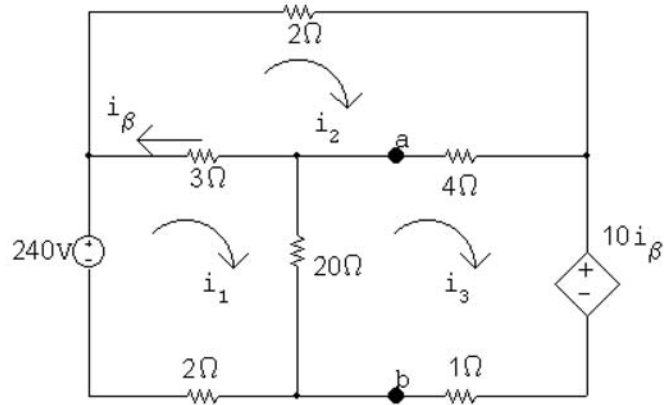


P 4.76 [a] Find the Thévenin equivalent with respect to the terminals of  $R_L$ .

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:

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

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

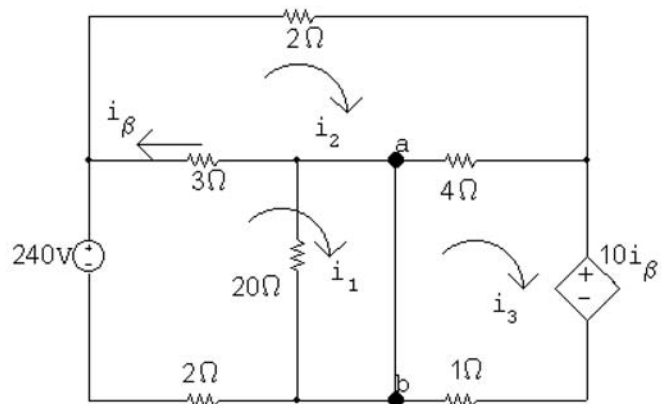
$$i_1(-20) + i_2(-4) + i_3(4 + 1 + 20) + i_\beta(10) = 0$$

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

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

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

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:

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

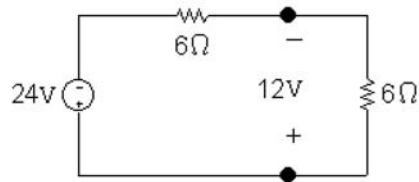
$$i_1(-3) + i_2(2 + 4 + 3) + i_3(-4) + i_\beta(0) = 0$$

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

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

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

$$i_{sc} = i_1 - i_3 = -4 \text{ A}; \quad R_{Th} = \frac{V_{Th}}{i_{sc}} = \frac{-24}{-4} = 6 \Omega$$

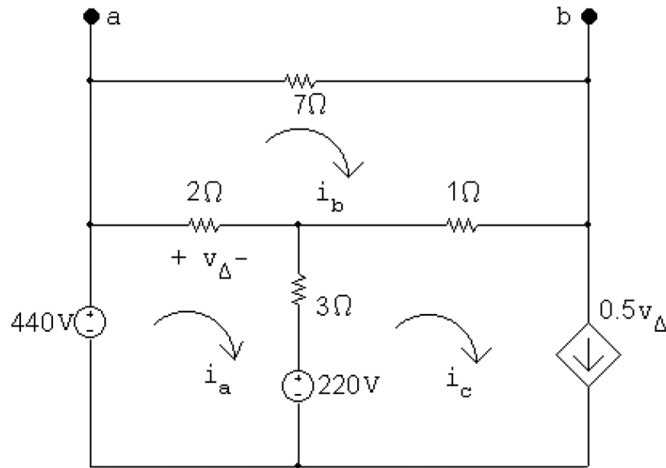


$$R_L = R_{Th} = 6 \Omega$$

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

P 4.81 Find the Thévenin equivalent with respect to the terminals of  $R_o$ .

Open circuit voltage:



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

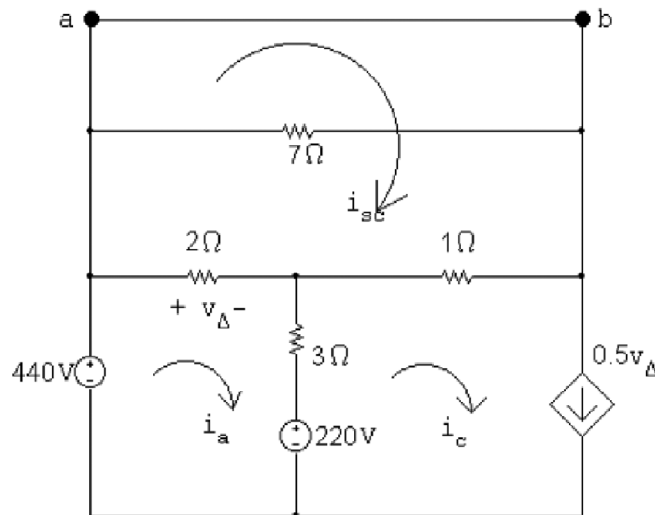
$$0 = -2i_a + 10i_b - i_c$$

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

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

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

Short circuit current:



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

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

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

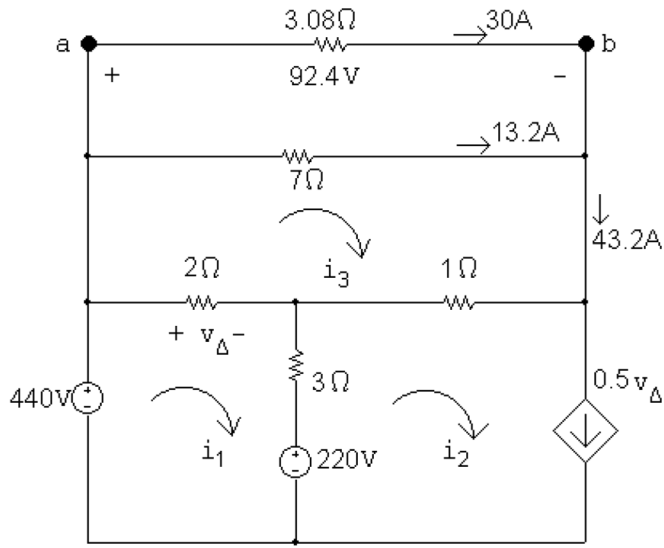
Solving,  $i_{sc} = 60 \text{ A}$ ;  $i_a = 80 \text{ A}$ ;  $i_c = 20 \text{ A}$ ;  $v_{\Delta} = 40 \text{ V}$

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

$$R_o = 3.08 \Omega$$

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

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



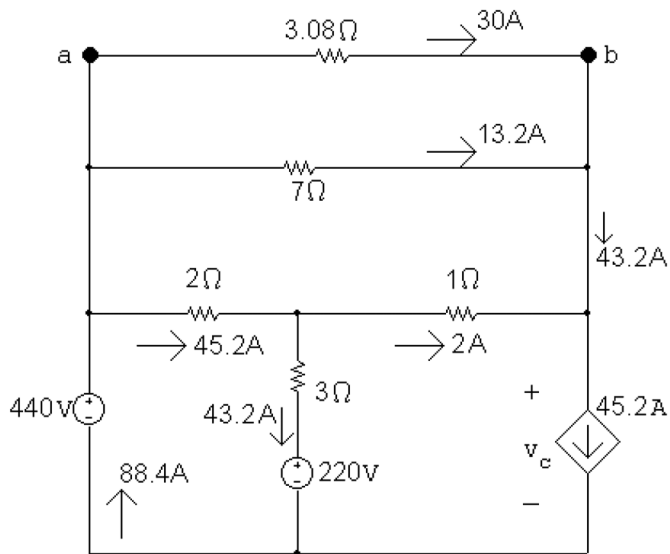
$$220 = 5i_1 - 3(0.5)(2)(i_1 - i_3) - 2i_3 = 2i_1 + i_3$$

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

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

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

Thus we have



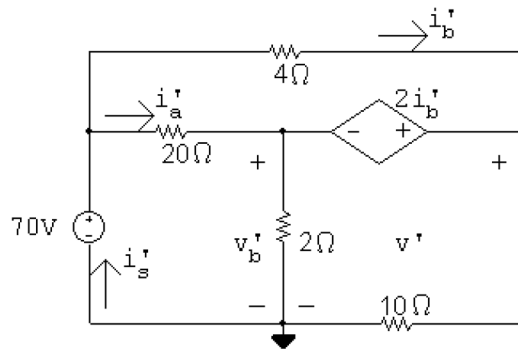
$$v_c = 220 + 3(43.2) - 2 = 347.6 \text{ V}$$

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

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

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

P 4.88 70-V source acting alone:



$$v' = 70 - 4i'_b$$

$$i'_s = \frac{v'_b}{2} + \frac{v'}{10} = i'_a + i'_b$$

$$70 = 20i'_a + v'_b$$

$$i'_a = \frac{70 - v'_b}{20}$$

$$\therefore i'_b = \frac{v'_b}{2} + \frac{v'}{10} - \frac{70 - v'_b}{20} = \frac{11}{20}v'_b + \frac{v'}{10} - 3.5$$

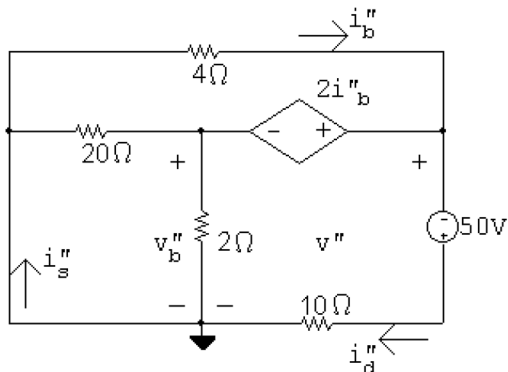
$$v' = v'_b + 2i'_b$$

$$\therefore v'_b = v' - 2i'_b$$

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

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

50-V source acting alone:



$$v'' = -4i''_b$$

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

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

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

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

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

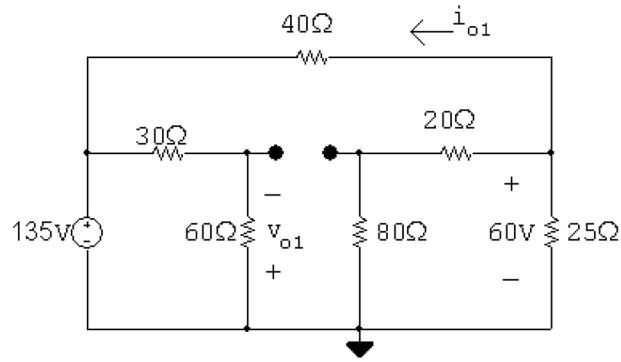
$$v_b'' = v'' - 2i_b''$$

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

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

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

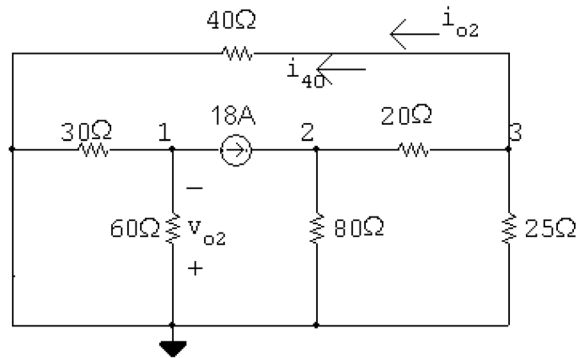
P 4.91 Voltage source acting alone:



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

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

Current source acting alone:



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

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

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

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

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

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