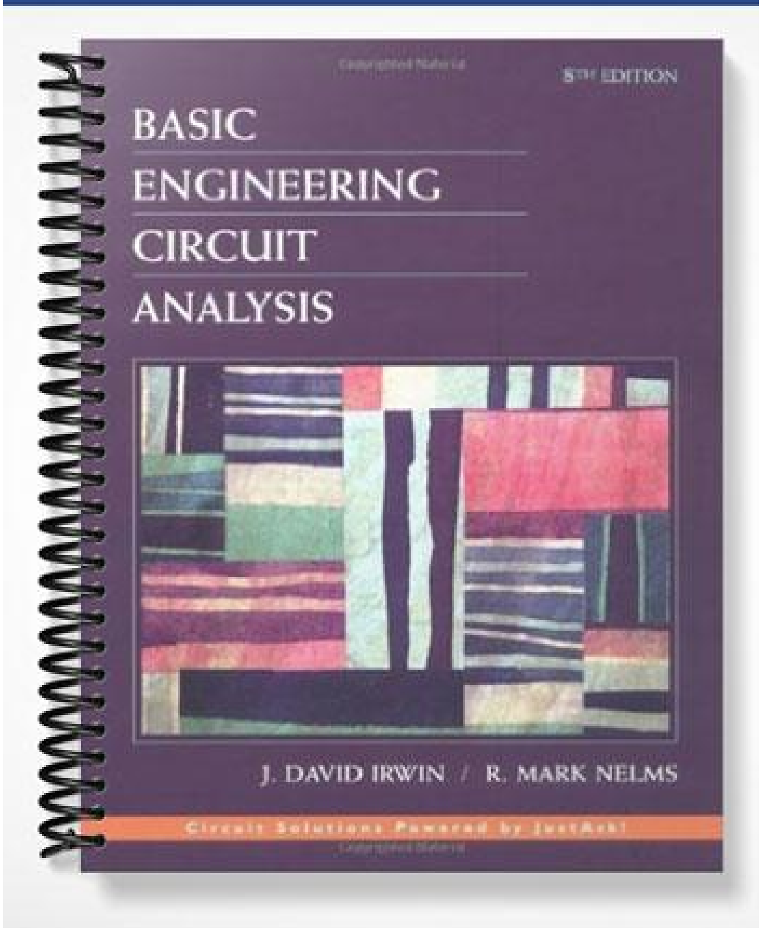
SOLUTIONS MANUAL



Chapter Two:

Resistive Circuits

2.1 Find the current I and the power supplied by the source in the network in Fig. P2.1. CS

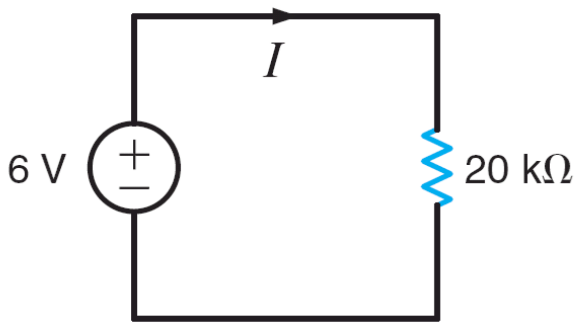
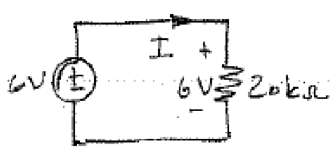


Figure P2.1

SOLUTION:

2.1 Find I & power supplied by source.



$P = VI$ $\quad I = V/R = \dfrac{6}{20 \times 10^3} = 300\,\mu A$

$P = 6(300 \times 10^{-6}) = 1.8\,mW$ (supplied)

Since voltage polarity & I do not obey passive sign convention, power calculated above is supplied!

2.2 In the network in Fig. P2.2, the power absorbed by R_x is 20 mW. Find R_x. **CS**

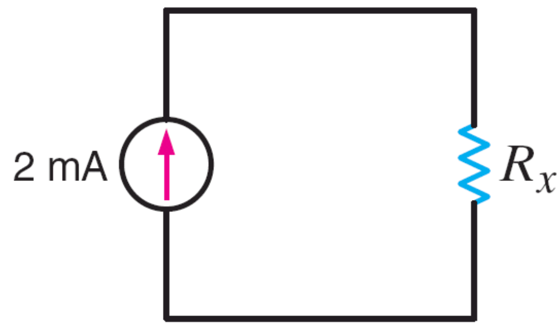
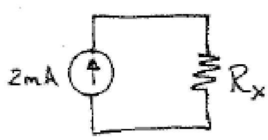


Figure P2.2

SOLUTION:

2.2 Find R_x if Power absorbed is 20mW



$P = I^2 R_x$ $\quad I = 2mA$ $\quad R_x = \dfrac{20 \times 10^{-3}}{(2 \times 10^{-3})^2} \Rightarrow R_x = 5k\Omega$

2.3 Find the current I and the power supplied by the source in the network in Fig. P2.3.

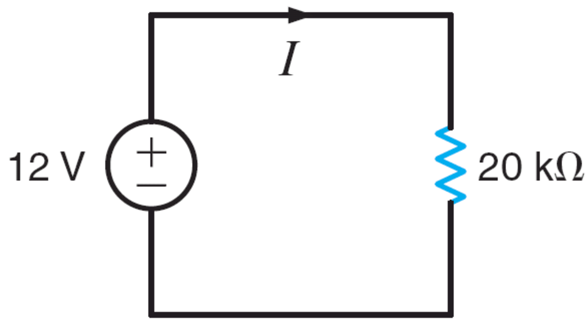
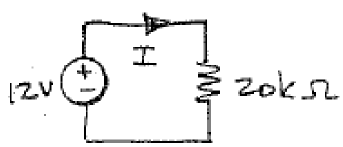


Figure P2.3

SOLUTION:

2.3 Find I and power supplied by source

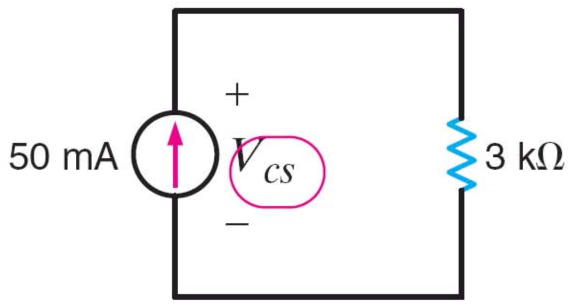


$$I = V/R = \frac{12}{20 \times 10^3} \Rightarrow I = 600\mu A$$

$$P = VI \Rightarrow P = (12)(600 \times 10^{-6}) \Rightarrow P = 7.2\,mW$$

Since voltage polarity & current direction for source do not obey passive sign convention, the power above is supplied.

2.4 In the circuit in Fig. P2.4, find the voltage across the current source and the power absorbed by the resistor.

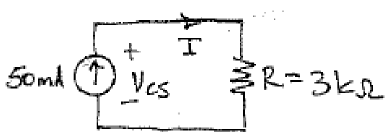


AU: Should "cs", subscript here be italic or roman?

Figure P2.4

SOLUTION:

2.4 Find V_{cs} and power absorbed by R



$V_{cs} = IR = (50\times10^{-3})(3\times10^{3})$

$V_{cs} = 150V$

$P_R = V_{cs}I = (150)(50\times10^{-3}) = 7.5W$

At R, V_{cs} and I obey passive sign convention, so, P_R is absorbed.

2.5 If the 5-kΩ resistor in the network in Fig. P2.5 absorbs 200 mW, find V_S.

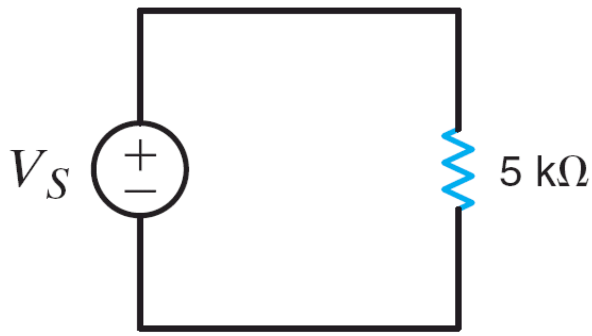
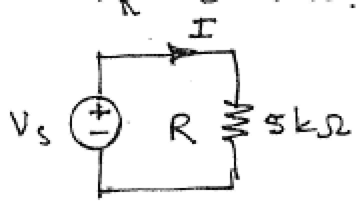


Figure P2.5

SOLUTION:

2.5 $P_R = 200\text{mW}$. Find V_S.



$$P_R = \frac{V_S^2}{R} = 0.2$$

$$V_S = \sqrt{(0.2)(5000)}$$

$$\boxed{V_s = 31.6\ \text{V}}$$

2.6 In the network in Fig. P2.6, the power absorbed by G_x is 20 mW. Find G_x. **PSV**

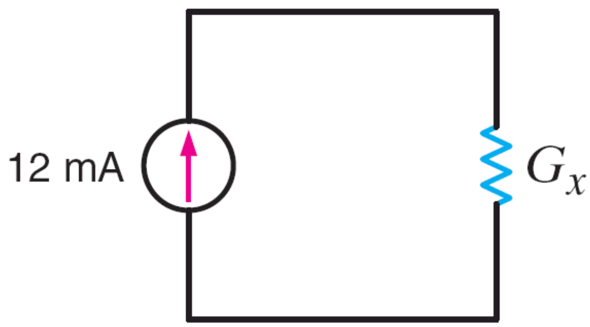
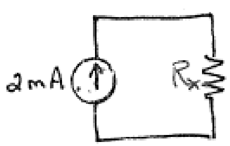


Figure P2.6

SOLUTION:

2.6 $P_G = 20\,mW$. Find R_x



$P_G = R_x I^2 = 0.02$ $\quad R_x = \dfrac{0.02}{(2\times10^{-3})^2} \rightarrow \boxed{R_x = 5\,k\Omega}$

2.7 A model for a standard two D-cell flashlight is shown in Fig. P2.7. Find the power dissipated in the lamp.

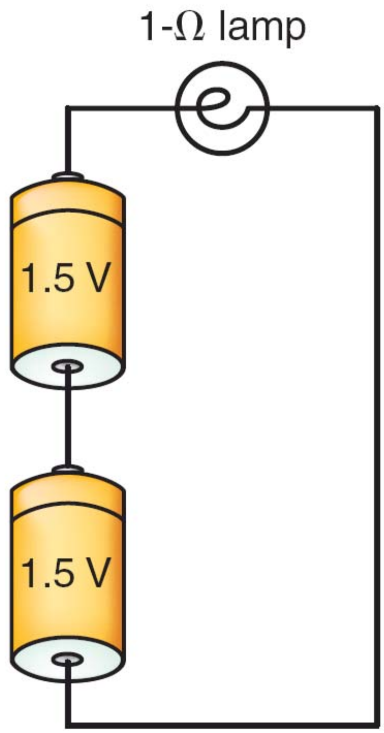
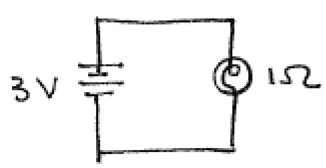


Figure P2.7

SOLUTION:

2.7 Find P_R.



$$P_R = V^2/R = \frac{3^2}{1}$$

$$\boxed{P_R = 9W}$$

2.8 An automobile uses two halogen headlights connected as shown in Fig. P2.8. Determine the power supplied by the battery if each headlight draws 3 A of current.

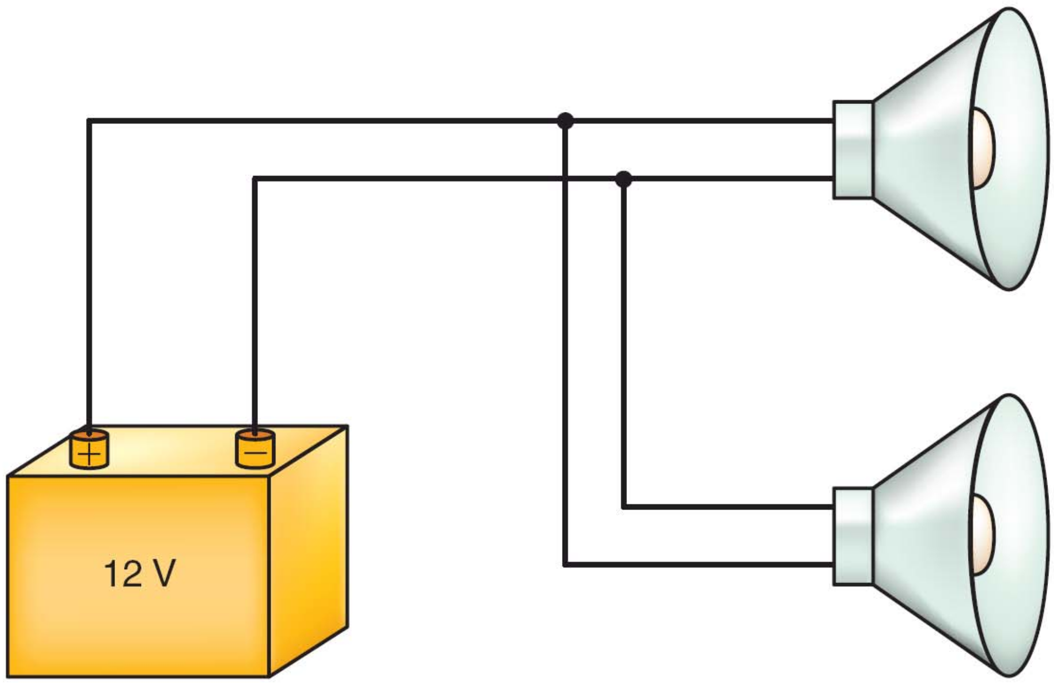
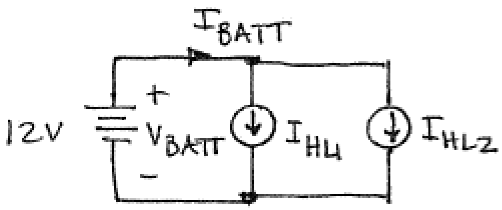


Figure P2.8

SOLUTION:

2.8 Find P_{BATT}.



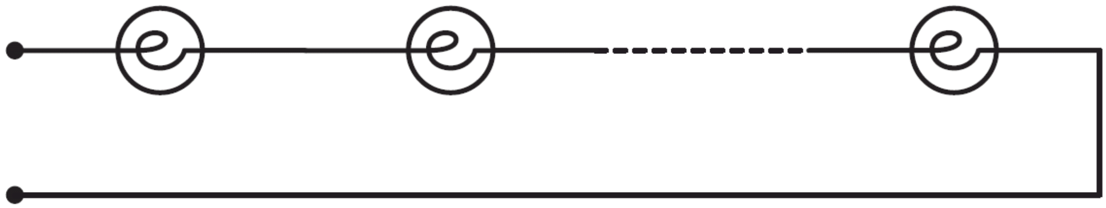
$I_{HL1} = I_{HL2} = 3\text{ A}$

$I_{BATT} = I_{HL1} + I_{HL2} = 6\text{A}$

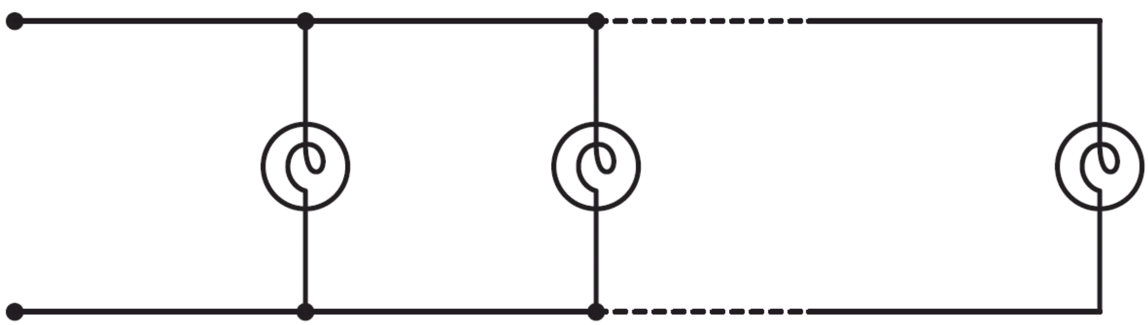
$P_{BATT} = V_{BATT} I_{BATT} = 12(6)$

$\boxed{P_{BATT} = 72\text{W}}$

2.9 Many years ago a string of Christmas tree lights was manufactured in the form shown in Fig. P2.9a. Today the lights are manufactured as shown in Fig. P2.9b. Is there a good reason for this change?



(a)



(b)

Figure P2.9

SOLUTION:

2.9 Why connect Christmas tree lights in parallel rather than series?

If a bulb fails as a open circuit (common failure), the series connect conducts no current and all bulbs are off. In the parallel connection, only the failed bulb is off, all others still function.

2.10 Find I_1 in the network in Fig. P2.10. CS

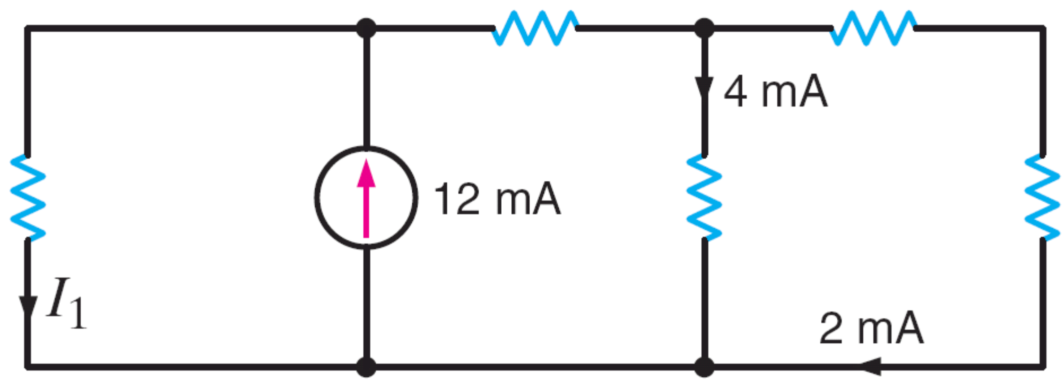
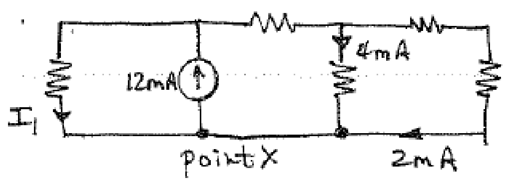


Figure P2.10

SOLUTION:

2.10 Find I_1



KCL at point X: all currents enter

$I_1 - 12 \times 10^{-3} + 4 \times 10^{-3} + 2 \times 10^{-3} = 0$

$\boxed{I_1 = 6\,mA}$

2.11 Find I_1 and I_2 in the circuit in Fig. P2.11. CS

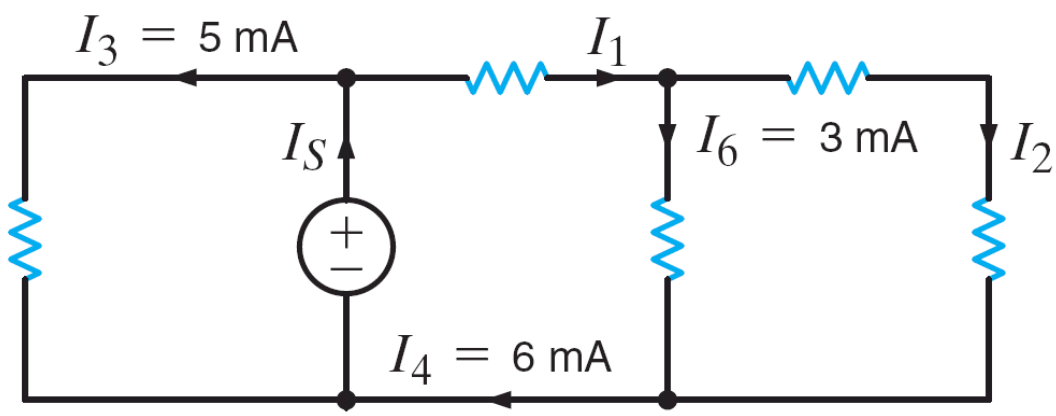
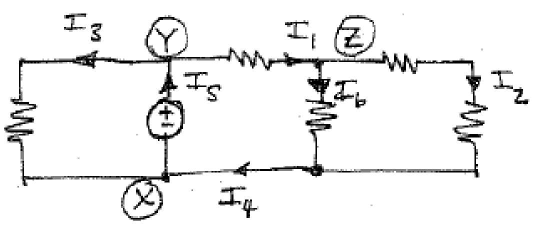


Figure P2.11

SOLUTION:

2.11 Find I_1 and I_2



$I_3 = 5mA \quad I_6 = 3mA \quad I_4 = 6mA$

KCL @ (X) : all currents enter

$I_3 - I_S + I_4 = 0$

$I_S = 5\times10^{-3} + 6\times10^{-3} \Rightarrow I_S = 11mA$

KCL @ (Y) : all currents enter

$-I_3 + I_S - I_1 = 0 \Rightarrow I_1 = I_S - I_3 = 11\times10^{-3} - 5\times10^{-3} \Rightarrow \boxed{I_1 = 6\,mA}$

KCL @ (Z) : all current enter

$I_1 - I_6 - I_2 = 0 \Rightarrow I_2 = I_1 - I_6 = 6\times10^{-3} - 3\times10^{-3} \Rightarrow \boxed{I_2 = 3\,mA}$

2.12 Find I_o and I_1 in the circuit in Fig. P2.12.

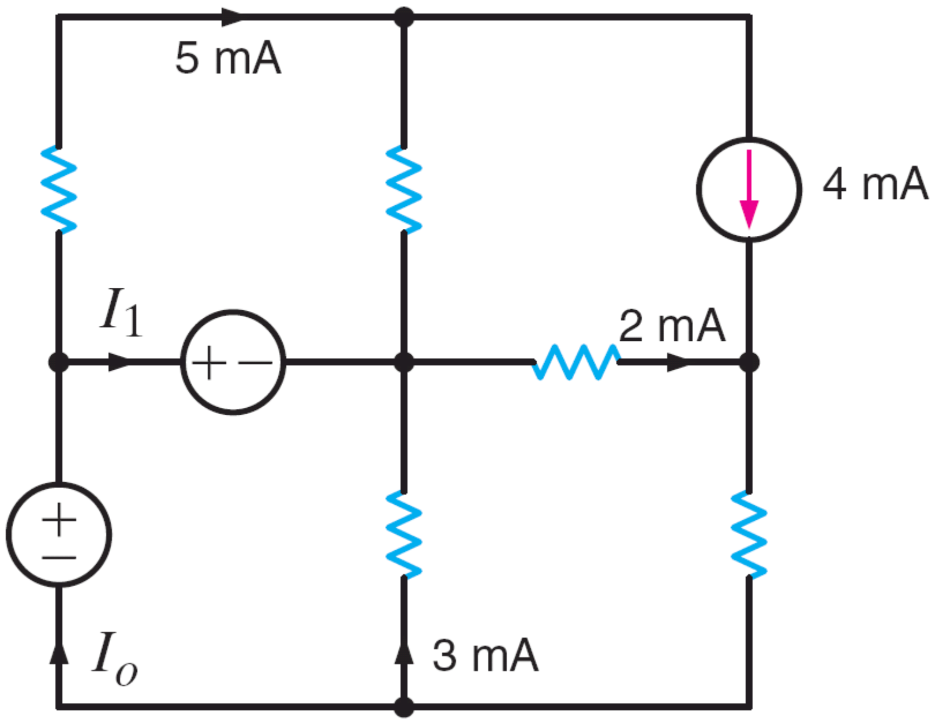
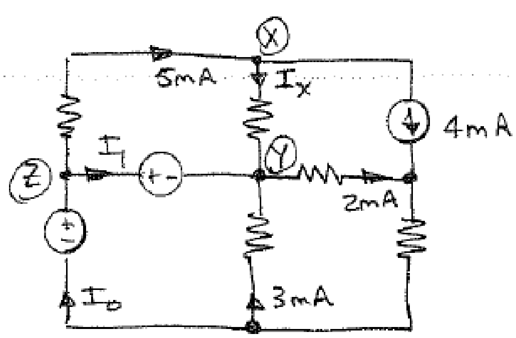


Figure P2.12

SOLUTION:

2.12 Find I_o and I_1



KCL @ (X): currents enter

$5\times10^{-3} - 4\times10^{-3} - I_x = 0 \Rightarrow I_x = 1\,mA$

KCL @ (Y): current enter

$I_x - 2\times10^{-3} + 3\times10^{-3} + I_1 = 0 \Rightarrow \boxed{I_1 = -2\,mA}$

KCL @ (Z): currents enter

$-5\times10^{-3} - I_1 + I_o = 0 \Rightarrow \boxed{I_o = 3\,mA}$

2.13 Find I_x in the circuit in Fig. P2.13.

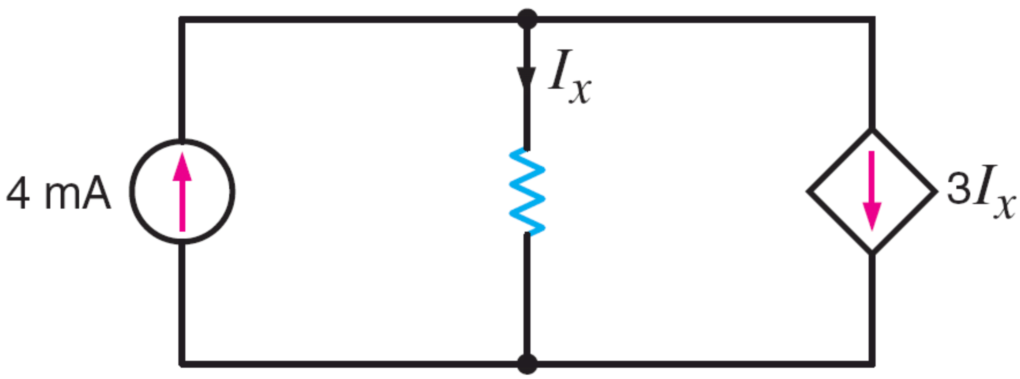
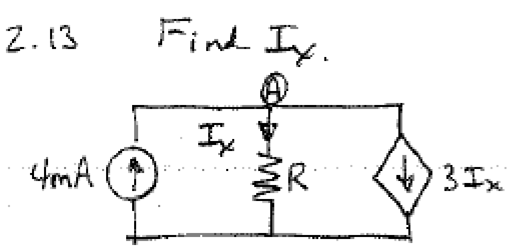


Figure P2.13

SOLUTION:



KCL @ Ⓐ: currents leaving

$$-4\times10^{-3} + I_x + 3I_x = 0$$

$$4I_x = 4\times10^{-3}$$

$$\boxed{I_x = 1\text{mA}}$$

2.14 Find I_x in the circuit in Fig. P2.14. **PSV**

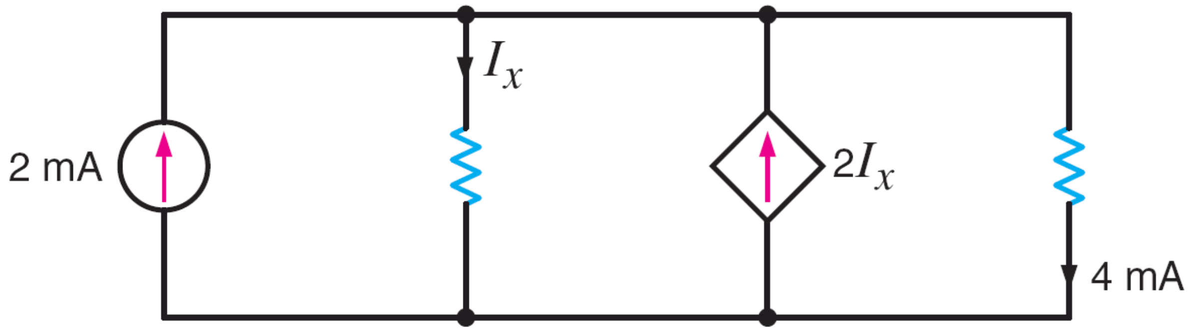
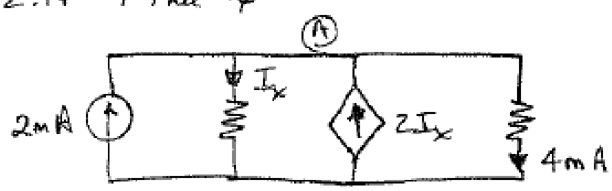


Figure P2.14

SOLUTION:

2.14 Find I_x



KCL @ Ⓐ : currents leaving

$$-2\times10^{-3} + 4\times10^{-3} + I_x - 2I_x = 0$$

$$\boxed{I_x = 2\,mA}$$

2.15 Find I_x in the circuit in Fig. P2.15. **CS**

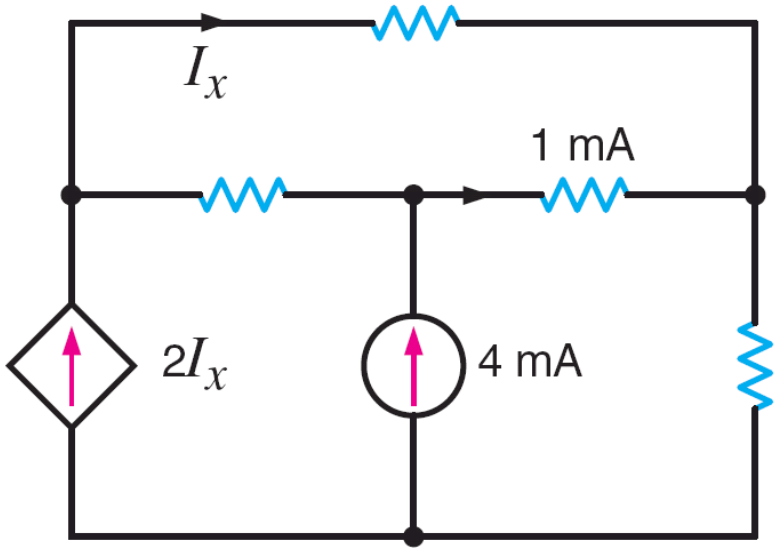
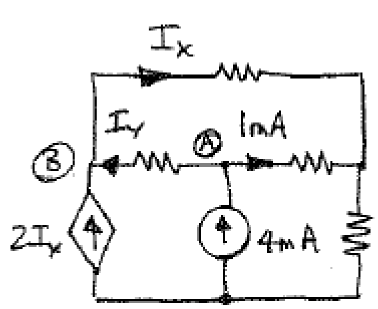


Figure P2.15

SOLUTION:

2.15 Find I_x.



KCL @ Ⓐ: currents leaving

$-4\times10^{-3} + 10^{-3} + I_y = 0 \qquad I_y = 3\,mA$

KCL @ Ⓑ: currents entering

$I_y + 2I_x - I_x = 0 \qquad \boxed{I_x = -3\,mA}$

2.16 Find V_x in the circuit in Fig. P2.16. **CS**

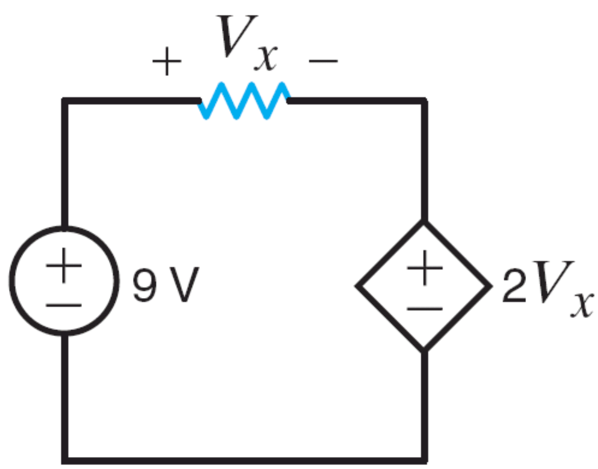
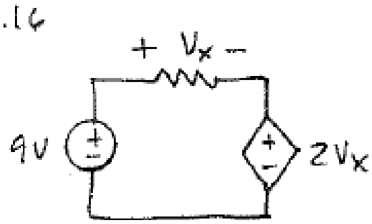


Figure P2.16

SOLUTION:

2.16



Find V_x.

KVL: $-9 + V_x + 2V_x = 0 \Rightarrow \boxed{V_x = 3V}$

2.17 Find V_{fb} and V_{ec} in the circuit in Fig. P2.17.

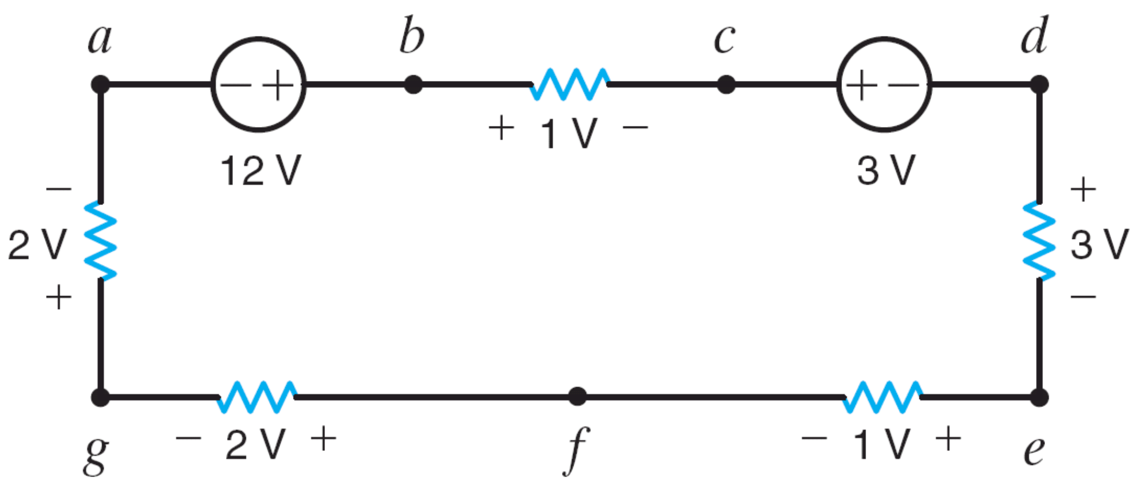
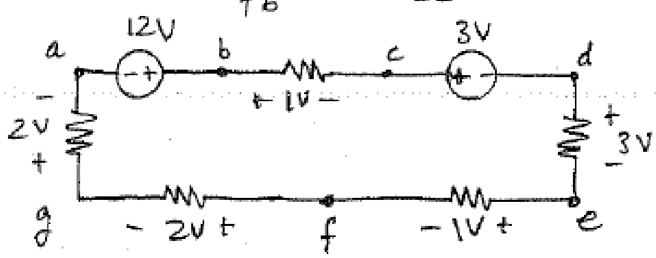


Figure P2.17

SOLUTION:

2.17 Find V_{fb} and V_{ec}



KVL along abfga:

$-12 + V_{bf} + 2 + 2 = 0$

$V_{bf} = 8V \Rightarrow \boxed{V_{fb} = -8V}$

KVL along cdec: $3 + 3 + V_{ec} = 0 \Rightarrow \boxed{V_{ec} = -6V}$

2.18 Find V_{ac} in the circuit in Fig. P2.18. CS

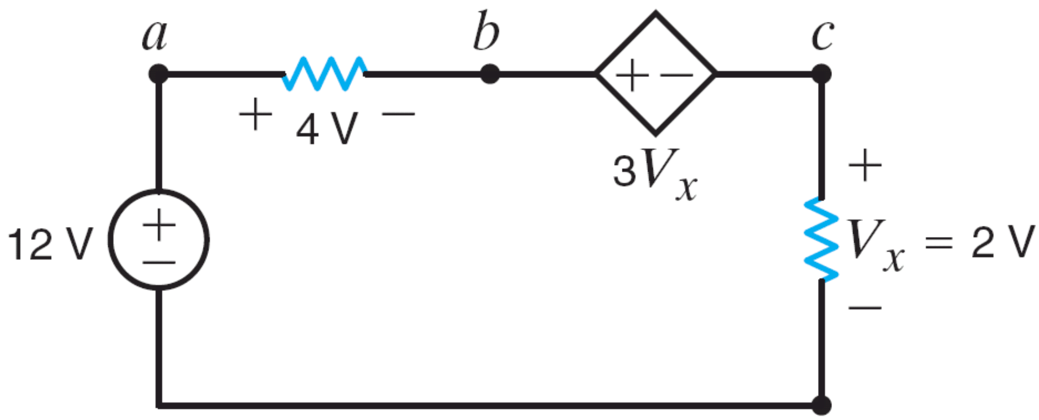
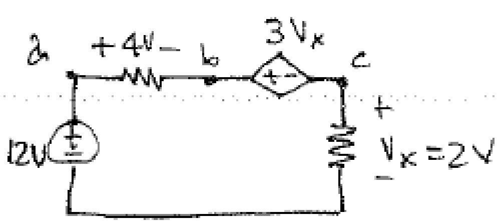


Figure P2.18

SOLUTION:

2.18 Find V_{ac}



$V_{ac} = V_{ab} + V_{bc} = 4 + 3V_x$

$V_x = 2\text{ V}$

$\boxed{V_{ac} = 10\text{V}}$

2.19 Find V_{da} and V_{be} in the circuit in Fig. P2.19.

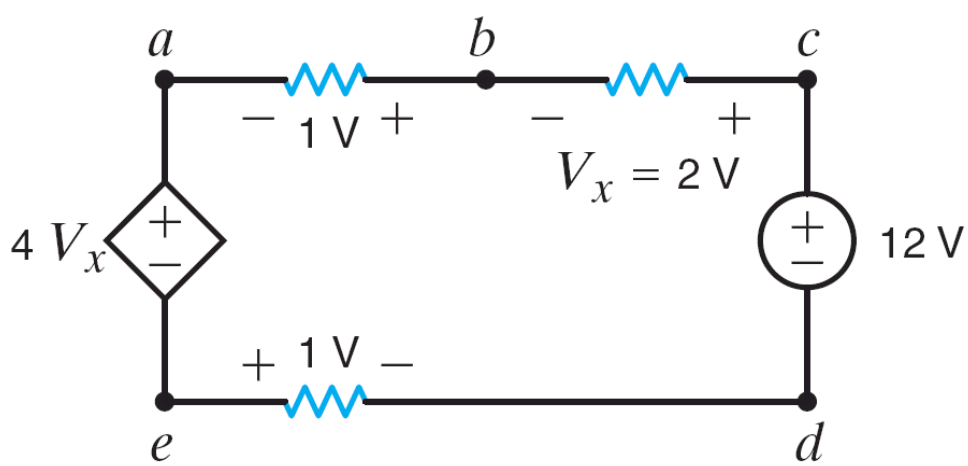
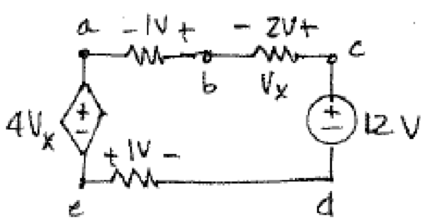


Figure P2.19

SOLUTION:

2.19 Find V_{da} and V_{be}



$V_{da} = V_{dc} + V_{cb} + V_{ba} = -12 + 2 + 1 = -9$

$\boxed{V_{da} = -9\text{V}}$

$V_{be} = V_{bc} + V_{cd} + V_{de} = -2 + 12 - 1 = 9$

$\boxed{V_{be} = 9\text{V}}$

2.20 The 10-V source absorbs 2.5 mW of power. Calculate V_{ba} and the power absorbed by the dependent voltage source in Fig. P2.20.

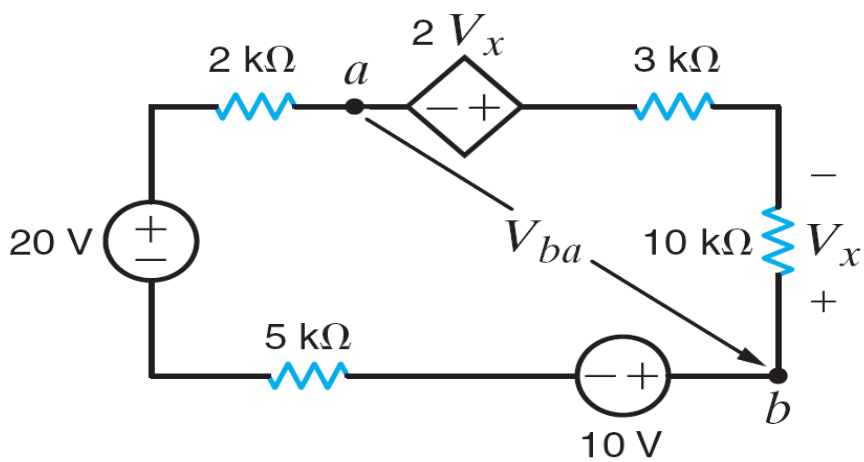
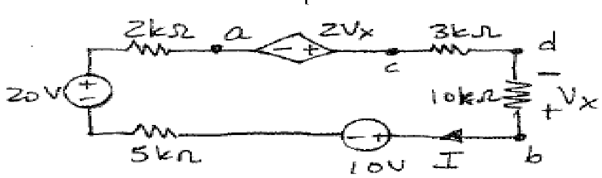


Figure P2.20

SOLUTION:

2.20 P_{10V} = 2.5mW absorbed. Find V_{ba} & power absorbed by dependent source



$P_{10V} = 10I = 2.5mW$

$I = 250\mu A$

$V_{ba} = V_{bd} + V_{dc} + V_{ca}$

$V_{bd} = -I(10 \times 10^3) = -2.5V$

$V_{dc} = -I(3 \times 10^3) = -0.75V$

$V_{ca} = 2V_x \qquad V_x = V_{bd} = -2.5V$

$V_{ca} = -5V$

$\boxed{V_{ba} = -8.25V}$

$P_{DS} = -(2V_x)(I) \qquad V_x = V_{bd} = -2.5V \qquad I = 250\mu A$

$\boxed{P_{DS} = 1.25mW}$

2.21 Find V_o in the network in Fig. P2.21.

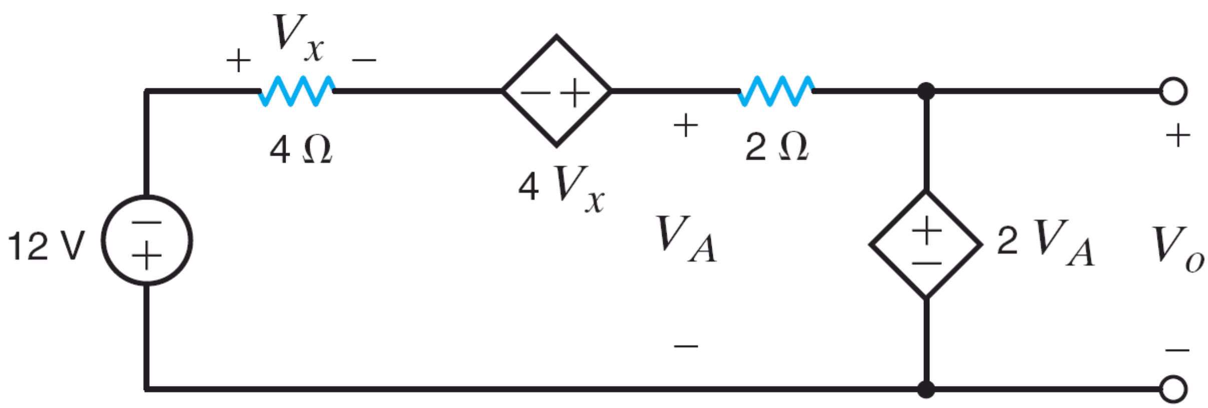
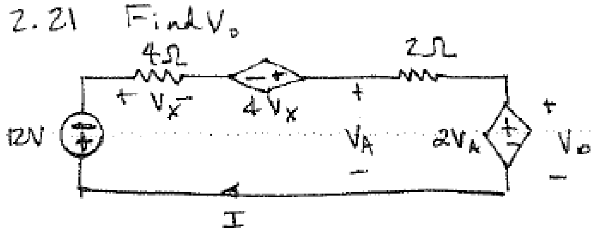


Figure P2.21

SOLUTION:

2.21 Find V_o



KVL:

$$12 + 4I - 4V_x + 2I + 2V_A = 0 \quad (1)$$

$$V_x = 4I \quad (2)$$

$$V_A = 2I + 2V_A \Rightarrow V_A = -2I \quad (3)$$

$$V_o = 2V_A \quad (4)$$

Substitute (2) & (3) into (1)

$$12 + 4I - 16I + 2I - 4I = 0$$

$$-14I = -12 \qquad I = 6/7 \text{ A} \Rightarrow V_A = -\frac{12}{7} \text{ V} \Rightarrow \boxed{V_o = -\frac{24}{7} \text{ V}}$$

2.22 Find V_o in the circuit in Fig. P2.22. **PSV**

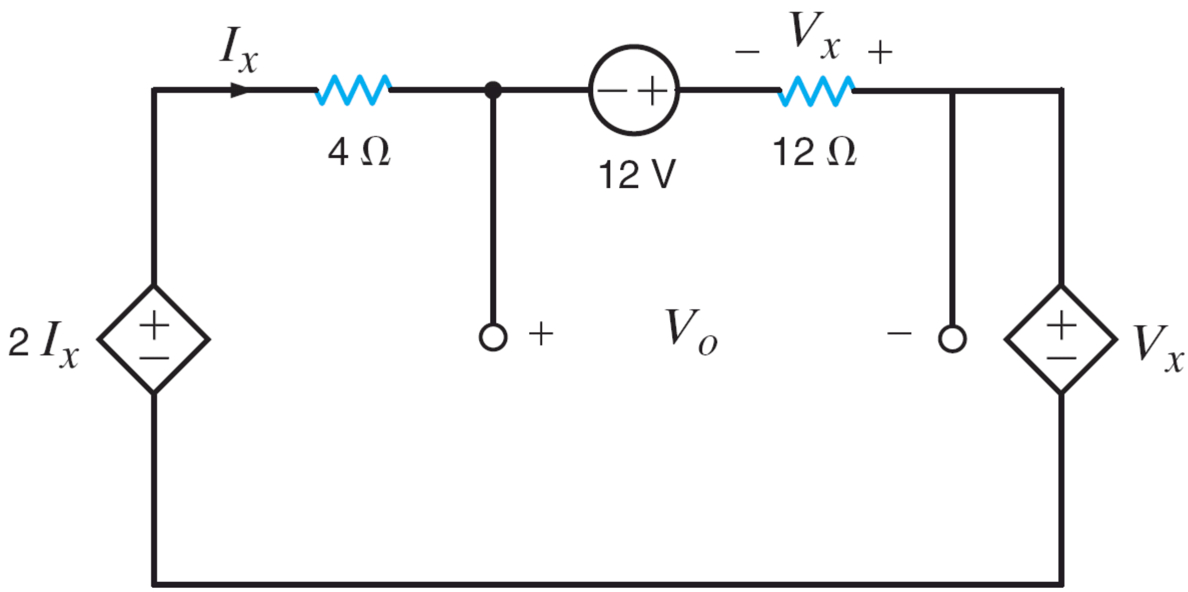
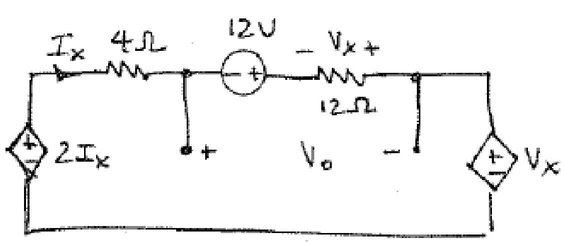


Figure P2.22

SOLUTION:

2.22 Find V_o



KVL :

$$4I_x - 12 + 12I_x + V_x - 2I_x = 0 \quad (1)$$

$$V_x = -12I_x \quad (2)$$

Substitute (2) into (1): $4I_x + 12I_x - 12I_x - 2I_x = 12$

$$2I_x = 12 \Rightarrow I_x = 6\,A$$

$$V_o = -12 + 12I_x = -12 + 12(6) \Rightarrow \boxed{V_o = 60V}$$

2.23 Find V_{ac} in the network in Fig. P2.23.

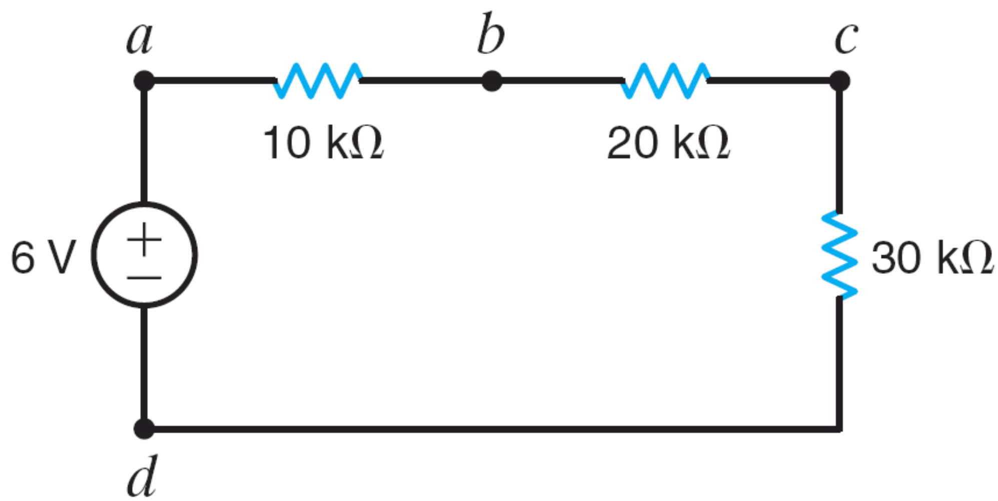
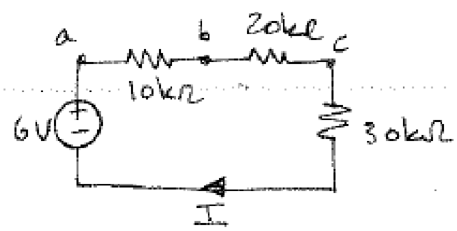


Figure P2.23

SOLUTION:

2.23 Find V_{ac}



KVL: $-6 + 10^4 I + 2\times10^4 I + 3\times10^4 I = 0$

$6\times10^4 I = 6 \Rightarrow I = 100\mu A$

$V_{ac} = V_{ab} + V_{bc} = 10^4 I + 2\times10^4 I$

$\boxed{V_{ac} = 3V}$

2.24 Find both I and V_{bd} in the circuit in Fig. P2.24.

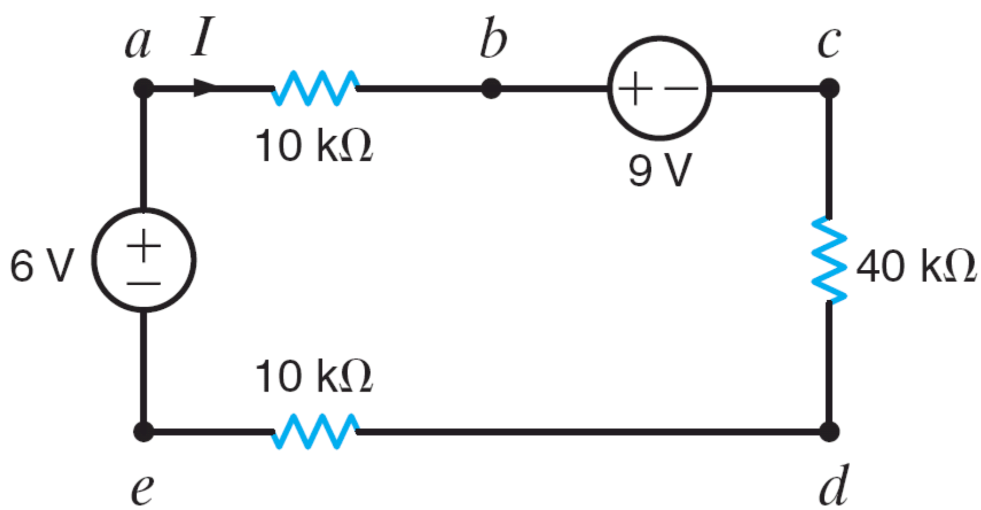
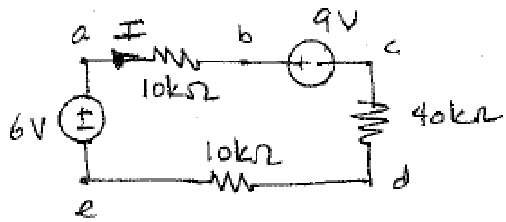


Figure P2.24

SOLUTION:

2.24 Find I and V_{bd}.



KVL: $-6 + 10^4 I + 9 + 4\times10^4 I + 10^4 I = 0$

$6\times10^4 I = -3$ $\boxed{I = -50.0\,\mu A}$

$V_{bd} = V_{bc} + V_{cd} = 9 + 4\times10^4 I$

$\boxed{V_{bd} = 7\,V}$

2.25 Find V_x in the circuit in Fig. P2.25. CS

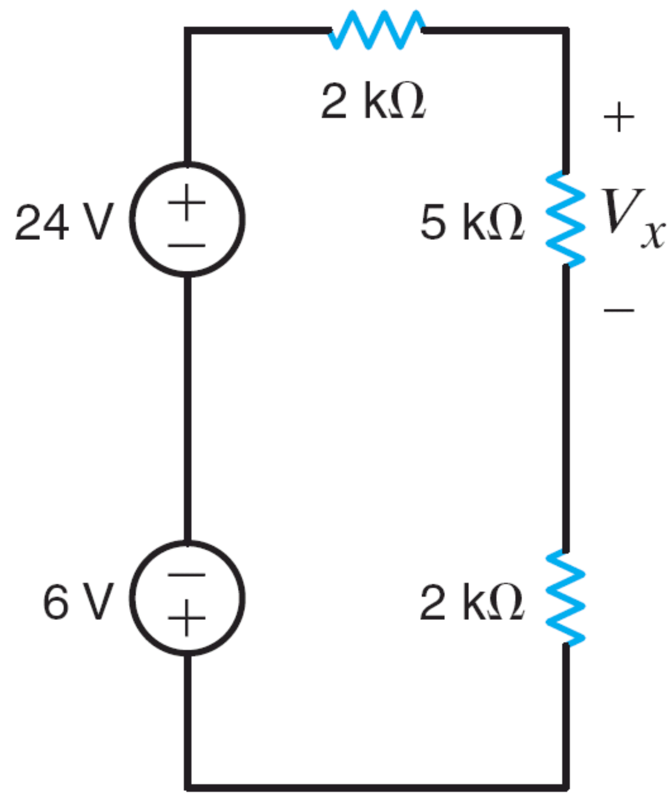
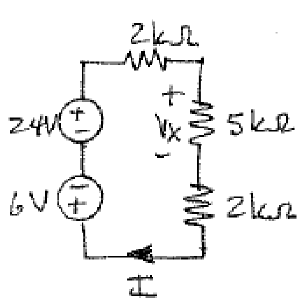


Figure P2.25

SOLUTION:

2.25 Find V_x



KVL: $6 - 24 + I(2\times10^3) + I(5\times10^3) + I(2\times10^3) = 0$

$9\times10^3 I = 18 \Rightarrow I = 2\text{mA}$

$V_x = 5\times10^3 I \Rightarrow \boxed{V_x = 10\text{V}}$

2.26 Find V_1 in the network in Fig. P2.26. **PSV**

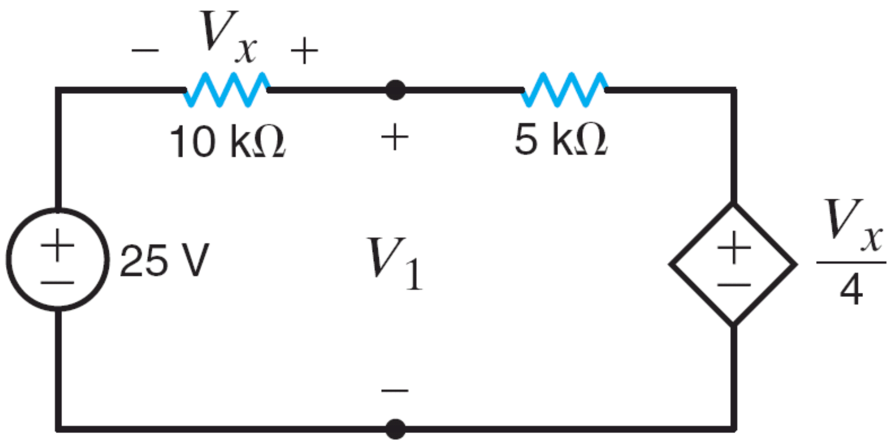
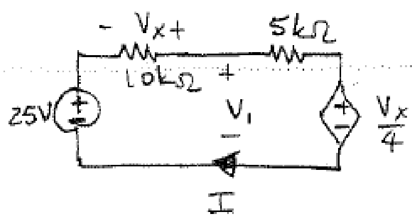


Figure P2.26

SOLUTION:

2.26 Find V_1.



KVL: $-25 + 10^4 I + 5\times10^3 I + V_x/4 = 0$ (1)

also: $V_x = -10^4 I$ (2)

Substitute (2) into (1):

$$-25 + I\left(10^4 + 5\times10^3 - 10^4/4\right) = 0$$

$$I = 2\,mA$$

$V_1 = 25 - 10^4 I \Rightarrow$ $\boxed{V_1 = 5V}$

2.27 Find the power absorbed by the 30-kΩ resistor in the circuit in Fig. P2.27. **CS**

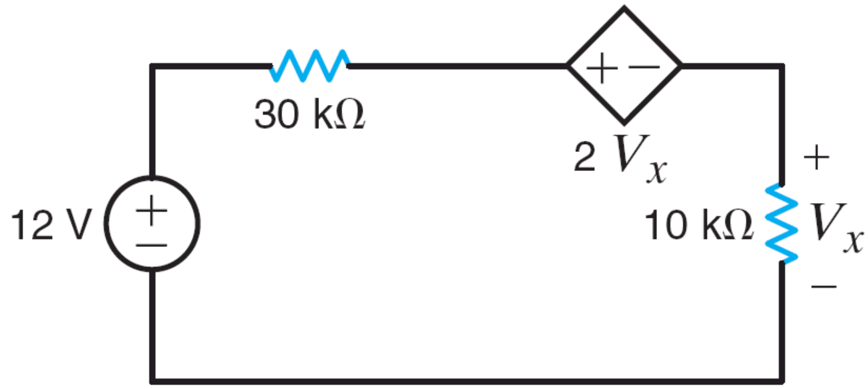
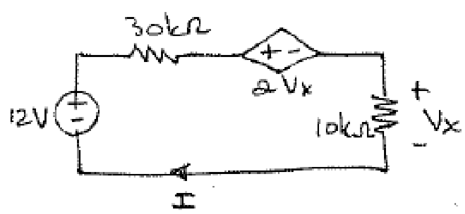


Figure P2.27

SOLUTION:

2.27 Find P_{30k} absorbed.



KVL: $-12 + 3\times10^4 I + 2V_x + 10^4 I$ (1)

also: $V_x = 10^4 I$ (2)

Substitute (2) into (1)

$I(3\times10^4 + 10^4 + 2\times10^4) = 12 \Rightarrow I = 200\,\mu A$

$P_{30k} = 3\times10^4 I^2 \Rightarrow \boxed{P_{30k} = 1.2\,mW}$

2.28 In the network in Fig. P2.28, if $V_x = 12$ V, find V_S.

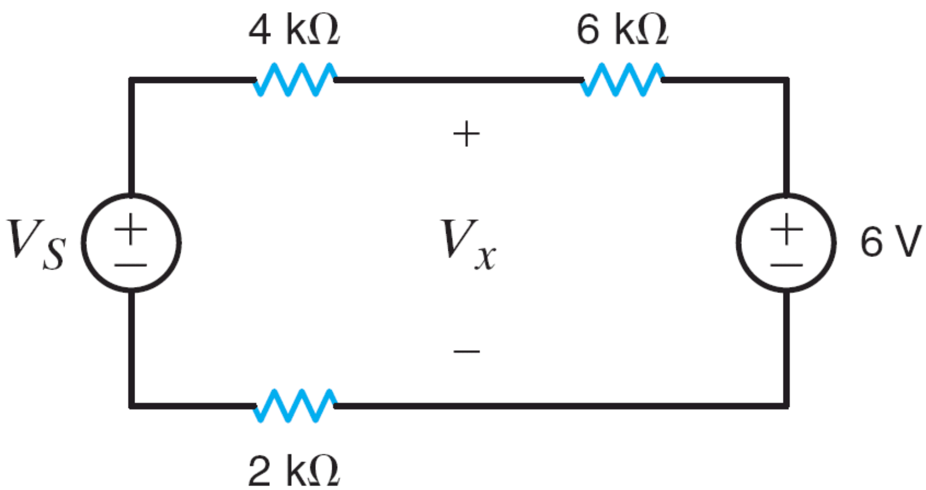
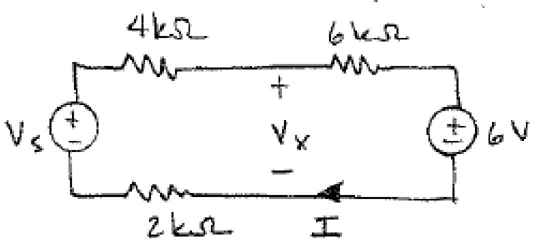


Figure P2.28

SOLUTION:

2.28 Find V_s if $V_x = 12V$



KVL: $-V_x + 6 \times 10^3 I + 6 = 0$

$$I = \frac{12-6}{6 \times 10^3} = 1mA$$

KVL: $-V_s + 4 \times 10^3 I + V_x + 2 \times 10^3 I = 0$

$$\boxed{V_s = 18V}$$

2.29 In the circuit in Fig. P2.29, $P_{3\,k\Omega} = 12$ mW. Find V_S.

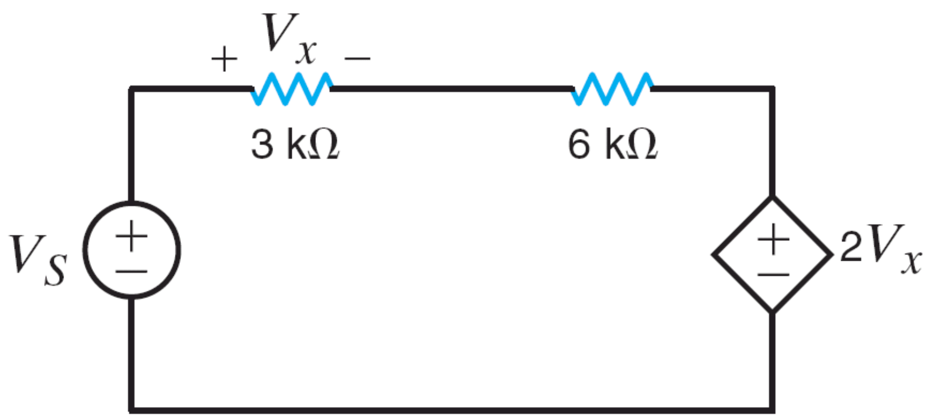
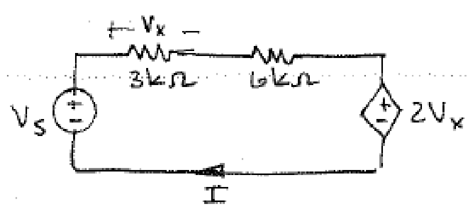


Figure P2.29

SOLUTION:

2.29 $P_{3k} = 12mW$. Find V_s



$$P_{3k} = 12mW = I^2 (3\times10^3)$$

$$I = \sqrt{\frac{12\times10^{-3}}{3\times10^{3}}} \Rightarrow I = 2mA$$

KVL: $-V_s + 3\times10^3 I + 6\times10^3 I + 2V_x = 0$ (1)

and: $V_x = I(3\times10^3)$ (2)

substitute (2) into (1): $I(3\times10^3 + 6\times10^3 + 6\times10^3) = V_s \Rightarrow \boxed{V_s = 30V}$

2.30 If $V_o = 4$ V in the network in Fig. P2.30, find V_S.

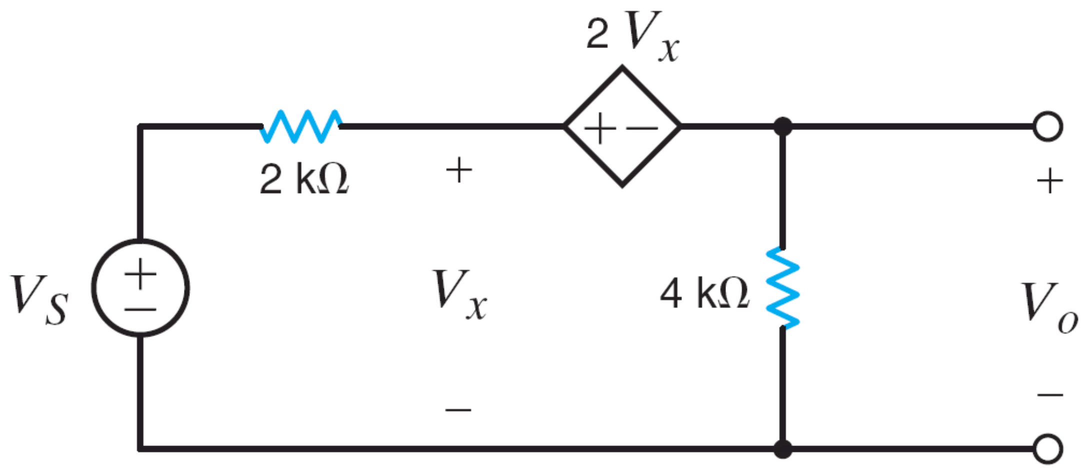
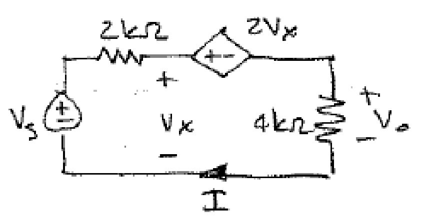


Figure P2.30

SOLUTION:

2.30 $V_o = 4V$, find V_S



KVL: $-V_S + 2\times10^3 I + 2V_x + 4\times10^3 I = 0$ (1)

also: $-V_x + 2V_x + V_o = 0 \Rightarrow V_x = -4V$ (2)

and $V_o = 4\times10^3 I \Rightarrow I = 1mA$ (3)

substitute (2) & (3) into (1): $I(6\times10^3) + 2V_x = V_S \Rightarrow \boxed{V_s = -2V}$

2.31 If $V_A = 12$ V in the circuit in Fig. P2.31, find V_S.

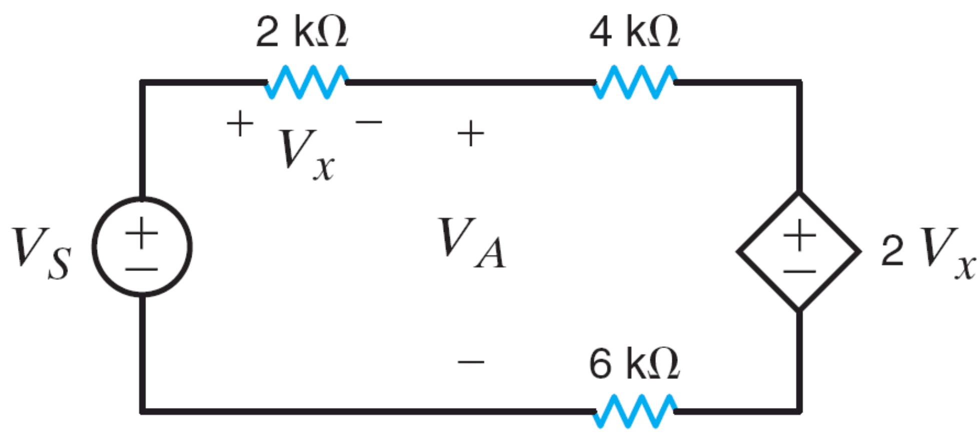
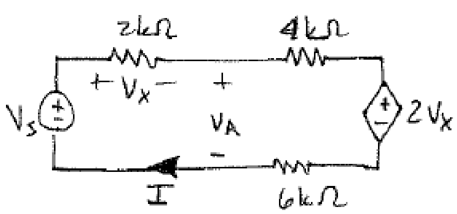


Figure P2.31

SOLUTION:

2.31 $V_A = 12\text{V}$. Find V_s.



KVL: $-V_S + 2\times10^3 I + 4\times10^3 I + 2V_x + 6\times10^3 I = 0$ (1)

KVL: $-V_A + 4\times10^3 I + 2V_x + 6\times10^3 I = 0$ (2)

also: $V_x = 2\times10^3 I$ (3)

Substitute (3) into (2): $-12 + I(4\times10^3 + 4\times10^3 + 6\times10^3) = 0$

$I = \frac{6}{7}$ mA

Substitute (3) into (1): $I[2+4+4+6]\times10^3 = V_S$

$$\boxed{V_s = \frac{96}{7}\text{ V} = 13.7\text{ V}}$$

2.32 A commercial power supply is modeled by the network shown in Fig. P2.32.

(a) Plot V_o versus R_{load} for $1\ \Omega \leq R_{\text{load}} \leq \infty$.

(b) What is the maximum value of V_o in (a)?

(c) What is the minimum value of V_o in (a)?

(d) If for some reason the output should become short circuited, that is, $R_{\text{load}} \rightarrow 0$, what current is drawn from the supply?

(e) What value of R_{load} corresponds to maximum power consumed?

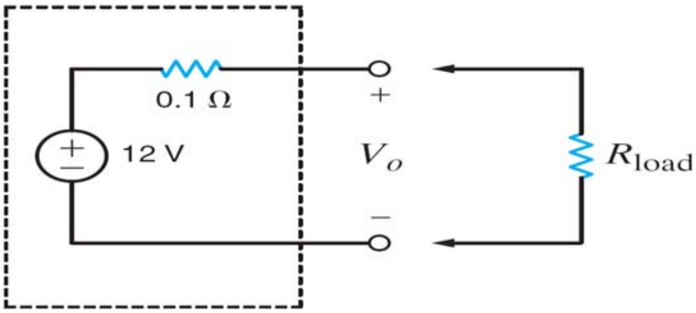
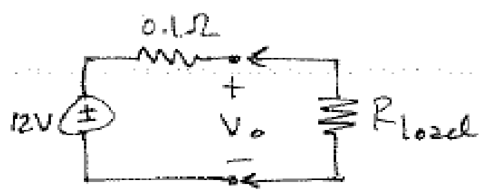


Figure P2.32

SOLUTION:

2.32 $1\Omega \leq R_{load} \leq \infty$

a) $V_o = 12\left[\dfrac{R_{load}}{R_{load}+0.1}\right]$



b) $V_{o\,max}$ occurs when $R_{load} = \infty$

$$V_o = 12\left[\frac{R_{load}}{0.1+R_{load}}\right]$$

$$\boxed{V_{o\,max} = 12V}$$

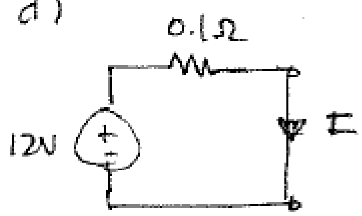
Continued on the next page.

c) $V_{o\,min}$ occurs when $R_{load} = 1\Omega$

$$V_{o\,min} = 12\left[\frac{1}{1+0.1}\right]$$

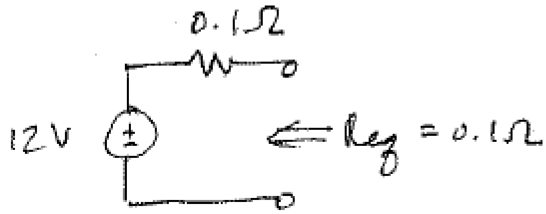
$$\boxed{V_{o\,min} = 10.9\,V}$$

d)



$$\boxed{I = \frac{12}{0.1} = 120A}$$

e) for max. power at R_{load}, $\boxed{R_{load} = R_{eq} = 0.1\Omega}$



2.33 A commercial power supply is guaranteed by the manufacturer to deliver 5 V ±1% across a load range of 0 to 10 A. Using the circuit in Fig. P2.33 to model the supply, determine the appropriate values of *R* and *V*.

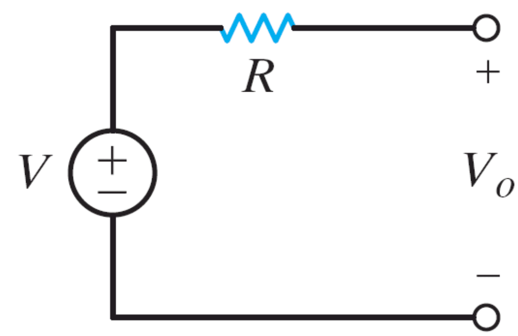
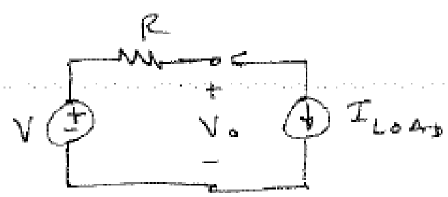


Figure P2.33

SOLUTION:

2.33. $V_o = 5 \pm 1\%$ for load of 0 to 10A. Find V & R.



at $I_{LOAD} = 0A$,

$$V_o = V = V_{o\,max} = 5(1.01)$$

$$\boxed{V = 5.05\,V}$$

at $I_{LOAD} = 10A$,

$$V_o = V - I_{LOAD}R = 5.05 - 10(R) = 5(0.99)$$

$$\boxed{R = 10\,m\Omega}$$

2.34 A power supply is specified to provide 48 ±2 V at 0–200 A and is modeled by the circuit in Fig. P2.34.

(a) What are the appropriate values for V and R?

(b) What is the maximum power the supply can deliver? What values of I_{load} and V_o correspond to that level?

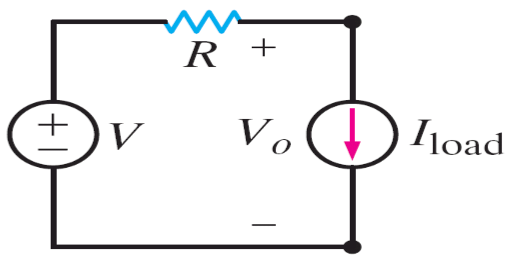


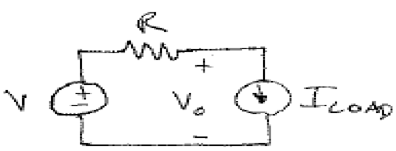
Figure P2.34

SOLUTION:

2.34 $V_o = 48 \pm 2V$ at I_{LOAD} from 0 → 200 A.

a). Find V & R.

b). Find P_{LOAD} max & corresponding I_{LOAD} & V_o



a) At $I_{LOAD} = 0A$, $V_o = V_{omax} = 50V$

$$\boxed{V_o = V = 50V}$$

At $I_{LOAD} = 200A$,

$$V_o = V - I_{LOAD}R = 46V$$

$$\boxed{R = 20\,m\Omega}$$

b) Max P_{LOAD} occurs at

$$\frac{\partial P_{OUT}}{\partial I_{LOAD}} = 0 \qquad P_{LOAD} = I_{LOAD}V_o = I_{LOAD}(V - RI_{LOAD})$$

$$\frac{\partial P_{OUT}}{\partial I_{LOAD}} = V - 2RI_{LOAD} = 0 \Rightarrow I_{LOAD} = V/2R$$

at max power out: $I_{LOAD} = 1250\,A$ ← beyond specs

∴ Max power occurs at $I_{LOAD} = 200A$ & $V_o = 46V$

2.35 Although power supply loads are often modeled as either resistors or constant current sources, some loads are best modeled as constant power loads, as indicated in Fig. P2.35. Given the model shown in the figure,

(a) Write a V–I expression for a constant power load that always draws P_L watts.

(b) If $P_L = 40$ W, $V_{ps} = 9$ V and $I_o = 5$ A, determine the values of V_o and R_{ps}.

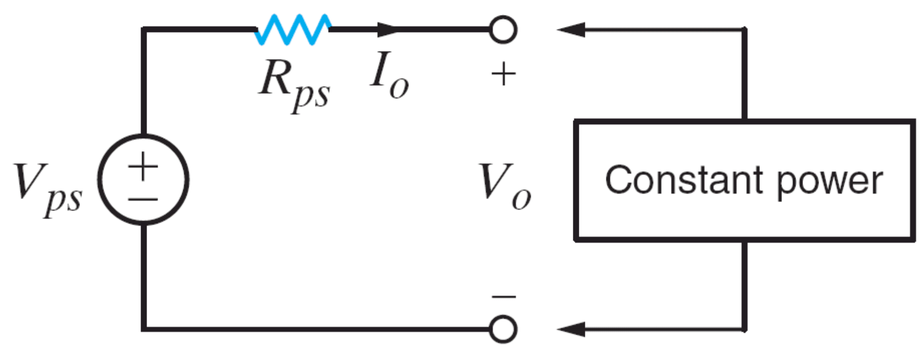
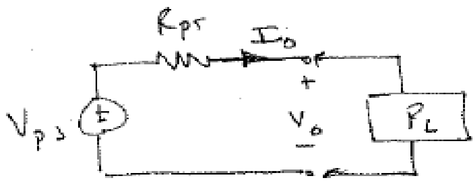


Figure P2.35

SOLUTION:

2.35 a) Write V-I expression for load @ $P = P_L$.

b) $P_L = 40W$ $V_{ps} = 9V$ $I_o = 5A$, find V_o & R_{ps}.



a) for the load $P_L = V_L I_L$

$$V_L = P_L / I_L$$

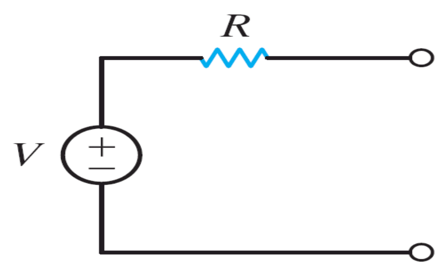
b) $V_o = P_L / I_o \Rightarrow V_o = 8V$

$$R_{ps} = \frac{V_{ps} - V_o}{I_o} = \frac{9-8}{5} \quad R_{ps} = 0.2\,\Omega$$

2.36 A student needs a 15-V voltage source for research. She has been able to locate two power supplies, a 10-V supply and a 5-V supply. The equivalent circuits for the two supplies are shown in Fig. P2.36.

(a) Draw an equivalent circuit for the effective 15-V supply.

(b) If she can tolerate a 0.5-V deviation from 15 V, what is the maximum current change the combined supply can satisfy?



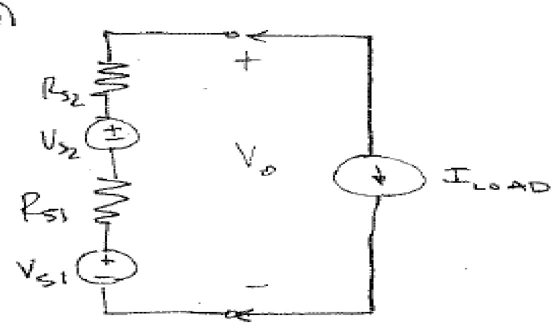
Voltage	5 V	10 V
Resistance	0.25 Ω	0.05 Ω

Figure P2.36

SOLUTION:

2.36 $V_{S1} = 5V$, $R_{S1} = 0.25\Omega$, $V_{S2} = 10V$ $R_{S2} = 0.05\Omega$

a)



b) $V_o = V_{S1} + V_{S2} - I(R_{S1} + R_{S2})$

$V_{o\,min} = 14.5 = 15 - I_o(0.3)$

$I_{o\,max} = \frac{0.5}{0.3}$

$I_{o\,max} = 1.67A$

2.37 Given the network in Fig. P2.37, we wish to obtain a voltage of $2\text{ V} \le V_o \le 9\text{ V}$ across the full range of the pot. Determine the values of R_1 and R_2.

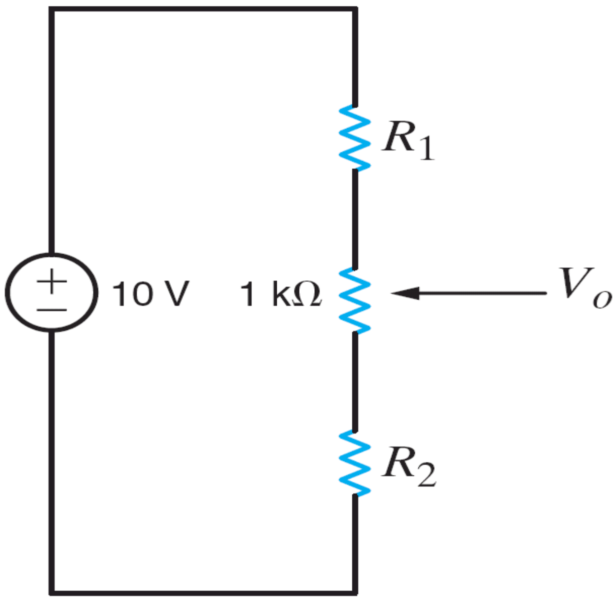
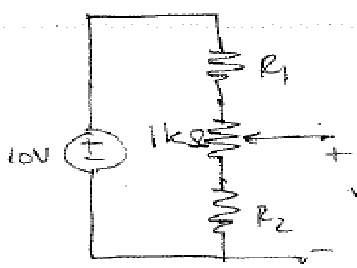


Figure P2.37

SOLUTION:

2.37 $2V \le V_o \le 9V$ Find R_1 & R_2.



Case a: wiper at bottom of variable R.

$$V_o = 10\left[\frac{R_2}{R_1 + R_2 + 1000}\right] = V_{o_{min}} = 2V$$

Case b: wiper at top of variable R,

$$V_o = 10\left[\frac{R_2 + 1000}{R_1 + R_2 + 1000}\right] = V_{o\,max} = 9V$$

$$\frac{V_{o\,max}}{V_{o\,min}} = \frac{9}{2} = \frac{R_2 + 1000}{R_2} \Rightarrow \boxed{\begin{array}{l} R_2 = 286\,\Omega \\ R_1 = 144\,\Omega \end{array}}$$

2.38 Determine I_L in the circuit in Fig. P2.38.

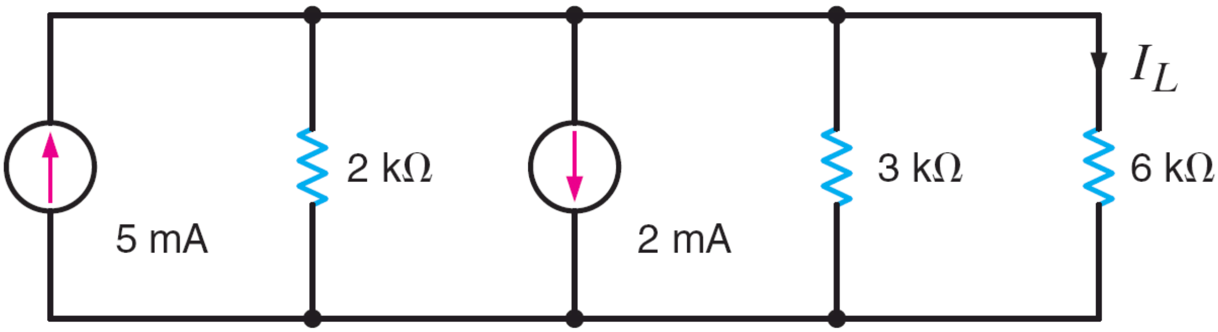
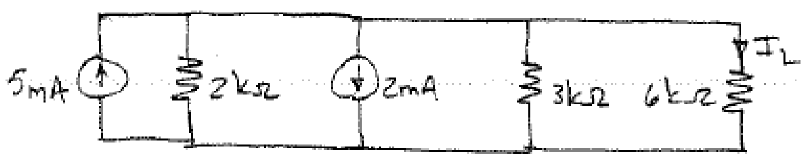
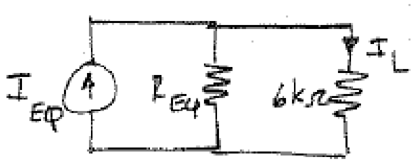


Figure P2.38

SOLUTION:

2.38 Find I_L.





$I_{EQ} = 5\times10^{-3} - 2\times10^{-3} = 3\text{mA}$

$R_{EQ} = 2000 // 3000 = 1200\,\Omega$

Current division: $I_L = I_{EQ}\left[\dfrac{R_{EQ}}{R_{EQ}+6000}\right]$

$\boxed{I_L = 0.5\text{mA}}$

2.39 Find V_o in the circuit in Fig. P2.39. CS

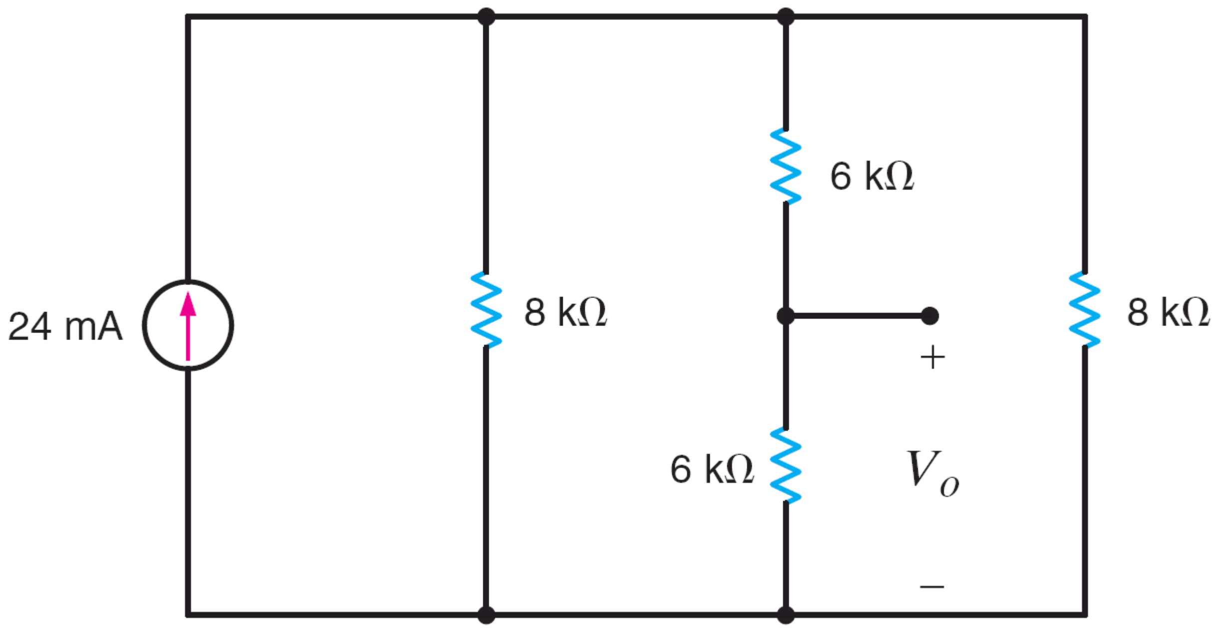
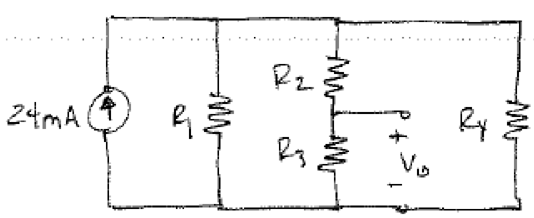


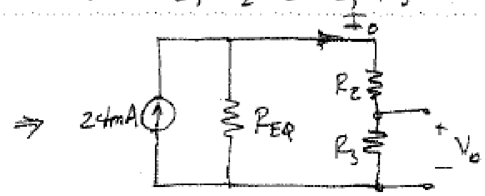
Figure P2.39

SOLUTION:

2.39 Find V_o



$R_1 = 8k\Omega$, $R_2 = 6k\Omega$, $R_3 = 6k\Omega$, $R_4 = 8k\Omega$



$R_{EQ} = R_1 // R_4 = 4k\Omega$

By current division: $I_o = 24 \times 10^{-3} \left[\frac{R_{EQ}}{R_{EQ} + (R_2 + R_3)} \right] = 6mA$

$V_o = R_3 I_o$ $\quad$ $\boxed{V_o = 36V}$

2.40 Find I_o in the network in Fig. P2.40. **PSV**

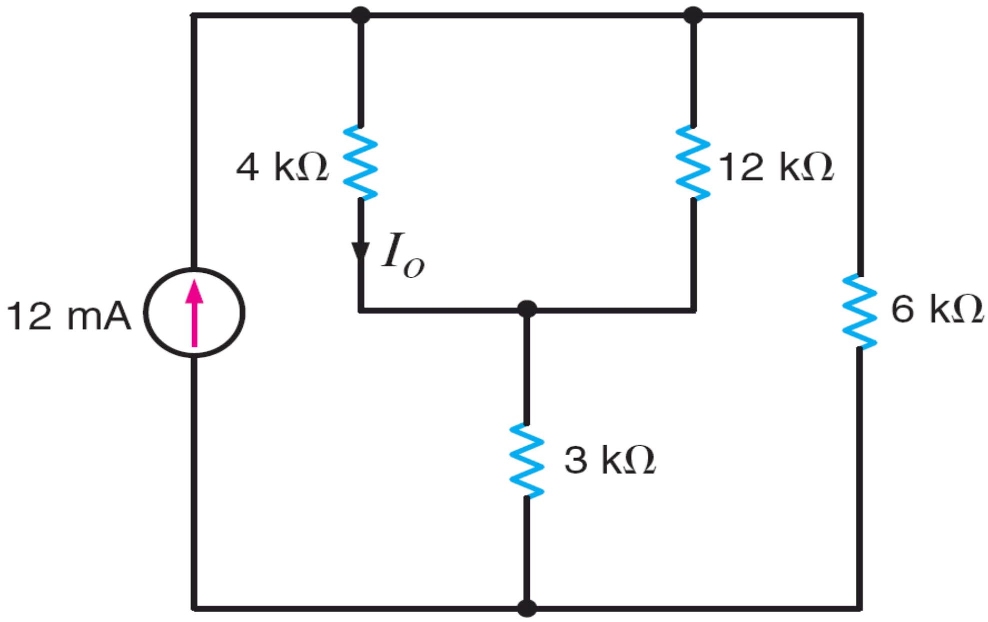
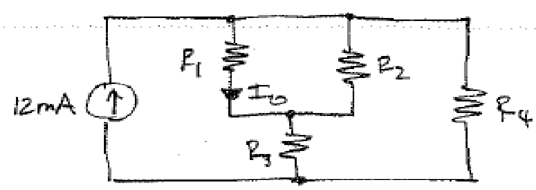


Figure P2.40

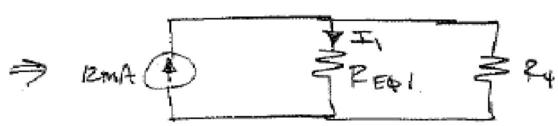
SOLUTION:

2.40 Find I_o

$R_1 = 4k\Omega$, $R_2 = 12k\Omega$, $R_3 = 3k\Omega$, $R_4 = 6k\Omega$



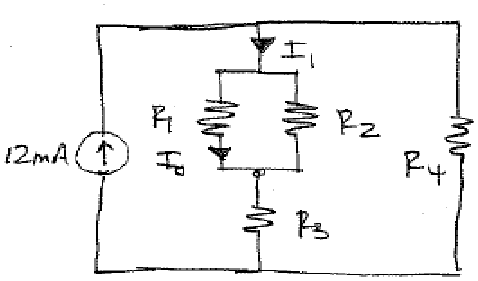
⇒



$$I_1 = 12\times10^{-3}\left[\frac{R_4}{R_4+R_{EQ1}}\right] = 6mA$$

$$R_{EQ1} = (R_1 /\!/ R_2) + R_3 = 6k\Omega$$

Isolate R_1 & R_2



Current division: $I_o = I_1\left[\frac{R_2}{R_1+R_2}\right]$

$$\boxed{I_o = 4.5mA}$$

2.41 Find V_o in the network in Fig. P2.41.

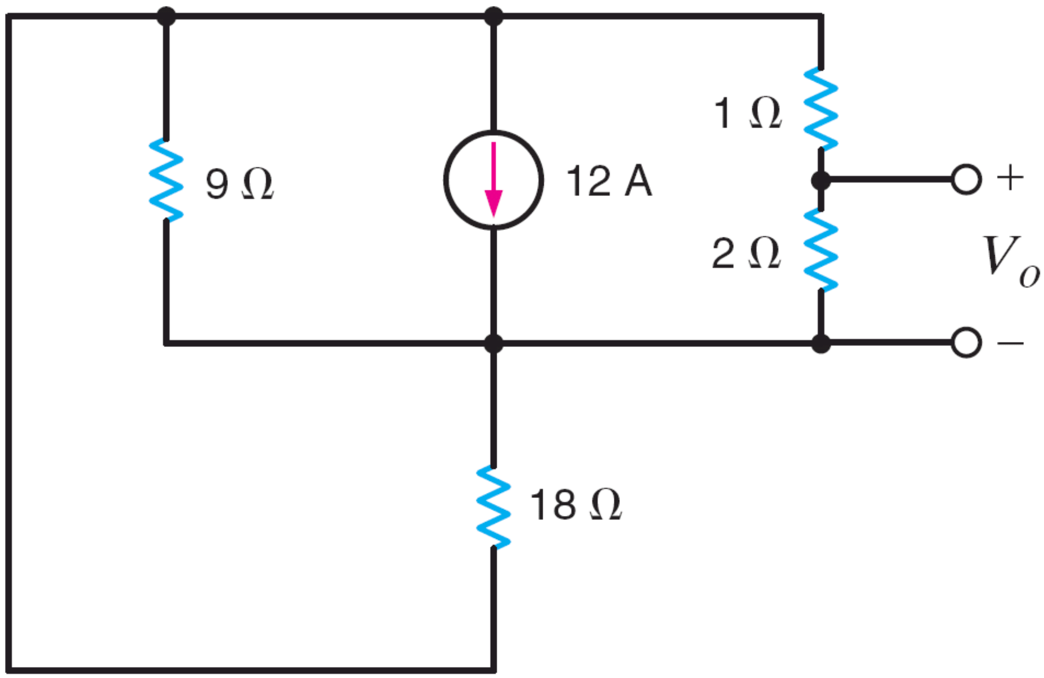
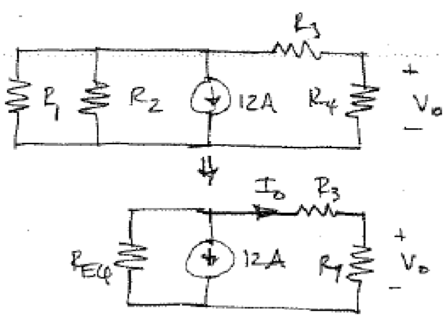


Figure P2.41

SOLUTION:

2.41 Find V_o (circuit is redrawn for readibility)



$R_1 = 18\Omega,\ R_2 = 9\Omega,\ R_3 = 1\Omega,\ R_4 = 2\Omega$

$R_{EQ} = R_1 // R_2 = 6\Omega$

Current division: $I_o = -12\left[\dfrac{R_{EQ}}{R_{EQ} + (R_3 + R_4)}\right]$

$I_o = -8A$

$V_o = I_o R_4$ $\boxed{V_o = -16V}$

2.42 In the network in Fig. P2.42, $P_{6\,\mathrm{k}\Omega} = 96$ mW. Find I_S.

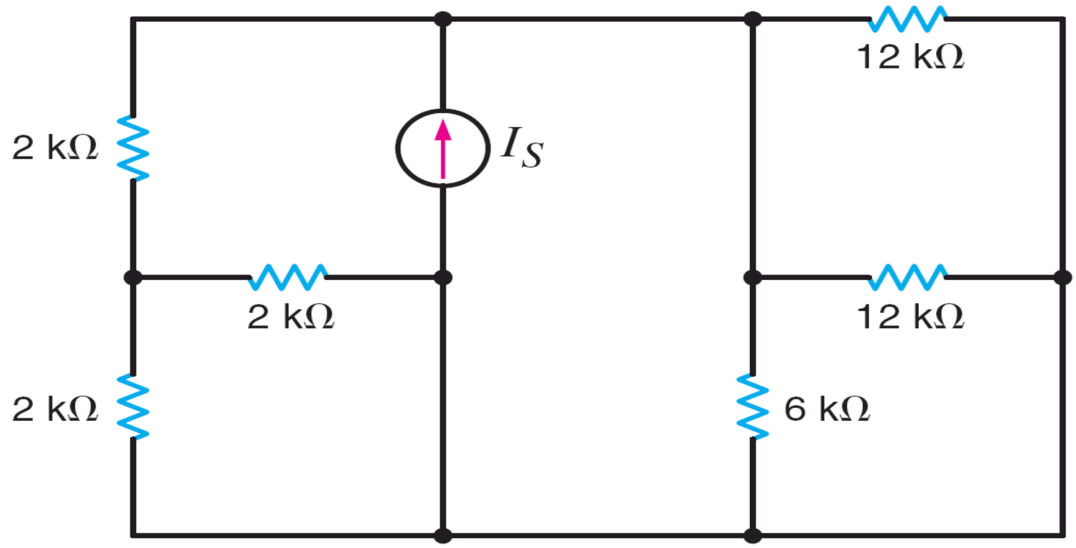
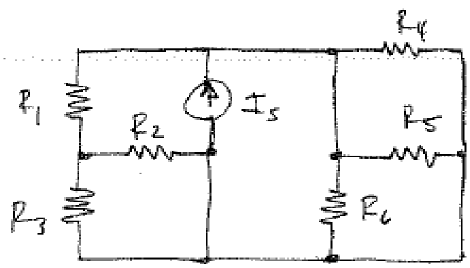


Figure P2.42

SOLUTION:

2.42 $P_{R6} = 96\text{mW}$. Find I_S.

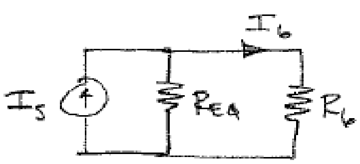


$R_1 = R_2 = R_3 = 2\text{k}\Omega$ $R_4 = R_5 = 12\text{k}\Omega$ $R_6 = 6\text{k}\Omega$

⇒

$R_{EQ1} = (R_3 // R_2) + R_1 = 3\text{k}\Omega$

$R_{EQ2} = R_4 // R_5 = 6\text{k}\Omega$



$R_{EQ} = R_{EQ1} // R_{EQ2} = 2\text{k}\Omega$

Current division: $I_6 = I_S \left[\dfrac{R_{EQ}}{R_{EQ} + R_6} \right] = \dfrac{I_S}{4}$

Also,

$P_{R_6} = I_6^2 R_6 = 96\text{mW}$ $I_6 = 4\text{mA}$ ⇒ $\boxed{I_S = 16\text{mA}}$

2.43 In the circuit in Fig. P2.43, $V_x = 12$ V. Find V_S.

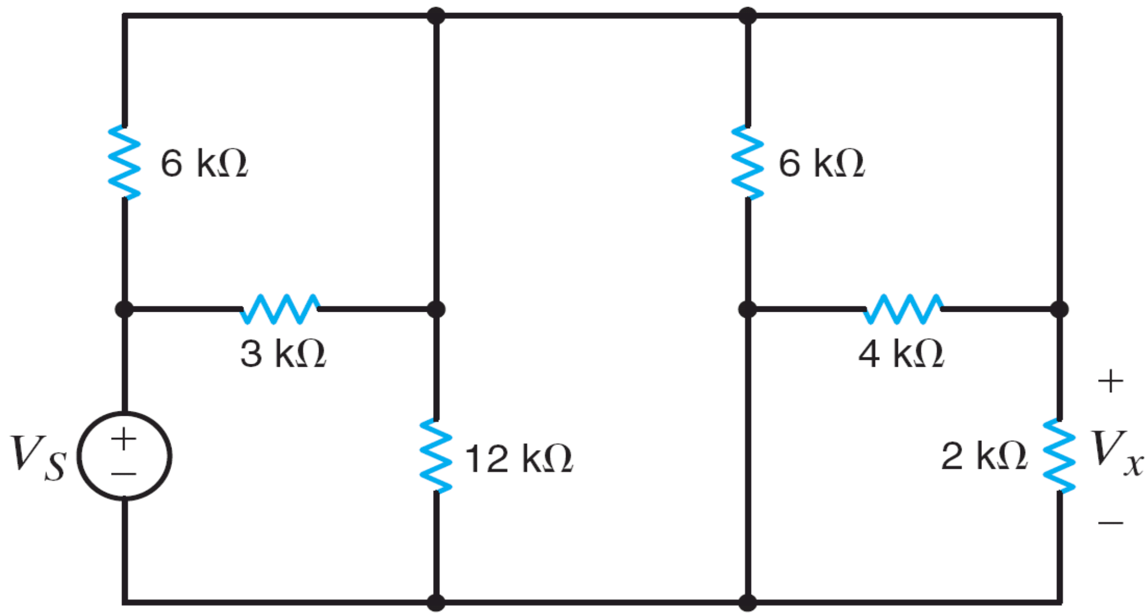


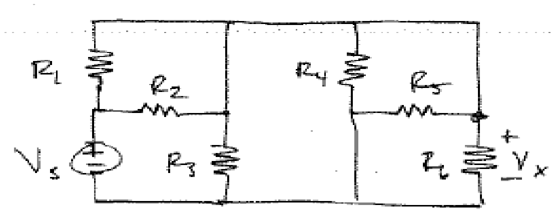
Figure P2.43

SOLUTION:

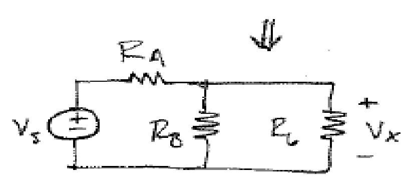
2.43 $V_x = 12V$, Find V_s.

$R_1 = R_4 = 6k\Omega$ $R_2 = 3k\Omega$ $R_3 = 12k\Omega$

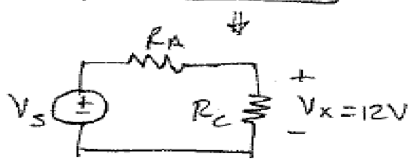
$R_5 = 4k\Omega$ $R_6 = 2k\Omega$



$R_A = R_1 // R_2 = 2k\Omega$ $R_B = R_3 // R_4 // R_5 = 2k\Omega$



$R_C = R_B // R_6 = 1k\Omega$



Voltage ÷ : $V_x = V_s \left[\frac{R_C}{R_A + R_C}\right]$

$\boxed{V_s = 36V}$

2.44 In the circuit in Fig. P2.44, $V_x = 6$ V. Find I_S.

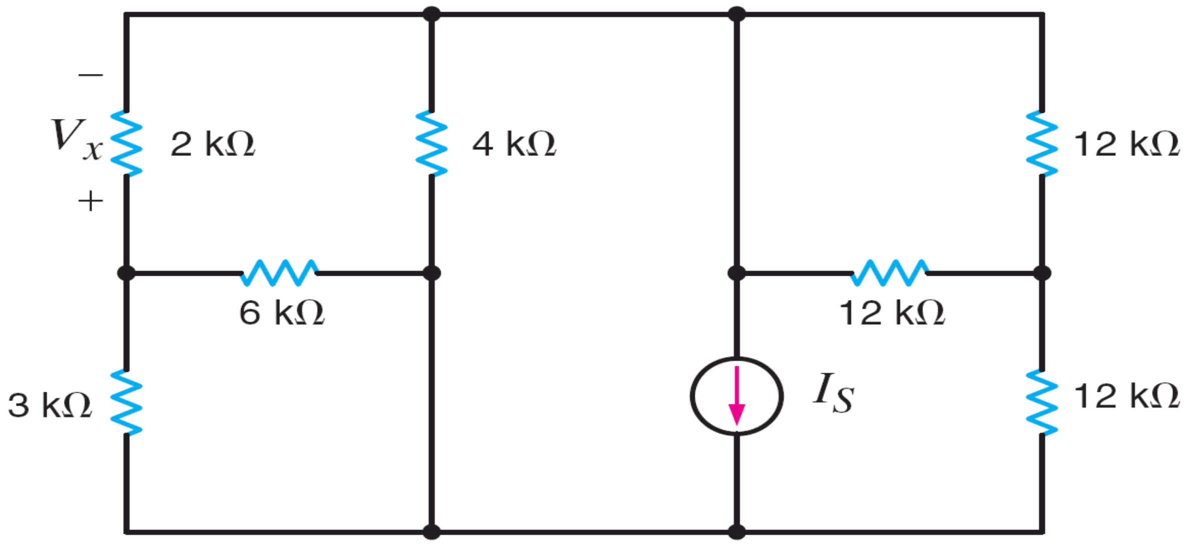
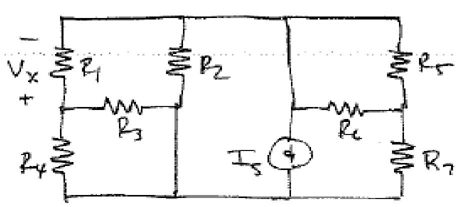


Figure P2.44

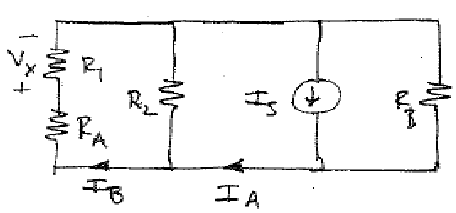
SOLUTION:

2.44. $V_x = 6V$, find I_s.



$R_1 = 2k\Omega$, $R_2 = 4k\Omega$, $R_3 = 6k\Omega$, $R_4 = 3k\Omega$

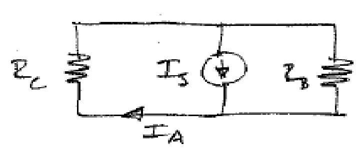
$R_5 = R_6 = R_7 = 12k\Omega$



$R_A = R_3 // R_4 = 2k\Omega$ $\quad R_B = R_7 + (R_5 // R_6) = 18k\Omega$

Current ÷ : $I_B = I_A \left[\frac{R_2}{R_2 + (R_A + R_1)} \right]$

$I_B = \frac{V_x}{R_1} = 3mA$ $\quad I_A = 6mA$



$R_C = R_2 // (R_A + R_1) = 2k\Omega$

$I_A = I_S \left[\frac{R_B}{R_B + R_C} \right] \Rightarrow \boxed{I_S = 6.67mA}$

2.45 Determine I_L in the circuit in Fig. P2.45.

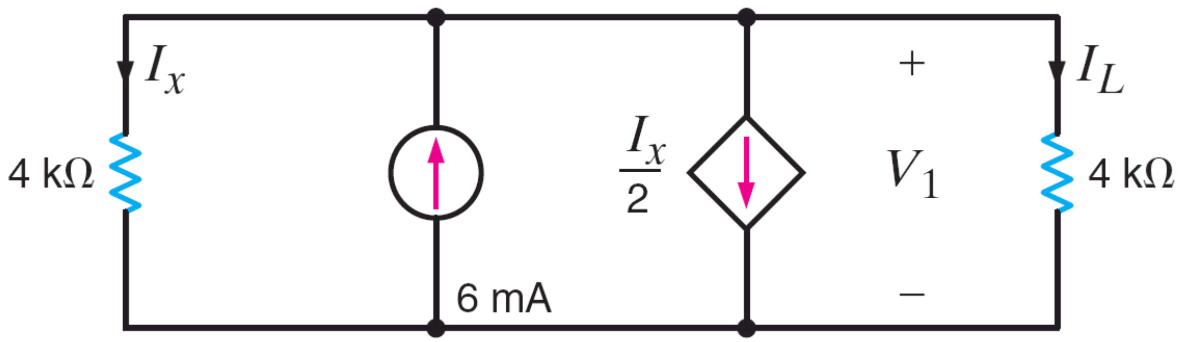
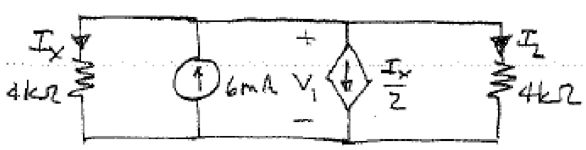


Figure P2.45

SOLUTION:

2.45 Find I_L



KCL: $\frac{V_1}{4\times10^3} + \frac{V_1}{4\times10^3} + \frac{I_x}{2} + (-6\times10^{-3}) = 0$

$I_x = \frac{V_1}{4\times10^3}$ $\quad I_L = \frac{V_1}{4\times10^3}$

$I_L = 2.4mA$

2.46 Determine I_L in the circuit in Fig. P2.46. **PSV**

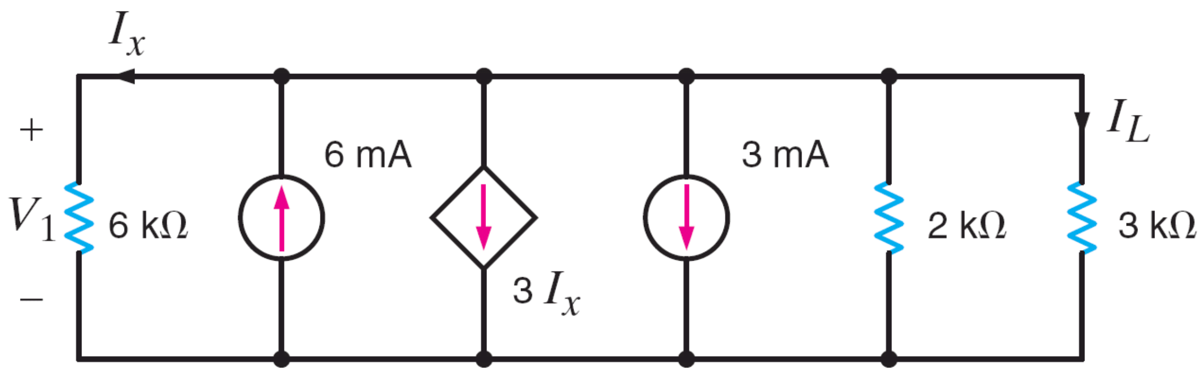
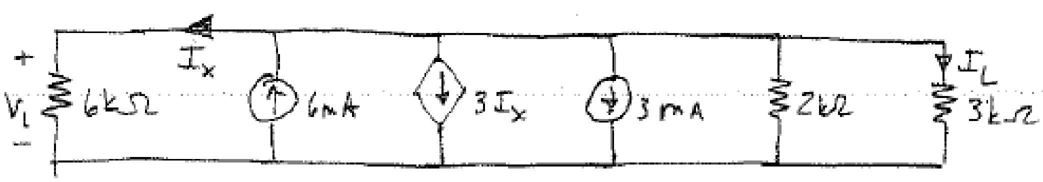


Figure P2.46

SOLUTION:

2.46 Find I_L



KCL: $$\frac{V_1}{6000} + 3I_x + 3\times10^{-3} + \frac{V_1}{2000} + \frac{V_1}{3000} - 6\times10^{-3} = 0 \qquad (1)$$

Also: $$I_x = \frac{V_1}{6000} \qquad (2)$$

Substitute (2) into (1) $\Rightarrow$ $V_1 = 2V$

$$I_L = \frac{V_1}{3000}$$

$$\boxed{I_L = \frac{2}{3}\,mA}$$

2.47 Find R_{AB} in the circuit in Fig. P2.47. CS

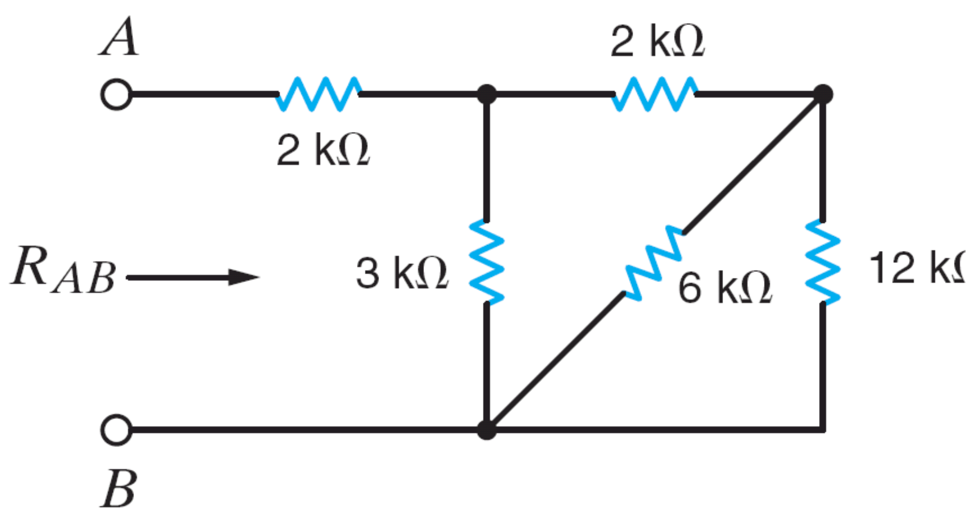
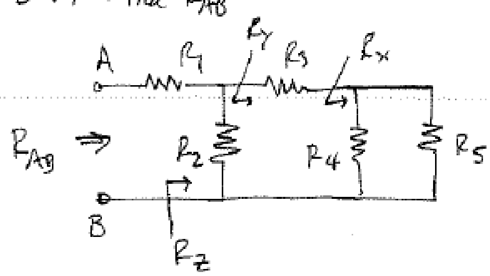


Figure P2.47

SOLUTION:

2.47 Find R_{AB}



$R_1 = R_3 = 2\,k\Omega \quad R_2 = 3\,k\Omega \quad R_4 = 6\,k\Omega \quad R_5 = 12\,k\Omega$

$R_x = R_4 /\!/ R_5 = 4\,k\Omega$

$R_y = R_3 + R_x = 6\,k\Omega$

$R_z = R_2 /\!/ R_y = 2\,k\Omega$

$R_{AB} = R_1 + R_z$ $\quad \boxed{R_{AB} = 4\,k\Omega}$

2.48 Find R_{AB} in the network in Fig. P2.48.

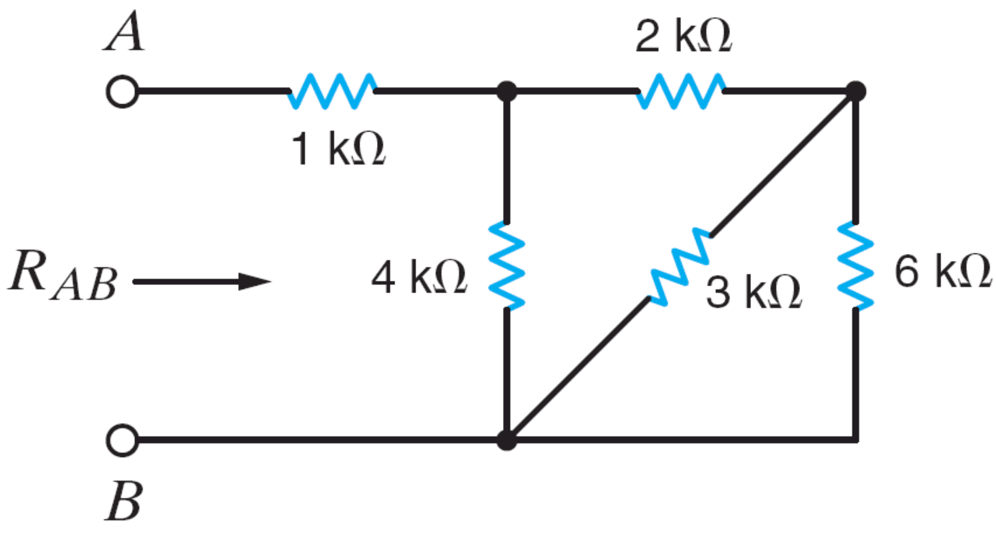
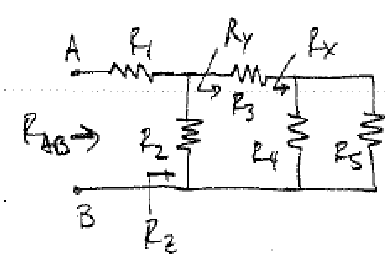


Figure P2.48

SOLUTION:

2.48 Find R_{AB}



$R_1 = 1k\Omega$, $R_2 = 4k\Omega$, $R_3 = 2k\Omega$ $R_4 = 3k\Omega$ $R_5 = 6k\Omega$

$R_x = R_4 // R_5 = 2k\Omega$

$R_y = R_3 + R_x = 4k\Omega$

$R_z = R_2 // R_y = 2k\Omega$

$R_{AB} = R_1 + R_z \Rightarrow$ $\boxed{R_{AB} = 3k\Omega}$

2.49 Find R_{AB} in the circuit in Fig. P2.49.

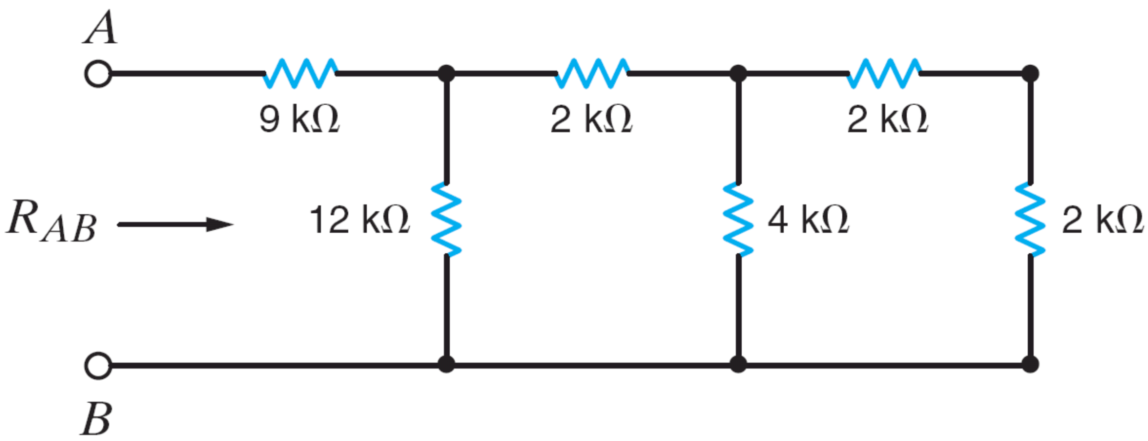
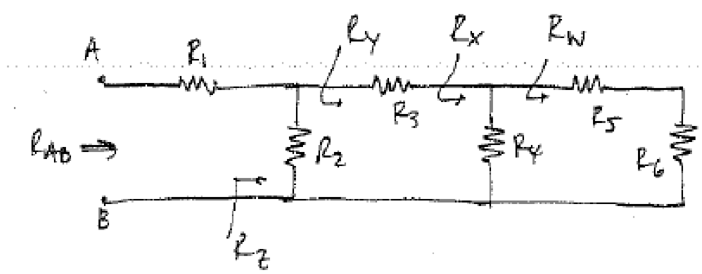


Figure P2.49

SOLUTION:

2.49 Find R_{AB}.



$R_1 = 9k\Omega \quad R_2 = 12k\Omega \quad R_3 = 2k\Omega$

$R_4 = 4k\Omega \quad R_5 = 2k\Omega \quad R_6 = 2k\Omega$

$R_W = R_5 + R_6 = 4k\Omega$

$R_X = R_4 // R_W = 2k\Omega$

$R_Y = R_3 + R_X = 4k\Omega \qquad R_Z = R_2 // R_Y = 3k\Omega$

$R_{AB} = R_1 + R_Z \Rightarrow \boxed{R_{AB} = 12k\Omega}$

2.50 Find R_{AB} in the circuit in Fig. P2.50. **PSV**

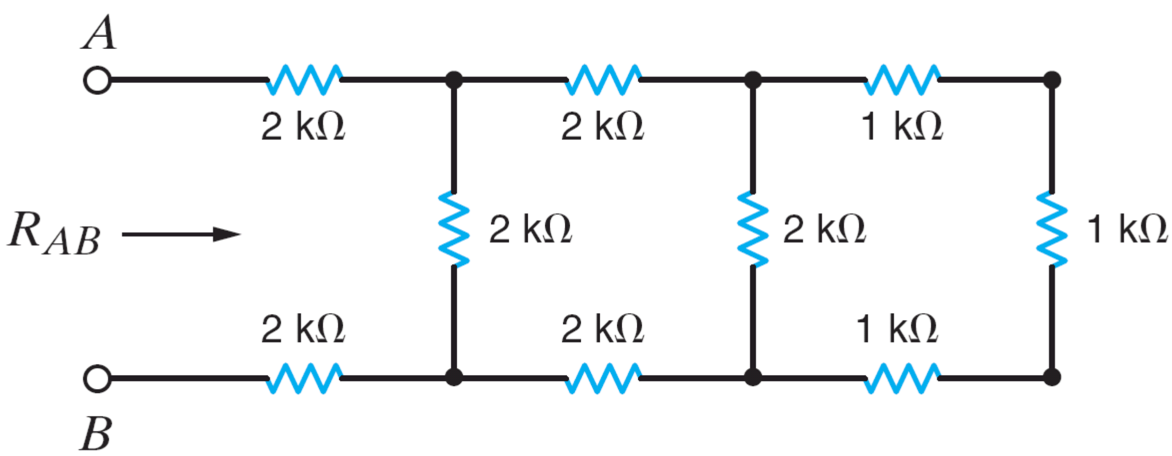
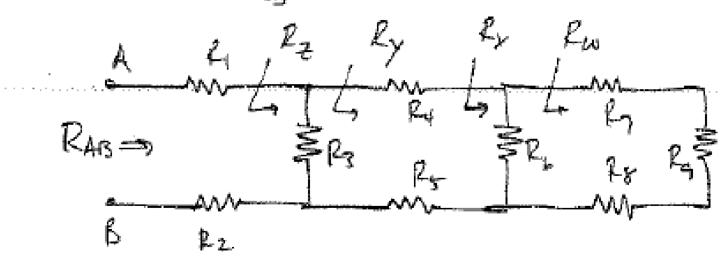


Figure P2.50

SOLUTION:

2.50 Find R_{AB}



$R_1 = R_2 = R_3 = R_4 = R_5 = R_6 = 2\,k\Omega$

$R_7 = R_8 = R_9 = 1\,k\Omega$

$R_w = R_7 + R_8 + R_9 = 3\,k\Omega$

$R_x = R_6 // R_w = \frac{6}{5}\,k\Omega = 1.2\,k\Omega$

$R_y = R_4 + R_x + R_5 = 5.2\,k\Omega$

$R_z = R_3 // R_y = 1.44\,k\Omega$

$R_{AB} = R_1 + R_z + R_2 = 5.44\,k\Omega$

$\boxed{R_{AB} = 5.44\,k\Omega}$

2.51 Determine R_{AB} in the circuit in Fig. P2.51.

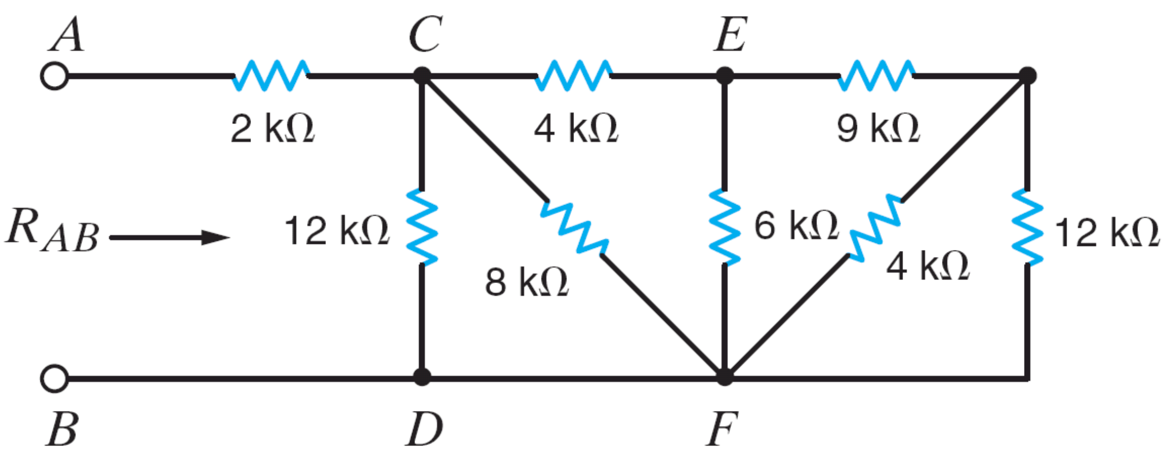
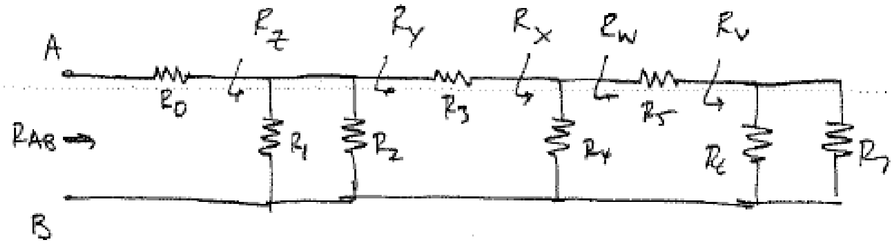


Figure P2.51

SOLUTION:

2.51 Find R_{AB}



$R_0 = 2k\Omega$, $R_1 = 12k\Omega$, $R_2 = 8k\Omega$, $R_3 = 4k\Omega$, $R_4 = 6k\Omega$, $R_5 = 9k\Omega$

$R_6 = 4k\Omega$ $\quad R_7 = 12k\Omega$

$R_V = R_6 \,//\, R_7 = 3k\Omega$ $\quad R_W = R_5 + R_V = 12k\Omega$ $\quad R_X = R_4 \,//\, R_W = 4k\Omega$

$R_Y = R_3 + R_X = 8k\Omega$ $\quad R_Z = R_1 \,//\, R_2 \,//\, R_Y = 3k\Omega$

$R_{AB} = R_0 + R_Z$ $\quad \boxed{R_{AB} = 5k\Omega}$

2.52 Find R_{AB} in the network in Fig. P2.52.

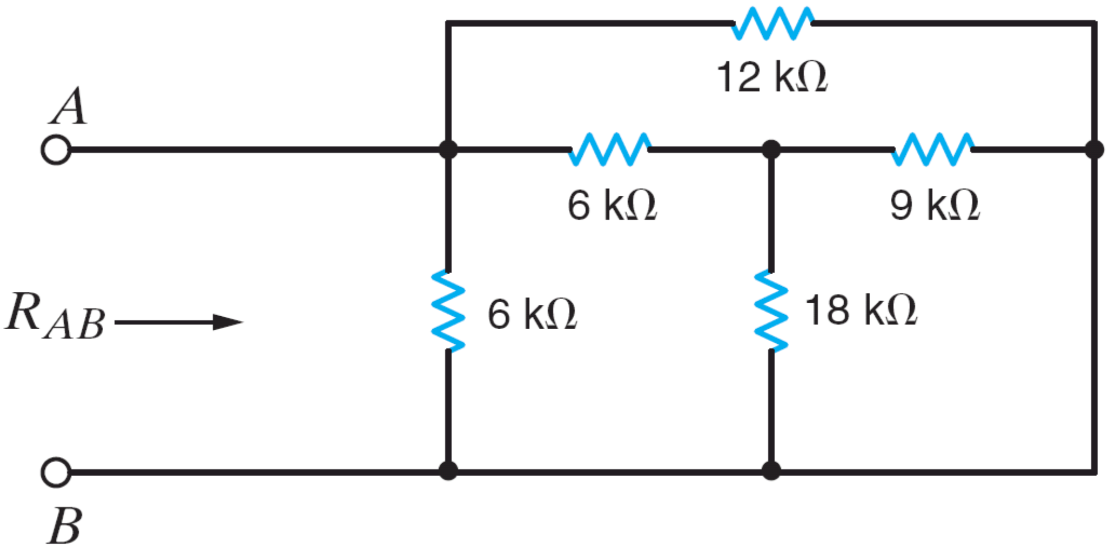
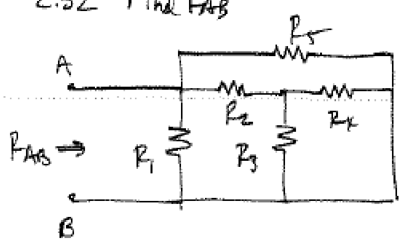


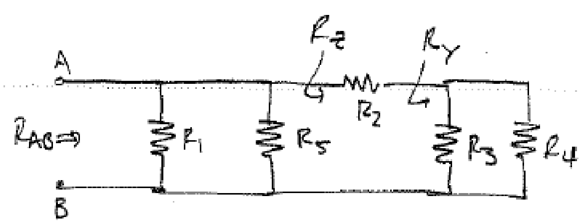
Figure P2.52

SOLUTION:

2.52 Find R_{AB}



⇒



$R_1 = R_2 = 6\,k\Omega \quad R_3 = 18\,k\Omega \quad R_4 = 9\,k\Omega \quad R_5 = 12\,k\Omega$

$R_Y = R_3 // R_4 = 6\,k\Omega \qquad R_Z = R_2 + R_Y = 12\,k\Omega$

$R_{AB} = R_1 // R_5 // R_Z \qquad \boxed{R_{AB} = 3\,k\Omega}$

2.53 Find R_{AB} in the network in Fig. P2.53. CS

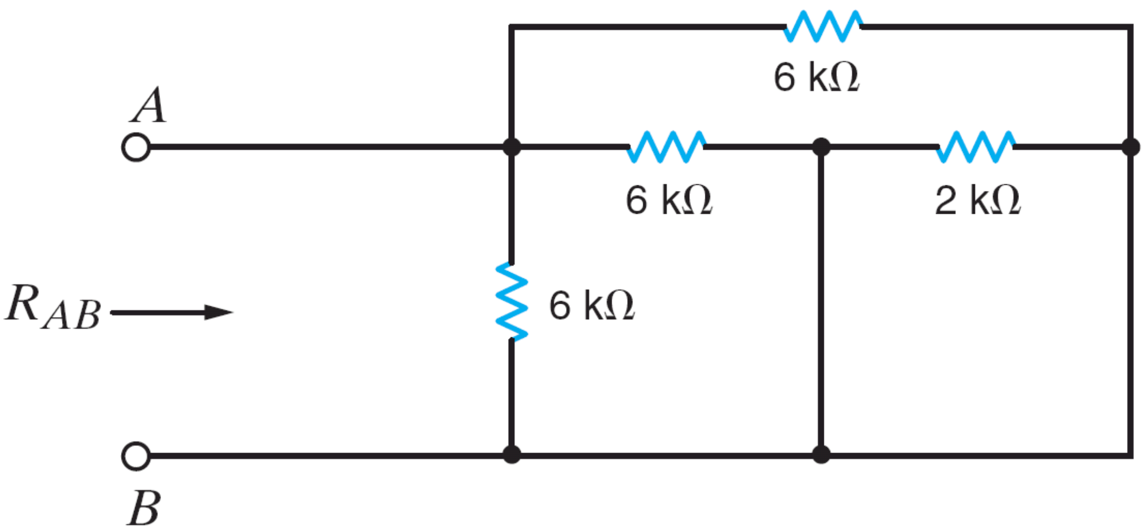
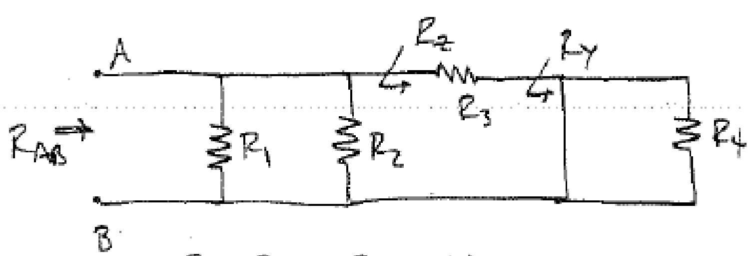


Figure P2.53

SOLUTION:

2.53 Find R_{AB} (circuit is redrawn)



$R_1 = R_2 = R_3 = 6k\Omega \quad R_4 = 2k\Omega$

$R_Y = 0 // R_4 = 0\Omega$

$R_Z = R_3 + R_Y = 6k\Omega$

$R_{AB} = R_1 // R_2 // R_Z$

$\boxed{R_{AB} = 2k\Omega}$

2.54 Find the equivalent resistance, R_{eq}, in the circuit in Fig. P2.54.

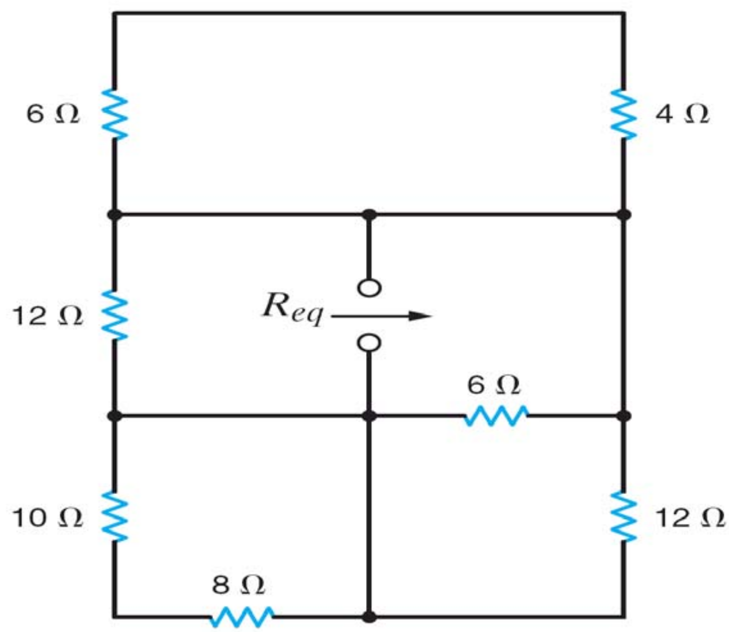
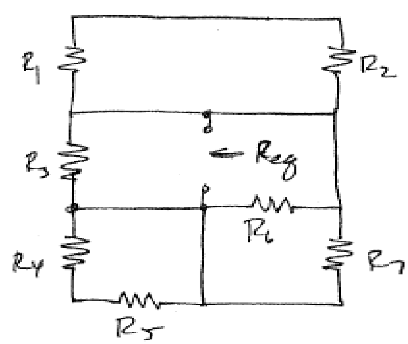


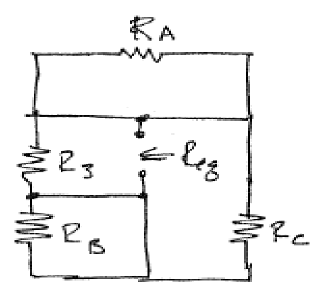
Figure P2.54

SOLUTION:

2.54 Find R_{eq}



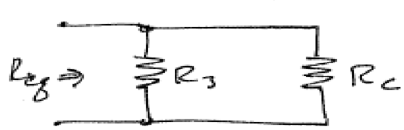
$\Rightarrow$



Note: R_A is shorted as is R_B!

$R_A = R_1 + R_2 \quad R_B = R_4 + R_5$

$R_C = R_6 // R_7$



$R_{eq} = R_3 // R_C = R_3 // R_6 // R_7$

Given: $R_3 = 12\Omega$, $R_6 = 6\Omega$ & $R_7 = 12\Omega$, $\boxed{R_{eq} = 3\Omega}$

2.55 Find the equivalent resistance, R_{eq}, in the network in Fig. P2.55.

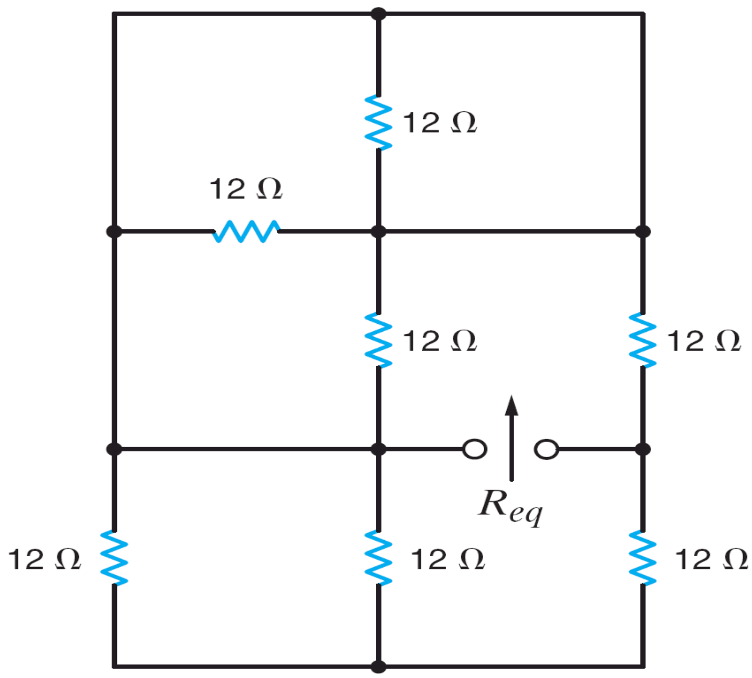
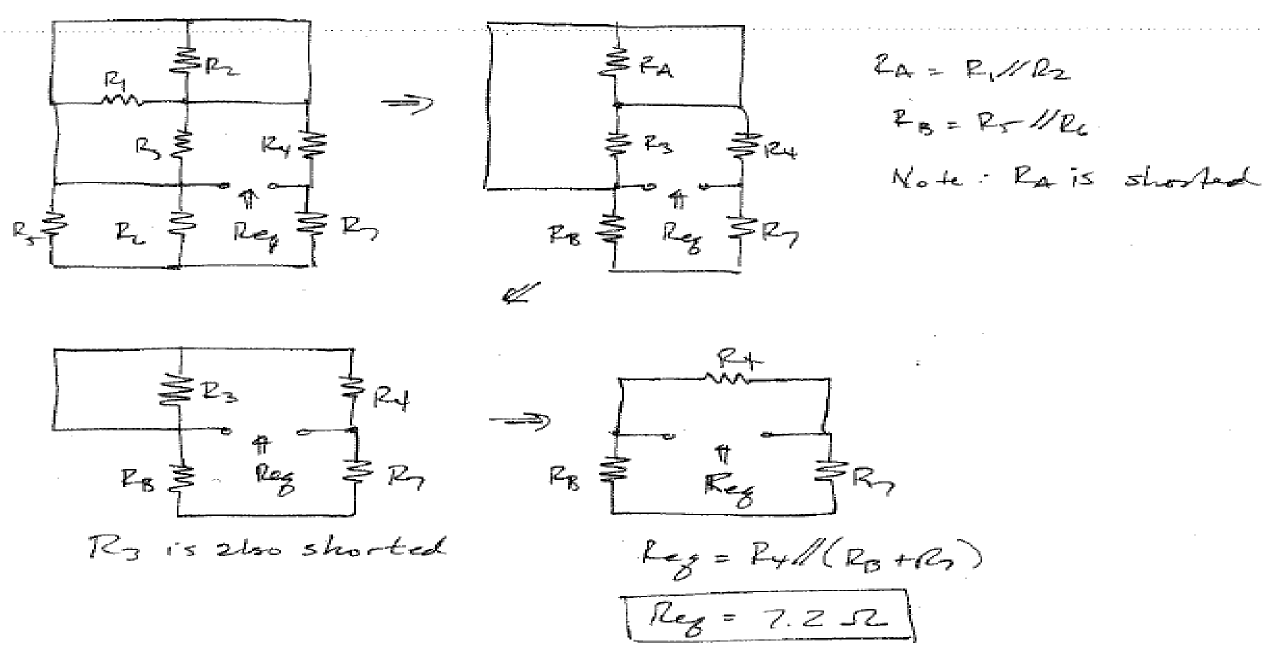


Figure P2.55

SOLUTION:



2.56 Find the range of resistance for the following resistors.

(a) 1 kΩ with a tolerance of 5%

(b) 470 Ω with a tolerance of 2%

(c) 22 kΩ with a tolerance of 10%

SOLUTION:

2.56 a) $R = 1\,k\Omega$ @ $\pm 5\%$

b) $R = 470\,\Omega$ @ $\pm 2\%$

c) $R = 22\,k\Omega$ @ $\pm 10\%$

Solution

a) $R_{min} = R(1 - tol.) = 1000(0.95) = 950\,\Omega$

$R_{max} = R(1 + tol.) = 1000(1.05) = 1050\,\Omega$

b) $R_{min} = 470(0.98) = 460.6\,\Omega$

$R_{max} = 470(1.02) = 479.4\,\Omega$

c) $R_{min} = 22\times10^3(0.9) = 19.8\,k\Omega$

$R_{max} = 22\times10^3(1.1) = 24.2\,k\Omega$

2.57 Given the network in Fig. P2.57, find the possible range of values for the current and power dissipated by the following resistors. **CS**

(a) 390 Ω with a tolerance of 1%

(b) 560 Ω with a tolerance of 2%

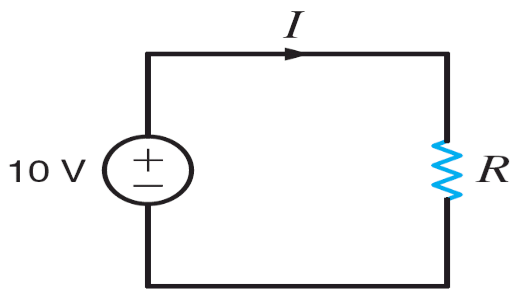
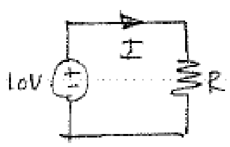


Figure P2.57

SOLUTION:

2.57 Find I and P ranges.



a) $R = 390\,\Omega$ @ $\pm 1\%$

$I = \frac{10}{R}$ $I_{max} = \frac{10}{R_{min}}$ $I_{min} = \frac{10}{R_{max}}$

$R_{min} = 390(0.99) = 386.1\,\Omega$ $I_{max} = 25.90\text{ mA}$

$R_{max} = 390(1.01) = 393.9\,\Omega$ $I_{min} = 25.39\text{ mA}$

$P_{max} = I_{max}(10) \Rightarrow P_{max} = 259.0\text{ mW}$

$P_{min} = I_{min}(10) \Rightarrow P_{min} = 253.9\text{ mW}$

b) $R = 560\,\Omega$ @ $\pm 2\%$

$R_{min} = 560(0.98) = 548.8\,\Omega$

$R_{max} = 560(1.02) = 571.2\,\Omega$

$I_{max} = 18.22\text{ mA}$	$P_{max} = 182.2\text{ mW}$
$I_{min} = 17.51\text{ mA}$	$P_{min} = 175.1\text{ mW}$

2.58 Given the circuit in Fig. P2.58,

(a) find the required value of R.

(b) use Table 2.1 to select a standard 10% tolerance resistor for R.

(c) calculate the actual value of I.

(d) determine the percent error between the actual value of I and that shown in the circuit.

(e) determine the power rating for the resistor R.

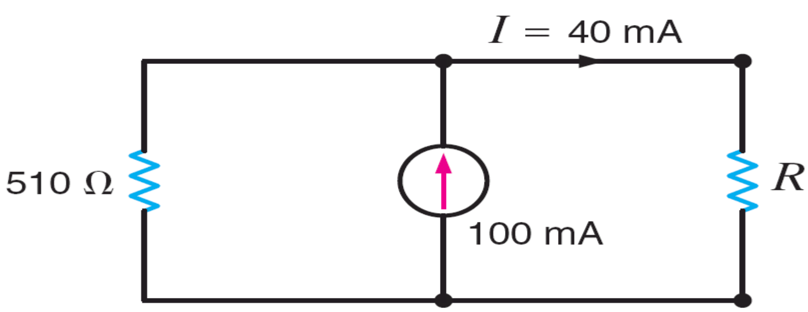
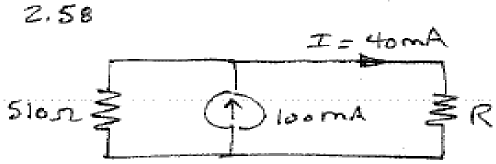


Figure P2.58

SOLUTION:

2.58



a) Find R

$$40\times10^{-3} = 100\times10^{-3}\left[\frac{510}{510+R}\right]$$

$$\boxed{R = 765\,\Omega}$$

b) From Table 2.1, best 10% tolerance choice is $\boxed{R = 820\,\Omega}$

c) $I = 10^{-1}\left[\frac{510}{510+820}\right]$ $\boxed{I = 38.3\text{mA}}$

d) percent error $= \left(\frac{\text{actual} - \text{target}}{\text{target}}\right)100 \Rightarrow$ % error $= \boxed{-4.25\%}$

e) $P_R = I^2R = (38.3\times10^{-3})^2(820) = 1.2\text{W}$

Recommend a 2-W resistor.

2.59 The resistors R_1 and R_2 shown in the circuit in Fig. P2.59 are 1 Ω with a tolerance of 5% and 2 Ω with a tolerance of 10%, respectively.

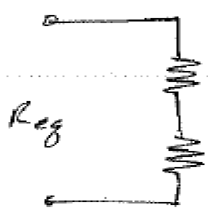
(a) What is the nominal value of the equivalent resistance?

(b) Determine the positive and negative tolerance for the equivalent resistance.

Figure P2.59

SOLUTION:

2.59



$R_1 = 1\Omega$ @ ±5%

$R_2 = 2\Omega$ @ ± 10%

a) Nominal value for $R_{eq} = R_1 + R_2$ $\quad R_{eq} = 3\Omega$

b) $R_{eq\,max} = R_1(1.05) + R_2(1.1) = 3.25\Omega$

$R_{eq\,min} = R_1(0.95) + R_2(0.9) = 2.75\Omega$

$+R_{eq}$ tolerance $= \dfrac{3.25-3}{3} = +8.33\%$

$-R_{eq}$ tolerance $= \dfrac{2.75-3}{3} = -8.33\%$

R_{eq} tolerence = ± 8.33%

2.60 Find V_{ab} and V_{dc} in the circuit in Fig. P2.60.

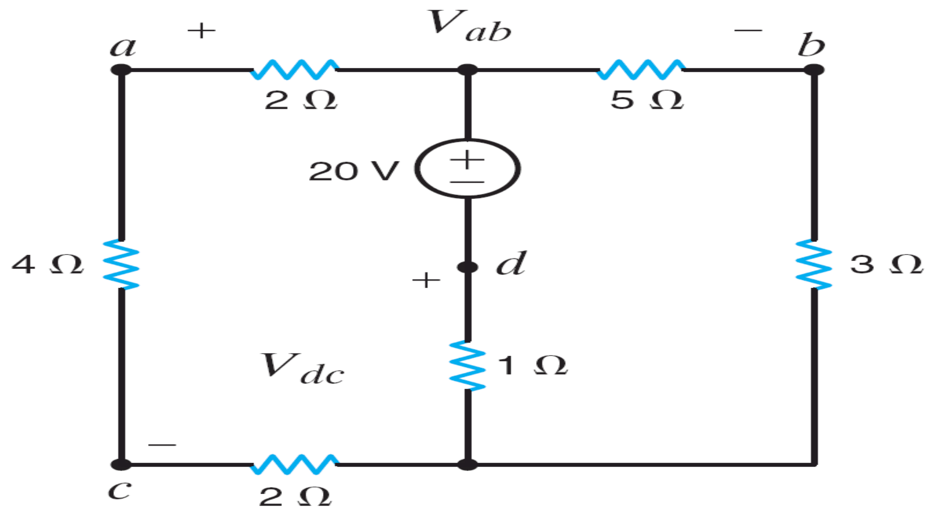
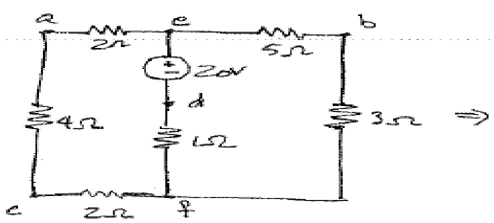


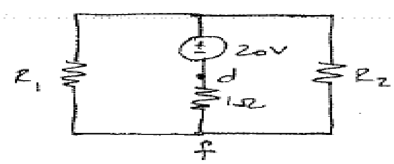
Figure P2.60

SOLUTION:

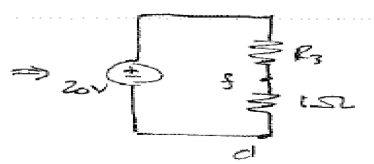
2.60 Find V_{ab} and V_{dc}



⇒



⇒



$R_1 = 2 + 4 + 2 = 8\Omega$

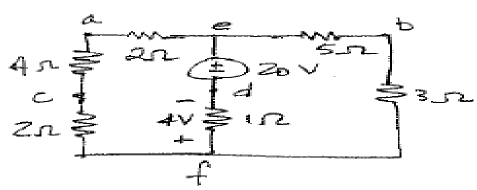
$R_2 = 5 + 3 = 8\Omega$

$R_3 = R_1 // R_2 = 4\Omega$

$V_{fd} = 20\left[\frac{1}{R_3+1}\right]$

$V_{fd} = 4V$

Now we have



$V_{ef} = 16V$

$V_{cf} = V_{ef}\left[\frac{2}{2+4+2}\right] = 4V$

$V_{dc} = V_{df} + V_{fc} = -4 + (-4) = -8V$

$\boxed{V_{dc} = -8V}$

$V_{ea} = V_{ef}\left[\frac{2}{2+2+4}\right] = 4V$ $\quad V_{eb} = V_{ef}\left[\frac{5}{5+3}\right] = 10V$

$V_{ab} = V_{ae} + V_{eb} = -4 + (10) = 6V$ $\quad \boxed{V_{ab} = 6V}$

2.61 Find I_1 and V_o in the circuit in Fig. P2.61.

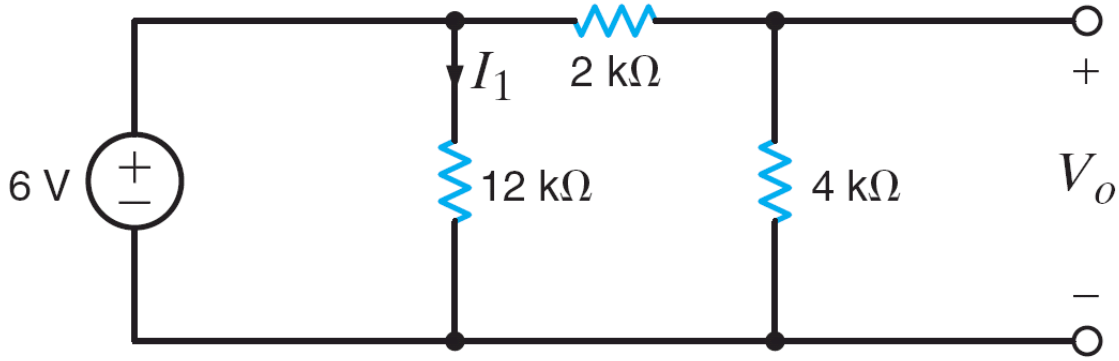
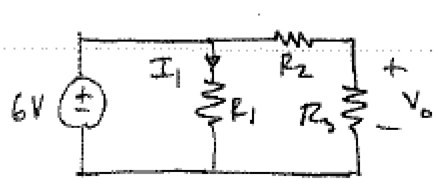


Figure P2.61

SOLUTION:

2.61 Find I_o & V_o



$R_1 = 12k\Omega$
$R_2 = 2k\Omega$
$R_3 = 4k\Omega$

$I_1 = \frac{6}{R_1} \Rightarrow I_1 = 0.5mA$

$V_o = 6\left[\frac{R_3}{R_2+R_3}\right] \Rightarrow \boxed{V_o = 4V}$

2.62 Find I_1 and V_o in the circuit in Fig. P2.62.

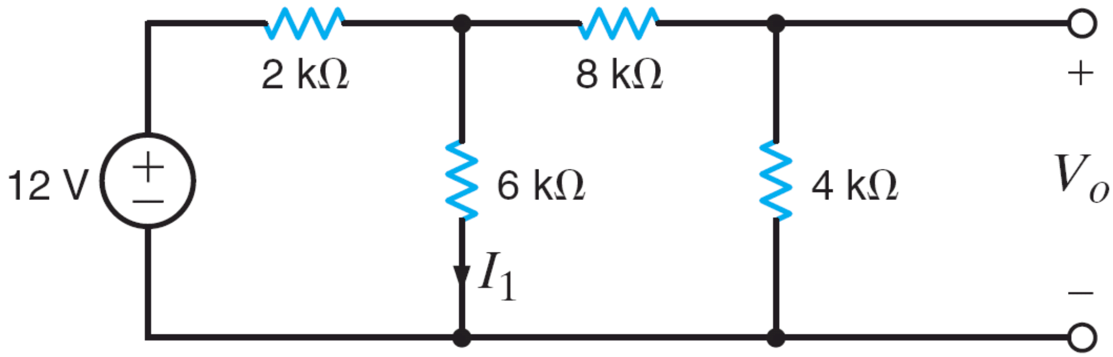
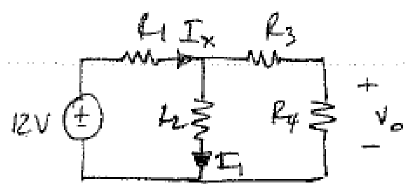


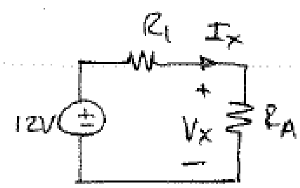
Figure P2.62

SOLUTION:

2.62 Find I_1 & V_o.



$\Rightarrow$



$I_x = \dfrac{12}{R_1 + R_x} = 2\text{mA}$

$V_x = 12\left[\dfrac{R_A}{R_A + R_1}\right] = 8\text{V}$

$R_1 = 2k\Omega$ $R_2 = 6k\Omega$

$R_3 = 8k\Omega$ $R_4 = 4k\Omega$

$R_A = R_2 \,//\, (R_3 + R_4)$

$R_A = 4k\Omega$

By current division: $I_1 = I_x\left[\dfrac{R_4 + R_3}{R_2 + R_4 + R_3}\right] \Rightarrow I_1 = 1.33\text{ mA}$

By voltage division: $V_o = V_x\left[\dfrac{R_4}{R_4 + R_3}\right] \Rightarrow$ $\boxed{V_o = 2.67\text{V}}$

2.63 Find I_o in the network in Fig. P2.63.

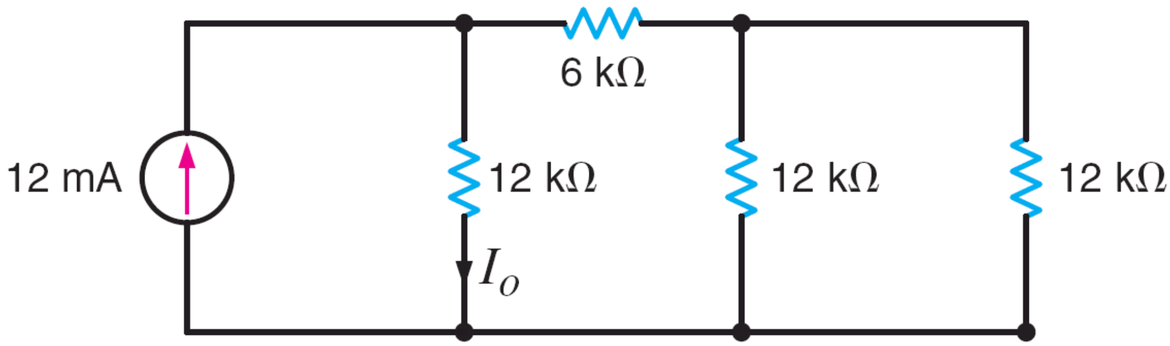
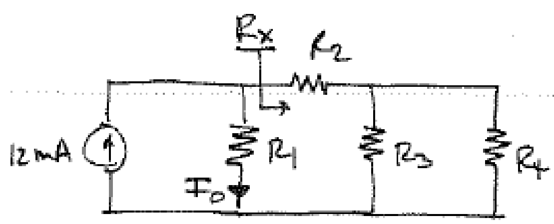


Figure P2.63

SOLUTION:

2.63 Find I_o



$R_1 = 12k\Omega \quad R_2 = 6k\Omega \quad R_3 = R_4 = 12k\Omega$

$$R_x = R_2 + (R_3 // R_4) = 12k\Omega$$

$$I_o = 12\times10^{-3}\left[\frac{R_x}{R_1 + R_x}\right]$$

$$\boxed{I_o = 6mA}$$

2.64 Find I_1 in the circuit in Fig. P2.64.

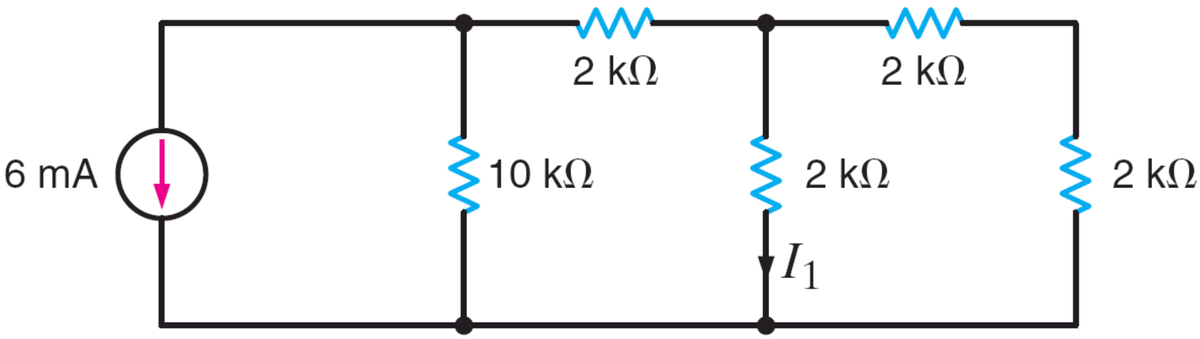
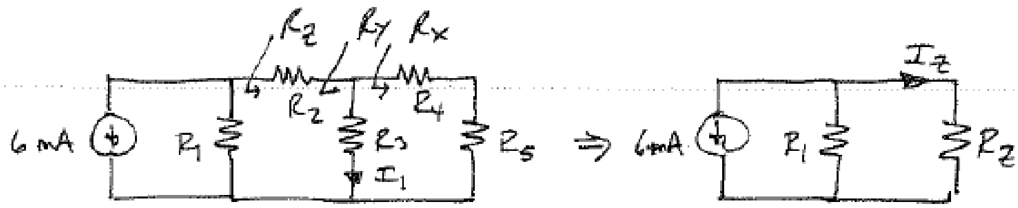


Figure P2.64

SOLUTION:

2.64 Find I_1



$R_1 = 10k\Omega \quad R_2 = R_3 = R_4 = R_5 = 2k\Omega$

$R_x = R_4 + R_5 = 4k\Omega$

$R_y = R_x // R_3 = 1.33k\Omega$

$R_z = R_2 + R_y = 3.33k\Omega$

$I_1 = I_z \left[\frac{R_x}{R_x + R_3} \right] \Leftarrow I_z = -6 \times 10^{-3} \left[\frac{R_1}{R_1 + R_z} \right] = -4.5mA$

$\boxed{I_1 = -3 mA}$

2.65 Determine V_o in the network in Fig. P2.65. PSV

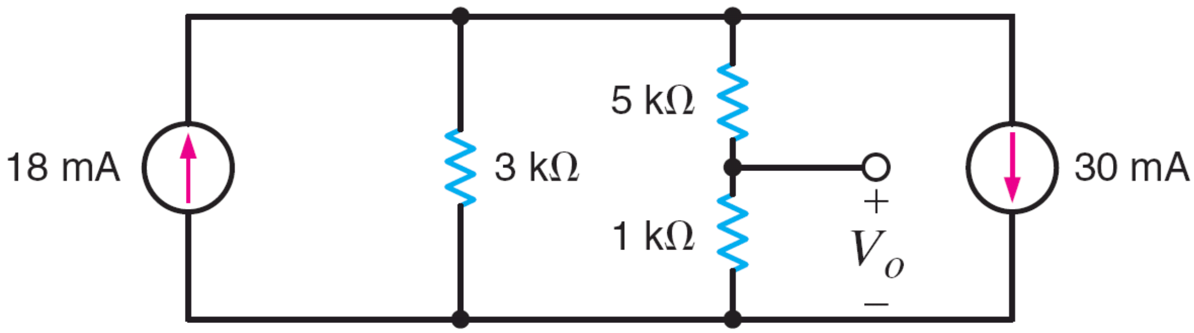
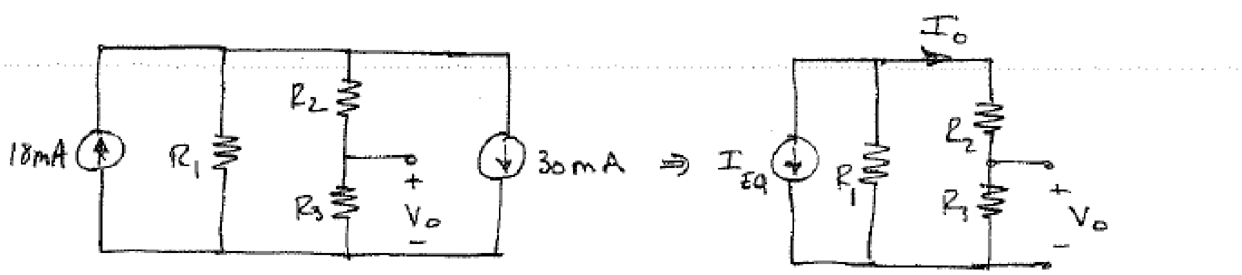


Figure P2.65

SOLUTION:

2.65 Find V_o:



$R_1 = 3k\Omega \quad R_2 = 5k\Omega \quad R_3 = 1k\Omega$

$I_{EQ} = 30\times10^{-3} - 18\times10^{-3} = 12mA$

$-I_o = I_{EQ}\left[\frac{R_1}{R_1+(R_2+R_3)}\right] \Rightarrow I_o = -4mA \qquad V_o = I_oR_3 \qquad \boxed{V_o = -4V}$

2.66 Determine I_o in the circuit in Fig. P2.66.

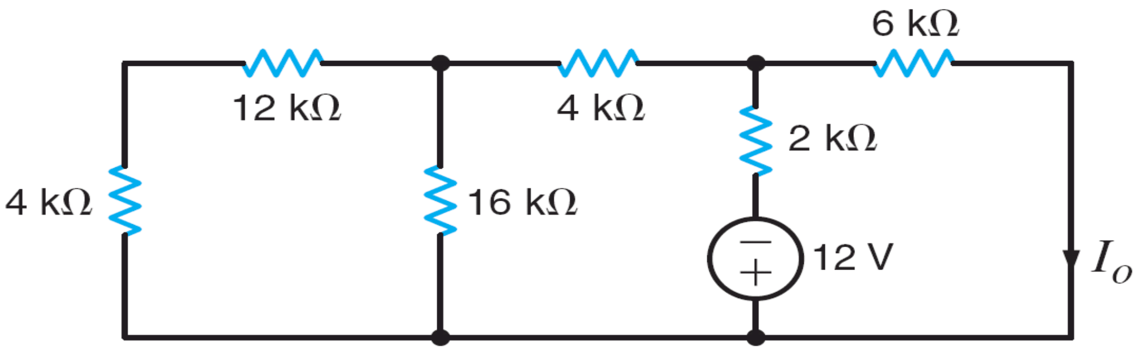
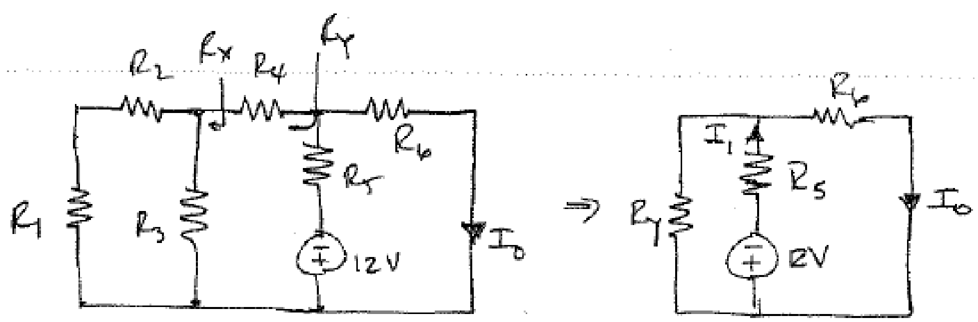


Figure P2.66

SOLUTION:

2.66 Find I_o.

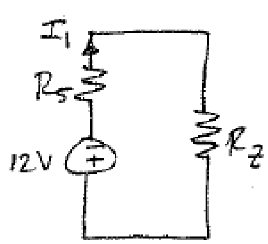


$R_1 = 4k\Omega$ $R_2 = 12k\Omega$ $R_3 = 16k\Omega$

$R_4 = 4k\Omega$ $R_5 = 2k\Omega$ $R_6 = 6k\Omega$

$R_Y = R_4 + R_Z$ $R_Z = (R_1 + R_2) // R_3$

$R_Y = 12k\Omega$ $R_Z = 8k\Omega$



$R_Z = R_Y // R_6 = 4k\Omega$

$I_1 = \dfrac{-12}{R_5 + R_Z} \Rightarrow I = -2mA$

By current division: $I_o = I_1 \left[\dfrac{R_Y}{R_Y + R_6} \right] \rightarrow \boxed{I_o = -1.33mA}$

2.67 Determine V_o in the network in Fig. P2.67.

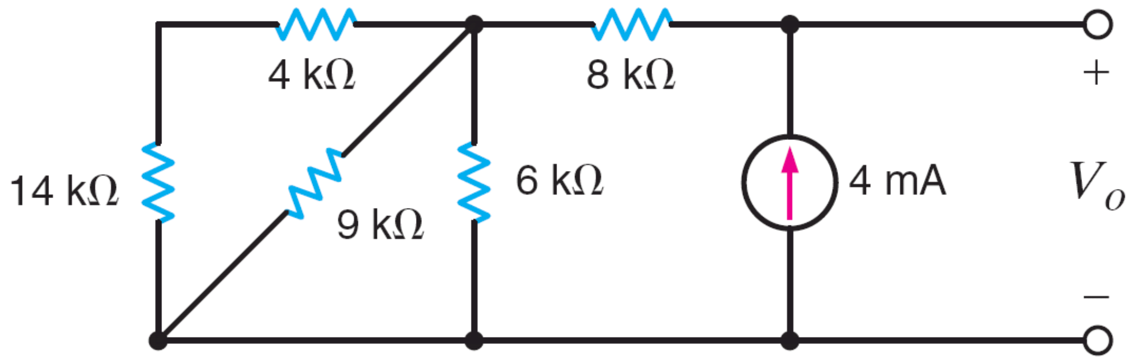
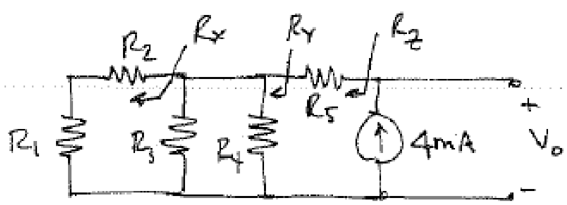


Figure P2.67

SOLUTION:

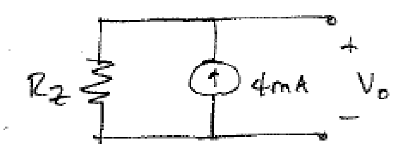
2.67 Find V_o



$R_1 = 14k\Omega$ $R_2 = 4k\Omega$ $R_3 = 9k\Omega$

$R_4 = 6k\Omega$ $R_5 = 8k\Omega$

$R_X = R_1 + R_2 = 18k\Omega$ $R_Y = R_3 // R_4 // R_X = 3k\Omega$ $R_Z = R_5 + R_Y = 11k\Omega$



$V_o = (4\times10^{-3})(R_Z)$ $\boxed{V_o = 44V}$

2.68 Find I_o in the circuit in Fig. P2.68. CS

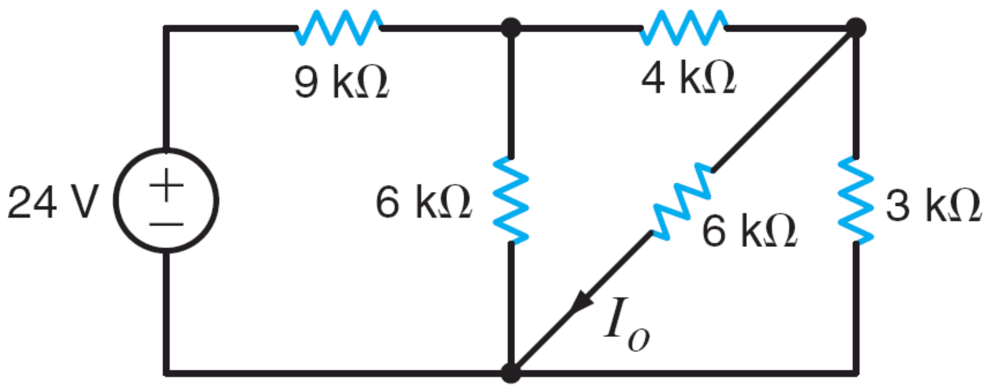
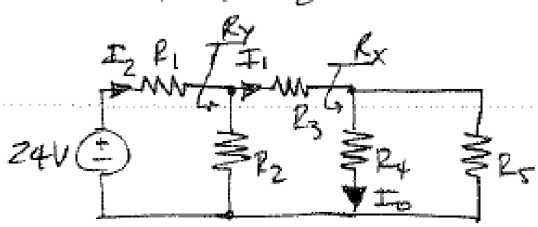


Figure P2.68

SOLUTION:

2.68 Find I_o

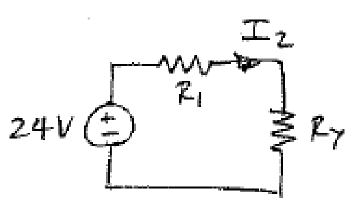


$R_1 = 9\,k\Omega$ $R_2 = 6\,k\Omega$ $R_3 = 4\,k\Omega$

$R_4 = 6\,k\Omega$ $R_5 = 3\,k\Omega$

$$I_1 = I_2\left[\frac{R_2}{R_2 + (R_3 + R_x)}\right] \quad \& \quad I_o = I_1\left[\frac{R_5}{R_4 + R_5}\right]$$

$R_x = R_4 // R_5 = 2\,k\Omega$ $R_y = R_2 // [R_3 + R_x] = 3\,k\Omega$



$$I_2 = \frac{24}{R_1 + R_y}$$

$I_2 = 2\,mA$

$I_1 = 1\,mA$

$\boxed{I_o = 0.33\,mA}$

2.69 Find the value of V_x in the network in Fig. P2.69 such that the 5-A current source supplies 50 W. **PSV**

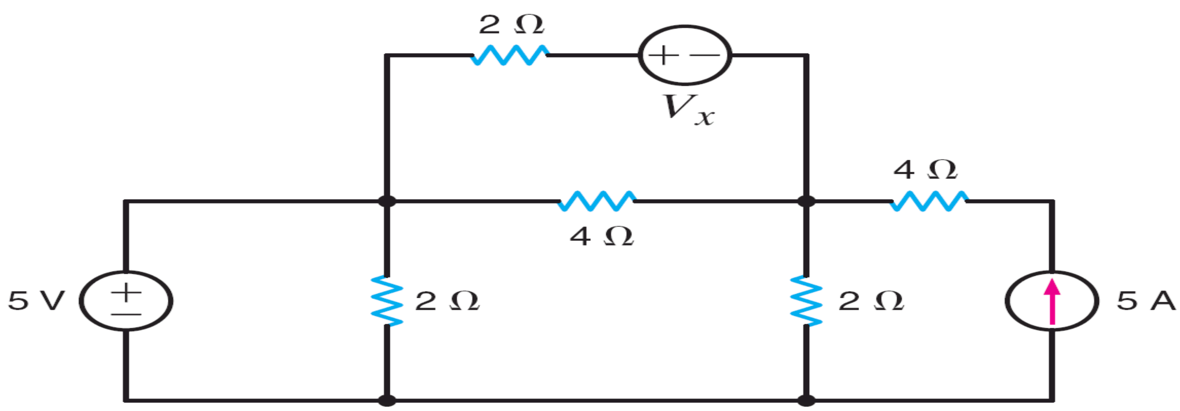
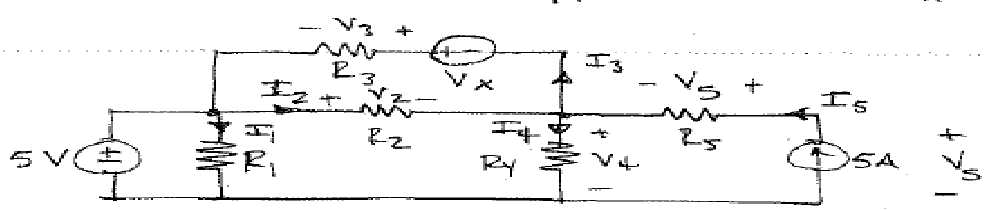


Figure P2.69

SOLUTION:

2.69 $P_{5A} = 50W$ supplied. Find V_x



$R_1 = 2\Omega$, $R_2 = 4\Omega$, $R_3 = 2\Omega$, $R_4 = 2\Omega$, $R_5 = 4\Omega$

$P_{5A} = (V_S)(5) = 50 \Rightarrow V_s = 10V$

$V_5 = I_5 R_5 = 20V$

$V_4 = -V_5 + V_s = -10V$

$I_4 = \frac{V_4}{R_4} = -5A$

$V_2 = 5 - V_4 = 15V$

$I_2 = \frac{V_2}{R_2} = \frac{15}{4} A = 3.75 A$

$I_3 = I_2 - I_4 + I_5 = 13.75 A$

$V_3 = I_3 R_3 = 27.5 V$

$V_x = V_3 + V_2 = 42.5V$

$\boxed{V_x = 42.5V}$

2.70 Find the value of V_1 in the network in Fig. P2.70 such that $V_a = 0$.

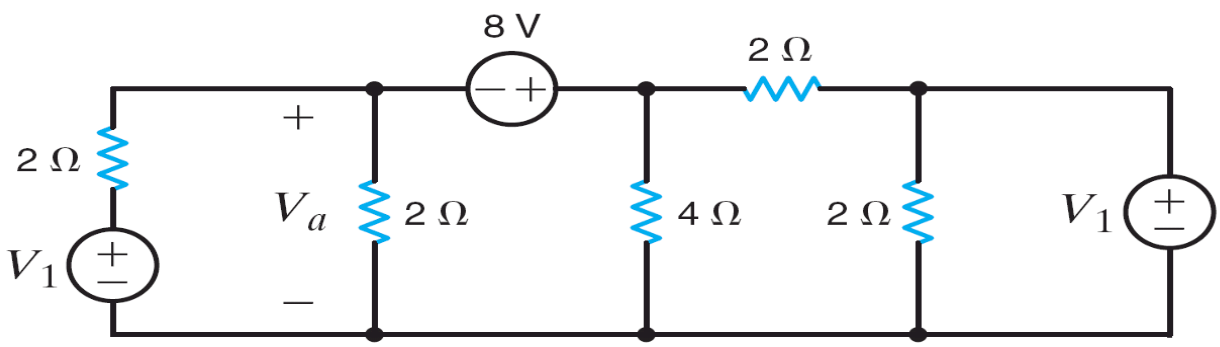
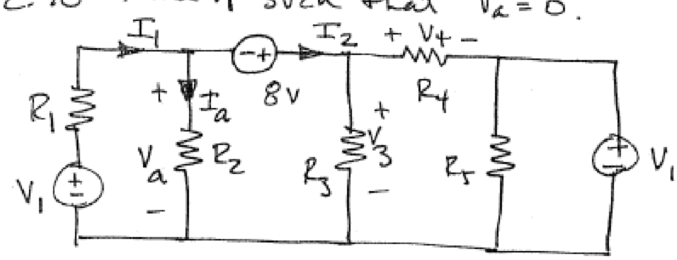


Figure P2.70

SOLUTION:

2.70 Find V_1 such that $V_a = 0$.



$R_1 = R_2 = R_4 = R_5 = 2\Omega$

$R_3 = 4\Omega$

$I_1 = I_a + I_2 \Rightarrow I_1 = I_2$ (By Ohm's Law, if $V_a = 0$, $I_a = 0$!)

$I_1 = \frac{V_1}{R_1} = \frac{V_1}{2}$

$I_2 = \frac{V_3}{R_3} + \frac{V_4}{R_4}$ $\quad V_3 = 8\text{V}$ $\quad V_4 = 8 - V_1$

So,

$I_2 = 6 - \frac{V_1}{2}$

$I_1 = I_2 \Rightarrow \frac{V_1}{2} = 6 - \frac{V_1}{2} \Rightarrow \boxed{V_1 = 6\text{V}}$

2.71 Find the value of V_x in the circuit in Fig. P2.71 such that the power supplied by the 5-A source is 60 W.

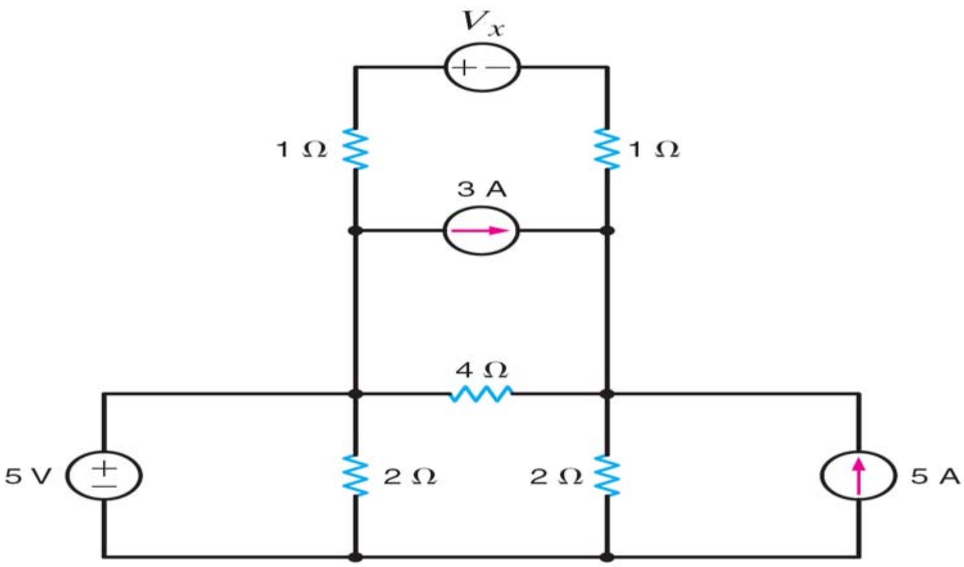
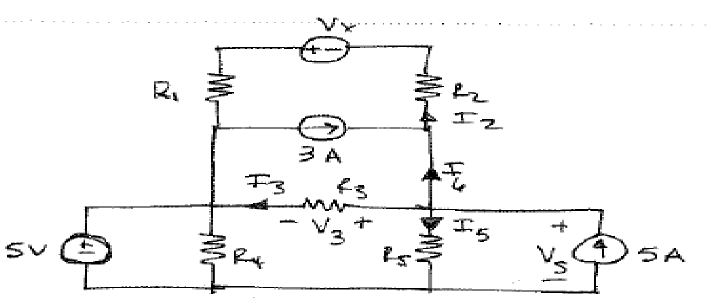


Figure P2.71

SOLUTION:

2.71 P_{5A} = 60 W supplied. Find V_x



$R_1 = R_2 = 1\Omega$

$R_3 = 4\Omega$

$R_4 = R_5 = 2\Omega$

$P_{5A} = 60 = 5 V_S \Rightarrow V_S = 12V$

$I_5 = \frac{V_S}{R_5} = 6A$

$V_3 = V_S - 5 = 7V$

$I_3 = V_3 / R_3 = \frac{7}{4} A$

$I_6 = 5 - I_3 - I_5 = -2.75A$

$I_2 = 3 + I_6 = 0.75A$

$V_x = I_2 R_1 - V_3 + I_2 R_2 = 0.75 - 7 + 0.75 = -5.5V$

$\boxed{V_x = -5.5V}$

2.72 Find the value of V_S in the network in Fig. P2.72 such that the power supplied by the current source is 0.

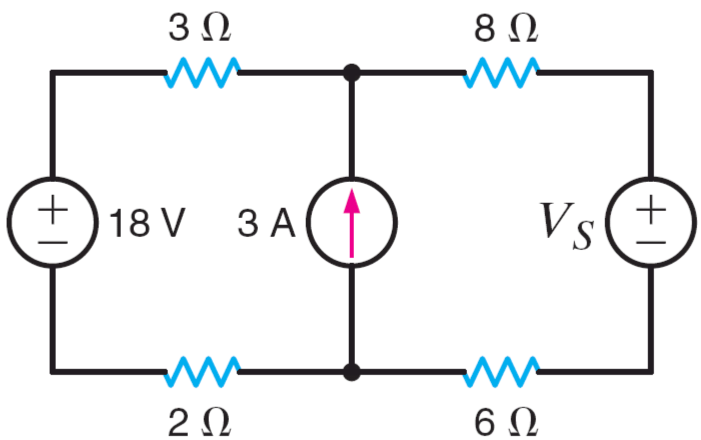
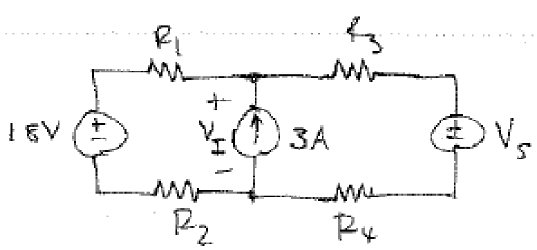


Figure P2.72

SOLUTION:

2.72 $P_{I_S} = 0\,W$. Find V_s



$R_1 = 3\Omega \quad R_2 = 2\Omega \quad R_3 = 8\Omega \quad R_4 = 6\Omega$

$P_{I_S} = 3V_I = 0 \Rightarrow V_I = 0$

KCL: $\frac{18}{R_1+R_2} + \frac{V_S}{R_3+R_4} + 3 = 0$

$\frac{18}{5} + \frac{V_S}{14} = -3$

$\boxed{V_S = -92.4V}$

2.73 Find V_o in the circuit in Fig. P2.73.

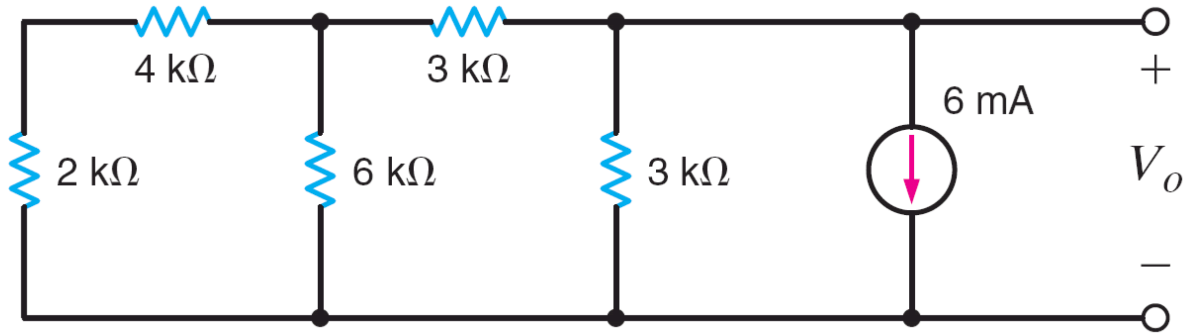
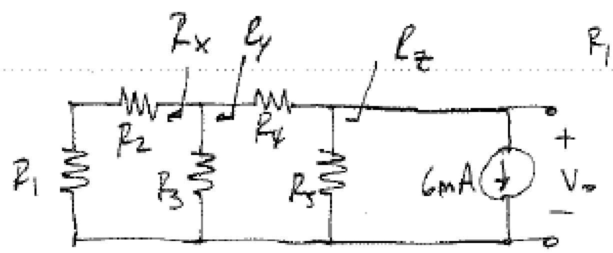


Figure P2.73

SOLUTION:

2.73 Find V_o

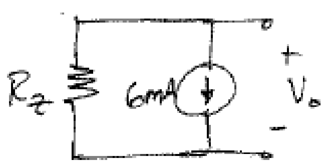


$R_1 = 2k\Omega$ $R_2 = 4k\Omega$ $R_3 = 6k\Omega$

$R_4 = 3k\Omega$ $R_5 = 3k\Omega$

$R_x = R_2 + R_1 = 6k\Omega$

$R_y = R_3 // R_x = 3k\Omega$ $R_z = (R_y + R_4) // R_5 = 2k\Omega$



$V_o = -6 \times 10^{-3} R_z$ $\boxed{V_o = -12V}$

2.74 Find I_o in the network in Fig. P2.74.

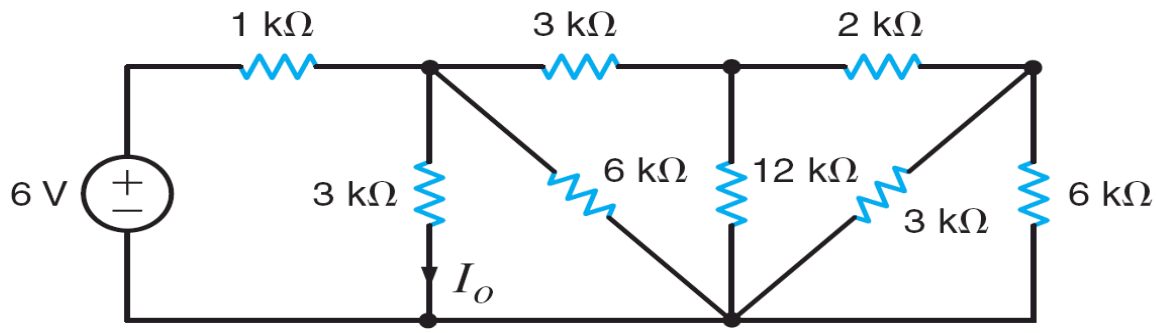


Figure P2.74

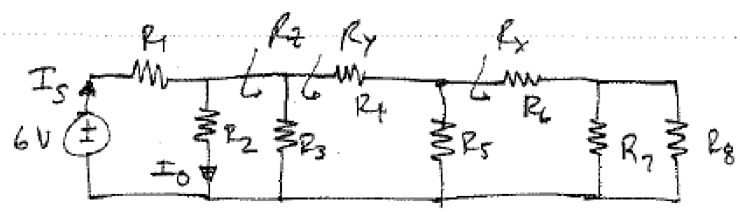
SOLUTION:

2.74 Find I_o

$R_1 = 1k\Omega \quad R_2 = R_4 = R_7 = 3k\Omega$

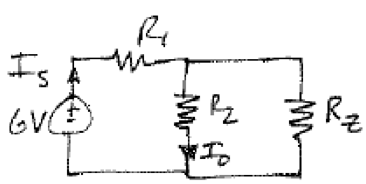
$R_3 = R_8 = 6k\Omega \quad R_5 = 12k\Omega$

$R_6 = 2k\Omega$

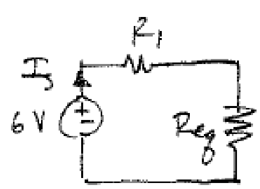


$R_x = R_6 + (R_7 // R_8) = 4k\Omega \qquad R_y = R_4 + (R_5 // R_x) = 6k\Omega$

$R_z = R_3 // R_y = 3k\Omega$



$\Rightarrow$



$R_{eq} = R_2 // R_z = 1.5k\Omega$

$I_o = I_s \left[\frac{R_z}{R_z + R_2} \right] \qquad I_s = \frac{6}{R_1 + R_{eq}} = 2.4mA$

$\boxed{I_o = 1.2mA}$

2.75 Find I_o in the circuit in Fig. P2.75. CS

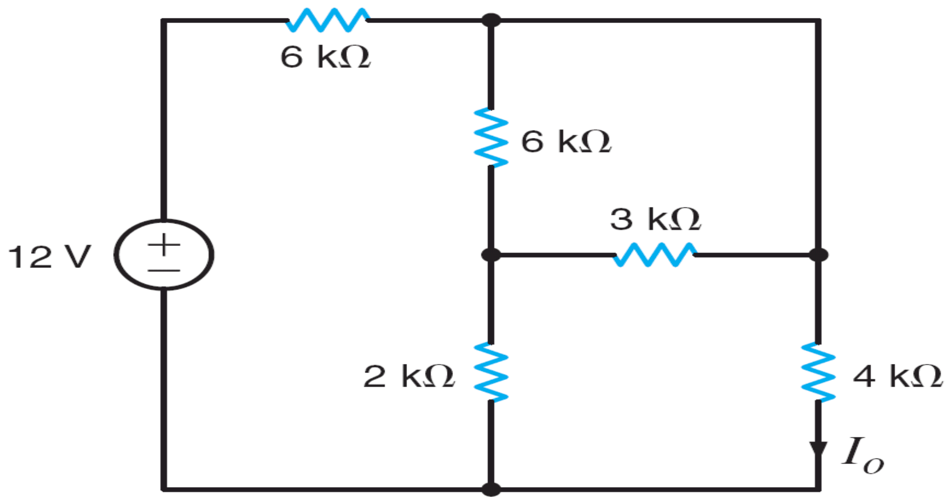
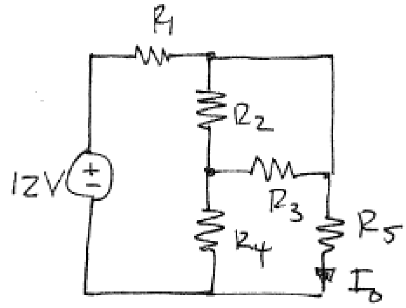


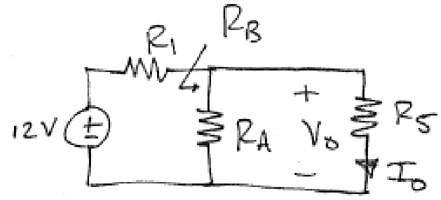
Figure P2.75

SOLUTION:

2.75 Find I_o.



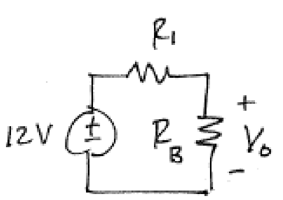
⇒



$R_1 = R_2 = 6k\Omega \quad R_3 = 3k\Omega \quad R_4 = 2k\Omega$

$R_5 = 4k\Omega \quad R_A = R_4 + (R_2 // R_3) = 4k\Omega$

$R_B = R_A // R_5 = 2k\Omega$



$V_o = 12\left(\frac{R_B}{R_B + R_1}\right) \qquad V_o = 3V$

$I_o = \frac{V_o}{R_5} \Rightarrow \boxed{I_o = 0.75\ mA}$

2.76 Determine V_o in the circuit in Fig. P2.76. **PSV**

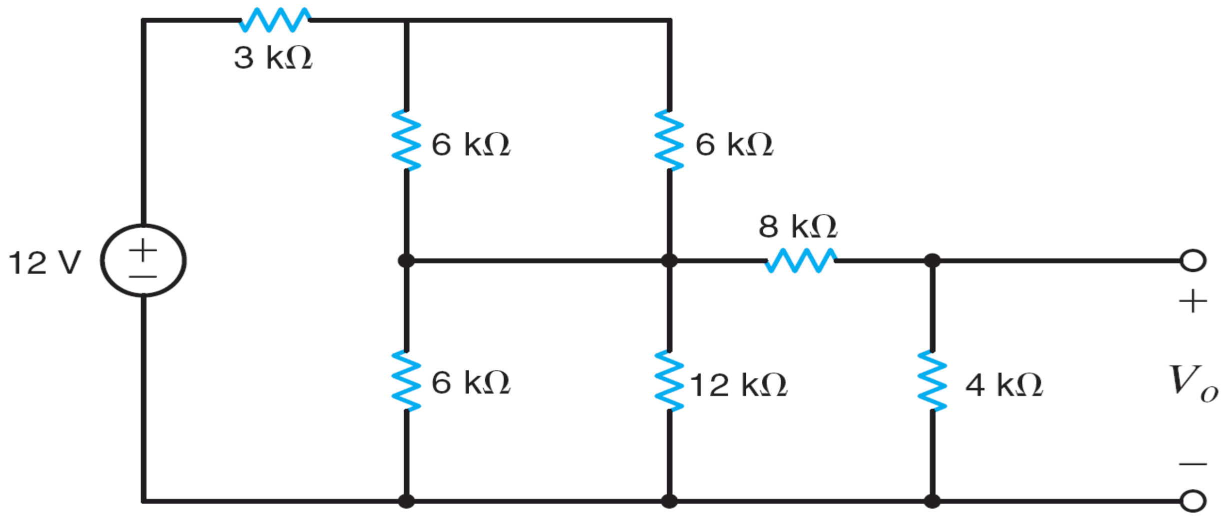
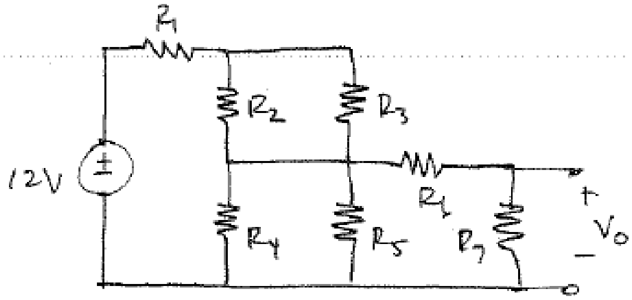


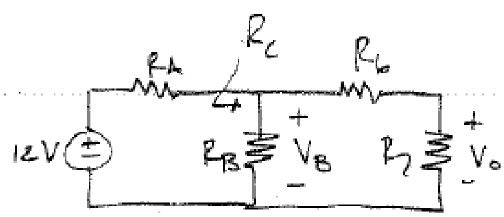
Figure P2.76

SOLUTION:

2.76 Find V_o



$\Rightarrow$



$R_1 = 3k\Omega \quad R_2 = R_3 = R_4 = 6k\Omega$

$R_5 = 12k\Omega \quad R_6 = 8k\Omega \quad R_7 = 4k\Omega$

$R_A = R_1 + (R_2 // R_3) = 6k\Omega$

$R_B = R_4 // R_5 = 4k\Omega$

$R_C = R_B // (R_6 + R_7) = 3k\Omega$

$V_B = 12\left(\frac{R_C}{R_C + R_A}\right) = 4V$

$V_o = V_B\left(\frac{R_7}{R_6 + R_7}\right) \Rightarrow \boxed{V_o = 1.33V}$

2.77 Find V_o in the circuit in Fig. P2.77.

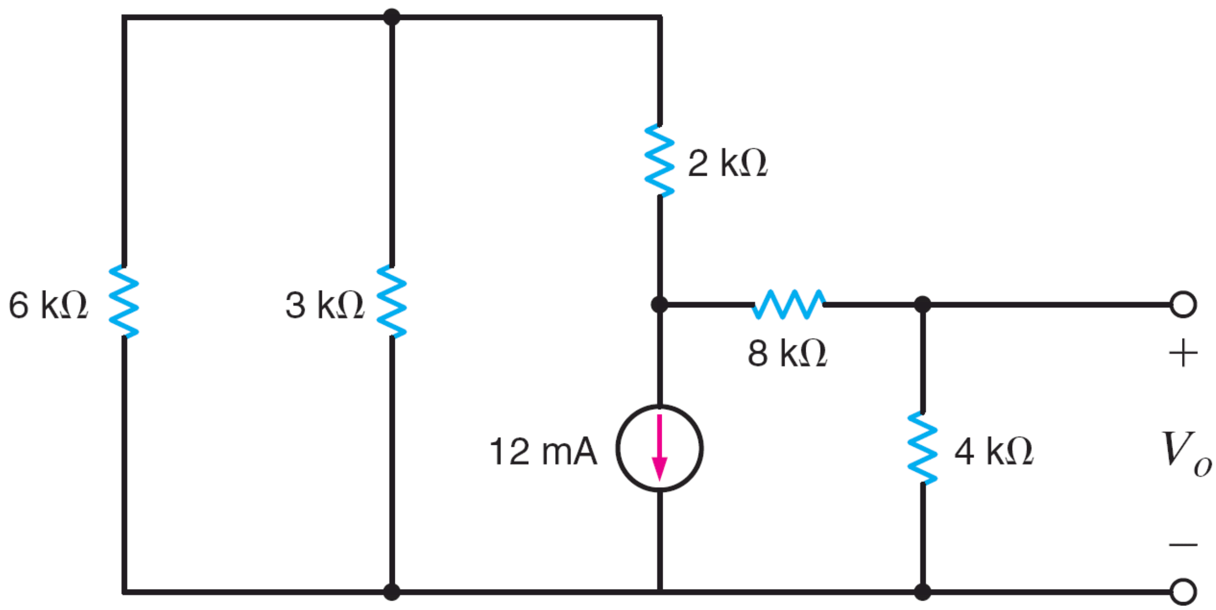
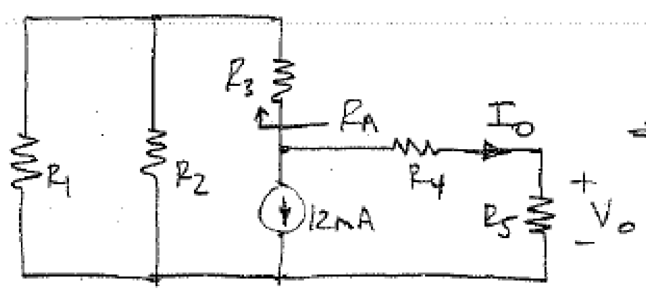
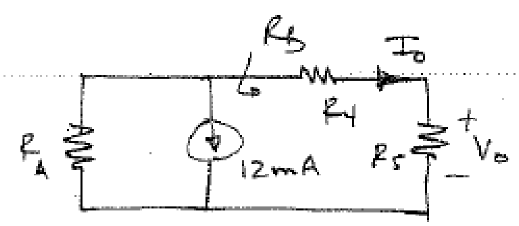


Figure P2.77

SOLUTION:

2.77 Find V_o





$R_1 = 6k\Omega \quad R_2 = 3k\Omega \quad R_3 = 2k\Omega$

$R_4 = 8k\Omega \quad R_5 = 4k\Omega$

$R_A = R_3 + (R_1 // R_2) = 4k\Omega$

$R_B = 12k\Omega$

$I_o = -12\times10^{-3}\left(\frac{R_A}{R_A + R_B}\right) = -3mA$

$V_o = I_o R_5$

$V_o = -12V$

2.78 Find V_o in the circuit in Fig. P2.78.

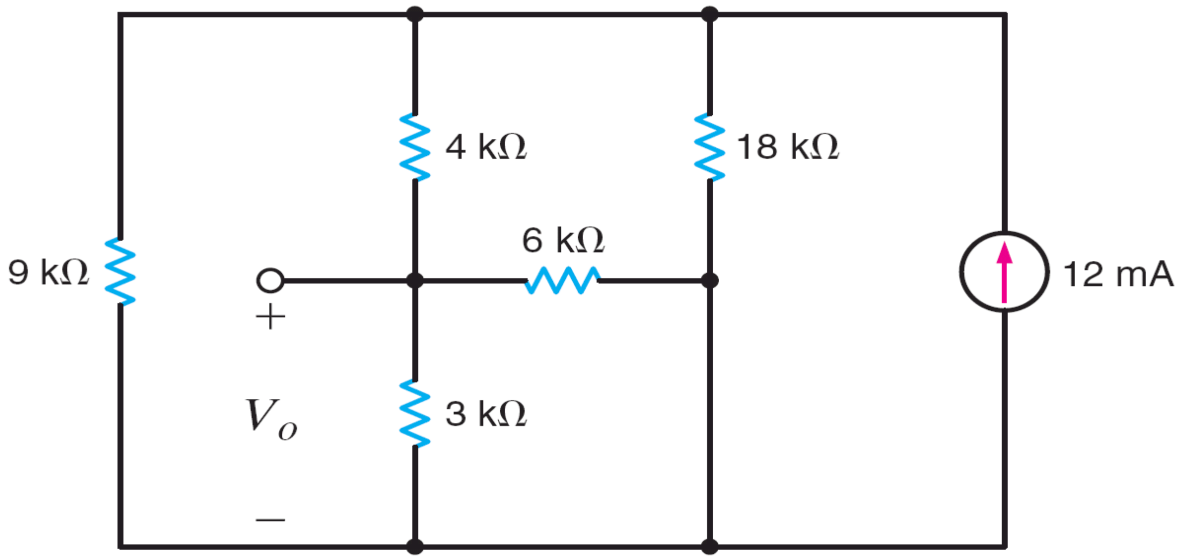
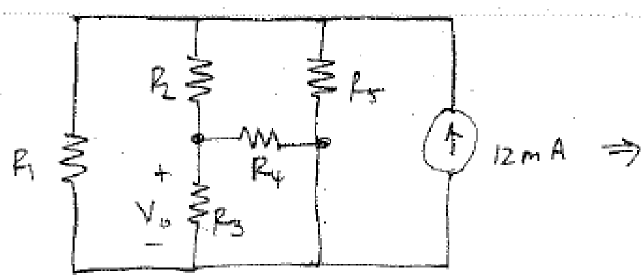
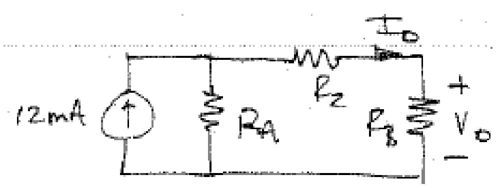


Figure P2.78

SOLUTION:

2.78 Find V_o.





$R_1 = 9k\Omega$ $R_2 = 4k\Omega$ $R_3 = 3k\Omega$

$R_4 = 6k\Omega$ $R_5 = 18k\Omega$

$R_A = R_1 // R_5 = 6k\Omega$

$R_B = R_3 // R_4 = 2k\Omega$

$$I_o = 12\times10^{-3}\left(\frac{R_A}{R_A + (R_2 + R_B)}\right)$$

$I_o = 6mA$

$V_o = R_B I_o \Rightarrow$ $\boxed{V_o = 12V}$

2.79 Find I_o in the circuit in Fig. P2.79.

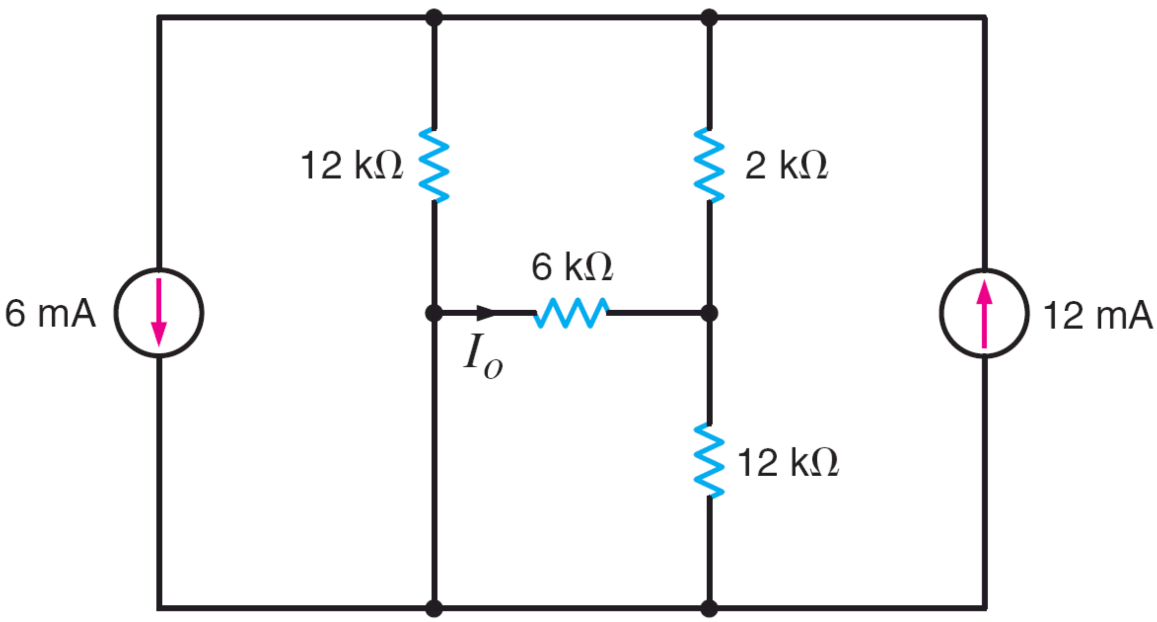
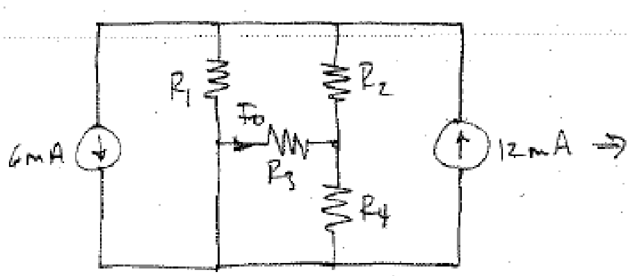
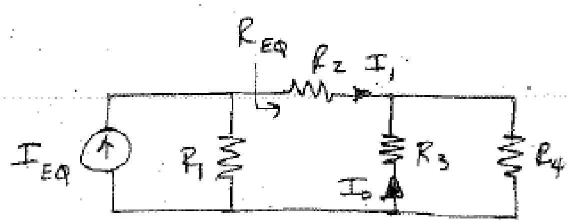


Figure P2.79

SOLUTION:

2.79 Find I_o





$R_1 = R_4 = 12k\Omega$, $R_2 = 2k\Omega$, $R_3 = 6k\Omega$

$$I_{EQ} = 12\times10^{-3} - 6\times10^{-3} = 6\,mA$$

$$R_{EQ} = R_2 + (R_3 // R_4) = 6k\Omega$$

$$I_1 = I_{EQ}\left[\frac{R_1}{R_1 + R_{EQ}}\right] = 4\,mA$$

$$I_o = -I_1\left[\frac{R_4}{R_3 + R_4}\right] \Rightarrow \boxed{I_o = -2.67\,mA}$$

2.80 Find I_o in the circuit in Fig. P2.80.

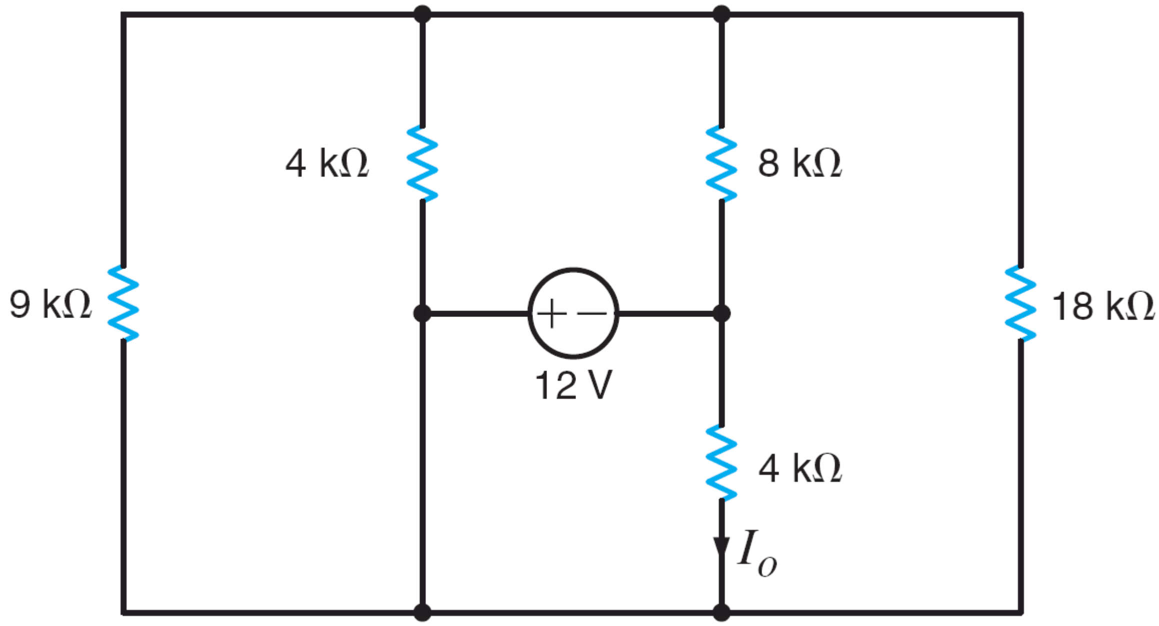
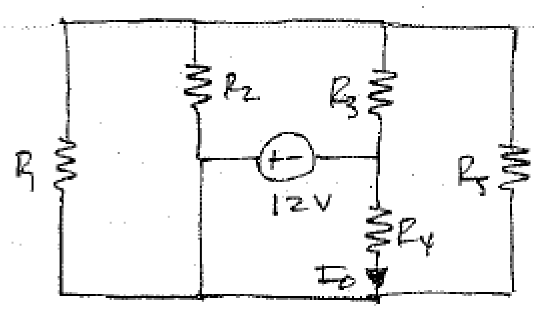


Figure P2.80

SOLUTION:

2.80 Find I_o.



$R_4 = 4k\Omega$

$$I_o = \frac{-12}{R_4} = -3mA$$

$$\boxed{I_o = -3mA}$$

2.81 Find I_o in the circuit in Fig. P2.81.

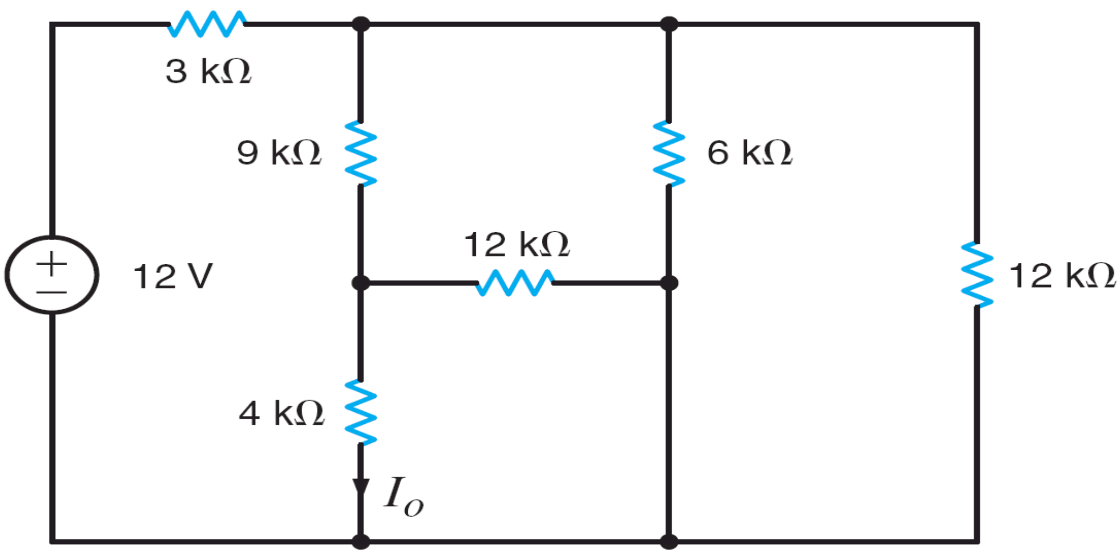
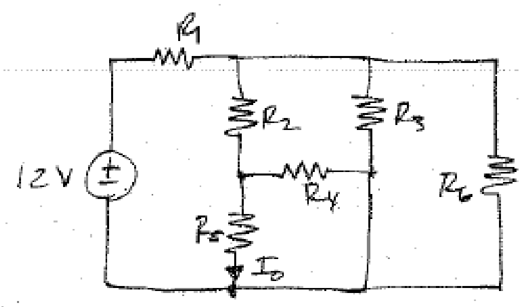


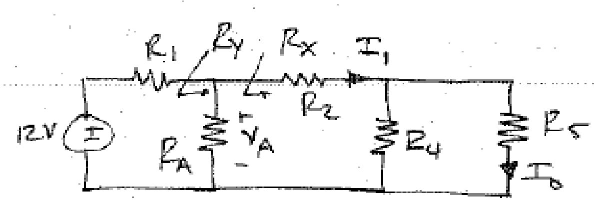
Figure P2.81

SOLUTION:

2.81 Find I_o



⇒



$R_1 = 3k\Omega$, $R_2 = 9k\Omega$, $R_3 = 6k\Omega$

$R_4 = 12k\Omega$, $R_5 = 4k\Omega$; $R_6 = 12k\Omega$

$R_A = R_3 // R_6 = 4k\Omega$

$R_X = R_2 + (R_4 // R_5) = 12k\Omega$

$R_Y = R_A // R_X = 3k\Omega$

$$V_A = 12\left[\frac{R_Y}{R_1 + R_Y}\right] = 6V \qquad I_1 = \frac{V_A}{R_X} = \frac{1}{2}\,mA$$

$$I_o = I_1\left[\frac{R_4}{R_4 + R_5}\right] \Rightarrow \boxed{I_o = 375\,\mu A}$$

2.82 Find V_o in the circuit in Fig. P2.82. **PSV**

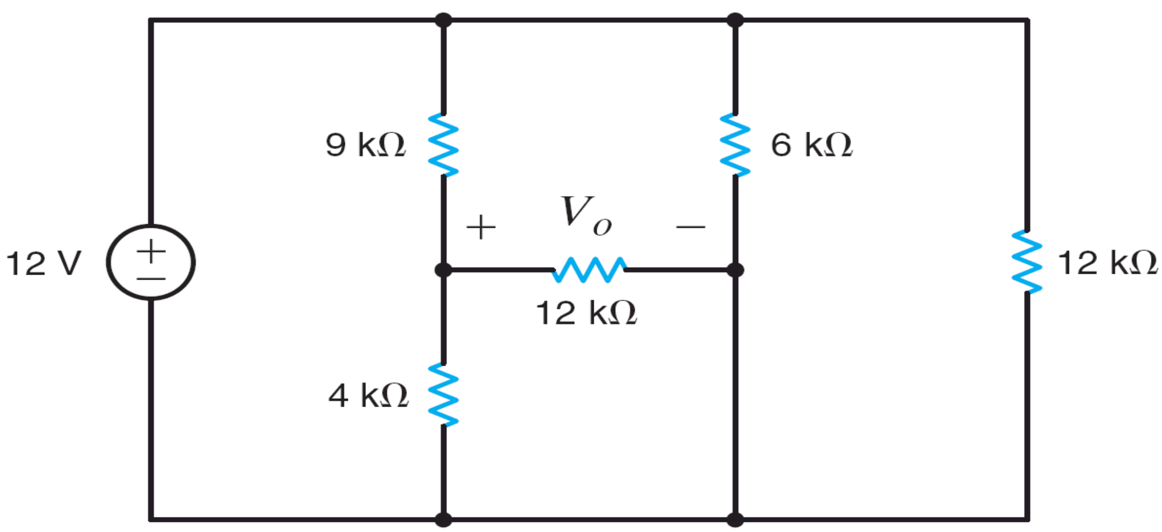
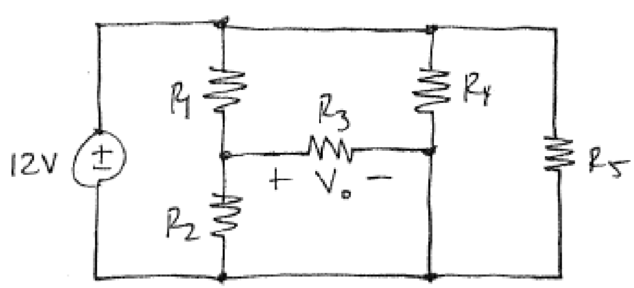


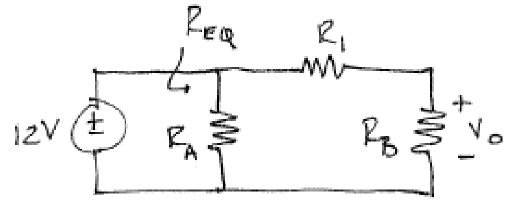
Figure P2.82

SOLUTION:

2.82 Find V_o.



⇒



$R_1 = 9k\Omega$, $R_2 = 4k\Omega$, $R_3 = 12k\Omega$

$R_4 = 6k\Omega$ $R_5 = 12k\Omega$

$R_{EQ} = R_A \,//\, (R_1 + R_B)$

$R_A = R_4 // R_5 = 4k\Omega$

$R_B = R_2 // R_3 = 3k\Omega$

$R_{EQ} = 3k\Omega$

$$V_o = 12\left[\frac{R_B}{R_B + R_1}\right] \Rightarrow \boxed{V_o = 3V}$$

2.83 Find I_o in the circuit in Fig. P2.83.

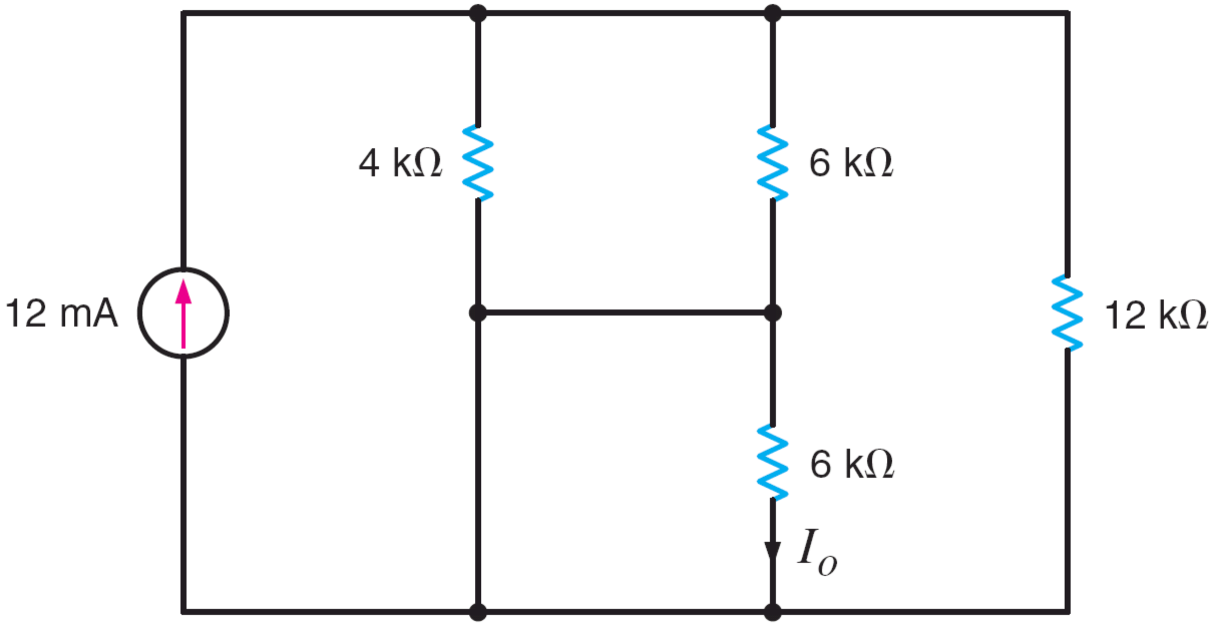
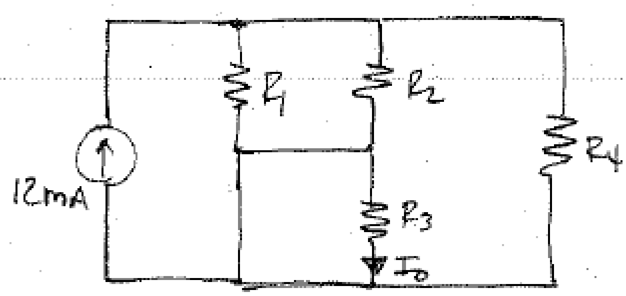


Figure P2.83

SOLUTION:

2.83 Find I_o.



R_3 is shorted, so

$$I_o = 0\,A$$

2.84 Determine the value of V_o in the circuit in Fig. P2.84.

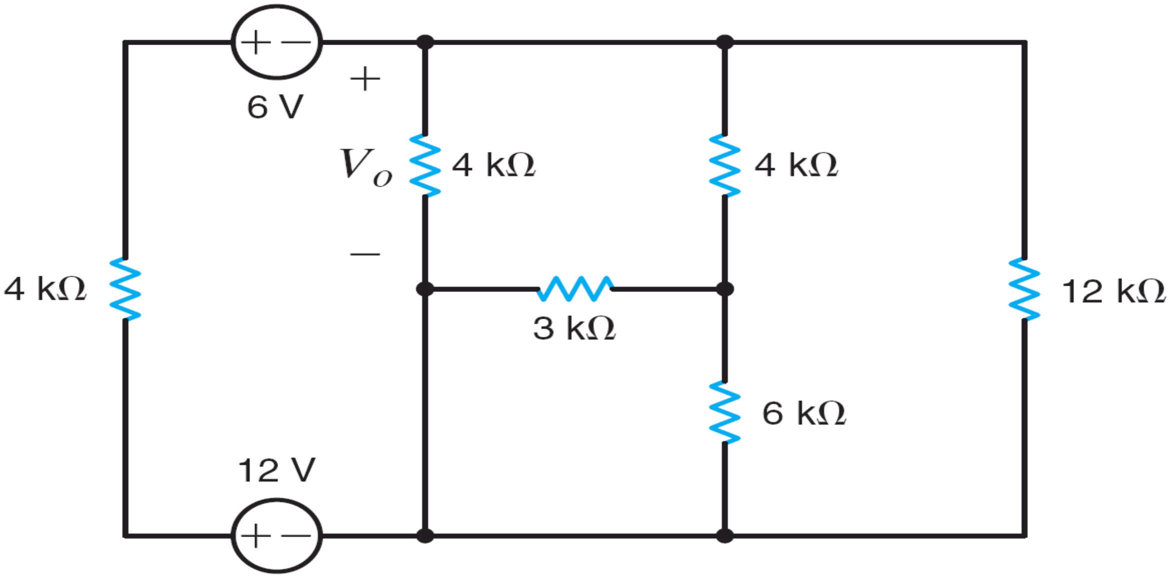
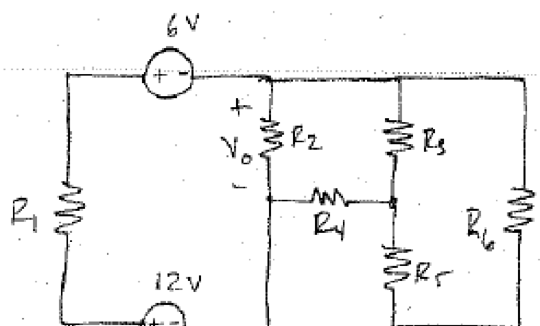


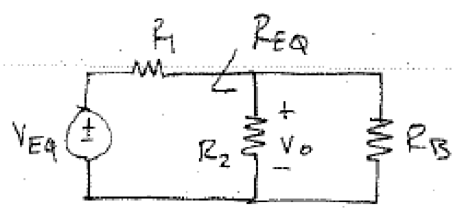
Figure P2.84

SOLUTION:

2.84



$\Rightarrow$



$R_1 = R_2 = R_3 = 4k\Omega \quad R_4 = 3k\Omega$

$R_5 = 6k\Omega \quad R_6 = 12k\Omega$

$V_{EQ} = 12 - 6 = 6V$

$R_B = R_6 \,//\, [R_3 + (R_4 // R_5)] = 4k\Omega$

$R_{EQ} = R_2 // R_B = 2k\Omega$

$V_o = V_{EQ}\left[\dfrac{R_{EQ}}{R_1 + R_{EQ}}\right] \Rightarrow \boxed{V_o = 2V}$

2.85 Find $P_{4\,\Omega}$ in the network in Fig. P2.85.

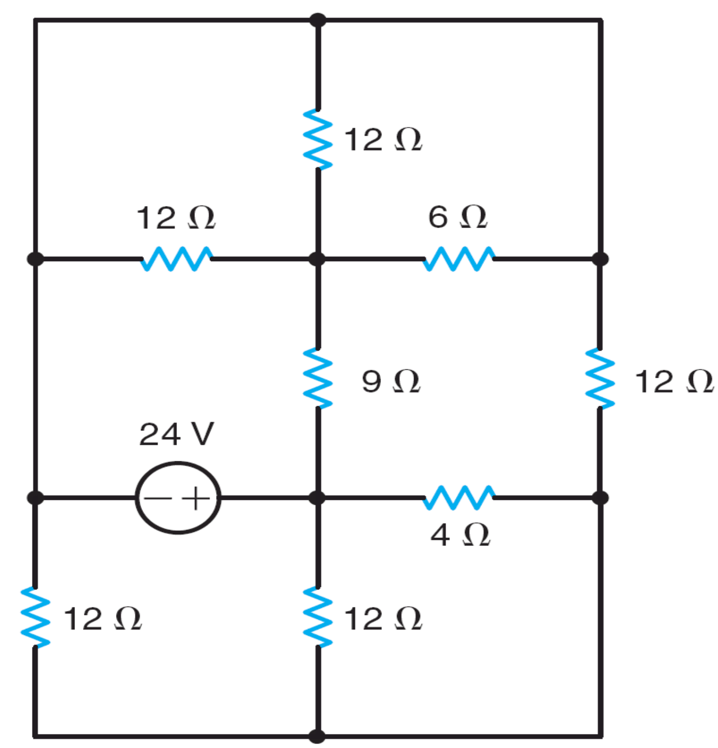
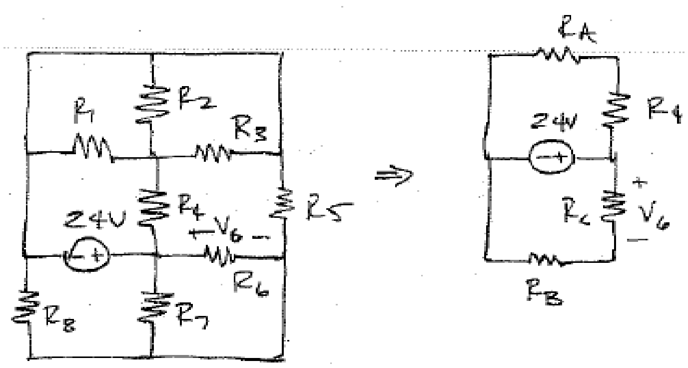


Figure P2.85

SOLUTION:

Find $P_{4\Omega}$ (P_{R6})



$R_1 = R_2 = R_5 = R_7 = R_8 = 12\Omega$

$R_3 = 6\Omega \quad R_4 = 9\Omega \quad R_6 = 4\Omega$

$R_A = R_1 // R_2 // R_3$

$R_B = R_5 // R_8 = 6\Omega$

$R_C = R_6 // R_7 = 3\Omega$

$V_6 = 24\left[\frac{R_C}{R_C + R_B}\right] = 8V$

$P_{R6} = \frac{V_6^2}{R_6}$

$\boxed{P_{R6} = 16W}$

2.86 Find I_o in the network in Fig. P2.86.

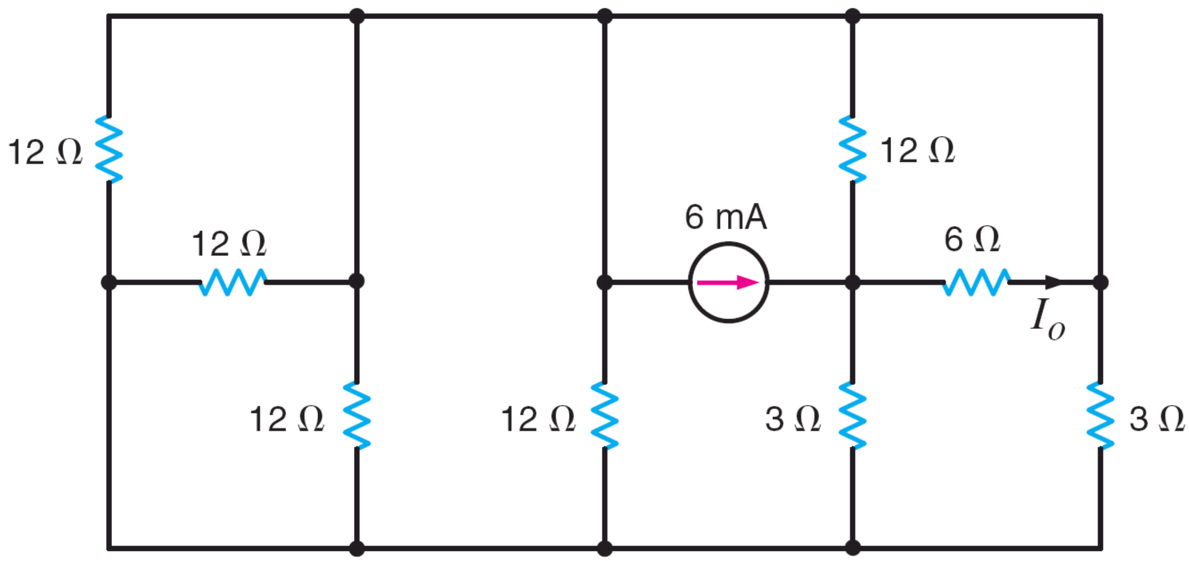
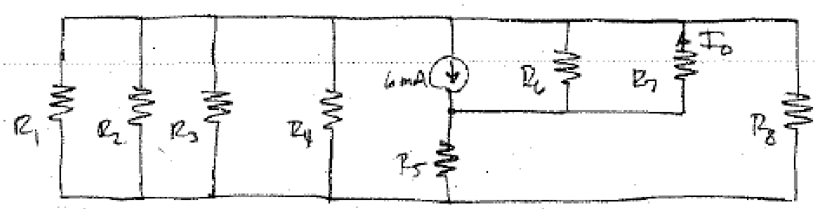


Figure P2.86

SOLUTION:

2. 86 Find I_o.

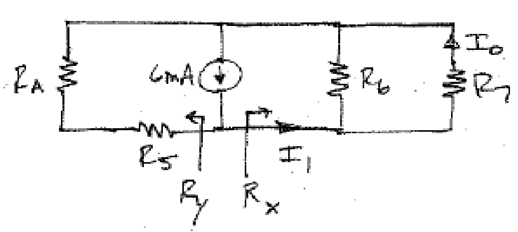


$R_1 = R_2 = R_3 = R_4 = R_6 = 12\Omega$

$R_5 = R_8 = 3\Omega$

$R_7 = 6\Omega$

⇓



$R_A = R_1 // R_2 // R_3 // R_4 // R_8 = 1.5\ \Omega$

$R_x = R_6 // R_7 = 4\Omega$

$R_y = R_5 + R_A = 4.5\Omega$

$I_1 = 6 \times 10^{-3} \left[\frac{R_y}{R_y + R_x} \right] = 3.18\ mA$

$I_o = I_1 \left[\frac{R_6}{R_6 + R_7} \right]$

$\boxed{I_o = 2.12\ mA}$

2.87 In the network in Fig. P2.87, the power absorbed by the 4-Ω resistor is 100 W. Find V_S. **CS**

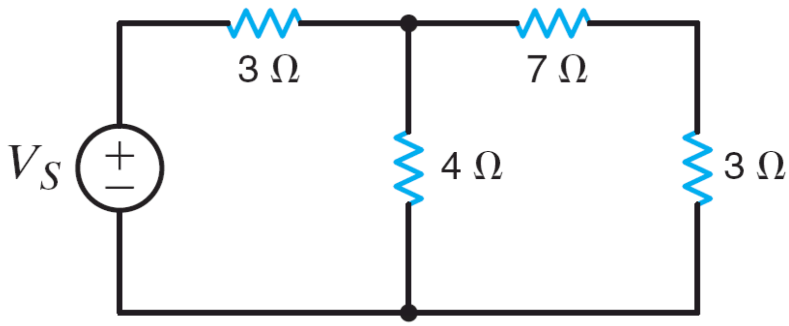
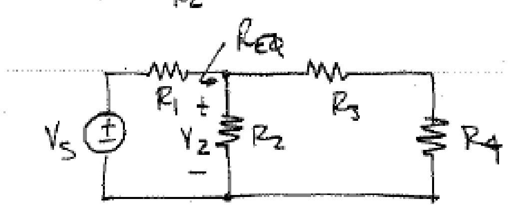


Figure P2.87

SOLUTION:

2.87 $P_{R2} = 100W$. Find V_S



$R_1 = 3\Omega \quad R_2 = 4\Omega \quad R_3 = 7\Omega \quad R_4 = 3\Omega$

$P_{R_2} = V_2^2 / R_2 \Rightarrow V_2 = 20V$

$V_2 = V_S \left[\frac{R_{EQ}}{R_1 + R_{EQ}} \right]$ but, $R_{EQ} = R_2 // (R_3 + R_4) = 2.86\,\Omega$

$\boxed{V_S = 41\,V}$

2.88 If $V_o = 2$ V in the circuit in Fig. P2.88, find V_S.

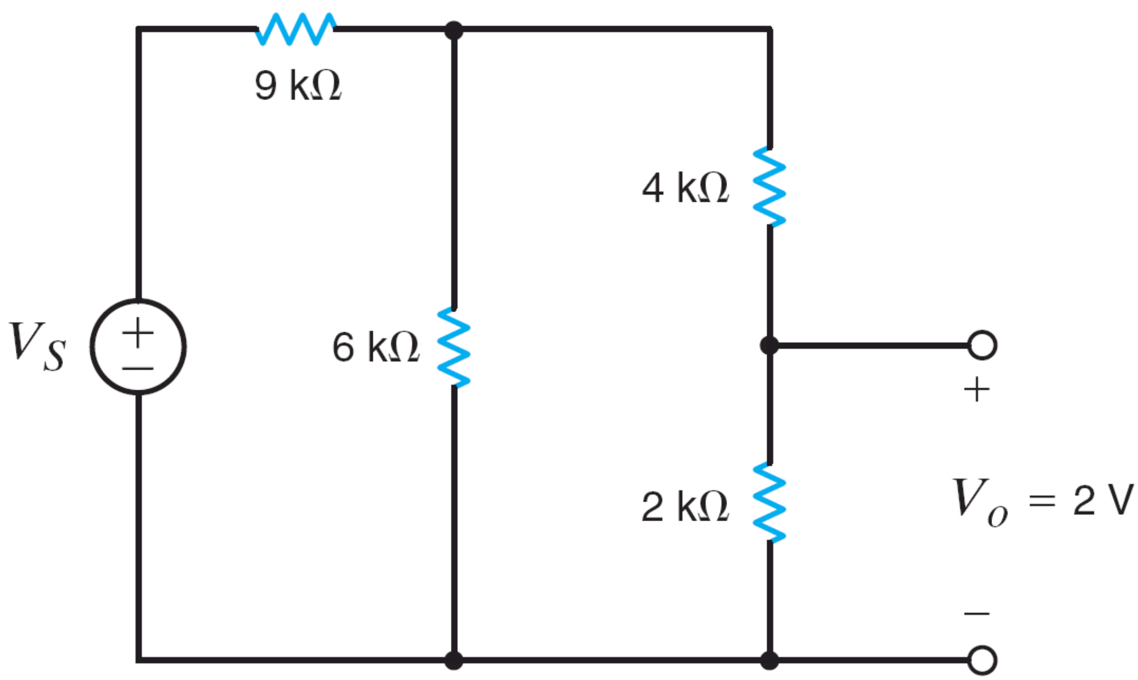
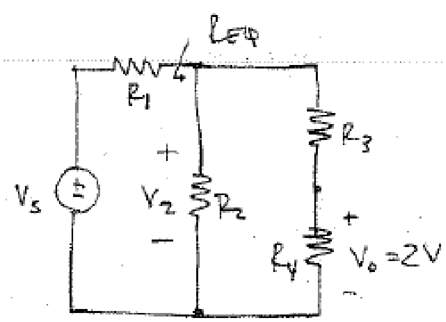


Figure P2.88

SOLUTION:

2.88 $V_o = 2V$, Find V_S



$R_1 = 9k\Omega \quad R_2 = 6k\Omega \quad R_3 = 4k\Omega \quad R_4 = 2k\Omega$

$$V_o = V_2\left[\frac{R_4}{R_3+R_4}\right] \Rightarrow V_2 = 6V$$

$$R_{EQ} = R_2 // (R_3 + R_4) = 3k\Omega$$

$$V_2 = V_S\left[\frac{R_{EQ}}{R_1+R_{EQ}}\right] \Rightarrow \boxed{V_S = 24V}$$

2.89 If $V_o = 6$ V in the circuit in Fig. P2.89, find I_S.

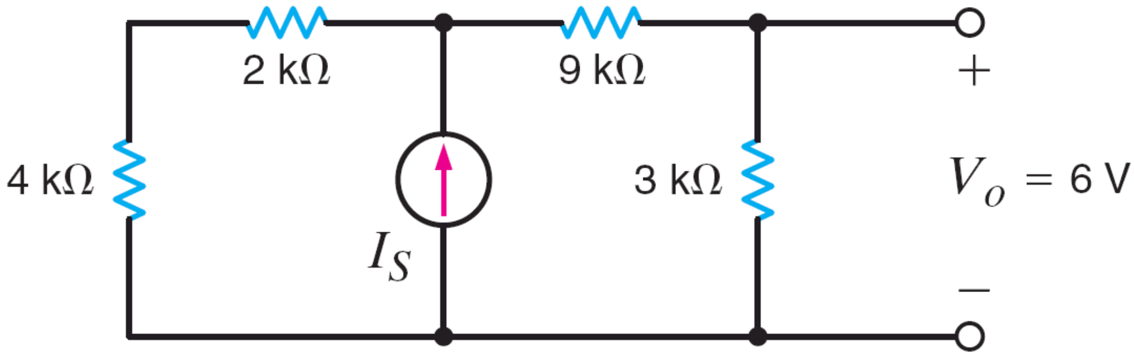
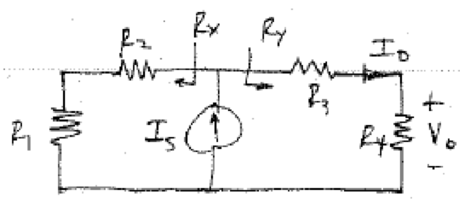


Figure P2.89

SOLUTION:

2.89 $V_o = 6$ V. Find I_S.



$R_1 = 4\text{k}\Omega$ $R_2 = 2\text{k}\Omega$ $R_3 = 9\text{k}\Omega$

$R_4 = 3\text{k}\Omega$

$R_x = R_1 + R_2 = 6\text{k}\Omega$ $R_y = R_3 + R_4 = 12\text{k}\Omega$

$I_o = I_S \left[\frac{R_x}{R_x + R_y} \right]$ and $I_o = \frac{V_o}{R_4} = 2\text{mA}$

$\boxed{I_S = 6\text{mA}}$

2.90 If $I_o = 2$ mA in the circuit in Fig. P2.90, find V_S.

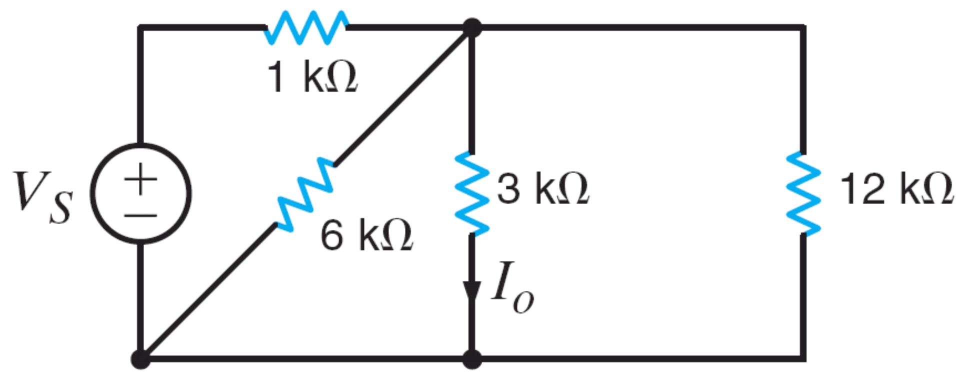
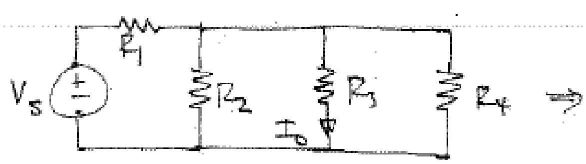
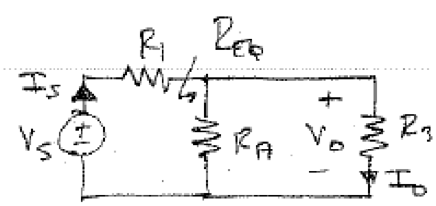


Figure P2.90

SOLUTION:

2.90 $I_o = 2mA$. Find V_s





$R_1 = 1k\Omega \quad R_2 = 6k\Omega \quad R_3 = 3k\Omega$

$R_4 = 12k\Omega$

$R_A = R_2 // R_4 = 4k\Omega$

$R_{EQ} = R_A // R_3 = 1.71k\Omega$

$V_o = V_s \left[\frac{R_{EQ}}{R_1 + R_{EQ}} \right]$ and $V_o = I_o R_3 = 6V$

$\boxed{V_s = 9.5V}$

2.91 If $V_1 = 5$ V in the circuit in Fig. P2.91, find I_S.

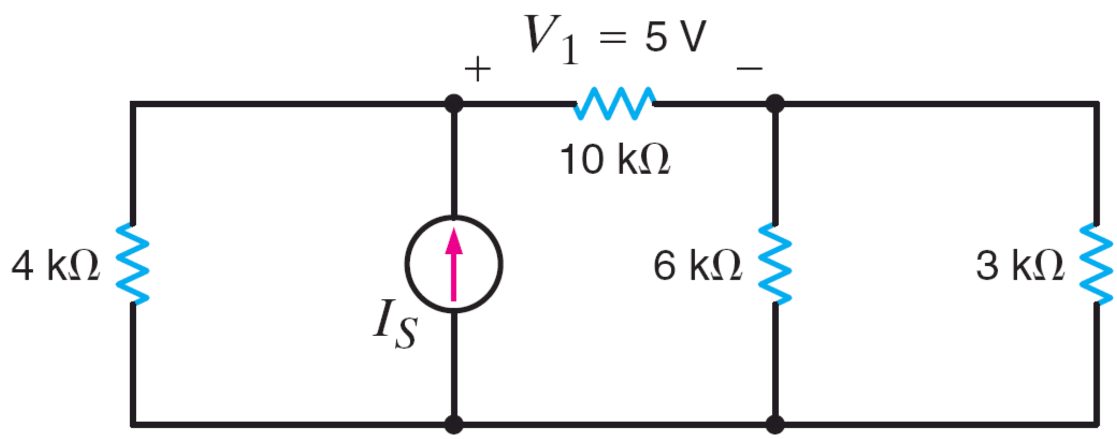
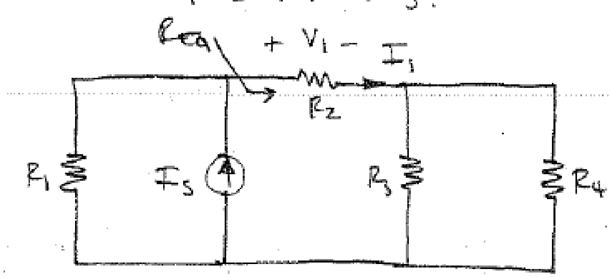


Figure P2.91

SOLUTION:

2.91 $V_1 = 5$V. Find I_S.



$R_1 = 4k\Omega$, $R_2 = 10k\Omega$, $R_3 = 6k\Omega$, $R_4 = 3k\Omega$

$R_{EQ} = R_2 + (R_3 /\!/ R_4) = 12k\Omega$

$I_1 = V_1/R_2 = \frac{1}{2}$ mA

$I_1 = I_S\left[\frac{R_1}{R_1 + R_{EQ}}\right] \Rightarrow \boxed{I_S = 2mA}$

2.92 In the network in Fig. P2.92, $V_1 = 12$ V. Find V_S. CS

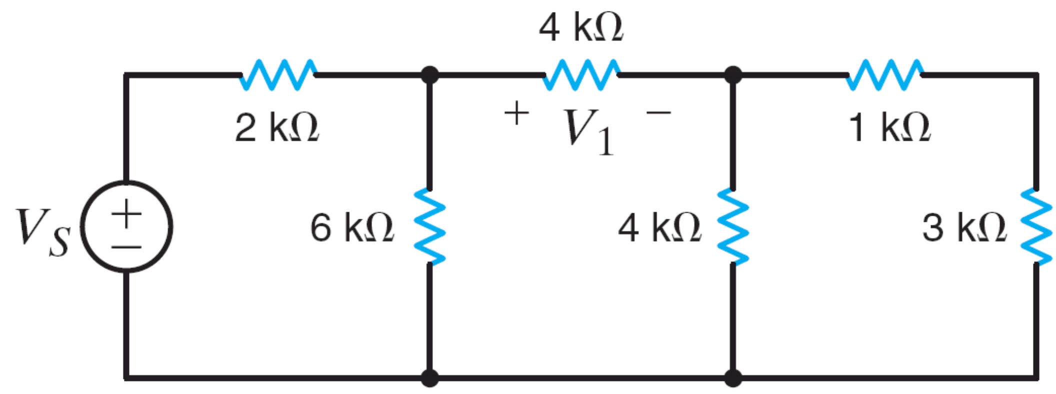
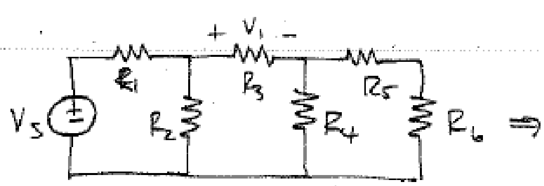
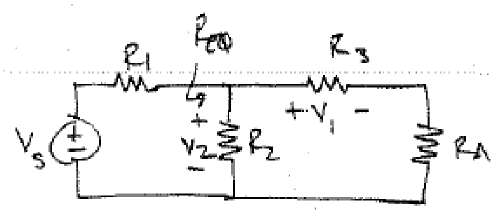


Figure P2.92

SOLUTION:

2.92 $V_1 = 12V$. Find V_S





$R_1 = 2k\Omega$ $R_2 = 6k\Omega$ $R_3 = 4k\Omega$

$R_4 = 4k\Omega$ $R_5 = 1k\Omega$ $R_6 = 3k\Omega$

$R_A = R_4 // (R_5 + R_6) = 2k\Omega$

$R_{EQ} = R_2 // (R_3 + R_A) = 3k\Omega$

$V_1 = V_2 \left[\frac{R_3}{R_3 + R_A} \right] \Rightarrow V_2 = 18\text{ V}$

$V_2 = V_s \left[\frac{R_{EQ}}{R_{EQ} + R_1} \right] \Rightarrow \boxed{V_S = 30V}$

2.93 In the circuit in Fig. P2.93, $V_o = 2$ V. Find I_S.

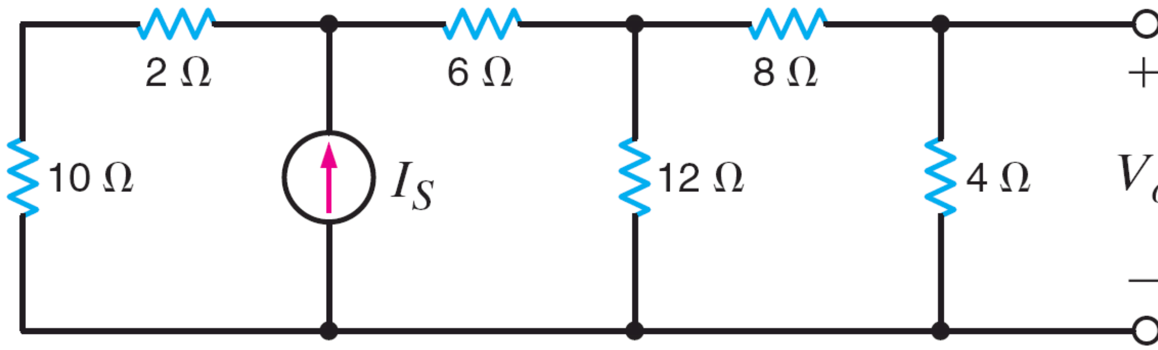
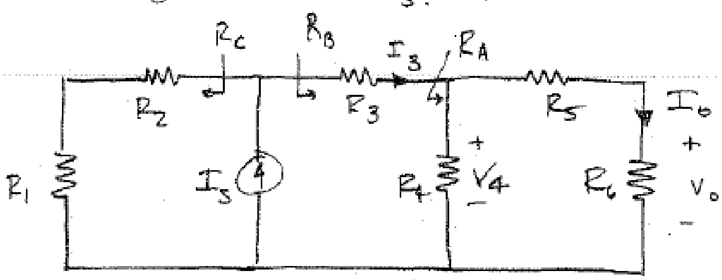


Figure P2.93

SOLUTION:

2.93 $V_o = 2V$. Find I_s.



$R_1 = 10\Omega$ $R_2 = 2\Omega$ $R_3 = 6\Omega$

$R_4 = 12\Omega$ $R_5 = 8\Omega$ $R_6 = 4\Omega$

$R_C = R_1 + R_2 = 12k\Omega$

$R_A = R_4 \,//\, (R_5 + R_6) = 6k\Omega$

$R_B = R_3 + R_A = 12k\Omega$

$$I_3 = I_S\left[\frac{R_C}{R_C + R_B}\right] = \frac{I_S}{2}$$

$$I_o = I_3\left[\frac{R_4}{R_4 + (R_5 + R_6)}\right] = \frac{I_3}{2}$$

$I_o = V_o / R_6 = 0.5A$

$\boxed{I_S = 2A}$

2.94 In the network in Fig. P2.94, $V_o = 6$ V. Find I_S.

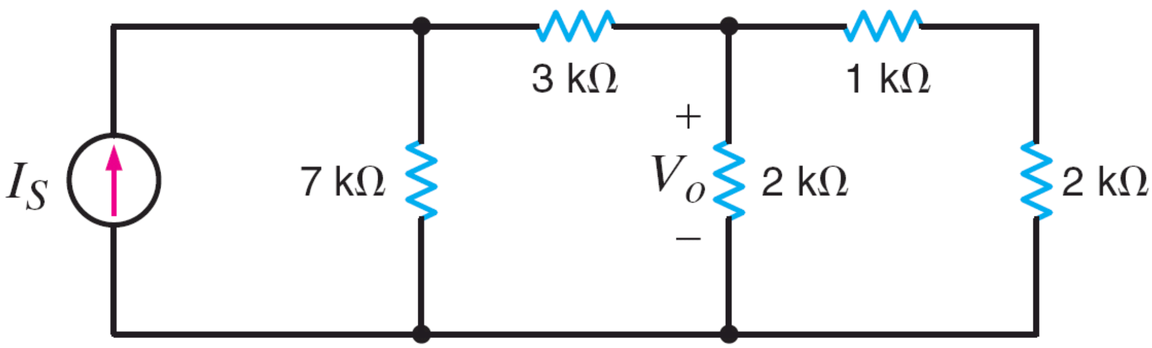
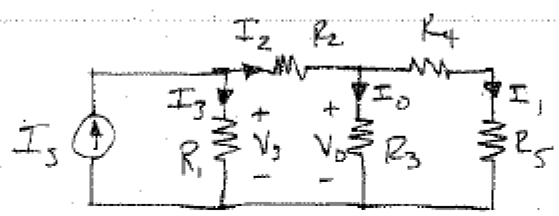


Figure P2.94

SOLUTION:

2.94 $V_o = 6V$. Find I_S.



$R_1 = 7k\Omega \quad R_2 = 3k\Omega$

$R_3 = R_5 = 2k\Omega \quad R_4 = 1k\Omega$

$I_o = V_o / R_3 = 3mA$

$I_1 = \dfrac{V_o}{R_4 + R_5} = 2mA$

$I_2 = I_o + I_1 = 5 mA$

$V_3 = I_2 R_2 + V_o = 21V$

$I_3 = V_3 / R_1 = 3 mA$

$I_S = I_2 + I_3 \Rightarrow$ $\boxed{I_S = 8 mA}$

2.95 In $I_o = 4$ mA in the circuit in Fig. P2.95, find I_S. CS

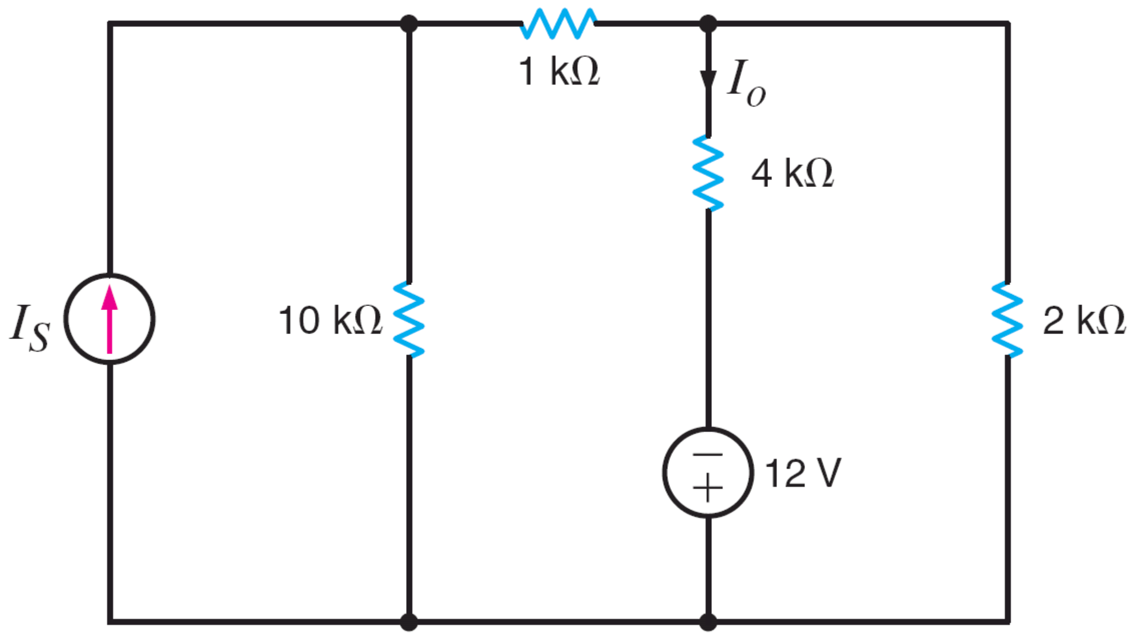
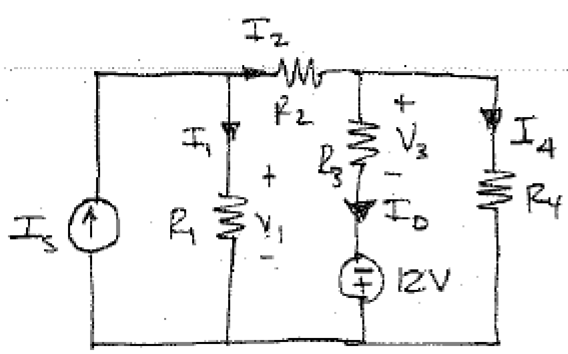


Figure P2.95

SOLUTION:

2.95 $I_o = 4mA$. Find I_S.



$R_1 = 10k\Omega$ $R_2 = 1k\Omega$ $R_3 = 4k\Omega$

$R_4 = 2k\Omega$

$V_3 = R_3 I_o = 16V$

$I_4 = \frac{V_3 - 12}{R_4} = 2mA$

$I_2 = I_o + I_4 = 6mA$

$V_1 = I_2 R_2 + I_4 R_4 = 10V$

$I_1 = V_1 / R_1 = 1mA$

$I_S = I_1 + I_2 \Rightarrow$ $\boxed{I_S = 7mA}$

2.96 If $V_o = 6$ V in the circuit in Fig. P2.96, find I_S.

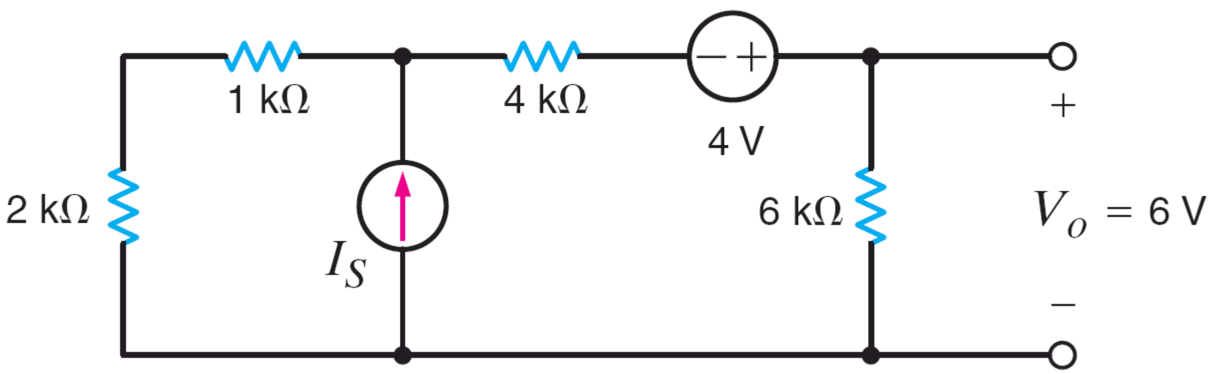
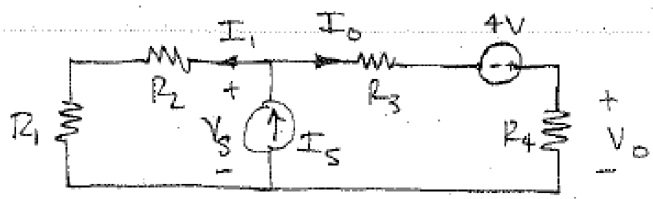


Figure P2.96

SOLUTION:

2.96 $V_o = 6V$. $I_S = ?$



$R_1 = 2k\Omega$ $R_2 = 1k\Omega$ $R_3 = 4k\Omega$ $R_4 = 6k\Omega$

$I_o = V_o / R_4 = 1mA$

$V_S = I_o R_3 - 4 + I_o R_4$

$V_S = 6V$

$I_1 = \dfrac{V_S}{R_1 + R_2} = 2mA$

$I_S = I_1 + I_o = 3mA$ $\boxed{I_S = 3mA}$

2.97 Given that $V_o = 4$ V in the network in Fig. P2.97, find V_S.

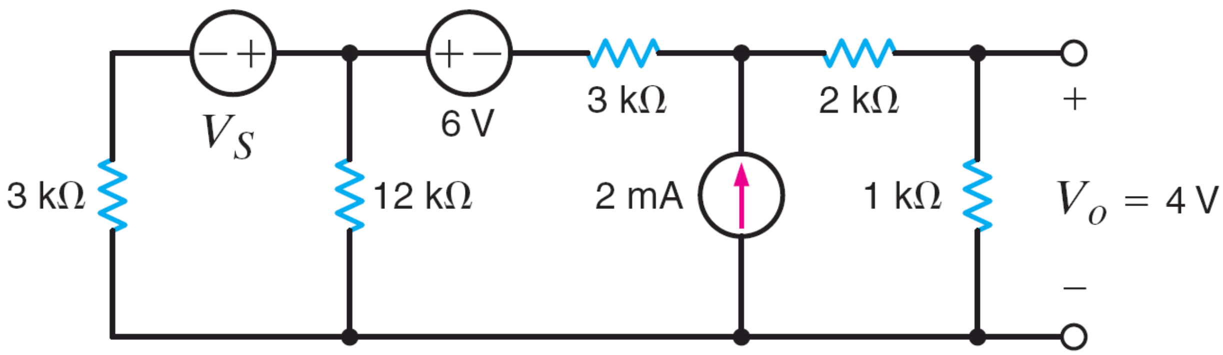
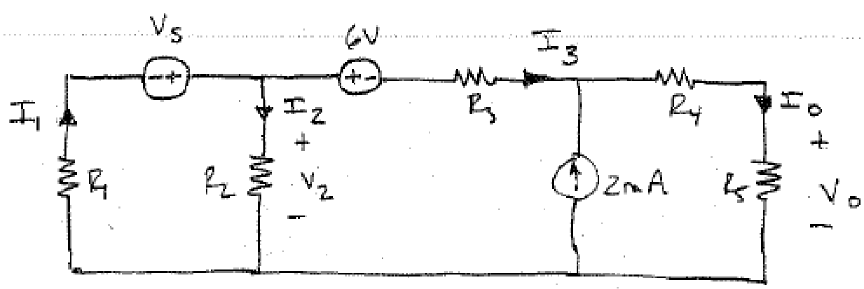


Figure P2.97

SOLUTION:

2.97 $V_o = 4V$. Find V_s.



$R_1 = 3k\Omega$ $R_2 = 12k\Omega$

$R_3 = 3k\Omega$ $R_4 = 2k\Omega$

$R_5 = 1k\Omega$

$I_o = V_o / R_5 = 4mA$ $I_3 = I_o - 2\times10^{-3} = 2mA$

$V_2 = 6 + R_3 I_3 + I_o R_4 + I_o R_5 = 24V$

$I_2 = V_2 / R_2 = 2mA$

$I_1 = I_2 + I_3 = 4mA$

$V_s = I_2 R_2 + I_1 R_1$ $\Rightarrow$ $\boxed{V_s = 36V}$

2.98 Find I_o in the circuit in Fig. P2.98.

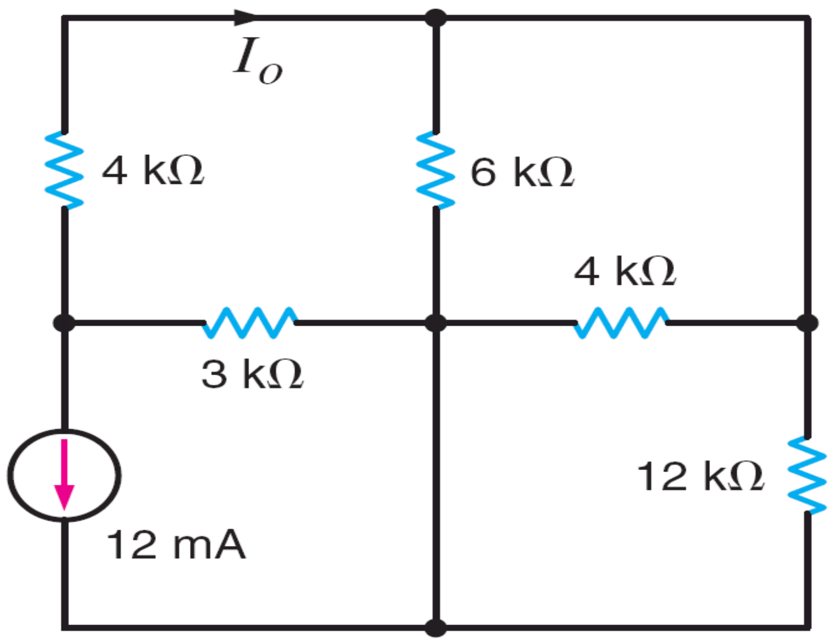
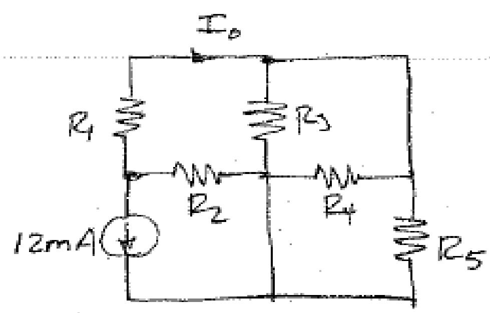


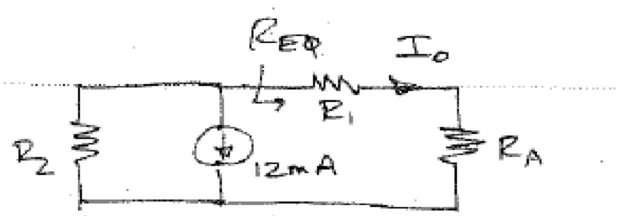
Figure P2.98

SOLUTION:

2.98 Find I_o



$\Rightarrow$



$R_1 = 4k\Omega \quad R_2 = 3k\Omega$

$R_3 = 6k\Omega \quad R_4 = 4k\Omega$

$R_5 = 12k\Omega$

$R_{EQ} = R_1 + R_A = 6k\Omega$

$R_A = R_3 // R_4 // R_5 = 2k\Omega$

$$I_o = -12\times10^{-3}\left[\frac{R_2}{R_2 + R_{EQ}}\right]$$

$$\boxed{I_o = -4mA}$$

2.99 Given V_o in the network in Fig. P2.99, find I_A.

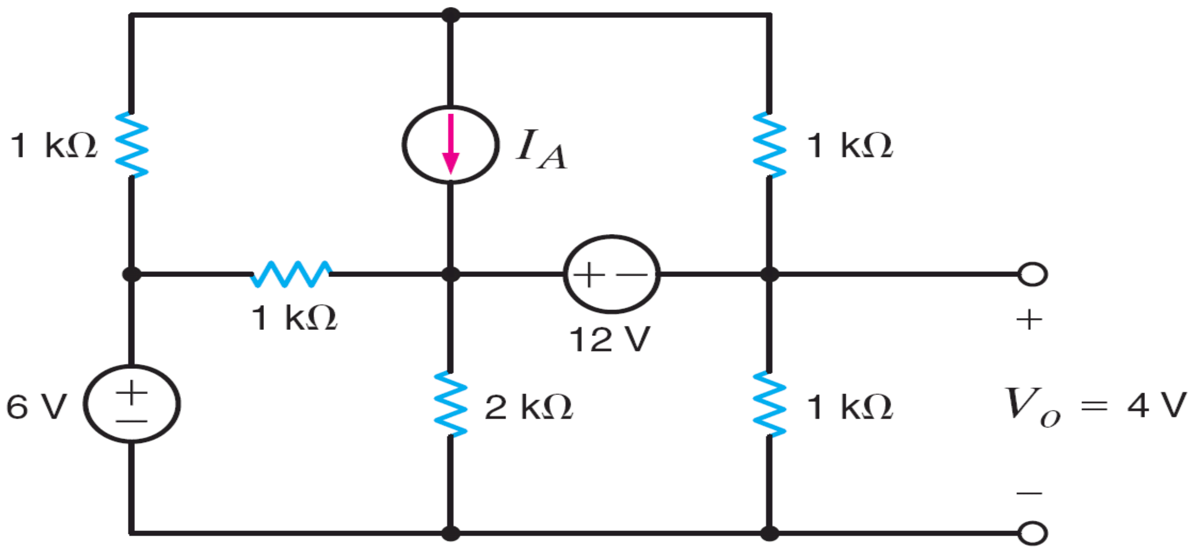
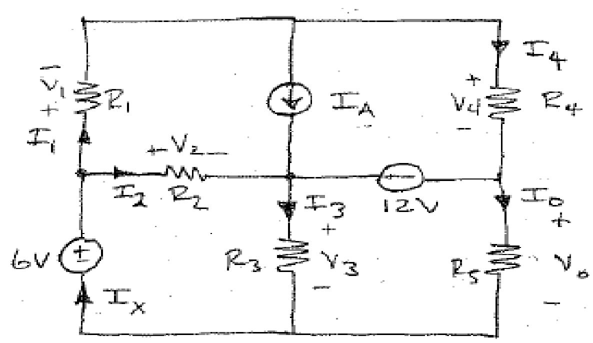


Figure P2.99

SOLUTION:

2.99 $V_o = 4V$. Find I_A



$R_1 = R_2 = R_4 = R_5 = 1k\Omega \quad R_3 = 2k\Omega$

$I_o = V_o / R_5 = 4mA$

$V_3 = 12 + I_o R_5 = 16V$

$I_3 = V_3 / R_3 = 8mA$

$I_x = I_3 + I_o = 12mA$

$V_2 = 6 - V_3 = -10V$

$I_2 = V_2 / R_2 = -10mA$

$I_1 = I_x - I_2 = 22mA$

$V_1 = I_1 R_1 = 22V$

$V_4 = -V_o + 6 - V_1 = -20V$

$I_4 = V_4 / R_4 = -20mA$

$I_A = I_1 - I_4 = 42mA$ $\boxed{I_A = 42mA}$

2.100 Given $I_o = 2$ mA in the circuit in Fig. P2.100, find I_A.

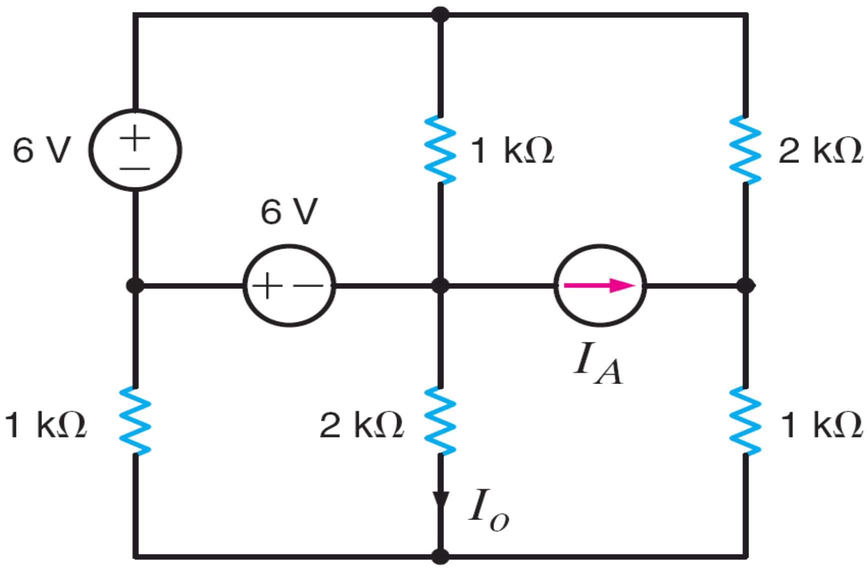
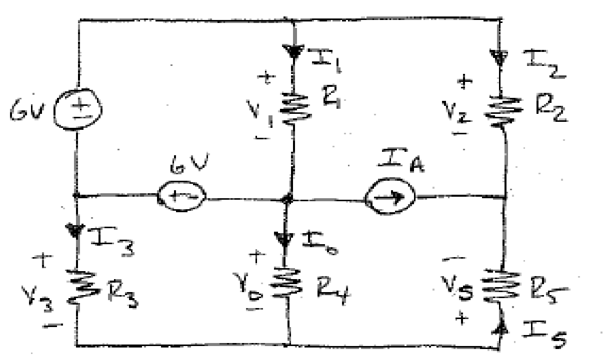


Figure P2.100

SOLUTION:

2.100 $I_o = 2mA$. Find I_A.



$R_1 = R_3 = R_5 = 1k\Omega \quad R_2 = R_4 = 2k\Omega$

$R_4 I_o = V_o = 4V$

$V_3 = 6 + V_o = 10V$

$I_3 = V_3 / R_3 = 10mA$

$I_5 = I_3 + I_o = 12mA$

$V_1 = 6 + 6 = 12V$

$I_1 = V_1 / R_1 = 12mA$

$V_2 = 6 + I_3 R_3 + I_5 R_5 = 28V$

$I_2 = V_2 / R_2 = 14mA$

$I_A = -I_2 - I_5 \Rightarrow \boxed{I_A = -26mA}$

2.101 Given $I_o = 2$ mA in the network in Fig. P2.101, find V_A.

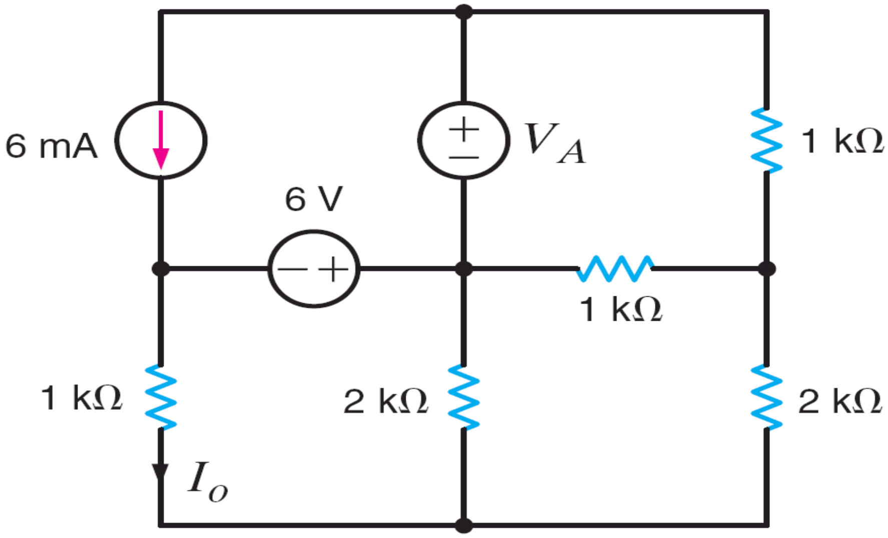
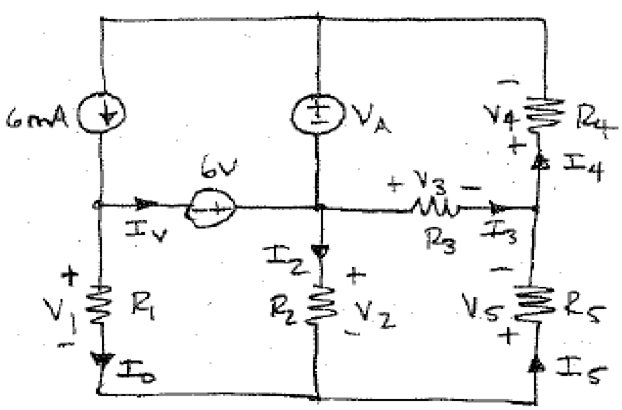


Figure P2.101

SOLUTION:

2.101 $I_o = 2mA$. Find V_A.

$V_1 = I_o R_1 = 2V$



$R_1 = R_3 = R_4 = 1k\Omega \quad R_2 = R_5 = 2k\Omega$

$V_2 = 6 + V_1 = 8V$

$I_2 = V_2 / R_2 = 4mA$

$I_5 = I_o + I_2 = 6mA$

$V_5 = I_5 R_5 = 12V$

$V_3 = 6 + V_1 + V_5 = 20V$

$I_3 = V_3 / R_3 = 20mA$

$I_4 = I_3 + I_5 = 26mA$

$V_4 = R_4 I_4 = 26V$

$V_A = -V_4 - V_3 \Rightarrow \boxed{V_A = -46V}$

2.102 Find the power absorbed by the network in Fig. P2.102.

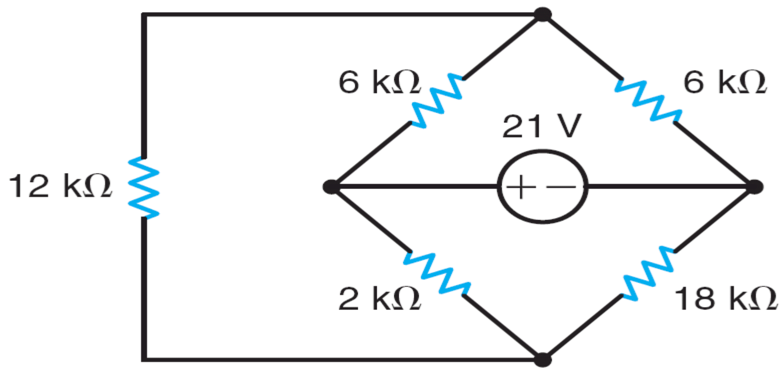
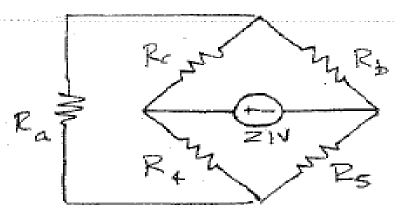


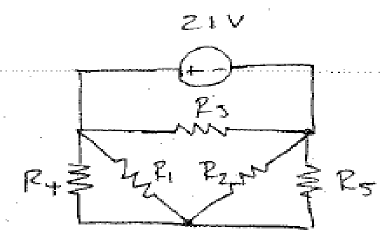
Figure P2.102

SOLUTION:

2.102 Find power absorbed.



R_a, R_b, R_c connected in wye config.



$R_a = 12k\Omega$ $R_b = 6k\Omega$

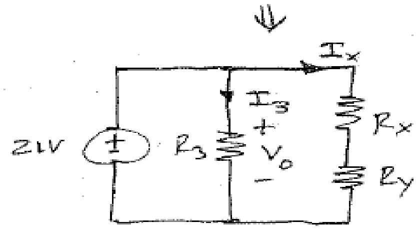
$R_c = 6k\Omega$ $R_4 = 2k\Omega$

$R_5 = 18k\Omega$

$$R_1 = \frac{R_a R_b + R_b R_c + R_a R_c}{R_b} = 30 k\Omega$$

$R_2 = 30k\Omega$ $R_3 = 15 k\Omega$

⇓



$R_x = R_1 // R_4 = 1.875 k\Omega$

$R_y = R_2 // R_5 = 11.25 k\Omega$

$$P = \frac{V_o^2}{R_3} + \frac{V_o^2}{R_x + R_y}$$

$P = 63 mW$

2.103 Find the value of g in the network in Fig. P2.103 such that the power supplied by the 3-A source is 20 W.

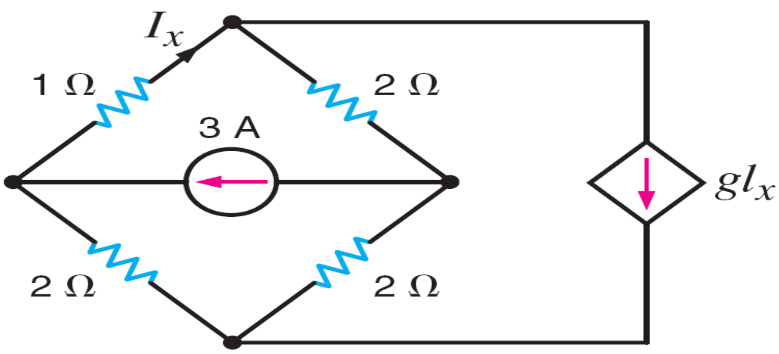
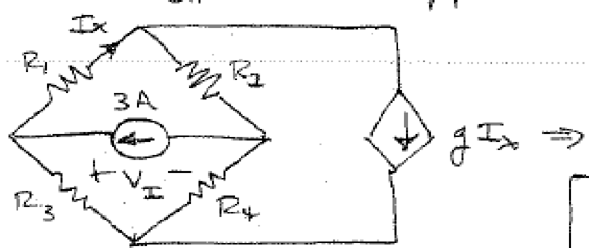
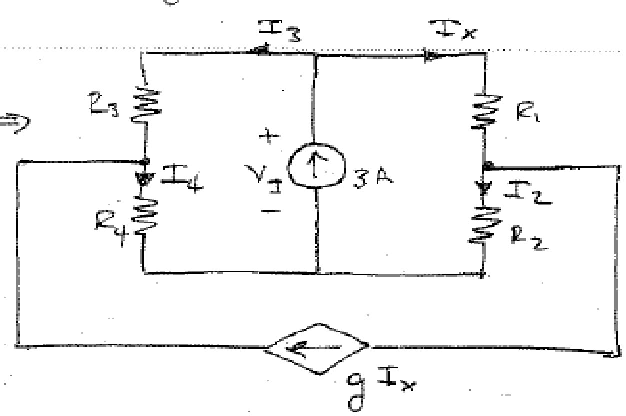


Figure P2.103

SOLUTION:

2.103 $P_{3A} = 20\text{W}$ supplied. Find g





$R_1 = 1\Omega \quad R_2 = R_3 = R_4 = 2\Omega$

$P_{3A} = 20 = V_I(3) \Rightarrow V_I = \frac{20}{3}V$

$V_I = I_x R_1 + I_2 R_2 \qquad I_2 = I_x(1-g)$

$V_I = I_3 R_3 + I_4 R_4 \qquad I_3 = 3 - I_x \qquad I_4 = I_3 + gI_x$

yields 2 equations

$$\left.\begin{aligned}\frac{20}{3} &= 3I_x - 2gI_x \\ \frac{20}{3} &= 12 - 4I_x + 2gI_x\end{aligned}\right\} \Rightarrow \boxed{g = 4}$$

2.104 Find the power supplied by the 24-V source in the circuit in Fig. P2.104.

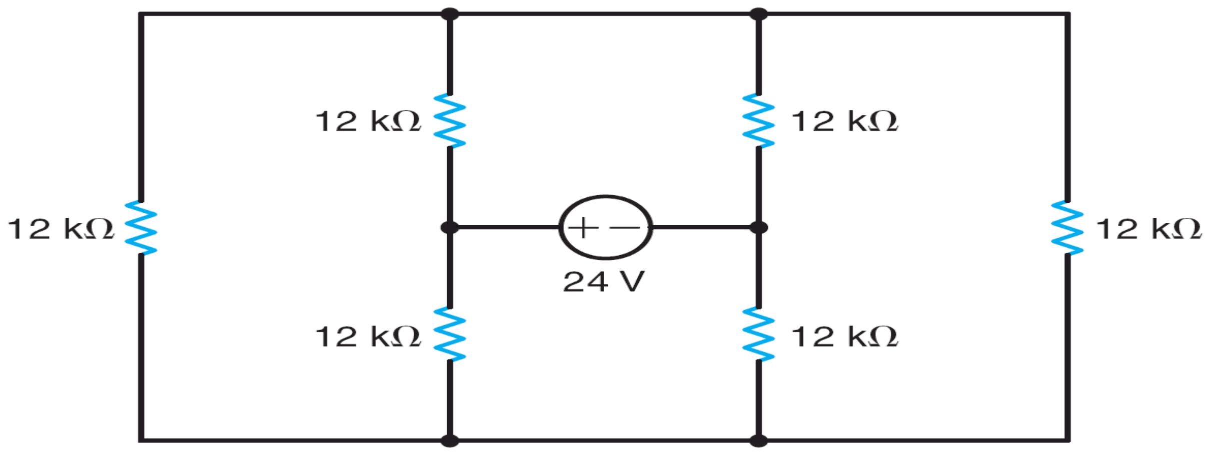
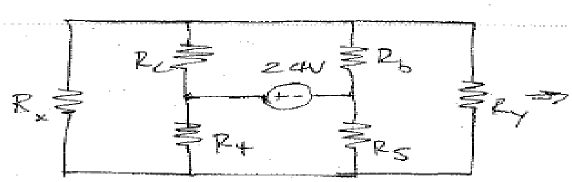


Figure P2.104

SOLUTION:

2.104 Find source power.



All R = 12 kΩ

$$R_1 = \frac{R_aR_b + R_bR_c + R_aR_c}{R_b}$$

$R_1 = 24\text{k}\Omega$

$R_2 = 24\text{k}\Omega$

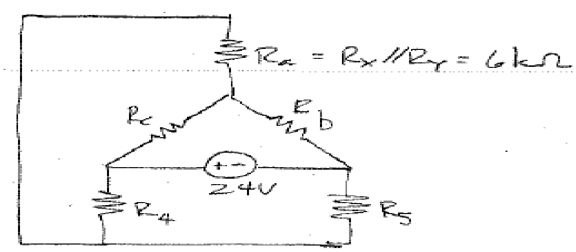
$R_3 = 48\text{k}\Omega$

$R_\alpha = R_1 // R_4 = 8\text{k}\Omega$

$R_\beta = R_2 // R_5 = 8\text{k}\Omega$

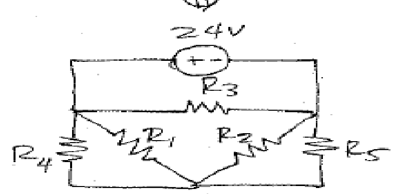
$$P_{24V} = \frac{24^2}{R_3} + \frac{24^2}{R_\alpha + R_\beta}$$

$P_{24V} = 48$ mW

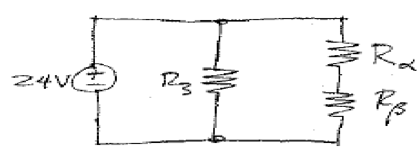


Ra − Rb − Rc ⇒ wye connected

⇓



⇓



2.105 Find I_o in the circuit in Fig. P2.105. **PSV**

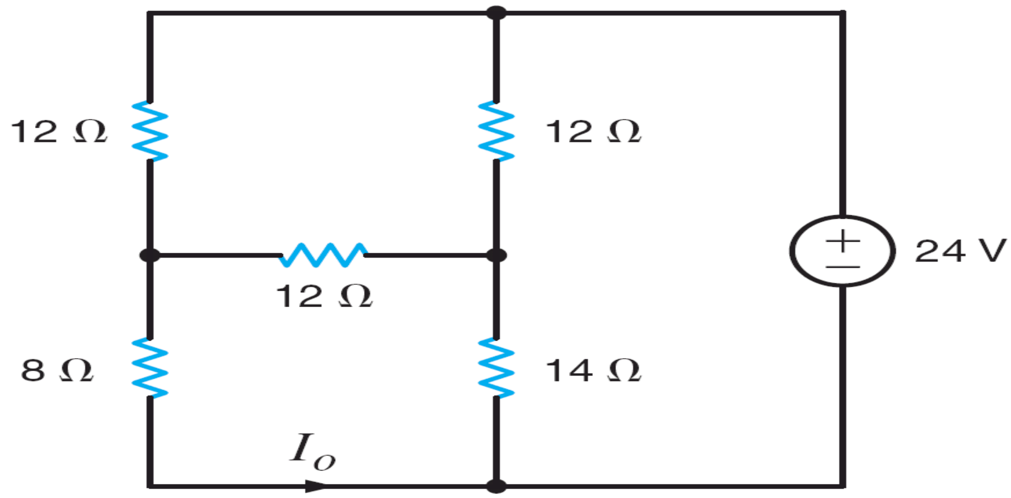
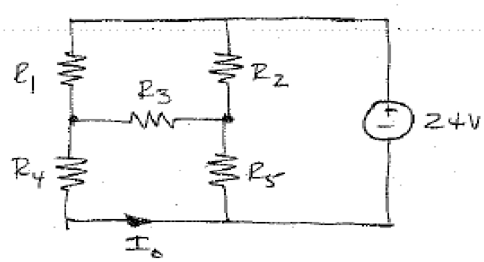


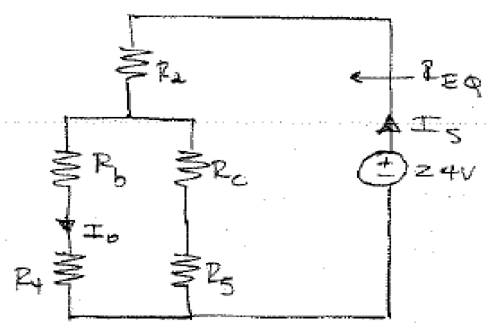
Figure P2.105

SOLUTION:

2.105 Find I_o



$R_1 - R_2 - R_3$ connected delta ⟶



$R_1 = R_2 = R_3 = 12\Omega \quad R_4 = 8\Omega \quad R_5 = 14\Omega$

$R_a = R_b = R_c = 4\Omega$

$R_{EQ} = R_a + [(R_b + R_4) // (R_c + R_5)]$

$R_{EQ} = 11.2\ \Omega$

$I_S = \frac{24}{R_{EQ}} = 2.14A \qquad I_o = I_S \left[\frac{R_c + R_5}{R_c + R_5 + R_b + R_4} \right]$

$$\boxed{I_o = 1.29A}$$

2.106 Find I_o in the circuit in Fig. P2.106. **CS**

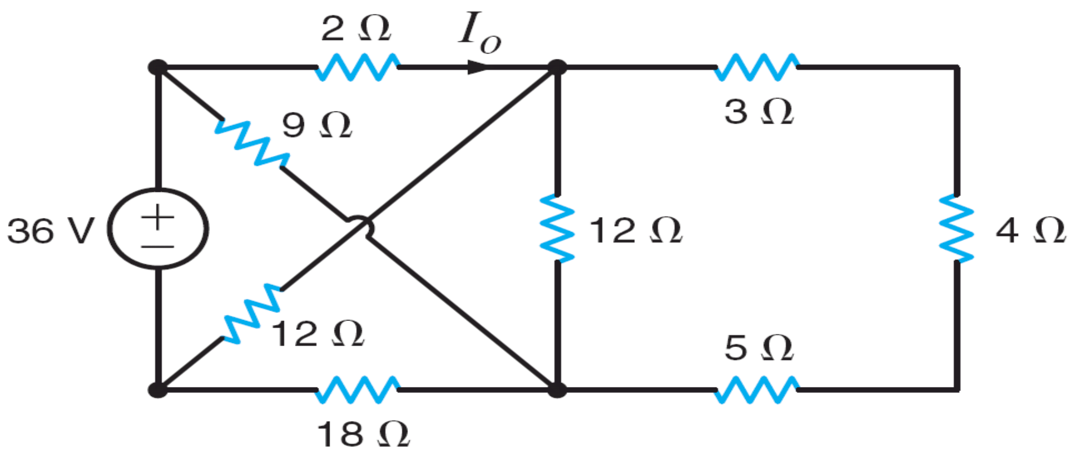
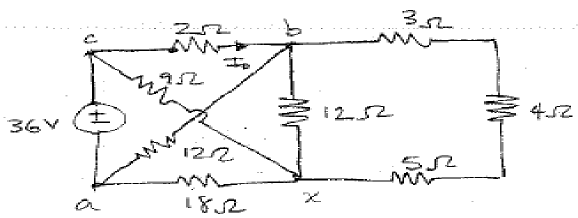


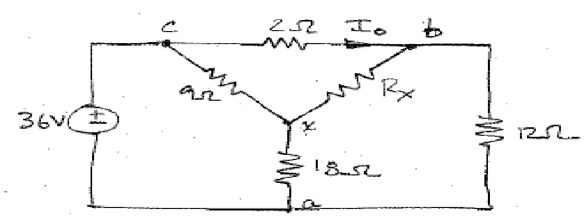
Figure P2.106

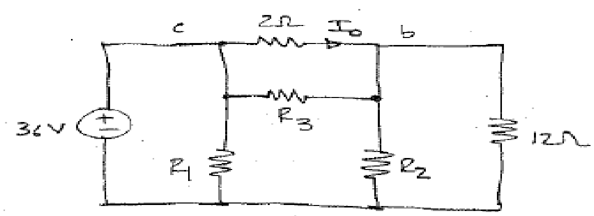
SOLUTION:

2.106 $I_o = ?$



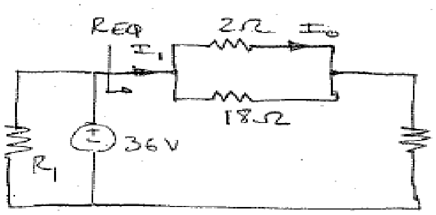
$R_x = 12 // (3+4+5) = 6\Omega$





18Ω, 9Ω, R_x are wye

$R_1 = 54\Omega$ $R_2 = 36\Omega$ $R_3 = 18\Omega$



$R_Y = R_2 // 12 = 9\Omega$

$R_{EQ} = 2//18 + R_Y = 10.8\Omega$

$I_1 = \frac{36}{R_{EQ}} = 3.33$ A

$I_o = I_1 \left[\frac{18}{18+2}\right] \Rightarrow \boxed{I_o = 3 \text{ A}}$

2.107 Find V_o in the network in Fig. P2.107.

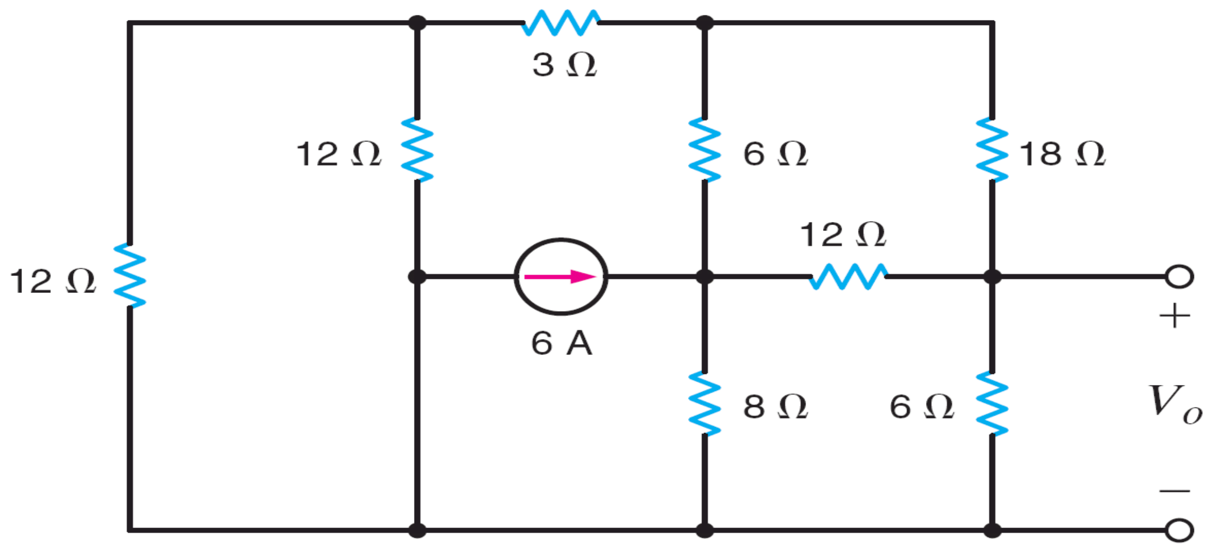
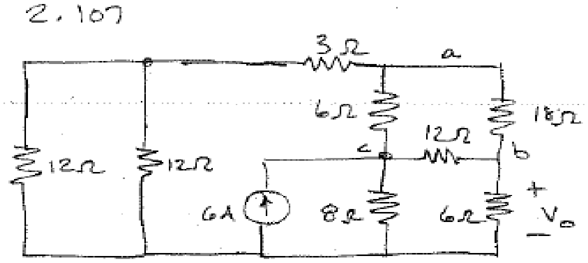
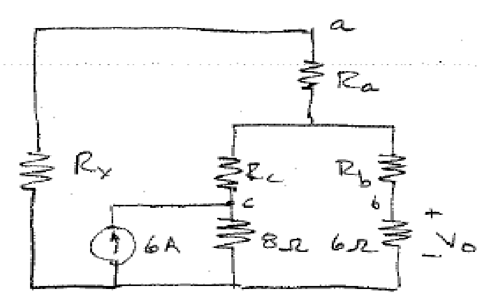


Figure P2.107

SOLUTION:

2.107



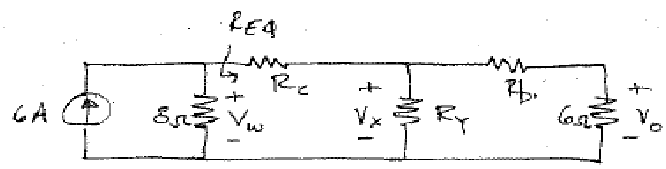


6Ω - 18Ω - 12Ω connected Δ

$R_x = 3 + (12 // 12) = 9\Omega$

$R_a = 3\Omega \quad R_b = 6\Omega \quad R_c = 2\Omega$

$R_Y = R_a + R_x = 12\Omega$



$$R_{EQ} = R_c + [R_Y // (R_b + 6)] = 8\Omega$$

$$V_W = 6 \left[8 // R_{EQ} \right] = 24V$$

$$V_x = V_W \left[\frac{R_{EQ} - R_c}{R_{EQ}} \right] = 18V$$

$$V_o = V_x \left[\frac{6}{6 + R_b} \right]$$

$$\boxed{V_o = 9V}$$

2.108 Find I_x in the circuit in Fig. P2.108.

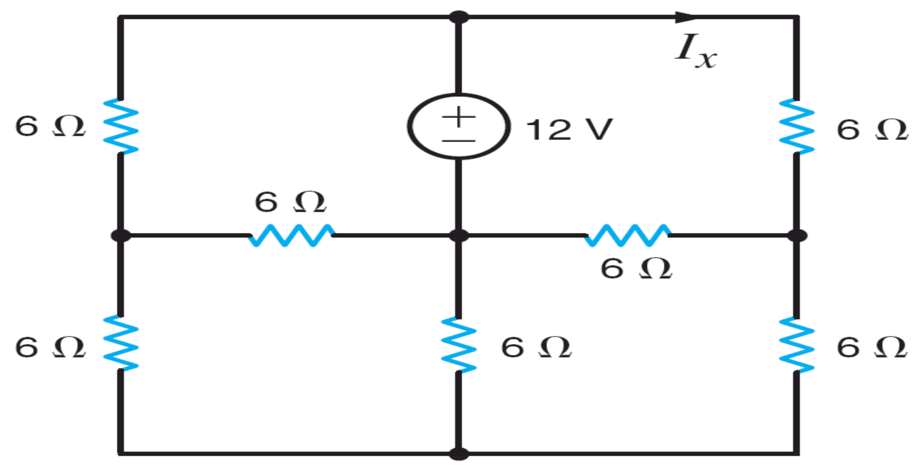
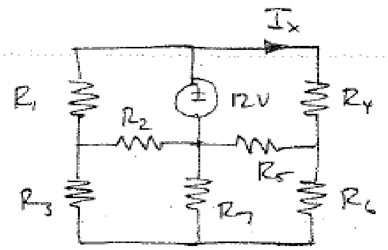


Figure P2.108

SOLUTION:

2.108 Find I_x



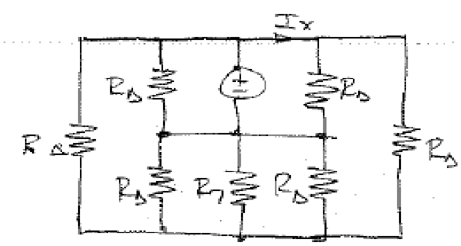
All $R = 6\Omega$

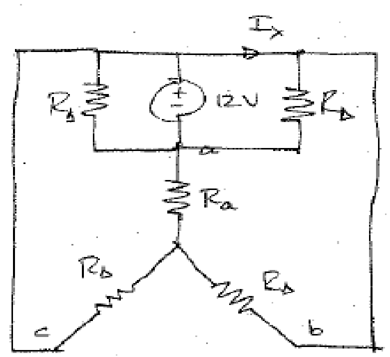
$R_1 - R_2 - R_3$ in wye

also

$R_4 - R_5 - R_6$ in wye

$R_Y = 6\Omega \Rightarrow R_\Delta = 18\Omega$

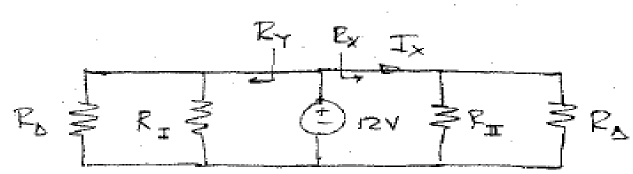




$R_a - R_\Delta - R_\Delta$ in wye!

$R_a = R_\Delta // R_\Delta // R_7 = 3.6\Omega$

$\Rightarrow$



$$R_I = \frac{R_a R_\Delta + R_\Delta^2 + R_a R_\Delta}{R_\Delta} = 25.2\Omega$$

$R_{II} = R_I = 25.2\Omega$

$R_x = R_I // R_\Delta = 10.5\Omega = R_Y$

$I_x = 12/R_x = 1.14\ A$

$\boxed{I_x = 1.14A}$

2.109 Find I_o in the circuit in Fig. P2.109. CS

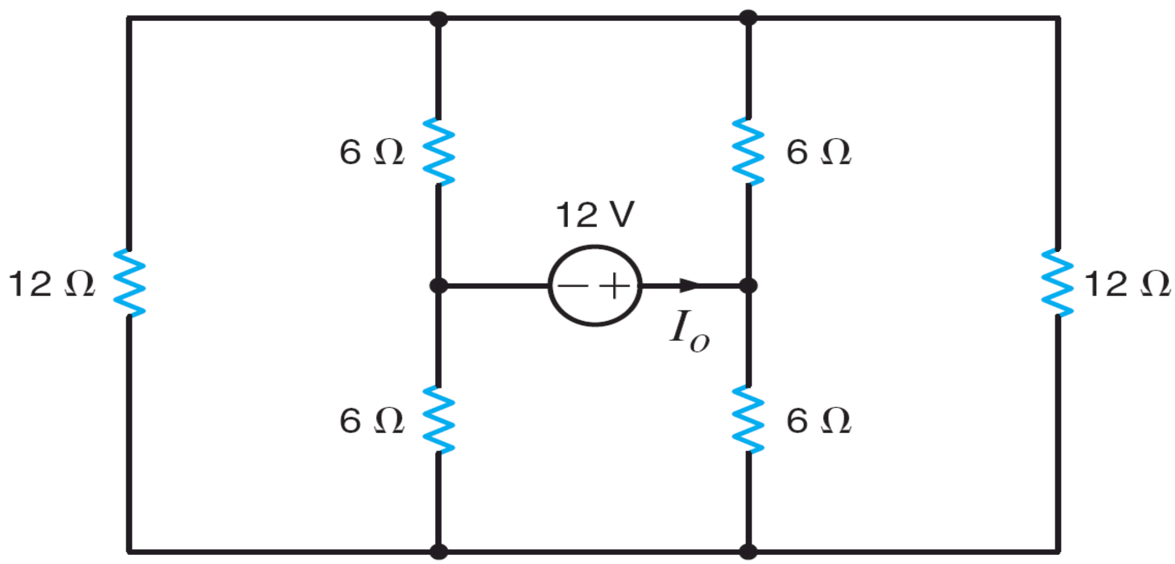
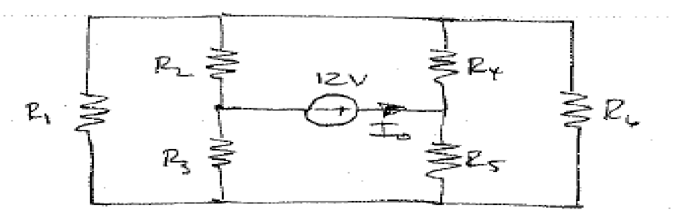


Figure P2.109

SOLUTION:

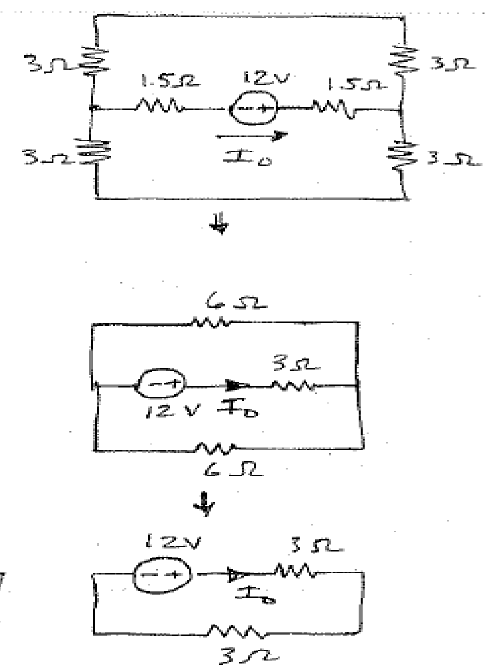
2.109 Find I_o.



$R_1 = R_6 = 12\Omega$ $R_2 = R_3 = R_4 = R_5 = 6\Omega$

$R_1 - R_2 - R_3$ connected Δ

$R_4 - R_5 - R_6$ connected Δ



$I_o = \frac{12}{6}$ $\boxed{I_o = 2A}$

2.110 Find V_o in the circuit in Fig. P2.110.

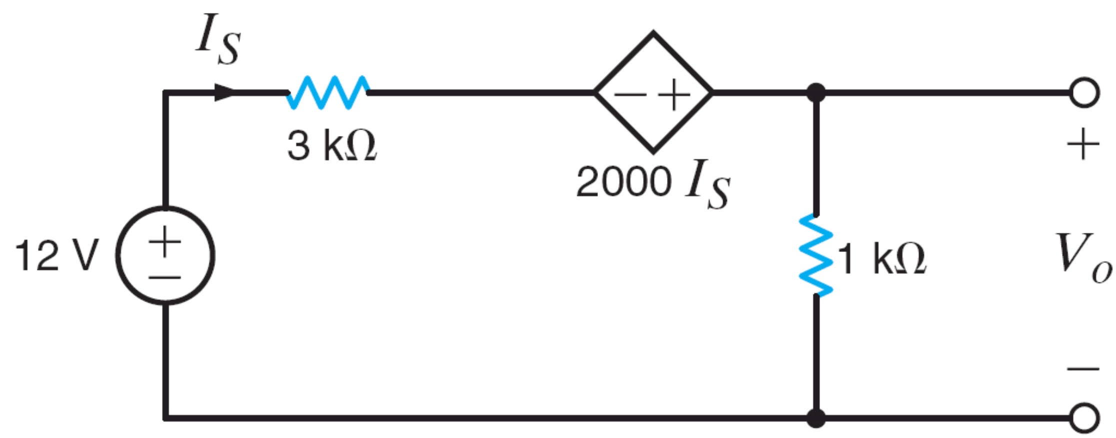
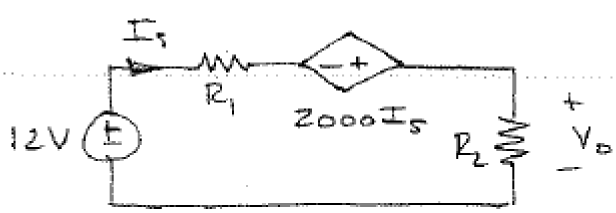


Figure P2.110

SOLUTION:

2.110 Find V_o



$R_1 = 3\,k\Omega \quad R_2 = 1\,k\Omega$

$$12 = I_S R_1 - 2000 I_S + R_2 I_S$$

$$I_S = \frac{12}{2000} = 6\,mA$$

$$V_o = I_S R_2$$

$$\boxed{V_o = 6\,V}$$

2.111 Find V_o in the network in Fig. P2.111.

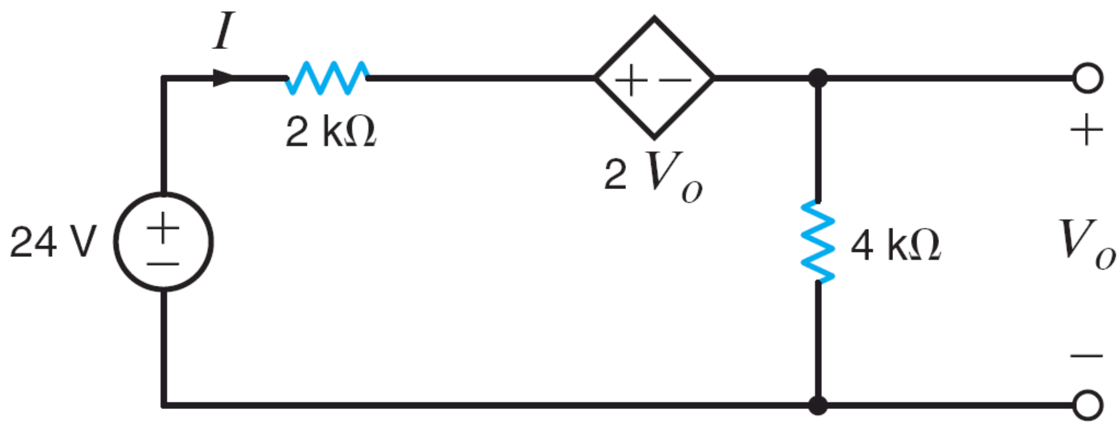


Figure P2.111

SOLUTION:

2.111 Find V_o.

$R_1 = 2k\Omega \quad R_2 = 4k\Omega$

$24 = R_1 I + 2V_o + R_2 I$

$V_o = R_2 I = 4I$

$24 = I(14) \Rightarrow I = \frac{12}{7}$

$\boxed{V_o = 6.86\text{ V}}$

2.112 Find V_o in the network in Fig. P2.112. **PSV**

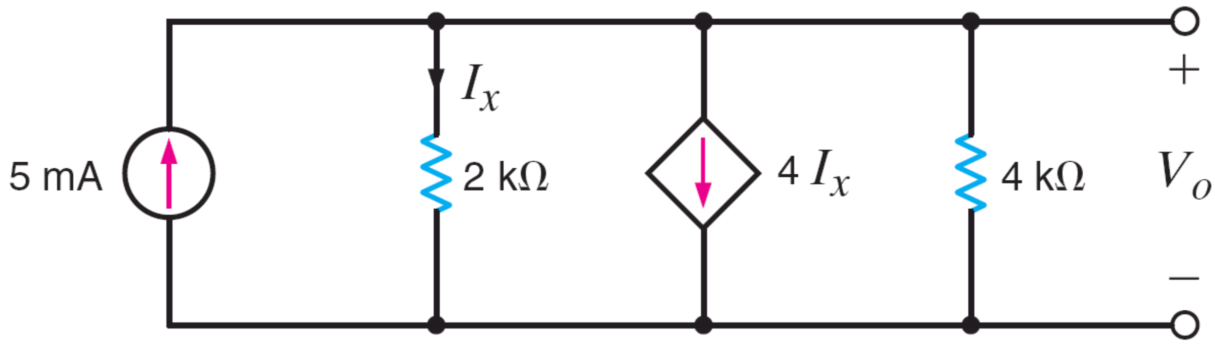
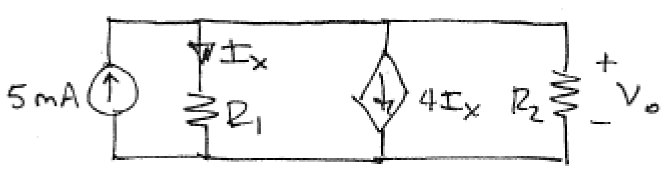


Figure P2.112

SOLUTION:

2.112 Find V_o



$R_1 = 2k\Omega$ $R_2 = 4k\Omega$

$$5\times10^{-3} = \frac{V_o}{R_1} + 4I_x + \frac{V_o}{R_2}$$

$$I_x = \frac{V_o}{R_1}$$

$$\boxed{V_o = 1.82\text{ V}}$$

2.113 Find I_o in the network in Fig. P2.113. CS

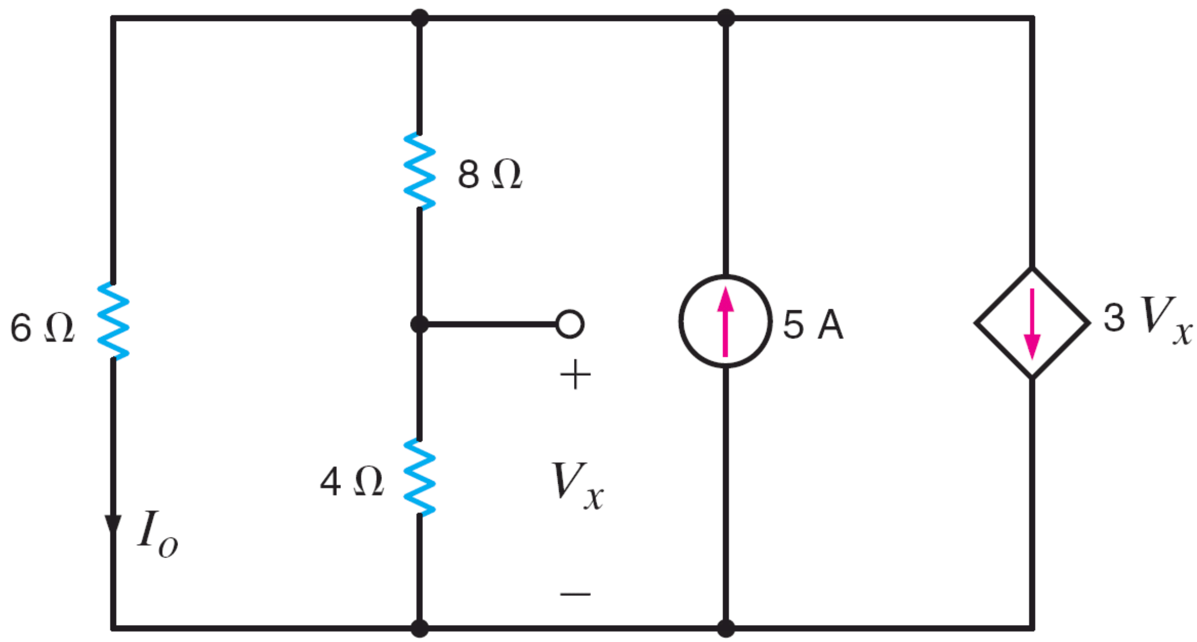
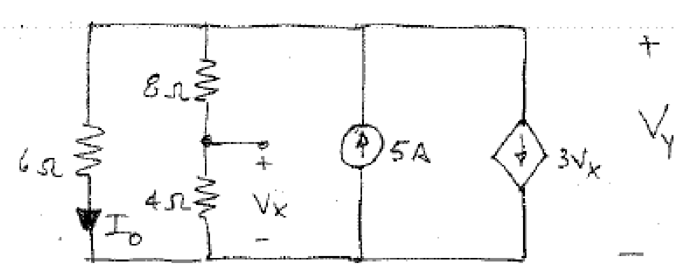


Figure P2.113

SOLUTION:

2.113 Find I_o



$$5 = 3V_x + \frac{V_Y}{6} + \frac{V_Y}{12}$$

$$V_x = V_Y\left[\frac{4}{4+8}\right] = \frac{V_Y}{3}$$

$$V_Y = 4V$$

$$I_o = \frac{V_Y}{6} \Rightarrow \boxed{I_o = 0.67\,A}$$

2.114 Find the power absorbed by the 10-kΩ resistor in the circuit in Fig. P2.114.

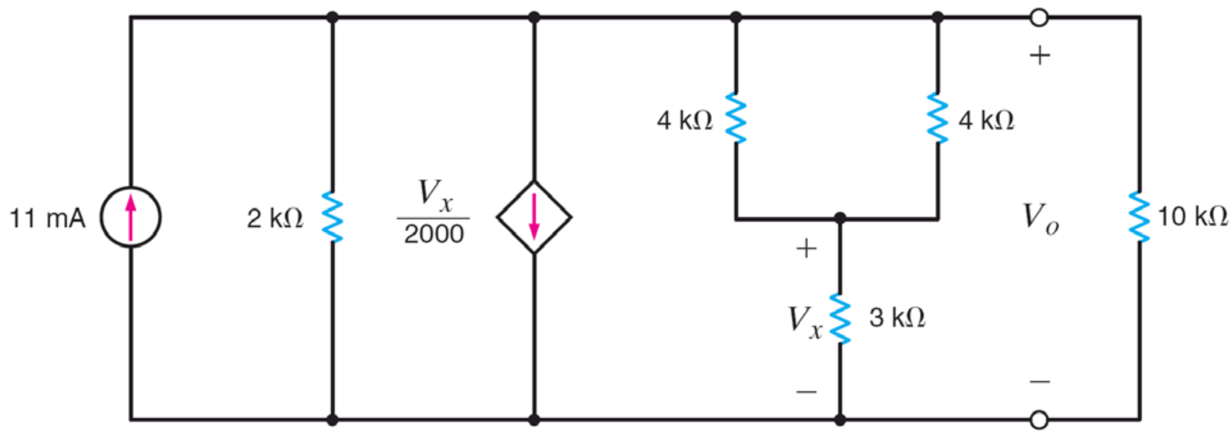
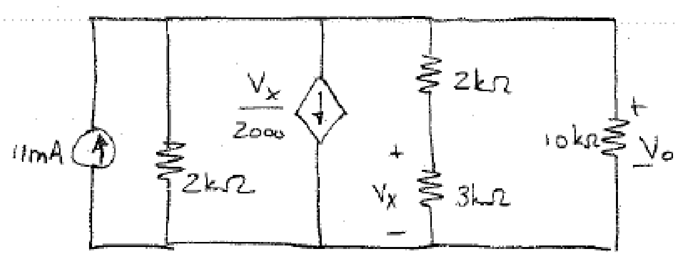


Figure P2.114

SOLUTION:

2.114 Find P_{10k}



$$11\times10^{-3} = \frac{V_o}{2000} + \frac{V_x}{2000} + \frac{V_o}{5000} + \frac{V_o}{10^4}$$

$$V_x = V_o\left[\frac{3000}{3000+2000}\right] = \frac{6V_o}{10}$$

$$V_o = 10V$$

$$P_{10k} = \frac{V_o^2}{10^4} \Rightarrow \boxed{P_{10k} = 10mW}$$

2.115 Find the value of k in the network in Fig. P2.115 such that the power supplied by the 6-A source is 108 W.

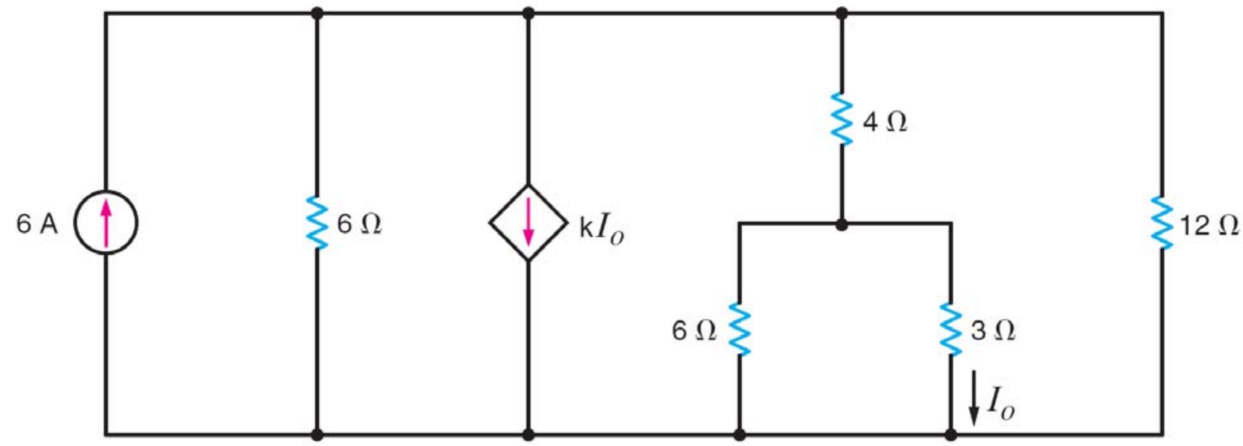
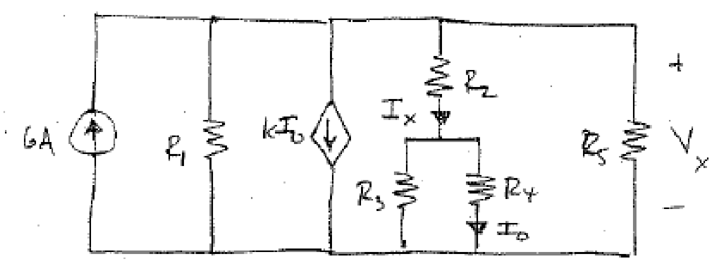


Figure P2.115

SOLUTION:

2.115 $P_{6A} = 108$ W supplied. Find k.



$$6 = \frac{V_x}{R_1} + kI_o + \frac{V_x}{R_A} + \frac{V_x}{R_5}$$

$$I_o = I_x\left[\frac{R_3}{R_3+R_4}\right] = \frac{2}{3} I_x$$

$$I_x = \frac{V_x}{R_A} = \frac{V_x}{6}$$

$R_1 = R_3 = 6\Omega \quad R_2 = 4\Omega$

$R_4 = 3\Omega \quad R_5 = 12\Omega$

$$R_A = R_2 + \left[R_3 // R_4\right] = 6\Omega$$

$P_{6A} = 6V_x = 108 \Rightarrow V_x = 18\text{V}$ So, $I_x = 3A$ $I_o = 2A$

$$\boxed{k = -0.75}$$

2.116 For the network in Fig. P2.116, choose the values of R_{in} and R_o such that is V_o maximized. What is the resulting ratio, V_o/V_S? CS

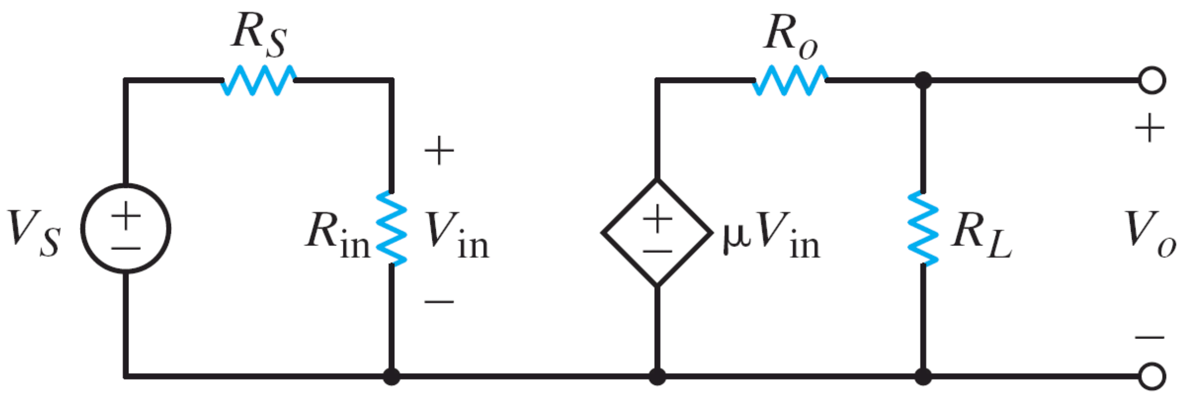
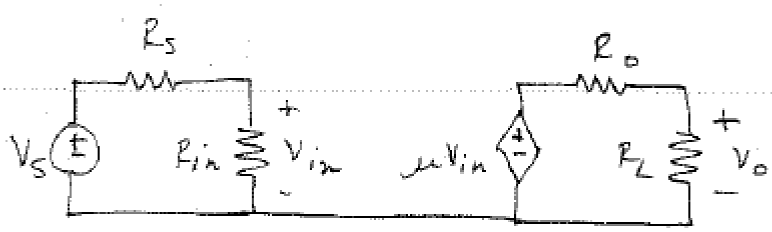


Figure P2.116

SOLUTION:

2.116 Find R_{in} and R_o to maximize V_o/V_S.



$$V_{in} = V_S\left[\frac{R_{in}}{R_{in}+R_S}\right] \qquad V_o = \mu V_{in}\left[\frac{R_L}{R_o+R_L}\right]$$

$$\frac{V_o}{V_S} = \mu\left[\frac{R_{in}}{R_{in}+R_S}\right]\left[\frac{R_L}{R_o+R_L}\right] \Rightarrow \mu \text{ at best.}$$

$$\boxed{R_{in} = \infty \;\;\&\;\; R_o = 0}$$

2.117 A typical transistor amplifier is shown in Fig. P2.117. Find the amplifier gain G (i.e., the ratio of the output voltage to the input voltage).

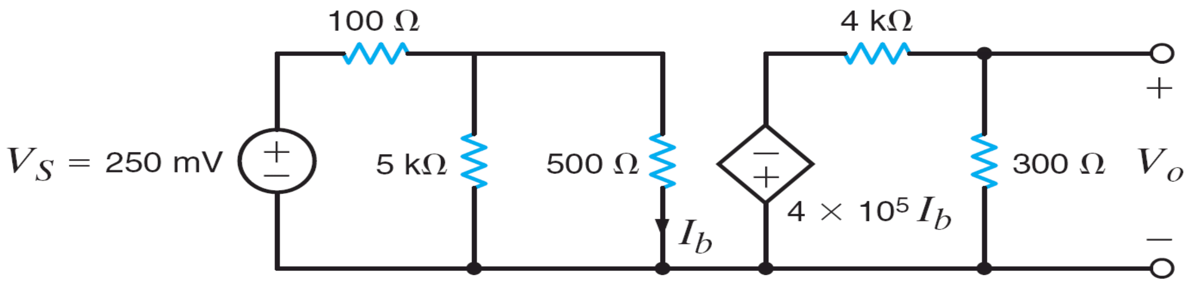
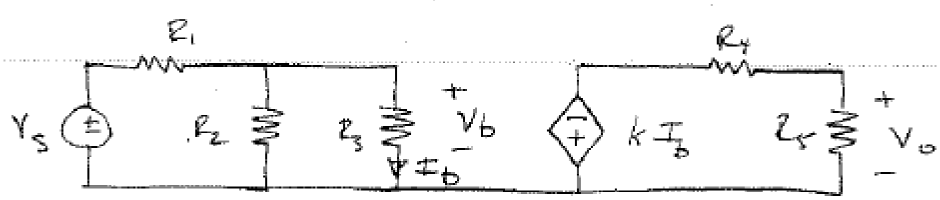


Figure P2.117

SOLUTION:

2.117 Find $G = V_o / V_S$



$V_S = \frac{1}{4}$ V $\quad R_1 = 100\,\Omega \quad R_2 = 5\,k\Omega \quad R_3 = 500\,\Omega$

$k = 4 \times 10^5 \quad R_4 = 4\,k\Omega \quad R_5 = 300\,\Omega$

$$V_b = V_S \left[\frac{R_2 /\!/ R_3}{R_1 + (R_2 /\!/ R_3)} \right] = 0.205\text{ V}$$

$$I_b = V_b / R_3 = 410\,\mu A$$

$$V_o = -kI_b \left[\frac{R_5}{R_4 + R_5} \right] \Rightarrow V_o = -11.4\text{ V}$$

$$G = \frac{V_o}{V_S}$$

$$\boxed{G = -45.8}$$

2.118 In many amplifier applications we are concerned not only with voltage gain, but also with power gain.

Power gain $= A_p$ (power delivered to the load)/(power delivered to the input)

Find the power gain for the circuit in Fig. P2.118, where $R_L = 60\ \text{k}\Omega$.

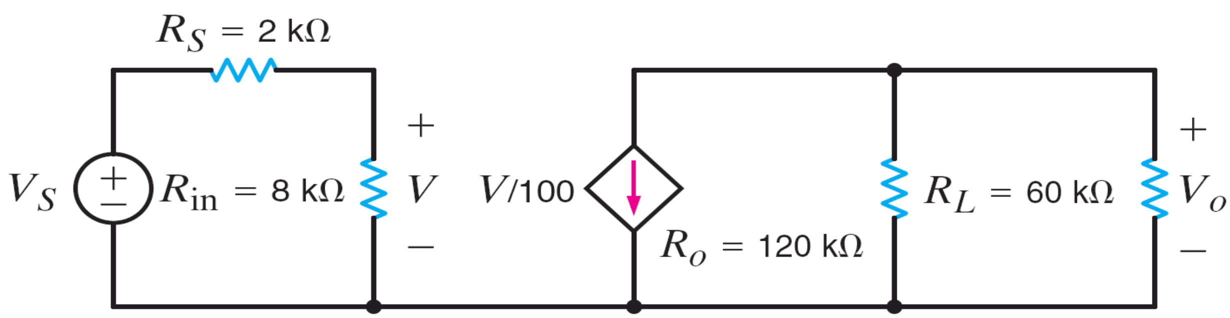


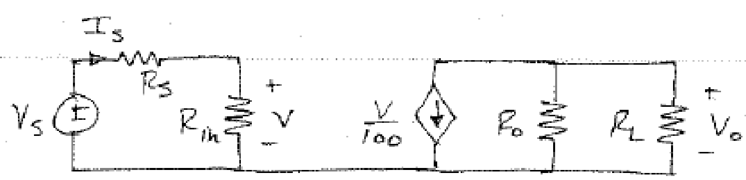
Figure P2.118

SOLUTION:

2.118 Find P_{OUT} / P_{in}

$R_S = 2\text{k}\Omega \quad R_{in} = 8\text{k}\Omega$

$R_o = 120\text{k}\Omega \quad R_L = 60\text{k}\Omega$



$P_{in} = V_S I_S \qquad I_S = \dfrac{V_S}{R_S + R_{in}} \qquad$ so, $\qquad P_{in} = \dfrac{V_S^2}{R_S + R_{in}}$

$P_{OUT} = \dfrac{V_o^2}{R_L} \qquad V_o = -V_S \left[\dfrac{R_{in}}{R_{in} + R_S} \right] \left(\dfrac{1}{100} \right) \left[R_o // R_L \right]$

$V_o = -320 V_S$

$P_{OUT} = 1.71\ V_S^2$

$A_P = \dfrac{P_{OUT}}{P_{IN}}$

$\boxed{A_P = 17.1 \times 10^3}$

2FE-1 Find the power generated by the source in the network in Fig. 2PFE-1. **CS**

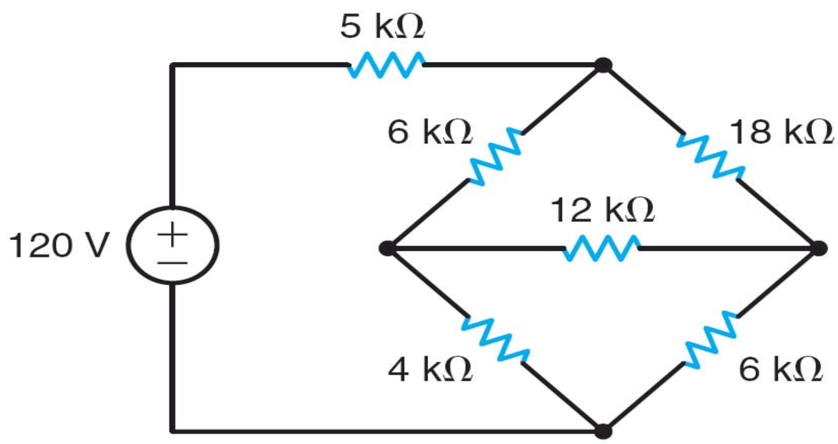
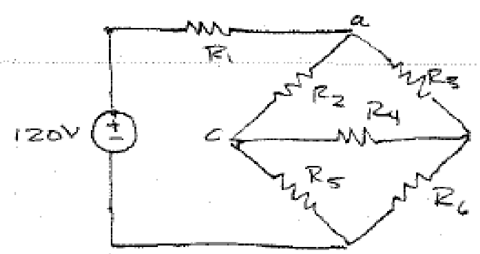


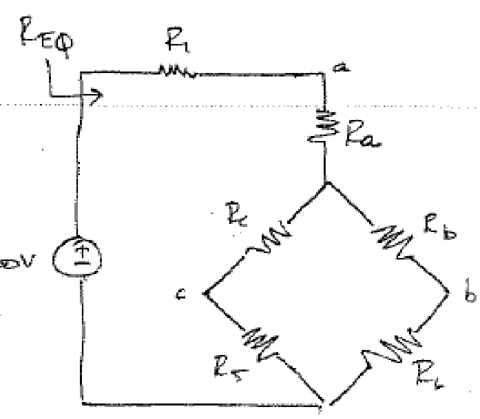
Fig. 2PFE-1

SOLUTION:

2FE-1 Find source Power, P_{VS}



$R_2 - R_3 - R_4$ are connected delta ⇒



$R_1 = 5k\Omega$ $R_2 = R_6 = 6k\Omega$

$R_3 = 18k\Omega$ $R_4 = 12k\Omega$

$R_5 = 4k\Omega$

$R_a = 3k\Omega$ $R_b = 6k\Omega$ $R_c = 2k\Omega$

$$R_{EQ} = R_1 + R_a + \left[(R_c + R_5) // (R_b + R_6)\right] = 12k\Omega$$

$$P_{VS} = \frac{V_s^2}{R_{EQ}} = \frac{120^2}{12\times10^3}$$

$P_{VS} = 1.2W$

2FE-2 Find the equivalent resistance of the circuit in Fig. 2PFE-2 at the terminals *A*-*B*.

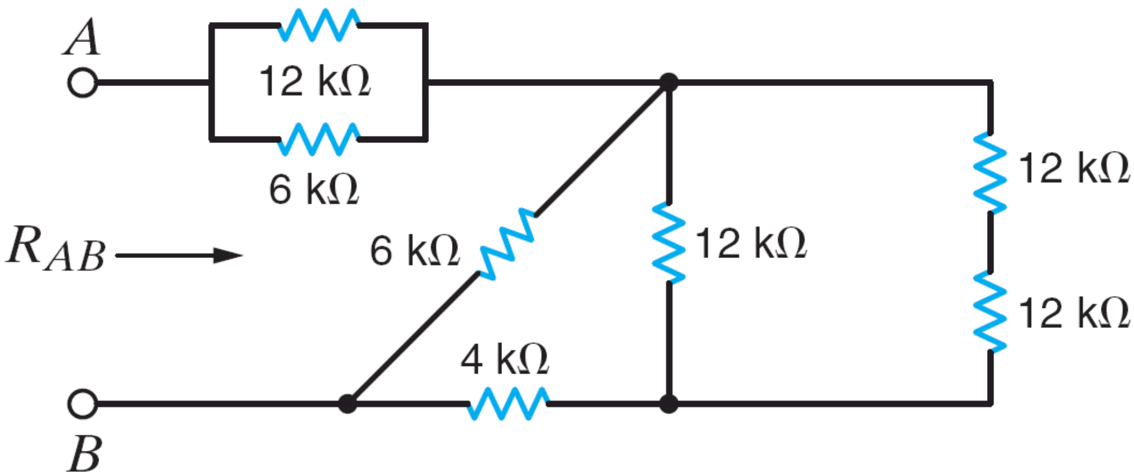
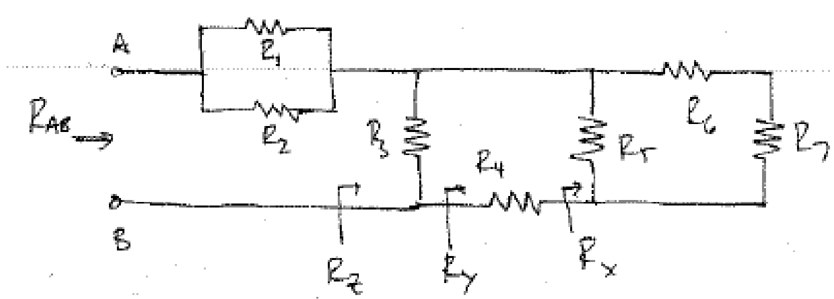


Fig. 2PFE-2

SOLUTION:

2FE-2 Find R_{AB}



$R_1 = R_5 = R_6 = R_7 = 12\,k\Omega$

$R_2 = R_3 = 6\,k\Omega$

$R_4 = 4\,k\Omega$

$R_x = R_5 \,//\, (R_6 + R_7) = 8\,k\Omega$ $\quad R_y = R_4 + R_x = 12\,k\Omega$

$R_z = R_3 \,//\, R_y = 4\,k\Omega$ $\quad R_{AB} = (R_1 \,//\, R_2) + R_z$ $\quad$ **$R_{AB} = 8\,k\Omega$**

2FE-3 Find the voltage V_o in the network in Fig. 2PFE-3. CS

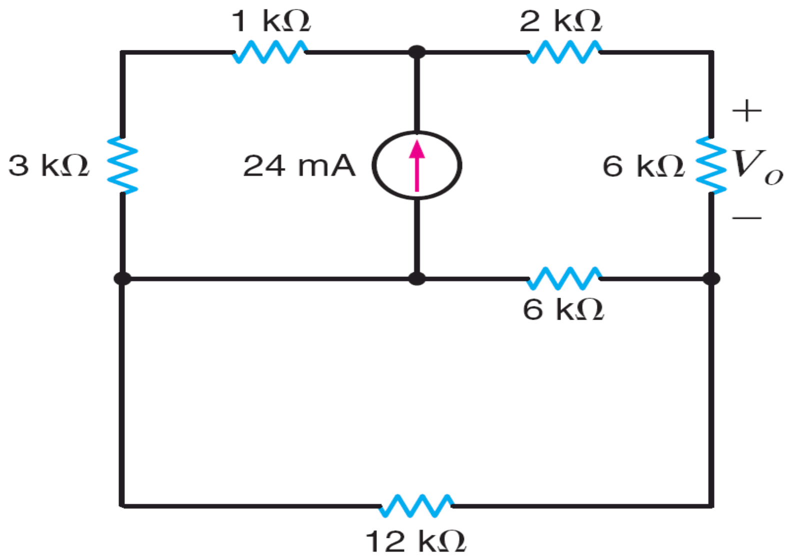
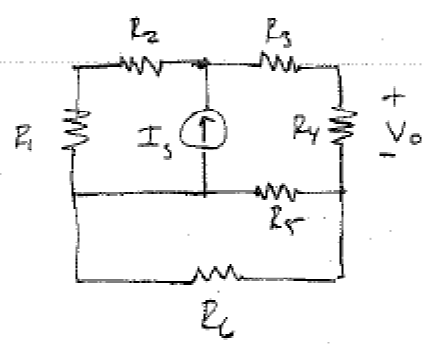


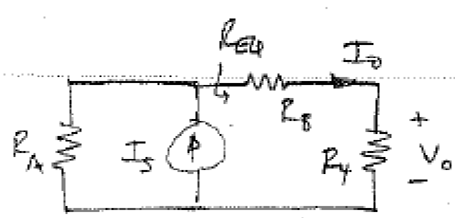
Fig. 2PFE-3

SOLUTION:

2FE-3 Find V_o.



⇒



$R_1 = 3k\Omega$ $R_2 = 1k\Omega$

$R_3 = 2k\Omega$ $R_4 = R_5 = 6k\Omega$

$R_6 = 12k\Omega$ $I_s = 24mA$

$R_A = R_1 + R_2 = 4k\Omega$

$R_B = R_3 + (R_5 // R_6) = 6k\Omega$

$R_{EQ} = R_B + R_4 = 12k\Omega$

$$I_o = I_s \left[\frac{R_A}{R_A + R_{EQ}} \right] = 6mA$$

$V_o = I_o R_4$ $\boxed{V_o = 24V}$

2FE-4 Find the current I_o in the circuit in Fig. 2PFE-4.

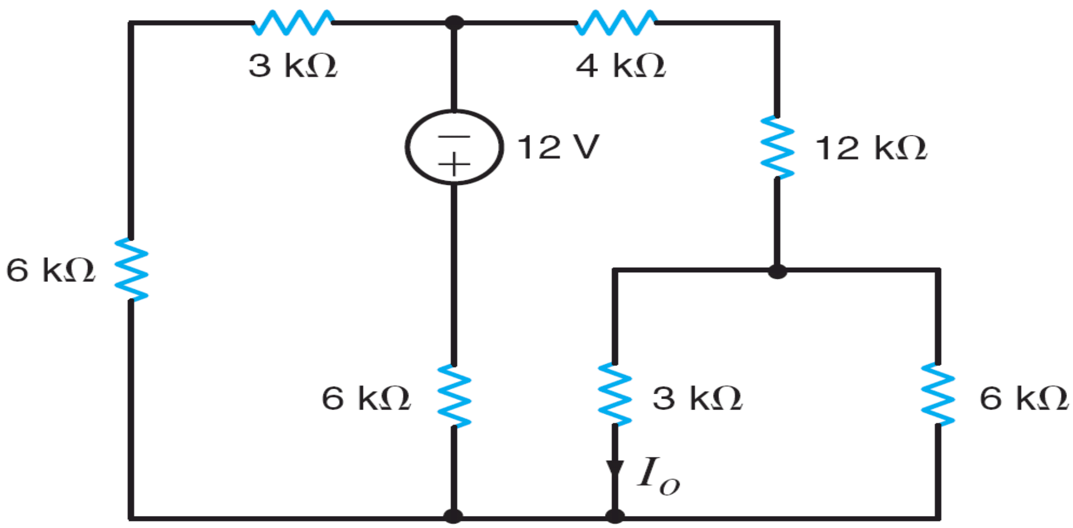
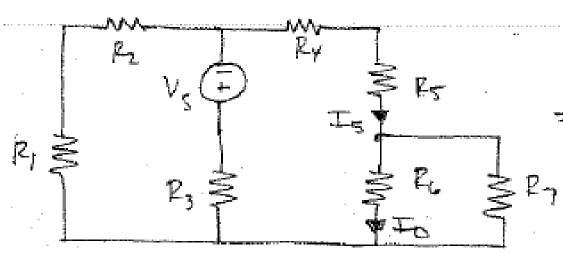


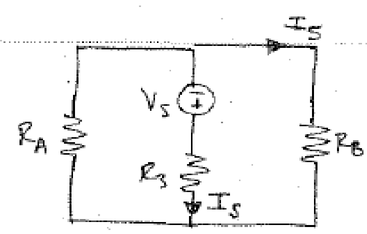
Fig. 2PFE-4

SOLUTION:

2FE-4 Find I_o.



⇒



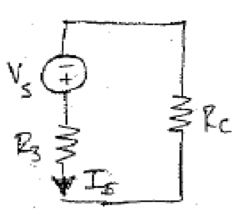
$R_1 = R_3 = R_7 = 6\,k\Omega \qquad R_4 = 4\,k\Omega$

$R_2 = R_6 = 3\,k\Omega \qquad R_5 = 12\,k\Omega \qquad V_s = 12\,V$

$R_A = R_1 + R_2 = 9\,k\Omega$

$R_B = R_4 + R_5 + (R_6 // R_7) = 18\,k\Omega$

$I_o = I_5\left(\frac{R_7}{R_6 + R_7}\right) = \frac{2 I_5}{3}$



$R_C = R_A // R_B = 6\,k\Omega$

$I_s = \frac{V_s}{R_3 + R_C} = 1\,mA$

$I_5 = -I_s\left[\frac{R_A}{R_A + R_B}\right] = -\frac{1}{3}\,mA$

$I_o = -0.22\,mA$