Thevenin,s Theroem:

- This theorem is used to find amount of power, current or voltage in a particular component of a given circuit. This theorem was proposed by a French engineer M. L. Thevenin in 1993, **according to which any complicated network containing energy sources and components such as resistors etc. can be replaced by an equivalent circuit consisting of voltage source in series with a single resistance.**
- Imagine that the block contains a network connected to its terminals A and B as shown in Fig. 1.12. The network inside the box can be replaced by equivalent circuit consisting of voltage source (V_{Th}) in series with single resistance (R_{Th}) as shown in Fig. 1.13.

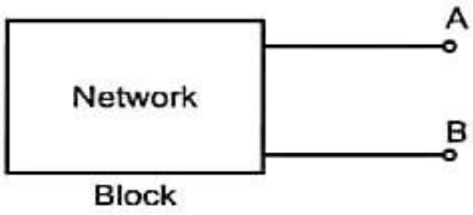


Fig. 1.12

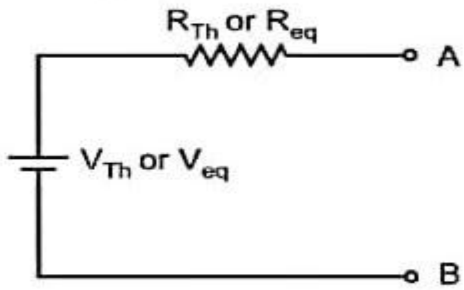
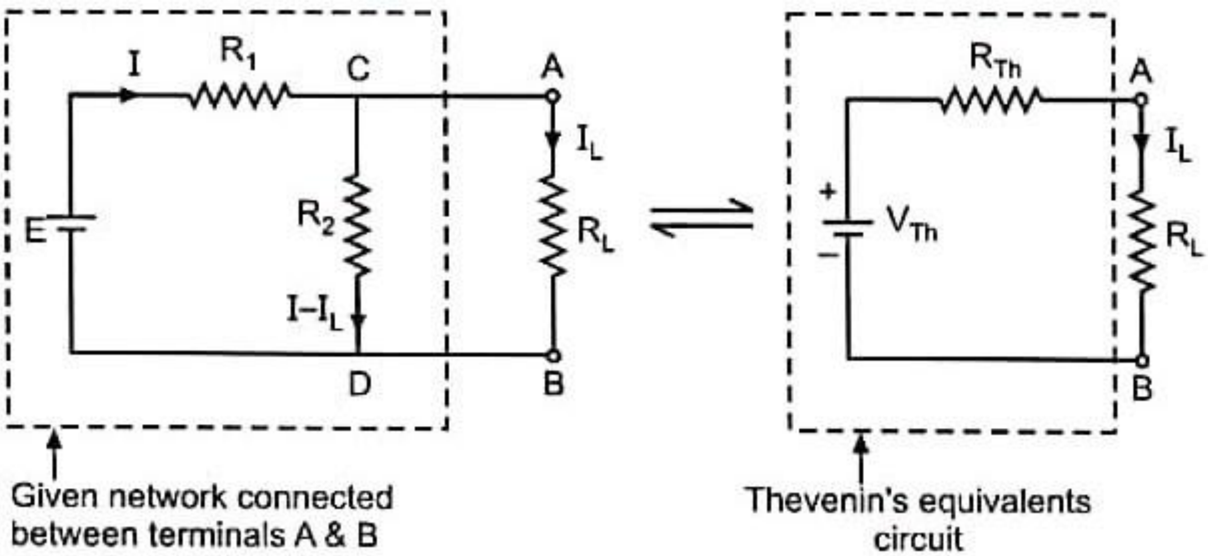


Fig. 1.13

Statement : Any two terminal linear network containing sources of e.m.f. and resistances can be replaced by an equivalent circuit consisting of voltage source (V_{Th}) in series with a single resistance R_{Th}. The value of V_{Th} is the open-circuit voltage between the terminals and R_{Th} is the resistance between the terminals when all the sources in the network have been replaced by their internal resistances.



How to Thevenize a circuit ?

To understand how to Thevenize a given network or circuit, consider a circuit as shown in Fig. 1.18. Let us find a current passing through R_L (connected between the terminals A and B) using Thevenin's theorem.

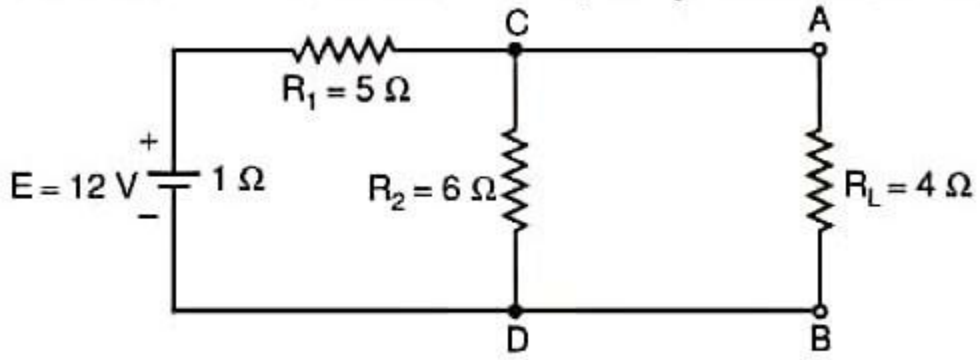


Fig. 1.18

The procedural steps for Thevenizing the circuit are as under.

Step I : Disconnect the load resistor $R_L = 4\ \Omega$ from the terminals A and B.

Step II : With load terminals A and B open (Fig. 1.19), calculate the open-circuit voltage (V_{OC}) between the terminals A and B.

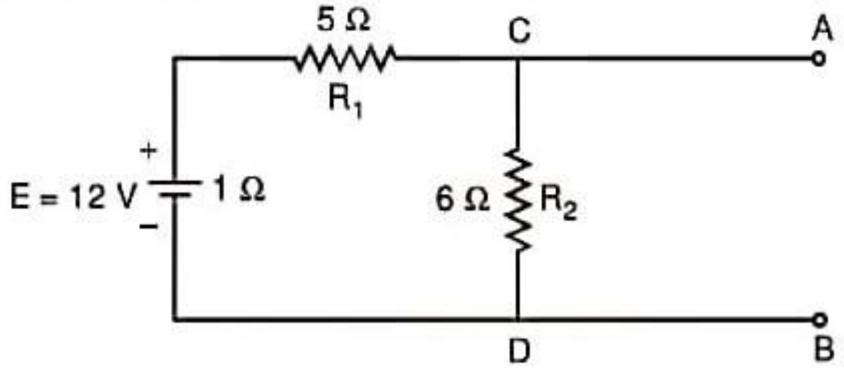


Fig. 1.19

Current passing through 6 Ω resistor is

$$I = \frac{12}{1 + 5 + 6}$$

$$I = 1\ A$$

Voltage drop across 6 Ω or between the terminals C and D is

$$V_{CD} = IR_2 = 1 \times 6 = 6\ V$$

Since point A is at the same potential as that of C and point B is also at the same potential as that of D,

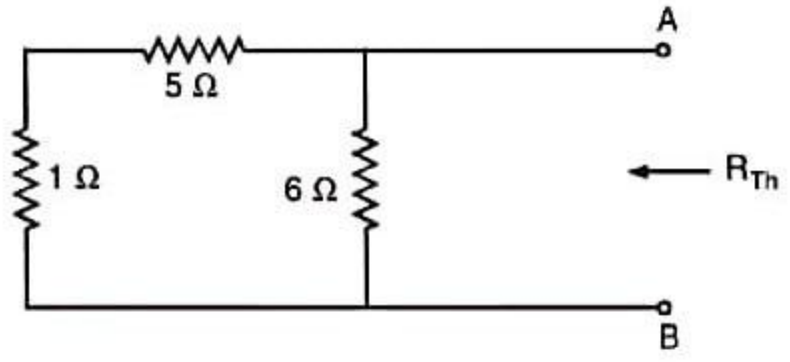
$$\therefore \quad V_{AB} = V_{CD} = V_{OC}$$

$$\therefore \quad V_{OC} = 6\ V$$

The open-circuit voltage (V_{OC}) is also called Thevenin's voltage. Thus

$$V_{Th} = 6\ V.$$

Step III : To calculate R_{eq} or R_{Th}, remove 12 volts battery leaving behind its internal resistance of 1 Ω as shown in Fig. 1.20.



Now the above circuit consists of two parallel paths : one having resistances of 6 Ω and other 6 Ω (5 Ω + 1 Ω) respectively, when looked from open circuit terminals A and B.

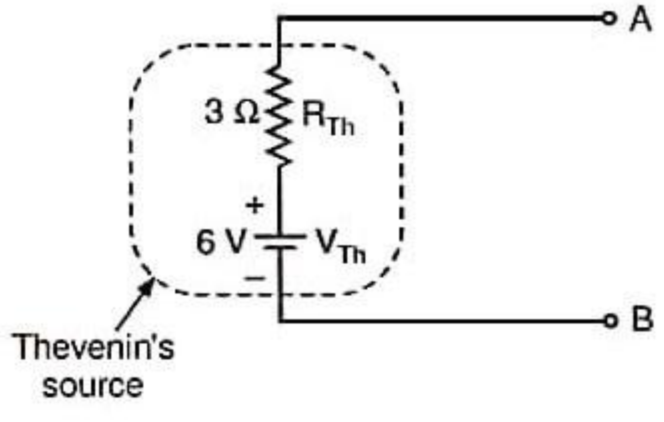
The equivalent resistance of the network when viewed from terminals A and B is

$$R_{eq} = \frac{6 \times 6}{6 + 6} = 3\ \Omega$$

This R_{eq} is also called Thevenin's resistance R_{Th}.

$$\therefore \qquad R_{Th} = 3\ \Omega$$

Step IV : Replace the entire given network by a single voltage source (called Thevenin's source) of 6 volts whose internal resistance R_{Th} is equal to 3 Ω as shown in Fig. 1.21.



Thevenin's equivalent circuit

The load resistor R_L is again connected between the terminals A and B which gives a simple series circuit as shown in

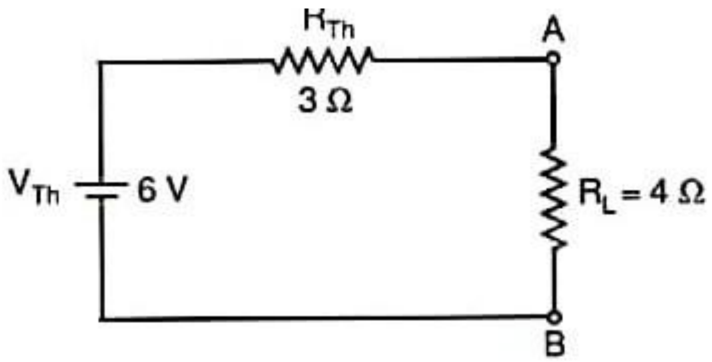


Fig. 1.22

Current passing through R_L is given as

$$I_L = \frac{V_{Th}}{R_{Th} + R_L} = \frac{6}{3+4}$$

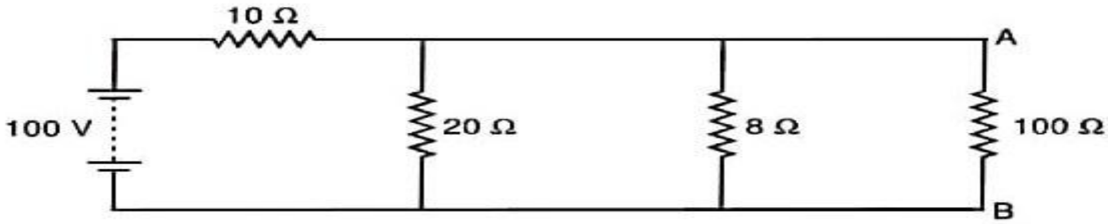
$$I_L = \frac{6}{7} = 0.85 \text{ A}$$

Limitations of Thevenin's Theorem :

1. Thevenin's theorem cannot be applied to non-linear circuits.
2. This theorem cannot be used for determining the efficiency of the circuits.
3. This theorem cannot be applied for calculating the power consumed internally, although it gives the power in load correctly.

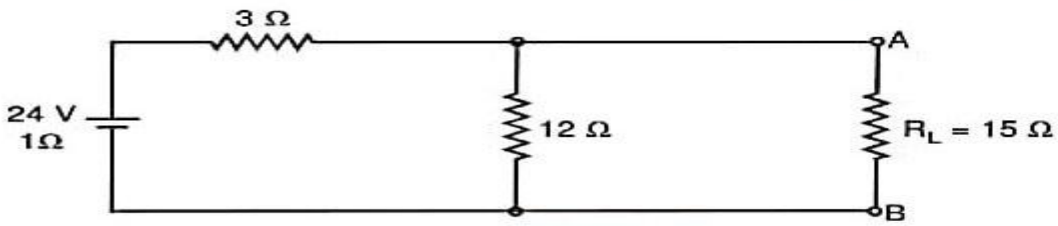
Problem:

1 Find out the current through 100 Ω resistor across A and B in the following circuit using Thevenin's theorem.



(**Ans.** 0.35 A)

2. Give Thevenin's equivalent of the circuit shown below.



(**Ans.** V_{Th} = 18 V, R_{Th} = 3 Ω)