Thevenin's Theorem and its Applications

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Thevenin’s Theorem and its Application

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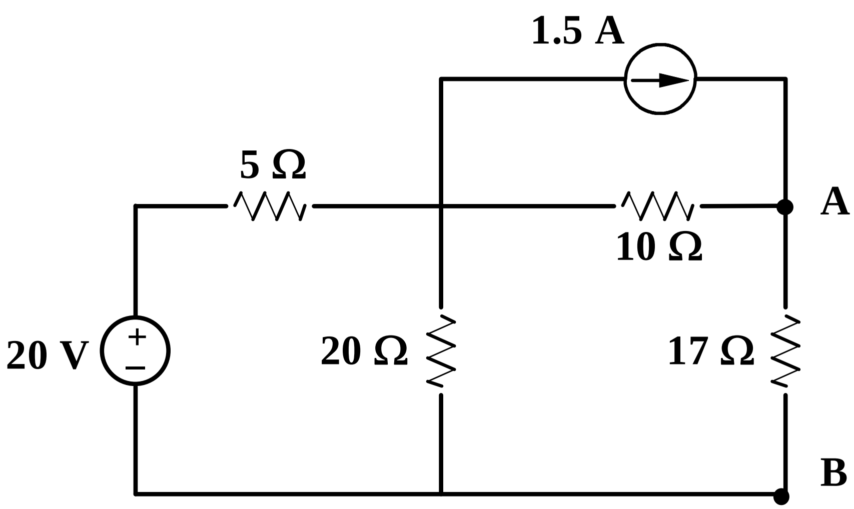
Outline of Lecture

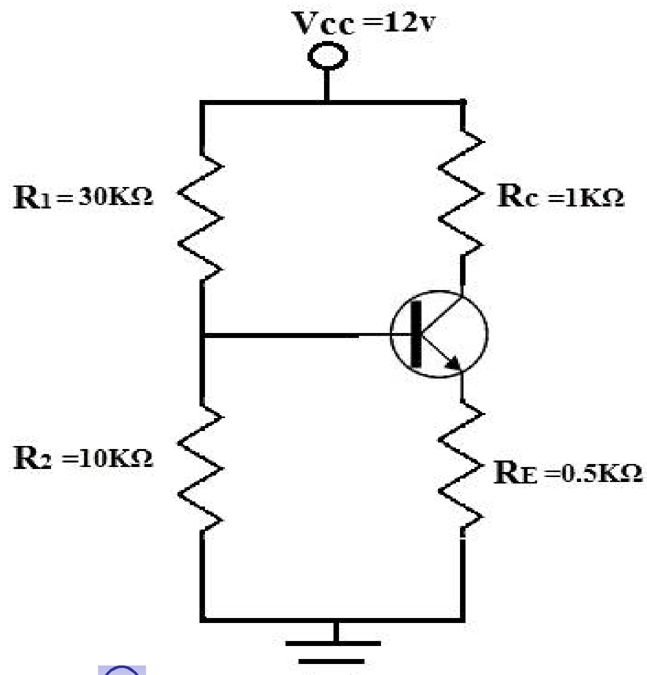
- **Lecture Objectives**
- **Thevenin's Theorem**
- **Examples**
- **Application**

Lecture Objectives

- **To understand Thevenin's theorem** and simplify electrical networks into simple equivalent circuits using the theorem.
- To study an application of the theorem.



1 An example of Network

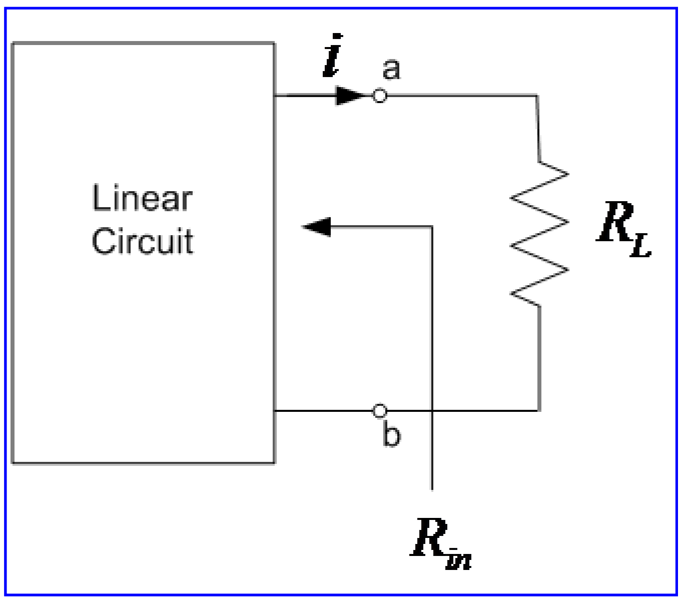


2 Transistor Circuit

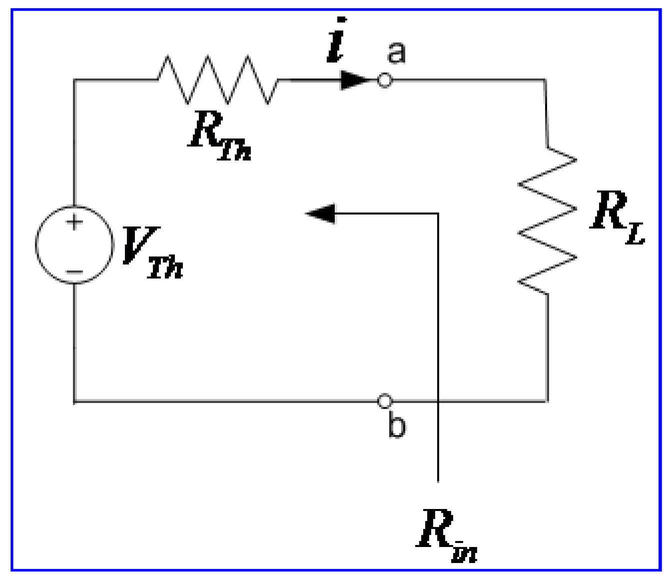
Thevenin's Theorem

Thevenin's theorem states that a **linear and bilateral network** can be replaced by an equivalent circuit consisting of a voltage source V_{Th} in series with a resistance R_{Th}.

where V_{Th} is the open-circuit voltage across load terminals, and R_{Th} is the input or equivalent resistance at the terminals when all the independent sources are turned off.



1



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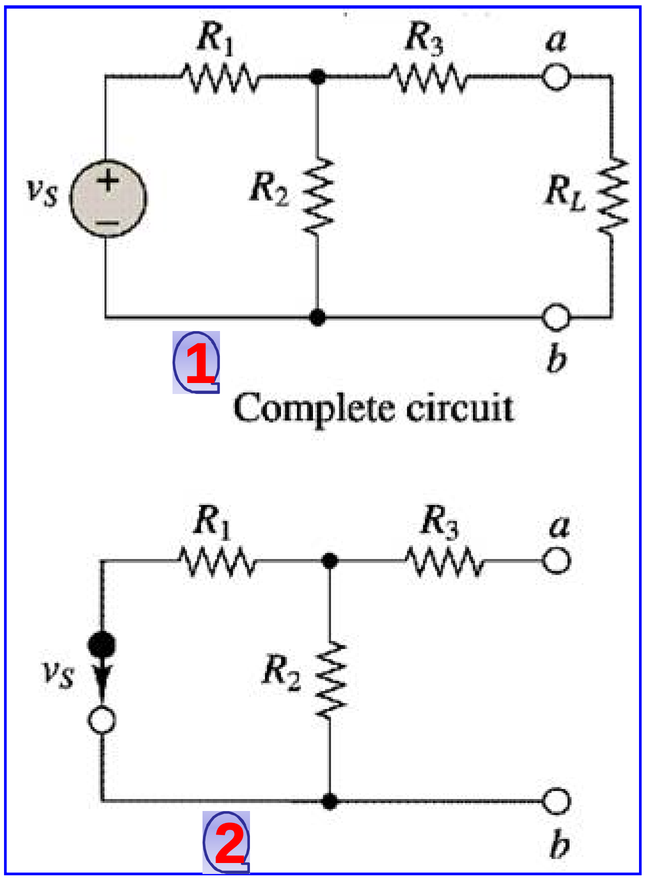
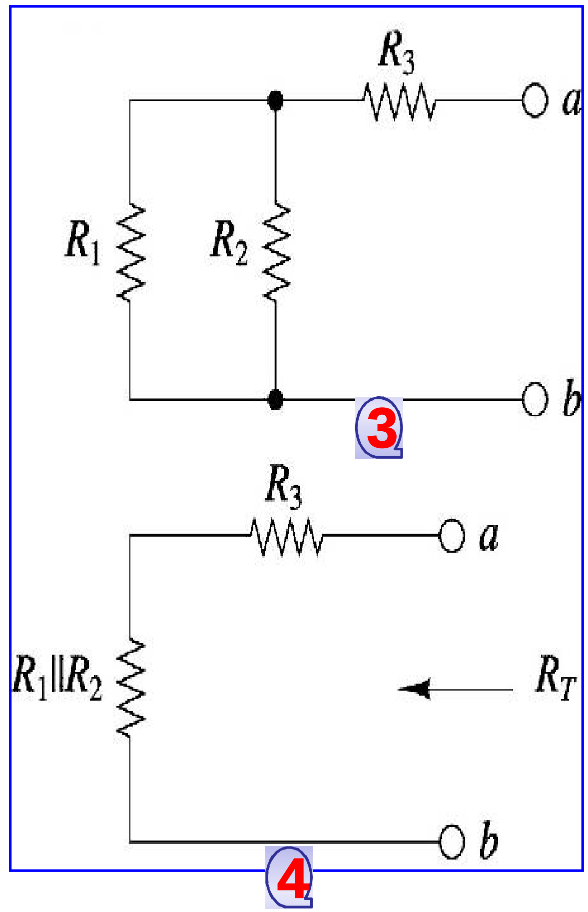
Thevenin's Theorem (*contd..)*

***Determination of R_{Th} (*Thevenin's Resistance):**

The resistance seen by the load, with removed load and all **independent** sources turned off (Voltage sources replaced by short circuits & current sources replaced by open circuits).

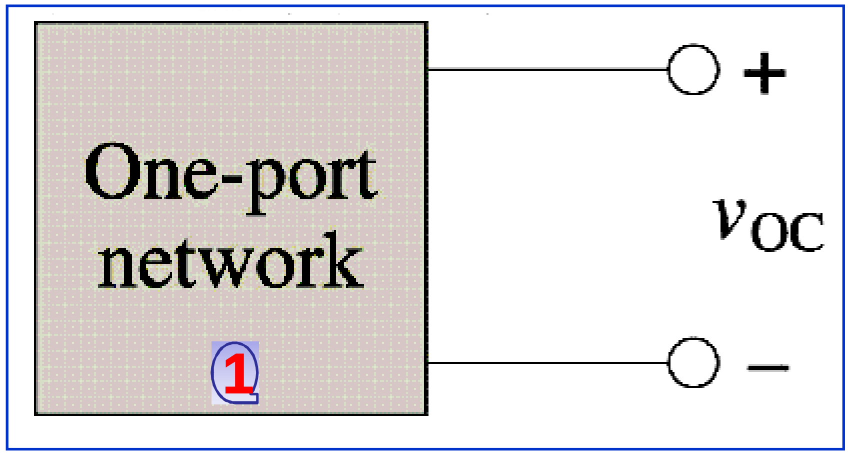


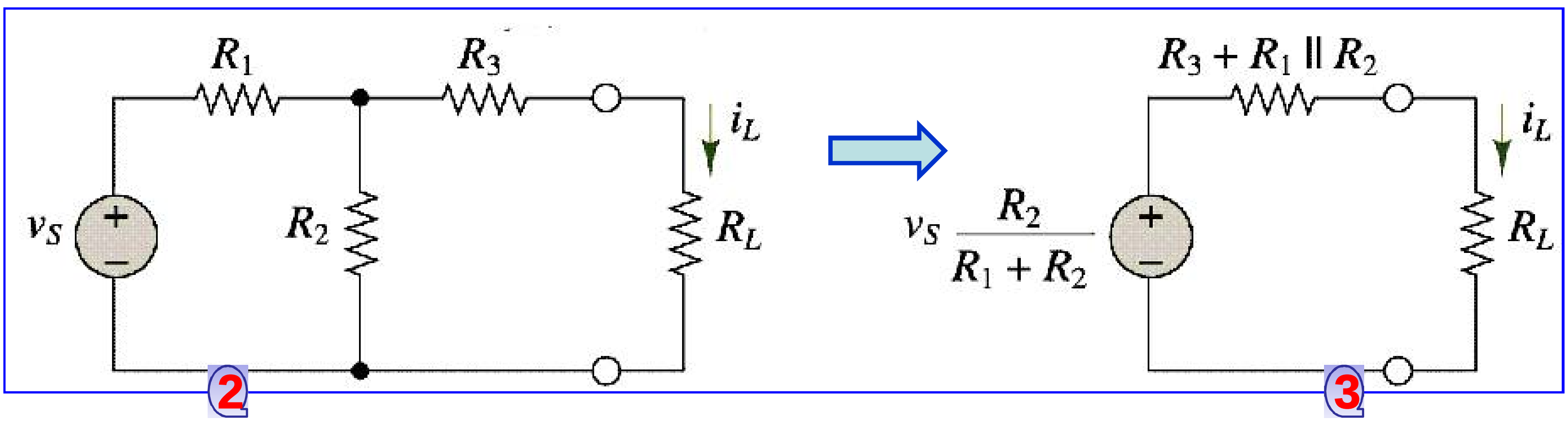


Thevenin's Theorem *(contd..)*

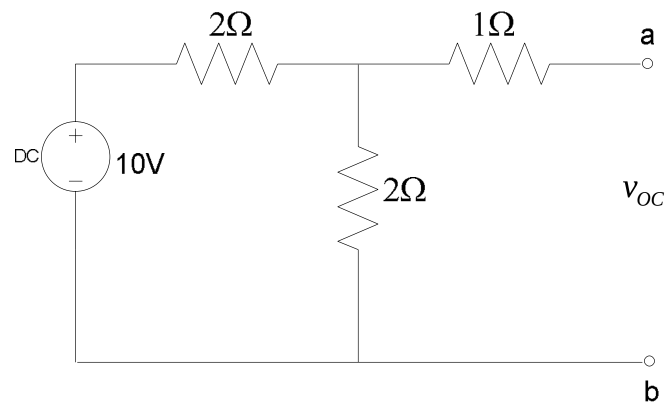
Determination of V_{Th} (Thevenin's Voltage):

The voltage across the load under open circuit condition, also called as open circuit voltage.



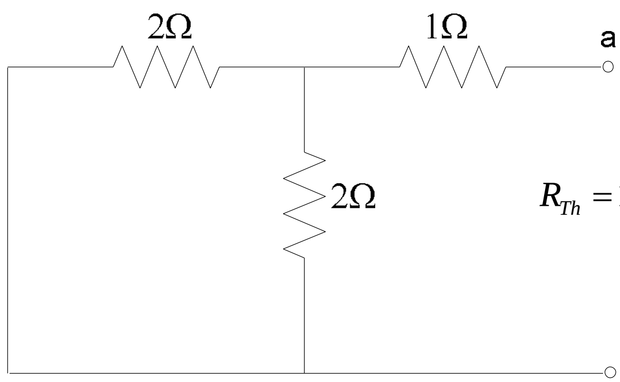


Example # 1



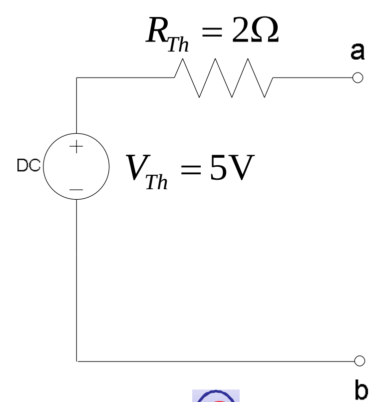
$$v_{OC} = \frac{2}{2+2} 10\text{V} = 5\text{V} = V_{Th}$$

1



$$R_{Th} = 1 + \frac{2 \times 2}{2+2} = 2\Omega$$

2



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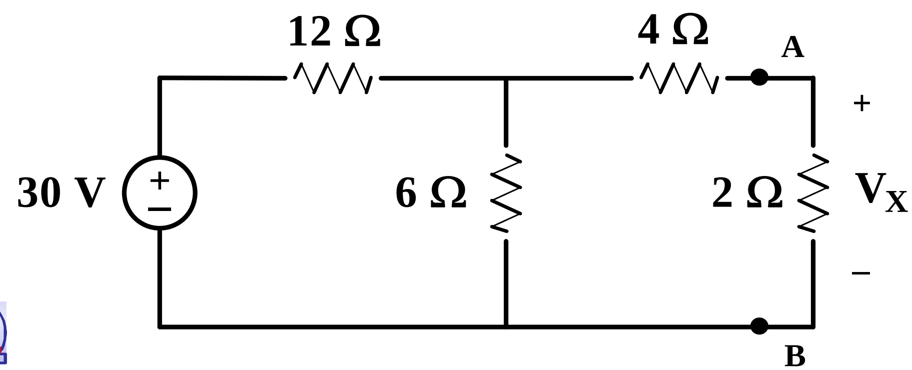
Example # 2

1



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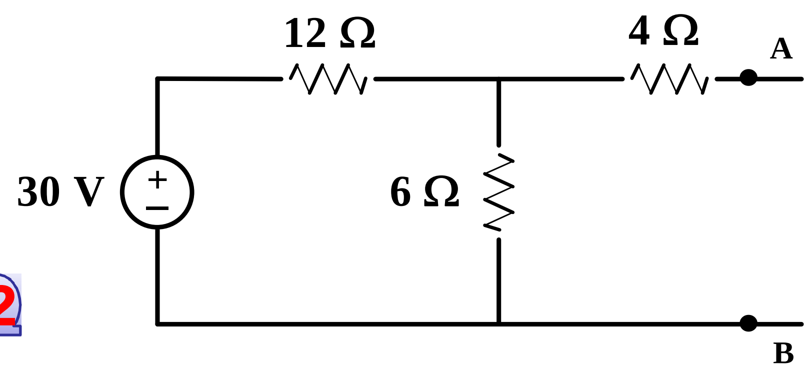
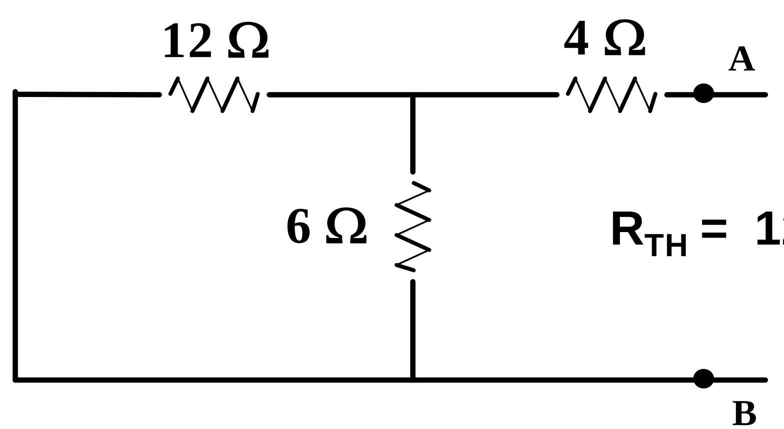


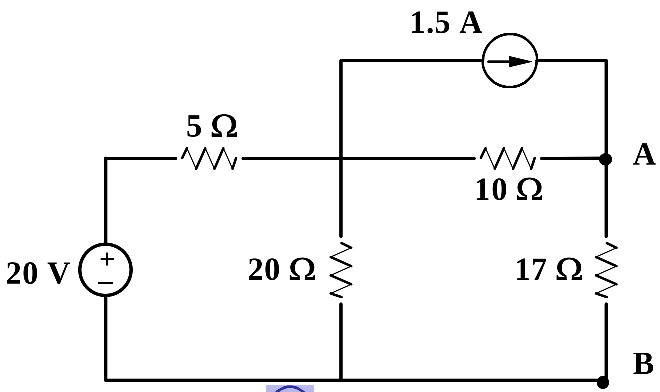
$$V_{AB} = \frac{(30)(6)}{6+12} = 10V$$

3

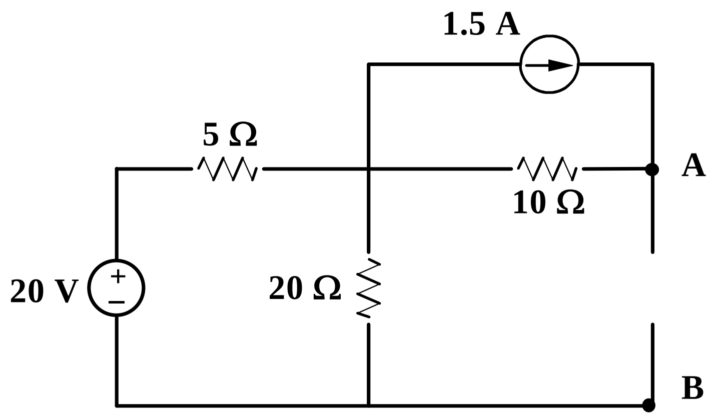


$$R_{TH} = 12||6 + 4 = 8\,\Omega$$

Example # 3



1



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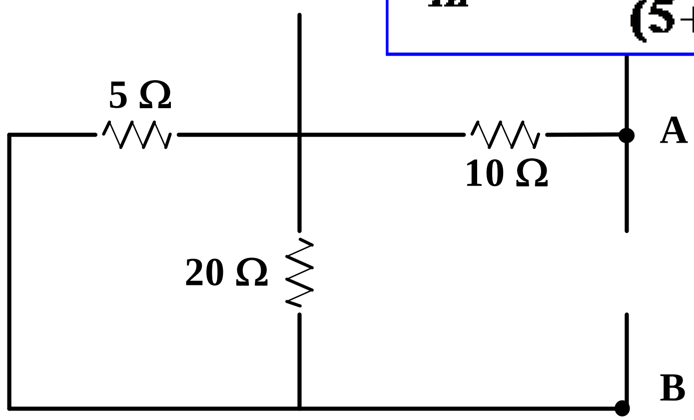
$$V_{AB} = V_{TH} = (1.5)(10) + \frac{20(20)}{(20+5)}$$

$$\therefore \quad V_{TH} = 31V$$

$$R_{TH} = 10 + \frac{5(20)}{(5+20)} = 14\Omega$$



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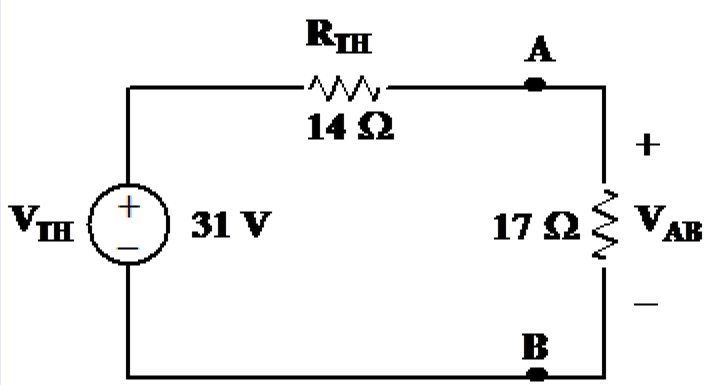

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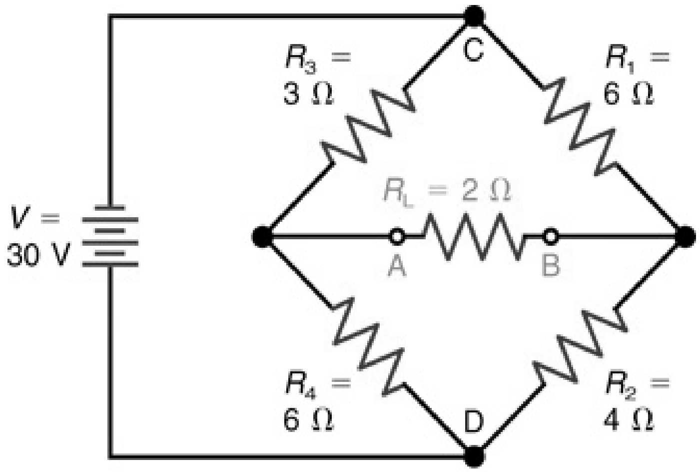
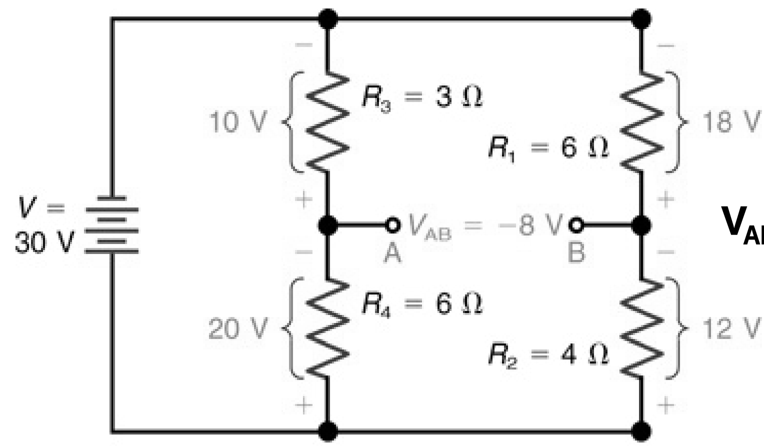
Example # 4

Determining the voltage drop across R_L



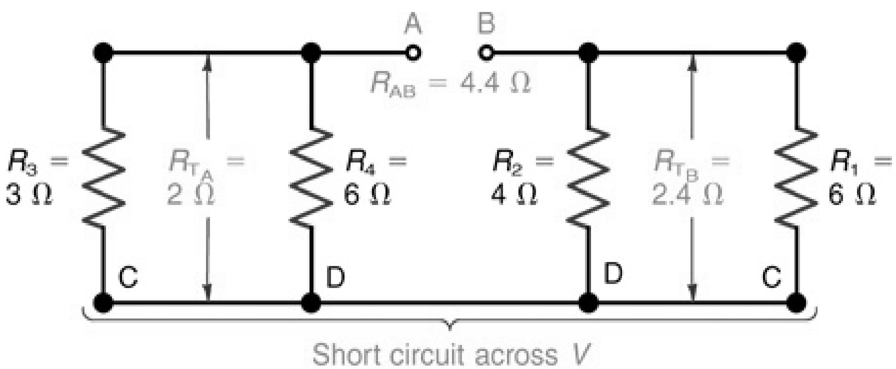
1



2

$V_{AB} = -20 - (-12) = -8V$

$R_{Th} = R_{TA} + R_{TB} = 2 + 2.4 = 4.4\ \Omega$



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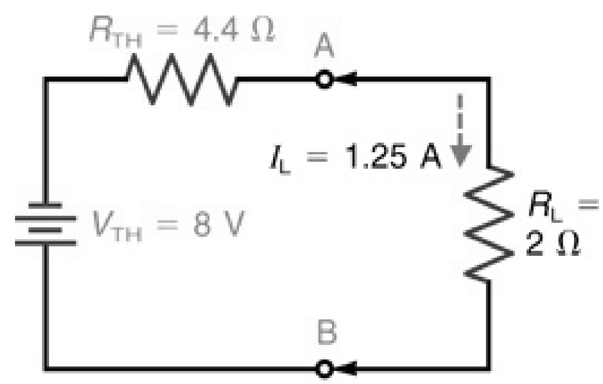

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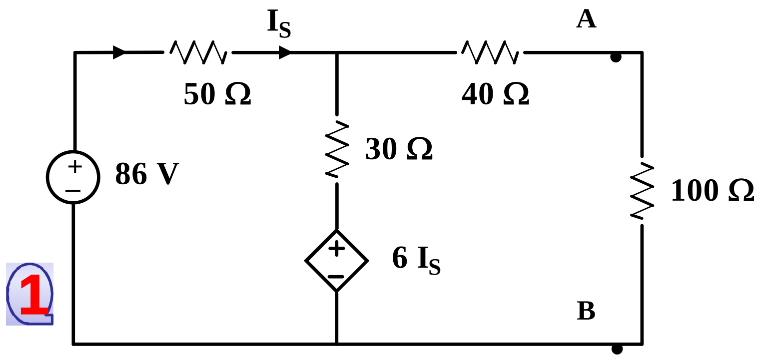
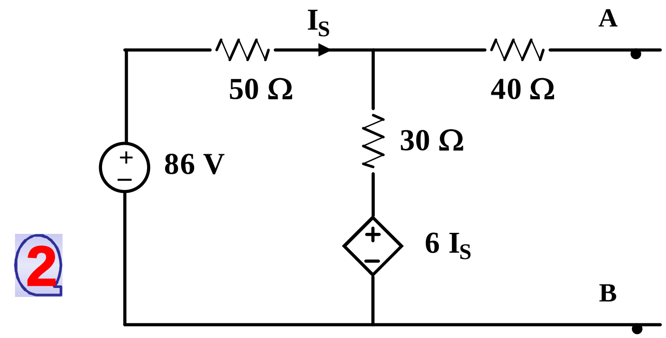
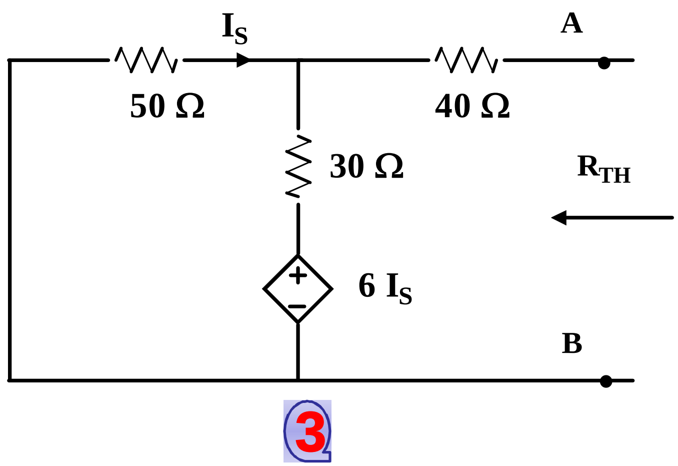
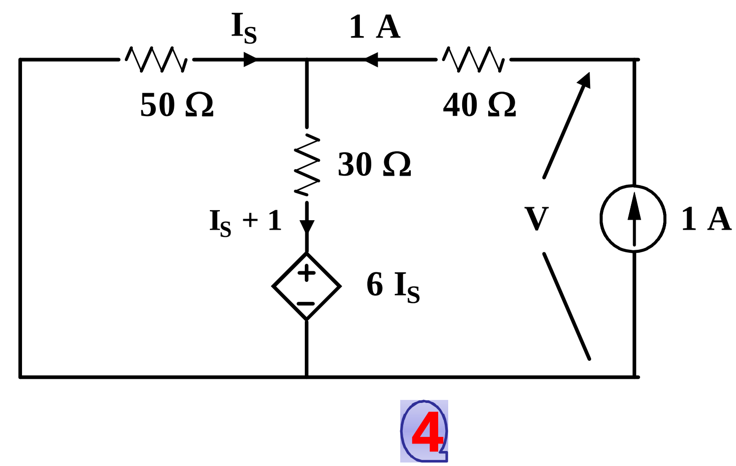
Example # 5

Find the voltage across the 100 Ω load.









$$50I_S + 30(I_S + 1) + 6I_S = 0$$

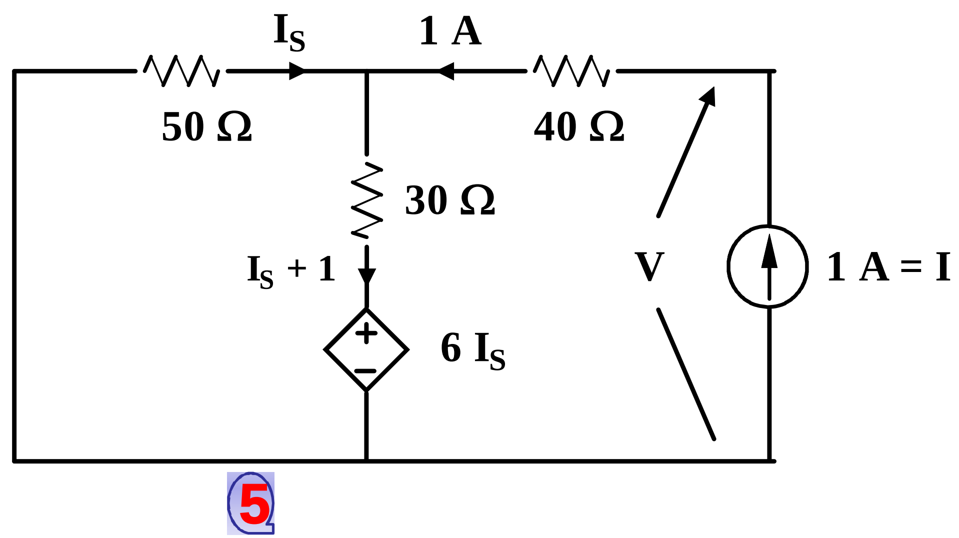
2

$$-86 + 80I_S + 6I_S = 0 \rightarrow I_S = 1\,A$$

$$V_{AB} = 6I_S + 30I_S = \rightarrow 36V$$

$$I_S = \frac{-15}{43}\,A$$

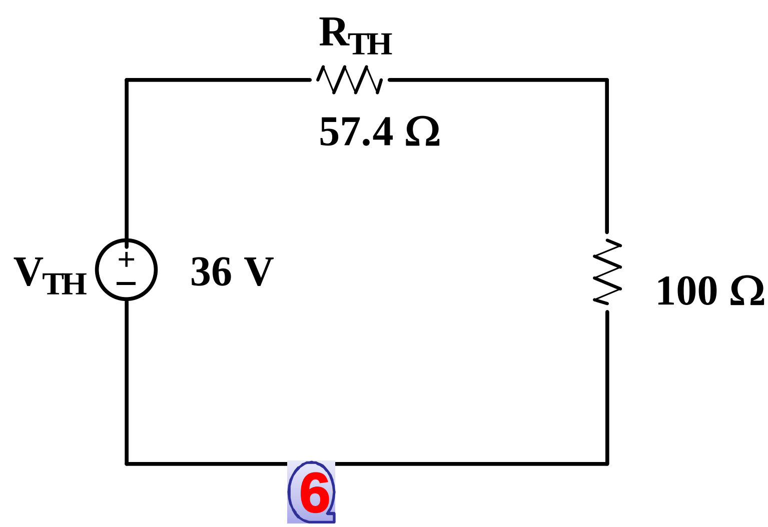
Example # 5 (*contd..*)



$$50\left(\frac{-15}{43}\right) - 1(40) + V = 0$$

$$V = 57.4 \text{ volts}$$

$$R_{TH} = \frac{V}{I} = \frac{V}{1} = 57.4\ \Omega$$



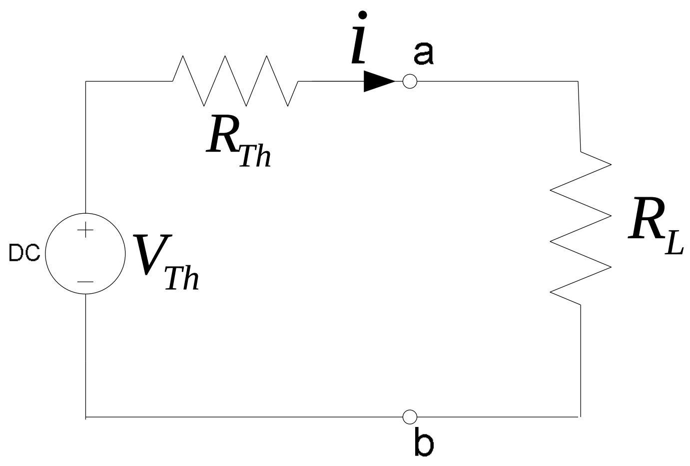
$$V_{100} = \frac{36x100}{57.4 + 100} = 22.9\ V$$

Applications of Thevenin's Theorem

- To determine Change in Load Voltage**:** To predict range of load voltage variation due to change in load resistance.
- To obtain Norton's equivalent circuit.
- To determine Maximum power that can be transferred to Load from the network.

Maximum Power Transfer Theorem

Maximum power transfer from a circuit to a variable load occurs when the load resistance equals the source resistance , $R_L = R_{TH.}$



$$p = i^2 R_L = \left[V_{Th} / \left(R_{Th} + R_L \right) \right]^2 R_L$$

This power is maximum when

$$\partial p / \partial R_L = 0$$

This gives: $R_L = R_{Th}$

$$p_{\max} = \left[V_{Th} / \left(R_{Th} + R_L \right) \right]^2 R_L \Big|_{R_L = R_{Th}}$$

$$p_{\max} = \left[V_{Th} / \left(2 R_{Th} \right) \right]^2 R_{Th} = V_{Th}^{\ 2} / 4 R_{Th}$$

Sincere Thanks with Inspiring Equation

$$E = mc^2$$

E= Excellence, m = Motivation, C =Commitment

c = 0.5 (Half hearted) E = ¼
c = 2 (Doubly enthused) E =4