Circuit Analysis Techniques

Lecture 6
Thevenin Theorem

Lecture delivered by:

Topics

- Thevnin's Theorem
- Computing Thevenin Equivalent
- Networks to Illustrate Thevenin Theorem

Objectives

At the end of this lecture, student will be able to:

- State and implement Thevenin's theorem on any complicate linear bilateral network

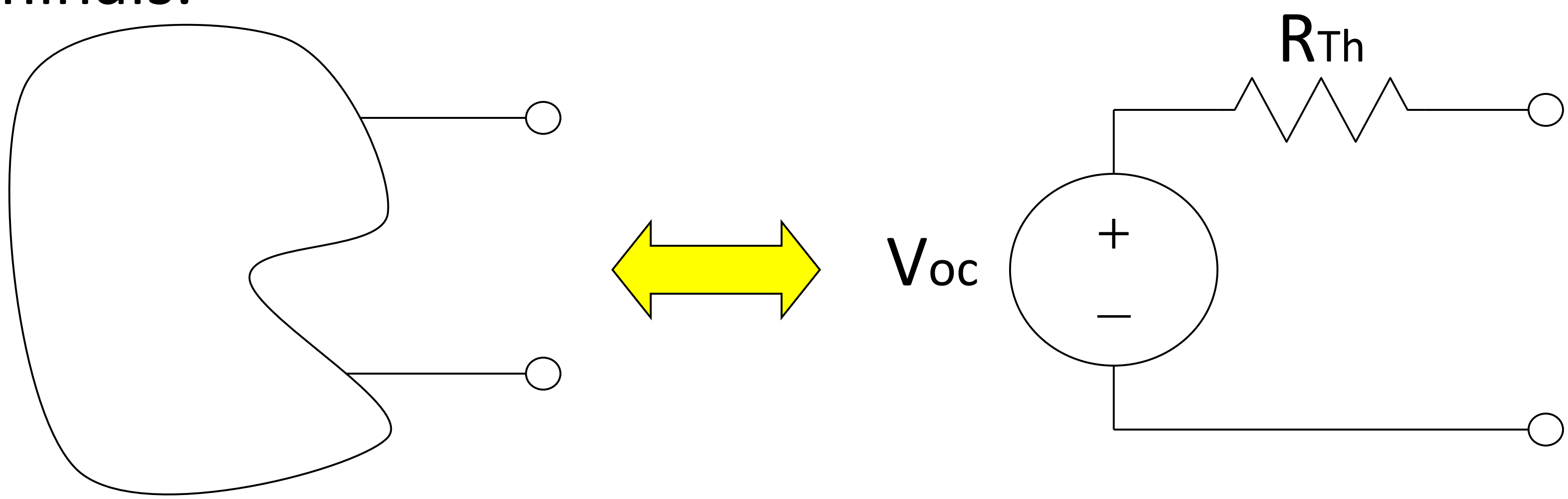
Thevenin’s Theorem

- **Thevenin’s Theorem** states that “Any circuit with sources (dependent or independent) and resistors can be replaced by an equivalent circuit containing a single voltage source and a single resistor”.

- Thevenin’s theorem implies that we can replace arbitrarily complicated networks with simple networks for purposes of analysis.

Independent Sources (Thevenin)

- Any network with two open terminals can be replaced by a **single voltage source (V_{TH})** and a **series resistance (R_{TH})** connected to the open terminals.
- A component can be removed to produce the open terminals.



Circuit with independent sources

Thevenin equivalent circuit

Computing Thevenin Equivalent

- Basic steps to determining Thevenin equivalent are
  - **Find v_{Th}**

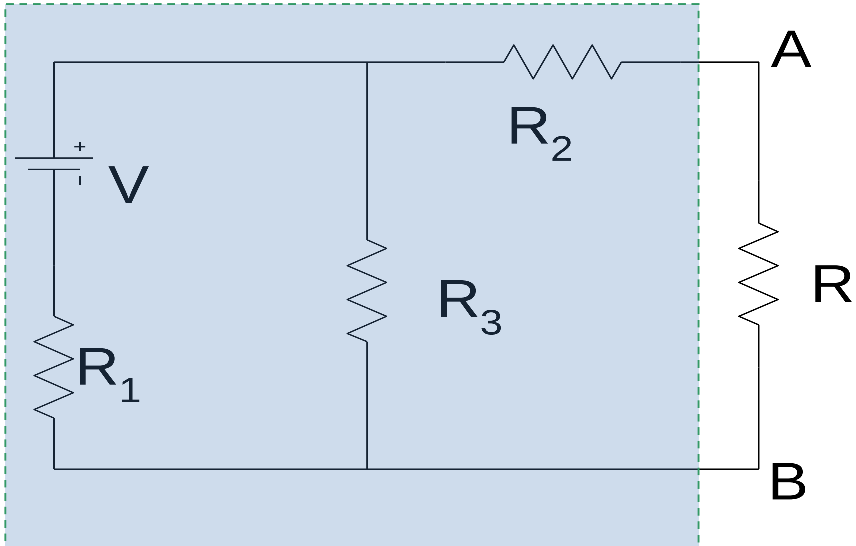
    V_{TH} is determined by calculating the voltage between open terminals A and B.

  - **Find R_{Th}**

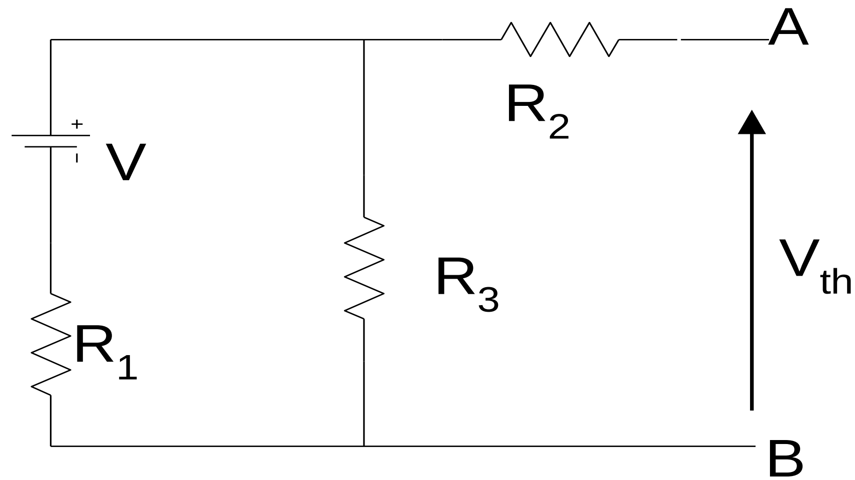
    R_{TH} is determined by shorting the voltage source and calculating the circuit's total resistance as seen from open terminals A and B.

Networks to Illustrate Thevenin Theorem

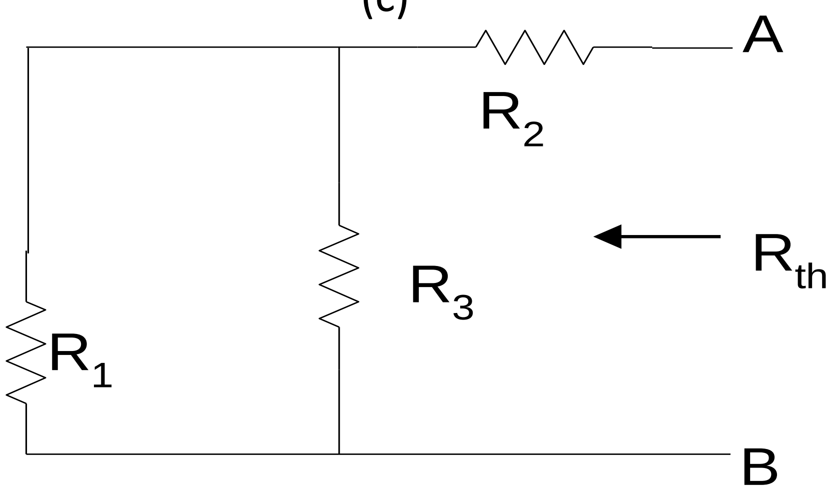
(a)



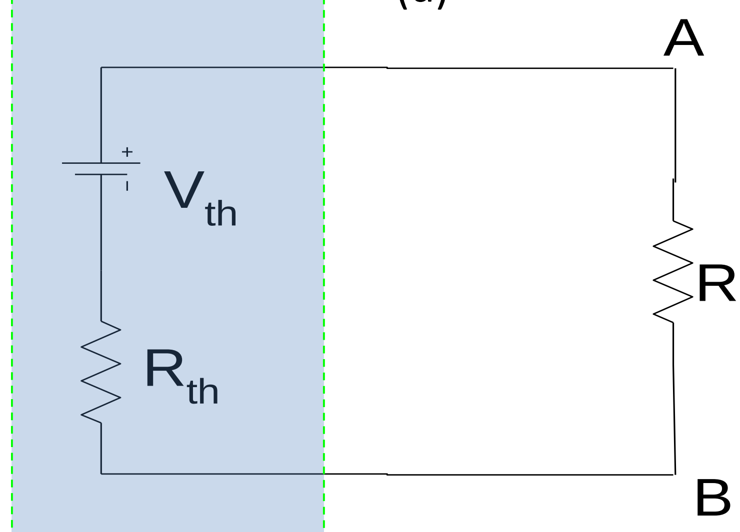
(b)



(c)



(d)



Computing Thevenin Equivalent

Refer to network (b), in R_2 there is not complete circuit, thus no current, thus current in R_3

$$I_{R3} = \frac{V}{R_1 + R_3} \quad (1)$$

And p.d across R_3 is

$$V_{R3} = \frac{VR_3}{R_1 + R_3} \quad (2)$$

Since no current in R_2, thus

$$V_{th} = \frac{VR_3}{R_1 + R_3} \quad (3)$$

Refer to network (c) the resistance at AB

$$R_{th} = R_2 + \frac{R_1 R_3}{R_1 + R_3} \quad (4)$$

Thus current in R (refer network (d))

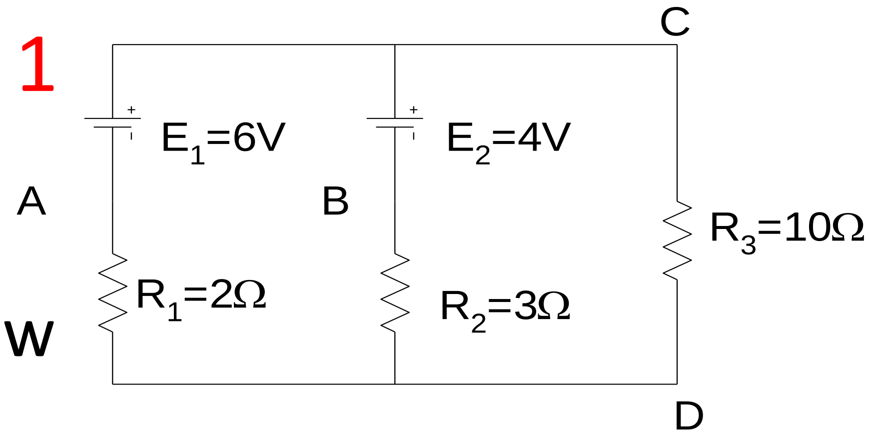
$$I = \frac{V_{th}}{R_{th} + R} \quad (5)$$

Thevnin's Theorem

Example 1

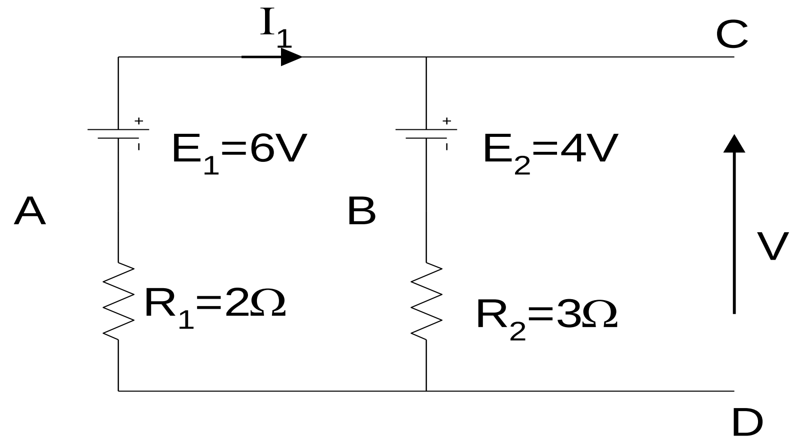
Calculate the current through R_3

Solution



With R3 disconnected as in figure below

$$I_1 = \frac{6-4}{R_1+R_2} = \frac{2}{2+3} = 0.4A$$



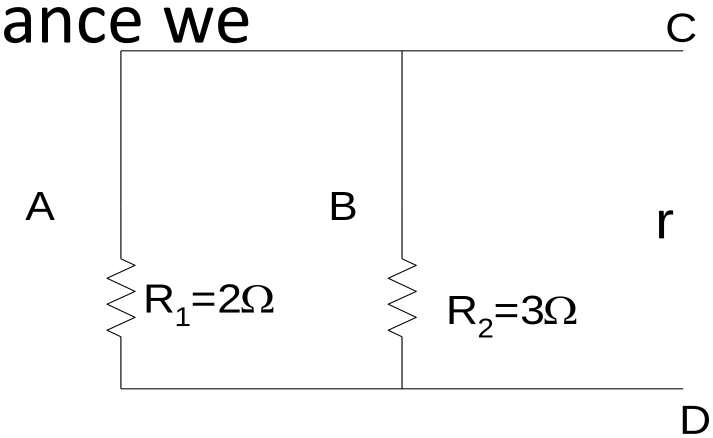
p.d across CD is E_1-I_1R_1

$$V = 6-(0.4\times 2) = 5.2V$$

Continued..

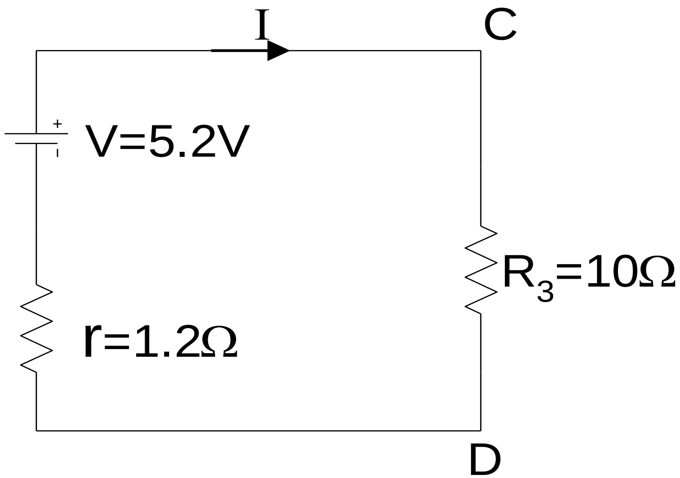
To determine the internal resistance we remove the e.m.f s

$$r = \frac{2 \times 3}{2+3} = 1.2\,\Omega$$



Replace the network with V=5.2V and r=1.2, then the at terminal CD, R3, thus the current

$$I = \frac{5.2}{1.2+10} = 0.46A$$

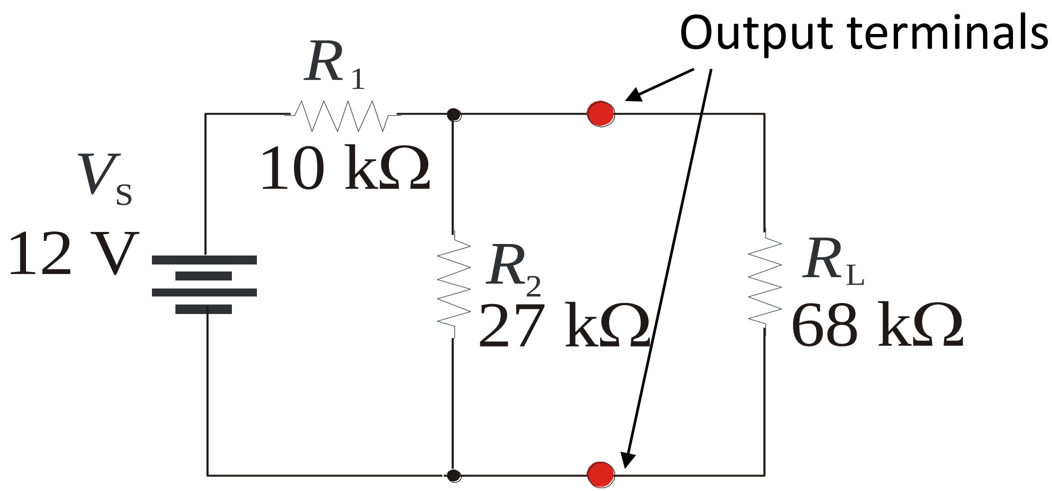


Thevnin's Theorem

Example 2

What is the Thevenin voltage for the circuit? 8.76 V

What is the Thevenin resistance for the circuit? 7.30 kΩ



Remember, the load resistor has no affect on the Thevenin parameters.

Summary

- Thevnin's Theorem states that “Any circuit with sources (dependent or independent) and resistors can be replaced by an equivalent circuit containing a single voltage source and a single resistor”.