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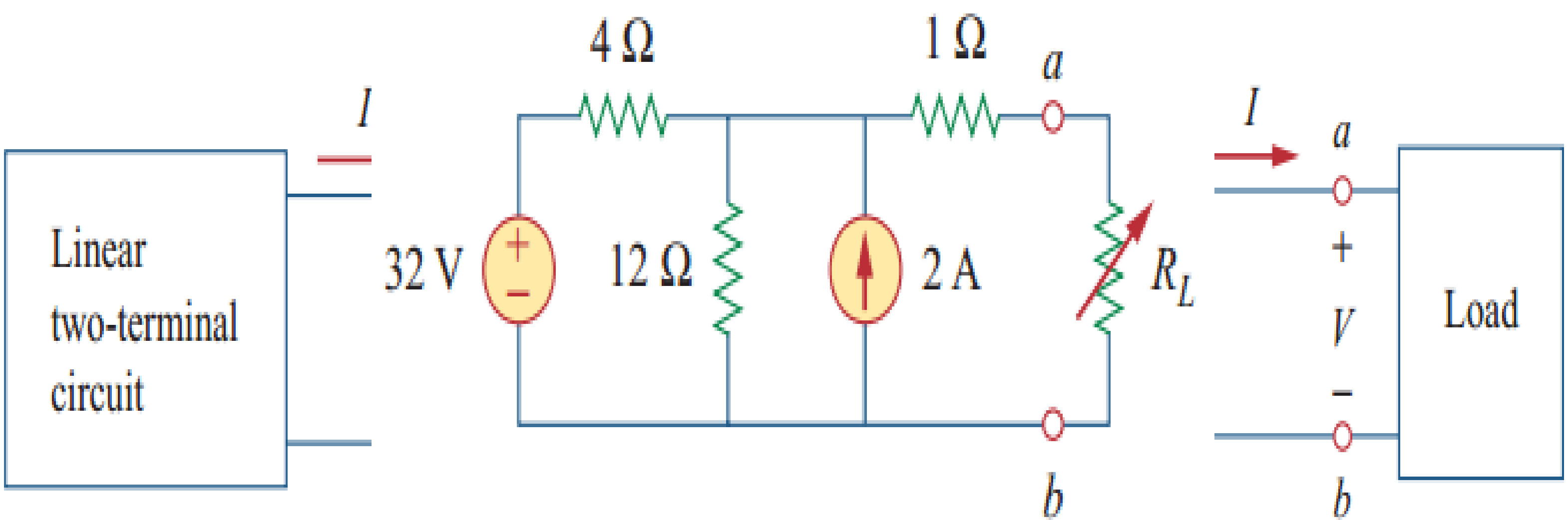
Thevenin’s Theorem

Thevenin’s theorem states that a linear two-terminal circuit can be replaced by an equivalent circuit consisting of a voltage source V_{Th}

Two circuits are said to be equivalent if they have the same voltage-current relation at their terminals.

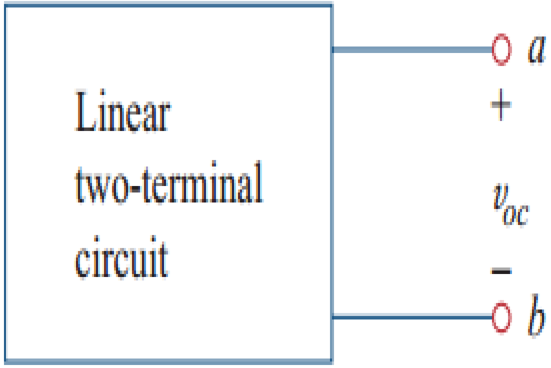
terminals when the independent sources are turned off.

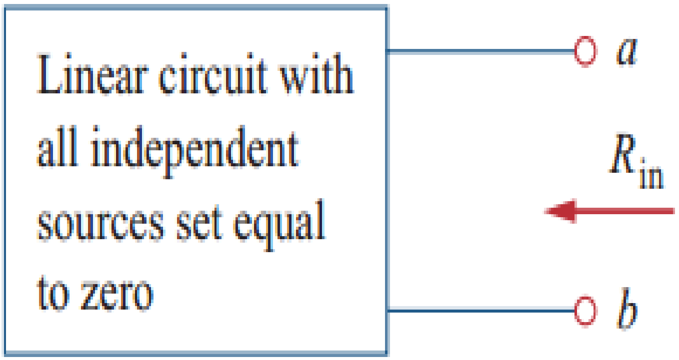


Linear two-terminal circuit

Thevenin equivalent circuit

Thevenin's Theorem



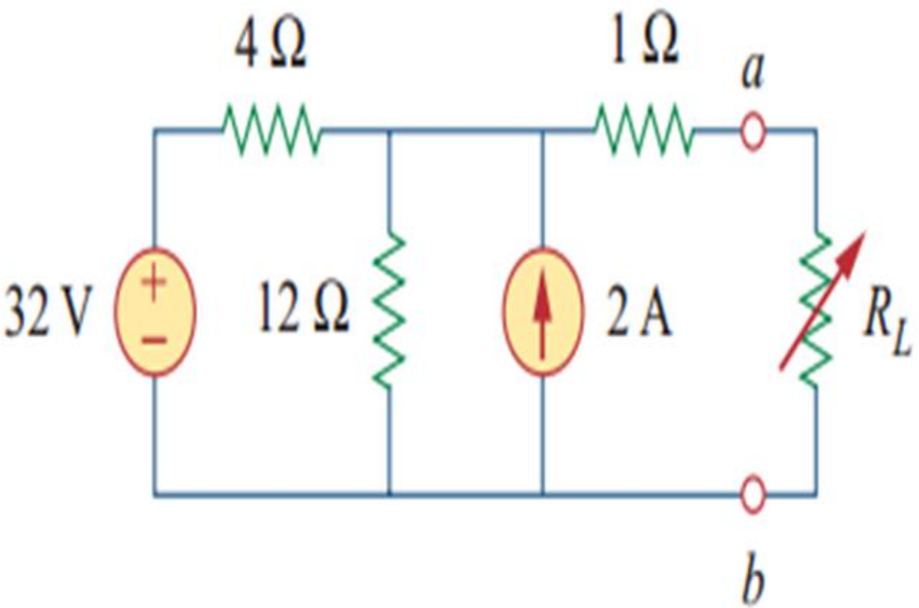


$$V_{Th} = v_{oc}$$

$$R_{Th} = R_{in}$$

Thevenin's Theorem

Find the Thevenin equivalent circuit of the following circuit, to the left of the terminals a-b. Then find the current through R_L=6, 16 and 26 Ω

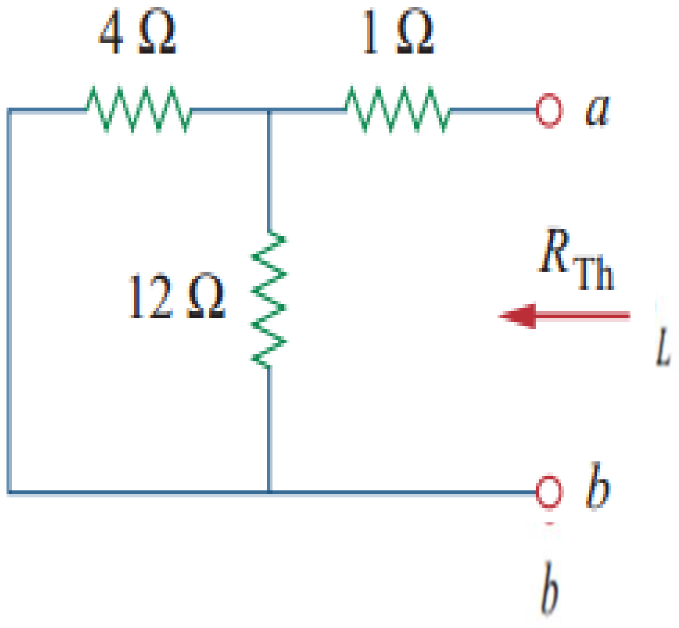


Thevenin’s Theorem

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).

$$R_{Th} = 4 \parallel 12 + 1$$

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



Thevenin's Theorem

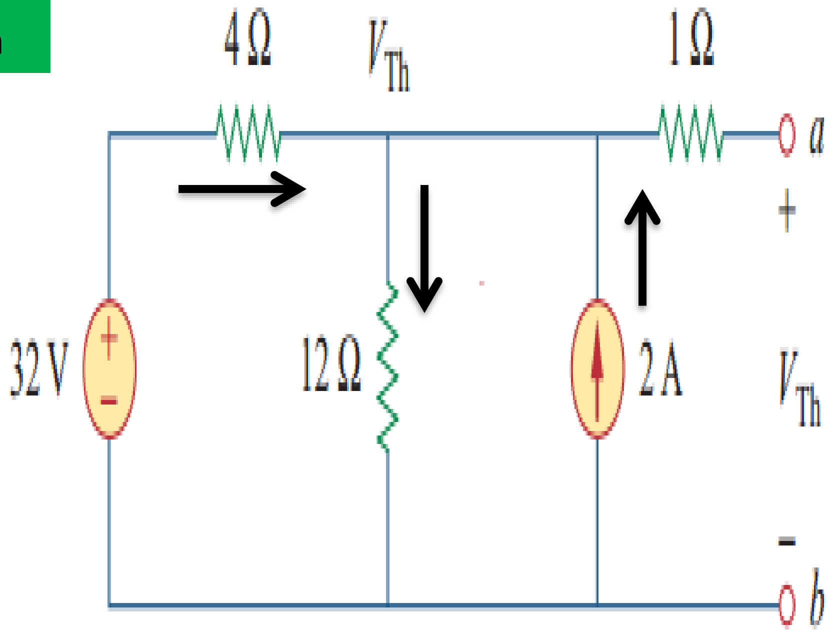
Applying nodal analysis to find V_{Th}

Applying KCL

$$\frac{32 - V_{Th}}{4} + 2 = \frac{V_{Th} - 0}{12}$$

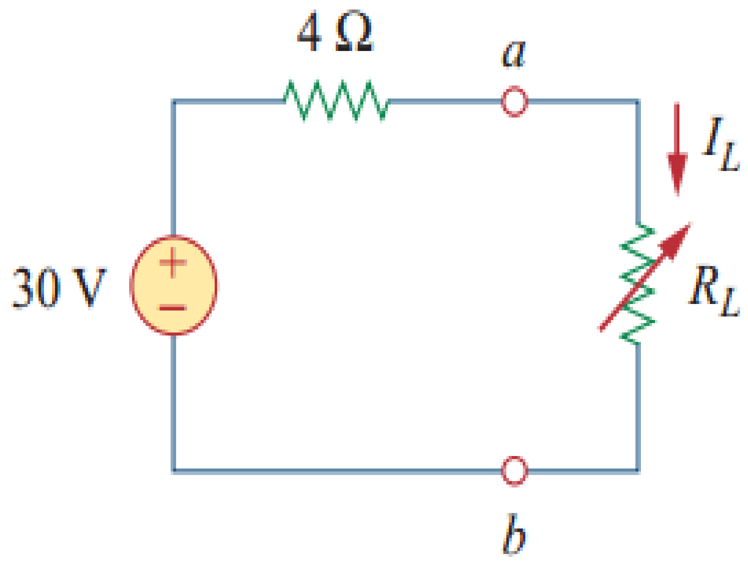
$$96 - 3V_{Th} + 24 = V_{Th}$$

$$V_{Th} = 30V$$



Thevenin's Theorem

The Thevenin equivalent circuit is



Thevenin's Theorem

The current through R_L is

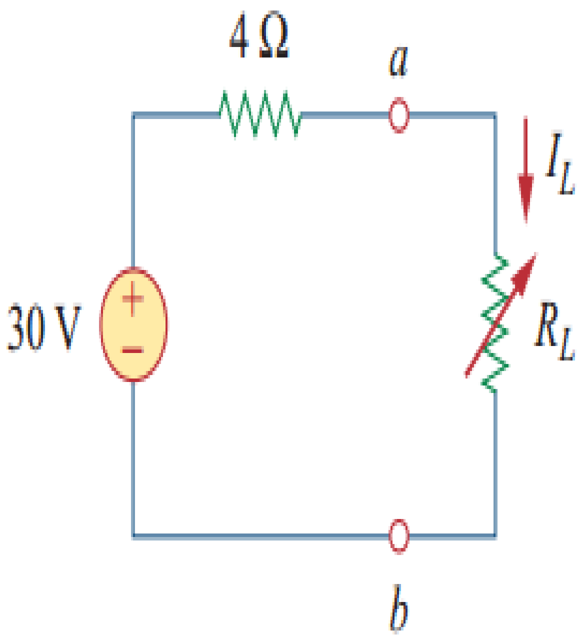
$$I_L = \frac{V_{Th}}{R_{Th} + R_L}$$

When R_L=6Ω,

$$I_L = \frac{30}{4+6} = 3\,A$$

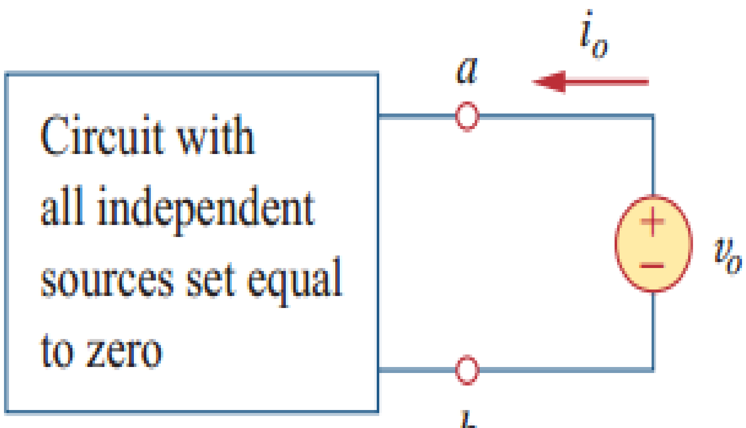
When R_L=16Ω,

$$I_L = \frac{30}{4+16} = 1.5\,A$$



Thevenin's Theorem

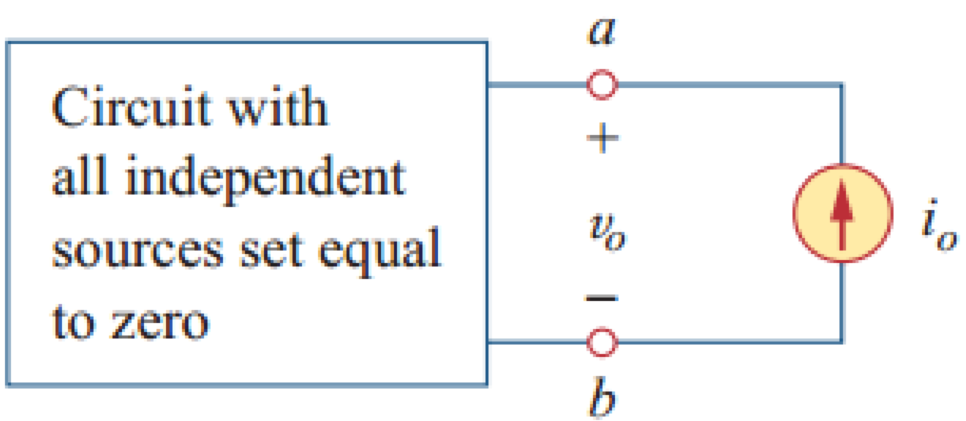
If the network has dependent sources, we turn off all independent sources. Dependent sources are not to be turned off because they are controlled by circuit variables. We apply a voltage source v_o at terminals a and b and determine the resulting current. Then $R_{Th} = v_o / i_o$,



$$R_{Th} = \frac{v_o}{i_o}$$

Thevenin's Theorem

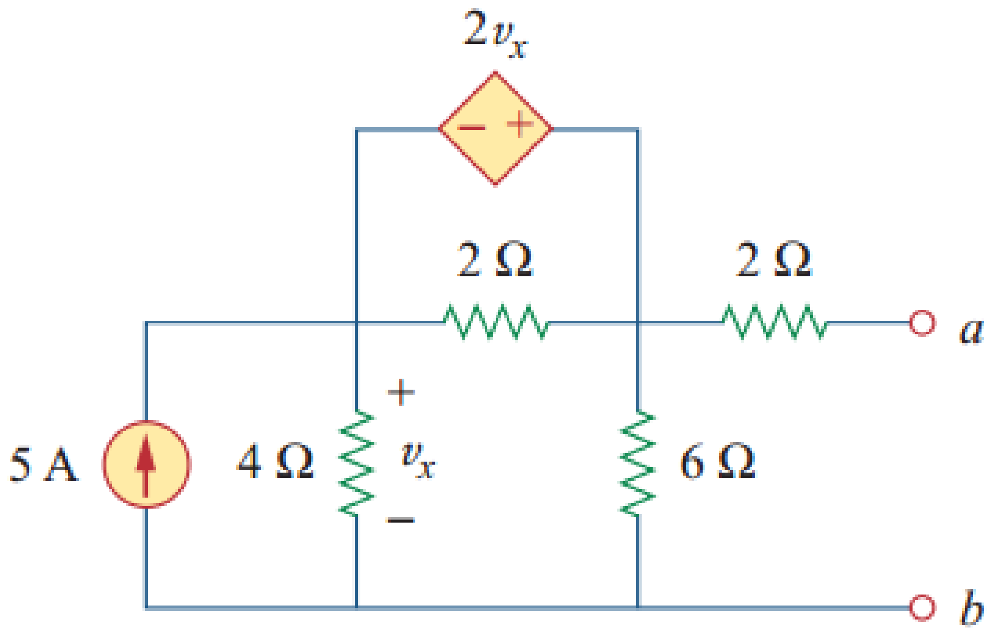
Alternatively, we may insert a current source at terminals i_o a-b as shown in Figure and find the terminal voltage. Again Then $R_{Th} = v_o / i_o$



$$R_{Th} = \frac{v_o}{i_o}$$

Thevenin's Theorem

Problem: Find the Thevenin equivalent of the circuit at terminals a-b.



Thevenin's Theorem

Solution: This circuit contains a dependent source. To find R_{Th}, we set the independent source equal to zero but leave the dependent source alone. we insert a voltage source v_o *at* the terminal a and b.

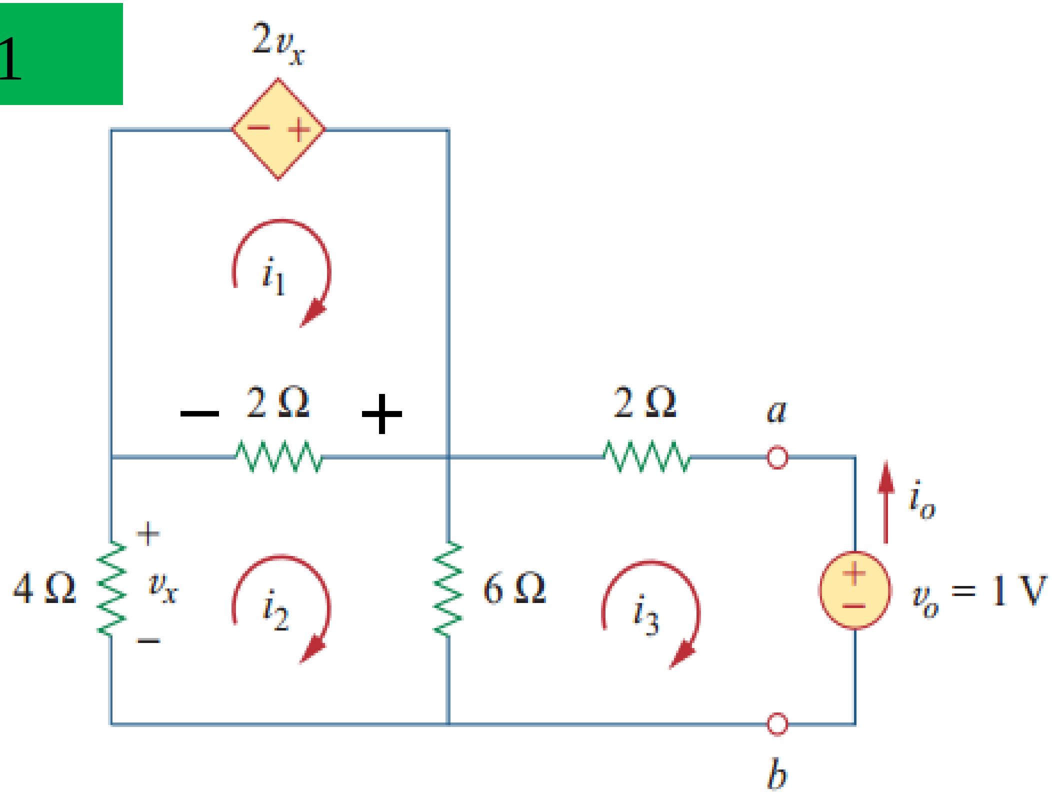
Applying mesh analysis to loop 1

$$-2v_x + 2(i_1 - i_2) = 0$$

But,

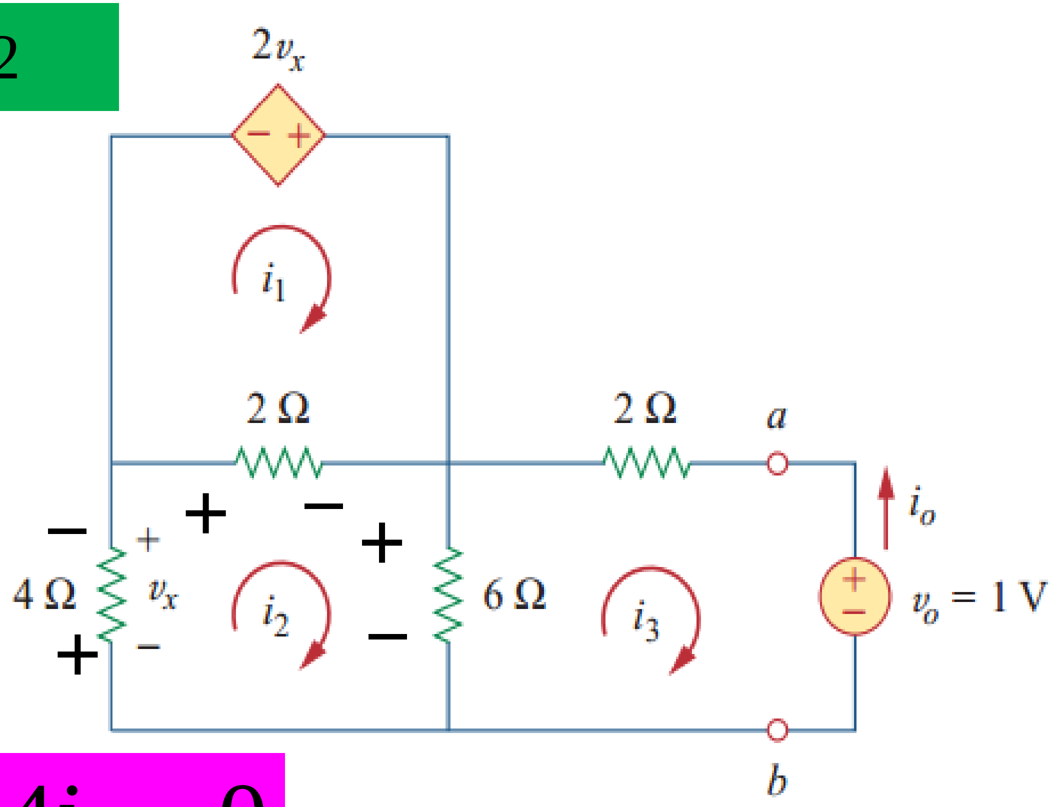
$$v_x = -4i_2$$

$$i_1 + 3i_2 = 0 \ldots (i)$$



Thevenin's Theorem

Applying mesh analysis to loop 2



$$2(i_2 - i_1) + 6(i_2 - i_3) + 4i_2 = 0$$

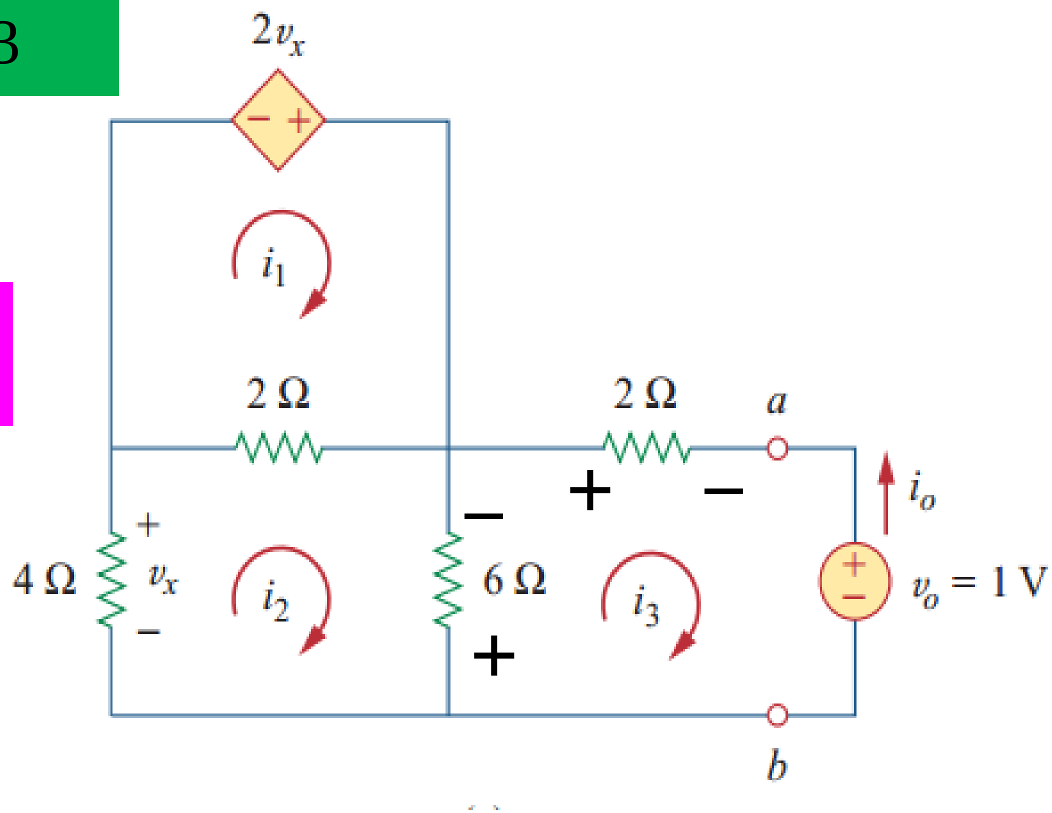
$$-2i_1 + 12i_2 - 6i_3 = 0......(ii)$$

Thevenin's Theorem

Applying mesh analysis to loop 3

$$6(i_3 - i_2) + 2i_3 + 1 = 0$$

$$2i_2 - 8i_3 = 1......(iii)$$



Thevenin's Theorem

After solving equation (i), (ii) and (iii), we get,

$$i_3 = -\frac{1}{6}A$$

But,

$$i_o = -i_3 = \frac{1}{6}A$$

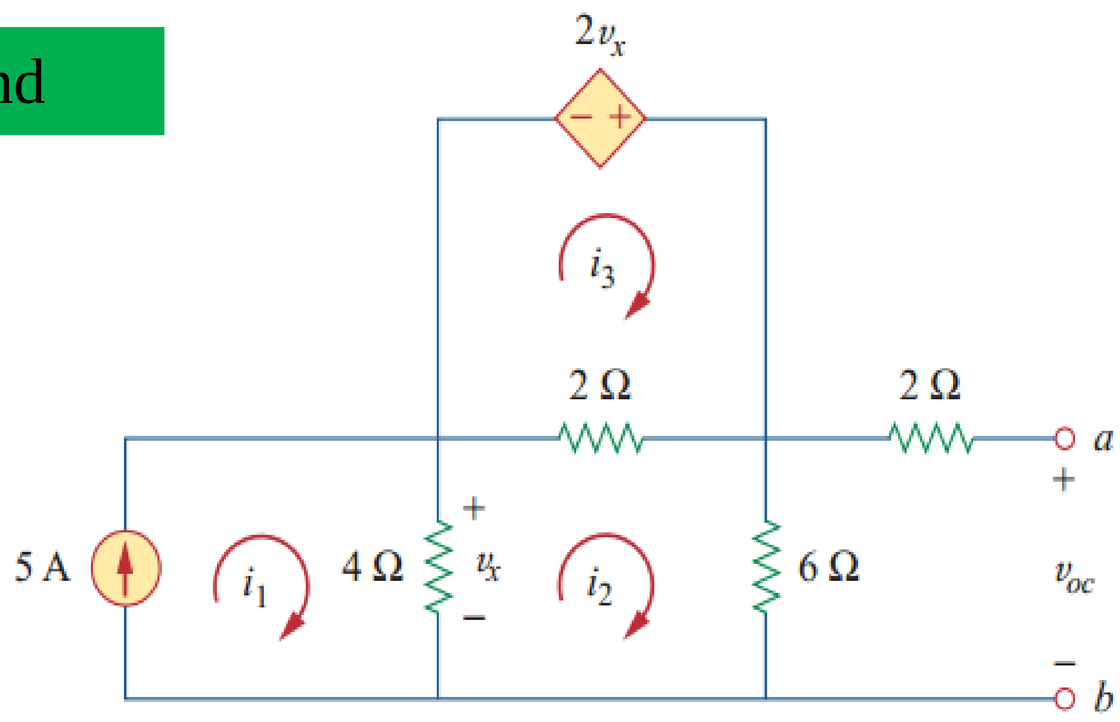
$$R_{Th} = \frac{v_o}{i_o} = 6 \ \ ohm$$

Thevenin's Theorem

To get V_{Th}, we find v_{oc} in the circuit,

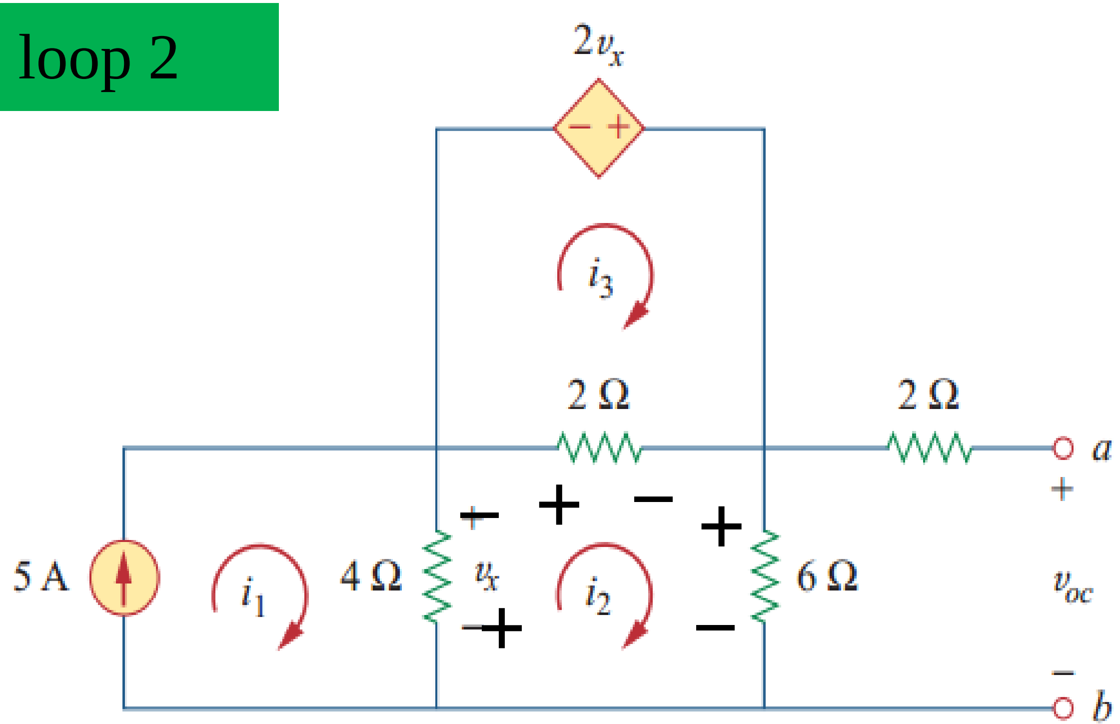
From loop 1, we can find

$$i_1 = 5\,A$$



Thevenin's Theorem

Applying mesh analysis to loop 2



$$4(i_2 - i_1) + 2(i_2 - i_3) + 6i_2 = 0$$

$$i_1 = 5A$$

$$12i_2 - 2i_3 = 20.....(i)$$

Thevenin's Theorem

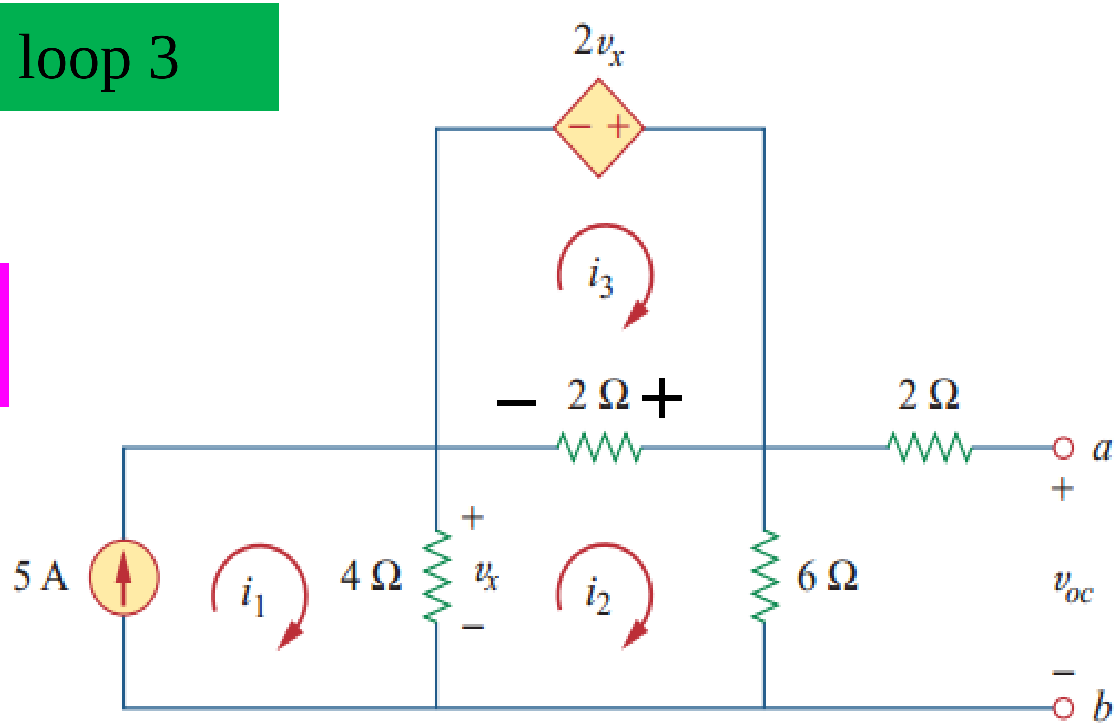
Applying mesh analysis to loop 3

$$-2v_x + 2(i_3 - i_2) = 0$$

But

$$v_x = 4(i_1 - i_2)$$

$$3i_2 + i_3 = 20....(ii)$$



Thevenin's Theorem

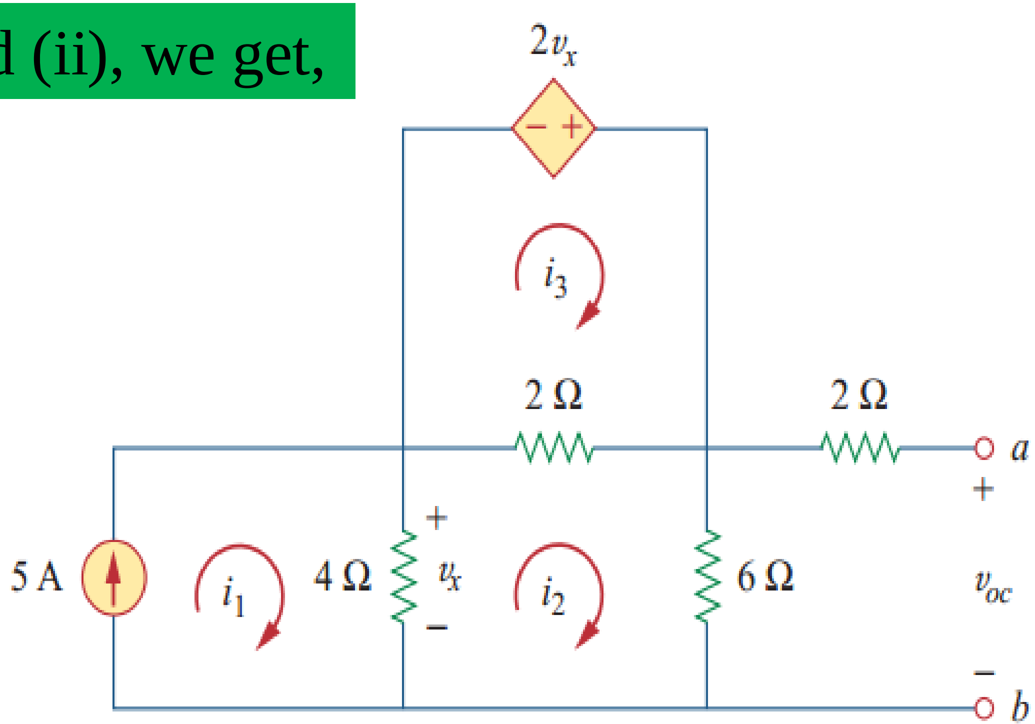
After solving equation (i), and (ii), we get,

$$i_2 = \frac{10}{3} A$$

Hence,

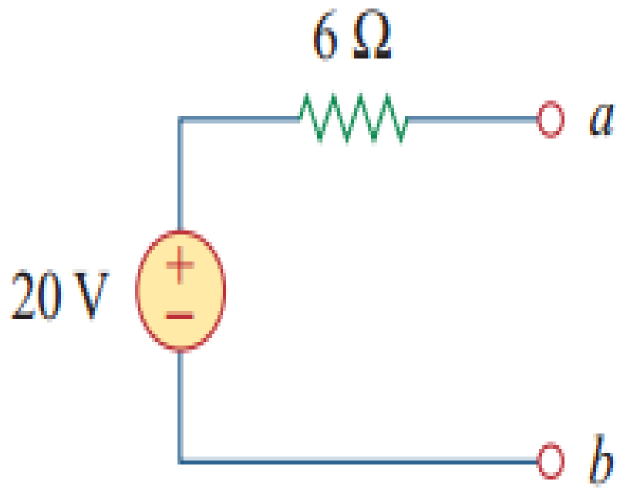
$$V_{Th} = 6i_2$$

$$V_{Th} = 6 * \frac{10}{3} = 20V$$



Thevenin's Theorem

The Thevenin equivalent circuit is



Thank You