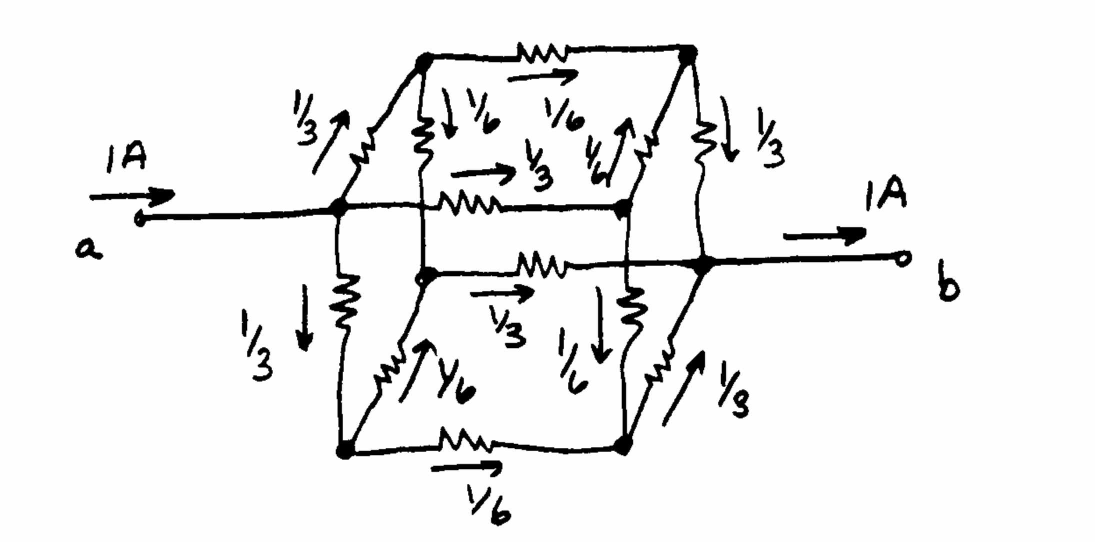
CHAPTER 2

P2.1* (a) $R_{eq} = 25\,\Omega$ (b) $R_{eq} = 25\,\Omega$

P2.12 By symmetry, we find the currents in the resistors as shown below:



Then, the voltage between terminals a and b is

$$v_{ab} = R_{eq} = 1/3 + 1/6 + 1/3 = 5/6$$

P2.24 In a similar fashion to the solution for Problem P2.6, we can write the following expression for the resistance seen by the 2-V source.

$$R_{eq} = 1 + \frac{1}{1/R_{eq} + 1/2}$$

The solutions to this equation are $R_{eq} = 2\ \Omega$ and $R_{eq} = -1\ \Omega$. However, we reason that the resistance must be positive and discard the negative root. Then, we have $i_1 = \frac{2\text{ V}}{R_{eq}} = 1\text{ A}$, $i_2 = i_1 \frac{R_{eq}}{2 + R_{eq}} = \frac{i_1}{2} = 0.5\text{ A}$, and $i_3 = \frac{i_1}{2} = 0.5\text{ A}$.

Similarly, $i_4 = \frac{i_3}{2} = \frac{i_1}{2^2} = 0.25\text{ A}$ and $i_{18} = \frac{i_1}{2^9} = 1.953\text{ mA}$.

P2.36* Combining R_2 and R_3, we have an equivalent resistance
$R_{eq} = \dfrac{1}{1/R_2 + 1/R_3} = 10\ \Omega$. Then using the voltage-division principle, we have
$v = \dfrac{R_{eq}}{R_1 + R_{eq}} \times v_s = \dfrac{10}{20+10} \times 10 = 3.333\text{ V}$.

P2.39* Writing a KVL equation, we have $v_1 - v_2 = 10$.

At the reference node, we write a KCL equation: $\dfrac{v_1}{5} + \dfrac{v_2}{10} = 1$.

Solving, we find $v_1 = 6.667$ and $v_2 = -3.333$.

Then, writing KCL at node 1, we have $i_s = \dfrac{v_2 - v_1}{5} - \dfrac{v_1}{5} = -3.333\ A$.

P2.51 First, we can write:

$$i_x = \frac{10i_x - v_2}{5}$$

Simplifying, we find $i_x = 0.2v_2$.

Then write KCL at nodes 1 and 2:

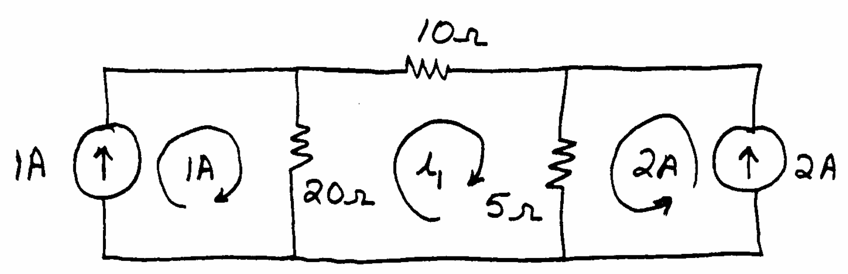
$$\frac{v_1 - 10i_x}{10} = -3 \qquad \frac{v_2}{20} - i_x = 1$$

Substituting for i_x and simplifying, we have

$$v_1 - 2v_2 = -30 \quad \text{and} \quad -.15v_2 = 1$$

which yield $v_1 = -43.333\text{ V}$ and $v_2 = -6.667\text{ V}$.

P2.61* Because of the current sources, two of the mesh currents are known.

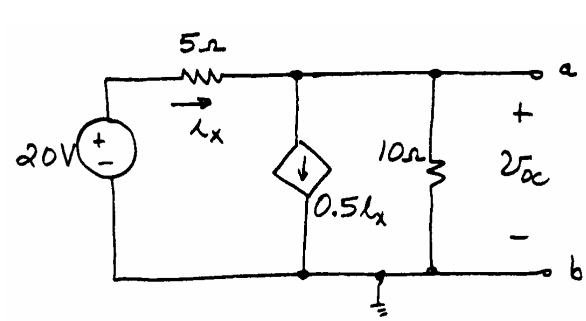


Writing a KVL equation around the middle loop we have

$$20(i_1 - 1) + 10i_1 + 5(i_1 + 2) = 0$$

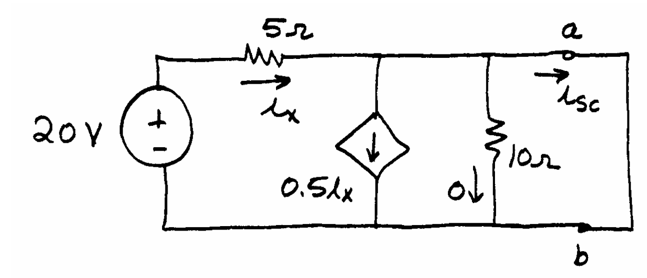
Solving, we find $i_1 = 0.2857$.

P2.72 Open-circuit conditions:



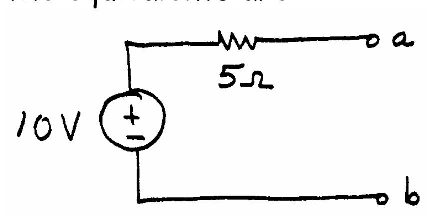
$$i_x = \frac{20 - v_{oc}}{5} \qquad \frac{v_{oc}}{10} - i_x + 0.5 i_x = 0 \qquad \text{Solving, we find } v_{oc} = 10\text{ V}.$$

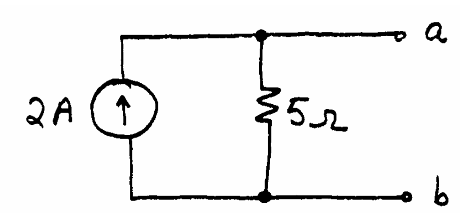
Short-circuit conditions:



$$i_x = 20/5 = 4\text{ A}$$
$$i_{sc} = i_x - 0.5 i_x = 2\text{ A}$$

Then we have $R_t = v_{oc}/i_{sc} = 5\,\Omega$. Thus the equivalents are:





P2.75* To maximize the power to R_L, we must maximize the voltage across it. Thus we need to have $R_t = 0$. The maximum power is

$$P_{\max} = \frac{20^2}{5} = 80\text{ W}$$

P2.85 (a) With only the 2-A source activated, we have

$$i_2 = 2 \text{ and } v_2 = 2(i_2)^3 = 16\text{ V}$$

(b) With only the 1-A source activated, we have

$$i_1 = 1\text{ A and } v_1 = 2(i_1)^3 = 2\text{ V}$$

(c) With both sources activated, we have

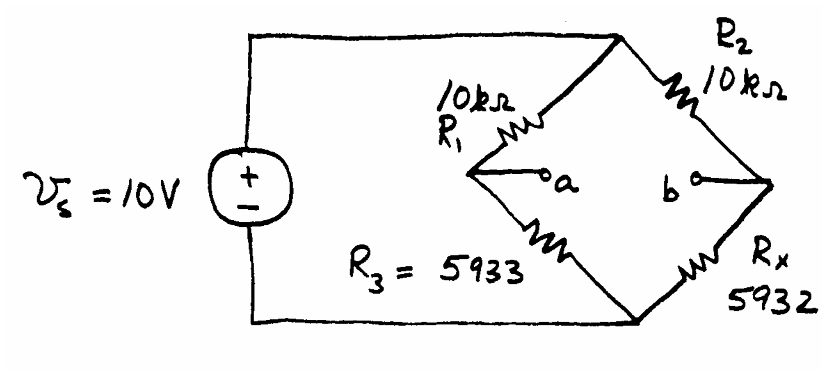
$$i = 3\text{ A and } v = 2(i)^3 = 54\text{ V}$$

Superposition does not apply because device A has a nonlinear relationship between v and i.

P2.87* (a) Rearranging Equation 2.80, we have

$$R_3 = \frac{R_1}{R_2} R_x = \frac{10k\Omega}{10k\Omega} \times 5932 = 5932\,\Omega$$

(b) The circuit is:



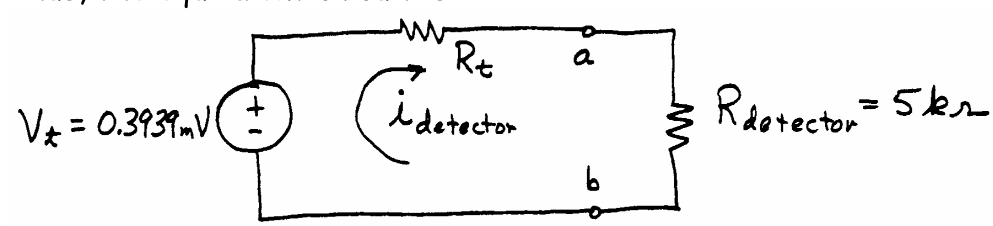
The Thevenin resistance is

$$R_t = \frac{1}{1/R_3 + 1/R_1} + \frac{1}{1/R_2 + 1/R_x} = 7447\ \Omega$$

The Thevenin voltage is

$$\begin{aligned} V_t &= V_s \frac{R_3}{R_1 + R_3} - V_s \frac{R_x}{R_x + R_2} \\ &= 0.3939\ \text{mV} \end{aligned}$$

Thus, the equivalent circuit is:



$$i_{\det ector} = \frac{V_t}{R_t + R_{\det ector}} = 31.65 \times 10^{-9}\ A$$

Thus the detector must be sensitive to very small currents if the bridge is to be accurately balanced.