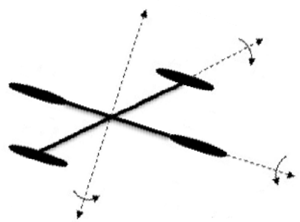
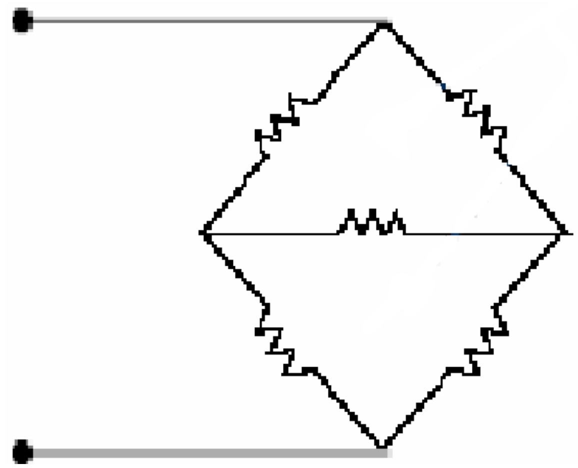
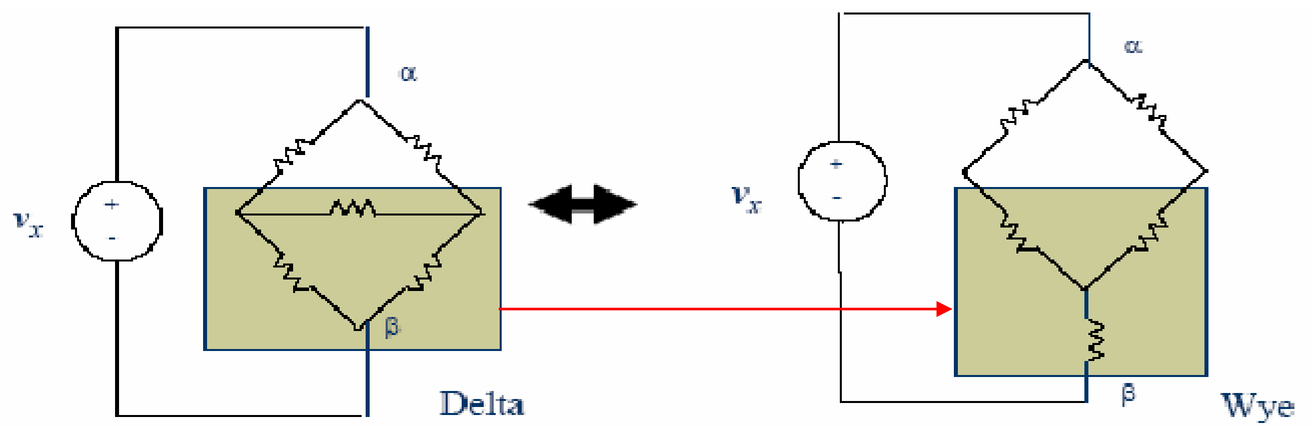
회 로 이 론

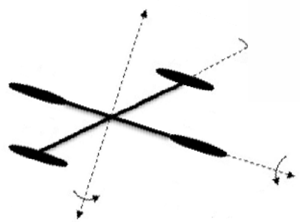
저항의 연결 보강자료

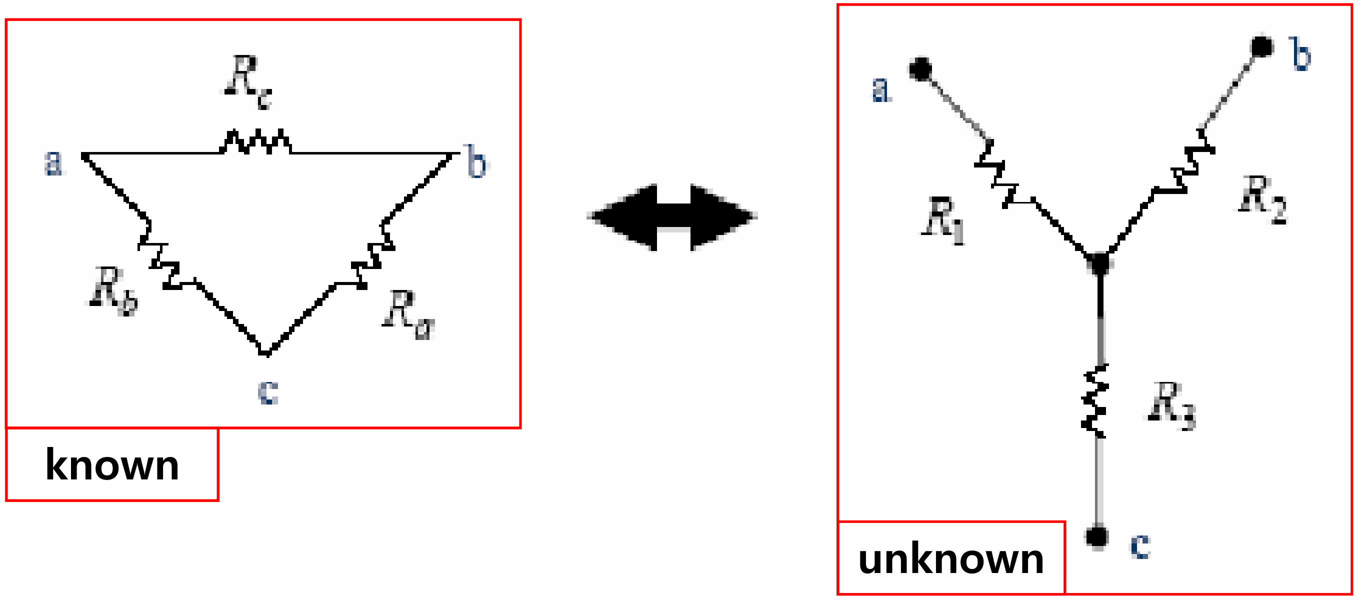


- Delta – Y 등가 회로







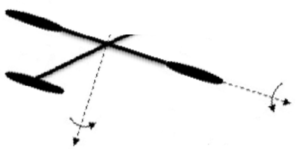


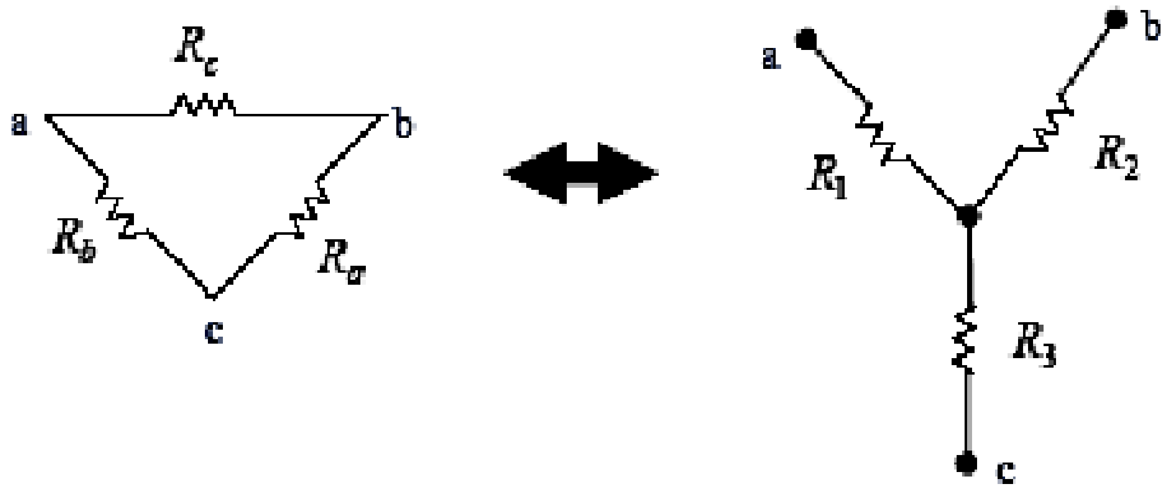
$$R_{ab} = R_{ab}$$

$$R_c \parallel (R_a + R_b) = R_1 + R_2$$

$$\frac{R_c(R_a + R_b)}{R_c + R_a + R_b} = R_1 + R_2$$

$$\frac{R_a R_c + R_b R_c}{R_a + R_b + R_c} = R_1 + R_2 \quad (\text{Eq}\,1)$$

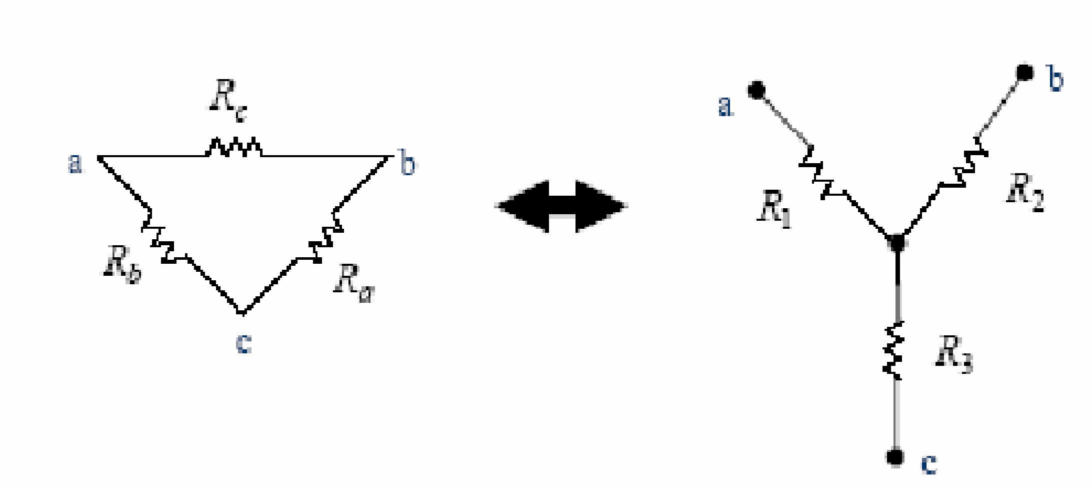




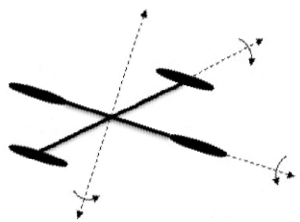
$$R_{ac} = R_{ac} \qquad\qquad R_{cb} = R_{cb}$$

$$\frac{R_b(R_a + R_c)}{R_a + R_b + Rc} = R_1 + R_3 \qquad\qquad \frac{R_a(R_b + R_c)}{R_a + R_b + Rc} = R_2 + R_3$$

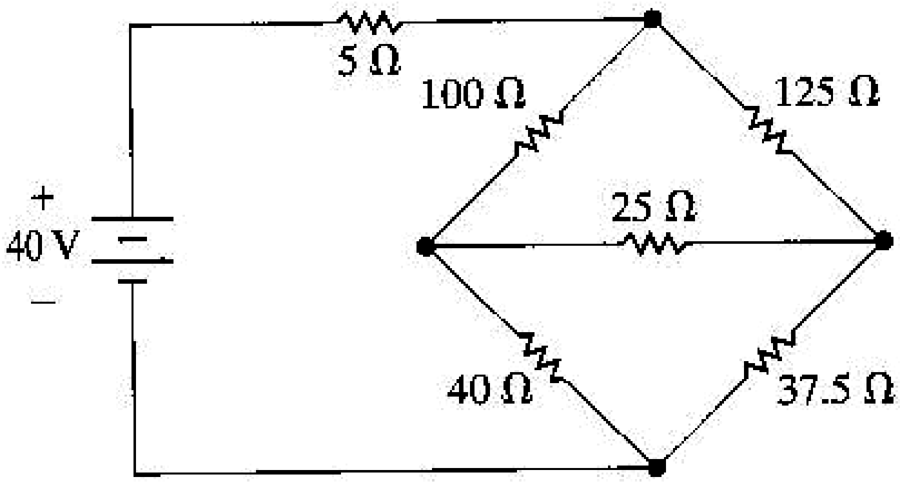
$$\frac{R_aR_b + R_bR_c}{R_a + R_b + R_c} = R_1 + R_3 \text{ (Eq 2)} \qquad\qquad \frac{R_aR_b + R_aR_c}{R_a + R_b + R_c} = R_2 + R_3 \text{ (Eq 3)}$$

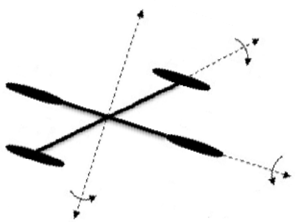


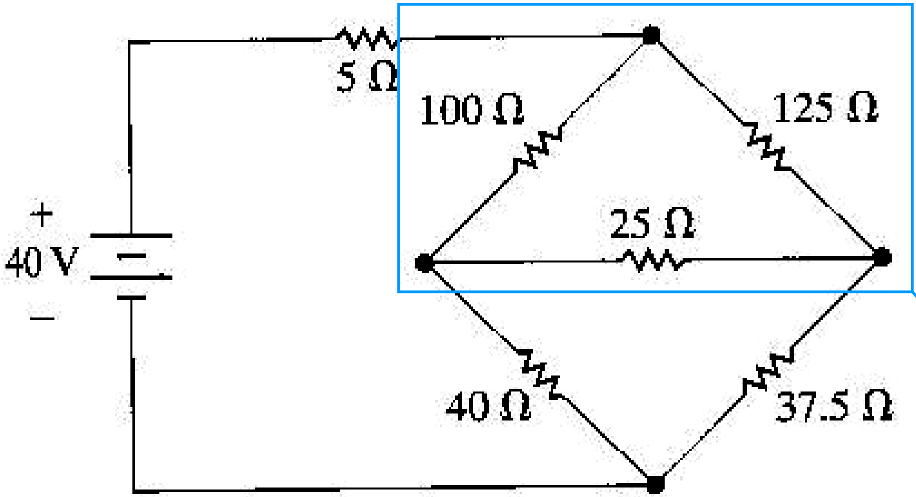
$$R_1 = \frac{R_b R_c}{R_a + R_b + R_c}, \quad R_2 = \frac{R_a R_c}{R_a + R_b + R_c}, \quad R_3 = \frac{R_a R_b}{R_a + R_b + R_c}$$

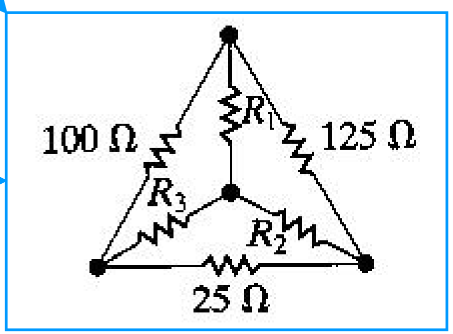


- Ex) 다음 회로에서 40V전원에 의해 공급된 전류와 전력을 구하라.







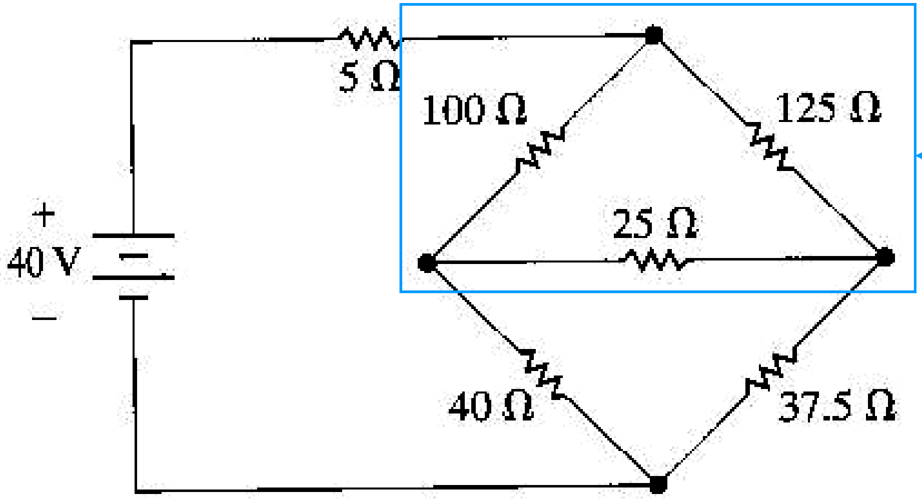


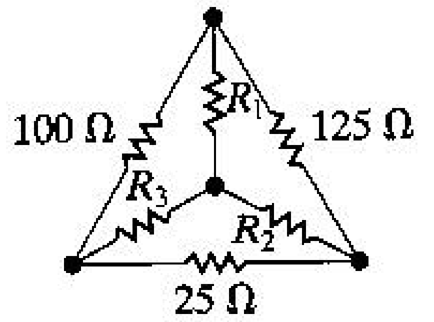
$$R_1 = \frac{R_b R_c}{R_a + R_b + R_c}, \quad R_2 = \frac{R_a R_c}{R_a + R_b + R_c}, \quad R_3 = \frac{R_a R_b}{R_a + R_b + R_c}$$

$$R_1 = \frac{100 \times 125}{250} = 50\ \Omega$$

$$R_2 = \frac{125 \times 25}{250} = 12.5\ \Omega$$

$$R_3 = \frac{100 \times 25}{250} = 10\ \Omega$$

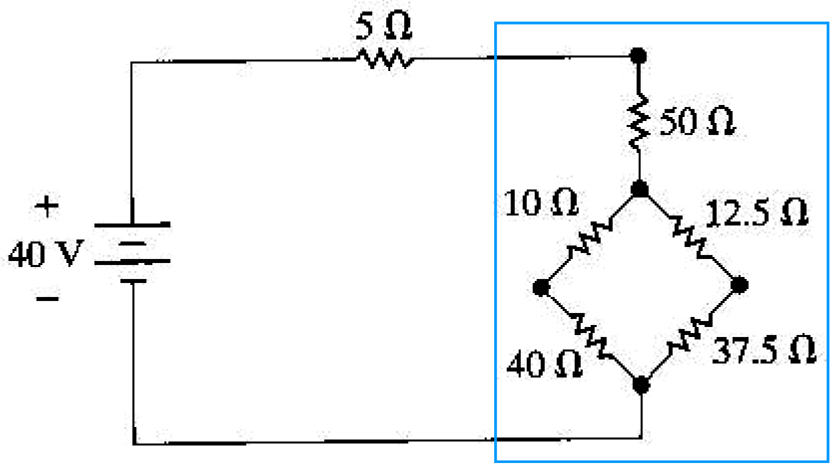


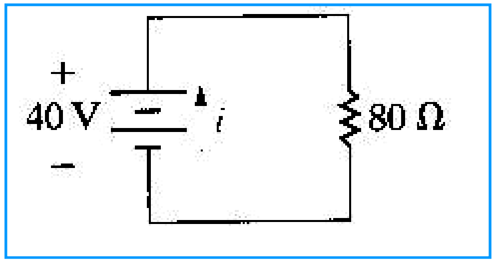


$$R_1 = \frac{100 \times 125}{250} = 50\ \Omega$$

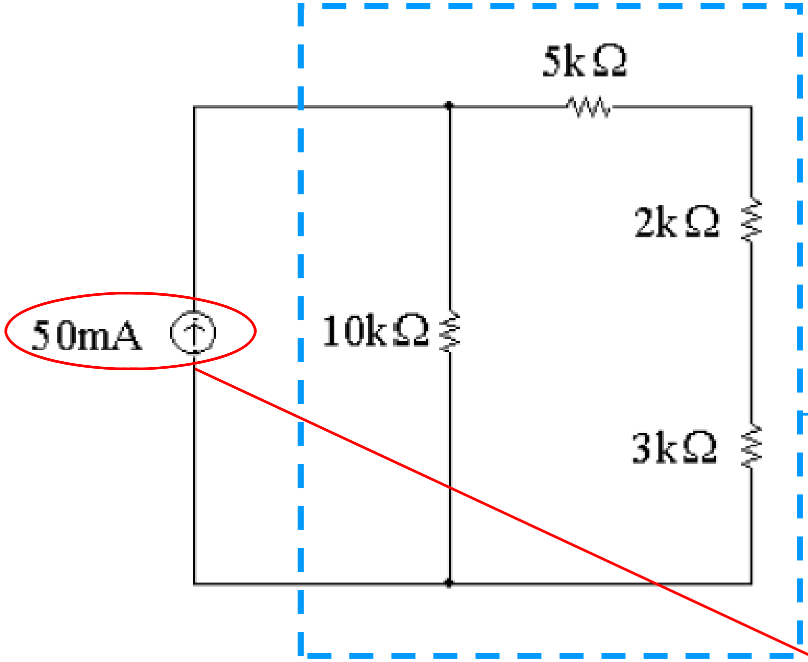
$$R_2 = \frac{125 \times 25}{250} = 12.5\ \Omega$$

$$R_3 = \frac{100 \times 25}{250} = 10\ \Omega$$



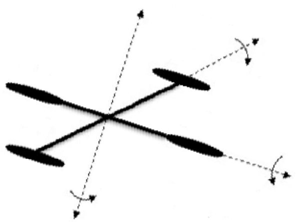


- Ex) 전체등가 저항을 구하고, 전류원에 인가되는 전압을 구하라.

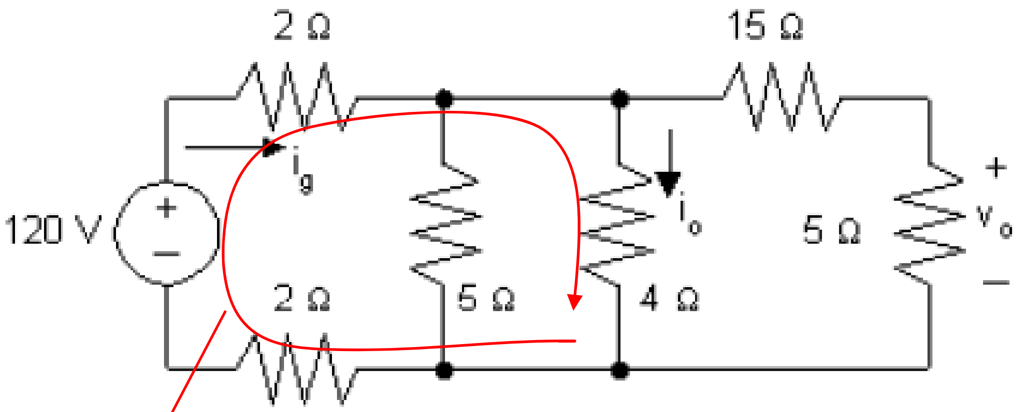


$$10k \| (5k + 2k + 3k) = 10k \| 10k = \frac{1}{\frac{1}{10k} + \frac{1}{10k}} = 5k$$

$$v = iR = 50m \times 5k = 250V$$



- Ex)



$$-120 + 2\times 20 + v_{4\Omega} + 2\times 20 = 0$$

$$R_{eq} = 2 + 2 + (1/4 + 1/5 + 1/20)^{-1} = 6\,\Omega$$

$$i_g = 120/6 = 20\text{ A}$$

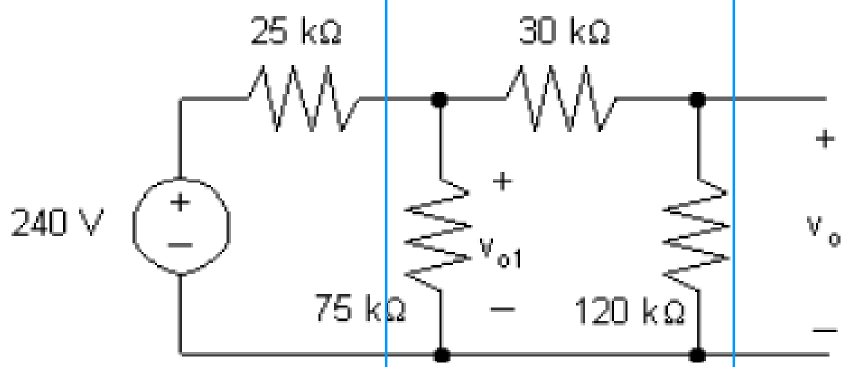
$$v_{4\Omega} = 120 - (2+2)20 = 40\text{ V}$$

$$i_o = 40/4 = 10\text{ A}$$

$$i_{(15+5)\Omega} = 40/(15+5) = 2\text{ A}$$

$$v_o = (5)(2) = \boxed{10\text{ V}}$$

- Ex)



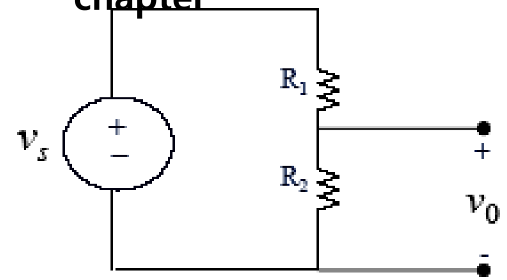
$$120\ \text{k}\Omega + 30\ \text{k}\Omega = 150\ \text{k}\Omega$$

$$75\ \text{k}\Omega \| 150\ \text{k}\Omega = 50\ \text{k}\Omega$$

$$v_{o1} = \frac{240}{(25{,}000 + 50{,}000)}(50{,}000) = 160\ \text{V}$$

$$v_o = \frac{120{,}000}{(150{,}000)}(v_{o1}) = 128\ \text{V}, \qquad v_o = 128\ \text{V}$$

In previous chapter



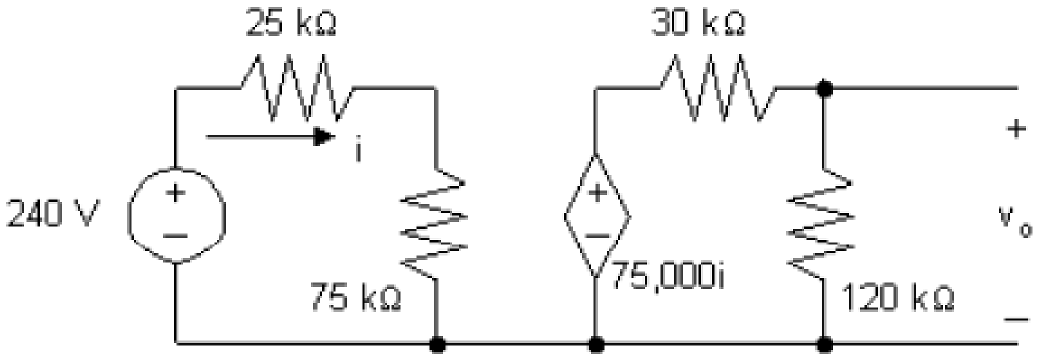
$$v_s = i(R_1 + R_2)$$

$$i = \frac{v_s}{R_1 + R_2}$$

$$v_o = iR_2$$

$$v_0 = \frac{R_2}{R_1 + R_2} v_s$$

- Ex)

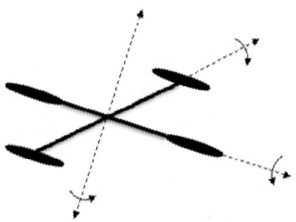


$$i = \frac{240}{100{,}000} = 2.4 \text{ mA}$$

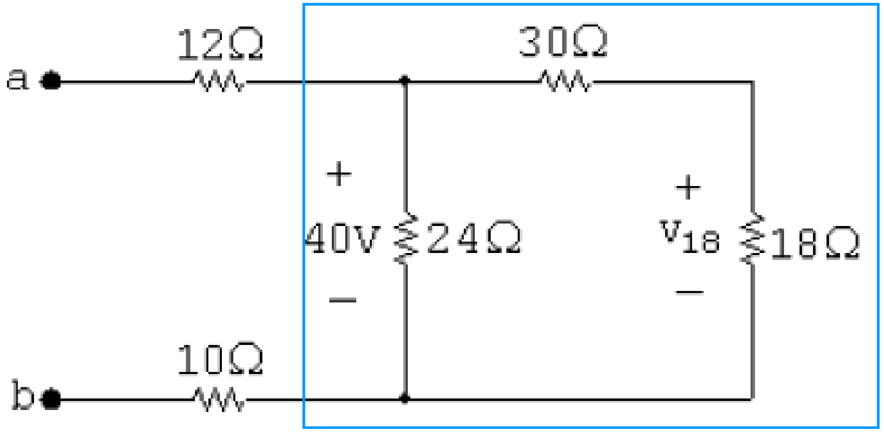
$$75{,}000i = 180 \text{ V}$$

$$v_o = \frac{120{,}000}{150{,}000}(180) = 144 \text{ V}; \qquad v_o = 144 \text{ V}$$

$$v_0 = \frac{R_2}{R_1 + R_2} v_s$$

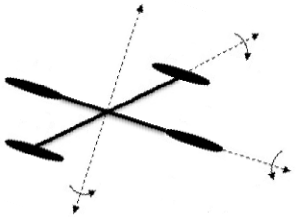


- Ex)

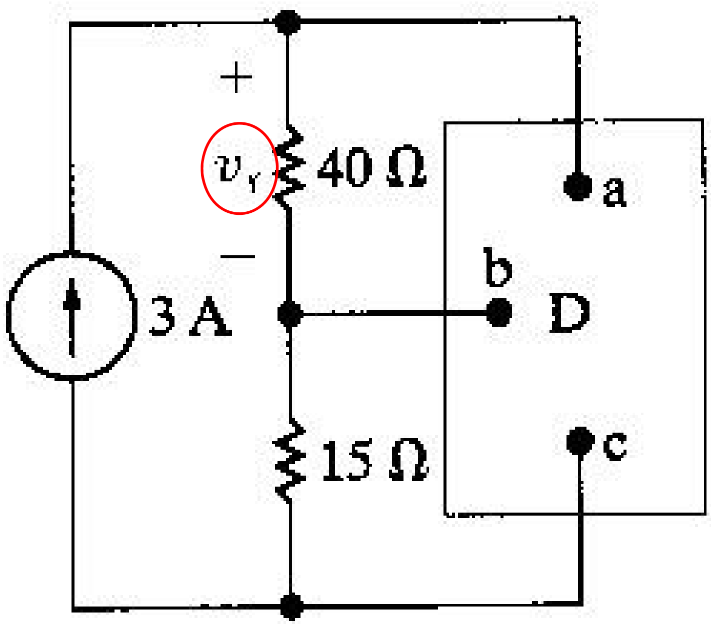


Using voltage division,

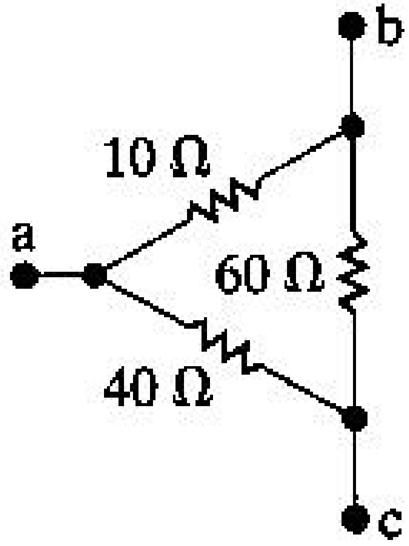
$$v_{18\Omega} = \frac{18}{18+30}(40) = 15 \text{ V positive at the top}$$



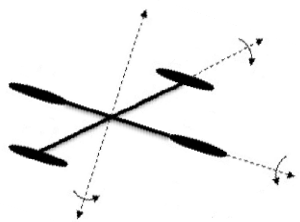
- Ex) 그림에 D표시가 있는 장치는 그림 (b)이다. 표시된 전압과 D장치가 소모한 전력을 구하라.

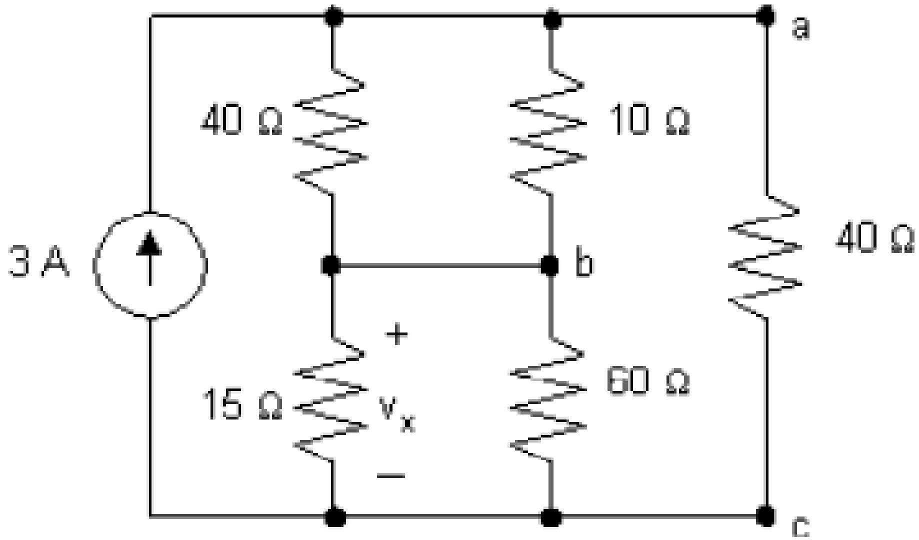


(a)

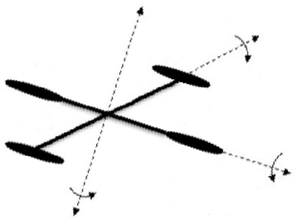


(b)

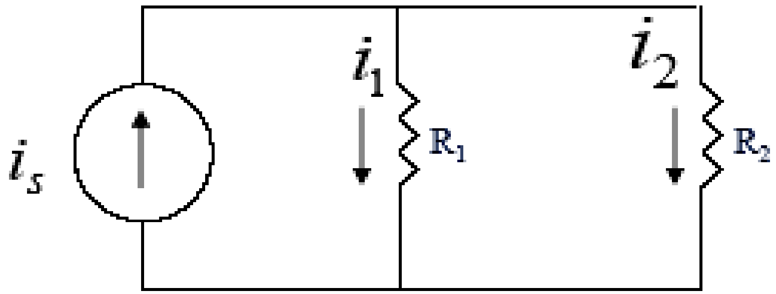




$$40 \| 10 = 8\,\Omega \qquad 15 \| 60 = 12\,\Omega$$



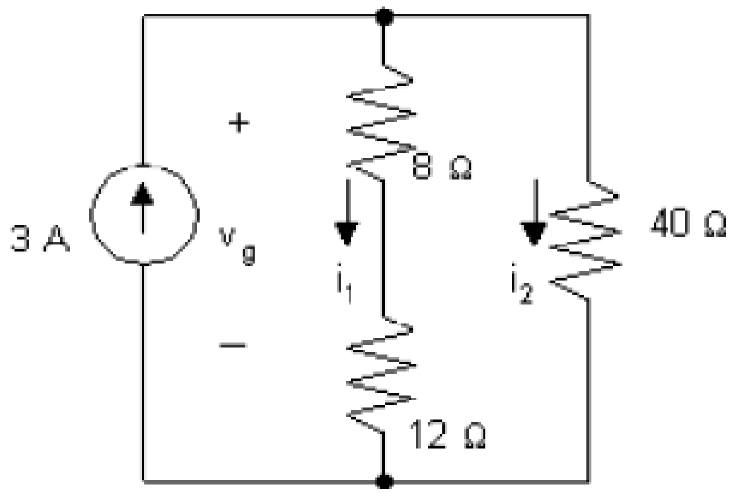
In previous chapter



$$i_1 R_1 = i_2 R_2 \Rightarrow i_1 = \frac{i_2 R_2}{R_1}$$

$$i_s = i_1 + i_2 = \frac{i_2 R_2}{R_1} + i_2 = \frac{i_2 R_2 + i_2 R_1}{R_1} = \frac{i_2 (R_2 + R_1)}{R_1}$$

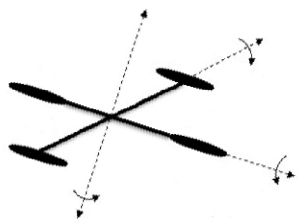
$$i_2 = \frac{R_1}{R_1 + R_2} i_s$$



$$i_1 = \frac{(3)(40)}{(60)} = 2\ \text{A}; \qquad v_x = 8i_1 = 16\ \text{V}$$

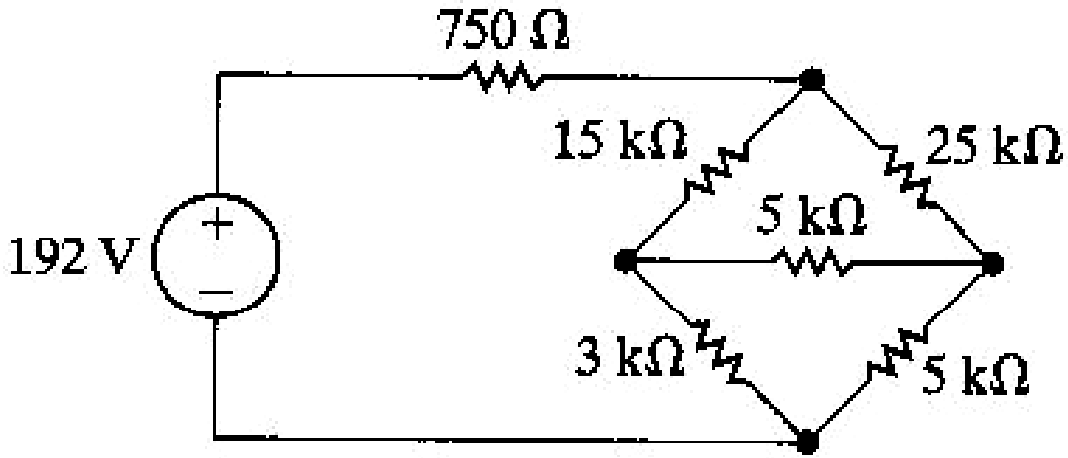
$$v_g = 20i_1 = 40\ \text{V}$$

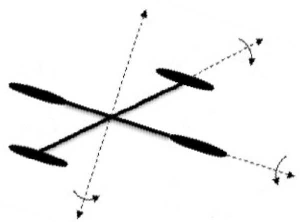
$$v_{60} = v_g - v_x = 24\ \text{V}$$



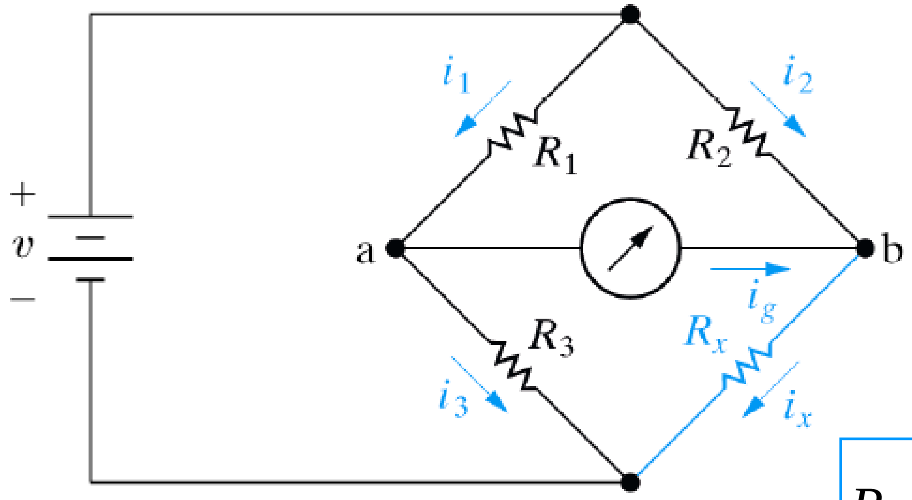
$$P_{\text{device}} = \frac{24^2}{60} + \frac{16^2}{10} + \frac{40^2}{40} = 75.2\ \text{W}$$

- Ex) 그림에서 5k저항에 흐르는 전류는 얼마인가?





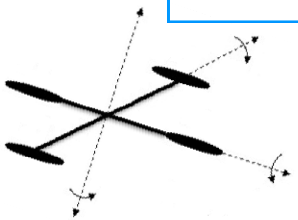
In previous chapter

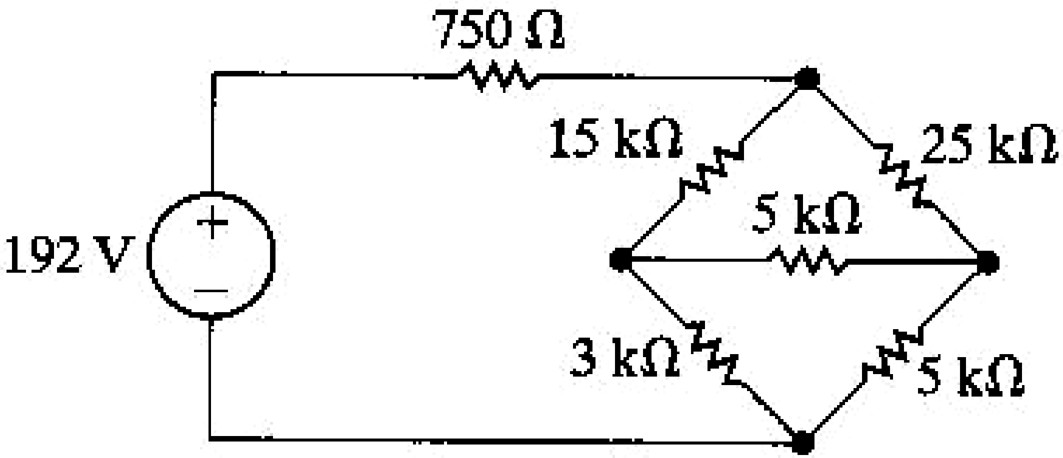


$$R_x = \frac{R_2}{R_1} R_3$$

Figure 3.27

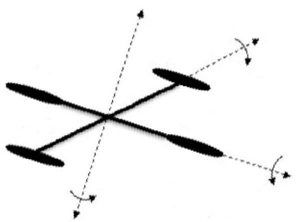
A balanced Wheatstone bridge ($i_g = 0$).



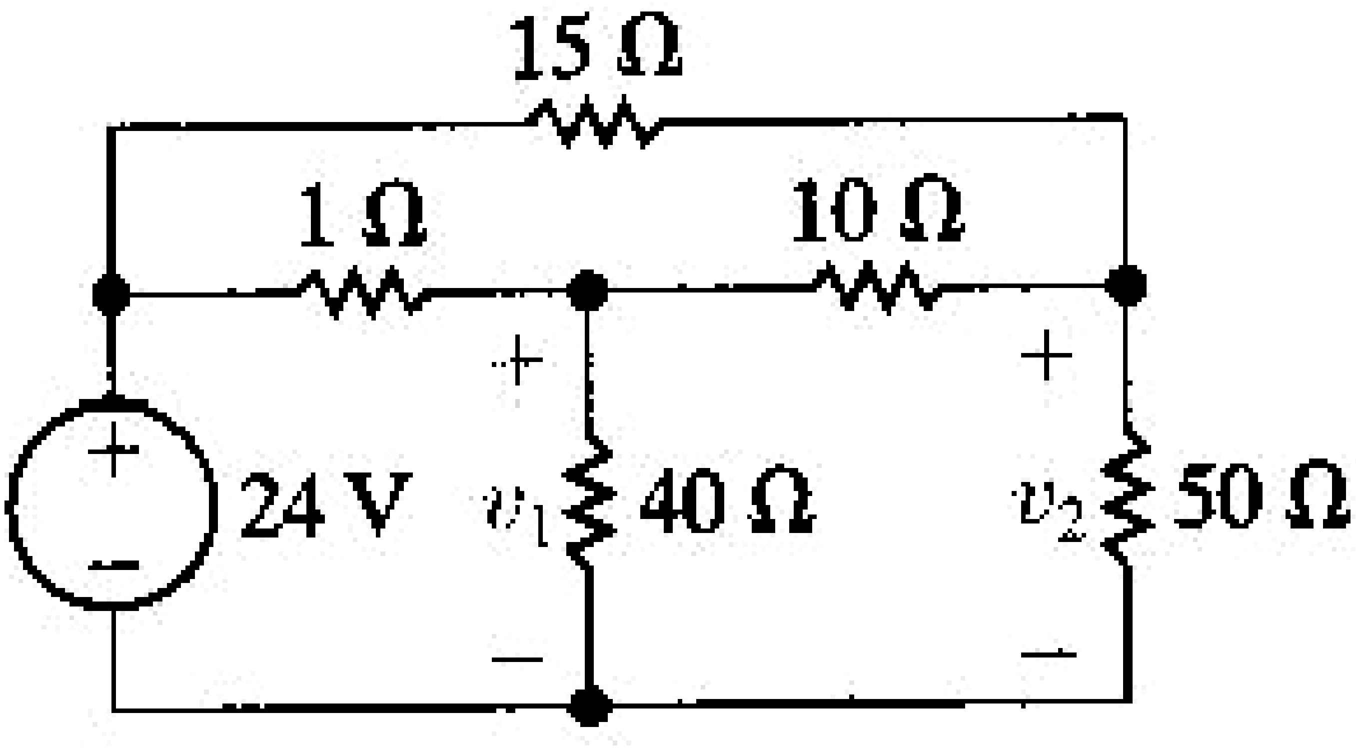


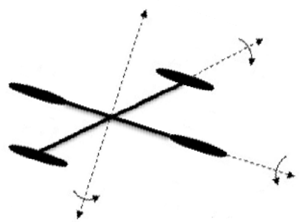
$$15 \times 5 = 3 \times 25$$

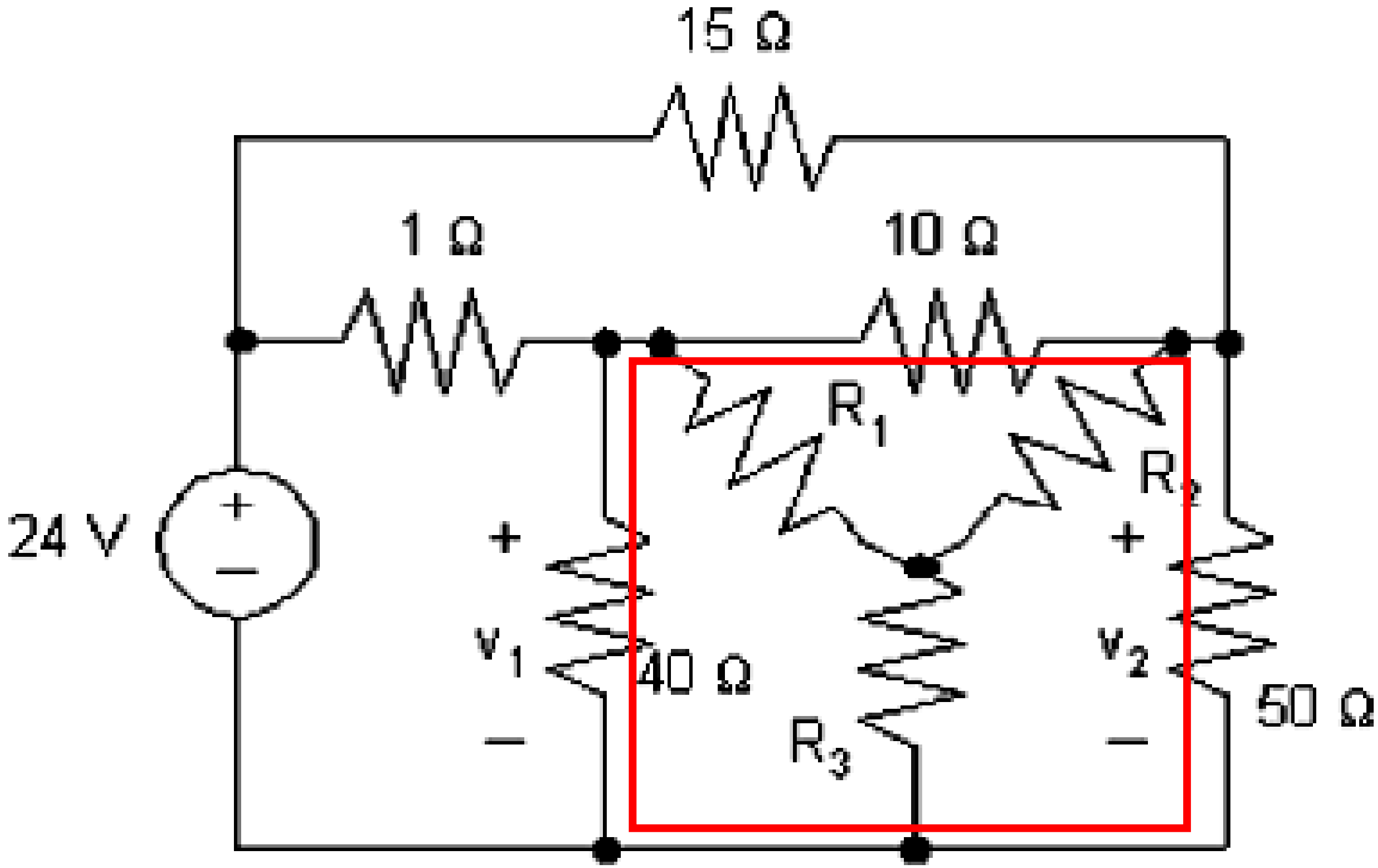
$$\therefore i_{5k\Omega} = 0$$

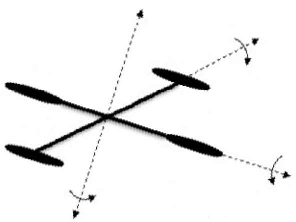


- Ex) Delta-Y 변환을 이용하여 표시된 v1, v2를 구하라.

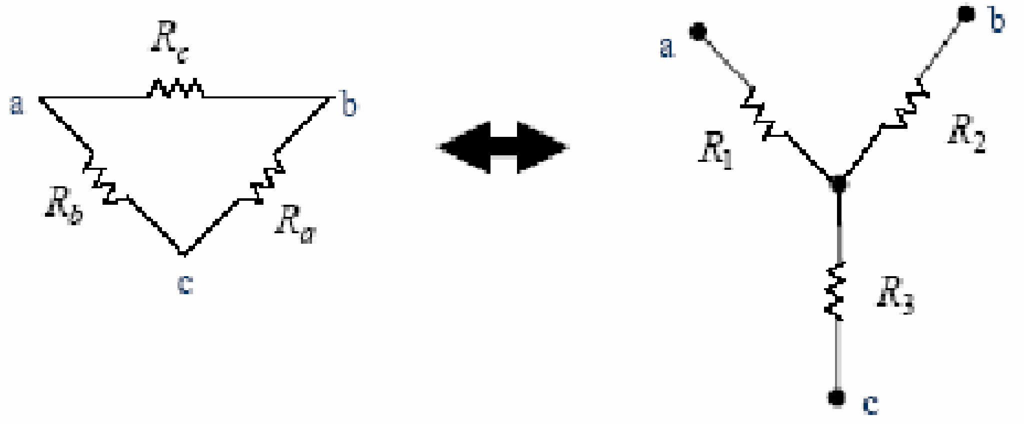




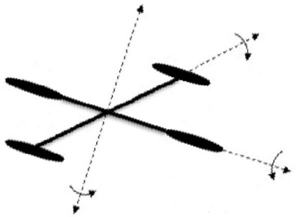

15 Ω
1 Ω
10 Ω
R1
R2
24 V
+
−
+
v1
−
40 Ω
R3
+
v2
−
50 Ω

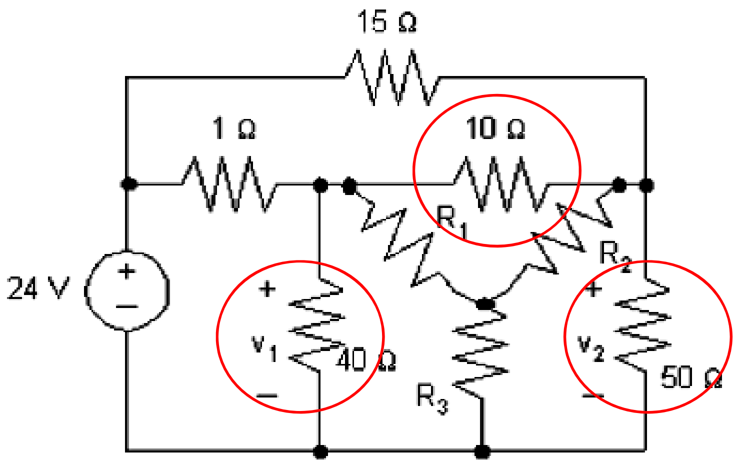


In previous chapter



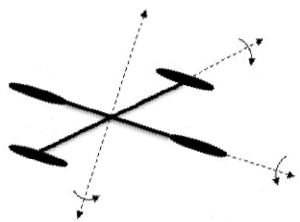
$$R_1 = \frac{R_b R_c}{R_a + R_b + R_c}, \quad R_2 = \frac{R_a R_c}{R_a + R_b + R_c}, \quad R_3 = \frac{R_a R_b}{R_a + R_b + R_c}$$

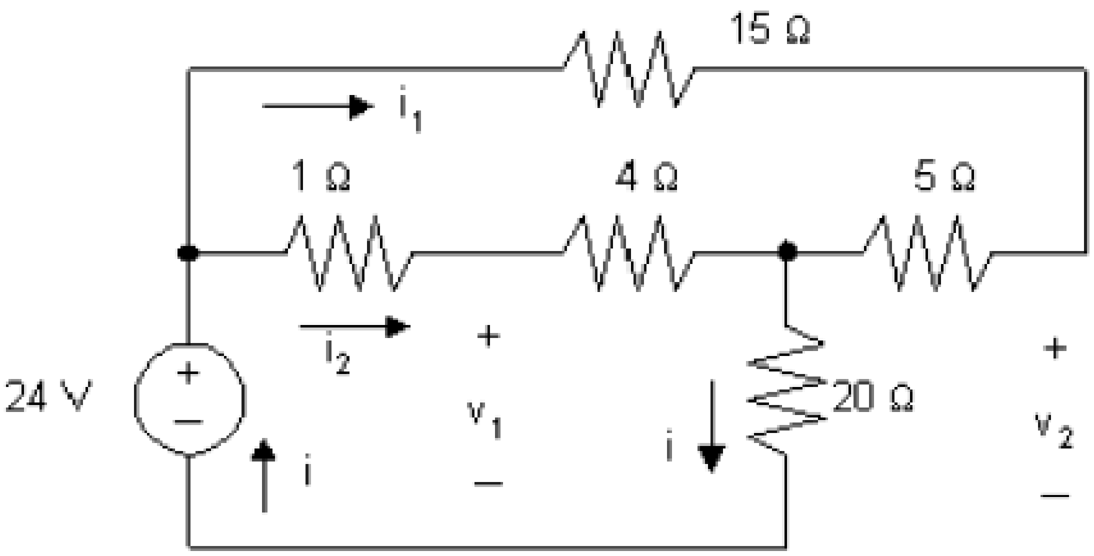




$$R_1 = \frac{R_b R_c}{R_a + R_b + R_c},\ R_2 = \frac{R_a R_c}{R_a + R_b + R_c},\ R_3 = \frac{R_a R_b}{R_a + R_b + R_c}$$

$$R_1 = \frac{(40)(10)}{10+40+50} = 4\,\Omega; \quad R_2 = \frac{(50)(10)}{10+40+50} = 5\,\Omega; \quad R_3 = \frac{(40)(50)}{10+40+50} = 20\,\Omega$$



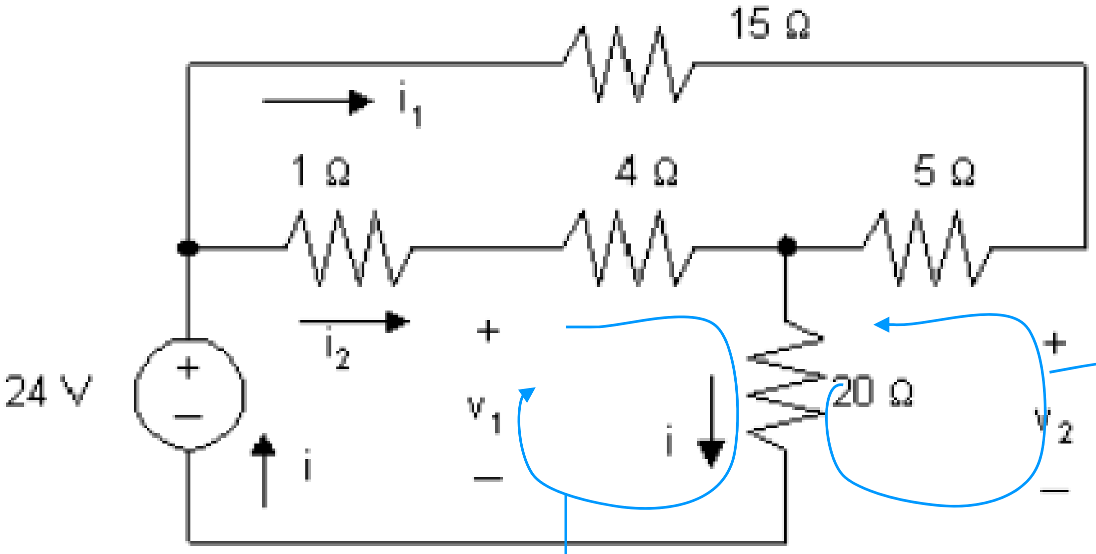


$$R_{eq} = (15+5)\|(4+1) + 20 = 20\|5 + 20 = 4 + 20 = 24\,\Omega$$

$$i = \frac{24\text{ V}}{24\,\Omega} = 1\text{ A}$$

$$i_1 = \frac{1+4}{1+4+15+5}(i) = \frac{5}{25}(1\text{ A}) = 0.2\text{ A}$$

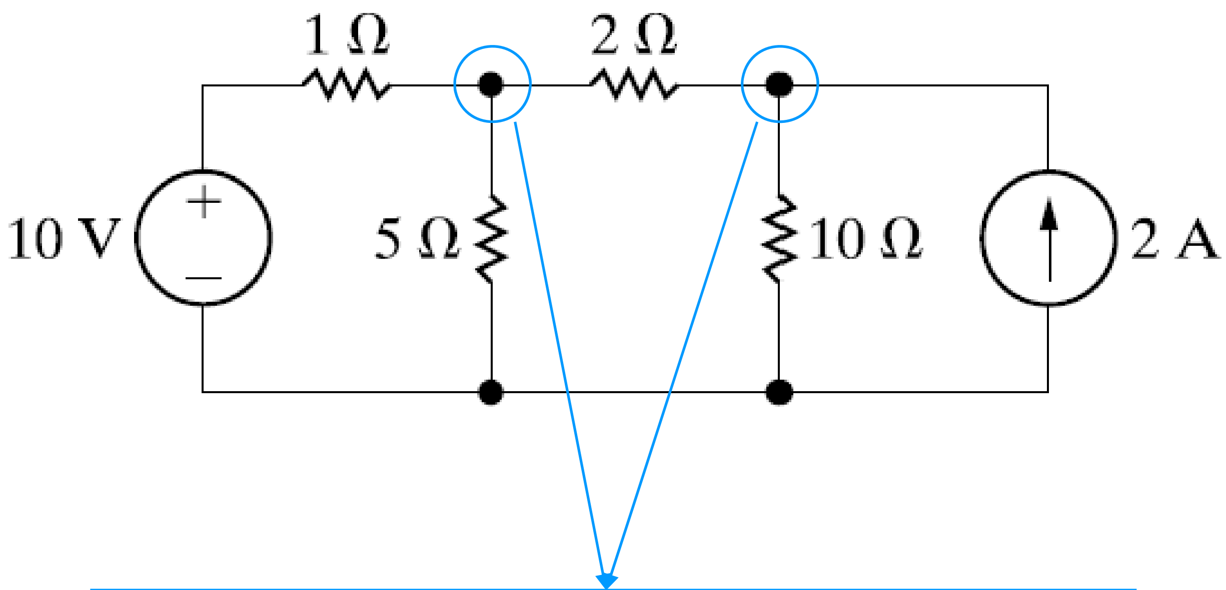
$$i_2 = 1\text{ A} - 0.2\text{ A} = 0.8\text{ A}$$



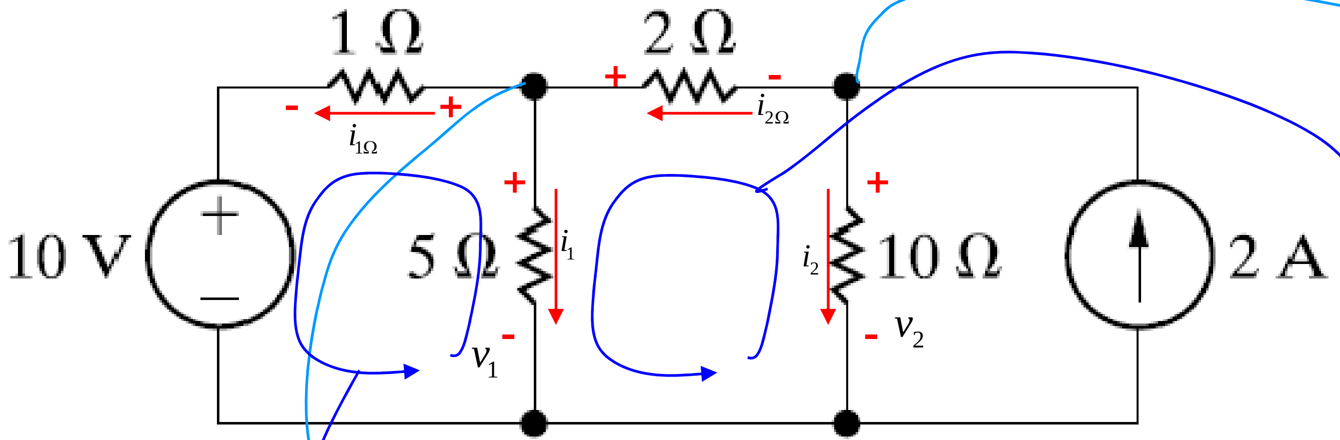
$$v_1 = 4i_2 + 20i = 4(0.8\ \mathrm{A}) + 20(1\ \mathrm{A}) = 3.2 + 20 = 23.2\ \mathrm{V}$$

$$v_2 = 5i_1 + 20i = 5(0.2\ \mathrm{A}) + 20(1\ \mathrm{A}) = 1 + 20 = 21\ \mathrm{V}$$

- 마디 전압법의 소개



3개의 이상의 소자가 결합된 마디를 먼저 해석한다.



$$i_{1\Omega} + i_1 - i_{2\Omega} = 0 \quad\quad i_{2\Omega} + i_2 - 2 = 0$$

$$\downarrow \quad\quad \downarrow$$

$$\frac{v_{1\Omega}}{1} + \frac{v_1}{5} + \frac{v_{2\Omega}}{2} = 0 \quad\quad \frac{v_{2\Omega}}{2} + \frac{v_2}{10} - 2 = 0$$

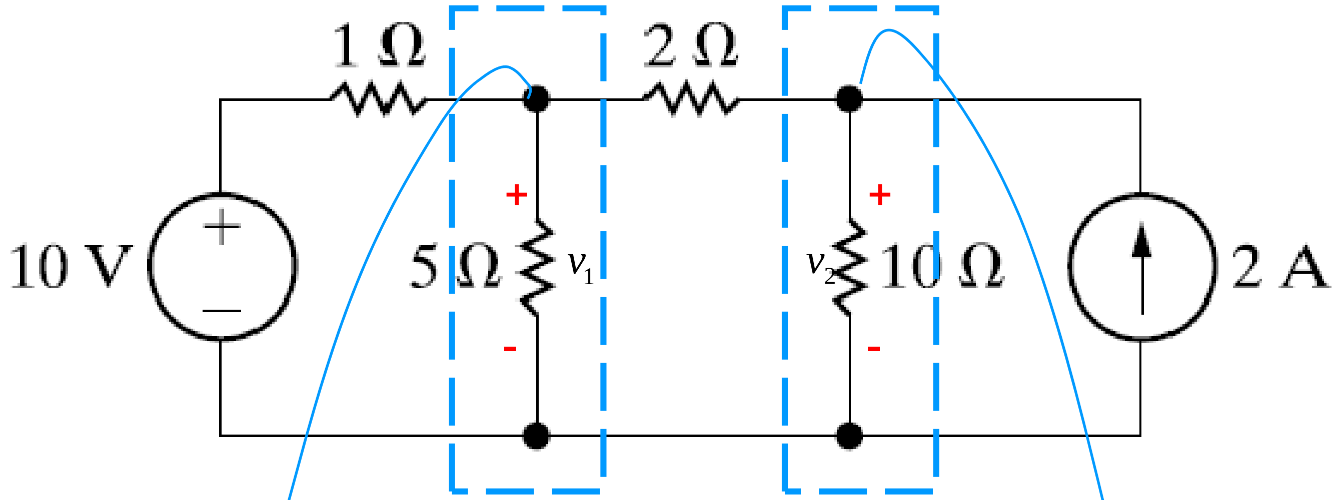
$$v_{1\Omega} + 10 - v_1 = 0 \quad\quad -v_{2\Omega} + v_1 - v_2 = 0$$

$$\downarrow \quad\quad \downarrow$$

$$\frac{v_1 - 10}{1} + \frac{v_1}{5} + \frac{v_1 - v_2}{2} = 0 \quad\quad \frac{v_2 - v_1}{2} + \frac{v_2}{10} - 2 = 0$$

$$v_1 = 9.09V \quad\quad v_2 = 10.91V$$

하지만 만약 직관적으로 전류의 식을 잡을 수만 있다면 곧바로 결과식을 도출할 수도 있다.



$$\frac{v_1 - 10}{1} + \frac{v_1}{5} + \frac{v_1 - v_2}{2} = 0$$

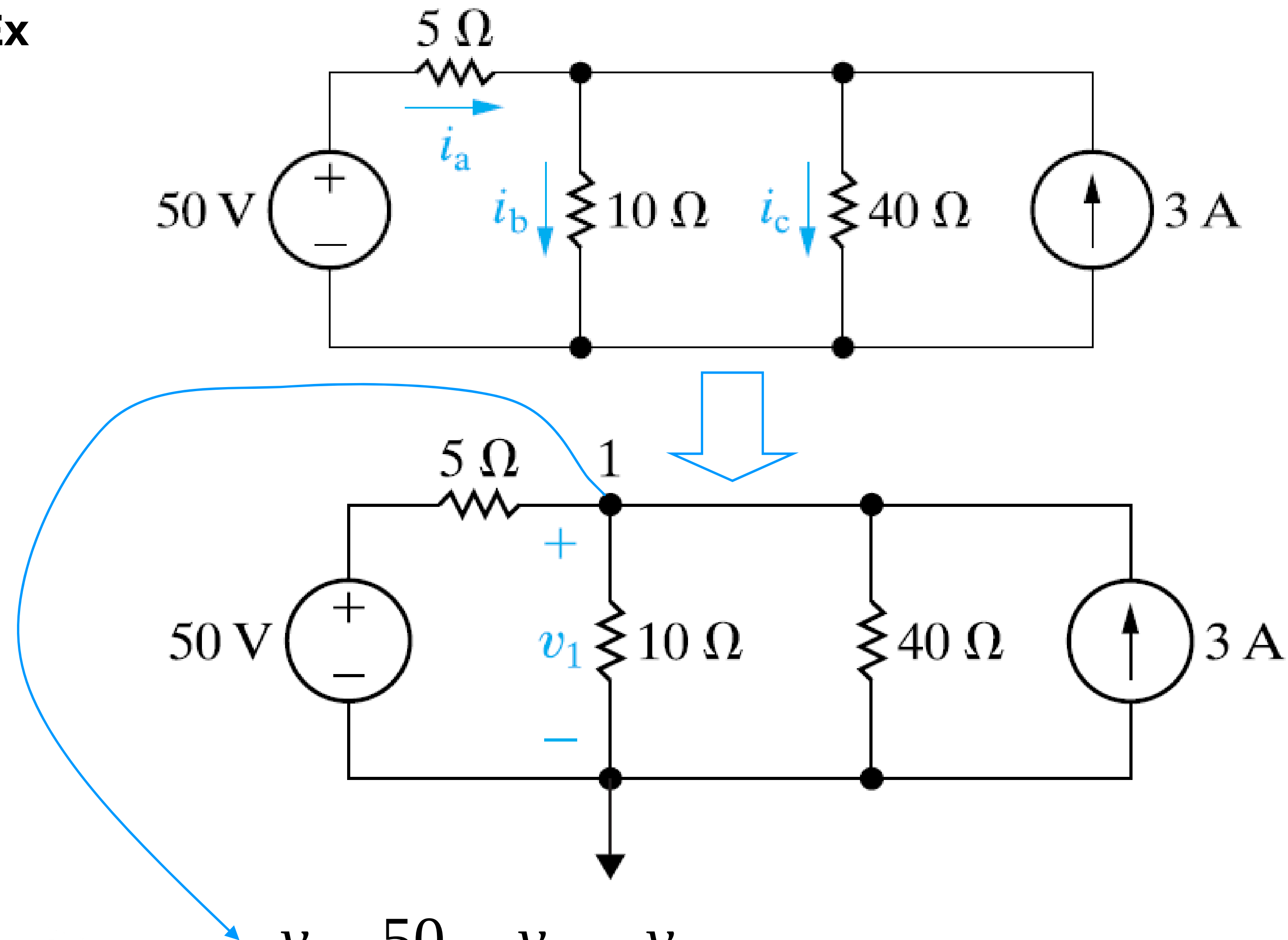
$$\frac{v_2 - v_1}{2} + \frac{v_2}{10} - 2 = 0$$

이 곳에 전류가 흐른다면, v1의 방향을 고려할때, v1의 전압과 10V의 차가 유입된다고 볼 수 있다.

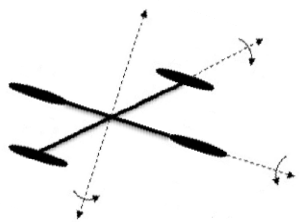
만약, 두 전압의 방향을 다르게 잡는다면? → Report^^

3가지경우에대해서

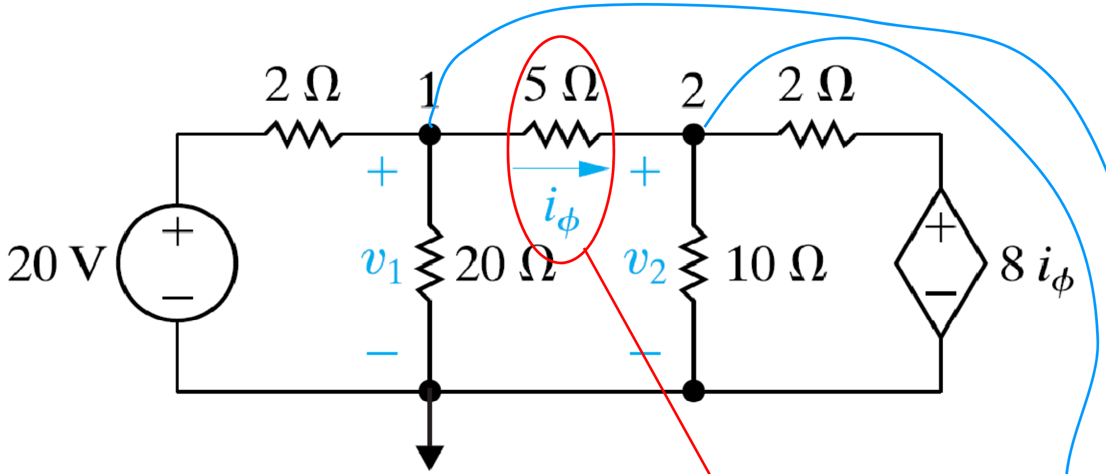
- **Ex**



$$\frac{v_1 - 50}{5} + \frac{v_1}{10} + \frac{v_1}{40} - 3 = 0 \rightarrow v_1 = 40$$



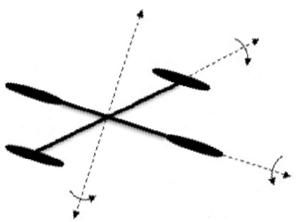
- 마디 전압법과 종속 전원



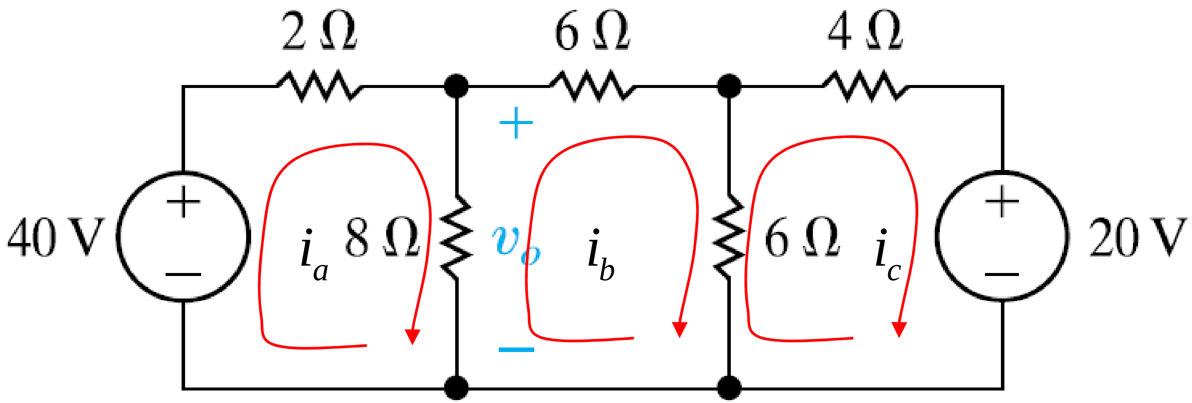
$$i_\phi = \frac{v_1 - v_2}{5}$$

$$\frac{v_1 - 20}{2} + \frac{v_1}{20} + \frac{v_1 - v_2}{5} = 0$$

$$\frac{v_2 - v_1}{5} + \frac{v_2}{10} + \frac{v_2 - 8i_\phi}{2} = 0$$



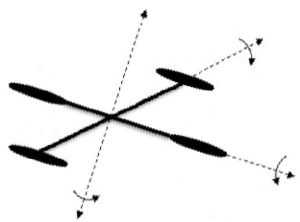
- 망 전류법의 소개



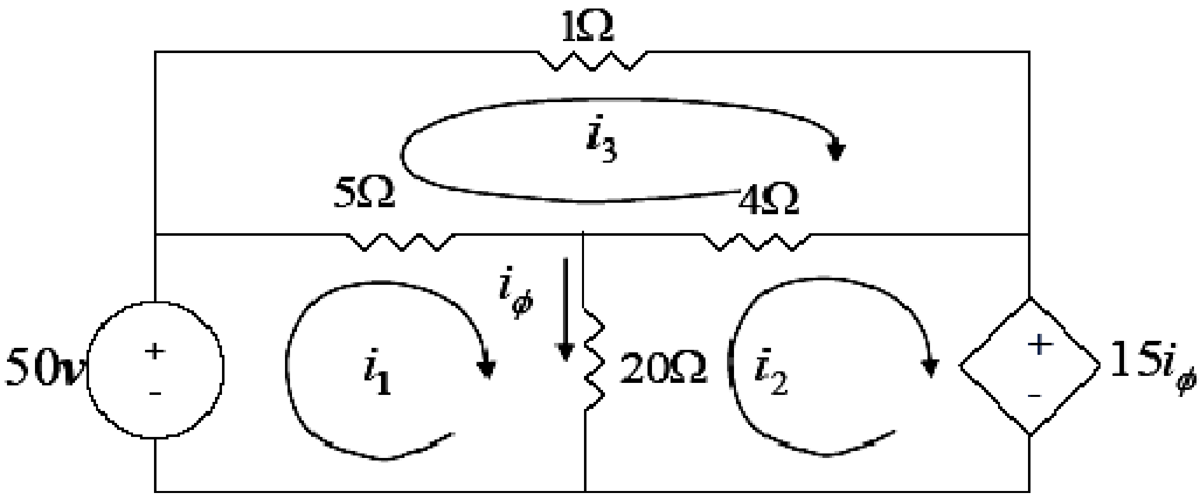
$$-40 + 2i_a + 8(i_a - i_b) = 0$$

$$8(i_b - i_a) + 6i_b + 6(i_b - i_c) = 0$$

$$6(i_c - i_b) + 4i_c + 20 = 0$$



- 망 전류법과 종속 전원

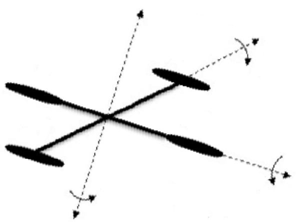


$$i_\phi = i_1 - i_2$$

$$-50 + 5(i_1 - i_3) + 20(i_1 - i_2) = 0$$

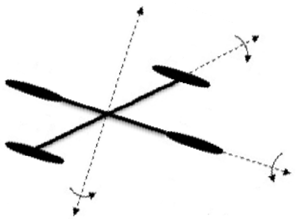
$$20(i_2 - i_1) + 4(i_2 - i_3) + 15i_\phi = 0$$

$$1(i_3) + 4(i_3 - i_2) + 5(i_3 - i_1) = 0$$

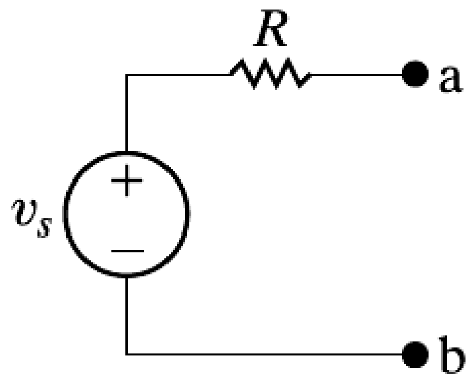


-. 방금 전까지의 마디전압법과 망전류법은 키르히호프의 법칙 위에서 좀 더 쉽게 회로해석을 접근하는 방법이다.

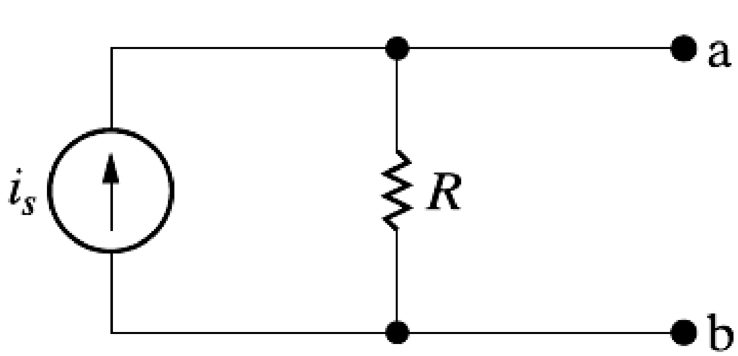
-. 그러나, 어렵다고 느껴진다면 그냥 앞선 방법대로 키르히호프의 법칙만을 적용해도 상관없다.



- 전원 변환

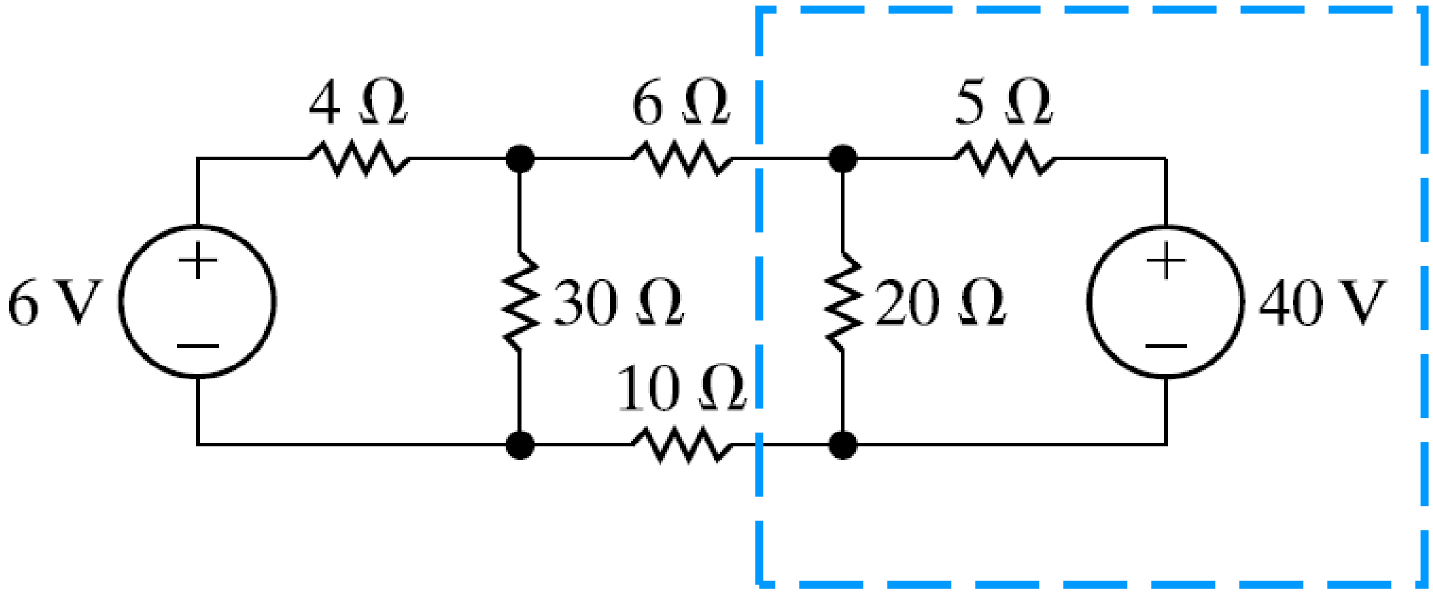


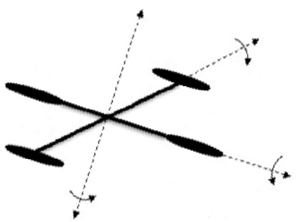
(a)

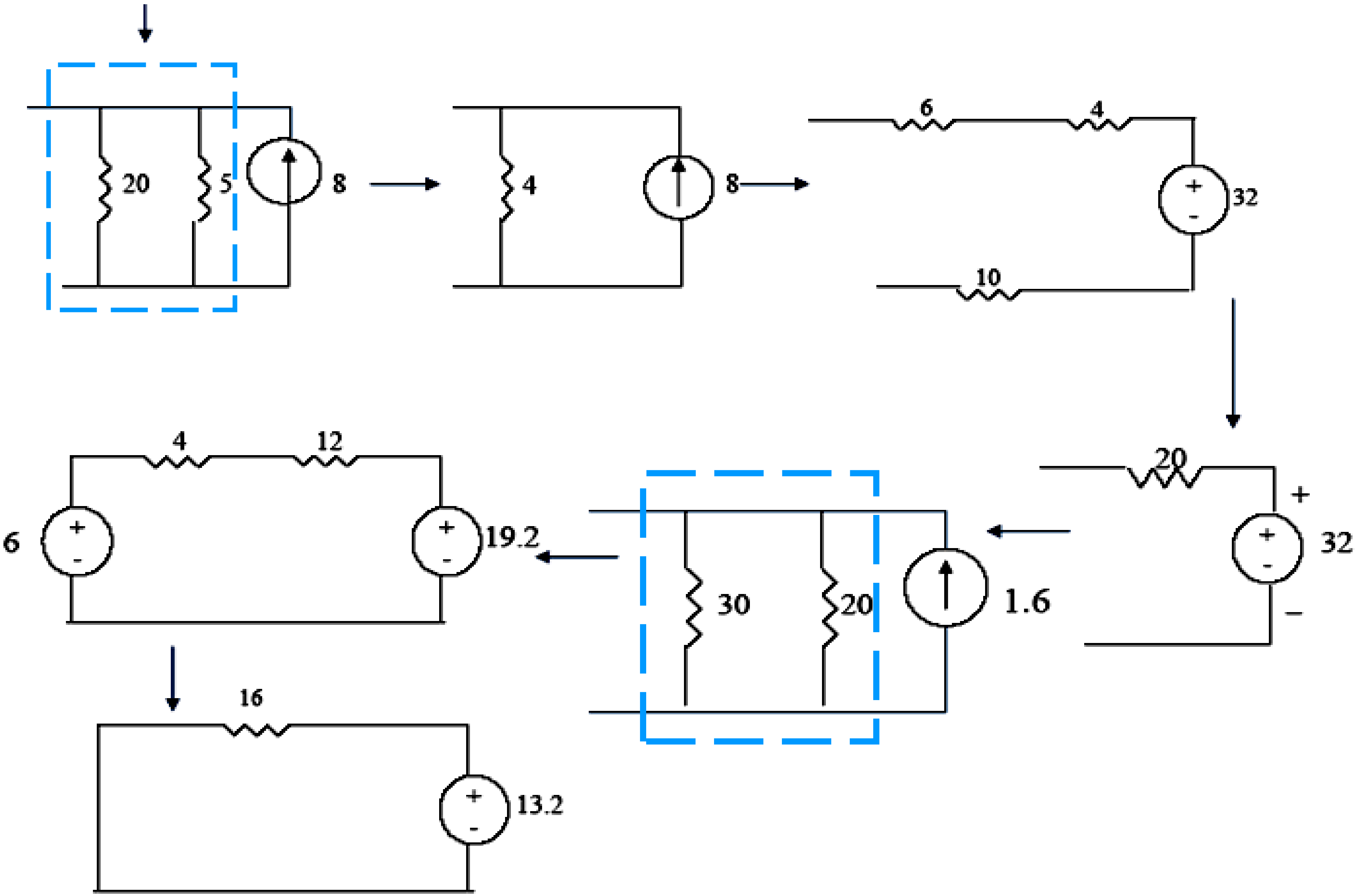


(b)

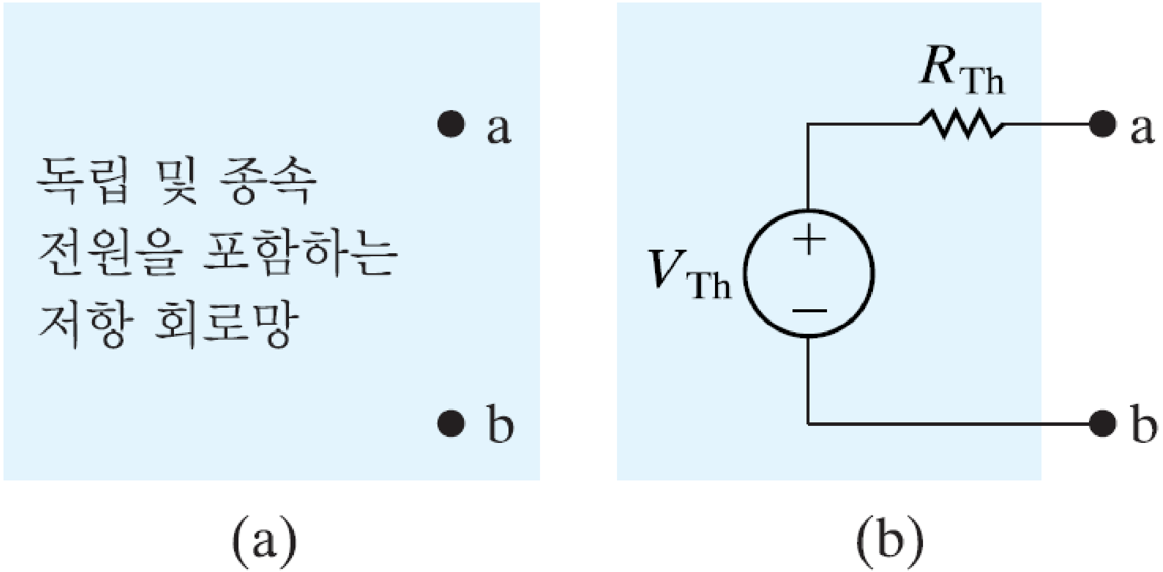
- Ex



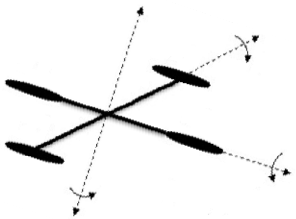



20
5
8
4
8
6
4
32
10
20
32
+
+
-
-
30
20
1.6
4
12
6
19.2
16
13.2

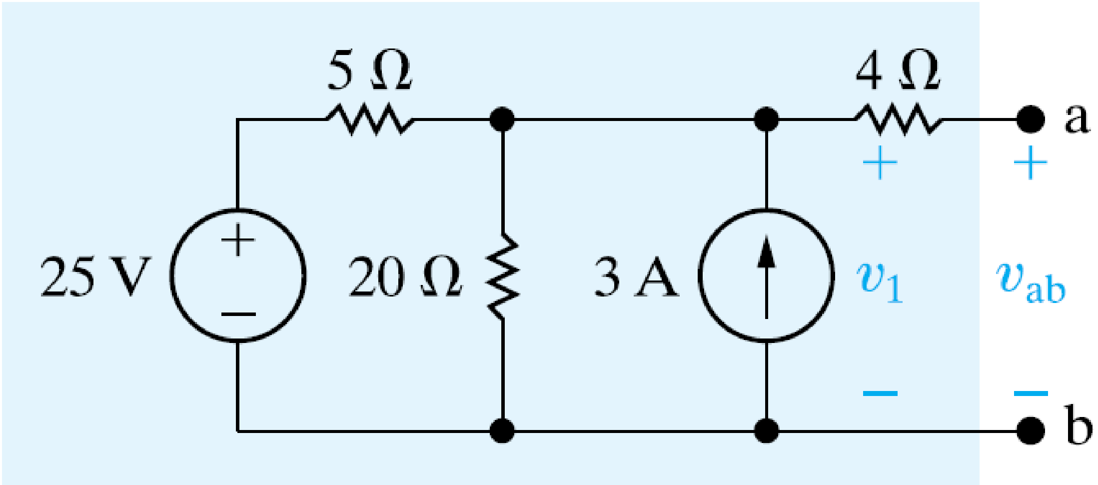
- 테브난 등가 회로

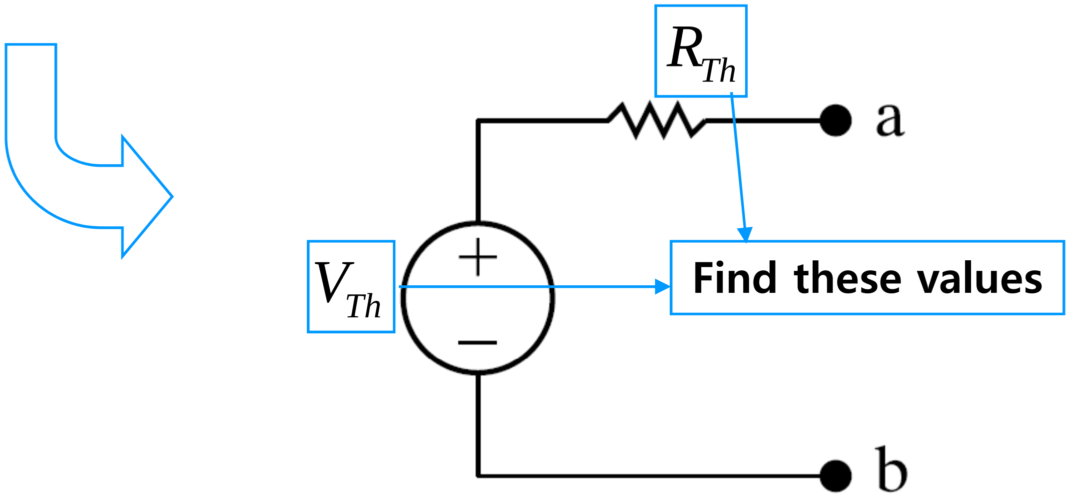


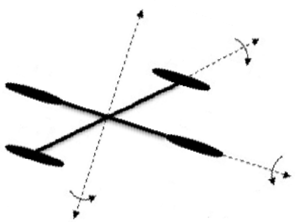
테브난 등가 회로는 전원과 저항의 상호연결을 대신하는 저항 R_{Th} 과 직렬로 연결된 독립 전압원 V_{Th} 으로 구성된다.

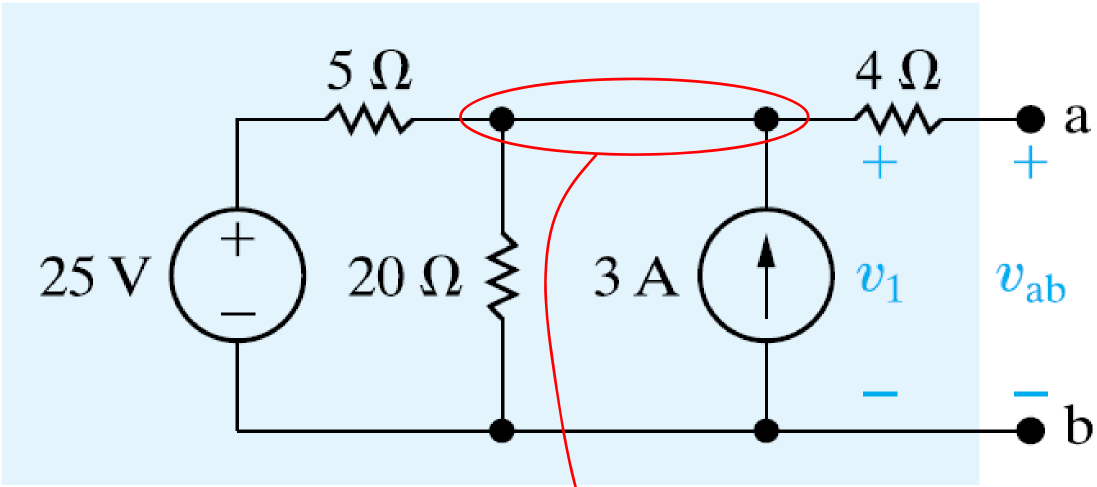


- **Ex**







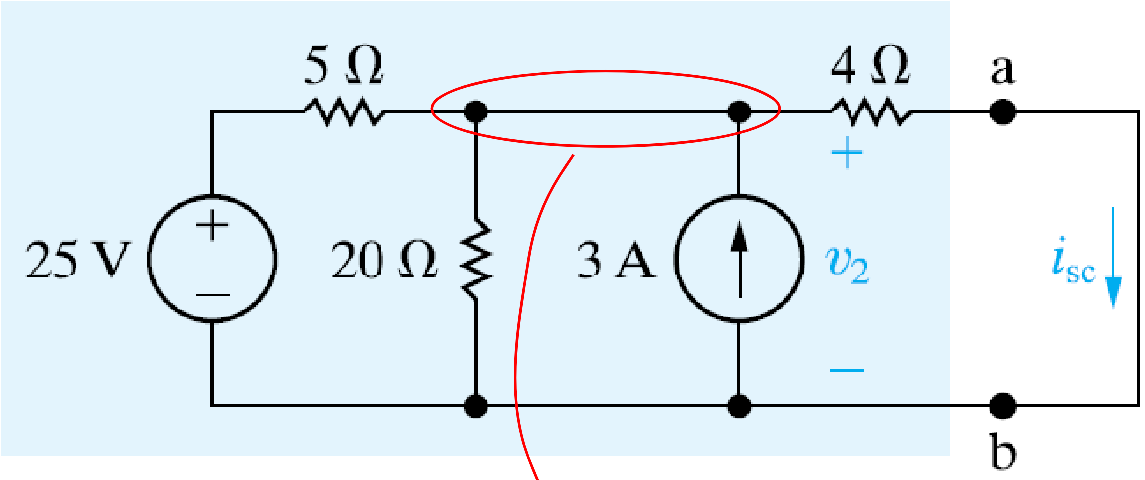


ab단자가 개방되었다고 가정하고 단자의 전압을 구한다. 4Ω 에는 개방되었다고 가정하면 전류가 흐르지 않을 것이다.

$$\frac{v_1 - 25}{5} + \frac{v_1}{20} - 3 = 0$$

$$v_1 = 32V$$

$$V_{Th} = 32V$$



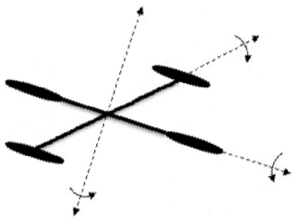
$$\frac{v_2 - 25}{5} + \frac{v_2}{20} - 3 + \frac{v_2}{4} = 0$$

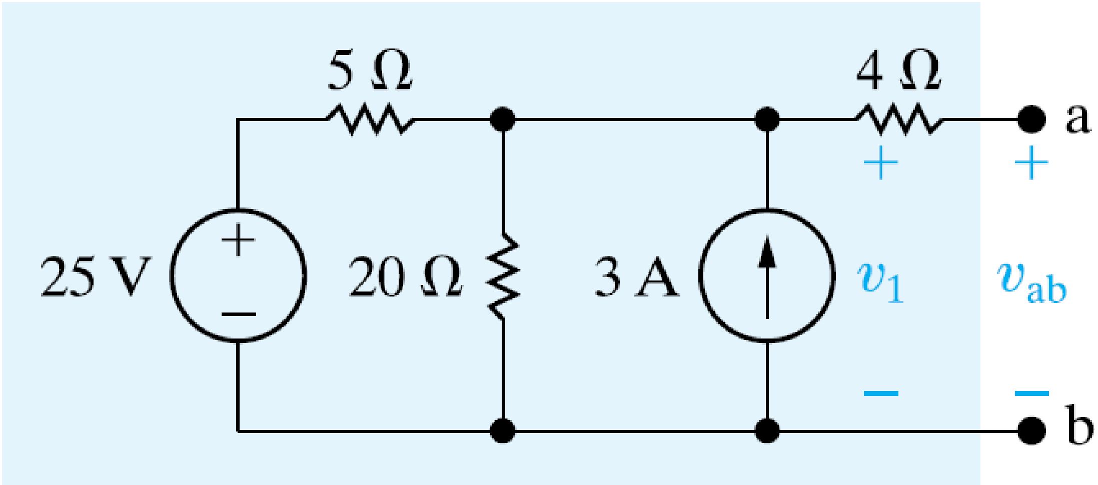
$$v_2 = 16V$$

$$i_{SC} = \frac{16}{4} = 4A$$

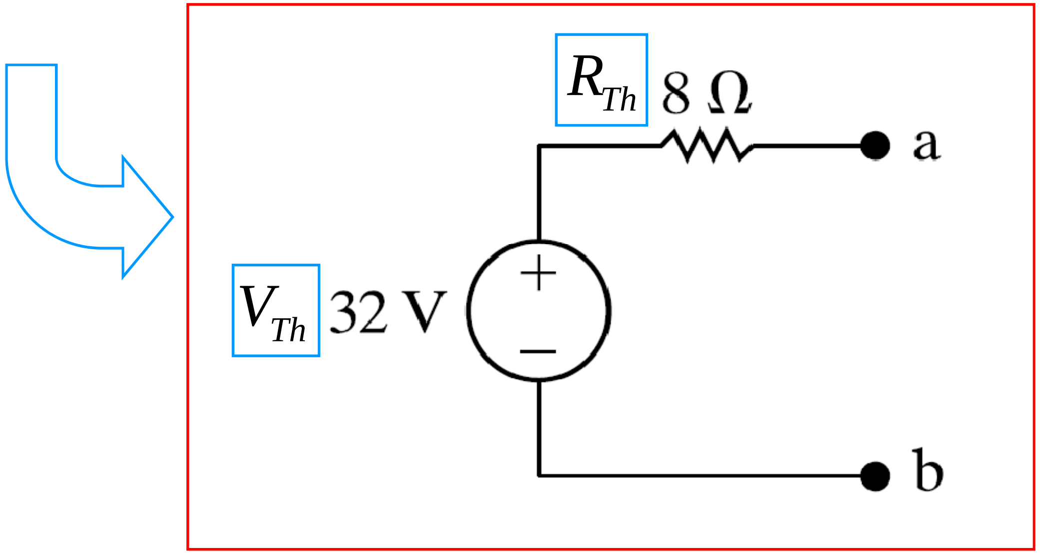
$$R_{Th} = \frac{V_{Th}}{i_{SC}} = \frac{32}{4} = 8\Omega$$

ab단자가 단락되었다고 가정하고
단자의 전류 i_{SC} 를 구한다.

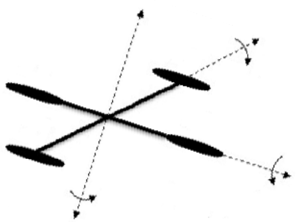




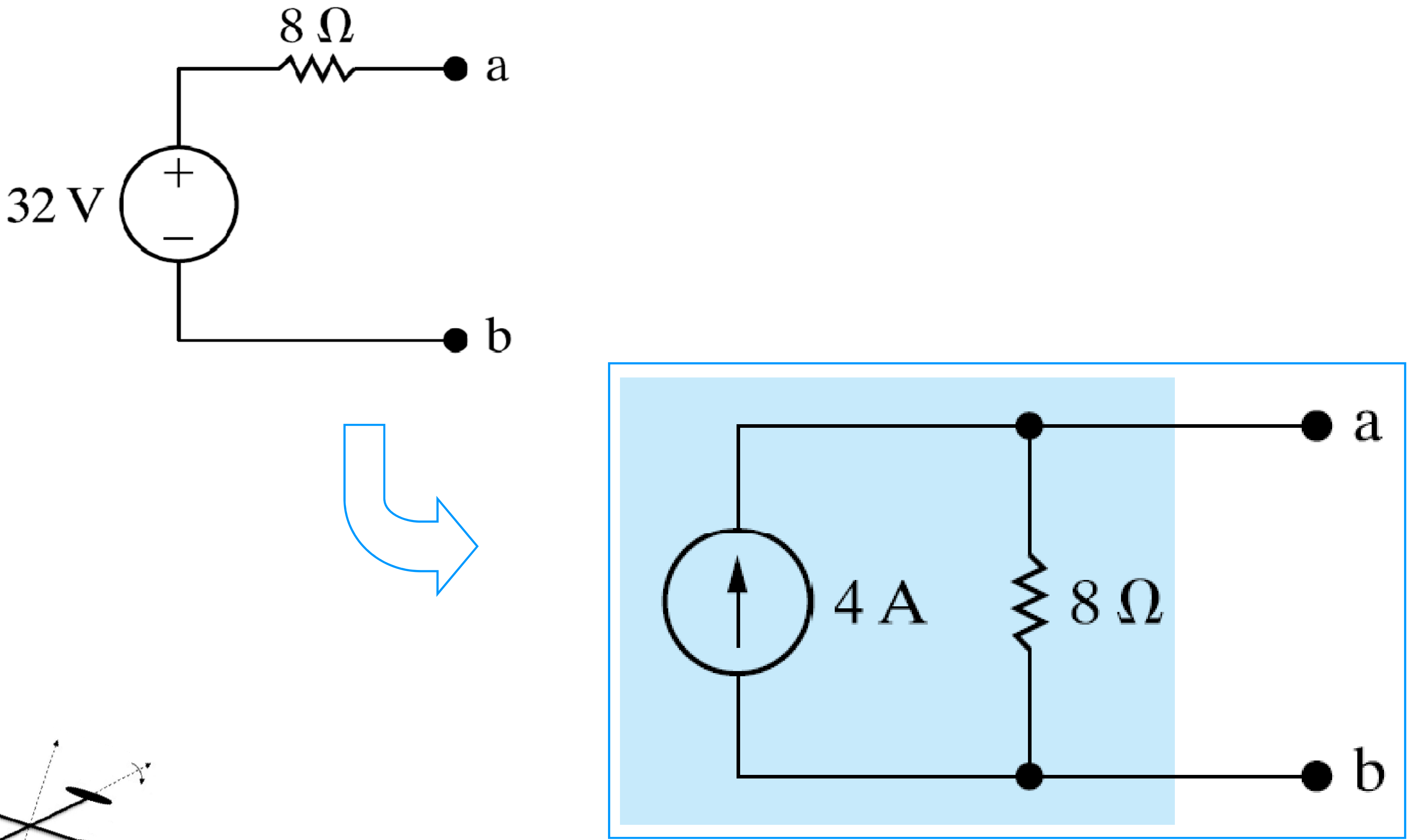
5 Ω
4 Ω
a
25 V
20 Ω
3 A
v_1
v_{ab}
b

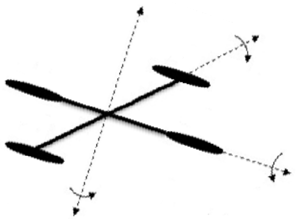


R_{Th} 8 Ω
a
V_{Th} 32 V
b

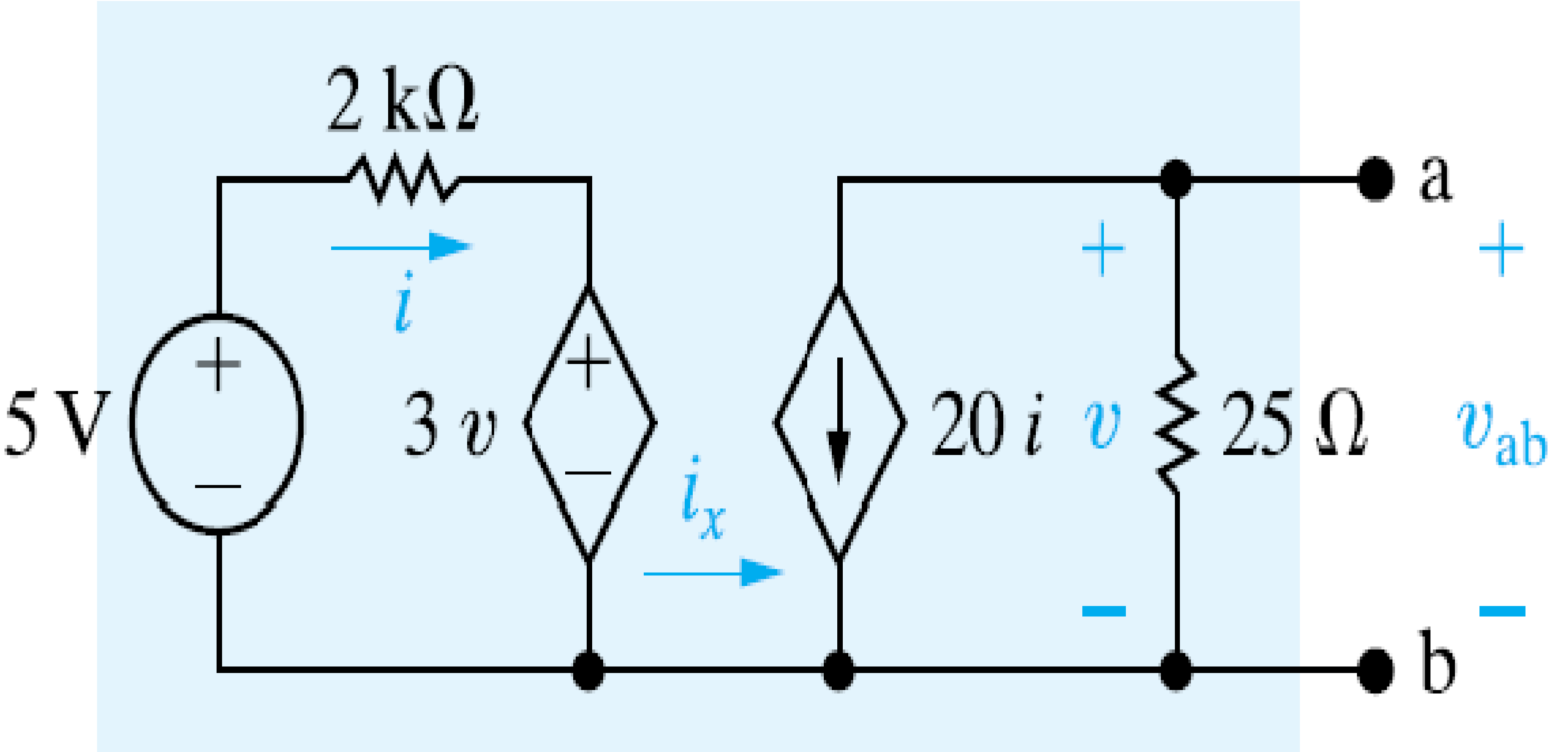


- 노튼 등가 회로 : 노튼 등가 저항과 병렬인 독립 전류원으로 구성 (전원변환을 이용)

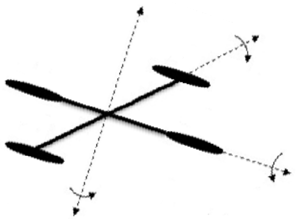


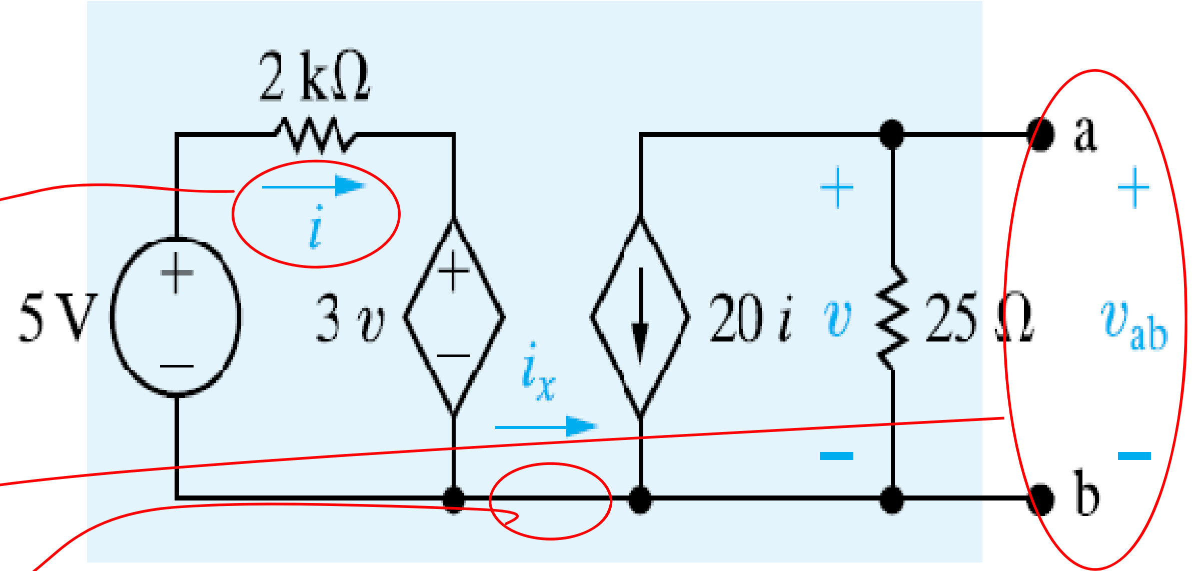


- **Ex**



테브난 등가회로는?



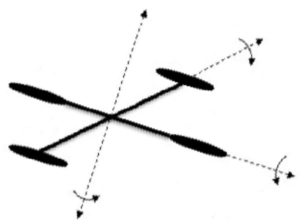


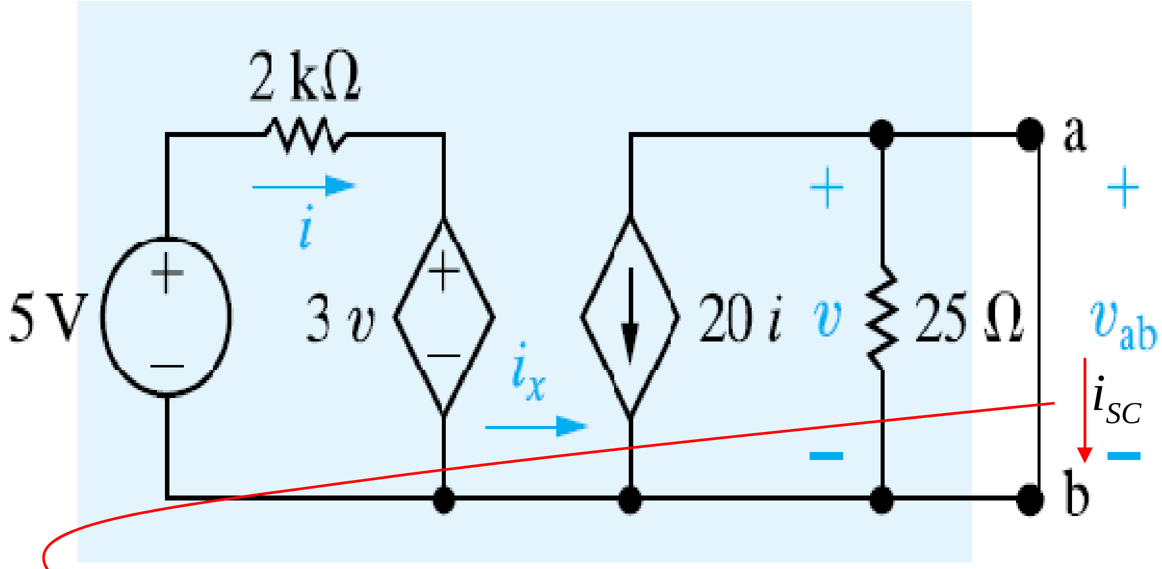
$$i_x = 0$$

$$V_{Th} = v_{ab} = (-20i)(25) = -500i$$

$$i = \frac{5-3v}{2000} = \frac{5-3V_{Th}}{2000}$$

$$\boxed{V_{Th} = -5V}$$



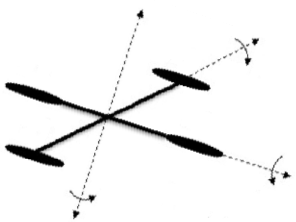


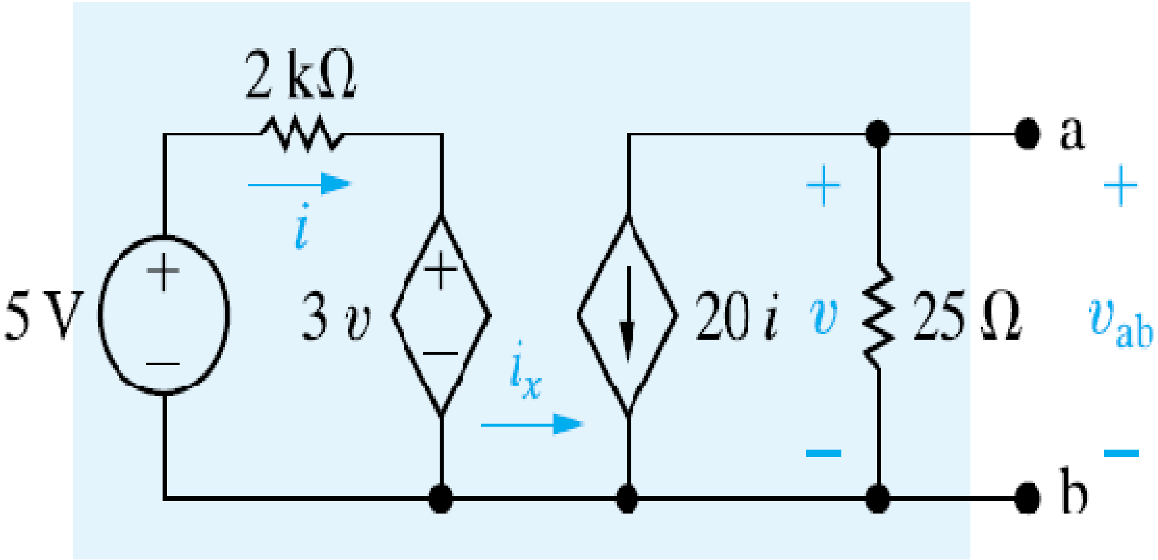
$$i_{SC} = -20i$$

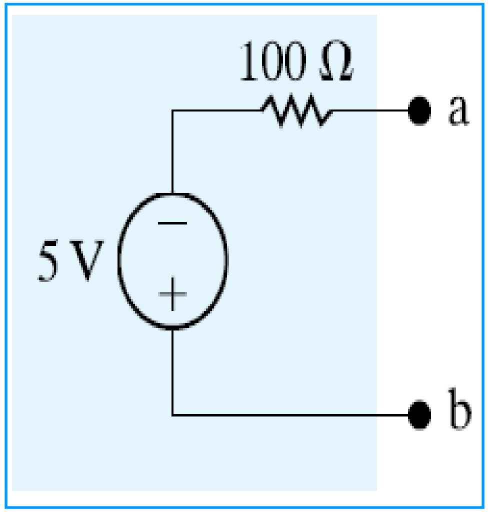
$$i = \frac{5}{2000} = 2.5mA$$

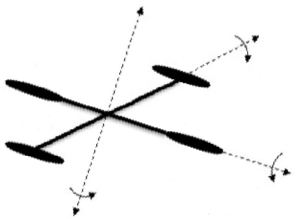
$$i_{SC} = -20(2.5) = -50mA$$

$$R_{Th} = \frac{V_{Th}}{i_{SC}} = \frac{-5}{-20} \times 10^3 = 100\Omega$$

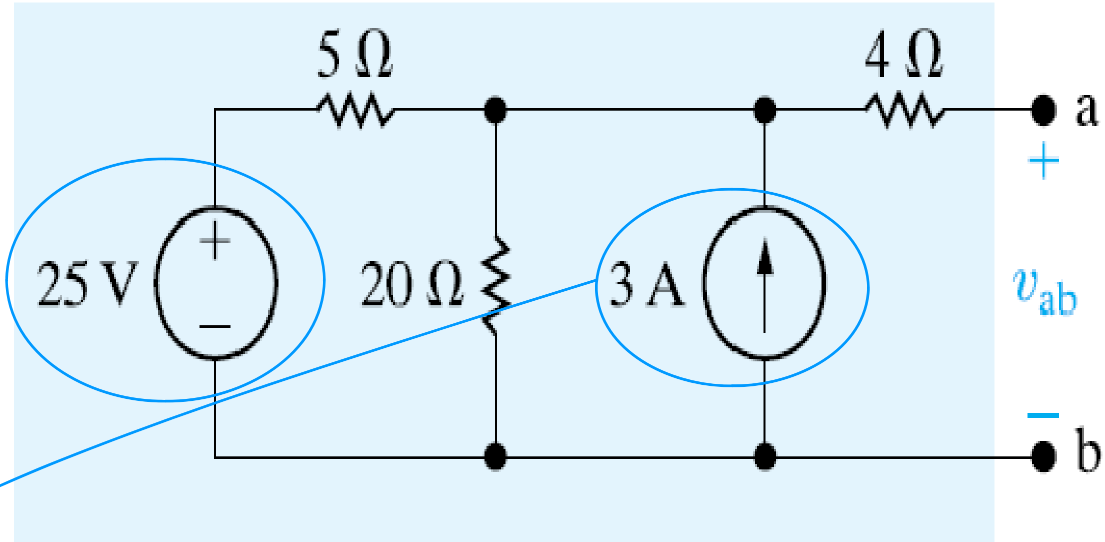



2 kΩ
i
5 V
3 v
i_x
20 i
v
25 Ω
a
b
v_{ab}

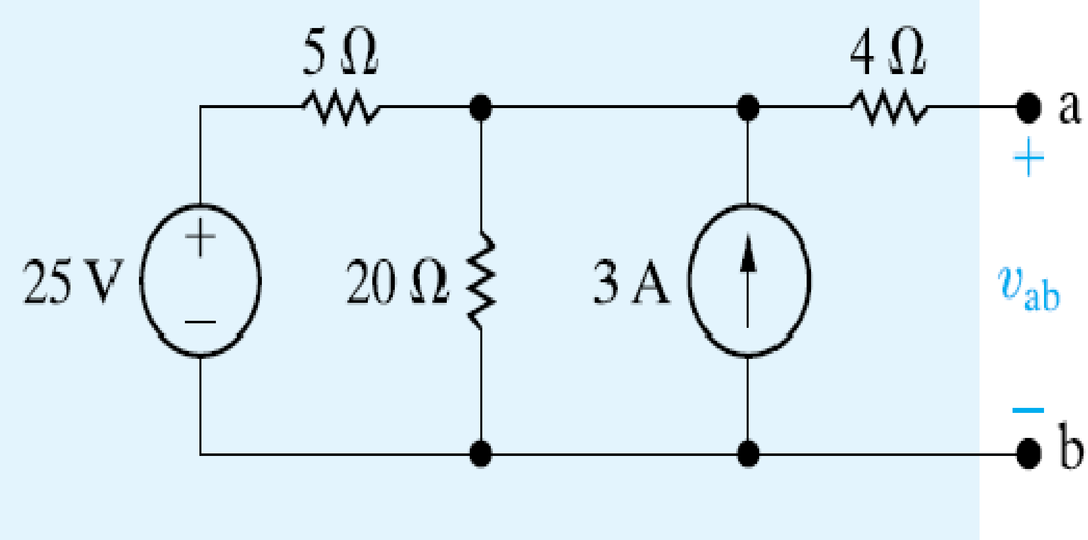

100 Ω
a
5 V
b

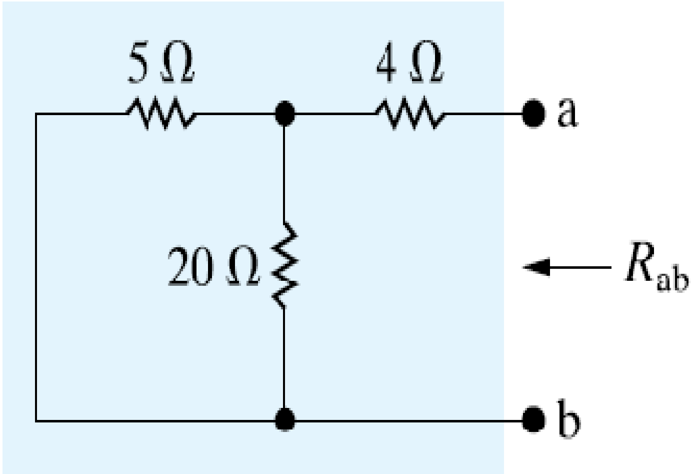


- 만약 회로가 독립전원만 사용하고 있다면...



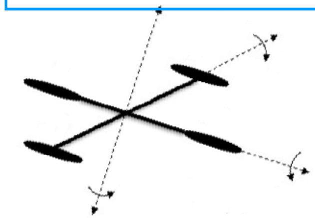
전압원 : 단락회로로 대체함으로써 동작하지 않게 하고
전류원 : 개방회로로 대체함으로써 동작하지 않게 해서
테브난 등가 저항을 바로 구할 수가 있다.



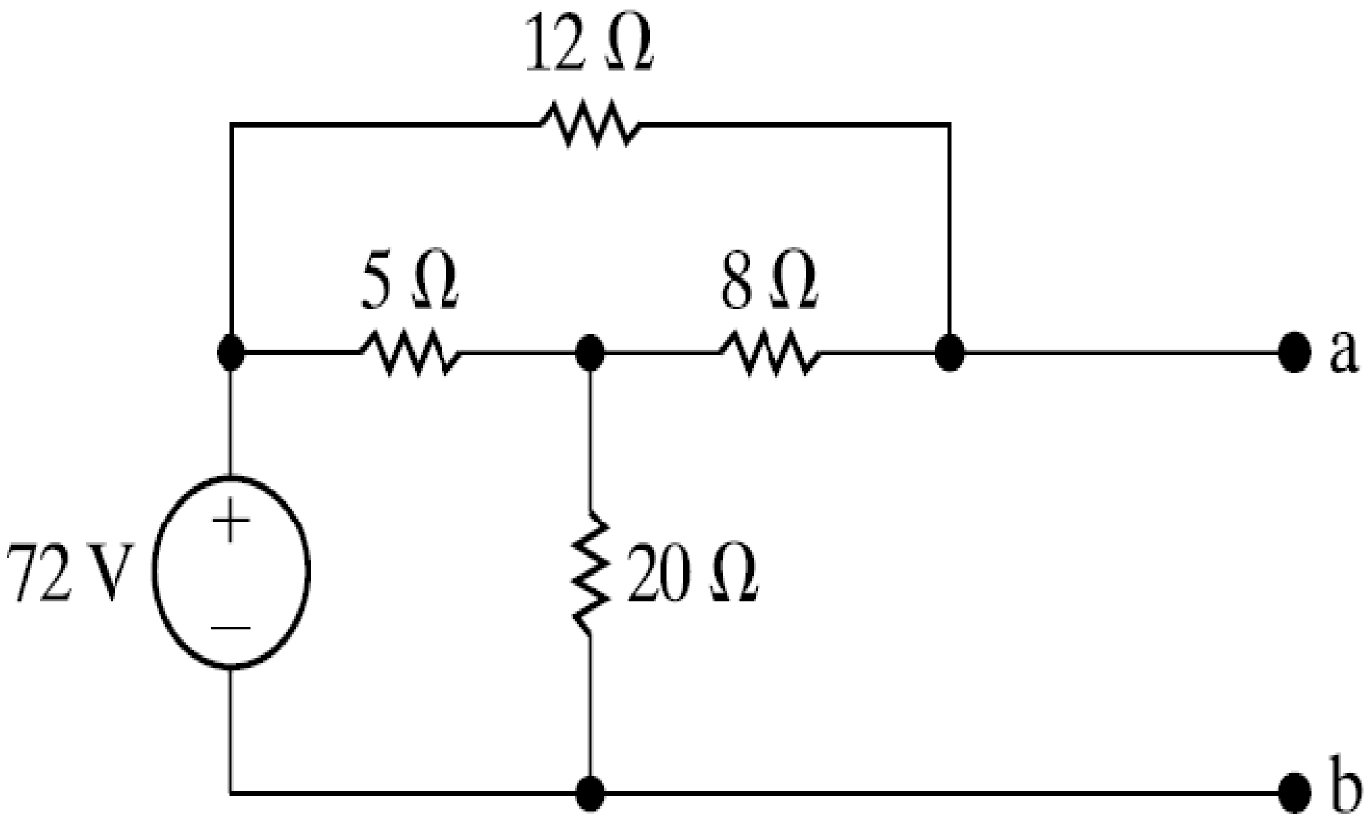


전압원 : 단락회로로 대체함으로써 동작하지 않게 하고
전류원 : 개방회로로 대체함으로써 동작하지 않게 해서

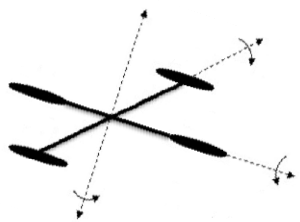
테브난 등가 저항을 바로 구할 수가 있다.



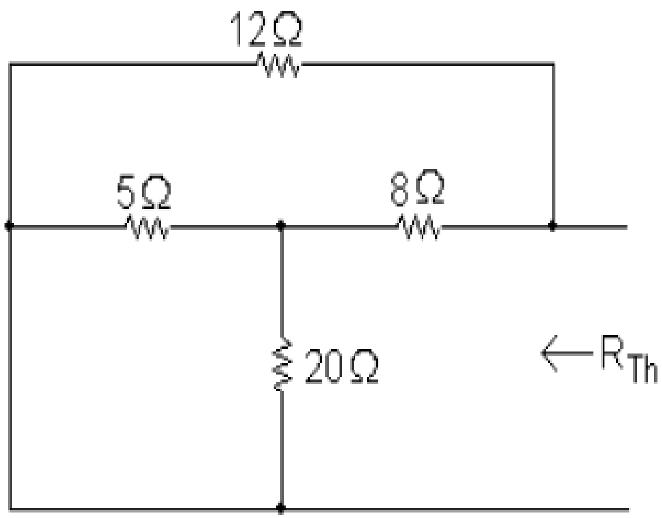
- Ex



테브난 등가 회로를 구하라.



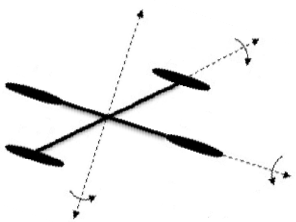
- 먼저 전원이 없다고 가정하고 등가 저항을 구한다.



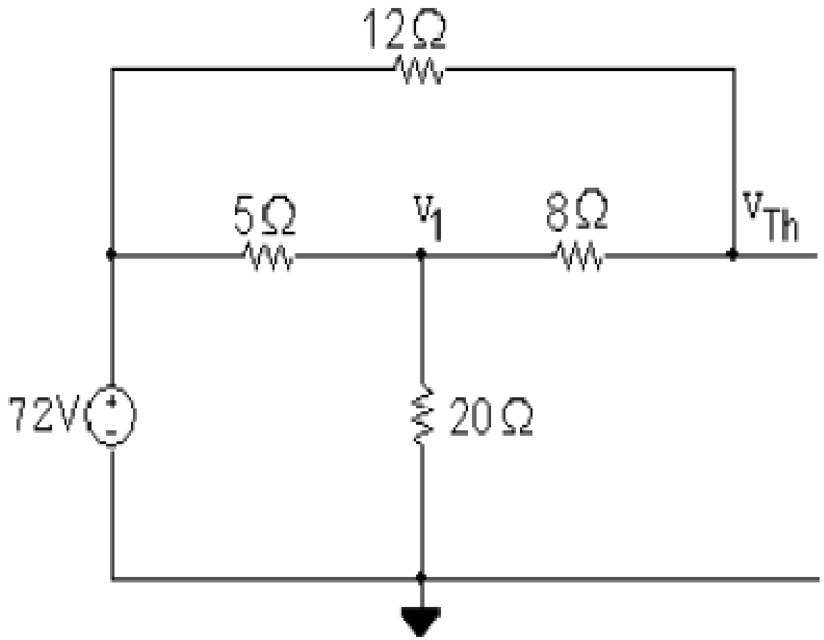
$$5||20 = 4\,\Omega.$$

$$4 + 8 = 12\,\Omega$$

$$R_{\mathrm{Th}} = 12||12 = 6\,\Omega$$



- 등가 전압을 구하보면



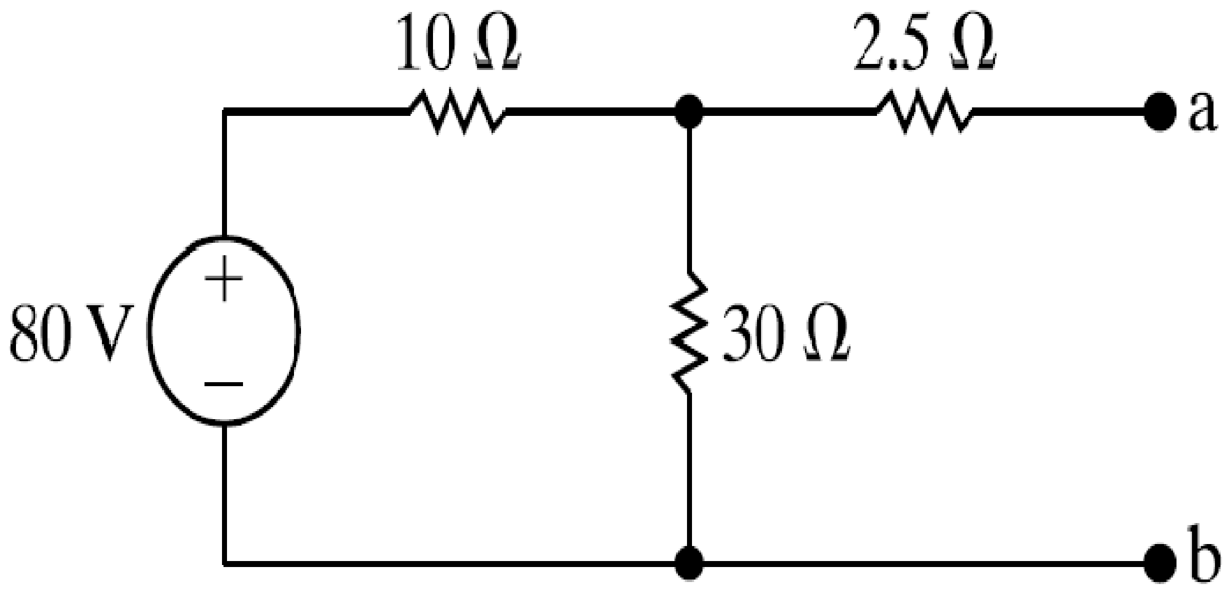
$$\frac{v_1 - 72}{5} + \frac{v_1}{20} + \frac{v_1 - v_{Th}}{8} = 0$$

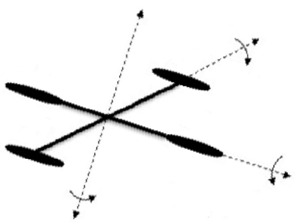
$$\frac{v_{Th} - v_1}{8} + \frac{v_{Th} - 72}{12} = 0$$

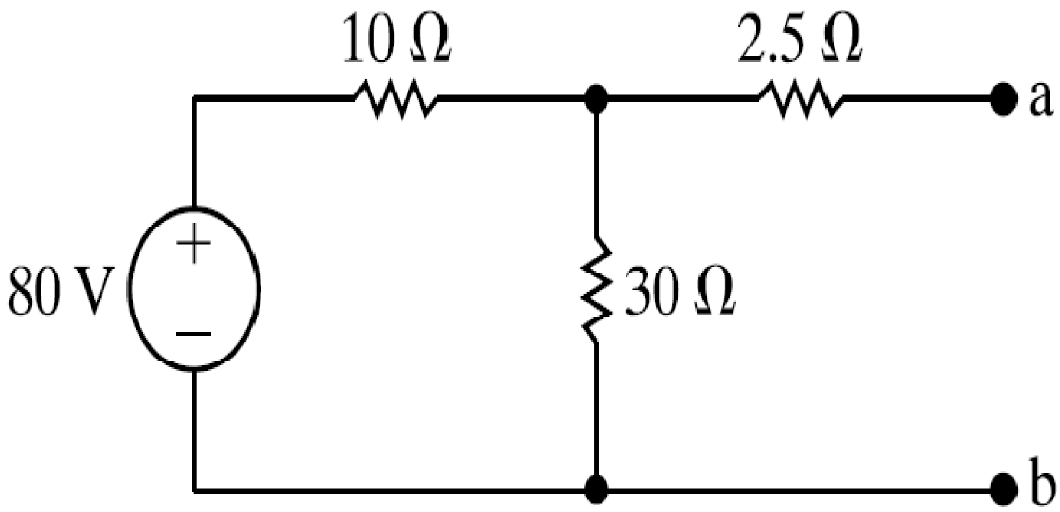
$$v_1 = 60 \text{ V}$$

$$\boxed{v_{Th} = 64.8 \text{ V.}}$$

- Ex – 전원분배를 이용한 해법

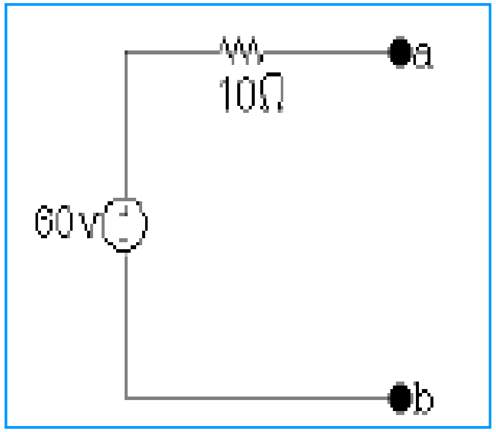




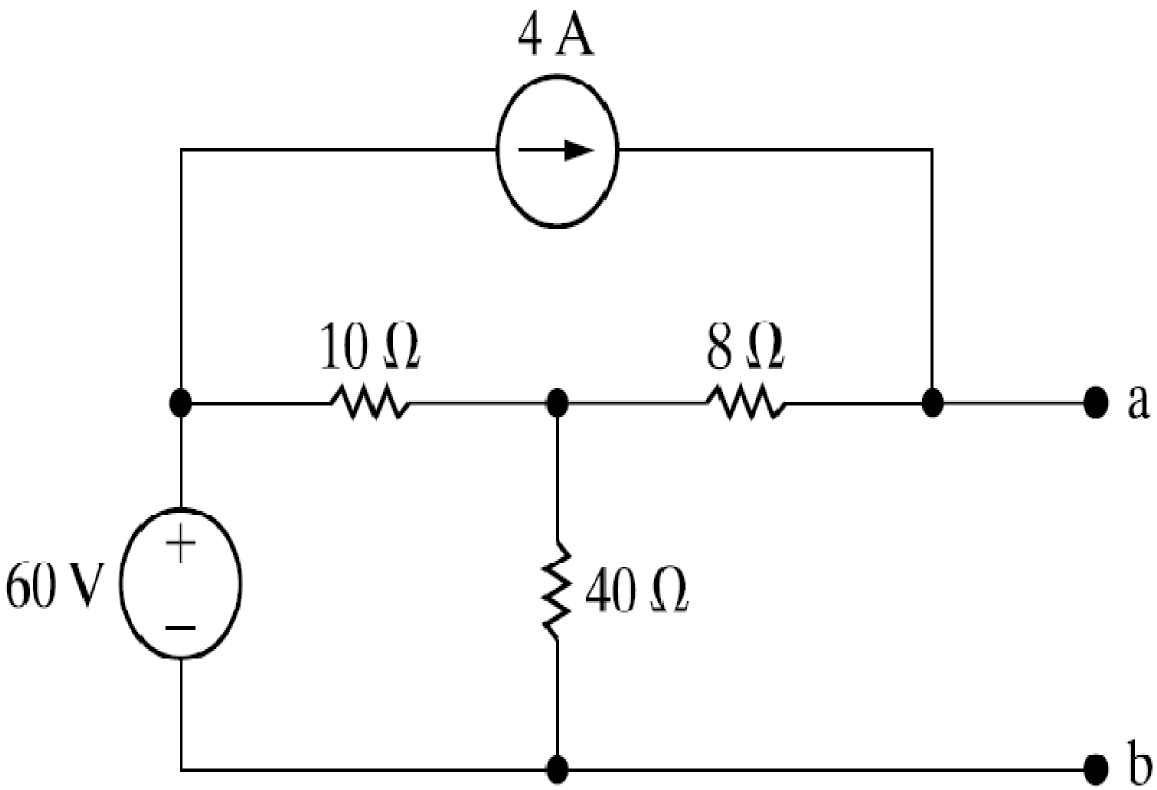


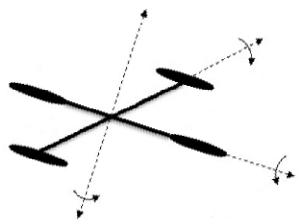
$$V_{Th} = \frac{30}{30+10}(80) = 60\text{ V}$$

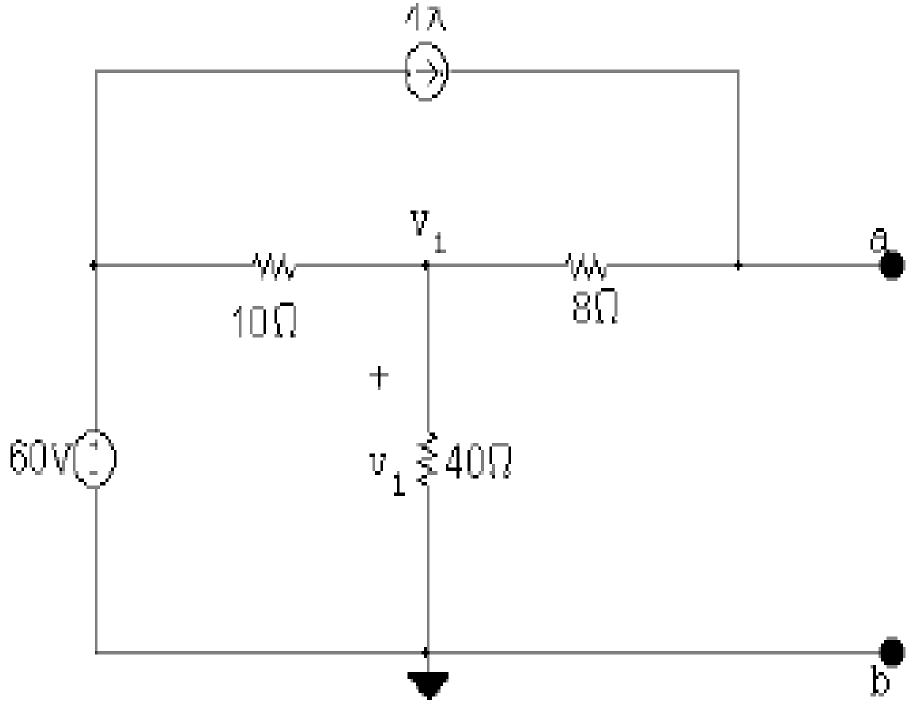
전압원이 단락되었다고 가정함 → $R_{Th} = 10||30 + 2.5 = 10\,\Omega$

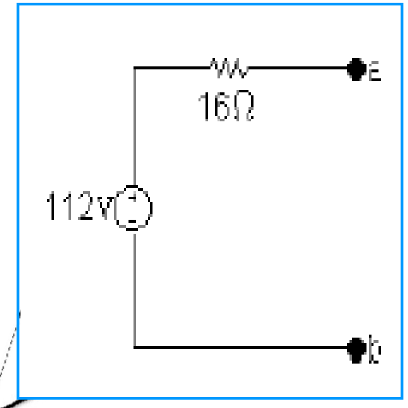


- Ex







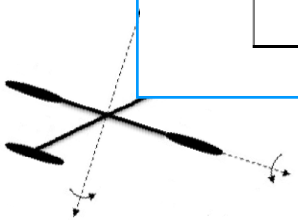


$$\frac{v_1 - 60}{10} + \frac{v_1}{40} - 4 = 0$$

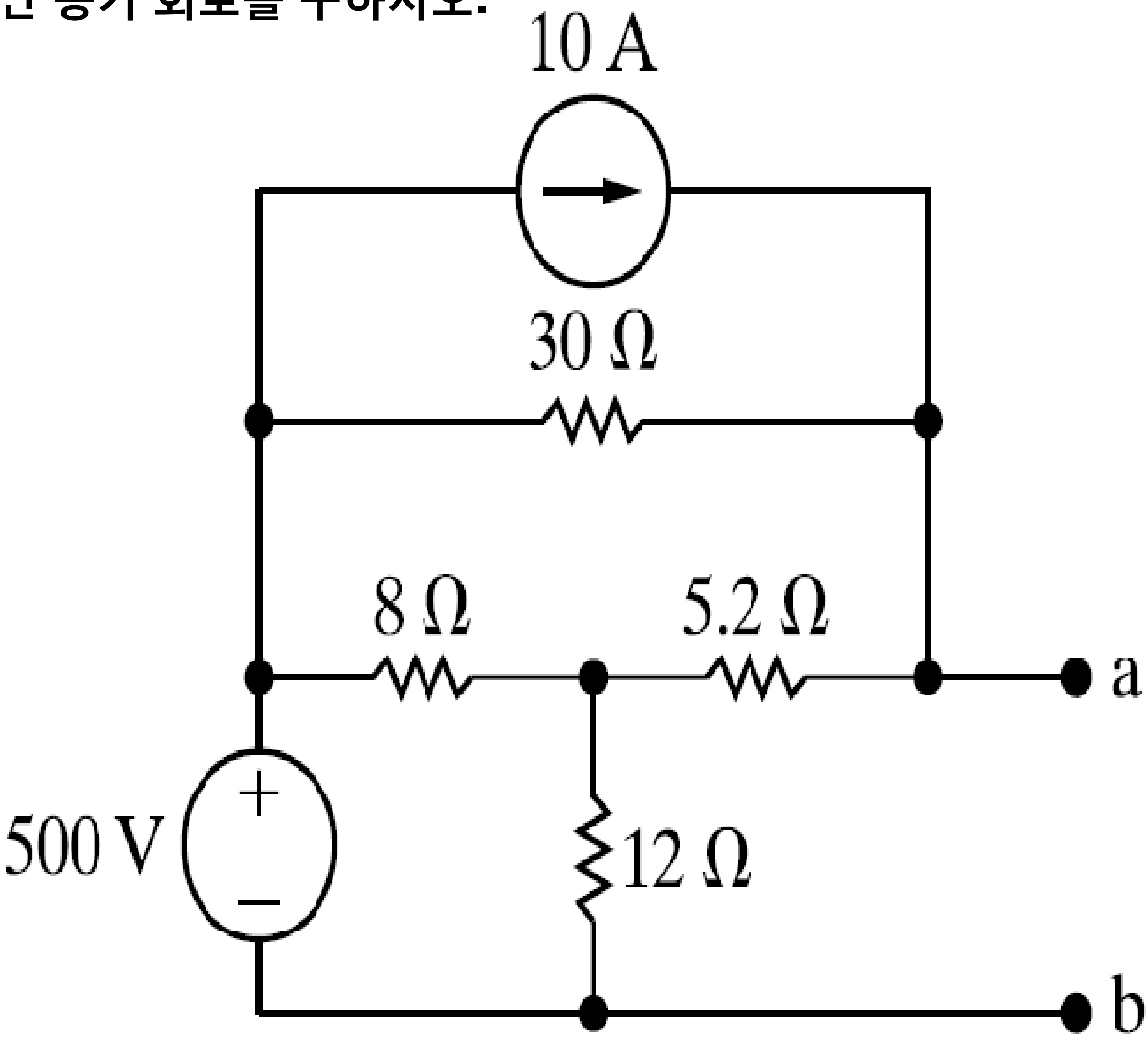
$$4v_1 - 240 + v_1 - 160 = 0 \quad \therefore \quad v_1 = 400/5 = 80\ \mathrm{V}$$

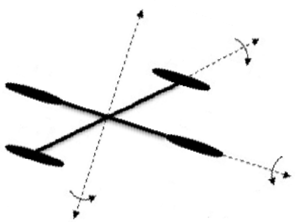
$$V_{\mathrm{Th}} = v_1 + (8)(4) = 80 + 32 = 112\ \mathrm{V}$$

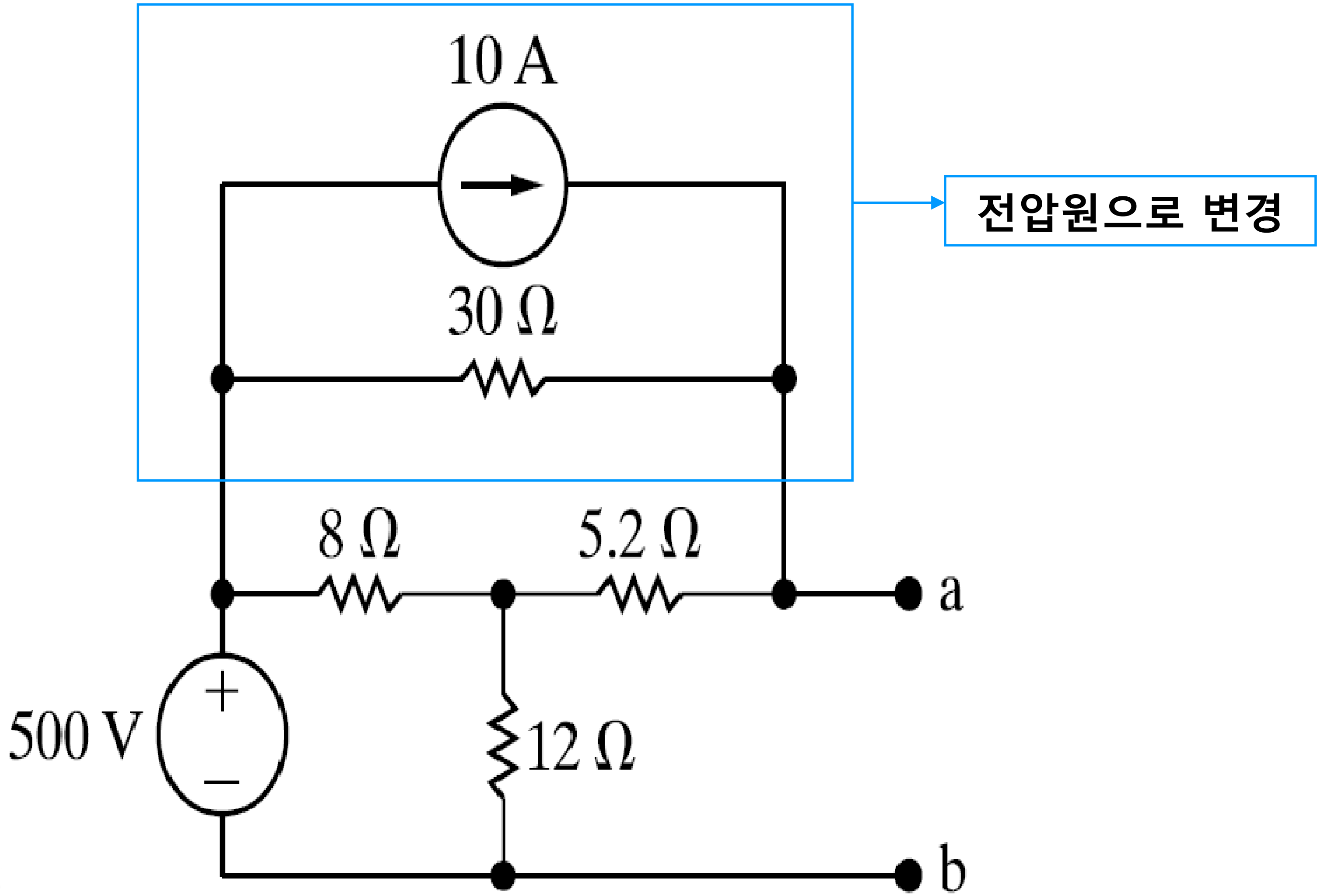
$$R_{\mathrm{Th}} = 8 + 40||10 = 8 + 8 = 16\,\Omega$$

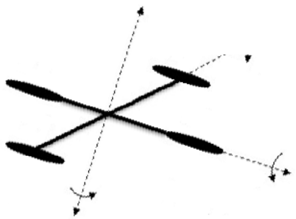


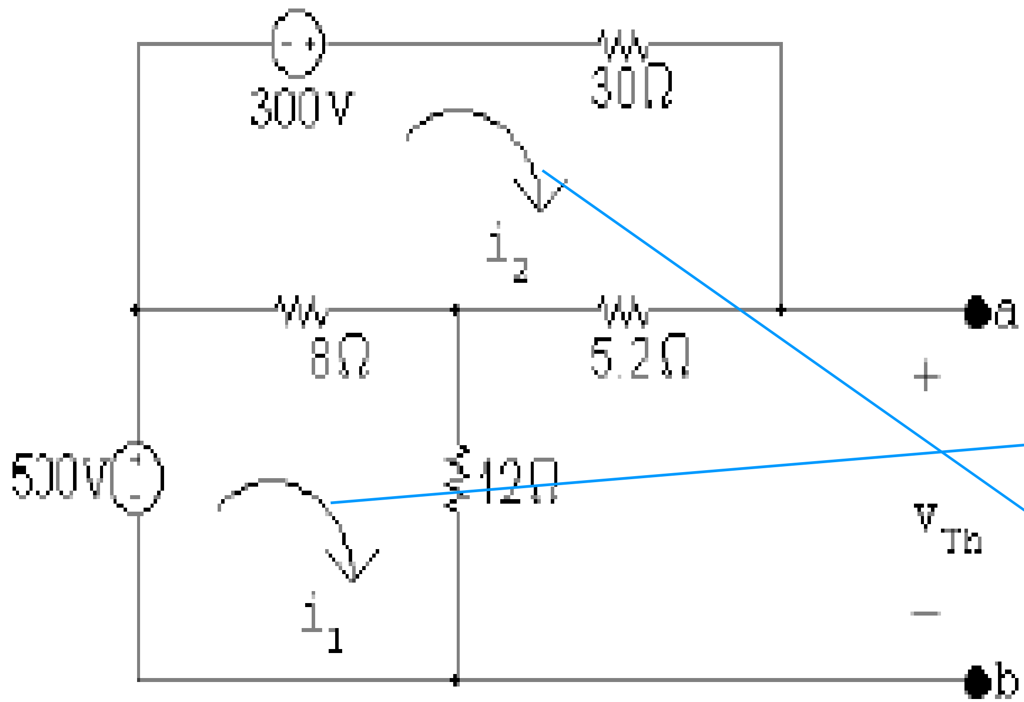
- **Ex – 테브난 등가 회로를 구하시오.**






10 A
30 Ω
전압원으로 변경
8 Ω
5.2 Ω
a
500 V
+
−
12 Ω
b





$$-500 + 8(i_1 - i_2) + 12i_1 = 0$$

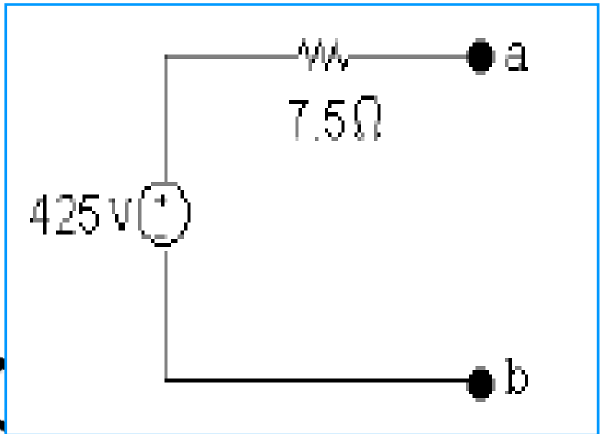
$$-300 + 30i_2 + 5.2i_2 + 8(i_2 - i_1) = 0$$

$i_1 = 30\text{ A}; \qquad i_2 = 12.5\text{ A}$

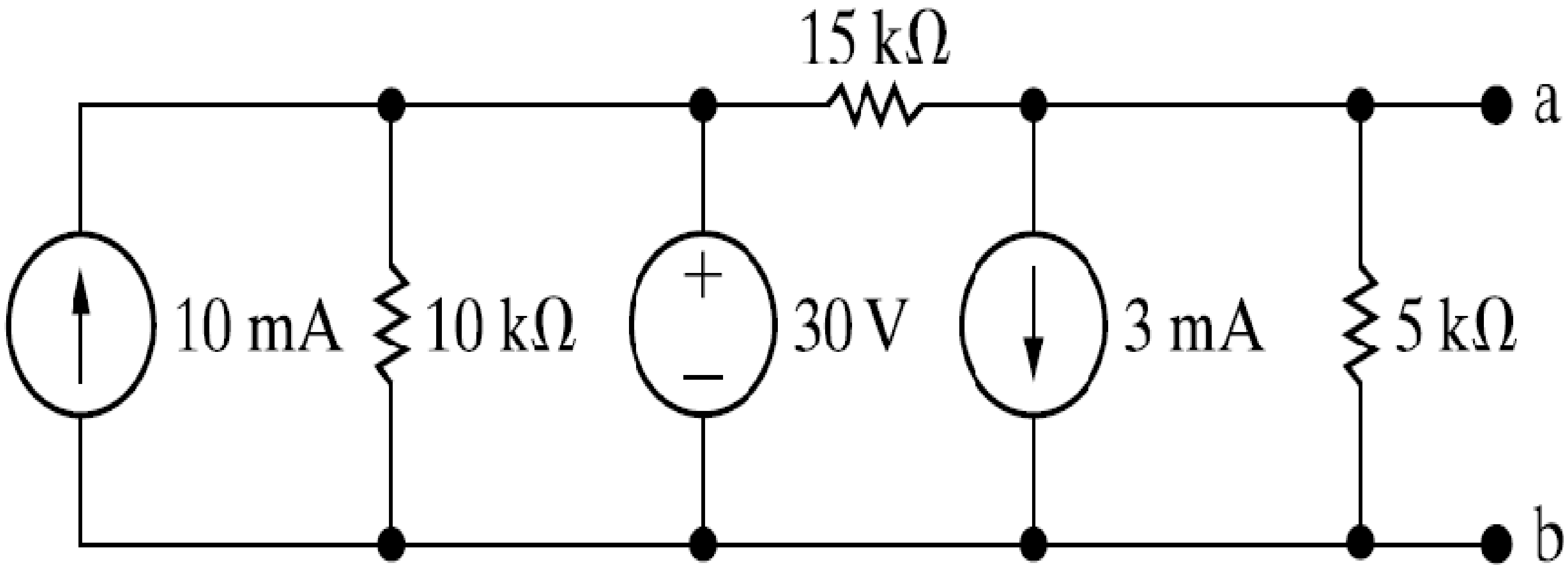
$$V_{Th} = 5.2i_2 + 12i_1 = 425\text{ V}$$

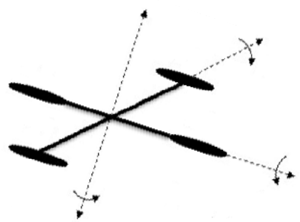
$R_{Th} = (8 \| 12 + 5.2) \| 30 = 7.5\,\Omega$

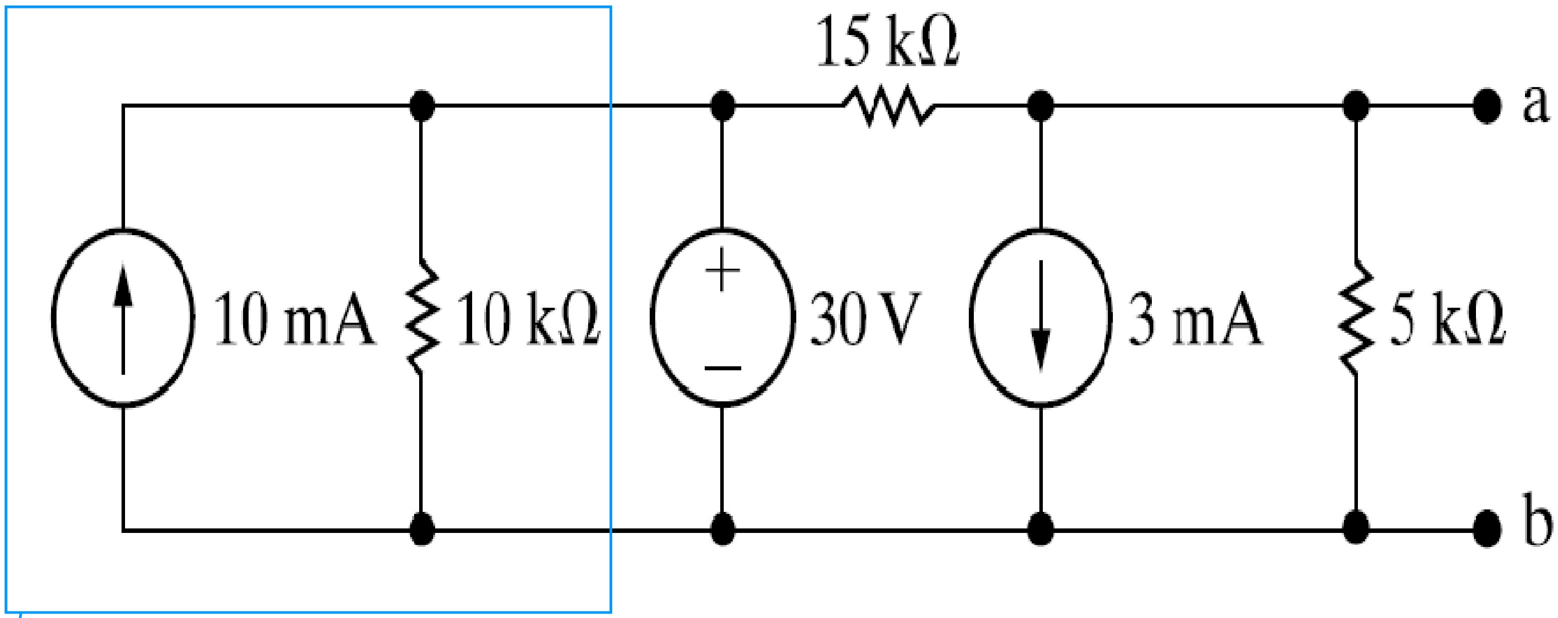
두 전압원이 단락되었다고 가정



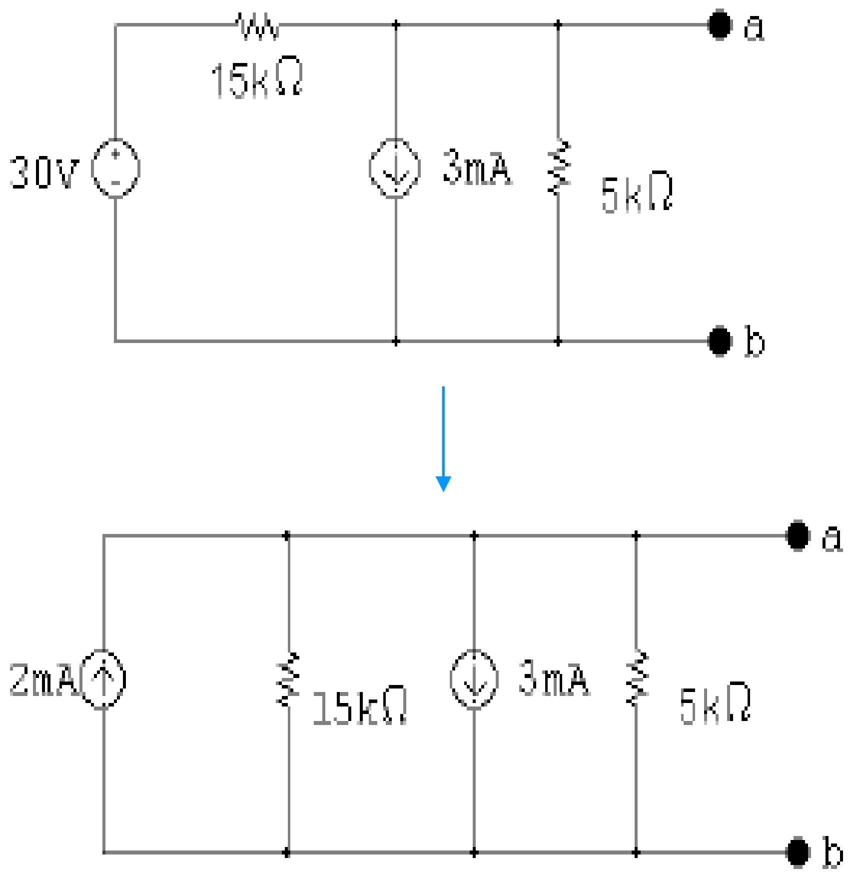
- Ex – 노튼 등가 회로를 구하시오.

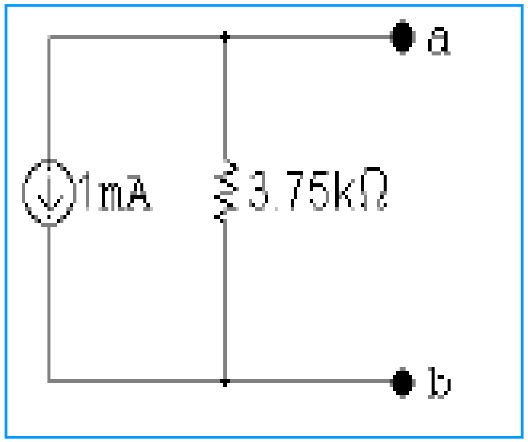






노튼등가회로는 전류원과 병렬인 등가 저항으로 구성되는데 a-b단자에서 보면 이 전류원과 저항은 a-b 단자를 노튼 등가 회로로 꾸밀 때, 병렬로 연결되어 있어 영향을 주지 못한다. 그러므로 좌측의 회로만 고려한다.


15kΩ
a
30V
3mA
5kΩ
b
a
2mA
15kΩ
3mA
5kΩ
b


a
1mA
3.75kΩ
b