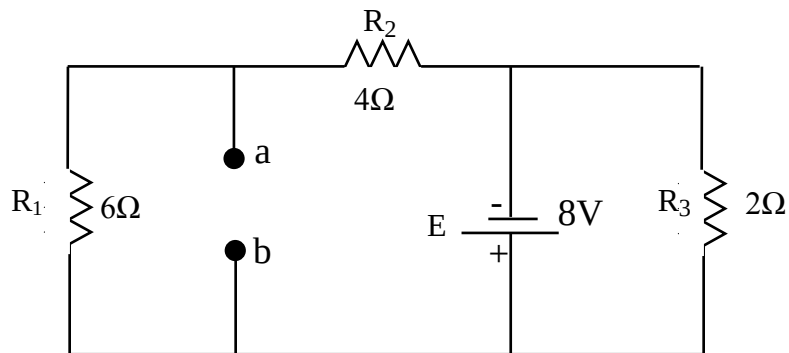


Example2: Using Thevenin's theorem, find the current through 3Ω of the circuit shown.

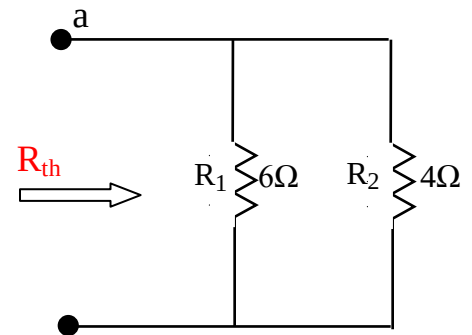
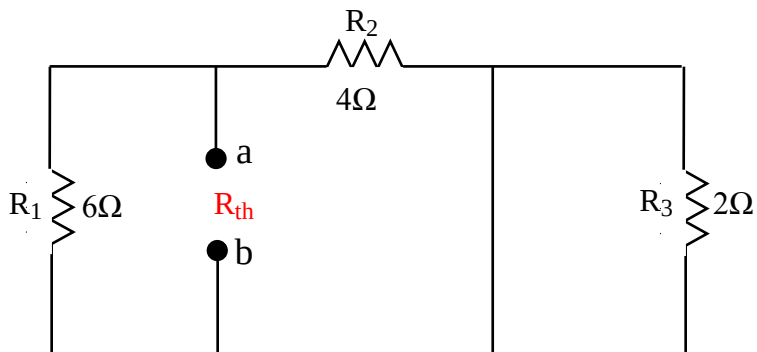


Solution:

Step1 and step2:



Step3: R_{th} ?



$$R_{th} = R_1 // R_2 = 6 // 4 = 2.4$$

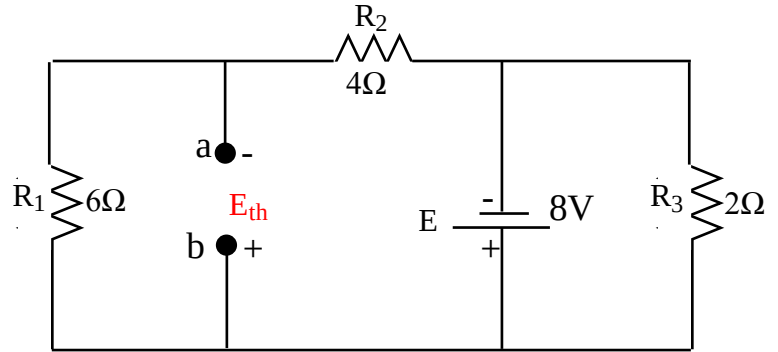
$$\therefore R_{th} = \frac{(6)(4)}{6 + 4} = 2.4\Omega$$

Step4: E_{th} ?

Using voltage divider rule

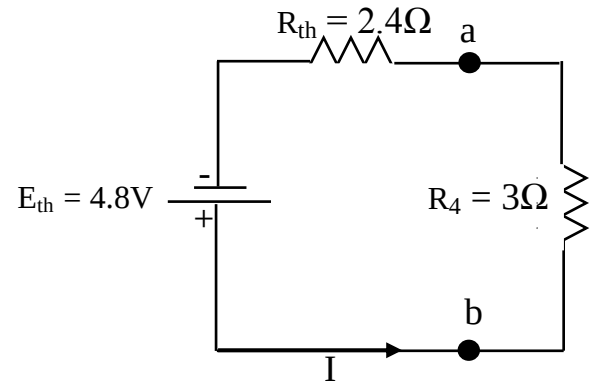
$$E_{th} = E \frac{R_1}{R_1 + R_2} = 8 \frac{6}{6+4} = 4.8V$$

Where $E_{th} = E_{R1}$



Step5: Draw the **Thevenin's equivalent circuit** representing the network between points (a) and (b) with $R_4 = 3\Omega$ added.

$$\therefore I = I_{3\Omega} = \frac{E_{th}}{R_{th} + R_4} = \frac{4.8}{2.4 + 3} = 0.889A$$



H.W

1) For the circuit shown, using **Thevenin's theorem**, Find the current through R_L , when $R_L = 3$, and 100Ω , then calculate V_L in both cases.

