Outline Solutions

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Chapter # 1

P 1.15) a) Power (Car A) $= IV = 30(12)$
$= 360$ watt

then Car A absorbing Power

$\therefore$ Car A has the dead battery.

b) $w(t) = \int_0^t p\,dx$;   1 min = 60 s

$$w(60) = \int_0^{60} 360\,dx = 360(60-0)$$
$$= 21600$$
$$= 21.6 \text{ KJ}.$$

P 1.29) $P_a = -i_a V_a = -(-4)(40) = 160$ mW
(absorbing)

$P_b = i_b V_b = (-4)(-24) = 96$ mW (absorbing)

$P_c = -i_c V_c = -(4)(-16) = 64$ mW (absorbing)

$P_d = -i_d V_d = -(-1.5)(-80) = -120$ mW (delivering)

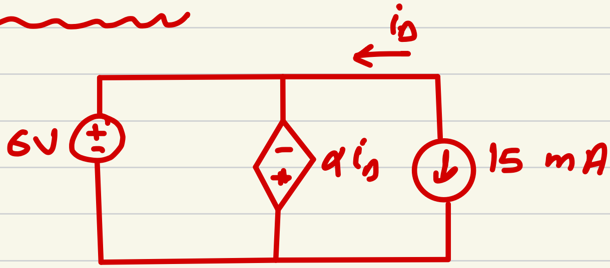
$P_e = i_e V_e = (2.5)(40) = 100$ mW (absorbing)

$P_f = i_f V_f = (-2.5)(120) = -300$ mW (delivering)

So, power developed $= -300 + -120 = -420$ mW.

Chapter #2

P 2.7)



a) to be a valid connection, then

1- $i_\Delta = -15\,mA$

2- $\alpha i_\Delta = -6$ Volt $\rightarrow (-15 \times 10^{-3})\alpha = -6$

$\therefore \alpha = 400\ V/A$

b) $V_{15mA} = 6$ Volt

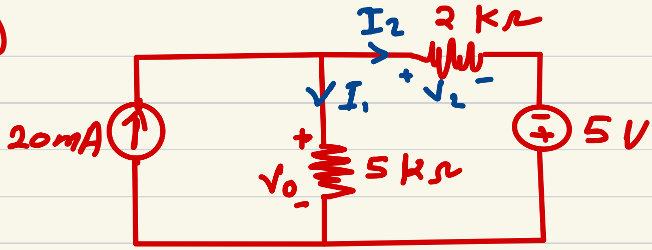
$P_{15\,mA} = (15)(6) = 90\ mW$.

c) Power of current source is positive, so absorbing power.

P 2.8) a) Yes, each of the voltage source can carry the current required in the interconnection and each of the current sources can carry the voltage drop required by the interconnection.

b) until now, NO because we can't determine the voltage drop on the current sources.

P 2.17)



a)

KCL : $I_1 + I_2 = 20\,mA$ —— ①

KVL : $-V_0 + V_2 - 5 = 0$

$-5I_1 + 2I_2 = 5$ —— ②

multiply ① by -2 :

$$
\begin{array}{r}
-2I_1 - 2I_2 = -40 \quad \text{—— ①} \\
+\ \ -5I_1 + 2I_2 = 5 \quad \text{—— ②} \\
\hline
-7I_1 = -35 \Rightarrow I_1 = 5\,mA
\end{array}
$$

$\therefore V_0 = I_1(5) = (5)(5) = 25$ volt.

b) $P_{20mA} = -0.02(25) = -0.5\ w.$

$P_{5k\Omega} = I_1(V_0) = (0.005)(25) = 0.125$

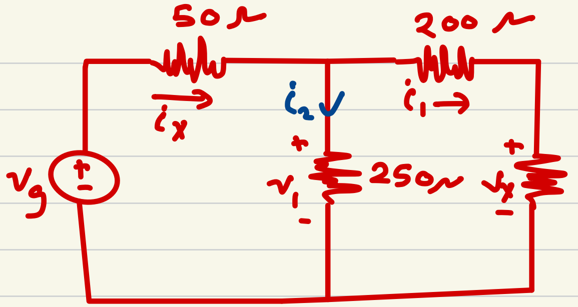
$P_{2k\Omega} = I_2^2 R = (0.015)^2(2000) = 0.45\ w.$

$P_{5V} = -I_2 V = -(0.015)(5) = -0.075$

$\Sigma P = -0.5 + 0.125 + 0.45 - 0.075$

$= 0$ (Balanced)

P 2.20)



$i_x = 50\,mA$
$v_x = 3.5\,V$

a). $v_x = i_1 R = 3.5$
$175\, i_1 = 3.5 \longrightarrow i_1 = 20\,mA.$

b) $i_2 = 30\,mA \quad (i_x - i_1)$

$v_1 = i_2 (250) = (0.03)(250) = 7.5$ Volt.

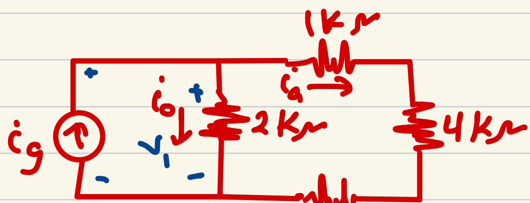
c) $v_g = i_x (50) + v_1$

$= (0.05)(50) + 7.5 = 10$ Volt.

d) $P_{v_g} = -(i_x)(V_g) = -(0.05)(10)$

$= -0.5$ Watt.

P 2.21)



$i_a = 2\,mA$

$v_1 = i_o (2) = 16\,V$

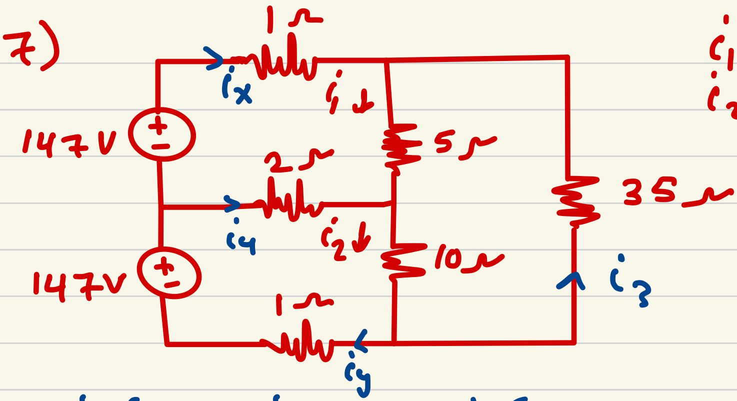
a) KVL: $2(1+4+3) - 2 i_o = 0$
$2 i_o = 16 \longrightarrow i_o = 8\,mA$

b) $i_g = i_o + i_a = 10\,mA$

c) $P_{i_g} = -i_g v_1 = -10(16) = -160\,mW$

P 2.27)

$i_1 = 21\,A$
$i_2 = 14\,A$



$$KVL: \quad i_1(5) + i_2(10) + i_3(35) = 0$$

$$-35\, i_3 = 105 + 140 \longrightarrow i_3 = -7\,A$$

$$i_x + i_3 = i_1 \longrightarrow i_x = 28\,A$$

$$P_{147\,(top)} = -(i_x)(147) = -28(147) = -4116\,W$$

$$i_y = i_2 - i_3 = 14 - -7 = 21\,A$$

$$P_{147\,(bottom)} = -(i_y)(147) = -(21)(147) = -3087\,W$$

$$P_{Res.} = i_3^2(35) + i_1^2(5) + i_2^2(10) + i_y^2(1) + i_x^2(1) + i_4^2(2)$$

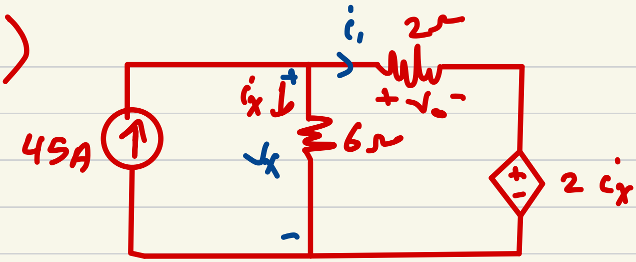
$$= (7)^2(35) + (21)^2(5) + (14)^2(10) + (21)^2 + (28)^2 + 7^2(2)$$

$$P_{abs.} = 7203\,W$$

$$P_{del.} = -4116 + -3087 = -7203\,W$$

So, $P_{absorbing} = P_{delivering}$

P 2.32)



a)

$$i_x + i_1 = 45 \rightarrow i_x = 45 - i_1$$

$$2i_1 + 2i_x - 6i_x = 0$$

$$2i_1 - 4i_x = 0$$

$$2i_1 - 4(45 - i_1) = 0$$

$$2i_1 - 180 + 4i_1 = 0 \rightarrow 6i_1 = 180 \rightarrow i_1 = 30A$$

then, $v_o = i_1(2) = 60$ Volt.

b)

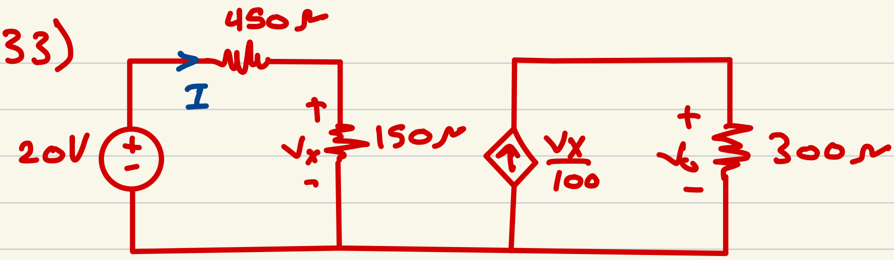
$$i_x = 15A$$
$$v_x = 15(6) = 90 \text{ Volt.}$$

$$P_{45A} = -(45)(90) = -4050W \text{(supplied)}$$

$$P_{2i_x} = i_1(2i_x) = 30(30) = 900W \text{(absorbed)}$$

then, the total Power supplied is 4050 watt.

P 2.33)



a)

KVL : $-20 + 450I + 150I = 0$

$600I = 20 \longrightarrow I = 33.33\,mA$

$v_x = I(150) = 5V$

$v_o = \left(\frac{v_x}{100}\right)(300) = 15\ V$

b) $P_{20V} = -(0.033)20 = -0.667\,W$ (delivering)

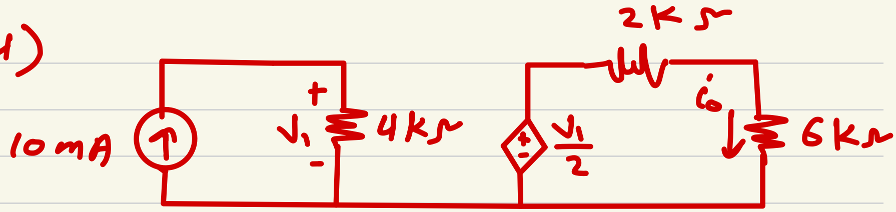
$P_{\frac{v_x}{100}} = -\left(\frac{v_x}{100}\right)v_o = -\frac{5}{100}(15) = -0.75\,w$ (del.)

So, $P_{absorbed} = P_{450} + P_{150} + P_{300}$

$= (0.033)^2(450) + (0.033)^2(150) + \frac{(15)^2}{300}$

$= 1.4$ Watt.

P 2.34)



a) $v_1 = (10\,mA)(4\,k\Omega) = 40$ Volt.

KVL: $-\frac{v_1}{2} + (2+6)\,i_o = 0$

$8\,i_o = 20 \rightarrow i_o = 2.5\,mA$

b) Show that $\sum P = 0$

$$\sum P = P_{10mA} + P_{4k\Omega} + P_{\frac{v_1}{2}} + P_{2k\Omega} + P_{6k\Omega}$$

$$= -(0.01)(40) + (0.01)(40) - 0.0025(20) + (0.0025)^2(8000)$$

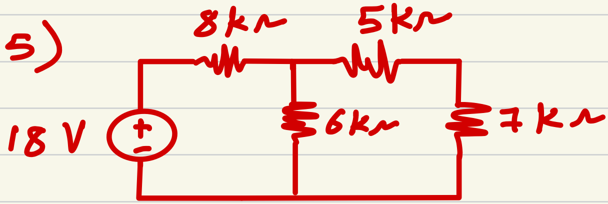
$$= -0.4 + 0.4 - 0.05 + 0.05$$

$$= 0$$

So, P delivered = $P_{absorbed}$.

Chapter #3

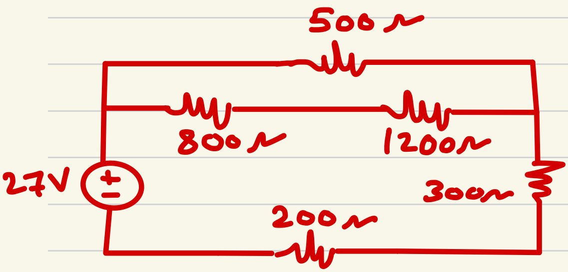
P 3.5)



$5+7 = 12\ k\Omega$

$(12 // 6) \rightarrow \frac{(12)(6)}{12+6} = \frac{(12)(6)}{18} = 4\ k\Omega$

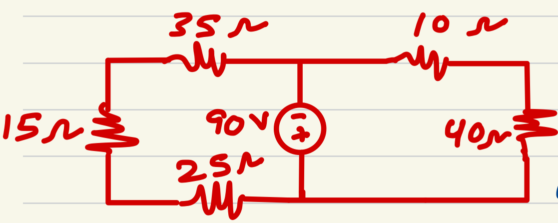
$R_{eq} = 4+8 = 12\ k\Omega$



$(1200+800) // 500$

$\frac{(2000)(500)}{2500} = 400\Omega$

$R_{eq} = 400+300+200 = 900\Omega$

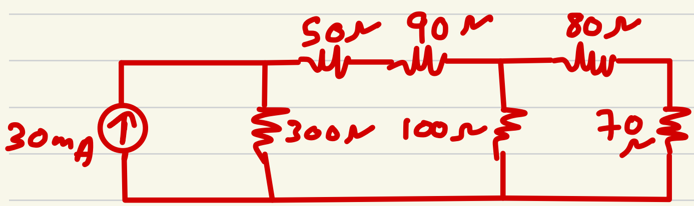


$10+40 = 50\ \Omega$

$35+15+25 = 75\Omega$

$(50 // 75)$

$R_{eq} = \frac{50(75)}{125} = 30\Omega$



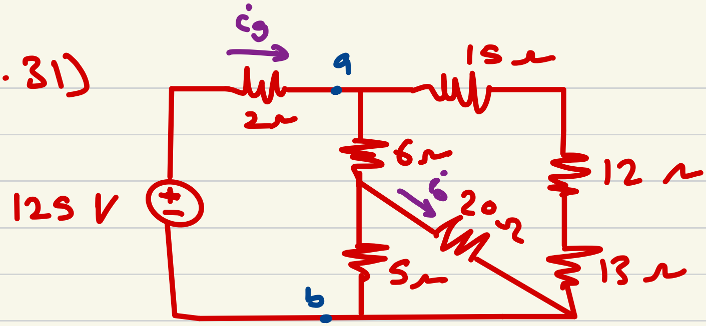
$80+70 = 150\Omega$

$(150 // 100) = \frac{(100)(150)}{250} = 60\Omega$

$50+90+60 = 200\Omega$

$(200 // 300)\ R_{eq} = \frac{200(300)}{500} = 120\ \Omega$

P 3.31)



R_{eq} between (a, b)

$$6 + (20 // 5) = 6 + \frac{(20)(5)}{25} = 10$$

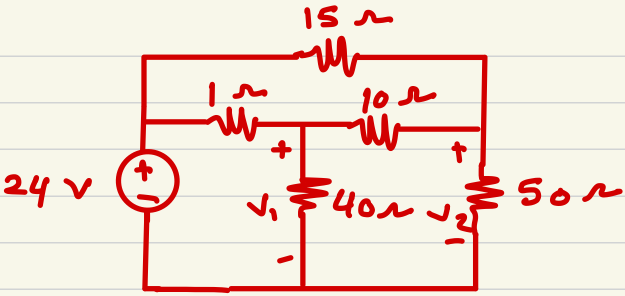
$$(15 + 12 + 13) // 10 = \frac{(40)(10)}{50} = 8\,\Omega = R_{eq}$$

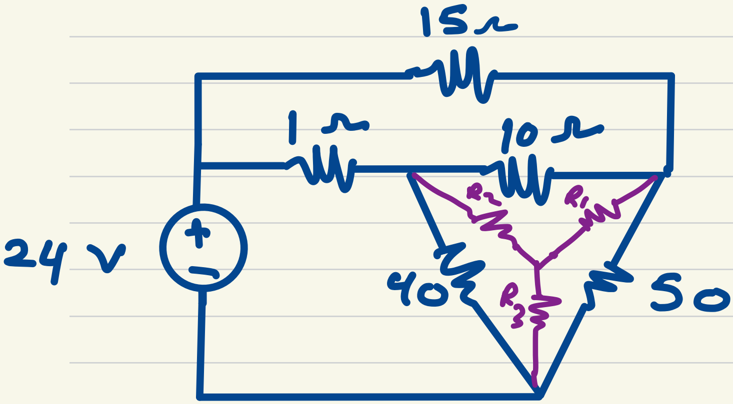
$$i_g = \frac{125}{2+8} = 12.5\ A$$

$$i_{6\Omega} = \frac{12.5(8)}{6+4} = 10\ A$$

$$i_o = \frac{10\ (4)}{20} = 2A$$

P 3.59)

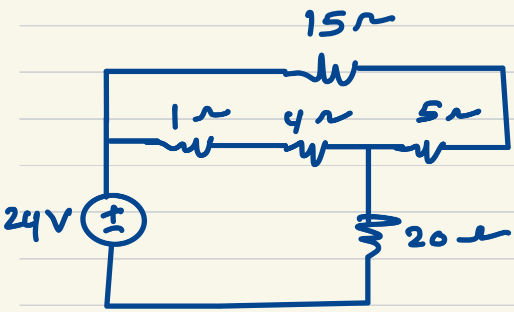




$$R_1 = \frac{(50)(10)}{40+10+50} = 5\Omega$$

$$R_2 = \frac{(10)(40)}{100} = 4\Omega$$

$$R_3 = \frac{(50)(40)}{100} = 20\Omega$$



R_{eq} :

$$\left((1+4)\,//\,15+5\right)+20$$

$$R_{eq} = \frac{(5)(20)}{25} + 20 = 24\Omega$$

$$I_{eq} = \frac{24}{24} = 1A$$

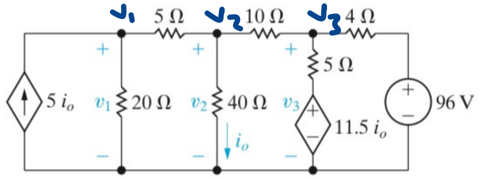
Chapter #4

4.21 PSPICE MULTISIM

a) Find the node voltages v_1, v_2, and v_3 in the circuit in Fig. P4.21.

b) Find the total power dissipated in the circuit.

Figure P4.21



For V_1 :

$$-5 i_o + \frac{v_1}{20} + \frac{v_1 - v_2}{5} = 0 \text{ , but } i_o = \frac{v_2}{40}$$

$$-\frac{5}{40} v_2 + \frac{v_1}{20} + \frac{v_1}{5} - \frac{v_2}{5} = 0$$

$$5V_1 - 6.5 V_2 = 0 \text{ —— } (1)$$

For V_2:

$$\frac{v_2 - v_1}{5} + \frac{v_2}{40} + \frac{v_2 - v_3}{10} = 0$$

$$\frac{v_2}{5} - \frac{v_1}{5} + \frac{v_2}{40} + \frac{v_2}{10} - \frac{v_3}{10} = 0$$

$$-8 V_1 + 13 V_2 - 4 V_3 = 0 \text{ —— } (2)$$

For v_3 :

$$\frac{v_3 - v_2}{10} + \frac{v_3 - 11.5 i_o}{5} + \frac{v_3 - 96}{4} = 0$$

$$\frac{v_3}{10} - \frac{v_2}{10} + \frac{v_3}{5} - 2.3\left(\frac{v_2}{40}\right) + \frac{v_3}{4} - 24 = 0$$

$$4 v_3 - 4 v_2 + 8 v_3 - 2.3 v_2 + 10 v_3 = 960$$

$$-6.3 v_2 + 22 v_3 = 960 \text{ —— } (3)$$

$$D = \begin{array}{ccc} + & - & + \end{array}$$

$$D = \begin{bmatrix} 5 & -6.5 & 0 \\ -8 & 13 & -4 \\ 0 & -6.3 & 22 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 960 \end{bmatrix}$$

$$|D| = 5(286 - 25.2) + 6.5(-176) = 160$$

$$D_1 = \begin{vmatrix} 0 & -6.5 & 0 \\ 0 & 13 & -4 \\ 960 & -6.3 & 22 \end{vmatrix} = 960(26) = 24960$$

$$D_2 = \begin{vmatrix} 5 & 0 & 0 \\ -8 & 0 & -4 \\ 0 & 960 & 22 \end{vmatrix} = -960(-20) = 19200$$

$$D_3 = \begin{vmatrix} 5 & -6.5 & 0 \\ -8 & 13 & 0 \\ 0 & -6.3 & 960 \end{vmatrix} = 960(65 - 52) = 12480$$

$$V_1 = \frac{D_1}{D} = \frac{24960}{160} = 156 \text{ Volt.}$$

$$V_2 = \frac{D_2}{D} = \frac{19200}{160} = 120 \text{ Volt.}$$

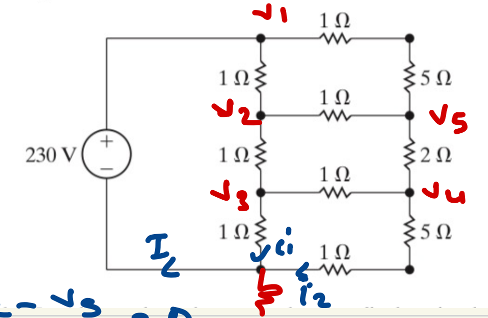
$$V_3 = \frac{D_3}{D} = \frac{12480}{160} = 78 \text{ Volt.}$$

(b) Find power ---

4.25 a) Use the node-voltage method to find the power dissipated in the 2 Ω resistor in the circuit in Fig. P4.25.

b) Find the power supplied by the 230 V source.

Figure P4.25



$v_1 = 230$ volt.

For v_2:

$$\frac{v_2 - 230}{1} + \frac{v_2 - v_3}{1} + \frac{v_2 - v_5}{1} = 0$$

$$v_2 - 230 + v_2 - v_3 + v_2 - v_5 = 0$$

$$3v_2 - v_3 - v_5 = 230 \quad \text{—} \quad (1)$$

For v_3:

$$\frac{v_3 - v_2}{1} + \frac{v_3}{1} + \frac{v_3 - v_4}{1} = 0$$

$$v_3 - v_2 + v_3 + v_3 - v_4 = 0$$

$$-v_2 + 3v_3 - v_4 = 0 \quad \text{—} \quad (2)$$

For v_4:

$$\frac{v_4}{6} + \frac{v_4 - v_3}{1} + \frac{v_4 - v_5}{2} = 0$$

$$v_4 + 6v_4 - 6v_3 + 3v_4 - 3v_5 = 0$$

$$-6v_3 + 10v_4 - 3v_5 = 0 \quad \text{—} \quad (3)$$

For v_5:

$$\frac{v_5 - v_4}{2} + \frac{v_5 - v_2}{1} + \frac{v_5 - 230}{6} = 0$$

$$3v_5 - 3v_4 + 6v_5 - 6v_2 + v_5 - 230 = 0$$

$$-6v_2 - 3v_4 + 10v_5 = 230 \quad (4)$$

Solution : $V_1 = 230$ Volt

$V_2 = 150$ Volt

$V_3 = 80$ Volt

$V_4 = 90$ Volt

$V_5 = 140$ Volt.

$$P_{2\Omega} = \left(\frac{V_5 - V_4}{2}\right)^2 2 = \left(\frac{140-90}{2}\right)^2 2$$

$$= 1250 \text{ watt.}$$

(b)

$$I = i_1 + i_2 = \frac{V_3}{1} + \frac{V_4}{6} = 80 + 15 = 95\text{A}$$

$$P_{230V} = -(I)(230)$$

$$= -(95)(230)$$

$$= -21850 \text{ watt.}$$

4.30 Use the node-voltage method to find the power developed by the 20 V source in the circuit in Fig. P4.30.

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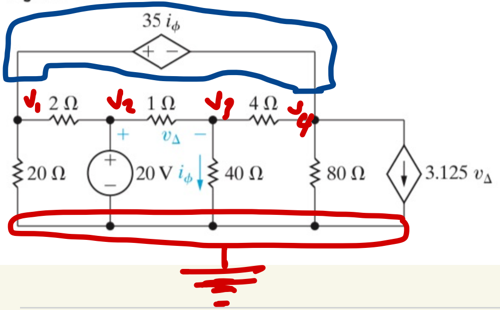
Figure P4.30



$V_1 - V_4$ Super node

$V_1 - V_4 = 35 i_\phi$

$V_1 - V_4 = 35\left(\frac{V_3}{40}\right)$

$$\boxed{V_1 - 0.875 V_3 - V_4 = 0}$$

$V_2 = 20$ volt.

* $V_1 - V_4$ Super node :

$$\frac{V_1}{20} + \frac{V_1 - V_2}{2} + \frac{V_4 - V_3}{4} + \frac{V_4}{80} + 3.125 V_\Delta = 0$$

$$V_1 + 10V_1 - 10V_2 + 5V_4 - 5V_3 + \frac{V_4}{4} + 62.5(V_2 - V_3) = 0$$

$$11V_1 - 200 + 5.25V_4 - 5V_3 + 1250 - 62.5V_3 = 0$$

$$\boxed{11V_1 - 67.5V_3 + 5.25V_4 = -1050}$$

* For V_3:

$$\frac{V_3 - V_2}{1} + \frac{V_3}{40} + \frac{V_3 - V_4}{4} = 0$$

$$4V_3 - 4V_2 + 0.1V_3 + V_3 - V_4 = 0$$

$$-4V_2 + 5.1V_3 - V_4 = 0$$

$$\boxed{0V_1 + 5.1V_3 - V_4 = 80}$$

$$D = \begin{bmatrix} 1 & -0.875 & -1 \\ 11 & -67.5 & 5.25 \\ 0 & 5.1 & -1 \end{bmatrix} \begin{bmatrix} V_1 \\ V_3 \\ V_4 \end{bmatrix} = \begin{bmatrix} 0 \\ -1050 \\ 80 \end{bmatrix}$$

$$|D| = (67.5 - 26.775) - 11(0.875 + 5.1)$$
$$= -25$$

$$|D_1| = \begin{vmatrix} 0 & -0.875 & -1 \\ -1050 & -67.5 & 5.25 \\ 80 & 5.1 & -1 \end{vmatrix} = 1050(0.875 + 5.1) + 80(-4.6 - 67.5) = 506.25$$

$$|D_3| = \begin{vmatrix} 1 & 0 & -1 \\ 11 & -1050 & 5.25 \\ 0 & 80 & -1 \end{vmatrix} = (1050 - 420) - 11(80) = -250$$

$$|D_4| = \begin{vmatrix} 1 & -0.875 & 0 \\ 11 & -67.5 & -1050 \\ 0 & 5.1 & 80 \end{vmatrix} = (-5400 + 5355) - 11(-70) = 725$$

then $v_1 = \dfrac{506.25}{-25} = -20.25$ volt

$v_2 = 20$ volt

$v_3 = \dfrac{-250}{-25} = 10$ Volt.

$v_4 = \dfrac{725}{-25} = -29$ Volt.

$$I = i_1 + i_2 = \frac{20 + 20.25}{2} + \frac{20 - 10}{1} = 30.125\,A$$

$$P_{20V} = -(I)(20) = -(30.125)(20) = -602.5\,W$$

4.41 a) Use the mesh-current method to find v_o in the circuit in Fig. P4.41.

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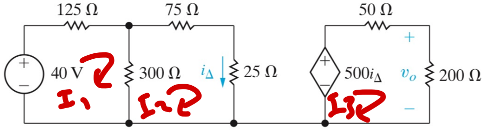
b) Find the power delivered by the dependent source.

Figure P4.41



For mesh ① :

$$-40 + I_1(125+300) - 300 I_2 = 0$$

$$425 I_1 - 300 I_2 = 40$$

$$\boxed{17 I_1 - 12 I_2 = 1.6} \rightarrow 17 I_1 = 1.6 + 12 I_2$$

$$I_1 = \frac{1.6 + 12 I_2}{17}$$

For mesh ② :

$$-300 I_1 + 400 I_2 = 0$$

$$\boxed{-12 I_1 + 16 I_2 = 0}$$

$$-12\left(\frac{1.6 + 12 I_2}{17}\right) + 16 I_2 = 0$$

$$17\left(-\frac{144 I_2}{17} + 16 I_2 = \frac{19.2}{17}\right)$$

$$-144 I_2 + 272 I_2 = 19.2 \rightarrow 128 I_2 = 19.2$$

$$\boxed{I_2 = 0.15 A}$$

$$I_1 = \frac{1.6 + 12(0.15)}{17} \rightarrow \boxed{I_1 = 0.2 A}$$

$$i_o = i_2$$

For mesh ③

$$-500 i_o + 250 i_3 = 0 \rightarrow 250 i_3 = 75$$

$$\boxed{i_3 = 0.3 A}$$

ⓐ $V_o = (i_3)(200) = 60$ Volt

ⓑ $P_{d.p} = -(I_3)(500 i_o) = -(0.3)(500 * 0.15) = -22.5 W$

4.60 a) Find the current i_o in the circuit in Fig. P4.60 by making a succession of appropriate source transformations.

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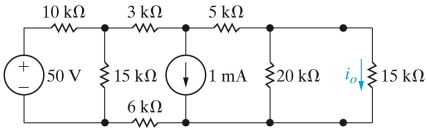
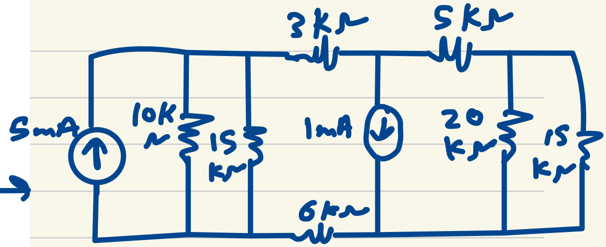
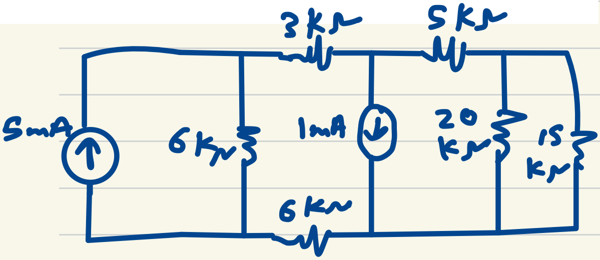
b) Using the result obtained in (a), work back through the circuit to find the power developed by the 50 V source.

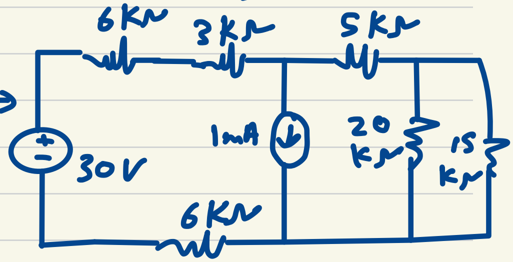
Figure P4.60

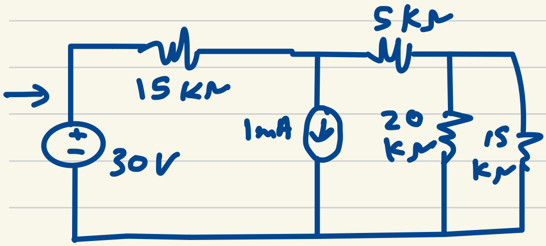


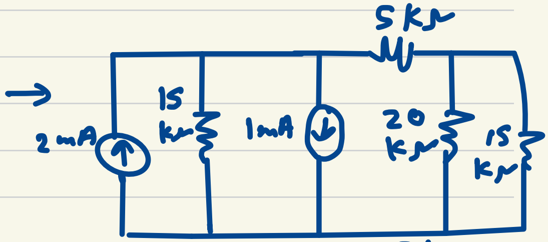


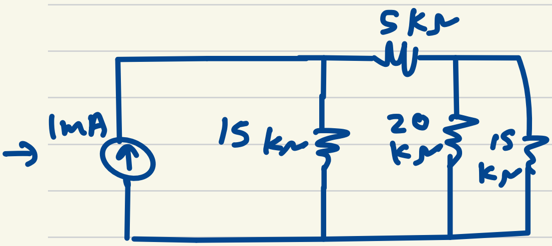
$$(10 \parallel 15) = \frac{(10)(15)}{25} = 6\ k\Omega$$

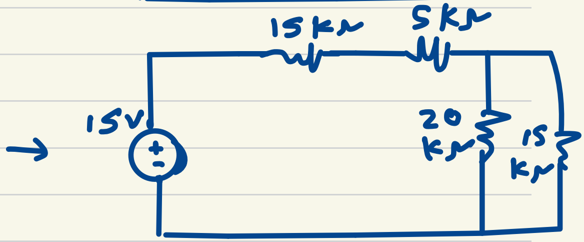


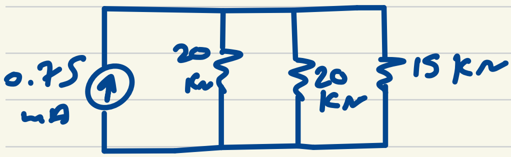








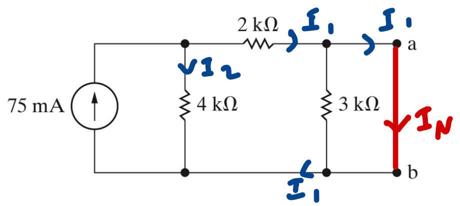




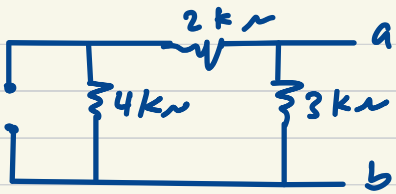
$$i_o = \frac{7.5}{10+15} = 0.3\,mA$$

4.65 Find the Norton equivalent with respect to the terminals a,b for the circuit in Fig. P4.65.

Figure P4.65



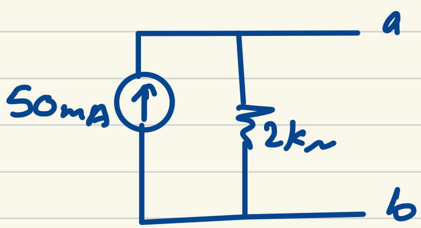
$$I_N = \frac{(4)(75)}{2+4} = 50\,mA$$



$(2+4) \,//\, 3$

$$R_N = \frac{(6)(3)}{9} = 2\,k\Omega$$

The equivalent Norton Circuit



4.67 Find the Thévenin equivalent with respect to the terminals a,b for the circuit in Fig. P4.67.

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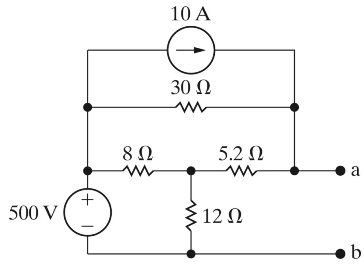
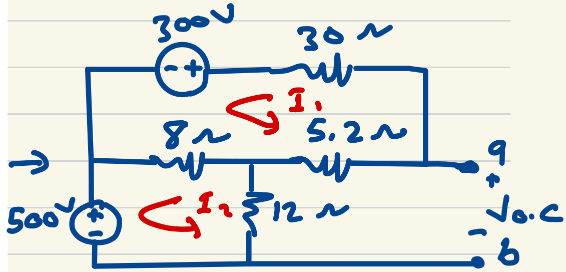
Figure P4.67





for mesh 1

$$300 + 43.2 I_1 - 8 I_2 = 0$$

$$43.2 I_1 - 8 I_2 = -300 \quad \text{— } 1$$

for mesh 2

$$500 + 20 I_2 - 8 I_1 = 0$$

$$-8 I_1 + 20 I_2 = -500 \quad \text{— } 2$$

$$1 \rightarrow \quad 108 I_1 - 20 I_2 = -750$$

$$+ \quad -8 I_1 + 20 I_2 = -500$$

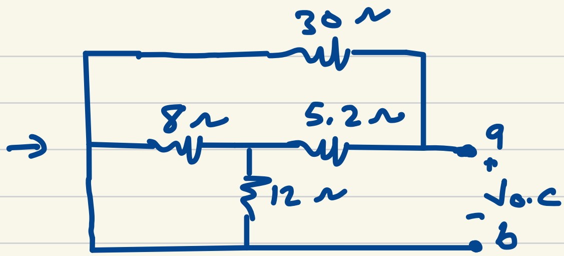
$$100 I_1 = -1250 \rightarrow I_1 = -12.5 \text{ A}$$

$$I_2 = -30 \text{ A}$$

$$V_{o.c} + (12)(-30) + (5.2)(-12.5) = 0$$

$$V_{o.c} = V_{th} = 425 \text{ volt}$$

for R_{th}

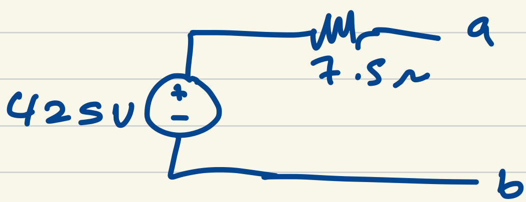


$$(8 \parallel 12) = \frac{(8)(12)}{20} = 4.8\ \Omega$$

$$4.8 + 5.2 = 10\ \Omega$$

$$30 \parallel 10 \rightarrow R_{th} = \frac{(30)(10)}{40} = 7.5\ \Omega$$

Thevenin equivalent circuit:



4.68 Find the Norton equivalent with respect to the terminals a,b in the circuit in Fig. P4.68.

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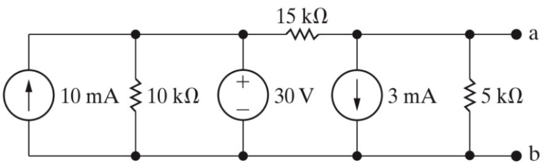
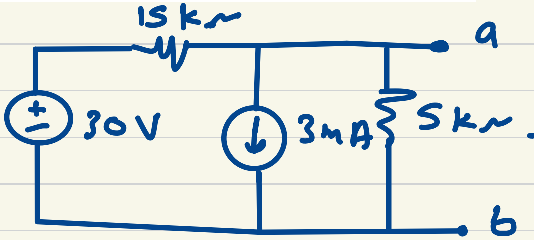
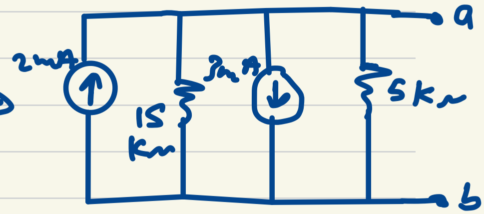
Figure P4.68



10 mA and 10 kΩ can be removed because they are in parallel with Voltage Source



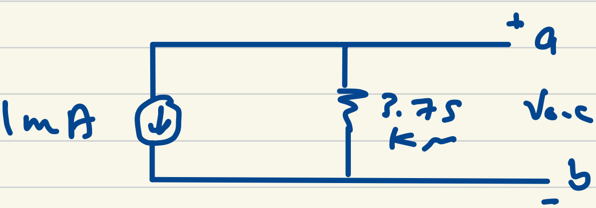
→



→

→ $(5 \parallel 15) = \frac{5(15)}{20}$

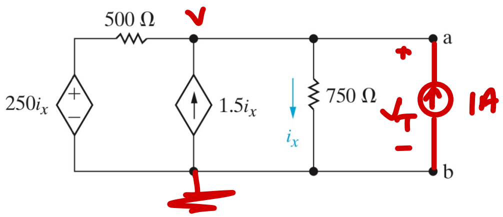
$= 3.75$



Therefor, this is the Norton equivalent Circuit.

4.81 Find the Norton equivalent with respect to the terminals a,b for the circuit seen in Fig. P4.81.

Figure P4.81



Because, there are no independent sources

so $V_{Th} = 0$ and $I_N = 0$

to find R_N

$$\frac{v - 250 i_x}{500} - 1.5 i_x + i_x - 1 = 0$$

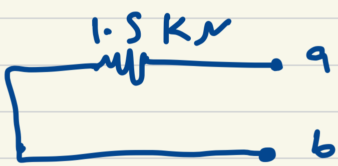
$$\frac{v}{500} - 0.5\left(\frac{v}{750}\right) - 0.5\left(\frac{v}{750}\right) - 1 = 0$$

$$\frac{v}{500} - \frac{v}{750} = 1 \rightarrow \frac{0.5v}{750} = 1$$

$$0.5v = 750 \rightarrow v = 1500$$

$$v_T = v = 1500 \text{ Volt}$$

$$R_N = \frac{v_T}{I_T} = 1500 = 1.5\ \text{k}\Omega$$



4.88 The variable resistor (R_o) in the circuit in Fig. P4.88 is adjusted until the power dissipated in the resistor is 250 W. Find the values of R_o that satisfy this condition.

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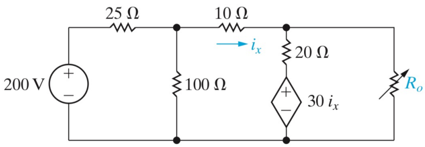
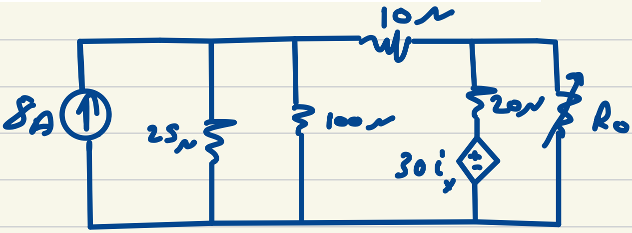
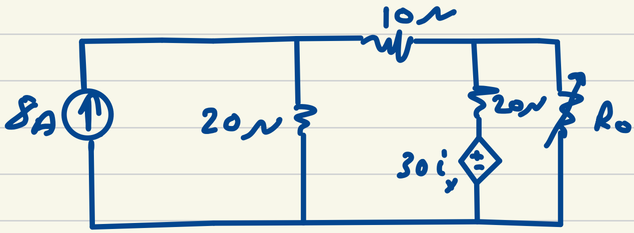
Figure P4.88

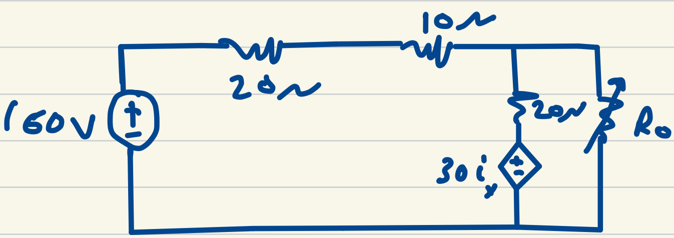


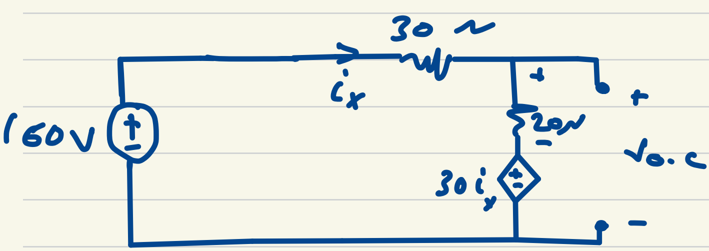
$$P = I^2 R_o$$

$$250 = I^2 R_o$$









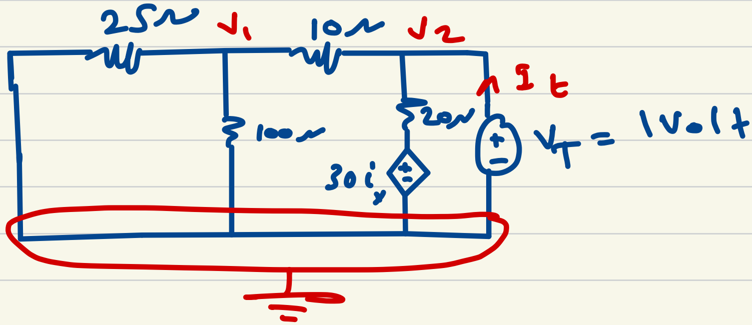
$$i_x = \frac{160 - 30 i_x}{50} \rightarrow 50 i_x = 160 - 30 i_x$$

$$i_x = 2A$$

$$v_{o.c} - 30\overset{i_x}{(2)} - 20\overset{i_x}{(2)} = 0$$

$$v_{o.c} = V_{Th} = 100 \text{ volt}$$

for R_{th}



$$\frac{v_1}{25} + \frac{v_1}{100} + \frac{v_1 - 1}{10} = 0 \qquad v_2 = 1 \text{ volt}$$

$$0.04 v_1 + 0.01 v_1 + 0.1 v_1 = 0.1$$

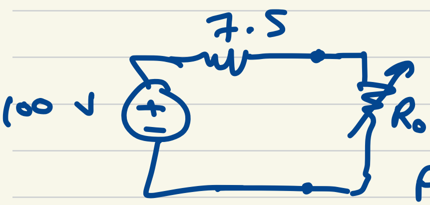
$$0.15 v_1 = 0.1 \rightarrow v_1 = 0.67 \text{ volt.}$$

for v_2

$$\frac{1 - 0.67}{10} + \frac{1 - 30\left(\frac{0.67 - 1}{10}\right)}{20} - I_t = 0$$

$$0.0333 + 0.05 - \frac{3}{20}(-0.33) - I_t = 0$$

$$I_t = 0.13284 A \rightarrow R_{th} = \frac{V_T}{I_t} = \frac{1}{0.1328} = 7.5\ \Omega$$



$$I = \frac{100}{7.5 + R_o}$$

$$P = I^2 R = \left(\frac{100}{7.5 + R_o}\right)^2 R_o = 250$$

$$\left(\frac{10^4}{56.25+15R_o+R_o^2}\right)R_o = 250$$

$$\frac{10^4 R_o}{250} = 56.25+15R_o+R_o^2$$

$$40R_o = 56.25+15R_o+R_o^2$$

$$R_o^2 - 25R_o + 56.25 = 0$$

$$R_o = \frac{25 \pm \sqrt{400}}{2} = 12.5 \pm 10$$

$R_o = 22.5\ \checkmark$

or $R_o = 2.5\ \checkmark$

4.89 The variable resistor in the circuit in Fig. P4.89 is adjusted for maximum power transfer to R_o.

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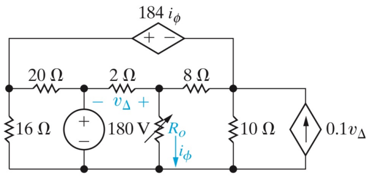
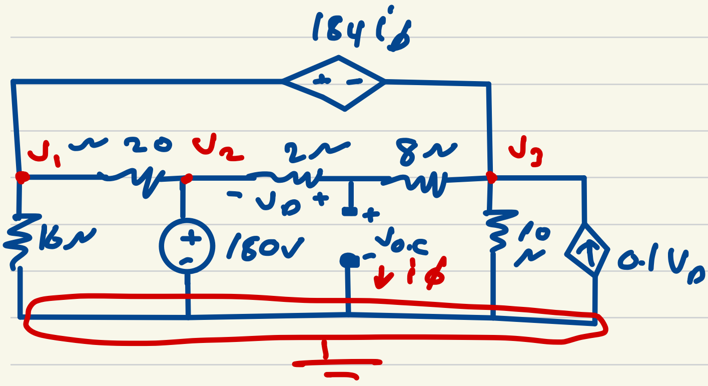
a) Find the numerical value of R_o.

b) Find the maximum power delivered to R_o.

c) How much power does the 180 V source deliver to the circuit when R_o is adjusted to the value found in (a)?

Figure P4.89





$$\boxed{V_2 = 180 \text{ Volt}}$$

$$i_\phi = 0 \rightarrow (184\, i_\phi) = 0 \text{, then } V_1 = V_3$$

$$\frac{V_1}{16} + \frac{V_1 - 180}{20} + \frac{V_3 - 180}{10} + \frac{V_3}{10} - 0.1 V_\Delta = 0$$

$$\frac{V_1}{16} + \frac{V_1}{20} - 9 + \frac{V_1}{10} - 18 + \frac{V_1}{10} - 0.1\left(\frac{V_1 - 180}{10}\right) 2 = 0$$

$$\frac{V_1}{16} + \frac{5V_1}{20} - 27 - 0.02 V_1 + 3.6 = 0$$

$$0.2925 V_1 = 23.4 \rightarrow \boxed{V_1 = 80 \text{ Volt.}}$$

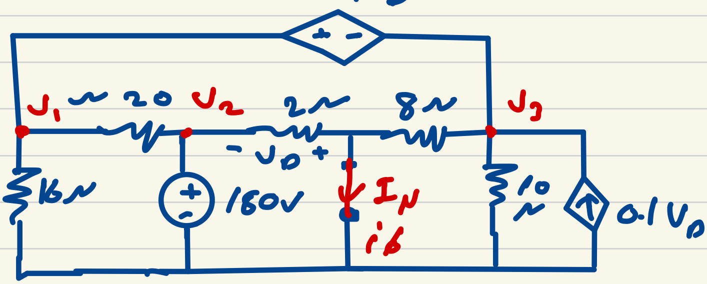
$$\boxed{V_3 = 80 \text{ Volt}}$$

$$i_{8\Omega} = \frac{180 - 80}{10} = 10\,A$$

$$i_{10\Omega} = \frac{80}{10} = 8\,A$$

$$V_{o.c} - 10(8) - 8(10) = 0$$

$$V_{o.c} = 160 \text{ Volt} = V_{th}$$



$v_2 = 180\,V$

$$v_1 - v_3 = 184\, i_\phi = 184\left(\frac{180}{2} + \frac{v_3}{8}\right)$$

$$v_1 - v_3 = 16560 + 23 v_3 \rightarrow v_1 = 16560 + 24 v_3$$

$v_D = -180$

$$\frac{v_1}{16} + \frac{v_1 - 180}{20} + \frac{v_3}{8} + \frac{v_3}{10} - 0.1 v_D = 0$$

$$\frac{v_1}{16} + \frac{v_1}{20} - 9 + \frac{v_3}{8} + \frac{v_3}{10} + 18 = 0$$

$$0.1125 v_1 + 0.225 v_3 = -9$$

$$0.1125(16560 + 24 v_3) + 0.225 v_3 = 9$$

$$1863 + 2.925 v_3 = 9 \rightarrow v_3 = -640 \text{ volt}$$

$v_1 = 1200$ volt

$$I_N = \frac{180}{2} + \frac{-640}{8} = 90 - 80 = 10 A$$

$$R_{th} = \frac{V_{th}}{I_N} = \frac{160}{10} = 16 \Omega$$

(b) $$P_{max} = \frac{V_{th}^2}{4R_o} = \frac{160^2}{4(16)} = 400 \text{ Watt}$$

4.92 a) In the circuit in Fig. P4.92, before the 5 mA current source is attached to the terminals a,b, the current i_o is calculated and found to be 3.5 mA. Use superposition to find the value of i_o after the current source is attached.

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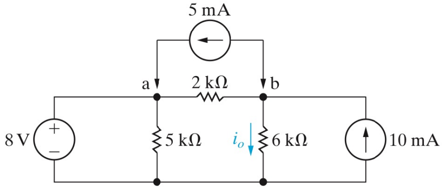
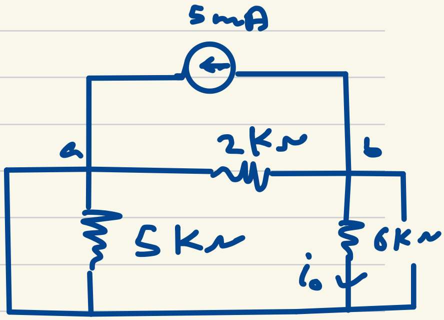
b) Verify your solution by finding i_o when all three sources are acting simultaneously.

Figure P4.92





$$R_{eq} = \frac{(2)(6)}{8} = \frac{3}{2} = 1.5 k\Omega$$

$$V_{1.5k\Omega} = (1.5)(5) = 7.5 V$$

$$V_{6k\Omega} = 7.5 = -i_o''(6) \rightarrow i_o'' = -1.25 mA$$

$$i_o = i_o' + i_o'' = 3.5 - 1.25 = 2.25 mA$$

4.98 Use the principle of superposition to find the current i in the circuit of Fig. P4.98.

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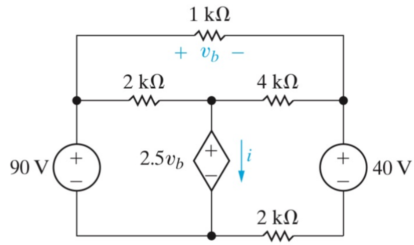
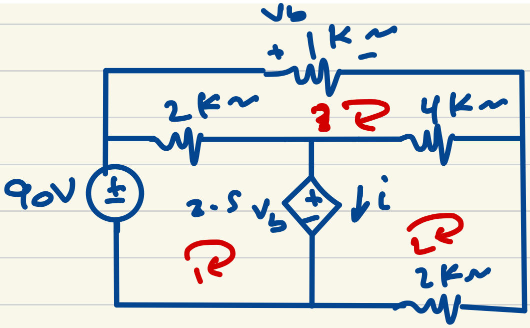
Figure P4.98





using mesh analysis

mesh 1

$$-90 + 2.5V_b + 2I_1 - 2I_3 = 0$$

$$V_b = I_3(1)$$

$$2.5I_3 + 2I_1 - 2I_3 = 90$$

$$2I_1 - 0.5I_3 = 90$$

mesh 2

$$-2.5V_b + 6I_2 - 4I_3 = 0$$

$$-2.5I_3 + 6I_2 - 4I_3 = 0$$

$$6I_2 - 6.5I_3 = 0$$

mesh 3

$$7I_3 - 2I_1 - 4I_2 = 0$$

$$-2I_1 - 4I_2 + 7I_3 = 0$$

$$\begin{array}{cccc} & + & - & + \\ D = & \multicolumn{3}{c}{\begin{bmatrix} 2 & 0 & -0.5 \\ 0 & 6 & -6.5 \\ -2 & -4 & 7 \end{bmatrix}} \end{array} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} 90 \\ 0 \\ 0 \end{bmatrix}$$

$$|D| = 2(42 - 26) - 0.5(-12) = 38$$

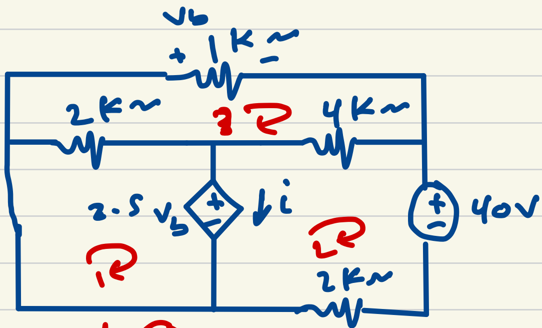
$$\begin{vmatrix} 90 & 0 & -0.5 \\ 0 & 6 & -6.5 \\ 0 & -4 & 7 \end{vmatrix} = 90(42-26) = 1440$$

$$\begin{vmatrix} 2 & 90 & -0.5 \\ 0 & 0 & -6.5 \\ -2 & 0 & 7 \end{vmatrix} = -90(-13) = 1170$$

$$\begin{vmatrix} 2 & 0 & 90 \\ 0 & 6 & 0 \\ -2 & -4 & 0 \end{vmatrix} = 90(12) = 1080$$

$I_1 = 37.9\ mA$, $I_2 = 30.8 mA$, $I_3 = 28.4$

$i' = I_1 - I_2 = 37.9 - 30.8 = 7.1\ mA$



mesh ①

$v_b = I_3$

$2.5 v_b + 2I_1 - 2I_3 = 0$

$2.5 I_3 + 2I_1 - 2I_3 = 0$

$2I_1 + 0.5 I_3 = 0$

mesh ②

$40 + 6I_2 - 2.5 v_b - 4I_3 = 0$

$6I_2 - 2.5 I_3 - 4I_3 = -40$

$6I_2 - 6.5 I_3 = -40$

mesh ③

$7I_3 - 2I_1 - 4I_2 = 0$

$-2I_1 - 4I_2 + 7I_3 = 0$

$$\begin{array}{ccc} + & - & + \end{array}$$

$$D = \begin{bmatrix} 2 & 0 & 0.5 \\ 0 & 6 & -6.5 \\ -2 & -4 & 7 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} 0 \\ -40 \\ 0 \end{bmatrix}$$

$$D = 2(42-26) + 0.5(12) = 38$$

$$\begin{vmatrix} 0 & 0 & 0.5 \\ -40 & 6 & -6.5 \\ 0 & -4 & 7 \end{vmatrix} = 40(2) = 80$$

$$\begin{vmatrix} 2 & 0 & 0.5 \\ 0 & -40 & -6.5 \\ -2 & 0 & 7 \end{vmatrix} = -40(14+1) = -600$$

$$\begin{vmatrix} 2 & 0 & 0 \\ 0 & 6 & -40 \\ -2 & -4 & 0 \end{vmatrix} = 40(-8-0) = -320$$

$I_1 = 2.1\ mA$, $I_2 = -15.8\ mA$, $I_3 = -8.4\ mA$

$$i'' = I_1 - I_2 = 2.1 - -15.8 = 17.9\ mA$$

then $i = i' + i'' = 7.1 + 17.9 = 25\ mA$

Chapter #9

9.3 Consider the sinusoidal voltage

$$v(t) = 25\cos(400\pi t + 60^\circ)\text{ V}.$$

a) What is the maximum amplitude of the voltage?
b) What is the frequency in hertz?
c) What is the frequency in radians per second?
d) What is the phase angle in radians?
e) What is the phase angle in degrees?
f) What is the period in milliseconds?
g) What is the first time after $t = 0$ that $v = 0$ V?
h) The sinusoidal function is shifted 5/6 ms to the right along the time axis. What is the expression for $v(t)$?
i) What is the minimum number of milliseconds that the function must be shifted to the left if the expression for $v(t)$ is $25\sin 400\pi t$ V?

ⓐ 25 Volt.

ⓑ $f = \frac{\omega}{2\pi} = \frac{400\pi}{2\pi} = 200\,Hz$

ⓒ $\omega = 400\pi$ rad/s

ⓓ $\phi = \frac{60\pi}{180} = \frac{\pi}{3}$ rad

ⓔ $\phi = 60^\circ$

ⓕ $T = \frac{1}{f} = \frac{1}{200} = 5$ ms

ⓖ $V(t) = 25\cos(400\pi t + 60)$

$0 = 25\cos(400\pi t + 60)$

$0 = \cos(400\pi t + 60)$

$400\pi t + \frac{\pi}{3} = \frac{\pi}{2} \Rightarrow 400\pi t = \frac{\pi}{2} - \frac{\pi}{3} = \frac{\pi}{6}$

$400\pi t = \frac{\pi}{6} \rightarrow 400t = \frac{1}{6} \Rightarrow t = 416\,\mu s$

ⓗ $V(t) = 25\cos\left(400\pi\left(t - \frac{0.005}{6}\right) + \frac{\pi}{3}\right)$

$= 25\cos(400\pi t)$ Volt.

ⓘ

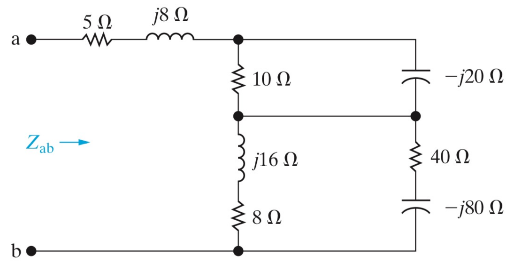
9.6 The rms value of the sinusoidal voltage supplied to the convenience outlet of a home in Scotland is 240 V. What is the maximum value of the voltage at the outlet?

$$V_{rms} = 240\,V \rightarrow V_{rms} = \frac{V_{max}}{\sqrt{2}}$$

$$V_{max} = \sqrt{2}\,V_{rms}$$

$$= \sqrt{2}\,(240) = 339.41 \text{ Volt}$$

9.22 Find the impedance Z_{ab} in the circuit seen in Fig. P9.22. Express Z_{ab} in both polar and rectangular form.



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9.28 Find the steady-state expression for $i_o(t)$ in the circuit in Fig. P9.28 if $v_s = 80 \cos 2000t$ V.

PSPICE
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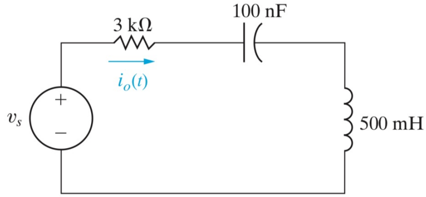
Figure P9.28



$$Z_C = \frac{-j}{\omega C} = \frac{-j}{100\times10^{-9}(2000)}$$
$$= -j\,5000$$

$$Z_L = j\omega L = j(2000)\,500\times10^{-3}$$
$$= j1000$$

$$\vec{I} = \frac{\vec{V}}{Z_{eq}}$$

$$Z_{eq} = Z_R + Z_C + Z_L$$
$$= 3000 - j\,5000 + j1000$$
$$= 3000 - j4000\ \Omega$$
$$= 5000\angle{-53.13}\ \Omega$$

$$\vec{I} = \frac{\vec{V}}{Z_{eq}} = \frac{80\angle 0}{5000\angle{-53.13}} = 16\angle 53.13\ \text{mA}$$

$$i(t) = 16\cos(2000t + 53.13)\ \text{mA}$$

9.36 The phasor current $\mathbf{I}_b$ in the circuit shown in Fig. P9.36 is $25\angle 0^\circ$ mA.

PSPICE
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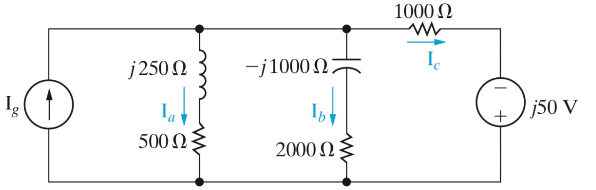
a) Find $\mathbf{I}_a$, $\mathbf{I}_c$, and $\mathbf{I}_g$.

b) If $\omega = 1500$ rad/s, write expressions for $i_a(t)$, $i_c(t)$, and $i_g(t)$.

Figure P9.36



(a)

$$\vec{V_b} = \vec{I_b} Z_b = (25)(2 - j) = 50 - j25 \text{ V}$$

$$= 55.9\angle -26.5$$

$$\vec{I_a} = \frac{\vec{V_b}}{Z_a} = \frac{55.9\angle -26.5}{500 + j250} = \frac{55.9\angle -26.5}{559\angle 26.5}$$

$$\vec{I_a} = 0.1\angle -53 = \boxed{100\angle -53 \text{ mA}}$$

$$-j50 - \vec{V_b} + \vec{I_c}(1000) = 0$$

$$-j50 - 50 + j25 + \vec{I_c}(1000) = 0$$

$$\frac{1000\,\vec{I_c}}{1000} = \frac{50 + 25j}{1000\angle 0} = \frac{55.9\angle 26.5}{1000\angle 0}$$

$$\vec{I_c} = \boxed{55.9\angle 26.5 \text{ mA}}$$

$$\vec{I_g} = \vec{I_a} + \vec{I_b} + \vec{I_c}$$

$$= 100\angle -53 + 25\angle 0 + 55.9\angle 26.5$$

$$= 60 - j80 + 25 + 50 + j25$$

$$= 135 - j55 \text{ mA} = 145.77\angle -22.17 \text{ mA}$$

(b) $i_a(t) = 100 \cos(1500t - 53)$ mA

$i_c(t) = 55.9 \cos(1500t + 26.5)$ mA

$i_g(t) = 145.77 \cos(1500t - 22.17)$ mA