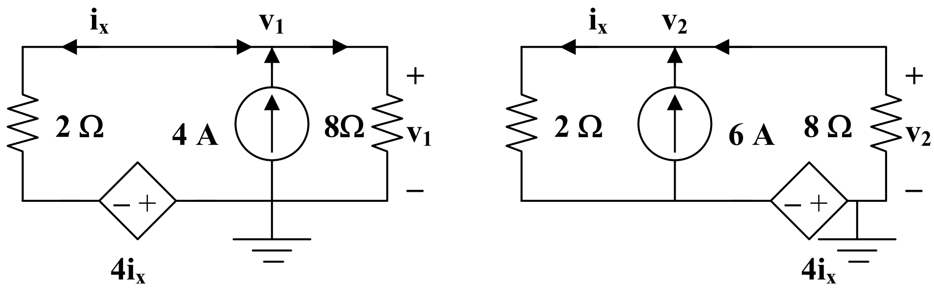
Boise State University
Electrical Engineering Department

EE 210: Circuits I

Solution 1

Let $v_x = v_1 + v_2$, where v_1 and v_2 are due to the 4-A and 6-A sources respectively.



(a) (b)

To find v_1, consider the circuit in Fig. (a).

$$v_1/8 - 4 + (v_1 - (-4i_x))/2 = 0 \text{ or } (0.125+0.5)v_1 = 4 - 2i_x \text{ or } v_1 = 6.4 - 3.2i_x$$

But, $i_x = (v_1 - (-4i_x))/2$ or $i_x = -0.5v_1$. Thus,

$$v_1 = 6.4 + 3.2(0.5v_1), \text{ which leads to } v_1 = -6.4/0.6 = -10.667$$

To find v_2, consider the circuit shown in Fig. (b).

$$v_2/8 - 6 + (v_2 - (-4i_x))/2 = 0 \text{ or } v_2 + 3.2i_x = 9.6$$

But $i_x = -0.5v_2$. Therefore,

$$v_2 + 3.2(-0.5v_2) = 9.6 \text{ which leads to } v_2 = -16$$

Hence, $v_x = -10.667 - 16 = \underline{\mathbf{-26.67V}}$.

Checking,

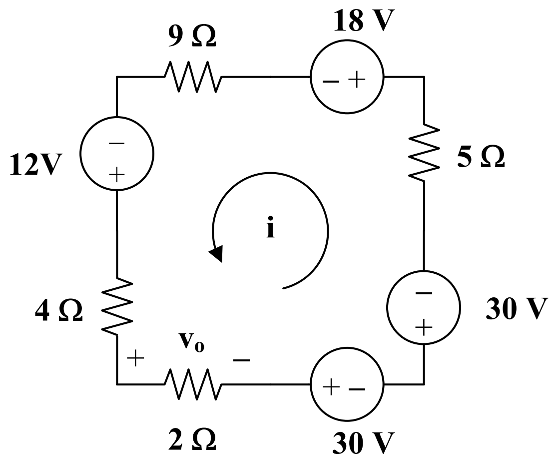
$$i_x = -0.5v_x = 13.333\text{A}$$

Now all we need to do now is sum the currents flowing out of the top node.

$$13.333 - 6 - 4 + (-26.67)/8 = 3.333 - 3.333 = 0$$

Solution 2

Transforming only the current source gives the circuit below.



Applying KVL to the loop gives,

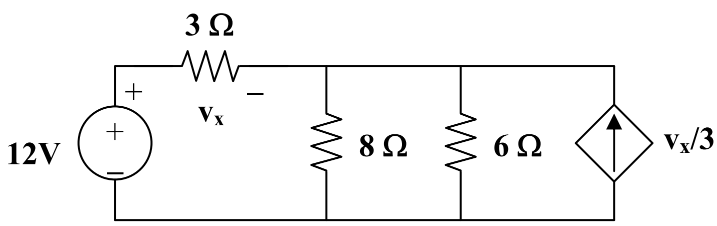
$$-(4 + 9 + 5 + 2)i + 12 - 18 - 30 - 30 = 0$$

$$20i = -66 \text{ which leads to } i = -3.3$$

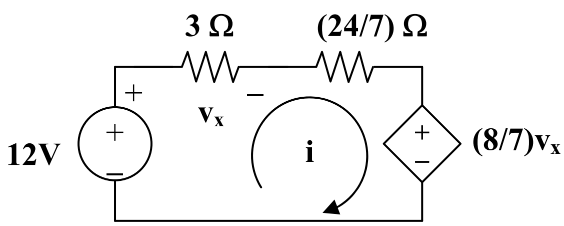
$v_o = 2i =$ **<u>–6.6 V</u>**

Solution 3

Transform the dependent source so that we have the circuit in
Fig. (a). 6||8 = (24/7) ohms. Transform the dependent source again to get the circuit in Fig. (b).



(a)



(b)

From Fig. (b),

$$v_x = 3i, \text{ or } i = v_x/3.$$

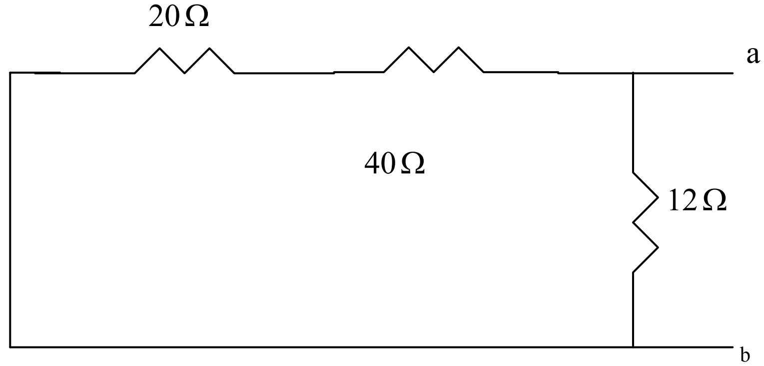
Applying KVL,

$$-12 + (3 + 24/7)i + (24/21)v_x = 0$$

$$12 = [(21 + 24)/7]v_x/3 + (8/7)v_x, \text{ leads to } v_x = 84/23 = \underline{\mathbf{3.652\ V}}$$

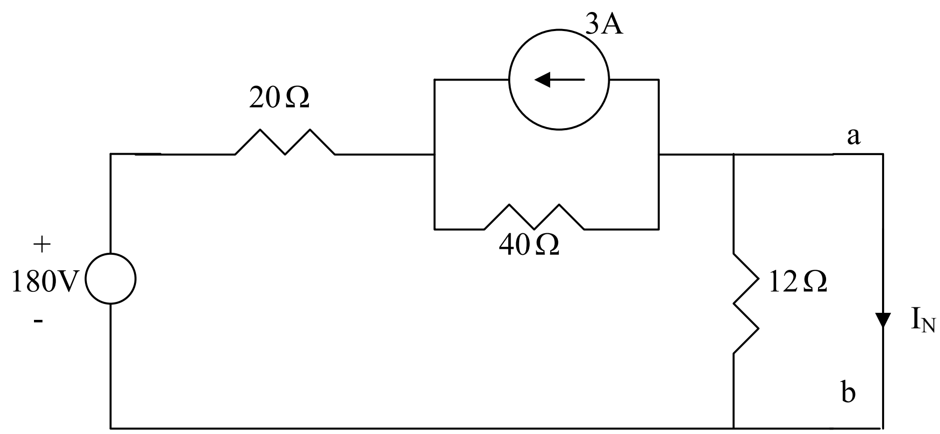
Solution 4

R_N is found from the circuit below.

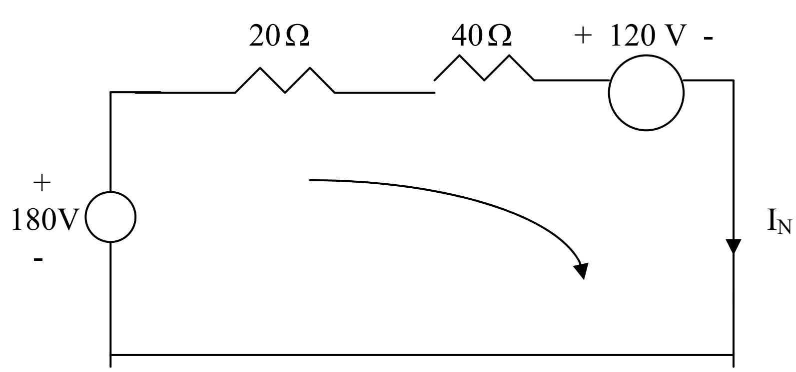


$R_N = 12//(20+40) = \underline{10\Omega}$

I_N is found from the circuit below.



Applying source transformation to the current source yields the circuit below.



Applying KVL to the loop yields

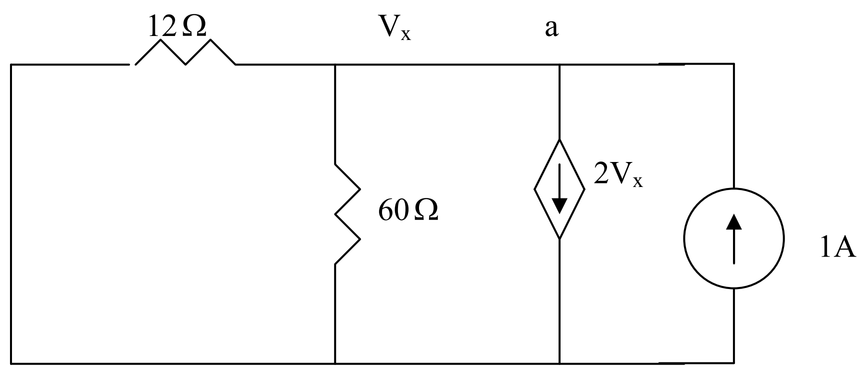
$-180+120+60I_N = 0 \quad \longrightarrow \quad I_N = 60/60 = \underline{\mathbf{1\ A}}$

Solution 5

Since $V_{Th} = V_{ab} = V_x$, we apply KCL at the node a and obtain

$$\frac{50 - V_{Th}}{12} = \frac{V_{Th}}{60} + 2V_{Th} \longrightarrow V_{Th} = 250/126 = 1.9841\text{ V}$$

To find R_{Th}, consider the circuit below.



At node a, KCL gives

$$1 = 2V_x + \frac{V_x}{60} + \frac{V_x}{12} \longrightarrow V_x = 60/126 = 0.4762$$

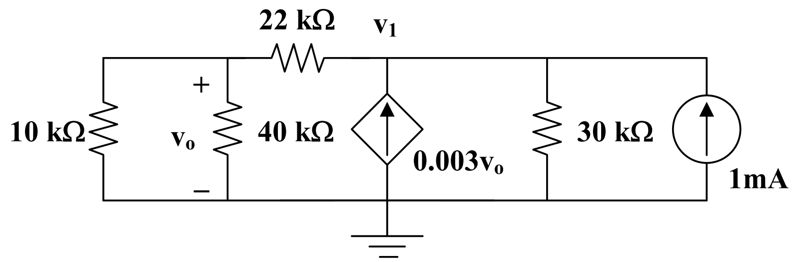
$$R_{Th} = \frac{V_x}{1} = 0.4762\Omega, \quad I_N = \frac{V_{Th}}{R_{Th}} = 1.9841/0.4762 = 4.167\text{A}$$

Thus,

V_{Th} = 1.9841 V, $R_{eq} = R_{Th} = R_N$ = 476.2 mΩ, I_N = 4.167 A

Solution 6

We need the Thevenin equivalent across the resistor R. To find R_{Th}, consider the circuit below.



Assume that all resistances are in k ohms urrents are in mA.

$$10||40 = 8, \text{ and } 8 + 22 = 30$$

$$1 + 3v_o = (v_1/30) + (v_1/30) = (v_1/15)$$

$$15 + 45v_o = v_1$$

But $v_o = (8/30)v_1$, hence,

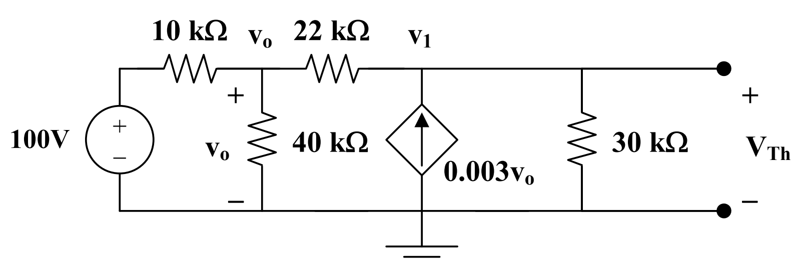
$$15 + 45x(8v_1/30) \; v_1, \text{ which leads to } v_1 = 1.3636$$

$$R_{Th} = v_1/1 = -1.3636 \text{ k ohms}$$

R_{Th} being negative indicates an active circuit and if you now make R equal to 1.3636 k ohms, then the active circuit will actually try to supply infinite power to the resistor. The correct answer is therefore:

$$p_R = \left(\frac{V_{Th}}{-1363.6+1363.6}\right)^2 1363.6 = \left(\frac{V_{Th}}{0}\right)^2 1363.6 = \underline{\infty}$$

It may still be instructive to find V_{Th}. Consider the circuit below.



$$(100 - v_o)/10 = (v_o/40) + (v_o - v_1)/22 \qquad (1)$$

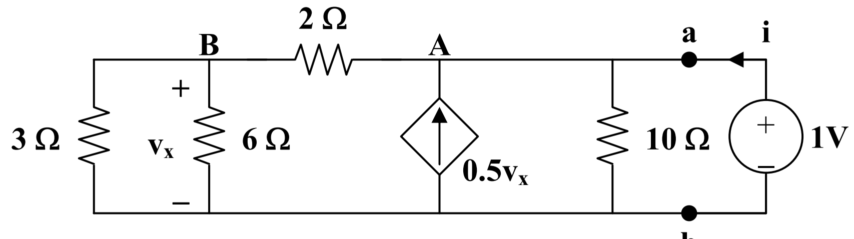
$$[(v_o - v_1)/22] + 3v_o = (v_1/30) \qquad (2)$$

Solving (1) and (2),

$$v_1 = V_{Th} = -243.6 \text{ volts}$$

Solution 7

To find R_{Th}, remove the 50V source and insert a 1-V source at a – b, as shown in Fig. (a).



(a)

We apply nodal analysis. At node A,

$$i + 0.5v_x = (1/10) + (1 - v_x)/2, \text{ or } i + v_x = 0.6 \qquad (1)$$

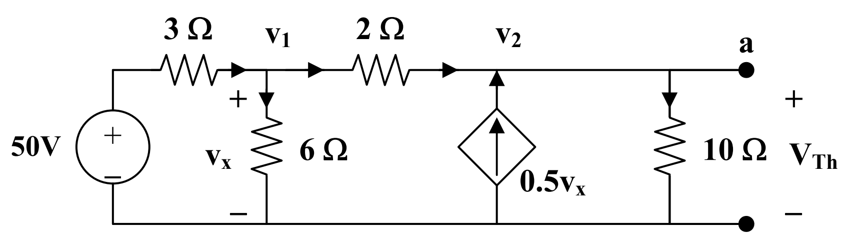
At node B,

$$(1 - v_o)/2 = (v_x/3) + (v_x/6), \text{ and } v_x = 0.5 \qquad (2)$$

From (1) and (2), $i = 0.1$ and

$$R_{Th} = 1/i = \underline{\textbf{10 ohms}}$$

To get V_{Th}, consider the circuit in Fig. (b).



(b)

At node 1, $(50 - v_1)/3 = (v_1/6) + (v_1 - v_2)/2, \text{ or } 100 = 6v_1 - 3v_2$ (3)

At node 2, $0.5v_x + (v_1 - v_2)/2 = v_2/10, \ v_x = v_1, \text{ and } v_1 = 0.6v_2$ (4)

From (3) and (4),

$$v_2 = V_{Th} = \underline{\textbf{166.67 V}}$$

$$I_N = V_{Th}/R_{Th} = \underline{\textbf{16.667 A}}$$

$$R_N = R_{Th} = \underline{\textbf{10 ohms}}$$