電工作業第三章
2012版

謝志誠

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Exercise 1: General network

1. For the series-parallel network in Fig. 3.77:

a. Determine R_T.

b. Calculate I.

c. Find I_1, I_2, and I_3.

d. Calculate the power to R_3.

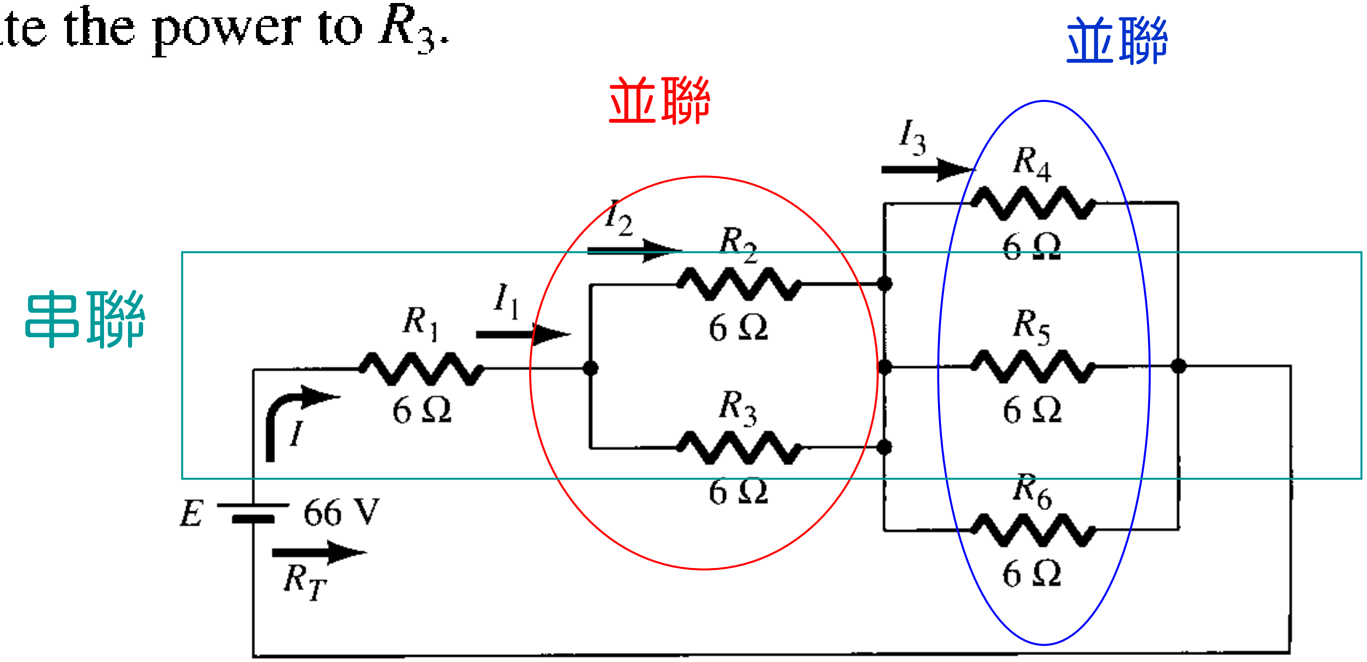


FIG. 3.77

Solution

a. $R_T = R_1 + (R_2 // R_3) + (R_4 // R_5 // R_6) = 11\Omega$

b. $I = \dfrac{E}{R_T} = \dfrac{66V}{11\Omega} = 6A$

c. $I_1 = I = 6A$ $\quad I_2 = I_{2'} = \dfrac{I_1}{2} = 3A$ $\quad I_3 = \dfrac{I_1}{3} = 2A$

d. $P_3 = I_{2'}{}^2 R_3 = (3A)^2 (6\Omega) = 54W$

Exercise 2: General network

2. For the series-parallel network in Fig. 3.78:
   a. Determine I_4.
   b. Determine I.
   c. Find P_3.

把R_3與R_4串聯成為R’，然後
R’、R_1、R_2彼此都與E相互並聯

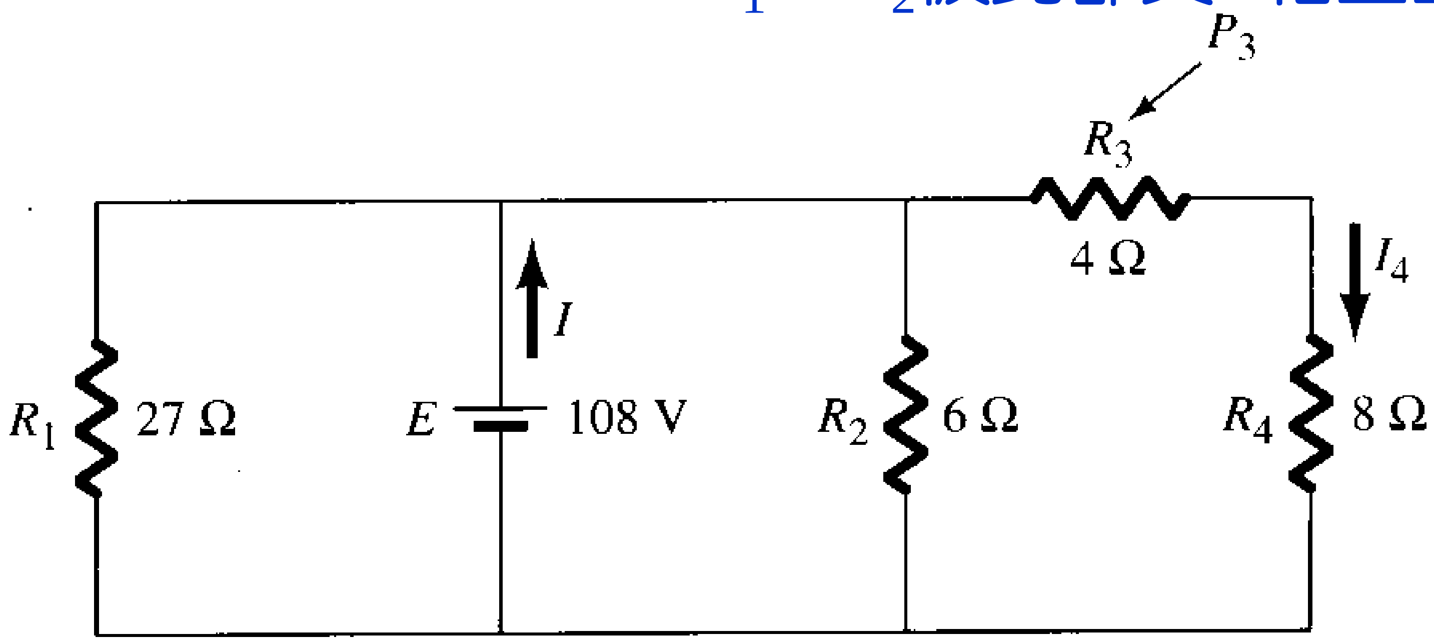


FIG. 3.78

Solution

a. $E = I_4 \times (R_3 + R_4)$ $I_4 = \dfrac{E}{R_3 + R_4} = 9A$

b. $I = I_1 + I_2 + I_4 = \dfrac{V_1}{R_1} + \dfrac{V_2}{R_2} + I_4$

$$= \frac{108V}{27\Omega} + \frac{108V}{6\Omega} + 9A = 31A$$

c. $P_3 = I_4{}^2 R_3 = 324W$

Exercise 3: General network

3. For the "ladder" network in Fig. 3.79 find I_6.

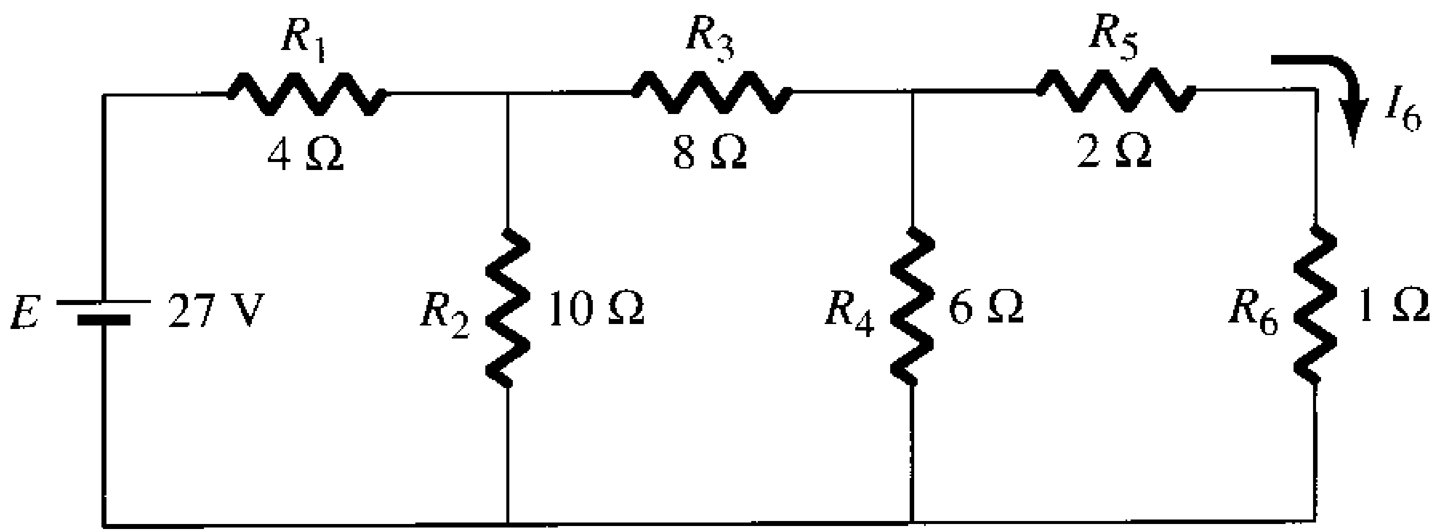


FIG. 3.79

Solution

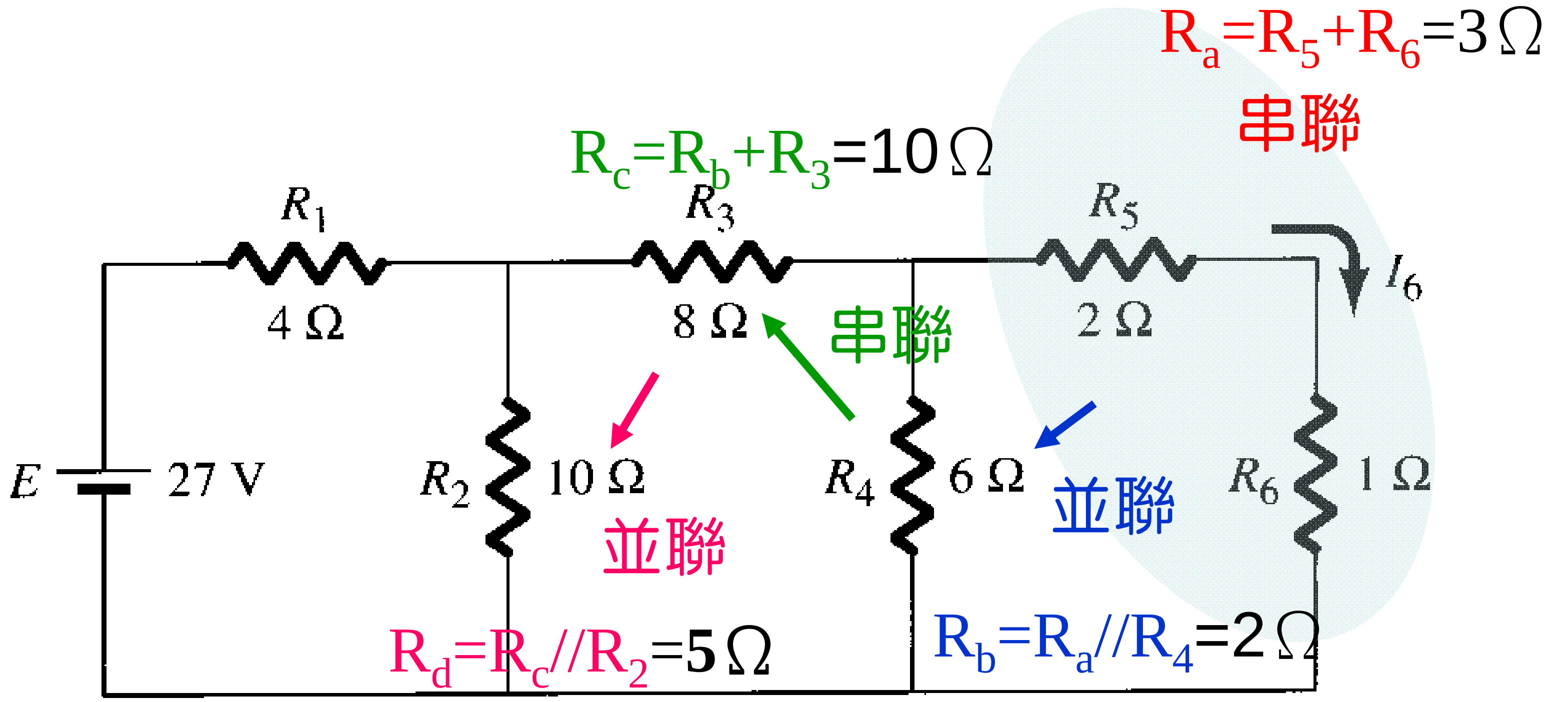


FIG. 3.79

$$R_T=R_1+R_d=9\Omega$$

$$I=\frac{E}{R_T}=\frac{27V}{9\Omega}=3A$$

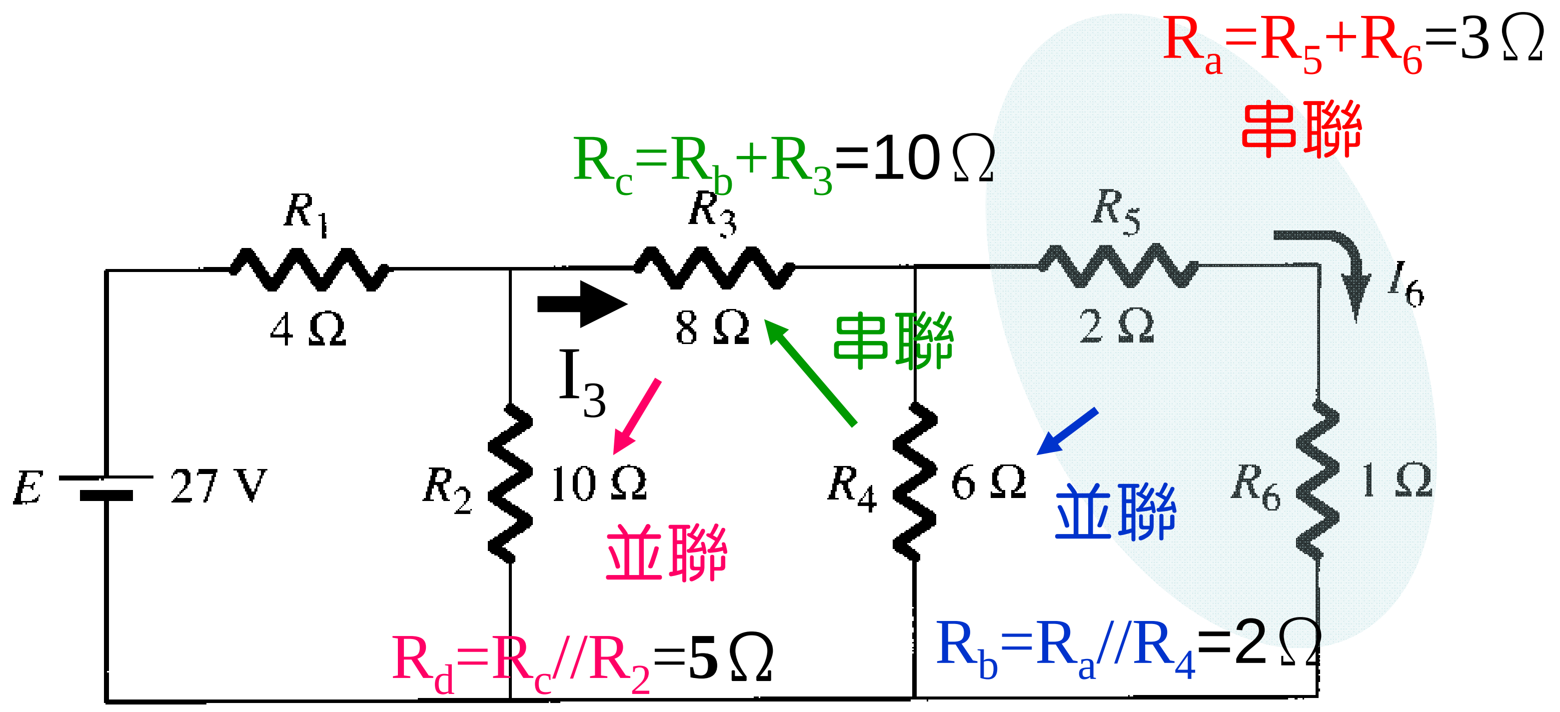


FIG. 3.79

$$I_3 = I \times \frac{R_2}{R_2 + R_c} = 3A \times \frac{10\Omega}{10\Omega + 10\Omega} = 1.5A$$

$$I_6 = I_3 \times \frac{R_4}{R_4 + R_a} = 1.5A \times \frac{6\Omega}{6\Omega + 3\Omega} = 1A$$

Exercise 4: General network

4. For the network in Fig. 3.80, find:

a. V_s.

b. I_1.

c. I_4.

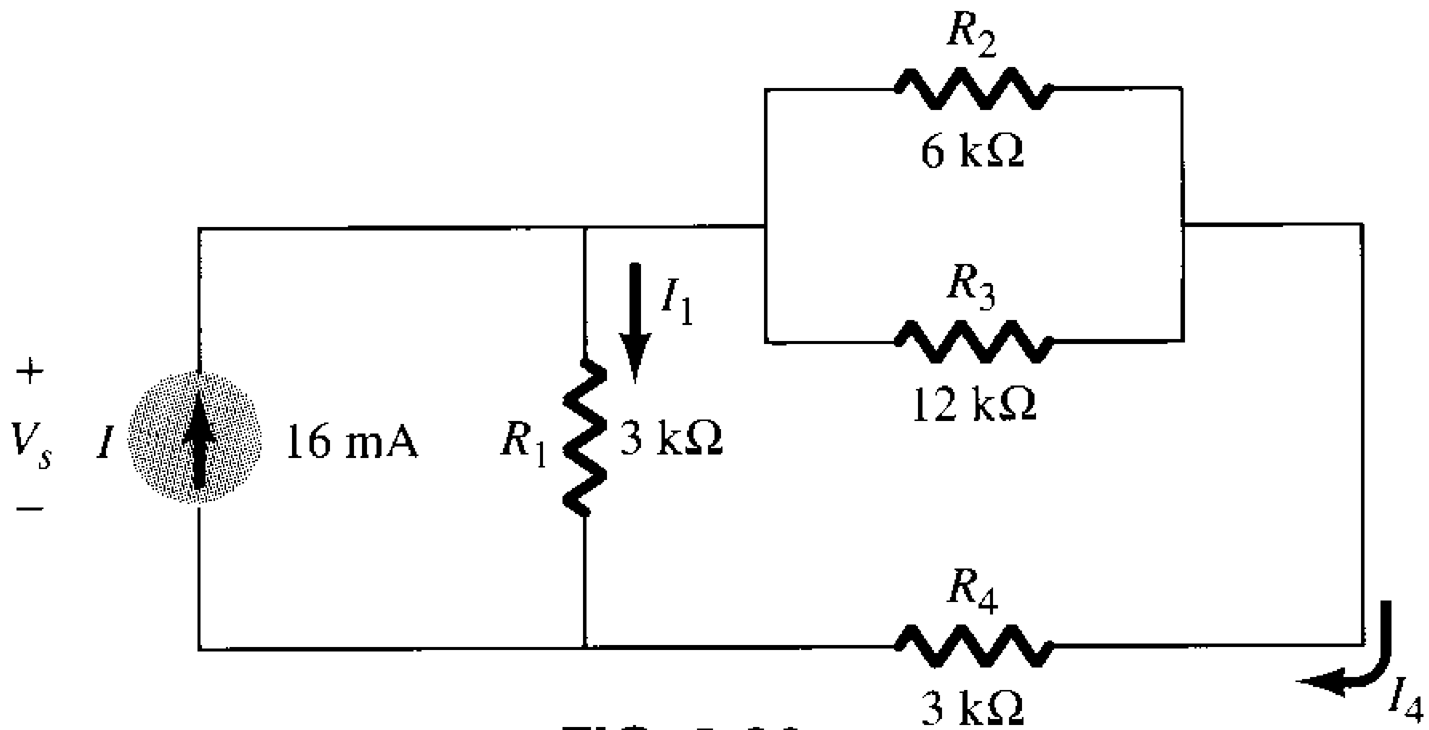


FIG. 3.80

Solution

$R_a = (R_2 // R_3) + R_4 = 7k\Omega$

$R_T = R_a // R_1 = 2.1k\Omega$

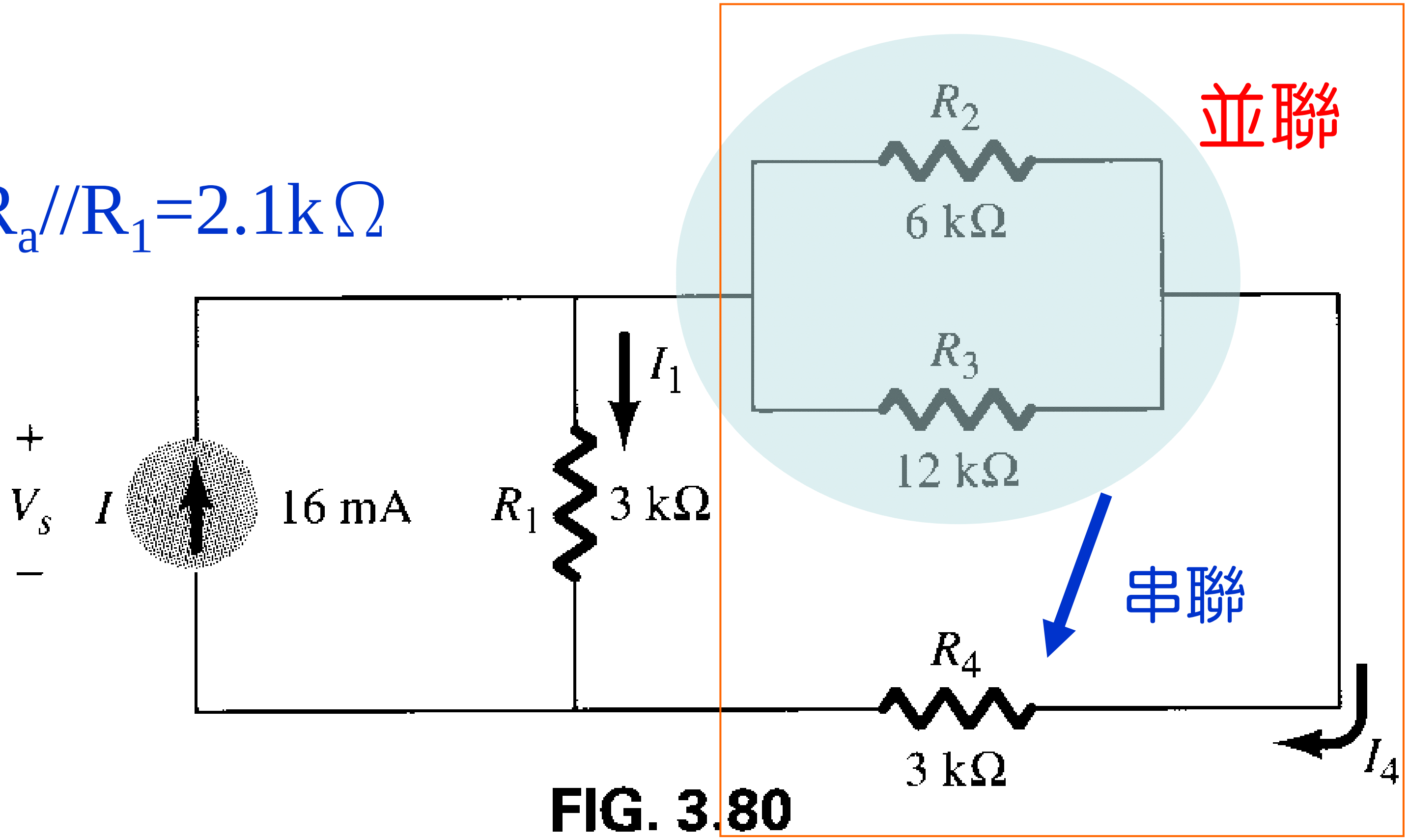


FIG. 3.80

$R_a=(R_2//R_3)+R_4=7k\Omega$

$R_T=R_a//R_1=2.1k\Omega$

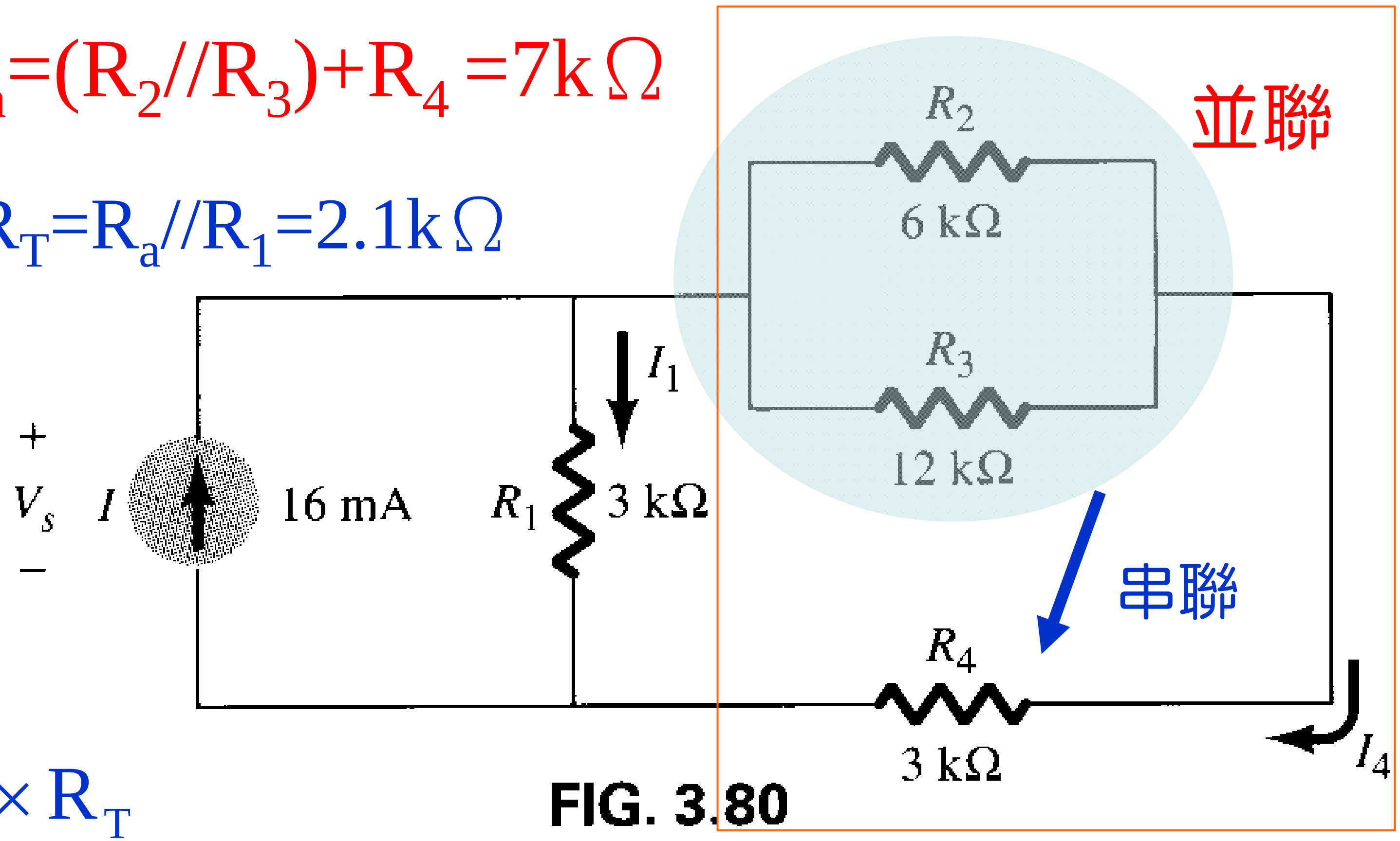


FIG. 3.80

$$V_s = I \times R_T$$
$$= (16mA)(2.1k\Omega) = 33.6V$$

$$I_1 = \frac{V_s}{R_1} = 11.2mA = I \times \frac{R_a}{R_1 + R_a} = 16mA \times \frac{7k\Omega}{10k\Omega}$$

$$I_4 = I - I_1 = 4.8mA$$

Exercise 5: General network

5. Find the current I for the network in Fig. 3.81.

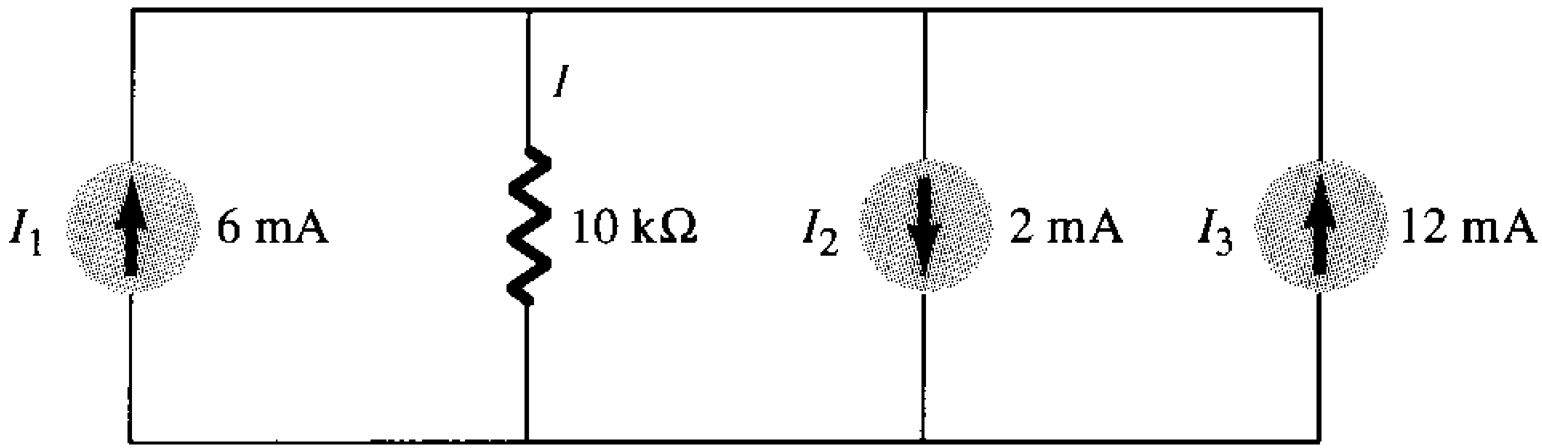


FIG. 3.81

Solution

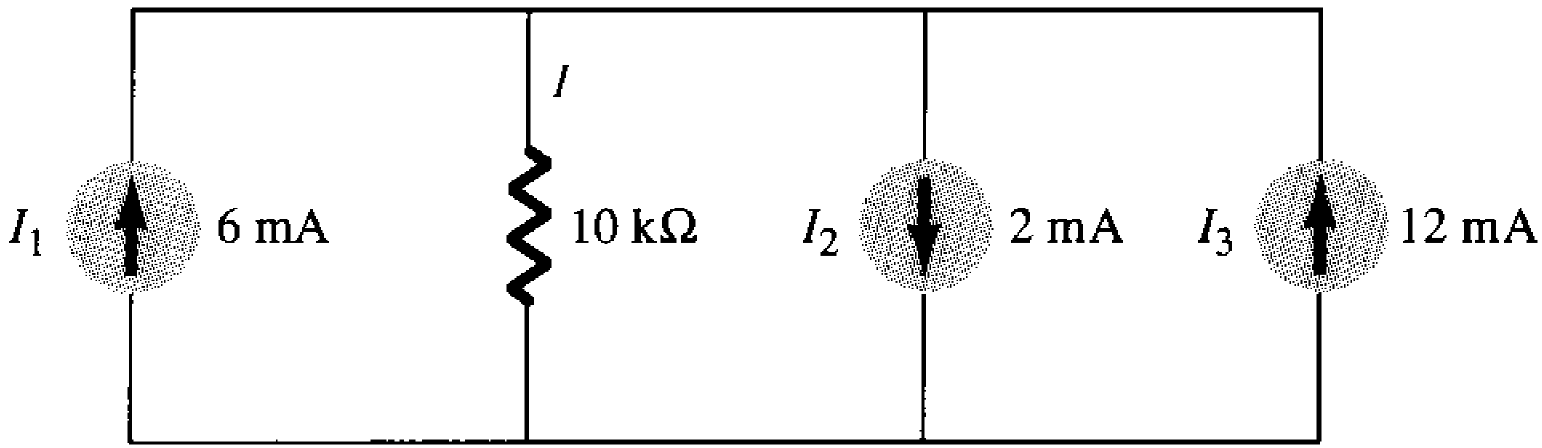


FIG. 3.81

$$I = I_1 + I_3 - I_2 = 16mA \downarrow$$

Exercise 6: Source conversion

6. **a.** Convert the voltage source in Fig. 3.82 to a current source.

b. Find the voltage V_1.

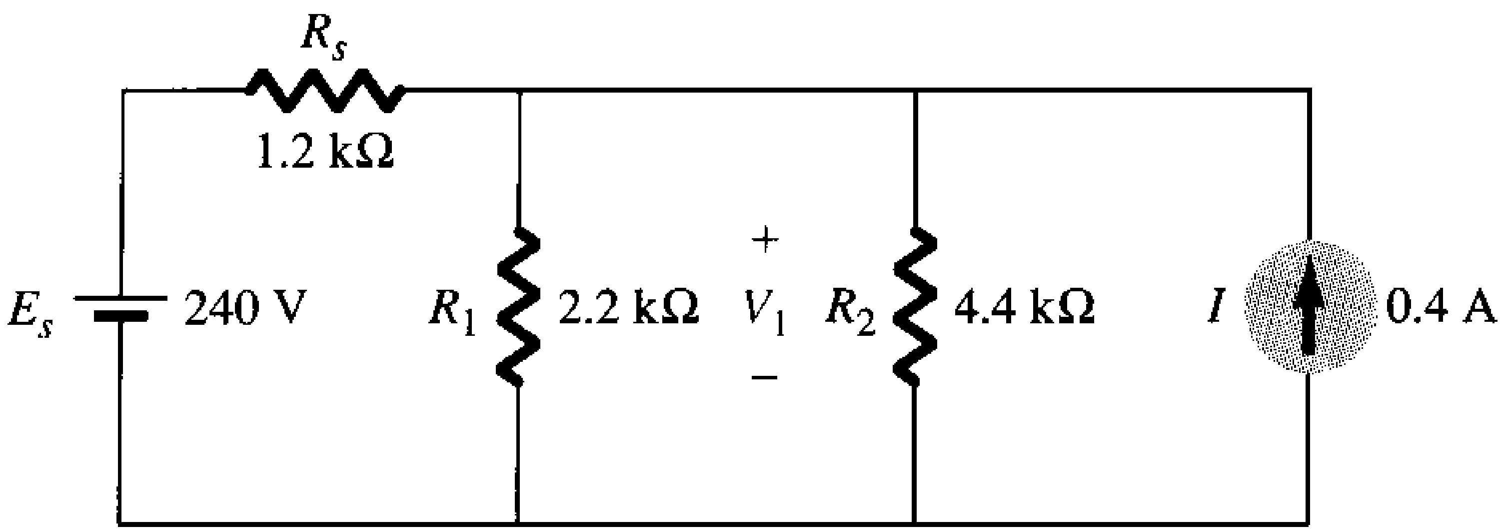
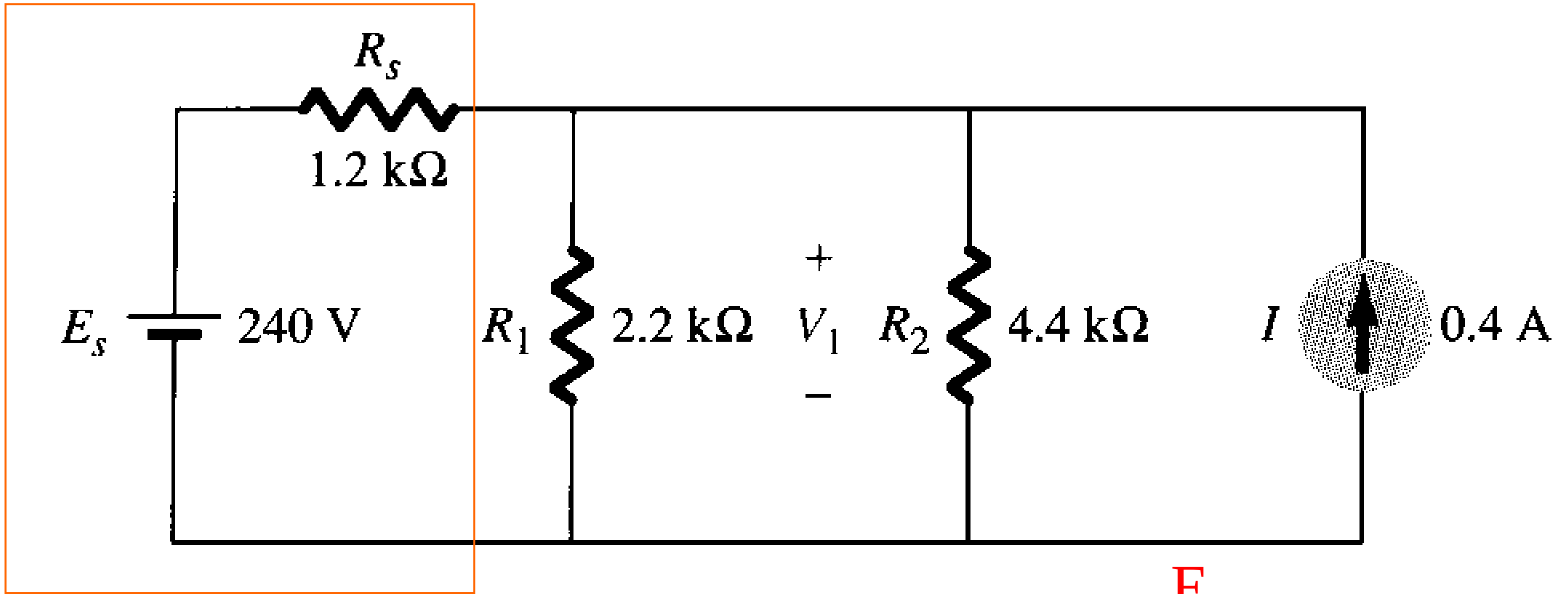
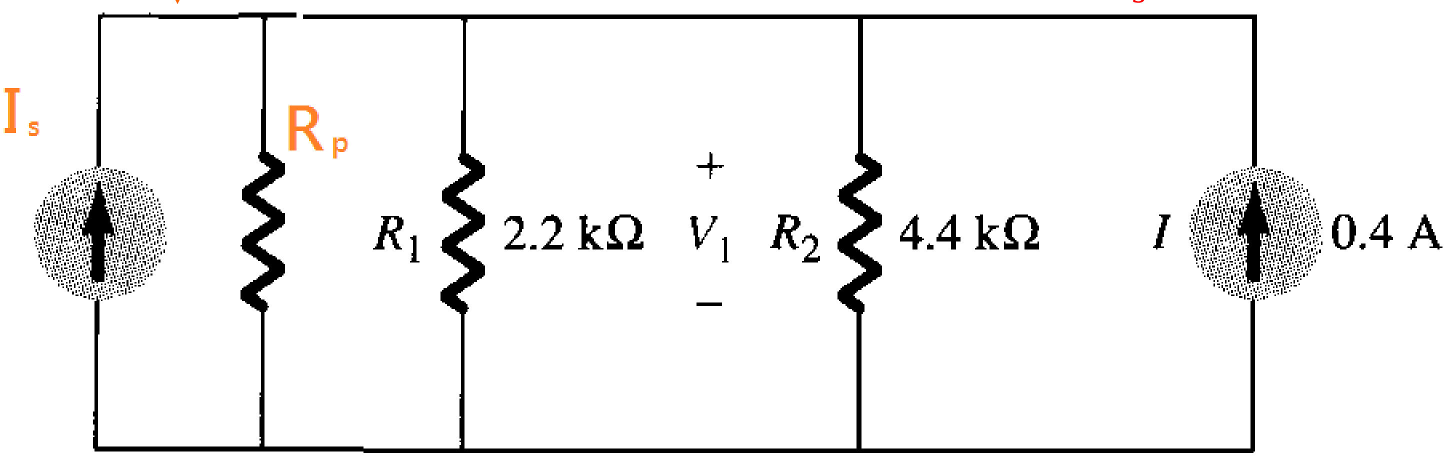


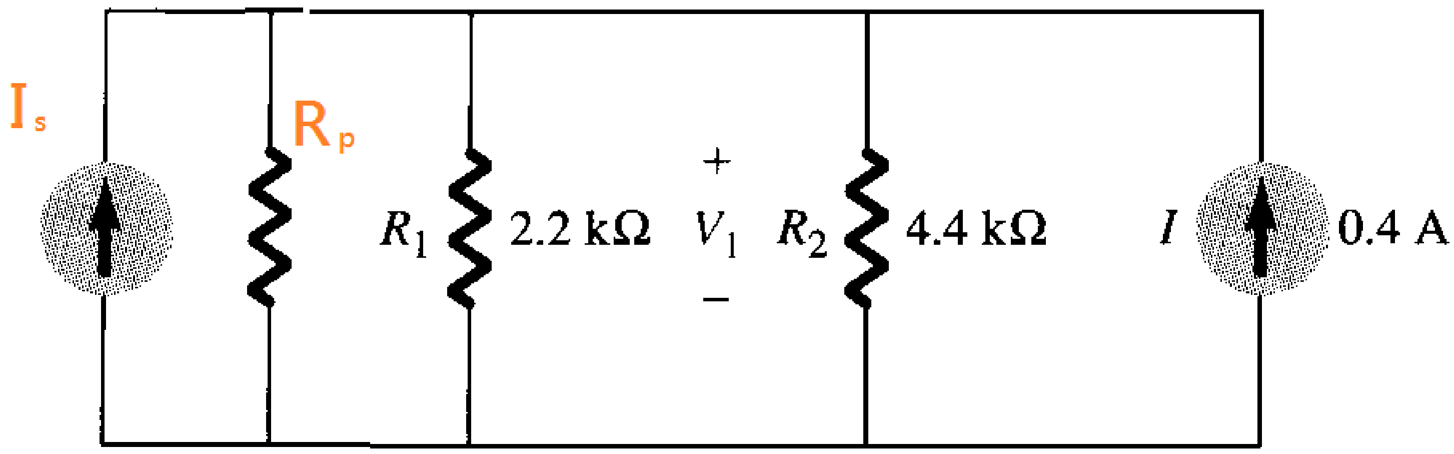
FIG. 3.82

Solution



$$R_p = R_s = 1.2\text{k}\Omega \qquad I_s = \frac{E_S}{R_s} = 0.2\text{A}$$





$I_T = I_s + I = 0.6\ A$

利用current-divider rule

$$I_1 = I_T \times \frac{1/R_1}{1/R_p + 1/R_1 + 1/R_2} = 0.18A$$

$$V_1 = I_1 R_1 = 396V$$

Exercise 7: Regulation

7. Determine the voltage regulation of a supply whose terminal voltage drops 1.8 V from open-circuit to full-load conditions if the full-load voltage is 220 V.

$$V_{FL} = 220V$$

$$V_{NL} = 220V + 1.8V = 221.8V$$

$$VR = \frac{V_{NL} - V_{FL}}{V_{FL}} \times 100\% = 0.82\%$$

Exercise 8: Regulation

8. A 12-V supply has an internal resistance of 0.05 Ω. An applied load of 1 Ω draws the full-load current from the supply. What is the percent voltage regulation of the supply?

$$V_{FL} = \frac{E}{R_S + R_L} \times R_L = \frac{12V}{0.05\Omega + 1\Omega} \times 1\Omega = 11.429V$$

$$V_{NL} = 12V$$

$$VR = \frac{V_{NL} - V_{FL}}{V_{FL}} \times 100\% = 5\%$$

Exercise 9: Regulation

9. A current source has a current regulation of 1.2%. If the full-load voltage draws a current of 200 mA, what is the no-load current?

$$IR = 1.2\%$$

$$I_{FL} = 200mA$$

$$IR = \frac{I_{NL} - I_{FL}}{I_{FL}} \times 100\% = 1.2\%$$

$$\rightarrow I_{NL} = 202.4mA$$

Exercise 10: Superposition

10. Using the superposition theorem, determine the current I for the network in Fig. 3.83.

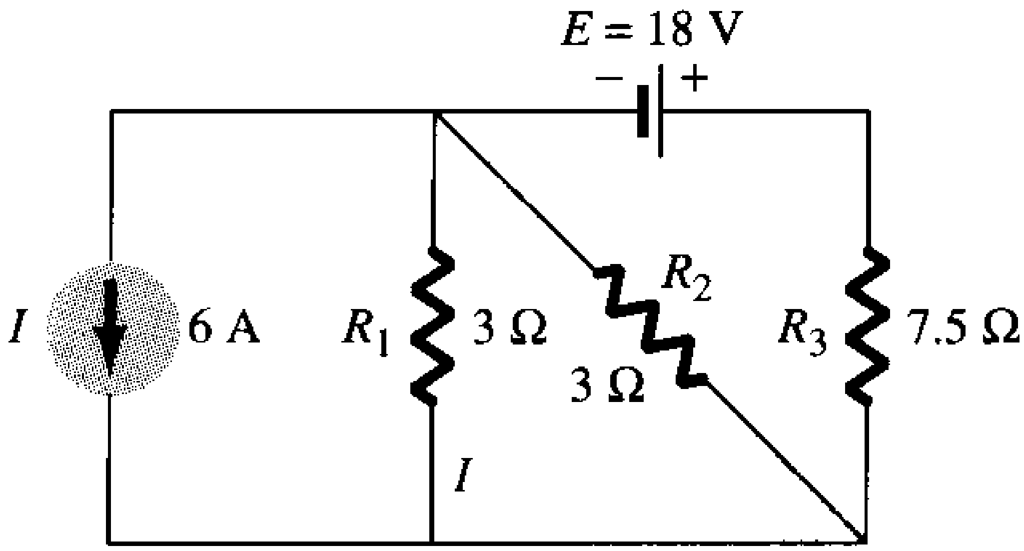
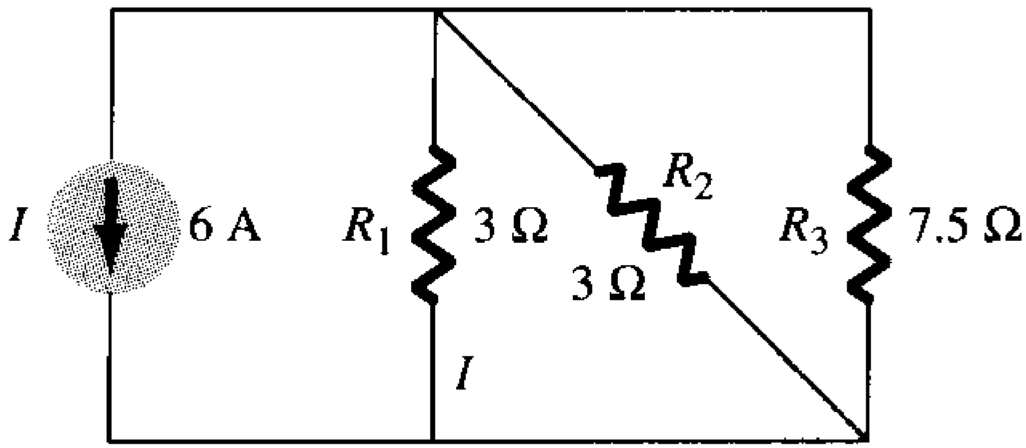


FIG. 3.83

先考慮電流源，
並將電壓源短路



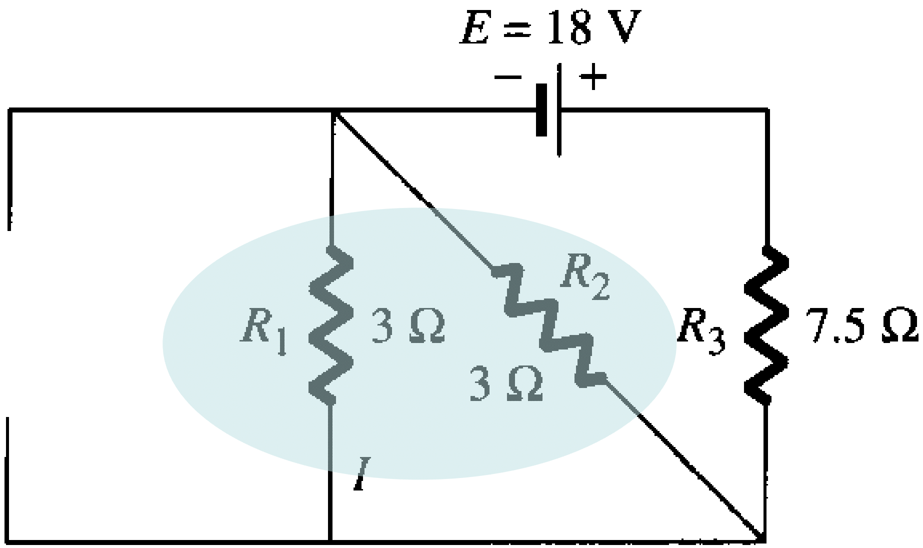
利用current divider rule

$$R_a = R_2 // R_3 = 2.143\Omega$$

$$I' = I \times \frac{1/R_1}{1/R_1 + 1/R_2 + 1/R_3} = I \times \frac{R_a}{R_1 + R_a} = 2.5A$$

驗證兩種方向切入，所得答案是一致的！

再考慮電壓源，
並將電流源斷路



$$R_b = R_1 // R_2 = 1.5\Omega$$

$$R_T = R_b + R_3 = 9\Omega$$

由E 出來的電流 $I_s = \dfrac{E}{R_T} = 2A$

利用current divider rule $I'' = I_s \times \dfrac{R_2}{R_1 + R_2} = 1A$

$$\Rightarrow I = I' + I'' = 3.5A$$

Exercise 11: Superposition

11. Using the superposition theorem, determine the current I for the network in Fig. 3.84.

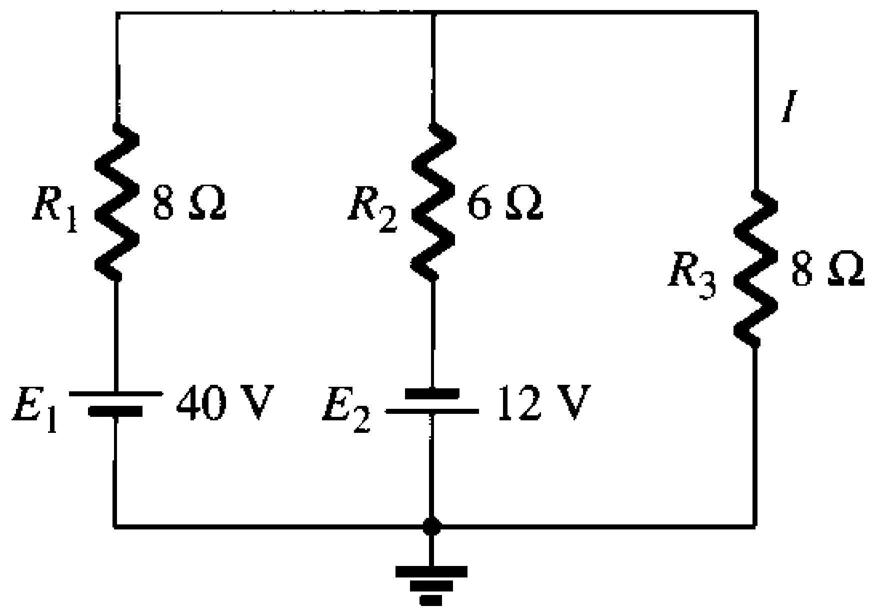
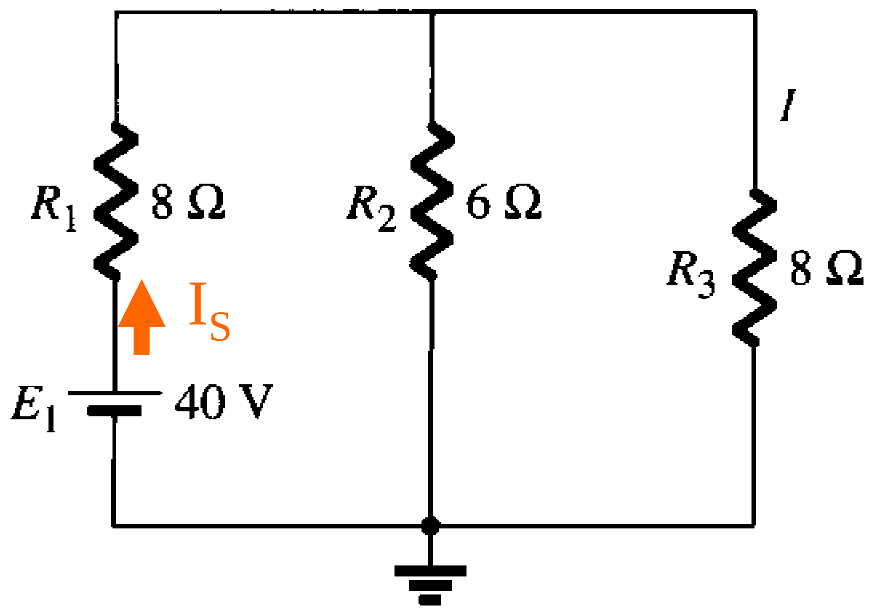


FIG. 3.84

先考慮電壓源E_1，
並將電壓源E_2短路

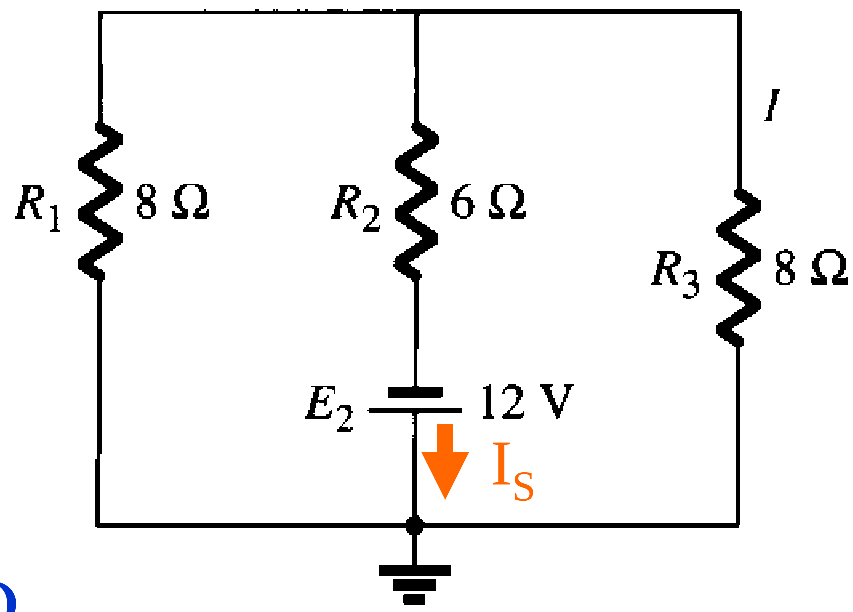


$$R_T = (R_2 // R_3) + R_1 = 11.429\Omega$$

$$I_s = \frac{E_1}{R_T} = 3.5A$$

$$I' = I_s \times \frac{R_2}{R_2 + R_3} = 1.5A \downarrow$$

再考慮電壓源E_2，
並將電壓源E_1短路



$$R_T = (R_1 // R_3) + R_2 = 10\Omega$$

$$I_s = \frac{E_2}{R_T} = 1.2A$$

$$I'' = I_s \times \frac{R_1}{R_1 + R_3} = 0.6A \uparrow$$

$$\Rightarrow I = I' + I'' = 0.9A \downarrow$$

Exercise 14: Mesh analysis

14. Repeat Problem 11 using mesh analysis.

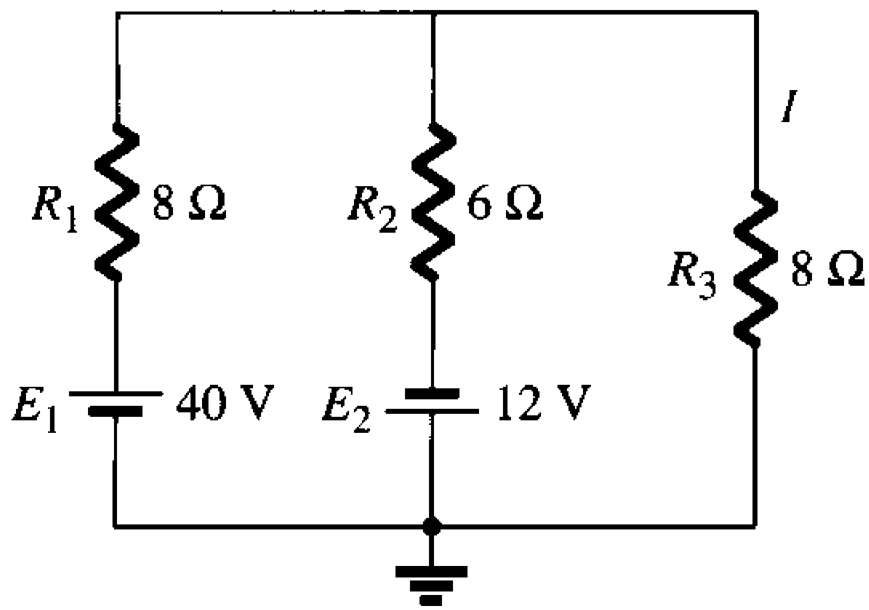


FIG. 3.84

STEP 1. 決定mesh數量、劃出mesh current並標示環繞mesh上的元件極性（正負）

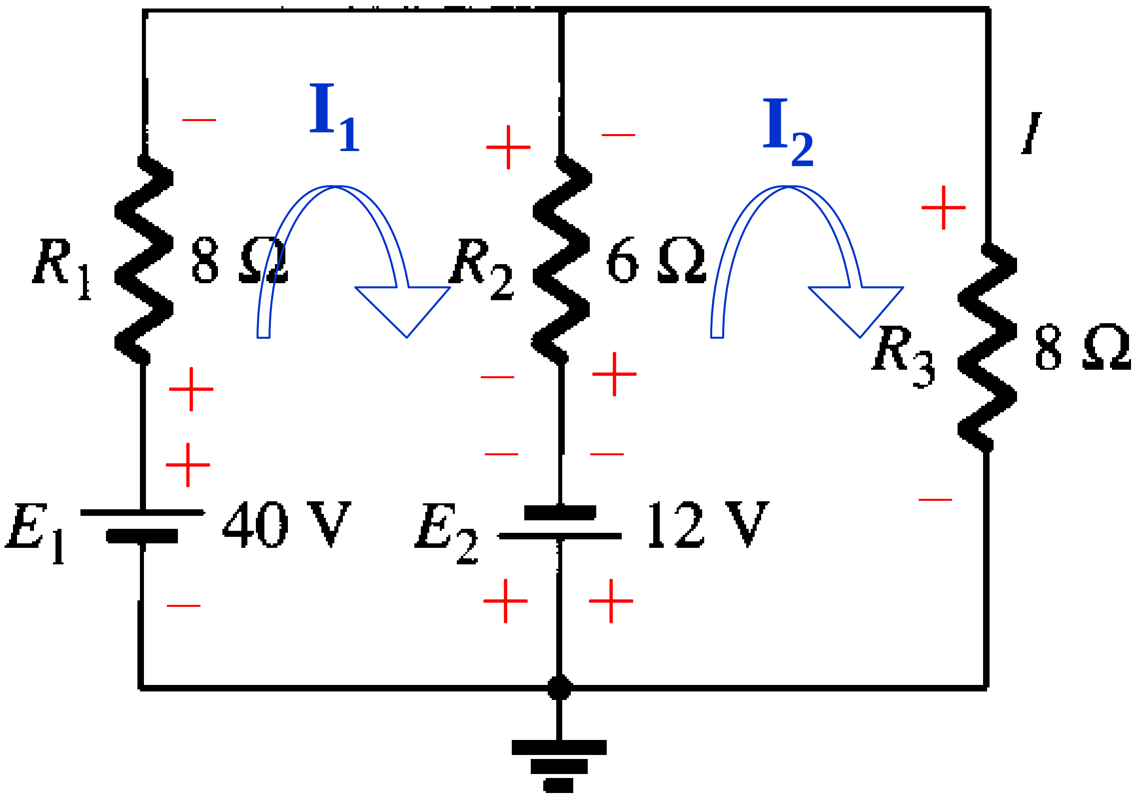


FIG. 3.84

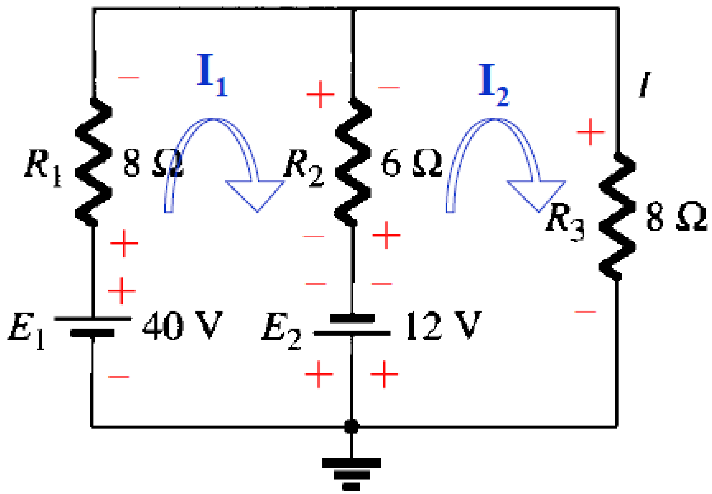
STEP 2. 寫出mesh equations

Mesh#1

$$E_1 - I_1R_1 - (I_1 - I_2)R_2 + E_2 = 0$$

Mesh#2

$$-E_2 - (I_2 - I_1)R_2 - I_2R_3 = 0$$

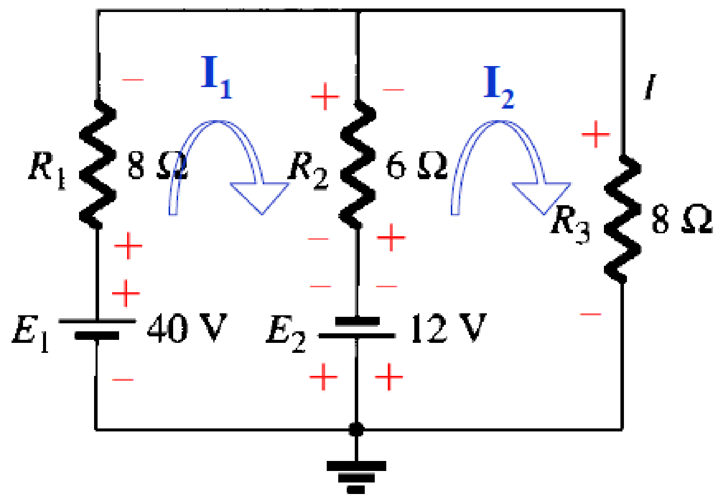


STEP 3. 整理mesh equations

$$I_1(R_1 + R_2) - I_2R_2 = E_1 + E_2$$

$$-I_1R_2 + I_2(R_2 + R_3) = -E_2$$

STEP 4. 代入數值



$$14I_1 - 6I_2 = 52$$

$$-6I_1 + 14I_2 = -12$$

STEP 5. 解方程式

$$I_1 = \frac{\begin{vmatrix} 52 & -6 \\ -12 & 14 \end{vmatrix}}{\begin{vmatrix} 14 & -6 \\ -6 & 14 \end{vmatrix}} = 4.1\text{A} \qquad I_2 = \frac{\begin{vmatrix} 14 & 52 \\ -6 & -12 \end{vmatrix}}{\begin{vmatrix} 14 & -6 \\ -6 & 14 \end{vmatrix}} = 0.9\text{A}$$

Exercise 15: Mesh analysis

15. Determine the current I_1 for the network in Fig. 3.86 using mesh analysis.

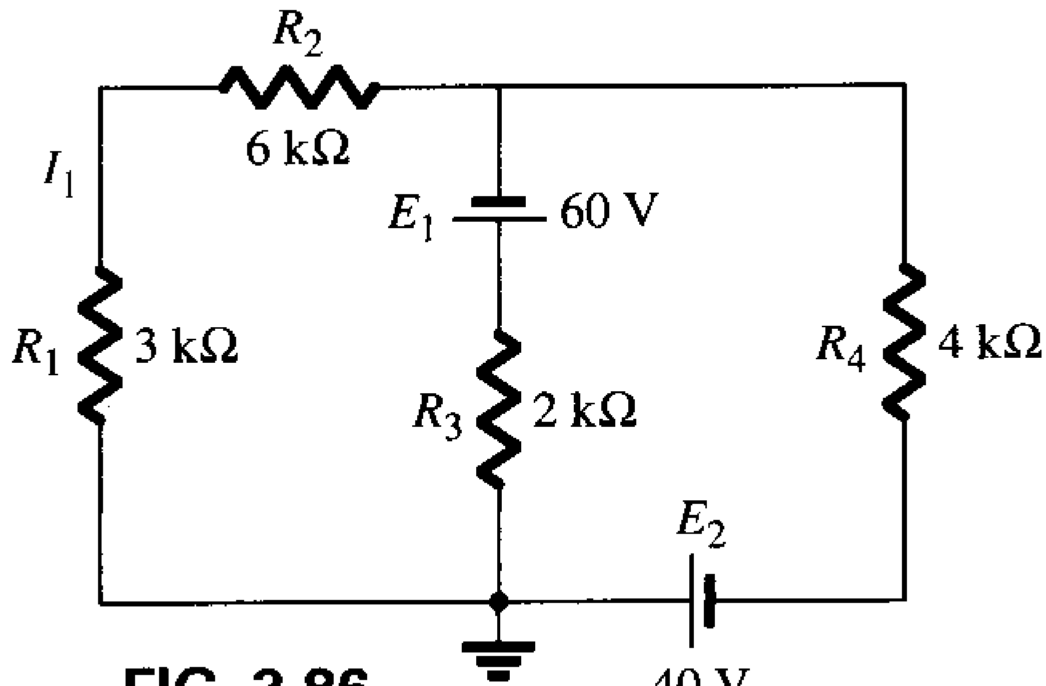


FIG. 3.86

STEP 1. 決定mesh數量、劃出mesh current並標示環繞mesh上的元件極性（正負）

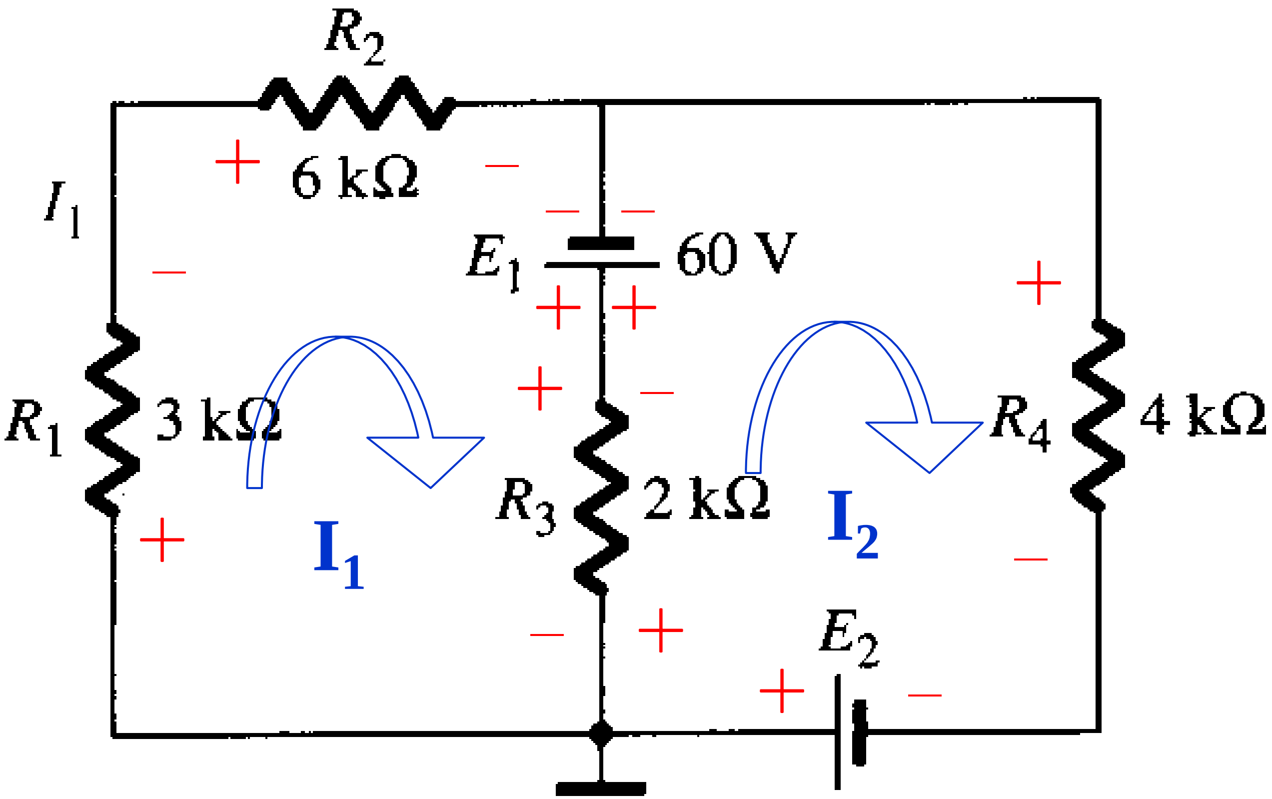


FIG. 3.86

STEP 2. 寫出mesh equations

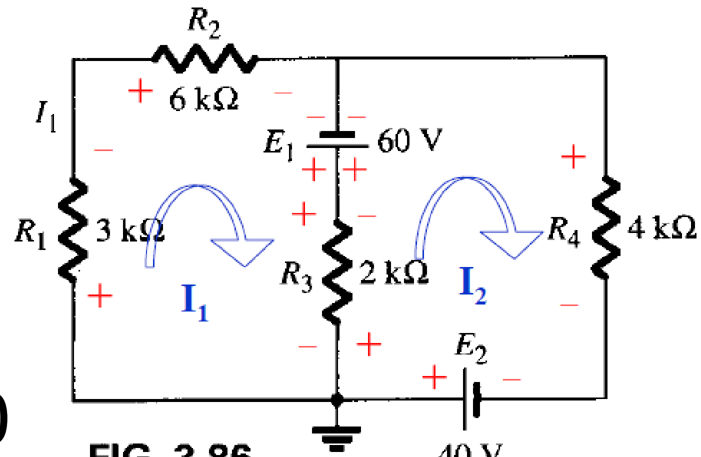


FIG. 3.86

Mesh#1

$$-I_1R_1 - I_1R_2 + E_1 - (I_1 - I_2)R_3 = 0$$

Mesh#2

$$-(I_2 - I_1)R_3 - E_1 - I_2R_4 + E_2 = 0$$

STEP 3. 整理mesh equations

$$I_1(R_1 + R_2 + R_3) - I_2R_3 = E_1$$

$$-I_1R_3 + I_2(R_3 + R_4) = E_2 - E_1$$

STEP 4. 代入數值

$$11kI_1 - 2kI_2 = 60$$

$$-2kI_1 + 6kI_2 = -20$$

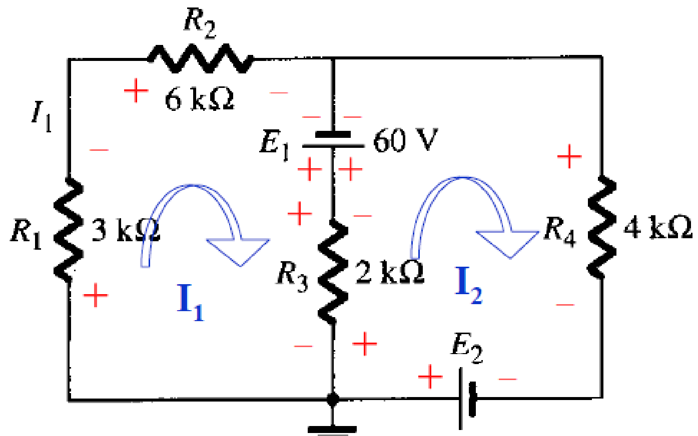


FIG. 3.86

STEP 5. 解方程式

$$I_1 = \frac{\begin{vmatrix} 60 & -2k \\ -20 & 6k \end{vmatrix}}{\begin{vmatrix} 11k & -2k \\ -2k & 6k \end{vmatrix}} = 5.161mA \qquad I_2 = \frac{\begin{vmatrix} 11k & 60 \\ -2k & -20 \end{vmatrix}}{\begin{vmatrix} 11k & -2k \\ -2k & 6k \end{vmatrix}} =$$

Exercise 16: Mesh analysis

16. Determine the current I_6 for the network in Fig. 3.79 using mesh analysis.

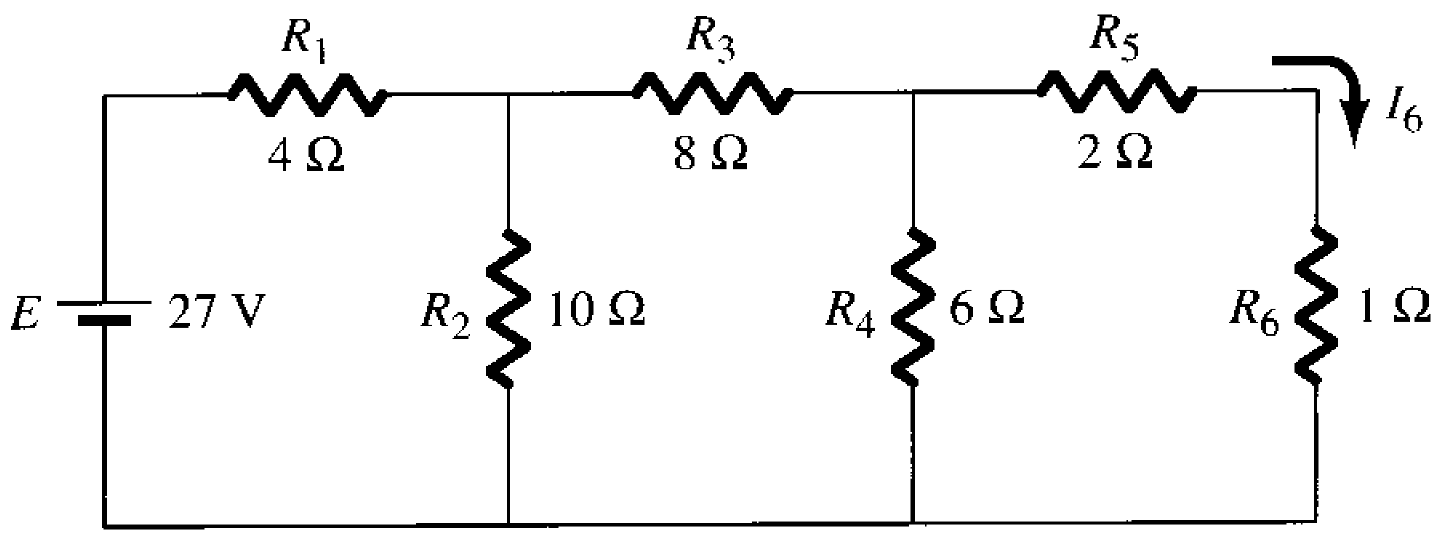


FIG. 3.79

STEP 1. 決定mesh數量、劃出mesh current並標示環繞mesh上的元件極性（正負）

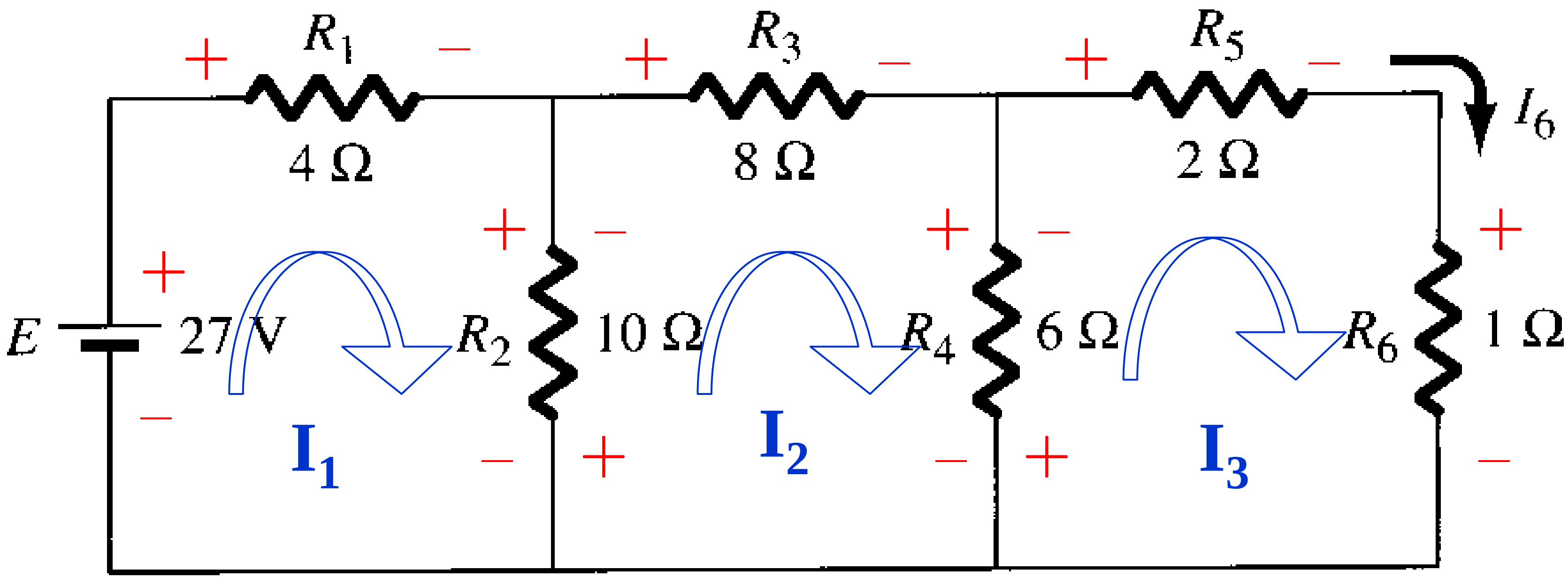


FIG. 3.79

STEP 2. 寫出mesh equations

Mesh#1

$$E - I_1R_1 - (I_1 - I_2)R_2 = 0$$

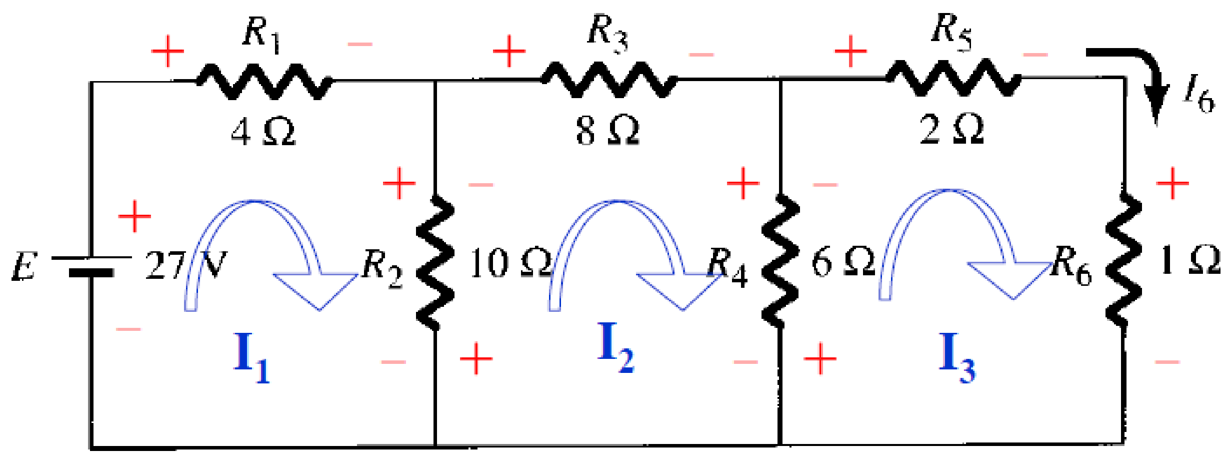
Mesh#2

$$-(I_2 - I_1)R_2 - I_2R_3 - (I_2 - I_3)R_4 = 0$$

Mesh#3

$$-(I_3 - I_2)R_4 - I_3R_5 - I_3R_6 = 0$$

$I_3 = I_6$



STEP 3. 整理mesh equations

$$I_1(R_1 + R_2) - I_2R_2 = E$$

$$-I_1R_2 + I_2(R_2 + R_3 + R_4) - I_3R_4 = 0$$

$$-I_2R_4 + I_3(R_4 + R_5 + R_6) = 0$$

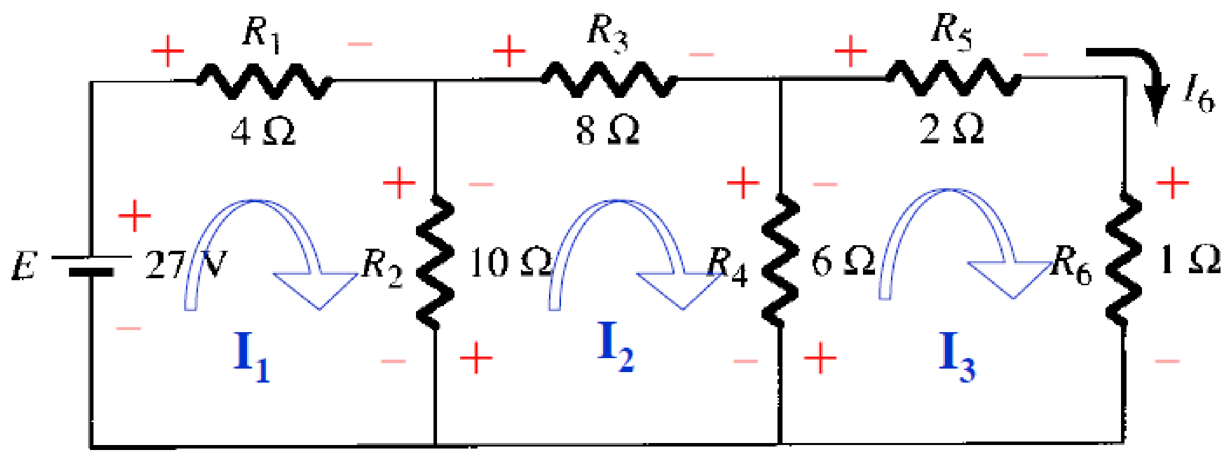
STEP 4. 代入數值

$$14I_1 - 10I_2 = 27$$

$$-10I_1 + 24I_2 - 6I_3 = 0$$

$$-6I_2 + 9I_3 = 0$$

$I_3 = I_6 = 1A$



Exercise 17: Nodal analysis

17. a. Determine the nodal voltages for the network in Fig. 3.87.

b. Using the nodal voltages, determine the current (magnitude and direction) through each resistive element.

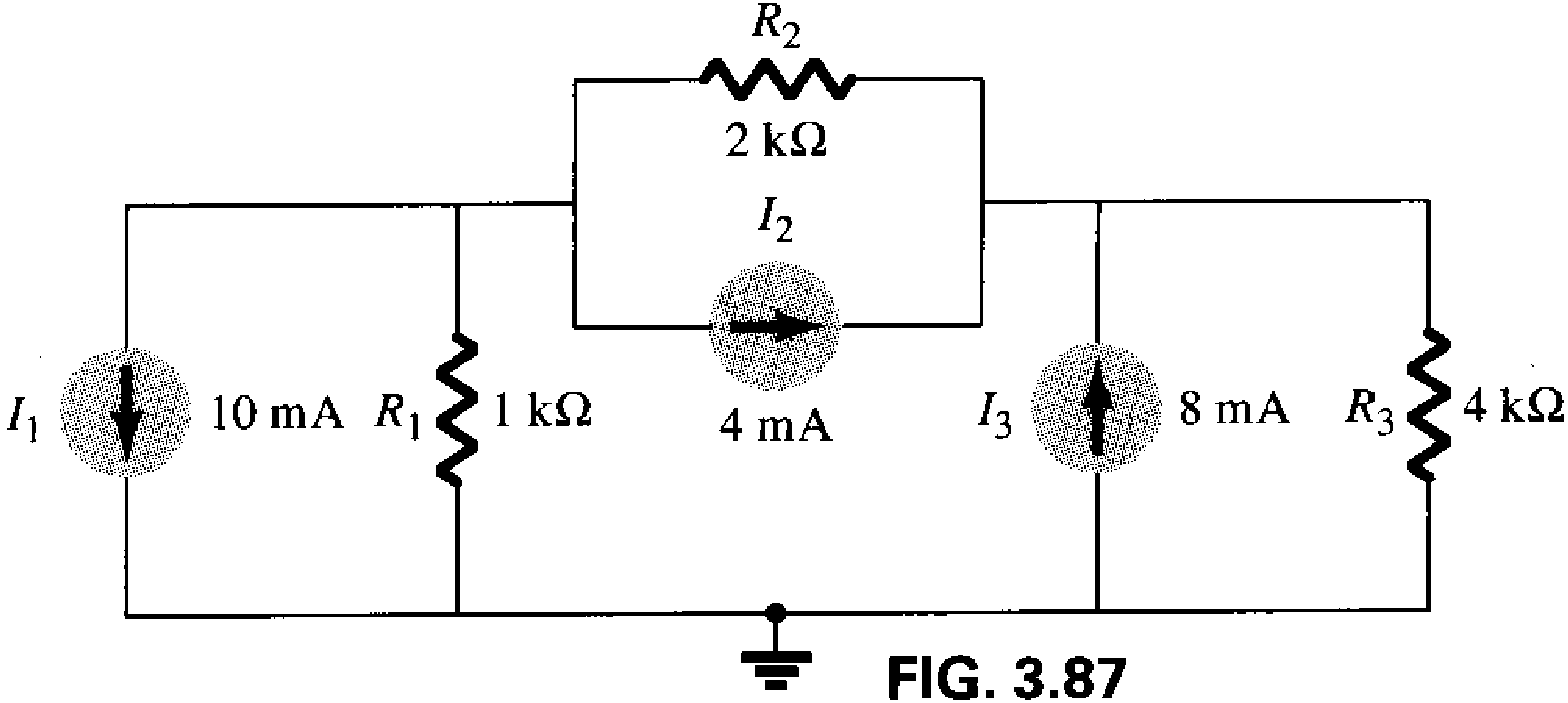


FIG. 3.87

STEP 1. 決定node數量、劃出nodal voltage並標示進出node的電流方向（branch）

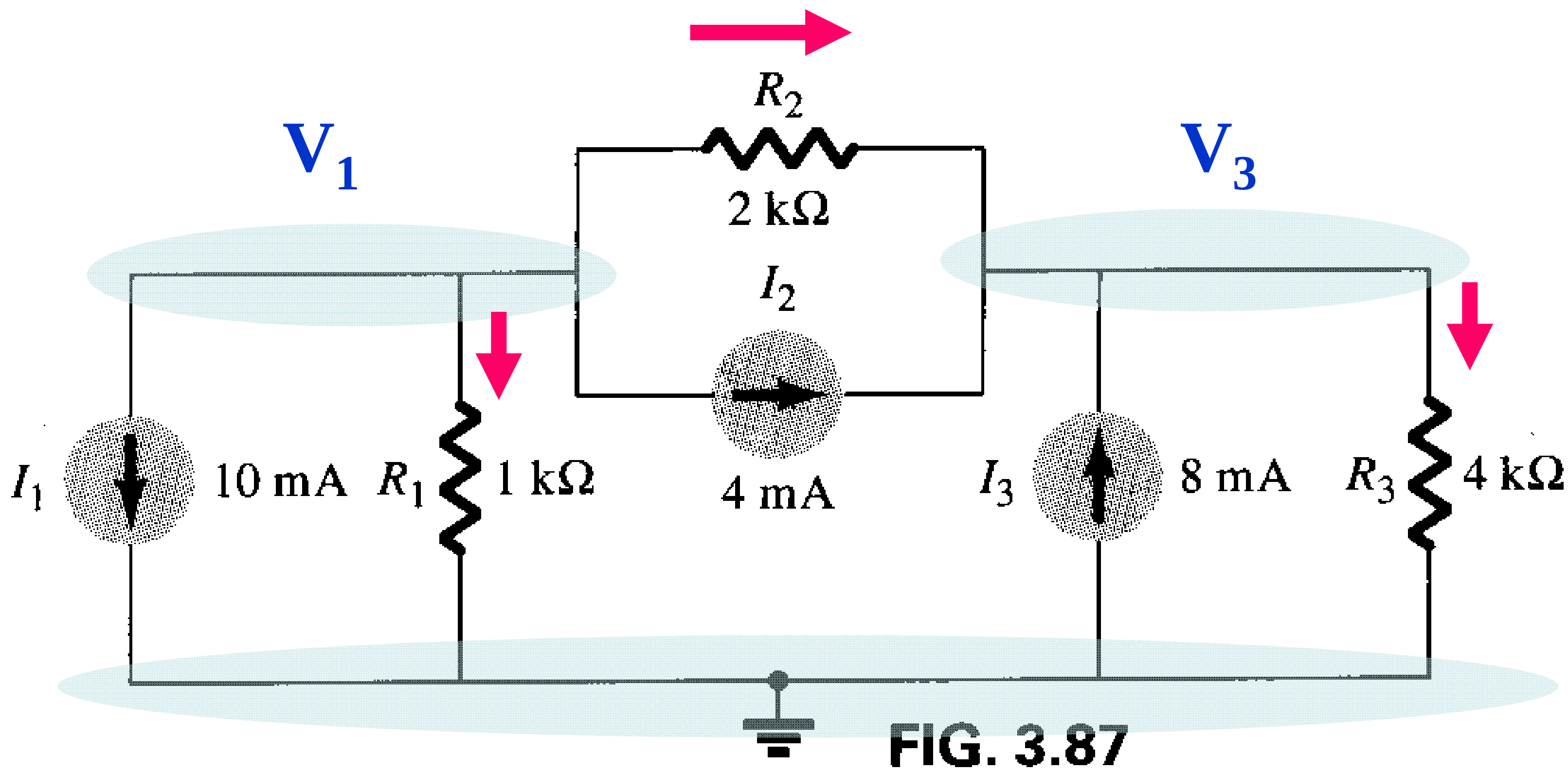


FIG. 3.87

STEP 2. 寫出nodal equations

Node#1

$$-I_1 - \frac{V_1}{R_1} - I_2 - \frac{V_1 - V_2}{R_2} = 0$$

Node#2

$$\frac{V_1 - V_2}{R_2} + I_2 + I_3 - \frac{V_2}{R_3} = 0$$

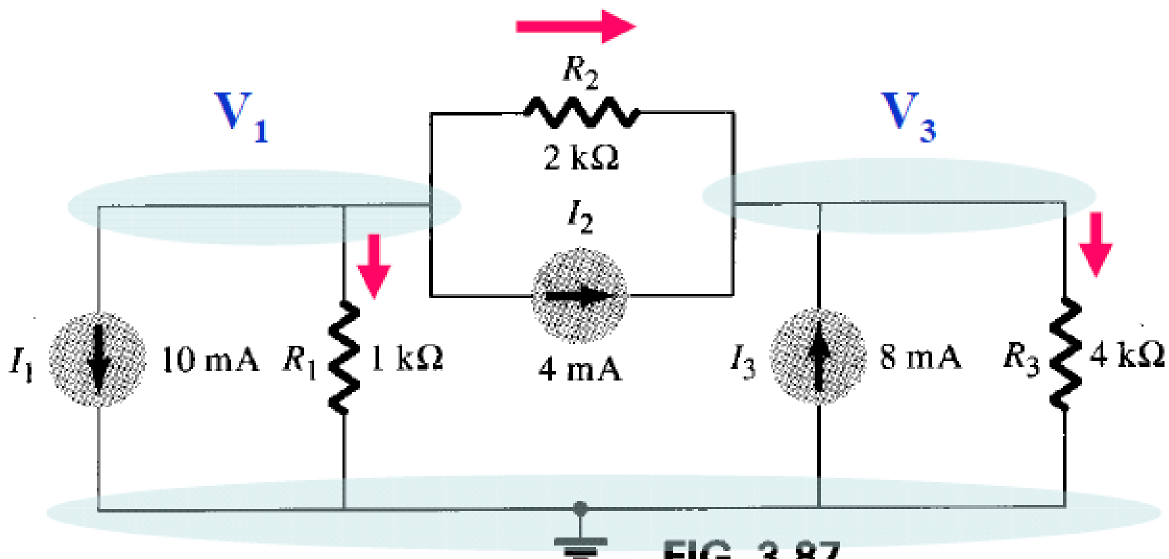


FIG. 3.87

STEP 3.整理nodal equations

$$-V_1\left(\frac{1}{R_1}+\frac{1}{R_2}\right)+V_2\left(\frac{1}{R_2}\right)=I_1+I_2$$

$$-V_1\left(\frac{1}{R_1}\right)+V_2\left(\frac{1}{R_2}+\frac{1}{R_3}\right)=I_2+I_3$$

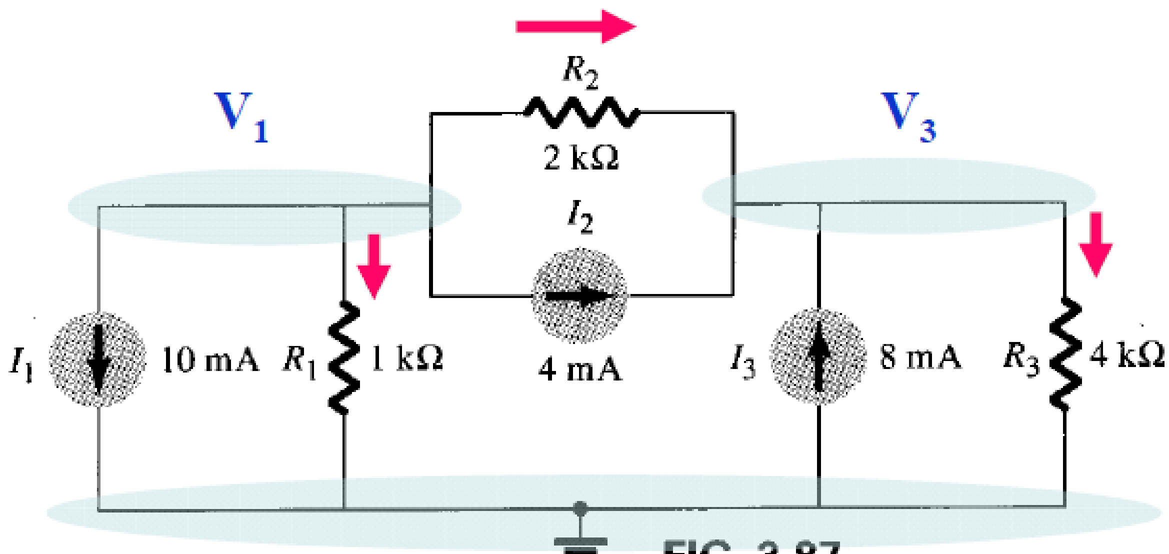


FIG. 3.87

STEP 4. 代入數值

$$-1.5\text{mS}\cdot V_1 + 0.5\text{mS}\cdot V_2 = 14\text{mA}$$

$$-0.5\text{mS}\cdot V_1 + 0.75\text{mS}\cdot V_2 = 12\text{mA}$$

STEP 5. 解方程式

→ V_1 = -5.143V V_2 =12.571V

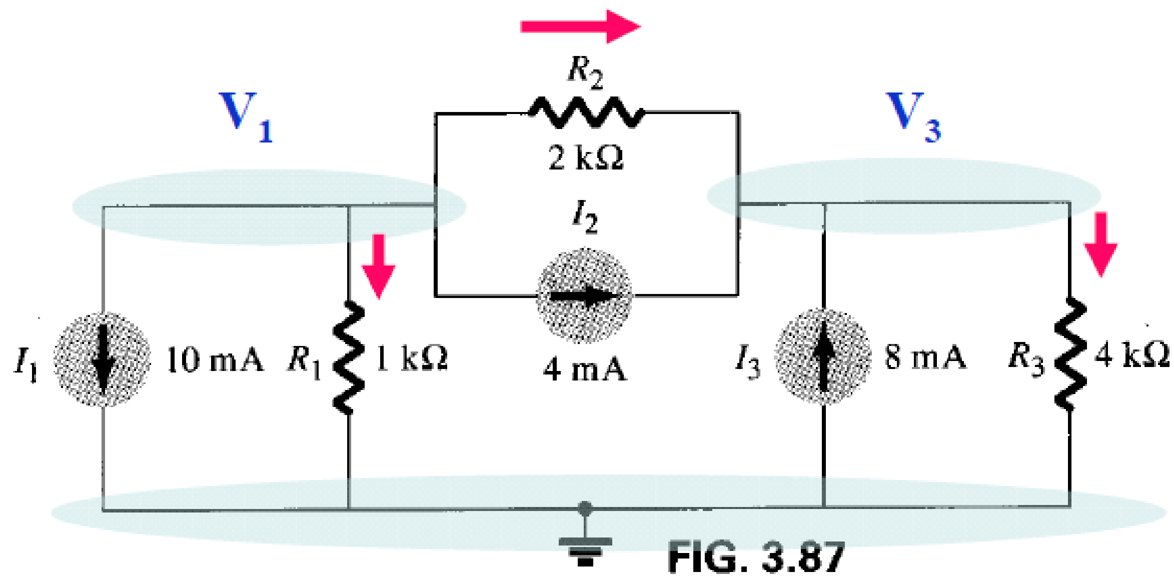


FIG. 3.87

Exercise 18: Nodal analysis

18. a. Convert the voltage sources in Fig. 3.84 to current sources.

b. Determine the nodal voltage for the resulting network.

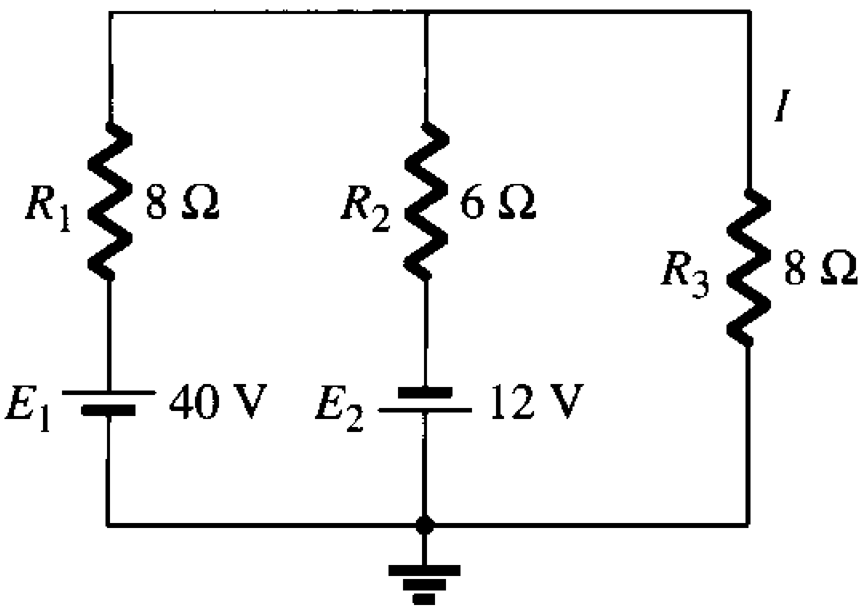
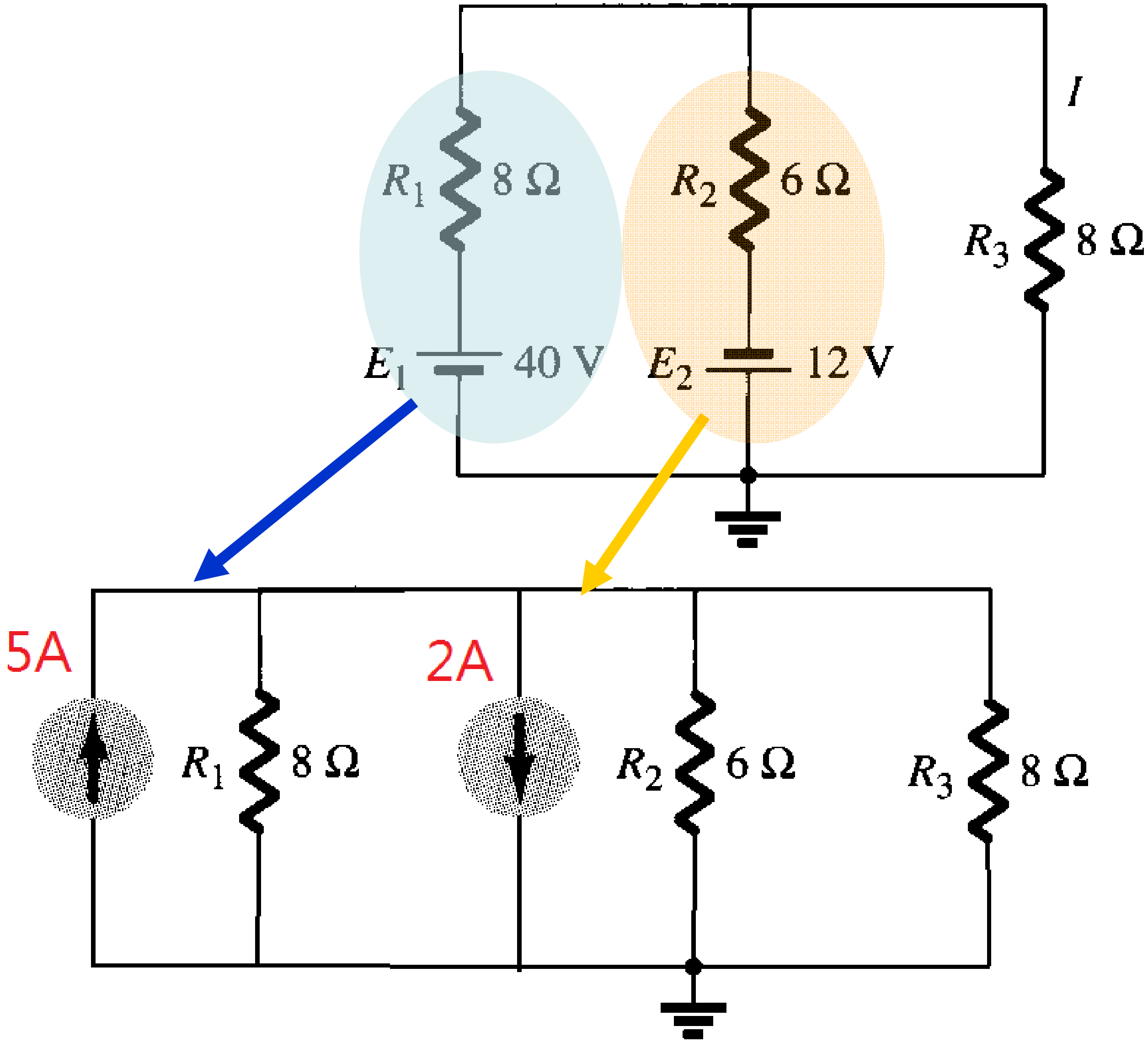


FIG. 3.84

Solution



$$I_T = 5A - 2A = 3A$$

$$V_1 = I_T \times R_T$$

$$= I_T \times \frac{1}{1/R_1 + 1/R_2 + 1/R_3} = 7.194V$$

Exercise 19: Nodal analysis

19. Determine the nodal voltages for the network in Fig. 3.88.

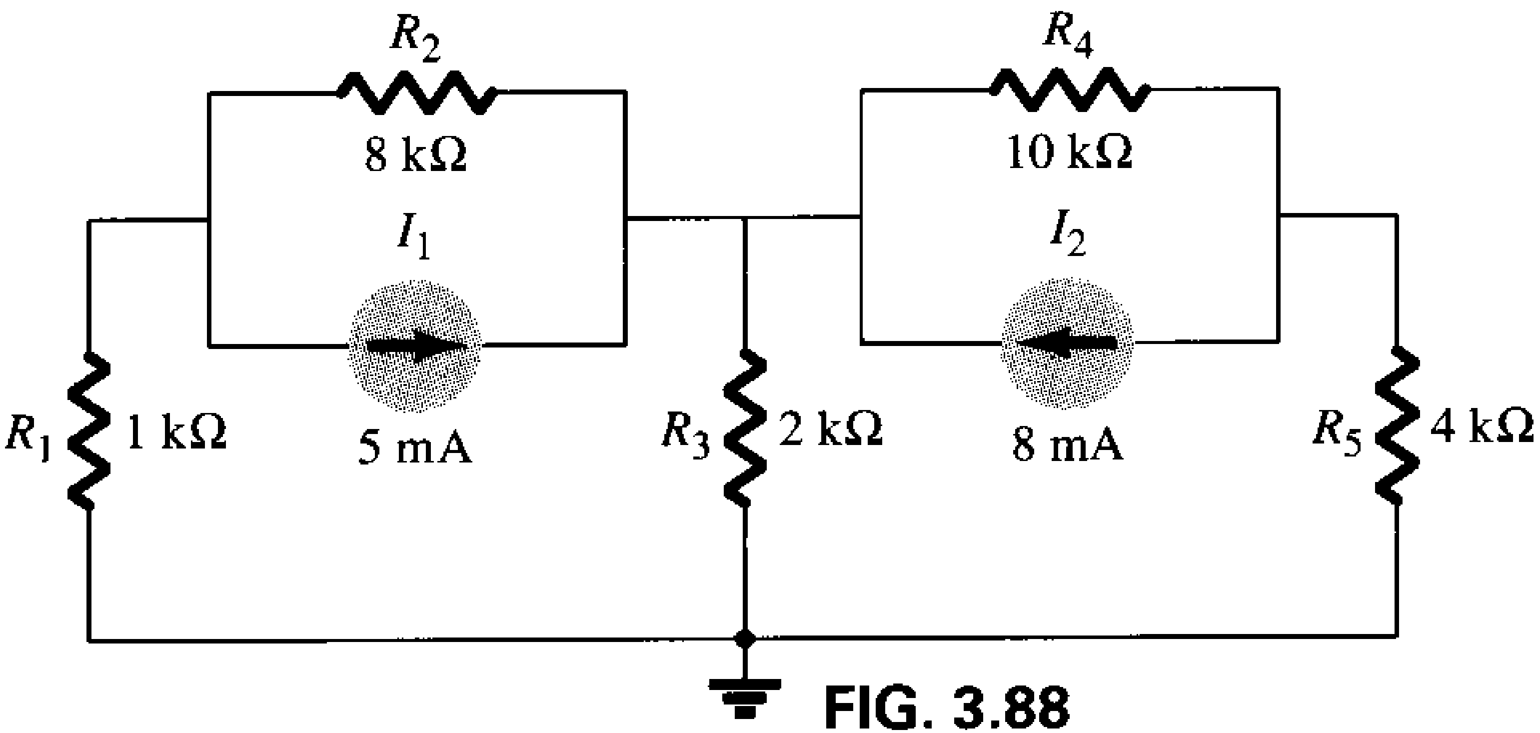
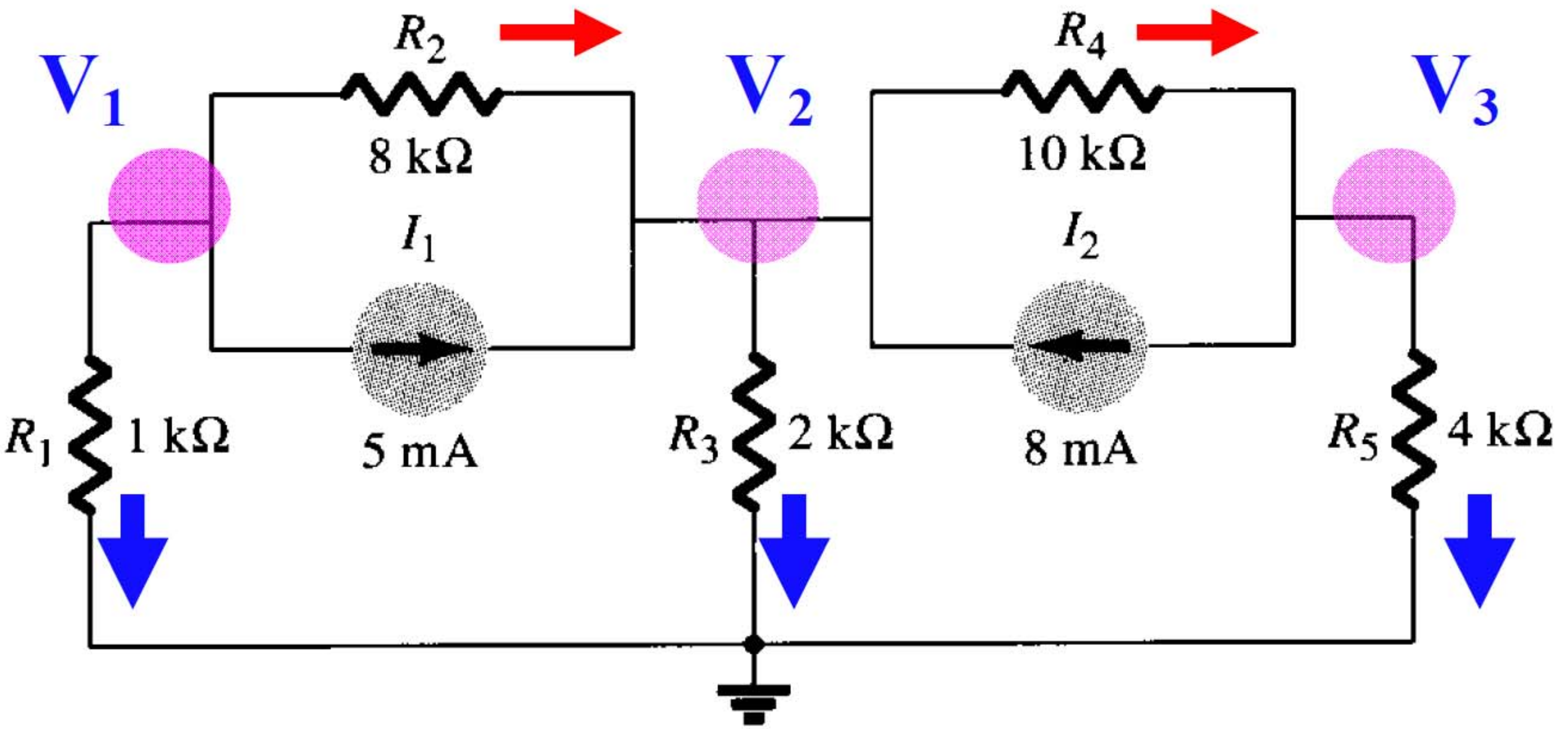


FIG. 3.88

STEP 1. 決定node數量、劃出nodal voltage並標示進出node的電流方向（branch）



STEP 2. 寫出nodal equations

Node#1

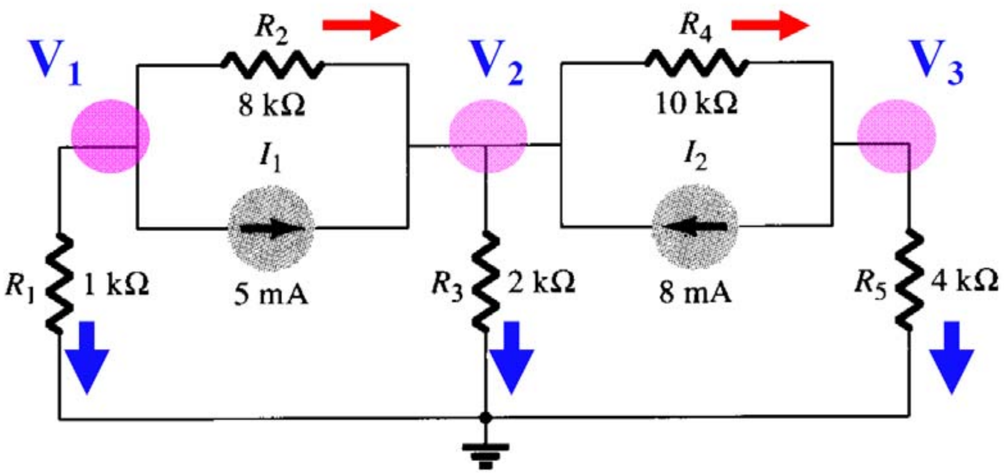
$$-\frac{V_1}{R_1}-\frac{V_1-V_2}{R_2}-I_1=0$$

Node#2

$$\frac{V_1-V_2}{R_2}+I_1-\frac{V_2}{R_3}-\frac{V_2-V_3}{R_4}+I_2=0$$

Node#3

$$\frac{V_2-V_3}{R_4}-I_2-\frac{V_3}{R_5}=0$$

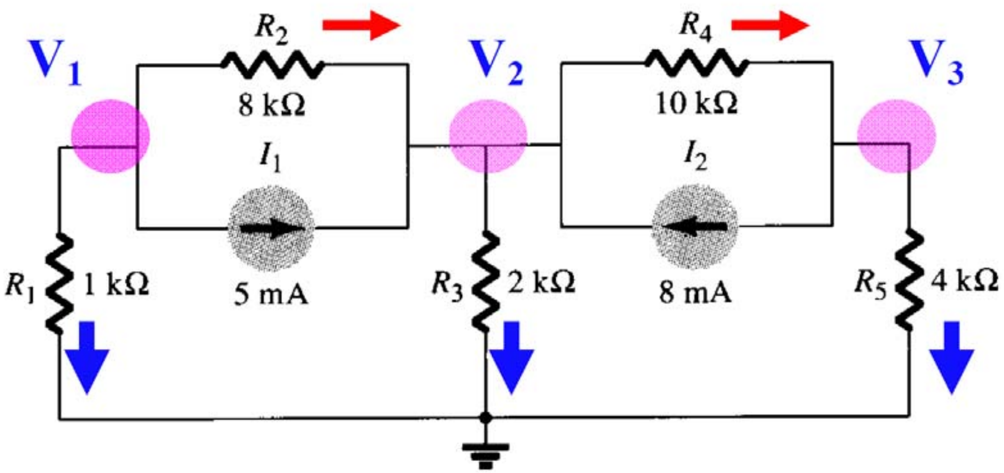


STEP 3. 整理nodal equations

$$V_1\left(\frac{1}{R_1}+\frac{1}{R_2}\right)-V_2\left(\frac{1}{R_2}\right)=-I_1$$

$$-V_1\left(\frac{1}{R_2}\right)+V_2\left(\frac{1}{R_2}+\frac{1}{R_3}+\frac{1}{R_4}\right)-V_3\left(\frac{1}{R_4}\right)=I_1+I_2$$

$$V_2\left(\frac{1}{R_4}\right)-V_3\left(\frac{1}{R_4}+\frac{1}{R_5}\right)=I_2$$



STEP 4. 代入數值

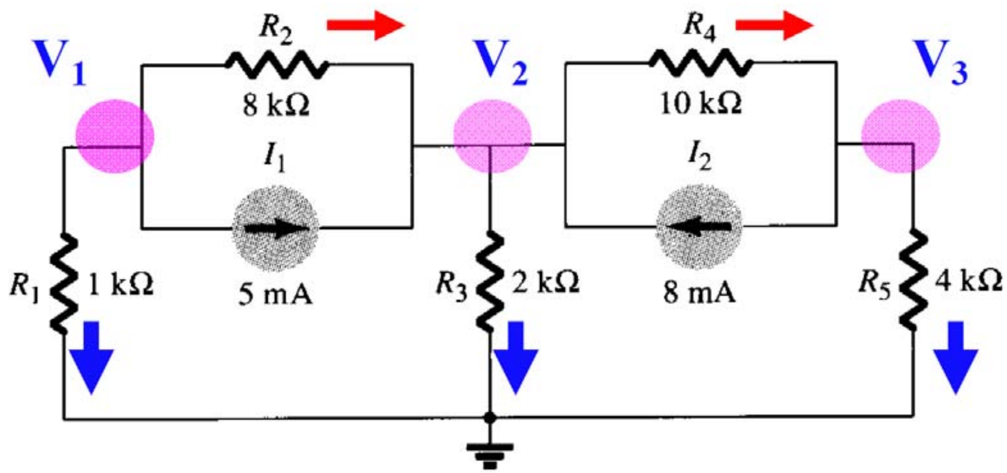
$$1.125\text{mS}\cdot V_1 - 0.125\text{mS}\cdot V_2 + 0 = -5\text{mA}$$

$$-0.125\text{mS}\cdot V_1 + 0.725\text{mS}\cdot V_2 - 0.1\text{mS}\cdot V_3 = 13\text{mA}$$

$$0.1\text{mS}\cdot V_2 - 0.35\text{mS}\cdot V_3 = 8\text{mA}$$

STEP 5. 解方程式

→ V_1 = -2.972V V_2 =13.255V V_3 = -19.07V



Exercise 20 Thevenin network

20. **a.** Find the Thévenin network for the portion of the network in Fig. 3.89 to the left of resistor R_L.

b. Using the Thévenin network, determine I_L.

c. Use series–parallel techniques on the original network to determine I_L, and compare the results with those for part (b).

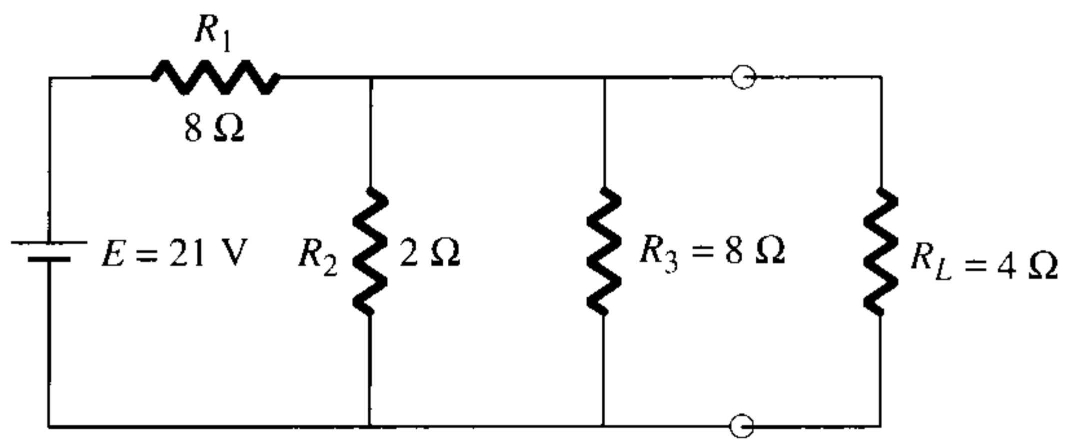
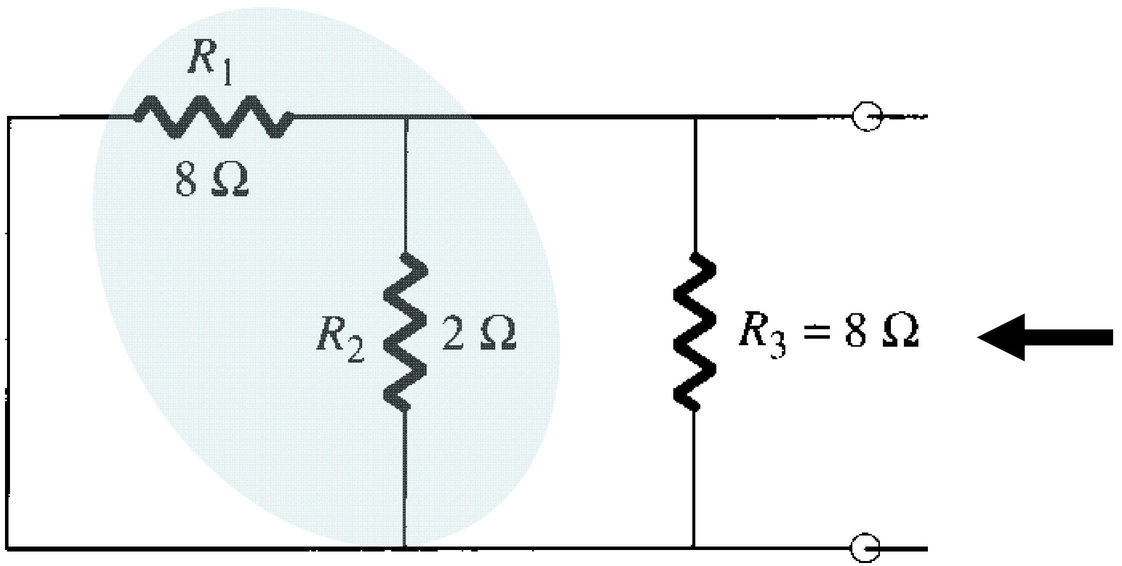


FIG. 3.89

R_{TH}

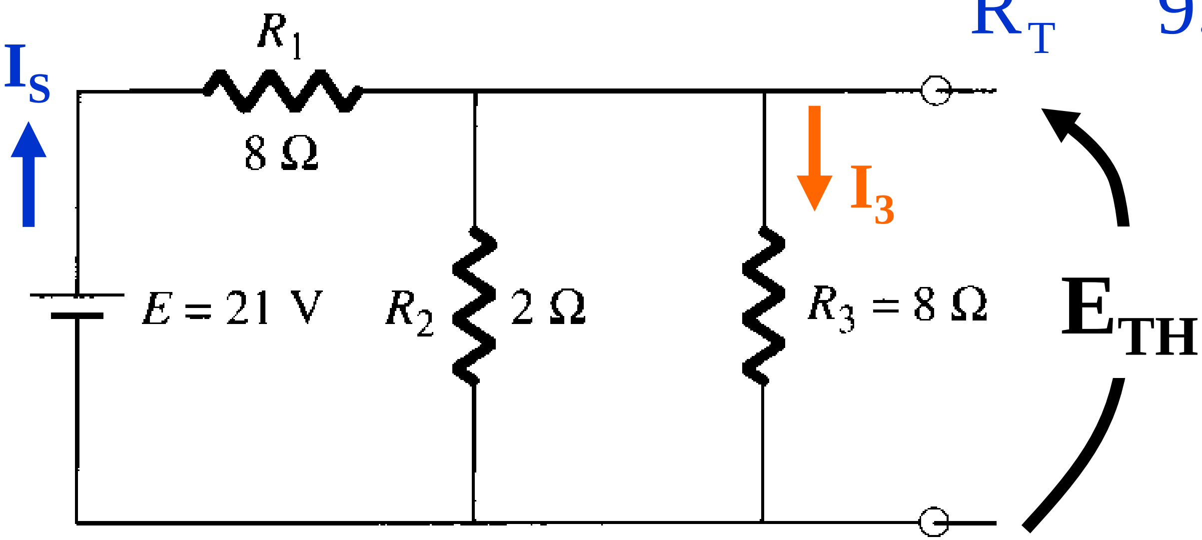


$$R_{TH} = (R_1 // R_2) // R_3 = 1.333\Omega$$

E_{TH}

$$R_T = (R_3 // R_2) + R_1 = 9.6\Omega$$

$$I_s = \frac{E}{R_T} = \frac{21V}{9.6\Omega} = 2.1985A$$

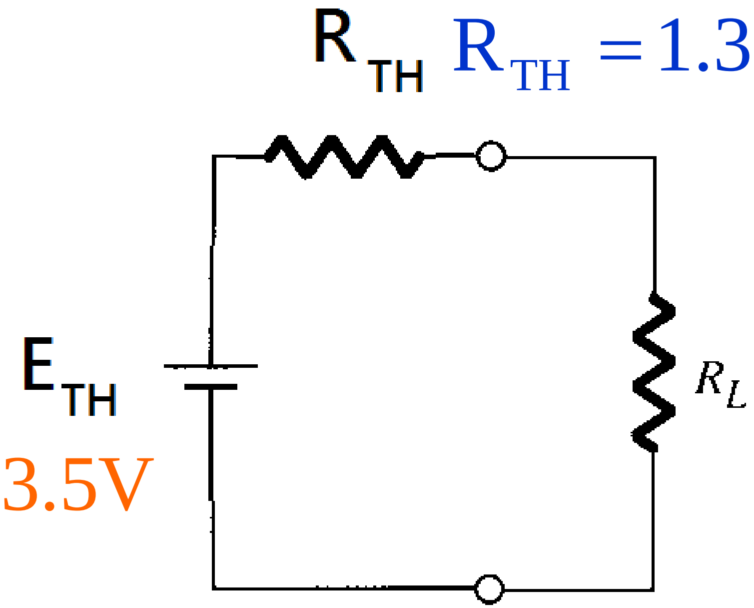


$$I_3 = I_S \times \frac{R_2}{R_2 + R_3} = 0.4375A$$

$$E_{TH} = I_3 \times R_3 = 3.5V$$

Thévenin Network

$R_{TH} = 1.333\Omega$



$E_{TH} = 3.5V$

$$I_L = \frac{E_{TH}}{R_{TH} + R_L} = \frac{3.5V}{(1.333\Omega + 4\Omega)} = 0.656A$$

$$P = I_L^{\ 2} \times R_L = 1.721W$$

Exercise 21 Thevenin network

21. a. Determine the value of R_L in Fig. 3.89 that would result in maximum power to R_L.

b. Calculate the maximum power that could be delivered to R_L if it were changed to that value.

c. Find the power delivered to R_L if $R_L = 4\ \Omega$ and verify that it is less than the maximum value in part (b).

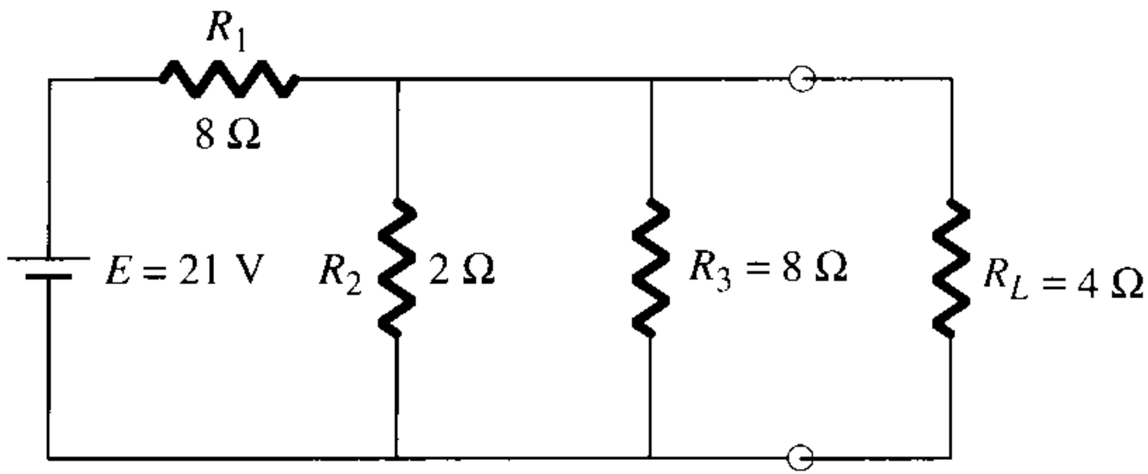


FIG. 3.89

Solution

當 $R_L = R_{TH} = 1.333\,\Omega$

$$I_L = \frac{E_{TH}}{R_{TH} + R_L} = \frac{3.5V}{(1.333\Omega + 1.333\Omega)} = 1.3125A$$

$$P = I_L^{\ 2} \times R_L = 2.297W = \frac{E_{TH}^{\ 2}}{4R_L} = \frac{E_{TH}^{\ 2}}{4R_{TH}} = 2.297W$$

$$I_L = \frac{E_{TH}}{R_{TH} + R_L} = \frac{3.5V}{(1.333\Omega + 4\Omega)} = 0.656A$$

$$P = I_L^{\ 2} \times R_L = 1.721W$$ （非最大）

Exercise 22 Thevenin network

22. **a.** Find the Thévenin network for the network external to the resistor R_L in Fig. 3.90.

b. Find R_L for maximum power to R_L.

c. Find the maximum power to R_L.

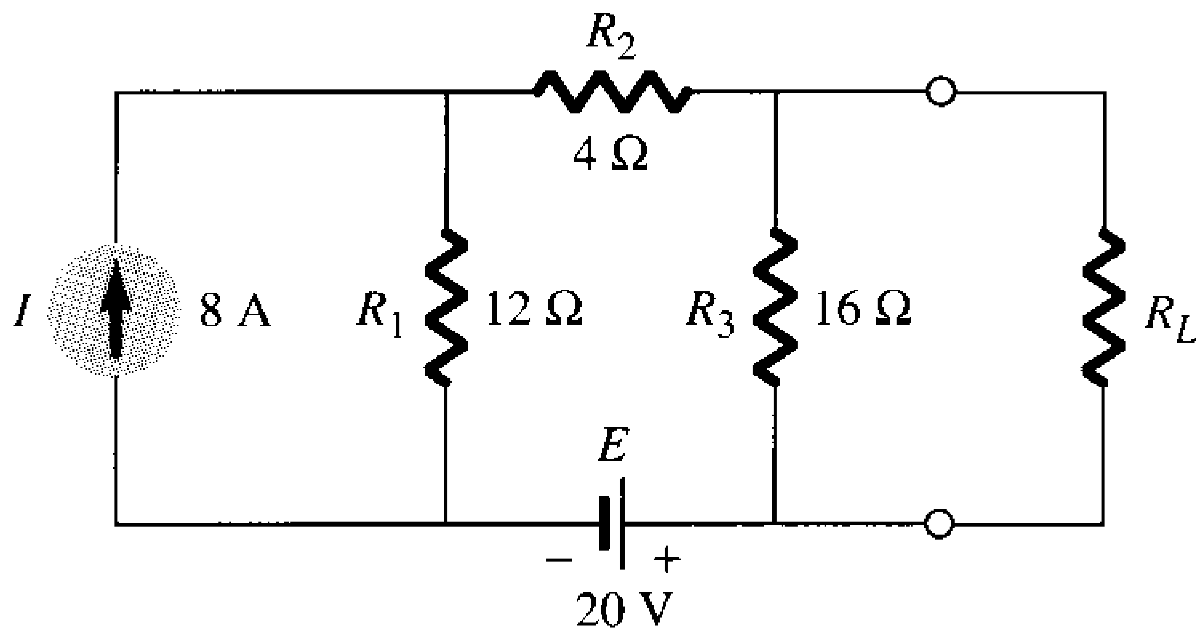
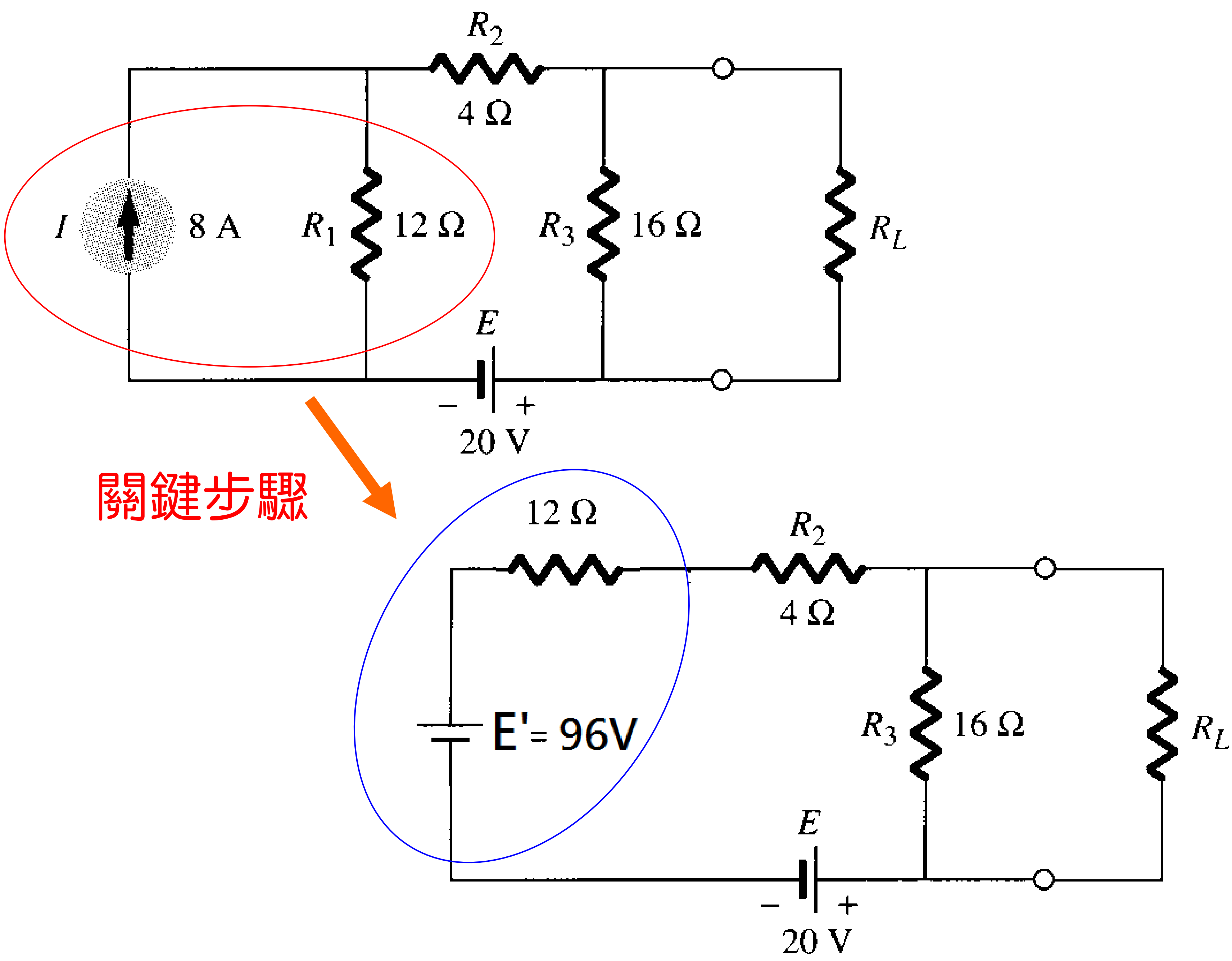
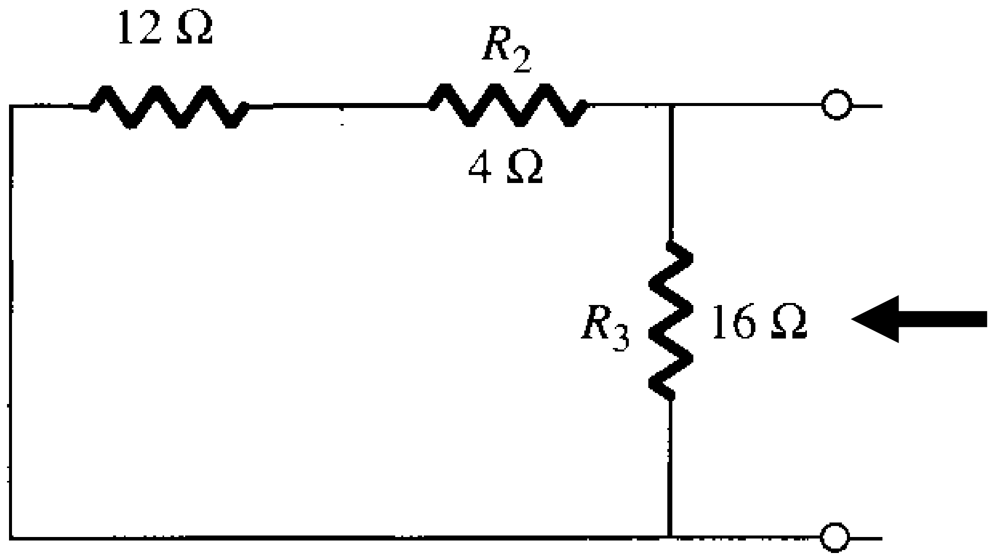


FIG. 3.90

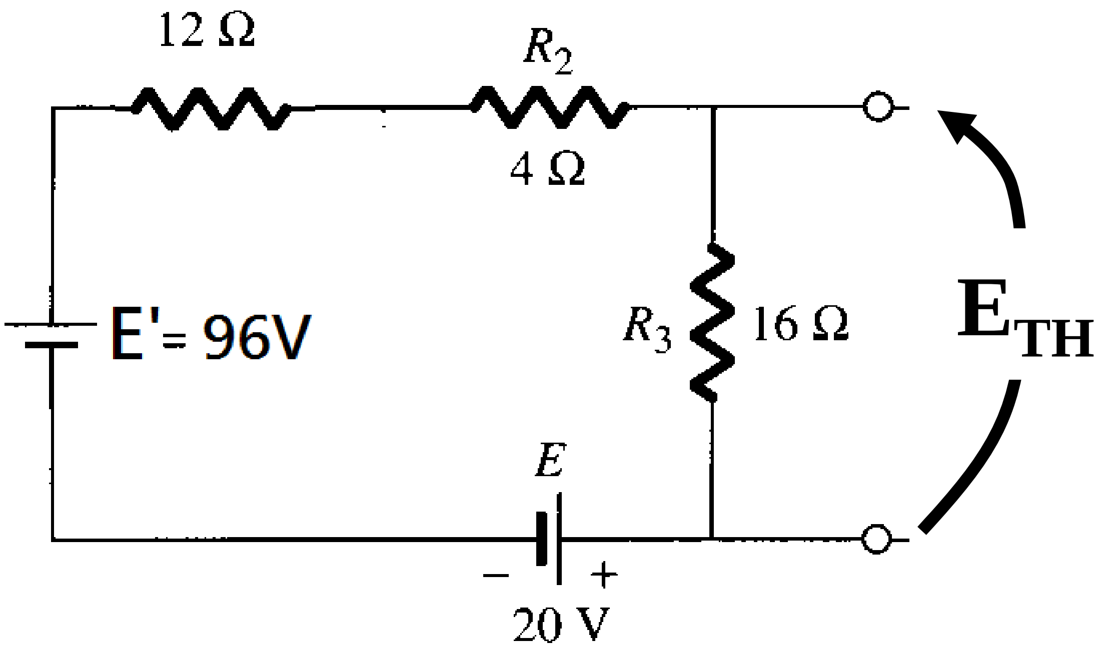

R2
4 Ω
I
8 A
R1
12 Ω
R3
16 Ω
RL
E
− +
20 V
關鍵步驟
12 Ω
R2
4 Ω
E'= 96V
R3
16 Ω
RL
E
− +
20 V

R_{TH}



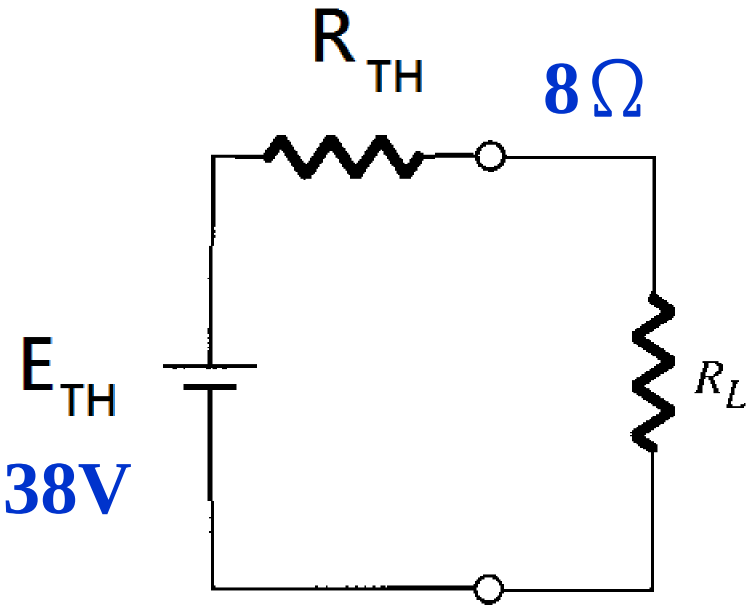
$$R_{TH} = (12\Omega + R_2) // R_3 = 8\Omega$$

E_{TH}



$$E_{TH} = (E' - E) \times \frac{R_3}{12\Omega + R_2 + R_3} = 38V$$

Thévenin Network



當$R_L = R_{TH} = 8\Omega$

$$P_{max} = \frac{E_{TH}^2}{4R_L} = \frac{E_{TH}^2}{4R_{TH}} = 45.125W$$

Exercise 23 Δ-Y Conversion

23. Determine the total resistance of the network in Fig. 3.91.

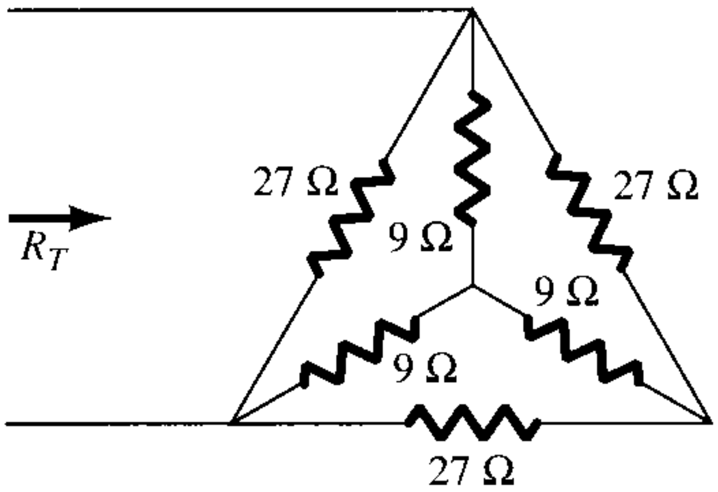
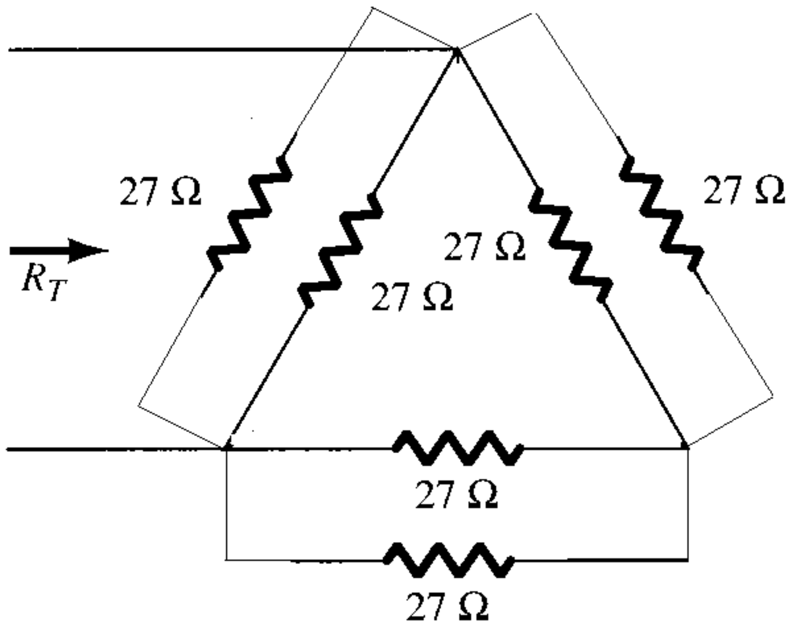
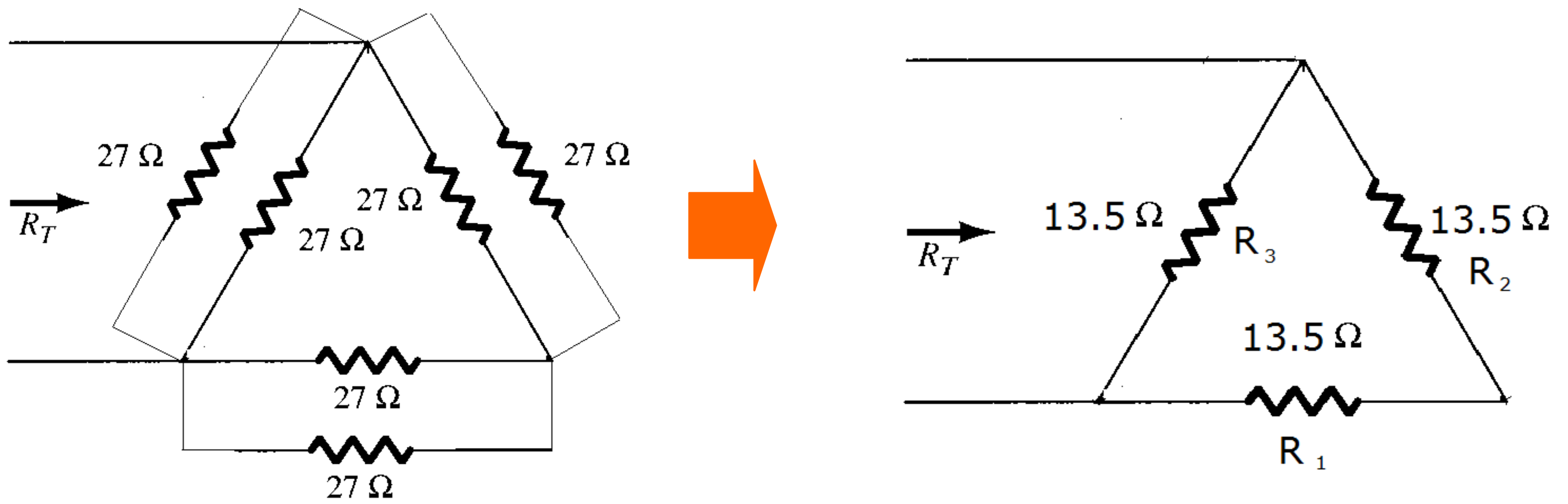


FIG. 3.91



將內部的Y型轉換成Δ型

Exercise 23 Δ-Y Conversion



Δ型的並聯的branch先行並聯，

然後R_1與R_2串聯，再與R_3並聯。

$$R_T = (R_1 + R_2) // R_3 = 9\Omega$$

Exercise 24 △-Y Conversion

24. Calculate the total resistance of the network in Fig. 3.92.

因為 $\dfrac{R_1}{R_2} = \dfrac{R_3}{R_4}$

，R_5去除與否，並不影響總電阻與電流。

$$R_T = (R_1 + R_2)//(R_3 + R_4) = 14.4\Omega$$

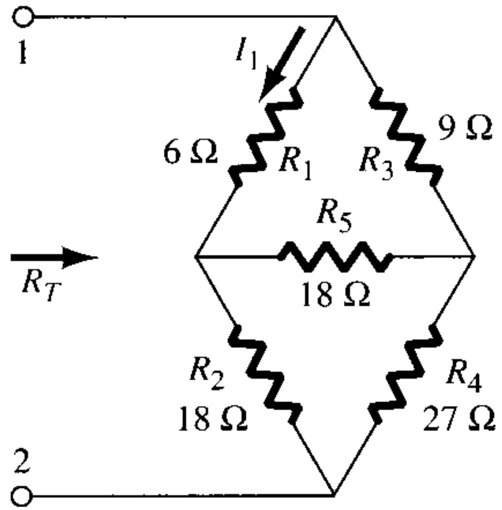


FIG. 3.92

Exercise 25 Δ-Y Conversion

25. Is the bridge in Problem 24 balanced? Balanced or not, find the current I_1 with 30 V applied between points 1 and 2.

因為 $\frac{R_1}{R_2} = \frac{R_3}{R_4}$ （**balanced**）

$$I = \frac{30V}{R_1 + R_2} = 1.25A$$

Exercise 26 Δ-Y Conversion

26. **a.** If $R_1 = 10\ \Omega$, $R_2 = 40\ \Omega$, $R_3 = 4\ \Omega$, $R_4 = 16\ \Omega$, and $R_5 = 18\ \Omega$ in Fig. 3.92, is the bridge balanced?

b. If 20 V is applied to points 1 and 2, determine the current through R_4 [for the values in part (a)].

c. With the 20 V applied, determine the current through R_1 [for the values of part (a)].

a. $$\frac{R_1}{R_2} = \frac{R_3}{R_4}$$ (**balanced**)

b. $$I = \frac{20V}{R_3 + R_4} = 1A$$

c. $$I = \frac{20V}{R_1 + R_2} = 0.4A$$

Exercise 27 Capacitor

27. If 3600 μC of charge is deposited on the plates of a capacitor having a potential drop of 120 V across the plates, determine the capacitance of the capacitor.

$$C = \frac{Q}{V} = \frac{3600\mu C}{120V} = 30\mu F$$

Exercise 28 Capacitor

28. For the network in Fig. 3.93:

a. Determine the time constant of the network.

b. For the charging phase, write the mathematical expression for the current i_C and voltages v_C and v_R.

c. Sketch the waveform of each quantity in part (b).

d. What is i_C in magnitude after one time constant?

e. At what instant of time will $v_C = 50$ V?

f. Find the energy stored by the capacitor at steady state.

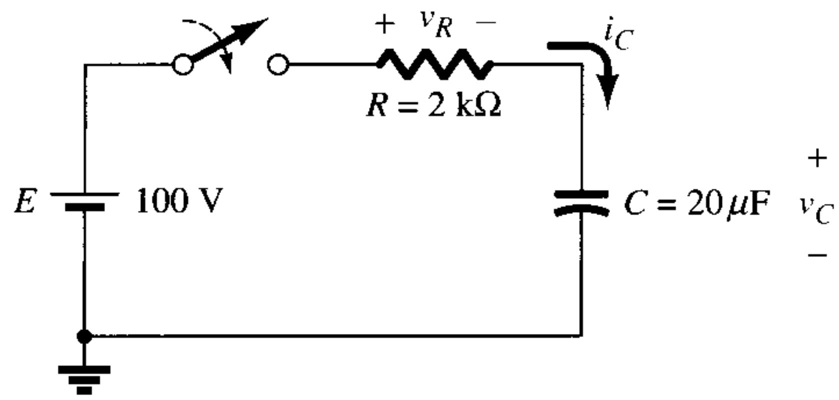


FIG. 3.93

Exercise 28 Capacitor

a. Time constant $\tau = RC = (2k\Omega)(20\mu F) = 40ms$

b. $v_c = E(1-e^{-t/\tau}) = 100V(1-e^{-t/40ms})$

$$i_c = \frac{E}{R}(e^{-t/\tau}) = 50mA \cdot e^{-t/40ms}$$

d. 當 t = τ 時，即 t = 40 ms時

$$i_c = 50mA \cdot e^{-1} = 18.4mA$$

Exercise 28 Capacitor

e. $t = ?$ $v_c = 50\ V$

$$v_c = 50V = 100V(1 - e^{-t/40ms})$$

$$t = 27.73ms$$

f. 到達steady state時，$v_c = 100\ V$

$$W_c = \frac{1}{2}Cv_c^{\ 2} = \frac{1}{2}(20\mu F)(100V)^2 = 100mJ$$

Exercise 29 Capacitor

29. Find the capacitance of a capacitor having $2 \times 10^{-4}\ \mathrm{m}^2$ plates, a dielectric of mica, and a *d* (distance between plates) of 50 μm.

$$C = \varepsilon_0 \varepsilon_r \frac{A}{d}$$

$$= (8.85 \times 10^{-12}\ \mathrm{F/m})(5) \frac{2 \times 10^{-4}\ \mathrm{m}^2}{50 \times 10^{-6}\ \mathrm{m}}$$

$$= 177\ \mathrm{pF}$$

Exercise 30 Capacitor

30. a. Find the total capacitance of four 10-μF capacitors in series.

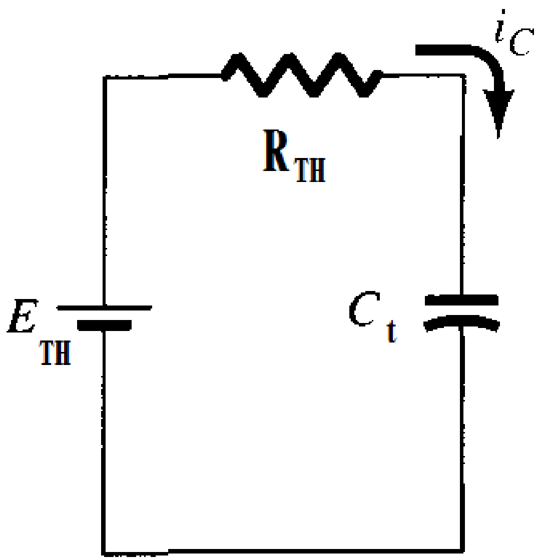
b. Repeat part (a) for capacitors in parallel.

a. 四個電容串聯 total capacitors = 2.5 μF

b.四個電容並聯 total capacitors = 40 μF

Exercise 31 Capacitor

31. a. Find the expression for v_C in the network in Fig. 3.94 following the closing of the switch.
b. Sketch the waveform of i_C.



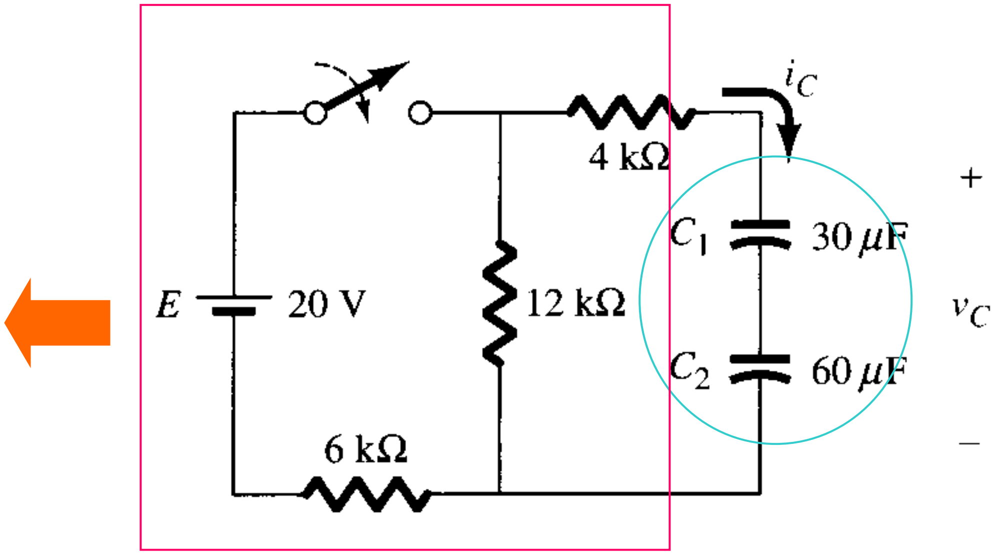
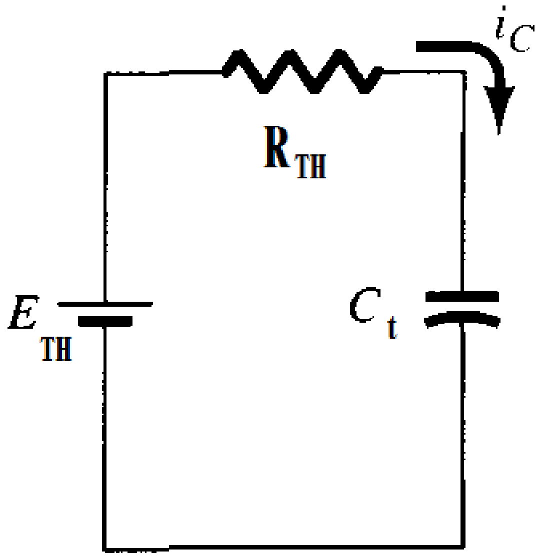


FIG. 3.94

C_1與C_2串聯$C_t = C_1 // C_2 = 20\ \mu F$

Exercise 31 Capacitor



$$R_{TH} = (R_1 // R_2) + R_3 = 8k\Omega$$

$$E_{TH} = E \times \frac{R_2}{R_1 + R_2} = 13.33V$$

$$\tau = R_{TH} \cdot C_t = (8k\Omega)(20\mu F) = 0.16s$$

$$v_c = E_{TH}(1 - e^{-t/\tau}) = 13.33V(1 - e^{-t/0.16s})$$

Exercise 32 Capacitor

32. Determine the waveform for the current i_C of a 2-μF capacitor for the applied voltage v_C in Fig. 3.95.

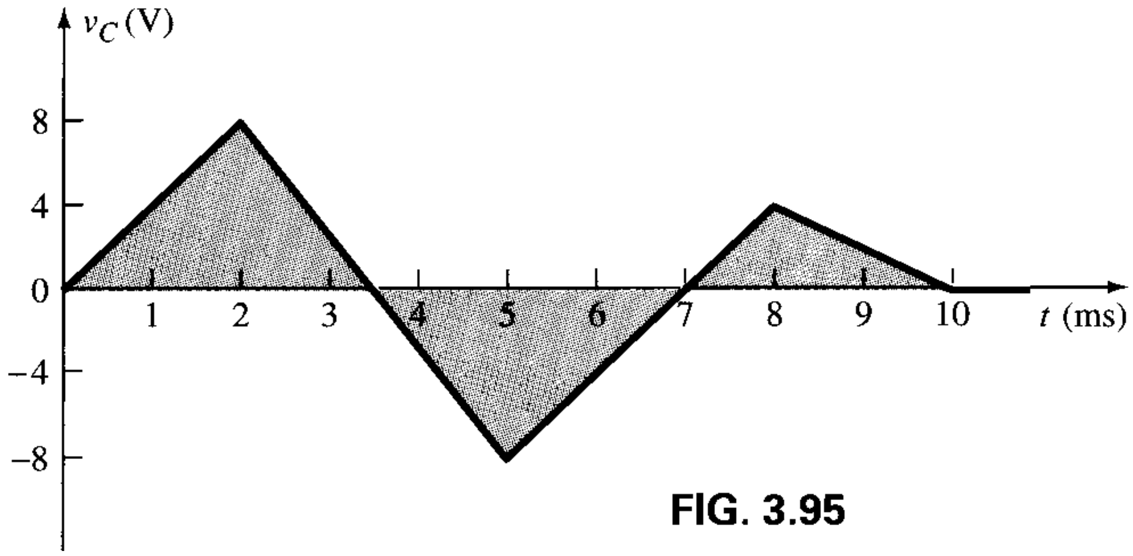


FIG. 3.95

$$i_c = C\frac{dv_c}{dt} \approx C\frac{\Delta v_c}{\Delta t}$$

Exercise 32 Capacitor

$$i_c = C\frac{dv_c}{dt} \approx C\frac{\Delta v_c}{\Delta t}$$

$0 \rightarrow 2ms$

$$i_c = (2\mu F)\frac{8V}{2ms} = +8mA$$

$2 \rightarrow 5ms$

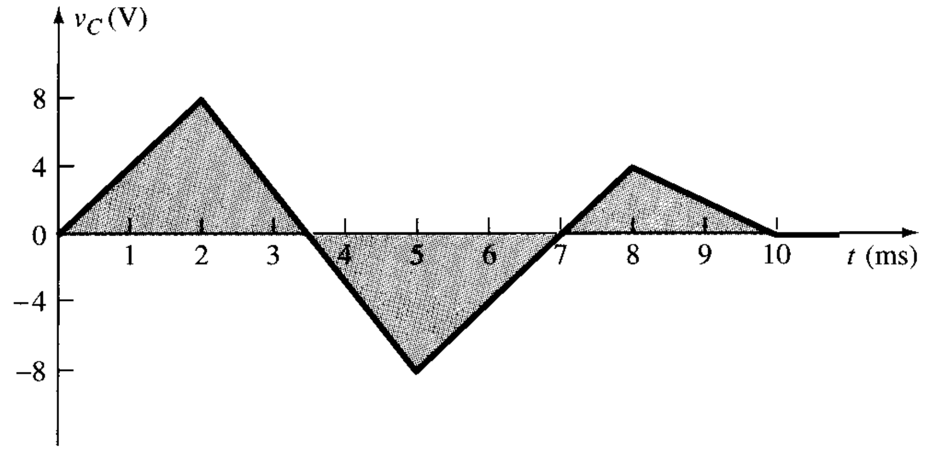
$$i_c = (2\mu F)\frac{-16V}{3ms} = -10.67mA$$

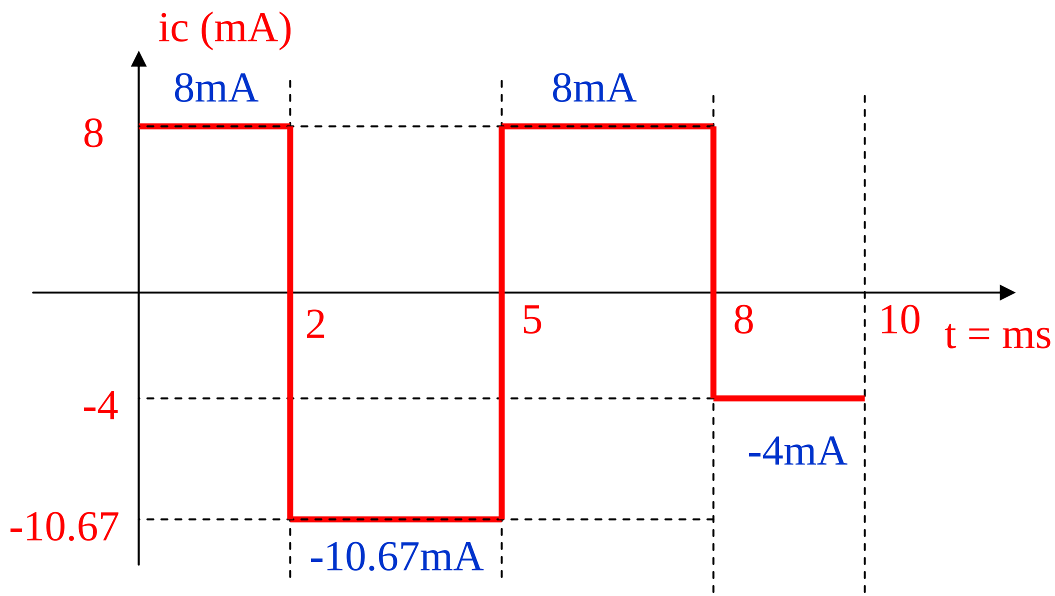
$5 \rightarrow 8ms$

$$i_c = (2\mu F)\frac{12V}{3ms} = +8mA$$

$8 \rightarrow 10ms$

$$i_c = (2\mu F)\frac{-4V}{2ms} = -4mA$$





Exercise 33 Inductor

33. For the network in Fig. 3.96:

a. Determine the time constant.

b. Determine the mathematical expressions for i_L, v_L, and v_R during the charging phase.

c. Sketch the waveforms for part (b).

d. What is the magnitude of v_R after one time constant?

e. At what instant will $i_L = 2$ mA?

f. Find the energy stored by the inductor.

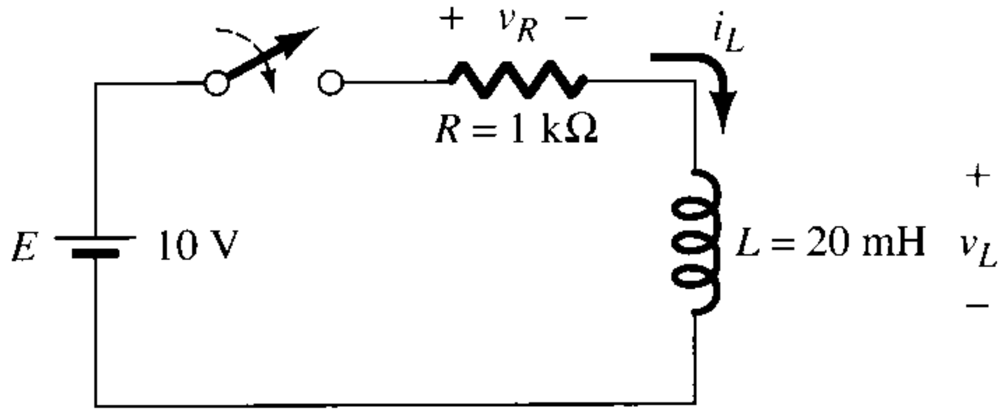


FIG. 3.96

Exercise 33 Inductor

a. Time constant $\tau = \frac{L}{R} = \frac{200mH}{1k\Omega} = 20\mu s$

b. $i_L = \frac{E}{R}(1 - e^{-t/\tau}) = 10mA(1 - e^{-t/20\mu s})$

$v_L = E(e^{-t/\tau}) = 10V \cdot e^{-t/20\mu s}$

$v_R = i_L \cdot R = 10V(1 - e^{-t/20\mu s})$

d.當 t = τ時，即 t = 20 μs時

$v_R = 10V \cdot 0.632 = 6.32V$

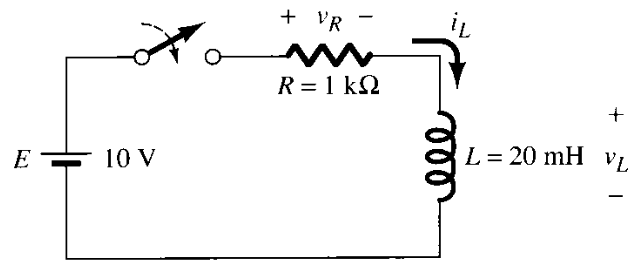


FIG. 3.96

Exercise 33 Inductor

e. $t = ?$ $i_L = 2\text{ mA}$

$$i_L = 2\text{mA} = 10\text{mA}(1 - e^{-t/20\mu s})$$

$$t = 4.46\mu s$$

f. 到達steady state時，$i_L = 10\text{mA}$

$$W_L = \frac{1}{2} L {i_L}^2 = 1\mu J$$

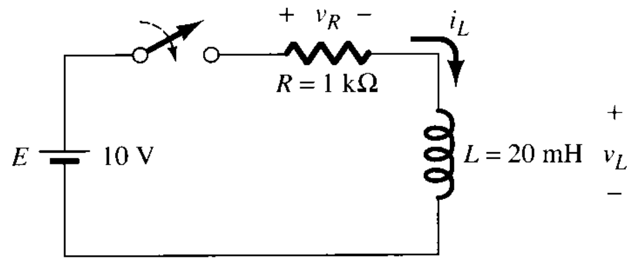


FIG. 3.96

Exercise 34 Inductor

34. Determine the inductance of an inductor with 250 turns, $\mu_r = 2000$, area $= 1.5 \times 10^{-4}$ m^2, and $l = 50$ mm.

$$\mu = \mu_r \mu_0 = (2000)(4\pi \times 10^{-7} \mathrm{Wb/A \cdot m})$$

$$= 25133 \times 10^{-7} \mathrm{Wb/A \cdot m}$$

$$L = \frac{N^2 \mu A}{\ell} = 471.24 \mathrm{mH}$$

Exercise 35 Inductor

35. a. Determine the total inductance of two series coils with values of 10 mH and 90 mH.

b. Repeat part (a) for the coils in parallel.

a. 二個電感串聯 total inductance = 100 mH

b. 二個電感並聯 total inductance = 9 mH

Exercise 36 Inductor[1]

36. **a.** Determine the expression for i_L when the switch is closed in Fig. 3.97.

b. Repeat part (a) for v_L.

並聯 $L_T = 5$ mH

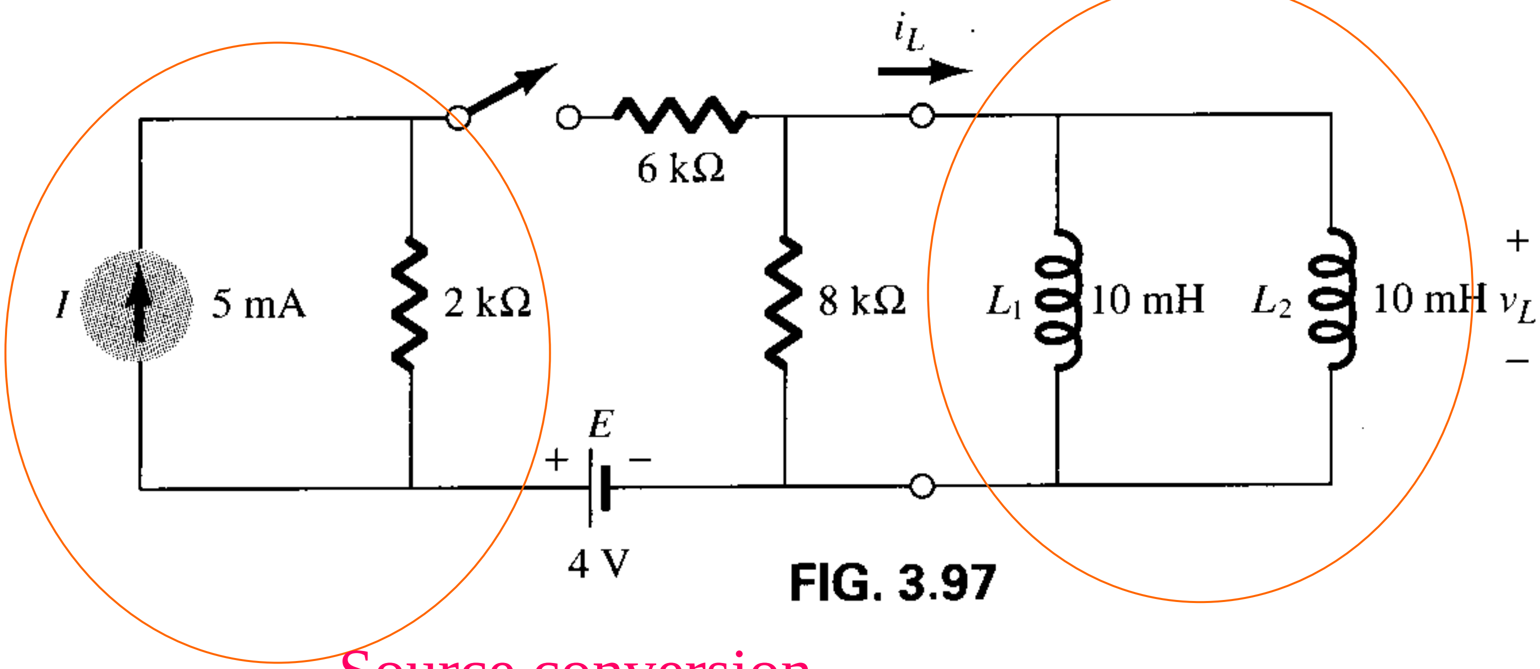


FIG. 3.97

Source conversion

Exercise 36 Inductor[2]

並聯 $L_T = 5$ mH

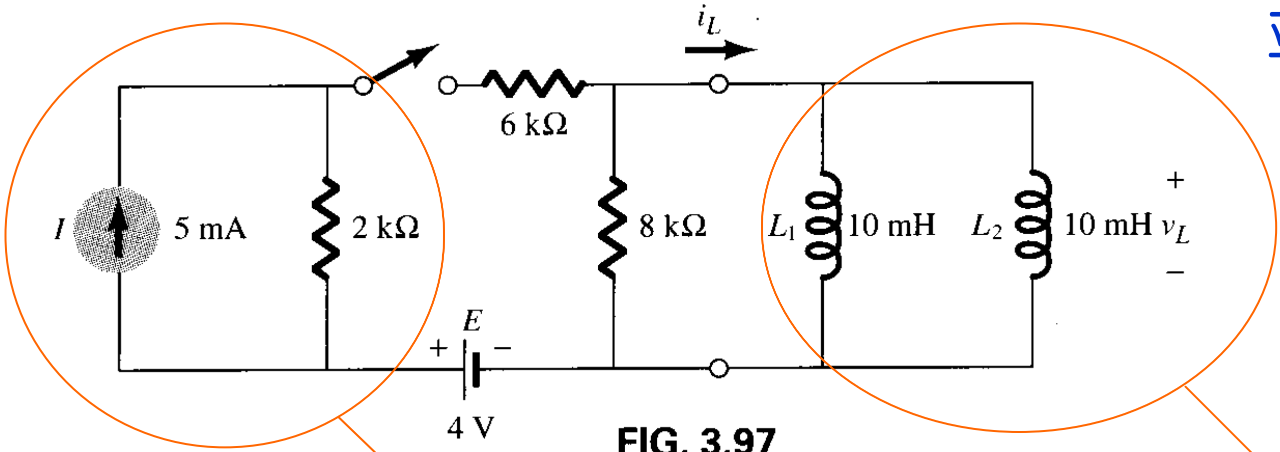
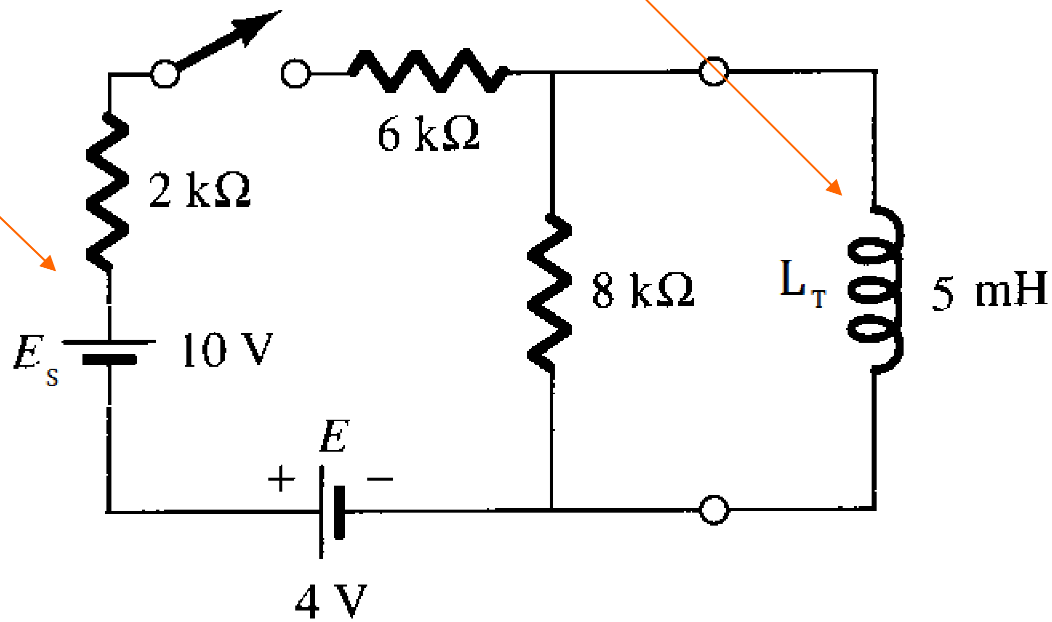
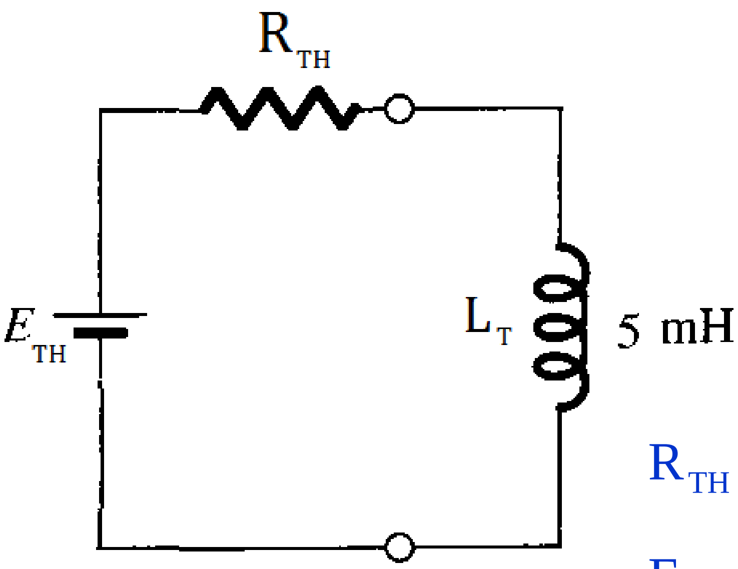


FIG. 3.97

Source conversion



Exercise 36 Inductor[3]



$$R_{TH} = (2k\Omega + 6k\Omega) // 8k\Omega = 4k\Omega$$

$$E_{TH} = (4V + 10V) \times \frac{8k\Omega}{2k\Omega + 6k\Omega + 8k\Omega} = 7V$$

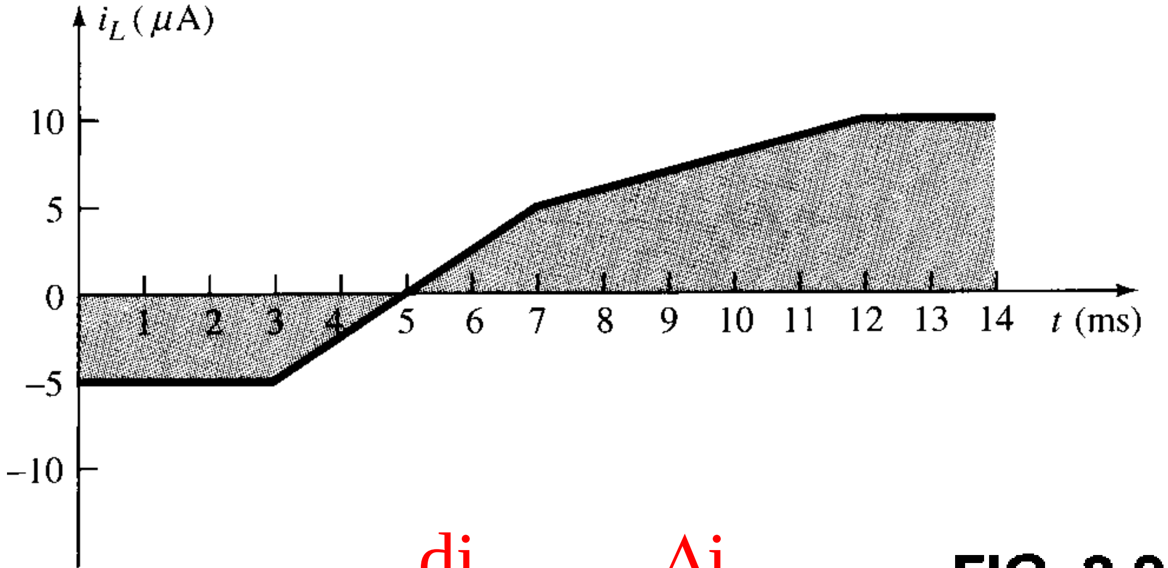
$$\tau = \frac{L}{R_{TH}} = \frac{5mH}{4k\Omega} = 1.25\mu s$$

$$i_L = \frac{E_{TH}}{R_{TH}}(1 - e^{-t/\tau}) = 1.75mA(1 - e^{-t/1.25\mu s})$$

$$v_L = E_{TH}e^{-t/\tau} = 7Ve^{-t/1.25\mu s}$$

Exercise 37 Inductor

37. Determine the waveform for the voltage v_L of a 0.5-H inductor for the current i_L in Fig. 3.98.



$$v_L = L\frac{di_L}{dt} \approx L\frac{\Delta i_L}{\Delta t}$$

FIG. 3.98

Exercise 37 Inductor

$$v_L = L\frac{di_L}{dt} \approx L\frac{\Delta i_L}{\Delta t}$$

$0 \rightarrow 3ms$

$$v_L = 0V$$

$3 \rightarrow 7ms$

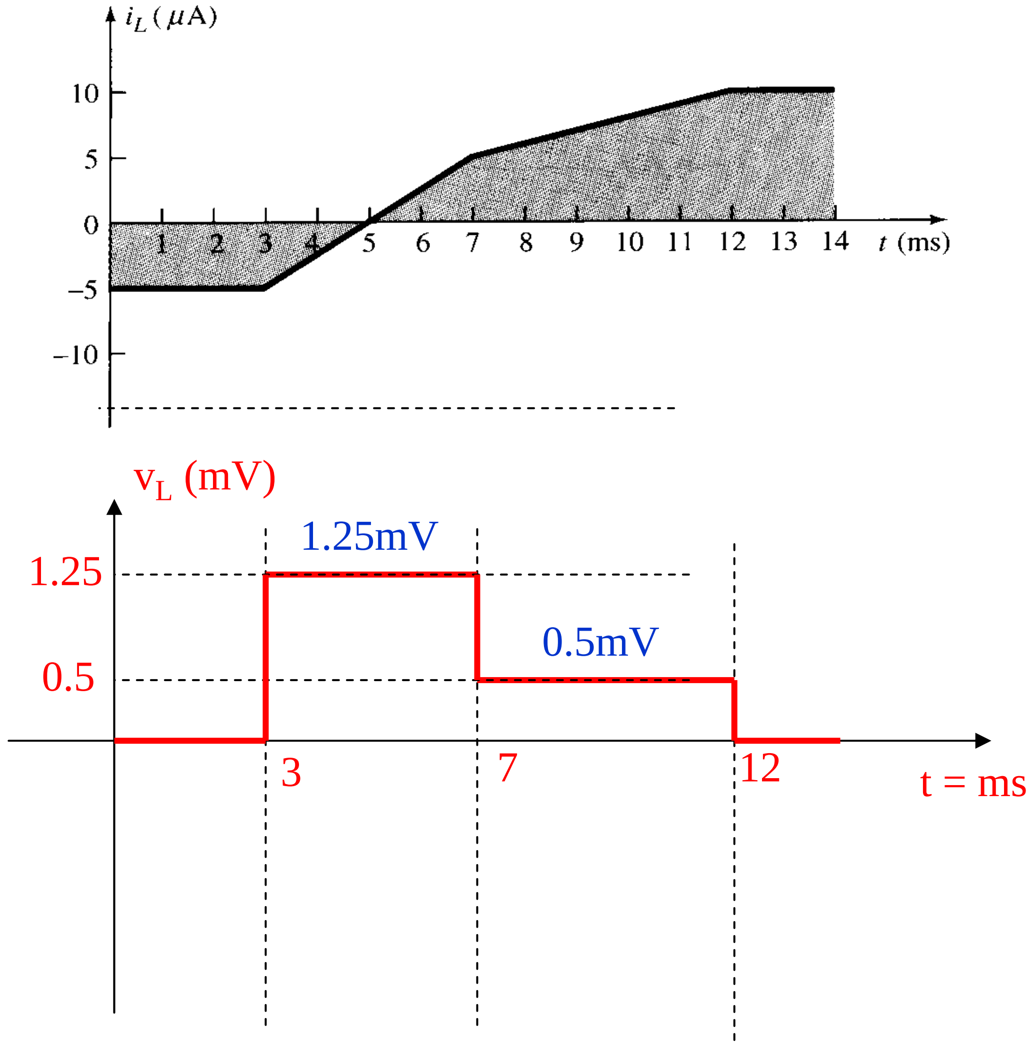
$$v_L = (0.5H)\frac{10\mu A}{4ms} = 1.25mV$$

$7 \rightarrow 12ms$

$$v_L = (0.5H)\frac{5\mu A}{5ms} = 0.5mV$$

$12 \rightarrow$

$$v_L = 0V$$



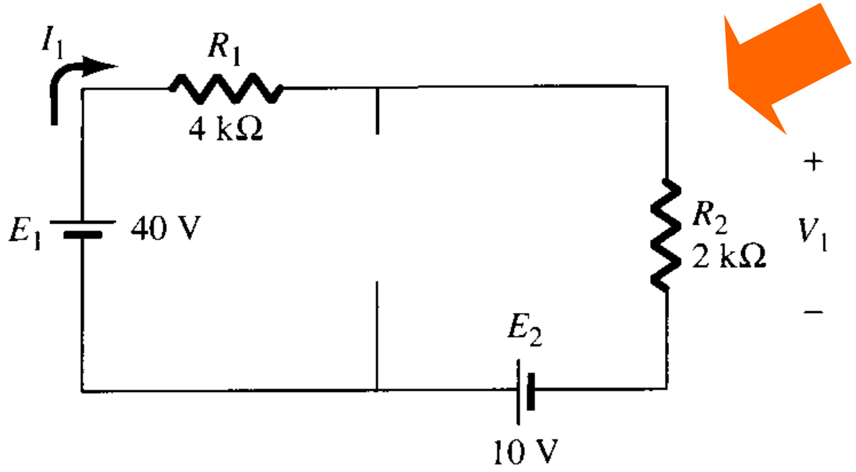
Exercise 38 Inductor

38. **a.** Determine I_1 and V_1 for the network in Fig. 3.99 under steady-state conditions.

b. Find V_C and I_L (steady state).

c. Determine the energy stored by L and C.

Steady state下，C斷路，L短路。電路形同一簡單的串聯電路。



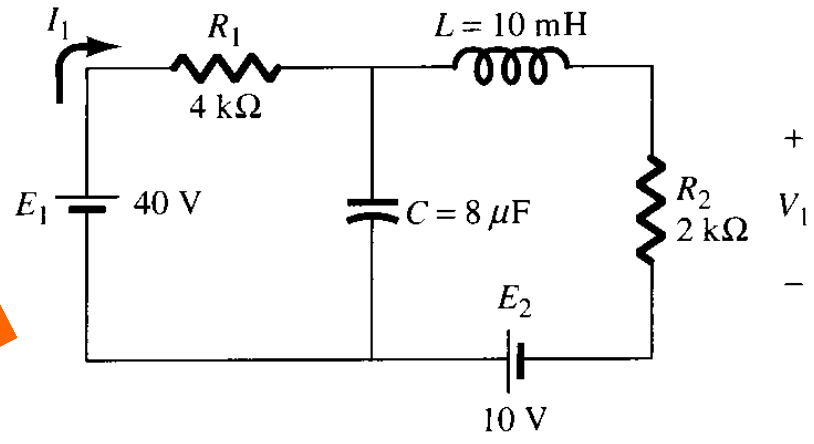
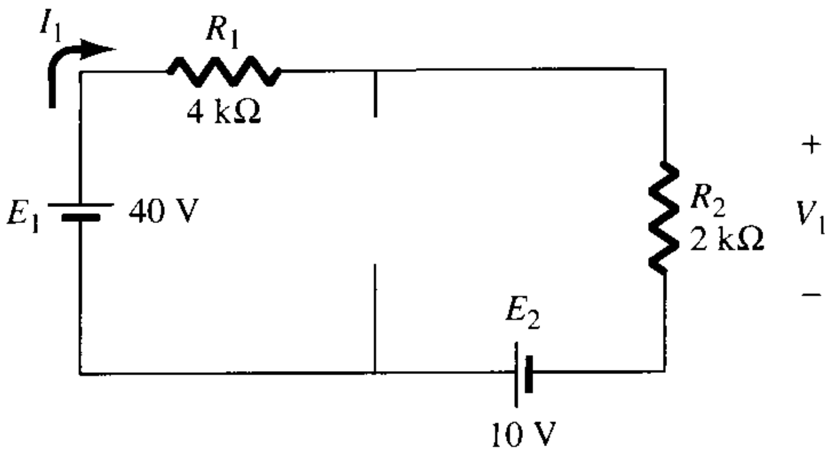


FIG. 3.99

Exercise 38 Inductor



$$I_1 = \frac{E_1 + E_2}{R_1 + R_2} = 8.33\text{mA}$$

$$V_1 = I_1 \cdot R_1 = 16.67\text{V}$$

$$V_c = E_1 - I_1 \cdot R_1 = 6.67\text{V}$$

$$W_C = \frac{1}{2} C V_C{}^2 = 177.96\mu\text{J}$$

$$W_L = \frac{1}{2} L i_L{}^2 = 0.347\mu\text{J}$$