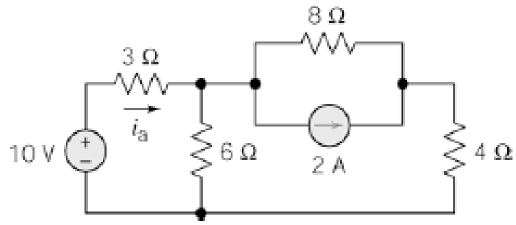
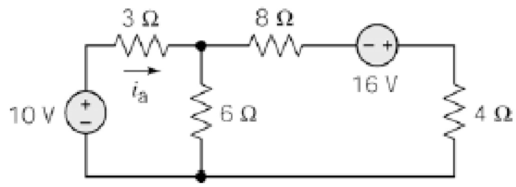
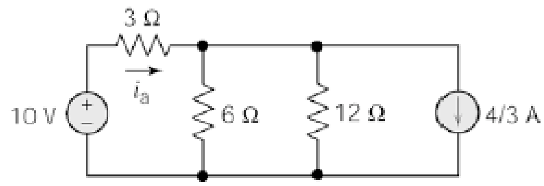
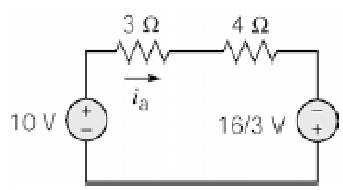
P5.3-2



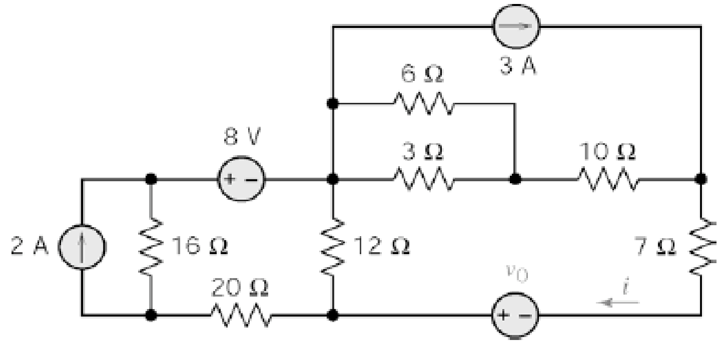




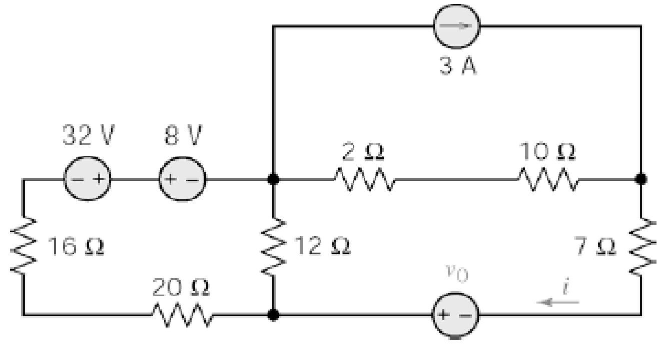


Finally, apply KVL: $-10+3\,i_a+4\,i_a-\dfrac{16}{3}=0 \quad \therefore \ \underline{i_a = 2.19 \text{ A}}$

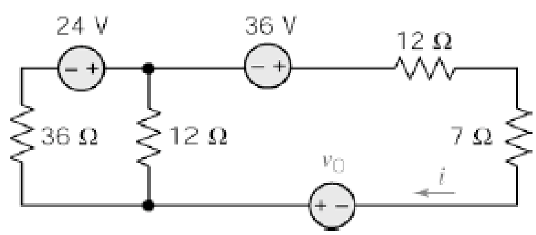
P5.3-3



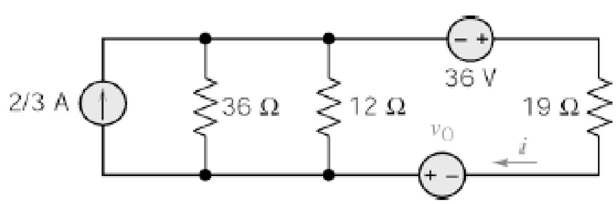
Source transformation at left; equivalent resistor for parallel 6 and 3 Ω resistors:



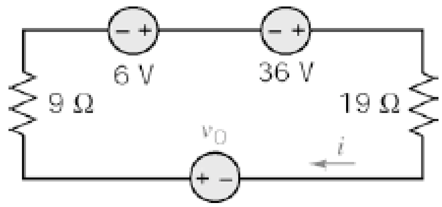
Equivalents for series resistors, series voltage source at left; series resistors, then source transformation at top:



Source transformation at left; series resistors at right:



Parallel resistors, then source transformation at left:

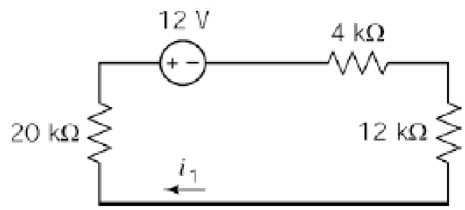


Finally, apply KVL to loop

$$-6 + i\,(9+19) - 36 - v_o = 0$$
$$i = 5/2 \;\Rightarrow v_o = -42 + 28\,(5/2) = 28 \text{ V}$$

P5.4-2

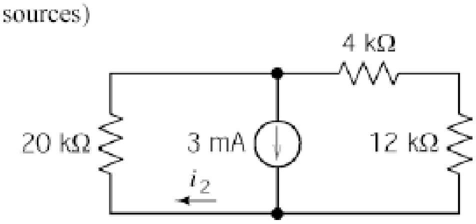
Consider 12 V source only (open both current sources)



KVL:

$$20\,i_1 + 12 + 4\,i_1 + 12\,i_1 = 0$$
$$\Rightarrow \underline{i_1 = -1/3 \text{ mA}}$$

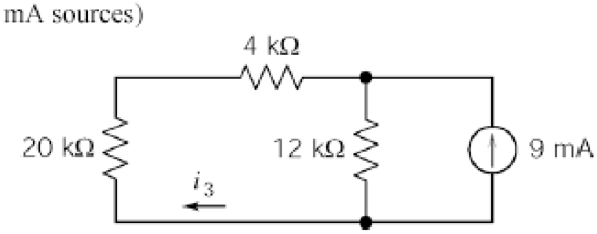
Consider 3 mA source only (short 12 V and open 9 mA sources)



Current Division:

$$i_2 = 3\left[\frac{16}{16+20}\right] = \underline{\frac{4}{3}} \text{ mA}$$

Consider 9 mA source only (short 12 V and open 3 mA sources)

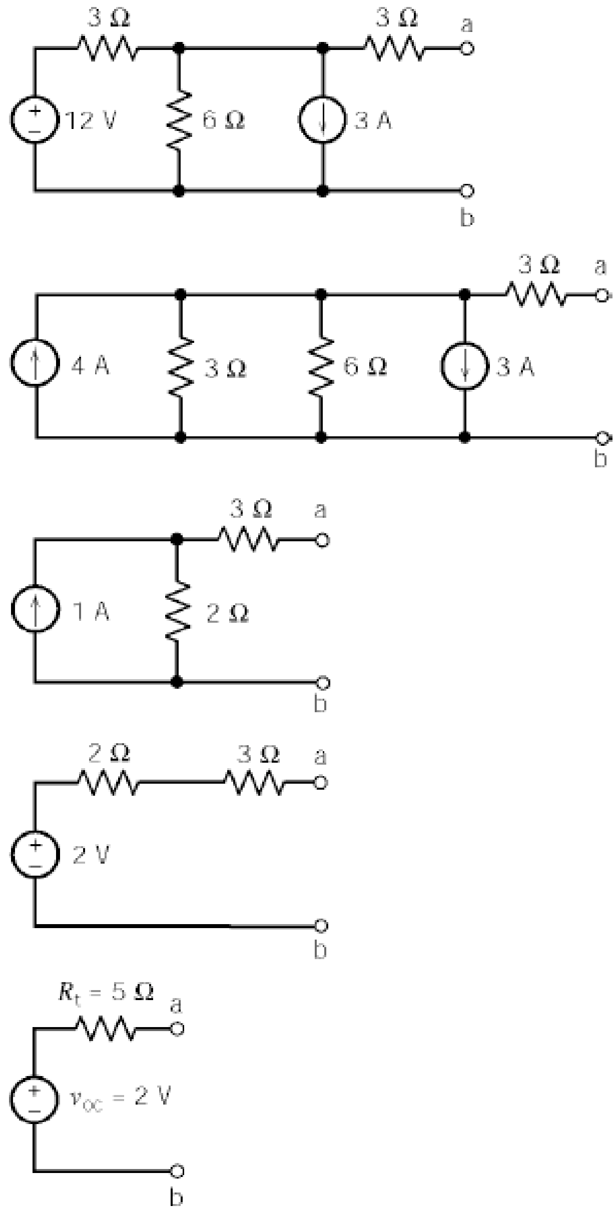


Current Division:

$$i_3 = -9\left[\frac{12}{24+12}\right] = \underline{-3 \text{ mA}}$$

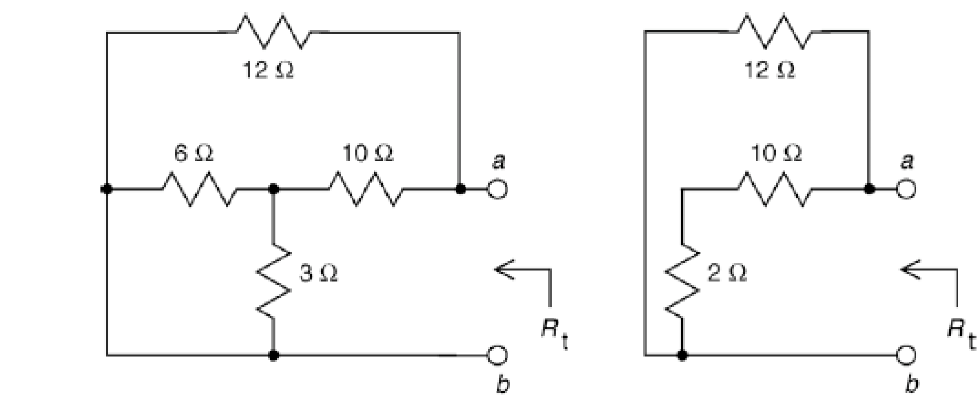
$$\underline{\therefore\; i = i_1 + i_2 + i_3 = -1/3 + 4/3 - 3 = -2 \text{ mA}}$$

P5.5-1


3 Ω
3 Ω
a
12 V
6 Ω
3 A
b
3 Ω
a
4 A
3 Ω
6 Ω
3 A
b
3 Ω
a
1 A
2 Ω
b
2 Ω
3 Ω
a
2 V
b
R_t = 5 Ω
a
v_{oc} = 2 V
b

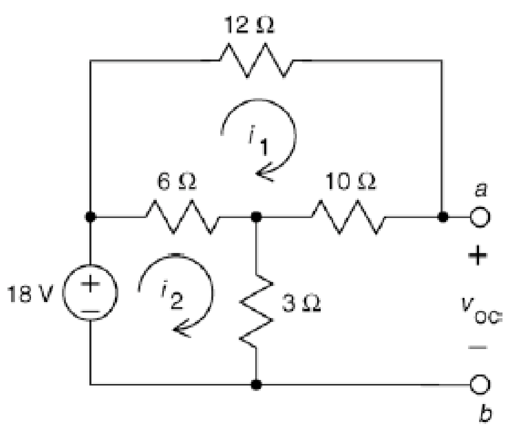
P5.5-4

Find R_t:



$$R_t = \frac{12(10+2)}{12+(10+2)} = 6\ \Omega$$

Write mesh equations to find v_{oc}:



Mesh equations:

$$12\, i_1 + 10\, i_1 - 6\left(i_2 - i_1\right) = 0$$

$$6\left(i_2 - i_1\right) + 3\, i_2 - 18 = 0$$

$$28\, i_1 = 6\, i_2$$

$$9\, i_2 - 6\, i_1 = 18$$

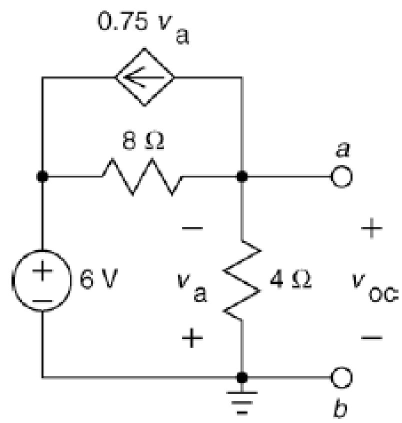
$$36\, i_1 = 18 \quad \Rightarrow \quad i_1 = \frac{1}{2}\ \text{A}$$

$$i_2 = \frac{14}{3}\left(\frac{1}{2}\right) = \frac{7}{3}\ \text{A}$$

Finally, $$v_{oc} = 3\, i_2 + 10\, i_1 = 3\left(\frac{7}{3}\right) + 10\left(\frac{1}{2}\right) = 12\ \text{V}$$

P5.5-5

Find v_{oc}:



Notice that v_{oc} is the node voltage at node a. Express the controlling voltage of the dependent source as a function of the node voltage:

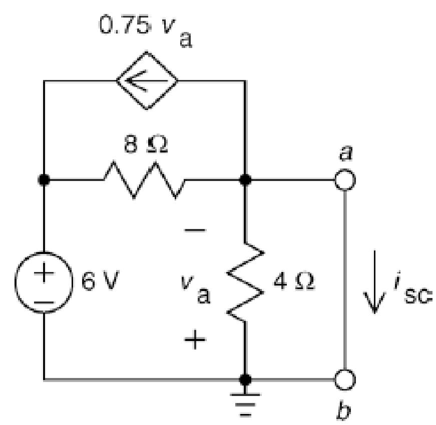
$$v_a = -v_{oc}$$

Apply KCL at node a:

$$-\left(\frac{6-v_{oc}}{8}\right)+\frac{v_{oc}}{4}+\left(-\frac{3}{4}v_{oc}\right)=0$$

$$-6+v_{oc}+2\,v_{oc}-6\,v_{oc}=0 \quad\Rightarrow\quad v_{oc}=-2\text{ V}$$

Find R_t:



We'll find i_{sc} and use it to calculate R_t. Notice that the short circuit forces

$$v_a = 0$$

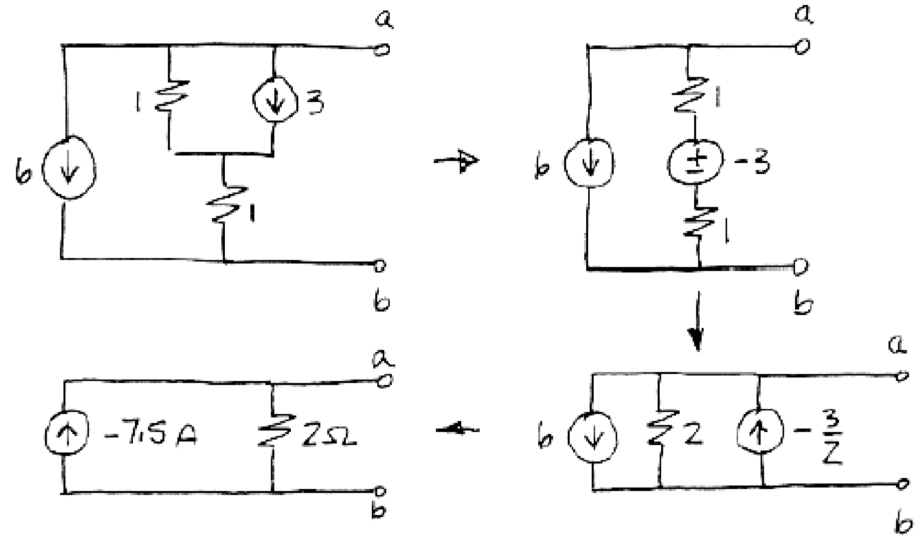
Apply KCL at node a:

$$-\left(\frac{6-0}{8}\right)+\frac{0}{4}+\left(-\frac{3}{4}0\right)+i_{sc}=0$$

$$i_{sc}=\frac{6}{8}=\frac{3}{4}\text{ A}$$

$$R_t=\frac{v_{oc}}{i_{sc}}=\frac{-2}{3/4}=-\frac{8}{3}\,\Omega$$

P5.6-2



P5.6-4

To determine the value of the short circuit current, i_{sc}, we connect a short circuit across the terminals of the circuit and then calculate the value of the current in that short circuit. Figure (a) shows the circuit from Figure 5.6-4*a* after adding the short circuit and labeling the short circuit current. Also, the meshes have been identified and labeled in anticipation of writing mesh equations. Let i_1 and i_2 denote the mesh currents in meshes 1 and 2, respectively.

In Figure (a), mesh current i_2 is equal to the current in the short circuit. Consequently, $i_2 = i_{sc}$. The controlling current of the CCVS is expressed in terms of the mesh currents as

$$i_a = i_1 - i_2 = i_1 - i_{sc}$$

Apply KVL to mesh 1 to get

$$3\,i_1 - 2\left(i_1 - i_2\right) + 6\left(i_1 - i_2\right) - 10 = 0 \quad \Rightarrow \quad 7\,i_1 - 4\,i_2 = 10 \qquad \textbf{(1)}$$

Apply KVL to mesh 2 to get

$$5\,i_2 - 6\left(i_1 - i_2\right) = 0 \quad \Rightarrow \quad -6\,i_1 + 11\,i_2 = 0 \quad \Rightarrow \quad i_1 = \frac{11}{6}\,i_2$$

Substituting into equation 1 gives

$$7\left(\frac{11}{6}\,i_2\right) - 4\,i_2 = 10 \quad \Rightarrow \quad i_2 = 1.13\text{ A} \quad \Rightarrow \quad i_{sc} = 1.13\text{ A}$$

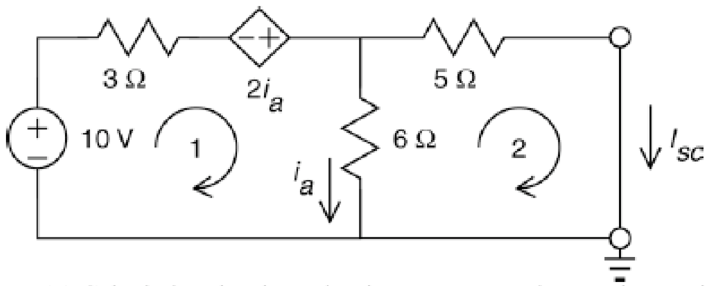


Figure (a) Calculating the short circuit current, i_{sc}, using mesh equations.

To determine the value of the Thevenin resistance, R_t, first replace the 10 V voltage source by a 0 V voltage source, i.e. a short circuit. Next, connect a current source across the terminals of the circuit and then label the voltage across that current source as shown in Figure (b). The Thevenin resistance will be calculated from the current and voltage of the current source as

$$R_t = \frac{v_T}{i_T}$$

In Figure (b), the meshes have been identified and labeled in anticipation of writing mesh equations. Let i_1 and i_2 denote the mesh currents in meshes 1 and 2, respectively.

In Figure (b), mesh current i_2 is equal to the negative of the current source current. Consequently, $i_2 = i_T$. The controlling current of the CCVS is expressed in terms of the mesh currents as

$$i_a = i_1 - i_2 = i_1 + i_T$$

Apply KVL to mesh 1 to get

$$3\,i_1 - 2\left(i_1 - i_2\right) + 6\left(i_1 - i_2\right) = 0 \quad \Rightarrow \quad 7\,i_1 - 4\,i_2 = 0 \quad \Rightarrow \quad i_1 = \frac{4}{7}\,i_2 \qquad \textbf{(2)}$$

Apply KVL to mesh 2 to get

$$5\,i_2 + v_T - 6\left(i_1 - i_2\right) = 0 \quad \Rightarrow \quad -6\,i_1 + 11\,i_2 = -v_T$$

Substituting for i_1 using equation 2 gives

$$-6\left(\frac{4}{7}\,i_2\right) + 11\,i_2 = -v_T \quad \Rightarrow \quad 7.57\,i_2 = -v_T$$

Finally,

$$R_t = \frac{v_T}{i_T} = \frac{-v_T}{-i_T} = \frac{-v_T}{i_2} = 7.57\ \Omega$$

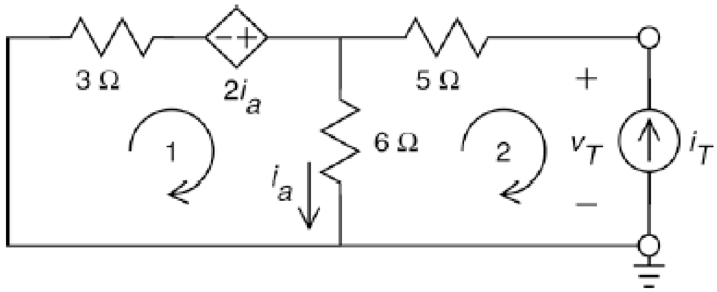


Figure (b) Calculating the Thevenin resistance, $R_t = \frac{v_T}{i_T}$, using mesh equations.

To determine the value of the open circuit voltage, v_{oc}, we connect an open circuit across the terminals of the circuit and then calculate the value of the voltage across that open circuit. Figure (c) shows the circuit from Figure 4.6-4*a* after adding the open circuit and labeling the open circuit voltage. Also, the meshes have been identified and labeled in anticipation of writing mesh equations. Let i_1 and i_2 denote the mesh currents in meshes 1 and 2, respectively.

In Figure (c), mesh current i_2 is equal to the current in the open circuit. Consequently, $i_2 = 0$ A. The controlling current of the CCVS is expressed in terms of the mesh currents as

$$i_a = i_1 - i_2 = i_1 - 0 = i_1$$

Apply KVL to mesh 1 to get

$$3\,i_1 - 2\left(i_1 - i_2\right) + 6\left(i_1 - i_2\right) - 10 = 0 \quad \Rightarrow \quad 3\,i_1 - 2\left(i_1 - 0\right) + 6\left(i_1 - 0\right) - 10 = 0$$

$$\Rightarrow \quad i_1 = \frac{10}{7} = 1.43 \text{ A}$$

Apply KVL to mesh 2 to get

$$5\,i_2 + v_{oc} - 6\left(i_1 - i_2\right) = 0 \quad \Rightarrow \quad v_{oc} = 6\left(i_1\right) = 6\left(1.43\right) = 8.58 \text{ V}$$

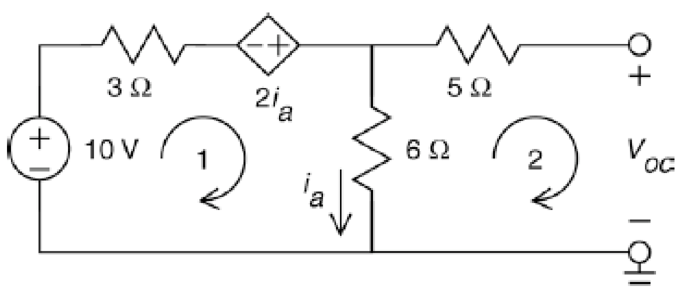
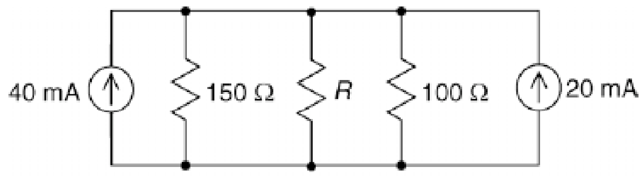


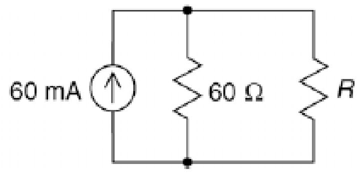
Figure (c) Calculating the open circuit voltage, v_{oc}, using mesh equations.

As a check, notice that $R_t\, i_{sc} = \left(7.57\right)\left(1.13\right) = 8.55 \approx v_{oc}$

P5.7-2

Reduce the circuit using source transformations:





Then (a) maximum power will be dissipated in resistor R when: $R = R_t = 60\ \Omega$ and (b) the value of that maximum power is

$$P_{max} = i_R^2(R) = (0.03)^2(60) = \underline{54\ \text{mW}}$$