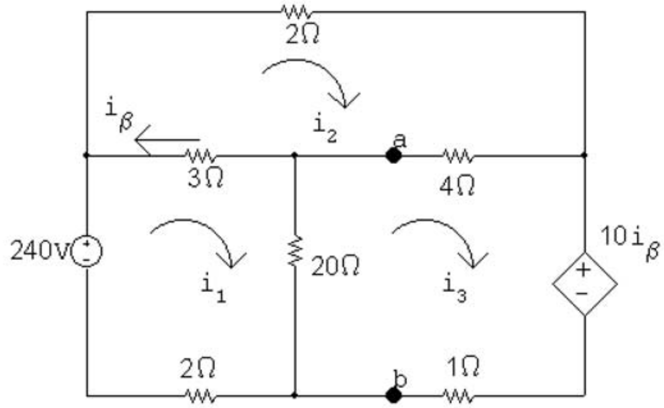
P 4.76 **[a]** Find the Thévenin equivalent with respect to the terminals of R_L.

Open circuit voltage:



The mesh current equations are:

$$-240 + 3(i_1 - i_2) + 20(i_1 - i_3) + 2i_1 = 0$$

$$2i_2 + 4(i_2 - i_3) + 3(i_2 - i_1) = 0$$

$$10i_\beta + 1i_3 + 20(i_3 - i_1) + 4(i_3 - i_2) = 0$$

The dependent source constraint equation is:

$i_\beta = i_2 - i_1$

Place these equations in standard form:

$$i_1(3 + 20 + 2) + i_2(-3) + i_3(-20) + i_\beta(0) = 240$$

$$i_1(-3) + i_2(2 + 4 + 3) + i_3(-4) + i_\beta(0) = 0$$

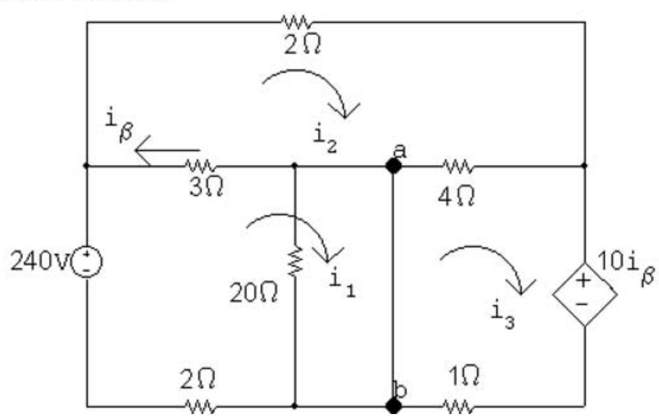
$$i_1(-20) + i_2(-4) + i_3(4 + 1 + 20) + i_\beta(10) = 0$$

$$i_1(1) + i_2(-1) + i_3(0) + i_\beta(1) = 0$$

Solving, $i_1 = 99.6$ A; $i_2 = 78$ A; $i_3 = 100.8$ A; $i_\beta = -21.6$ A

$V_{\mathrm{Th}} = 20(i_1 - i_3) = -24$ V

Short-circuit current:



The mesh current equations are:

$$-240 + 3(i_1 - i_2) + 2i_1 = 0$$

$$2i_2 + 4(i_2 - i_3) + 3(i_2 - i_1) = 0$$

$$10i_\beta + 1i_3 + 4(i_3 - i_2) = 0$$

The dependent source constraint equation is:

$i_\beta = i_2 - i_1$

Place these equations in standard form:

$$i_1(3+2) + i_2(-3) + i_3(0) + i_\beta(0) = 240$$

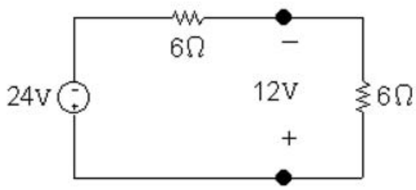
$$i_1(-3) + i_2(2+4+3) + i_3(-4) + i_\beta(0) = 0$$

$$i_1(0) + i_2(-4) + i_3(4+1) + i_\beta(10) = 0$$

$$i_1(1) + i_2(-1) + i_3(0) + i_\beta(1) = 0$$

Solving, $i_1 = 92$ A; $i_2 = 73.33$ A; $i_3 = 96$ A; $i_\beta = -18.67$ A

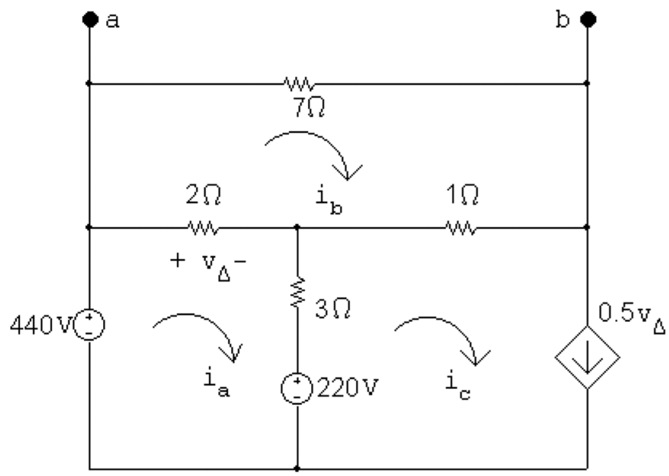
$i_{sc} = i_1 - i_3 = -4$ A; $R_{Th} = \dfrac{V_{Th}}{i_{sc}} = \dfrac{-24}{-4} = 6\,\Omega$



$R_L = R_{Th} = 6\,\Omega$

[b] $p_{max} = \dfrac{12^2}{6} = 24$ W

P 4.81 Find the Thévenin equivalent with respect to the terminals of R_o.
Open circuit voltage:



$$(440 - 220) = 5i_a - 2i_b - 3i_c$$

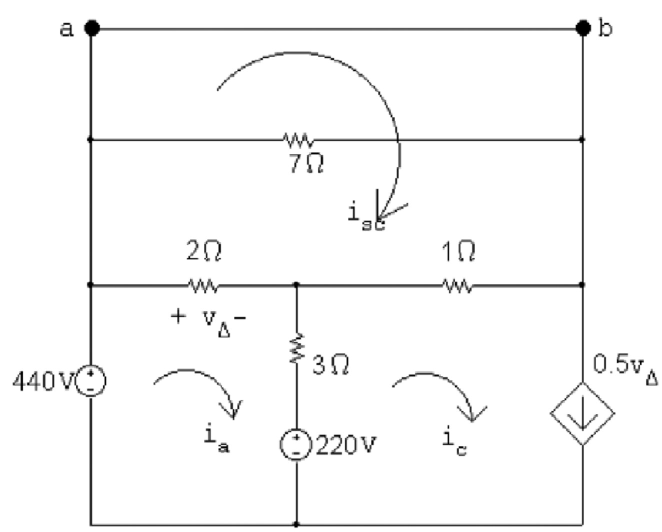
$$0 = -2i_a + 10i_b - i_c$$

$$i_c = 0.5v_\Delta; \qquad v_\Delta = 2(i_a - i_b); \qquad i_c = i_a - i_b$$

Solving, $i_a = 96.8$ A; $i_b = 26.4$ A; $i_c = 70.4$ A; $v_\Delta = 140.8$ V

$$\therefore \quad V_{Th} = 7i_b = 184.8 \text{ V}$$

Short circuit current:



$$440 - 220 = 5i_a - 2i_{sc} - 3i_c$$

$$0 = -2i_a + 3i_{sc} - 1i_c$$

$$i_c = 0.5v_\Delta; \qquad v_\Delta = 2(i_a - i_{sc}) \quad \therefore \quad i_c = i_a - i_{sc}$$

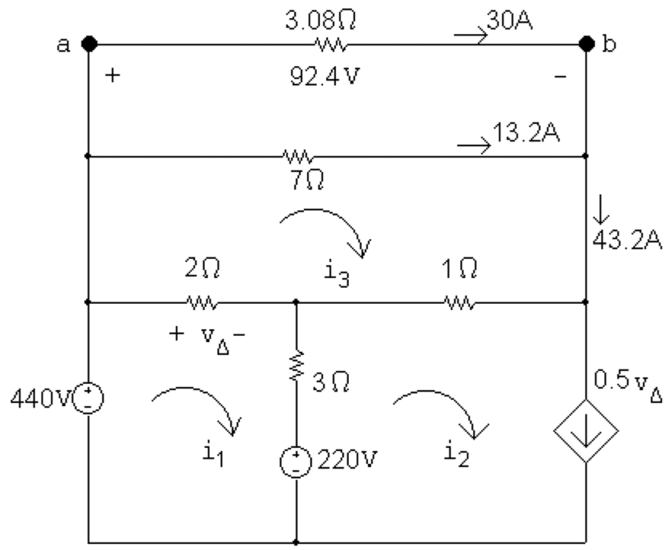
Solving, $i_{\rm sc} = 60$ A; $i_{\rm a} = 80$ A; $i_{\rm c} = 20$ A; $v_\Delta = 40$ V

$$R_{\rm Th} = V_{\rm Th}/i_{\rm sc} = 184.8/60 = 3.08\,\Omega$$

$$R_o = 3.08\,\Omega$$

$$p_{R_o} = \frac{(92.4)^2}{3.08} = 2772 \text{ W}$$

With R_o equal to $3.08\,\Omega$ the circuit becomes



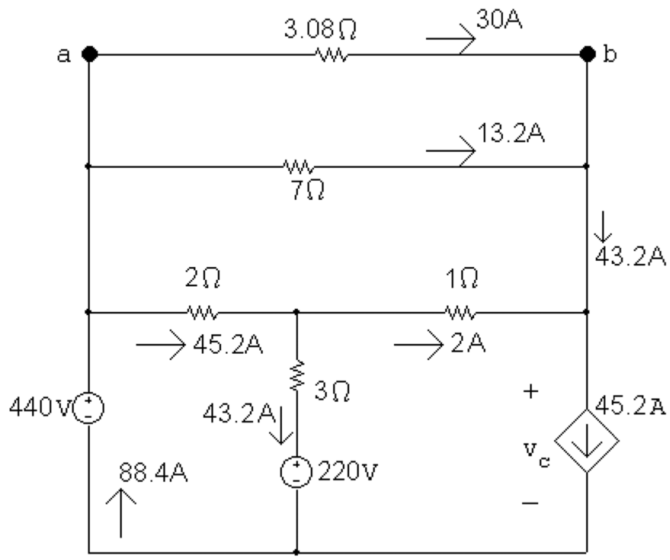
$$220 = 5i_1 - 3(0.5)(2)(i_1 - i_3) - 2i_3 = 2i_1 + i_3$$

$$\therefore \quad 2i_1 = 220 - i_3 = 220 - 43.2 = 176.8 \quad \therefore \quad i_1 = 88.4 \text{ A}$$

$$v_\Delta = 2(i_1 - i_3) = 90.4 \text{ V}$$

$$i_2 = 0.5v_\Delta = 45.2 \text{ A}$$

Thus we have



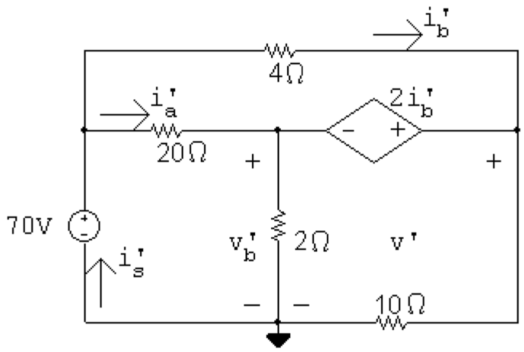
$v_c = 220 + 3(43.2) - 2 = 347.6$ V

Therefore, the only source developing power is the 440 V source.

$p_{440\text{V}} = -(440)(88.4) = -38{,}896$ W   Power delivered is 38,896 W

$$\%\text{ delivered } = \frac{2772}{38{,}896}(100) = 7.13\%$$

P 4.88 70-V source acting alone:



$$v' = 70 - 4i_b'$$

$$i_s' = \frac{v_b'}{2} + \frac{v'}{10} = i_a' + i_b'$$

$$70 = 20i_a' + v_b'$$

$$i_a' = \frac{70 - v_b'}{20}$$

$$\therefore \qquad i_b' = \frac{v_b'}{2} + \frac{v'}{10} - \frac{70 - v_b'}{20} = \frac{11}{20}v_b' + \frac{v'}{10} - 3.5$$

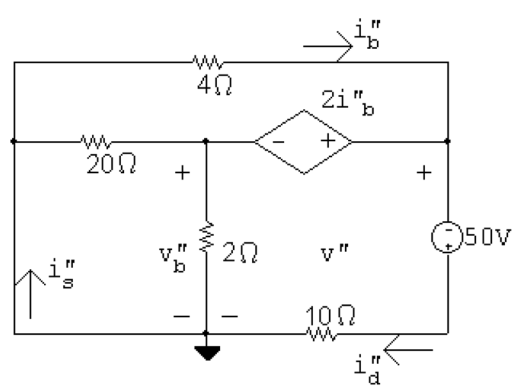
$$v' = v_b' + 2i_b'$$

$$\therefore \quad v_b' = v' - 2i_b'$$

$$\therefore \quad i_b' = \frac{11}{20}(v' - 2i_b') + \frac{v'}{10} - 3.5 \qquad \text{or} \qquad i_b' = \frac{13}{42}v' - \frac{70}{42}$$

$$\therefore \quad v' = 70 - 4\left(\frac{13}{42}v' - \frac{70}{42}\right) \qquad \text{or} \qquad v' = \frac{3220}{94} = \frac{1610}{47}\ \text{V}$$

50-V source acting alone:



$$v'' = -4i_b''$$

$$v'' = v_b'' + 2i_b''$$

$$v'' = -50 + 10i_d''$$

$$\therefore \quad i_d'' = \frac{v'' + 50}{10}$$

$$i_s'' = \frac{v_b''}{2} + \frac{v'' + 50}{10}$$

$$i_b'' = \frac{v_b''}{20} + i_s'' = \frac{v_b''}{20} + \frac{v_b''}{2} + \frac{v'' + 50}{10} = \frac{11}{20}v_b'' + \frac{v'' + 50}{10}$$

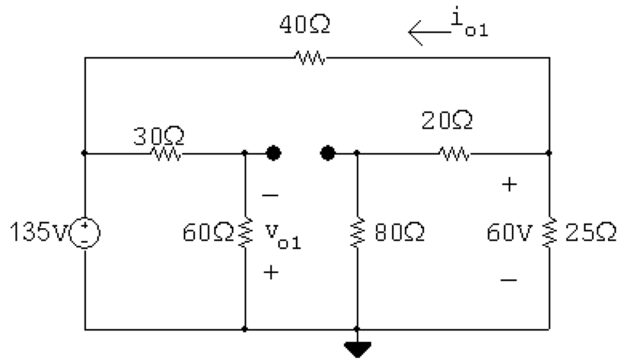
$$v_b'' = v'' - 2i_b''$$

$$\therefore \quad i_b'' = \frac{11}{20}(v'' - 2i_b'') + \frac{v'' + 50}{10} \qquad \text{or} \qquad i_b'' = \frac{13}{42}v'' + \frac{100}{42}$$

Thus, $\quad v'' = -4\left(\frac{13}{42}v'' + \frac{100}{42}\right) \qquad \text{or} \qquad v'' = -\frac{200}{47}\text{ V}$

Hence, $\quad v = v' + v'' = \frac{1610}{47} - \frac{200}{47} = \frac{1410}{47} = 30\text{ V}$

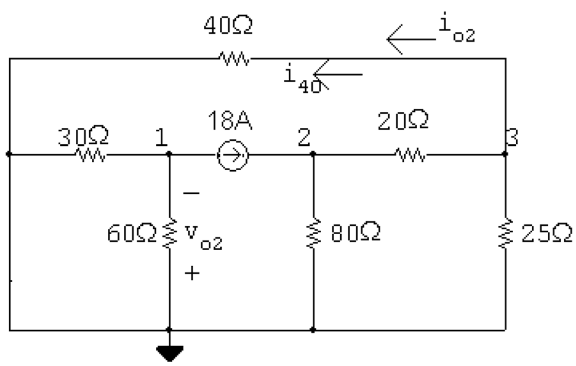
P 4.91 Voltage source acting alone:



$$i_{o1} = \frac{-135}{40 + 100\|25} = -2.25 \text{ A}$$

$$v_{o1} = \frac{60}{90}(-135) = -90 \text{ V}$$

Current source acting alone:



$$\frac{v_1}{30} + \frac{v_1}{60} + 18 = 0 \quad \therefore \quad v_1 = -360 \text{ V}; \quad v_{o2} = 360 \text{ V}$$

$$-18 + \frac{v_2}{80} + \frac{v_2 - v_3}{20} = 0$$

$$\frac{v_3 - v_2}{20} + \frac{v_3}{25} + \frac{v_3}{40} = 0$$

$$\therefore \quad v_2 = 441.6 \text{ V}; \quad v_3 = 192 \text{ V}; \quad i_{o2} = 192/40 = 4.8 \text{ A}$$

$$\therefore \; v_o = v_{o1} + v_{o2} = -90 + 360 = 270 \text{ V}$$

$$i_o = i_{o1} + i_{o2} = -2.25 + 4.8 = 2.55 \text{ A}$$