Electrical Circuits

Star – Delta connection

الافكار المركزيـة

1 – Delta connection

2 – Star connection

3- Delta to Star conversion

4 – Star to Delta conversion

5 – Examples

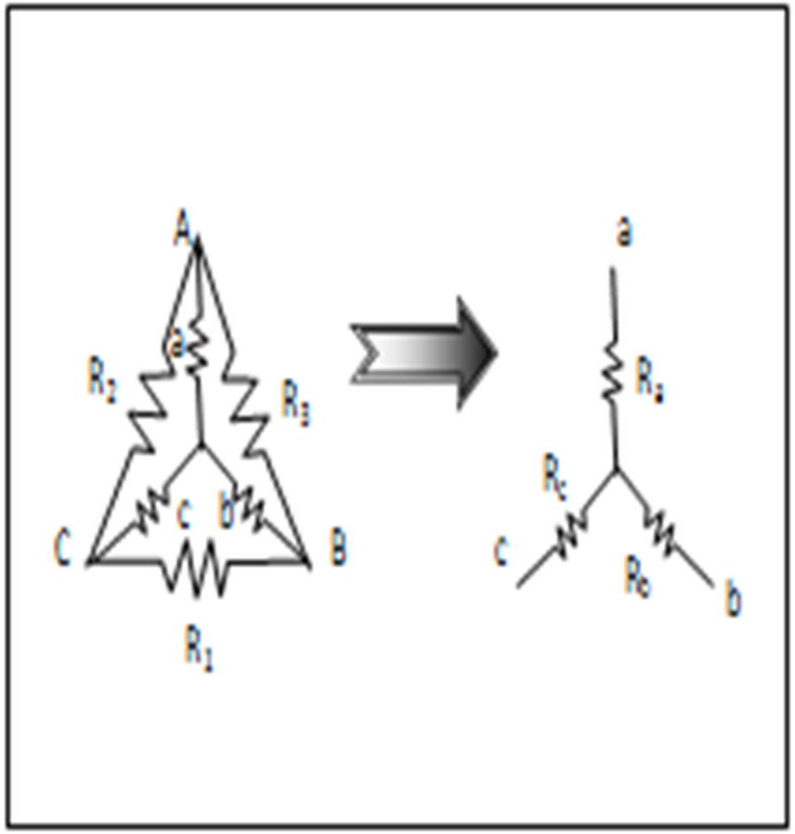
6 - Homework

Delta to Star conversion (Δ *TO Y*

$$Ra = \frac{R2\ R3}{R1+R2+R3}$$

$$Rb = \frac{R3\ R1}{R1+R2+R3}$$

$$Rc = \frac{R1\ R2}{R1+R2+R3}$$



If R1 = R2 = R3

In this case $Ra = Rb = Rc = \frac{R\Delta}{3}$

$$Ry = \frac{R\Delta}{3}$$

Example :Three Resistances 20,30,50 ohm are connected in delta find star equivalent

Solution :

$$Ra = \frac{30*50}{20+30+50} = \frac{1500}{100} = 15\ \Omega$$

$$Rb = \frac{20*50}{100} = 10\ \Omega$$

$$Rc = \frac{20*30}{100} = 6\ \Omega$$

If $R1 = R2 = R3 = 30\ \Omega$

$$Ra = Rb = Rc = \frac{R\Delta}{3} = \frac{30}{3} = 10\Omega$$

Star to delta transformation

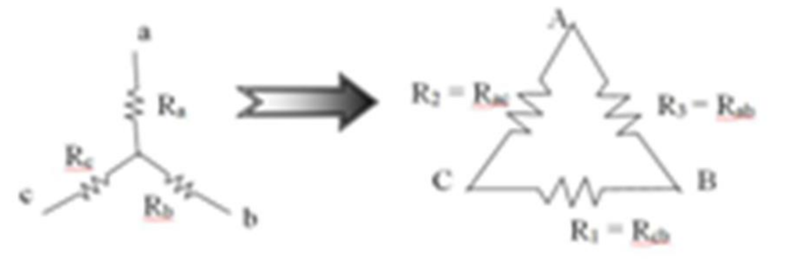
When the resistors Ra , Rb , Rc are connected to point a , b , c , this is star connection (y)

Star to delta conversion (Y to Δ)

$$Rab = Ra + Rb + \frac{Ra\,Rb}{RC}$$

$$Rbc = Rb + Rc + \frac{Rb\,Rc}{Ra}$$

$$Rac = Ra + Rc + \frac{Ra\,Rc}{Rb}$$



Fig(1) Stare Fig(2) Delta

Example :

Three resistances Ra =5 Ω , Rb = 10 Ω , Rc = 20 Ω are connected in star to point a , b , c Find the Delta – equivalent resistance .

Solution :

$$Rab = Ra + Rb + \frac{Ra\,Rb}{RC}$$

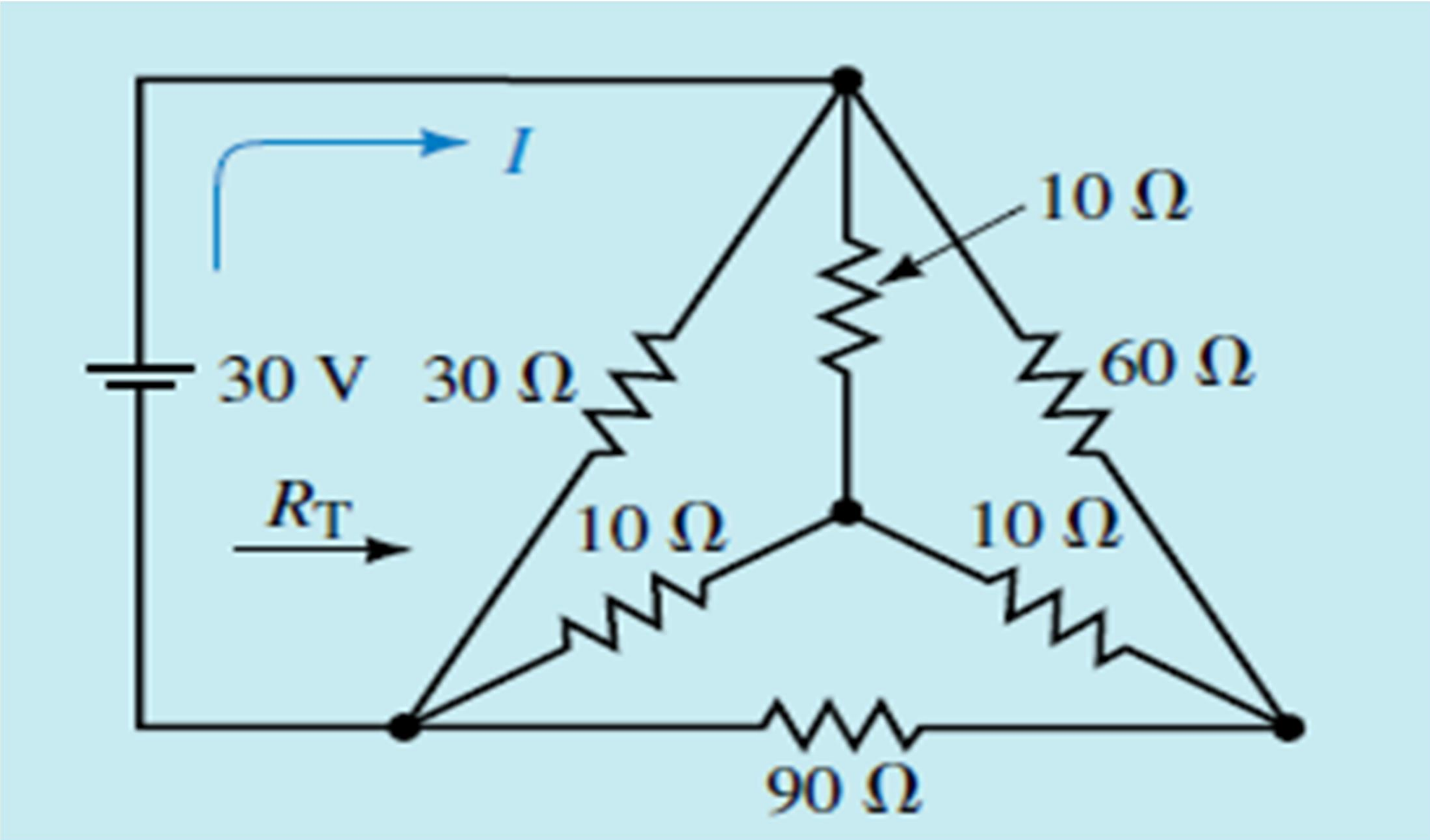
$$= 5 + 10 + \frac{5 * 10}{20} = 17.5\ \Omega$$

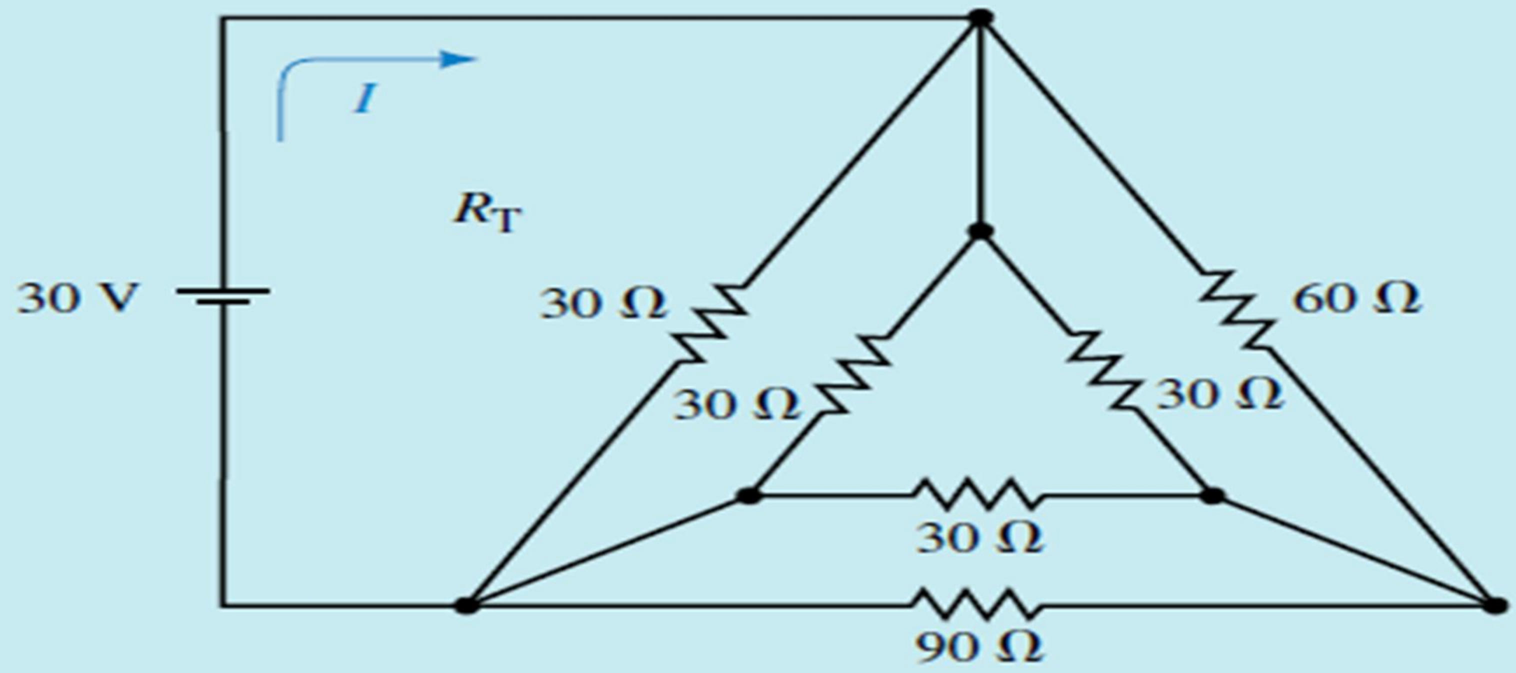
$$Rbc = Rb + Rc + \frac{Rb\,Rc}{Ra}$$

$$= 10 + 20 + \frac{20 * 10}{5} = 70\ \Omega$$

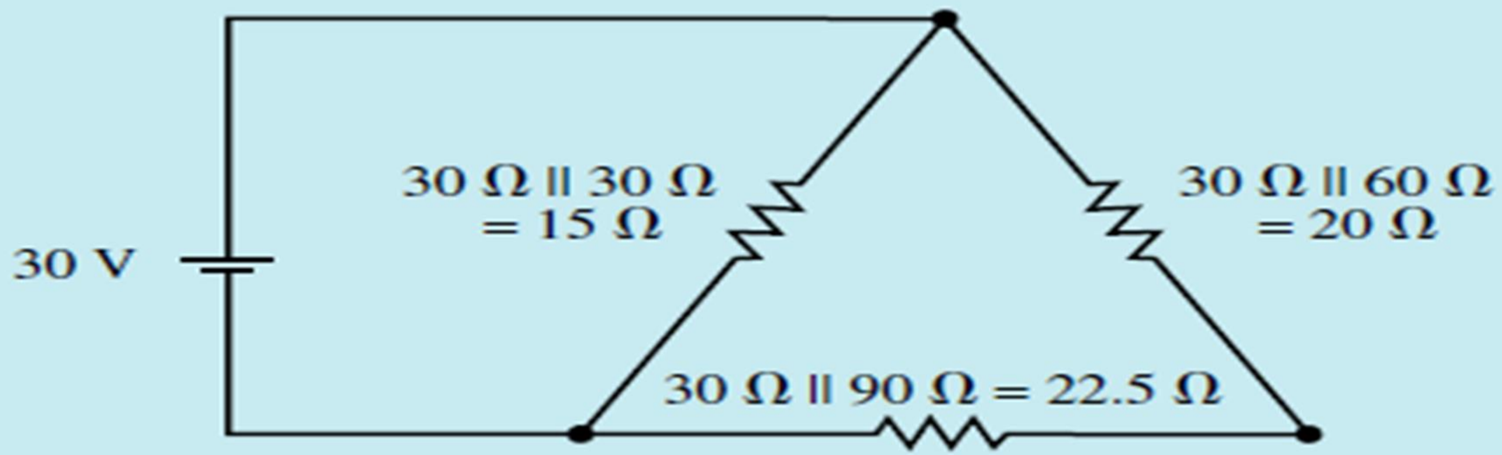
$$Rac = Ra + Rc + \frac{Ra\,Rc}{Rb}$$

Example :4- find the total current




I
R_T
30 V
30 Ω
60 Ω
30 Ω
30 Ω
30 Ω
90 Ω

(a)


30 V
30 Ω || 30 Ω
= 15 Ω
30 Ω || 60 Ω
= 20 Ω
30 Ω || 90 Ω = 22.5 Ω

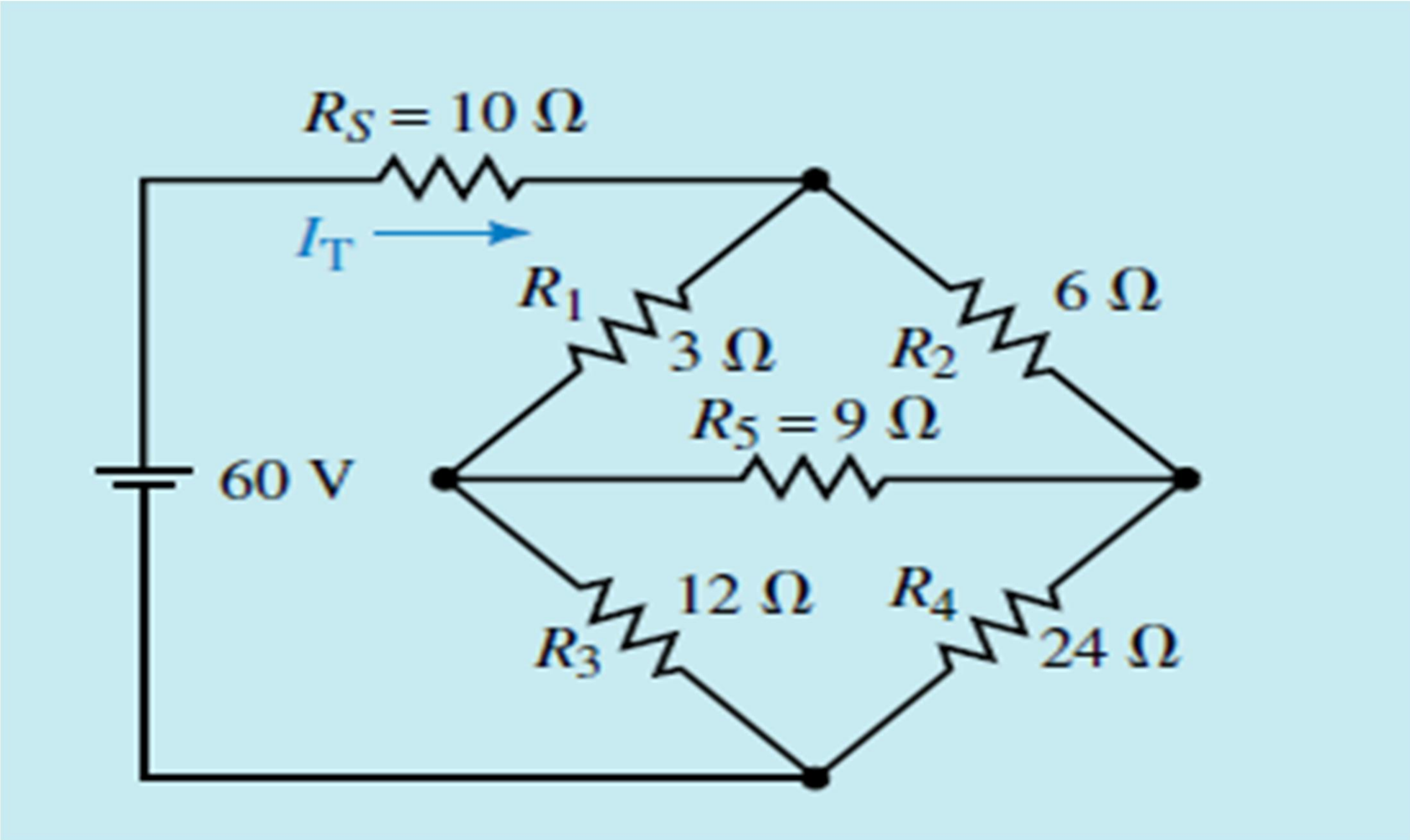
(b)

$$R_T = 15\ \Omega \| (20\ \Omega + 22.5\ \Omega)$$
$$= 11.09\ \Omega$$

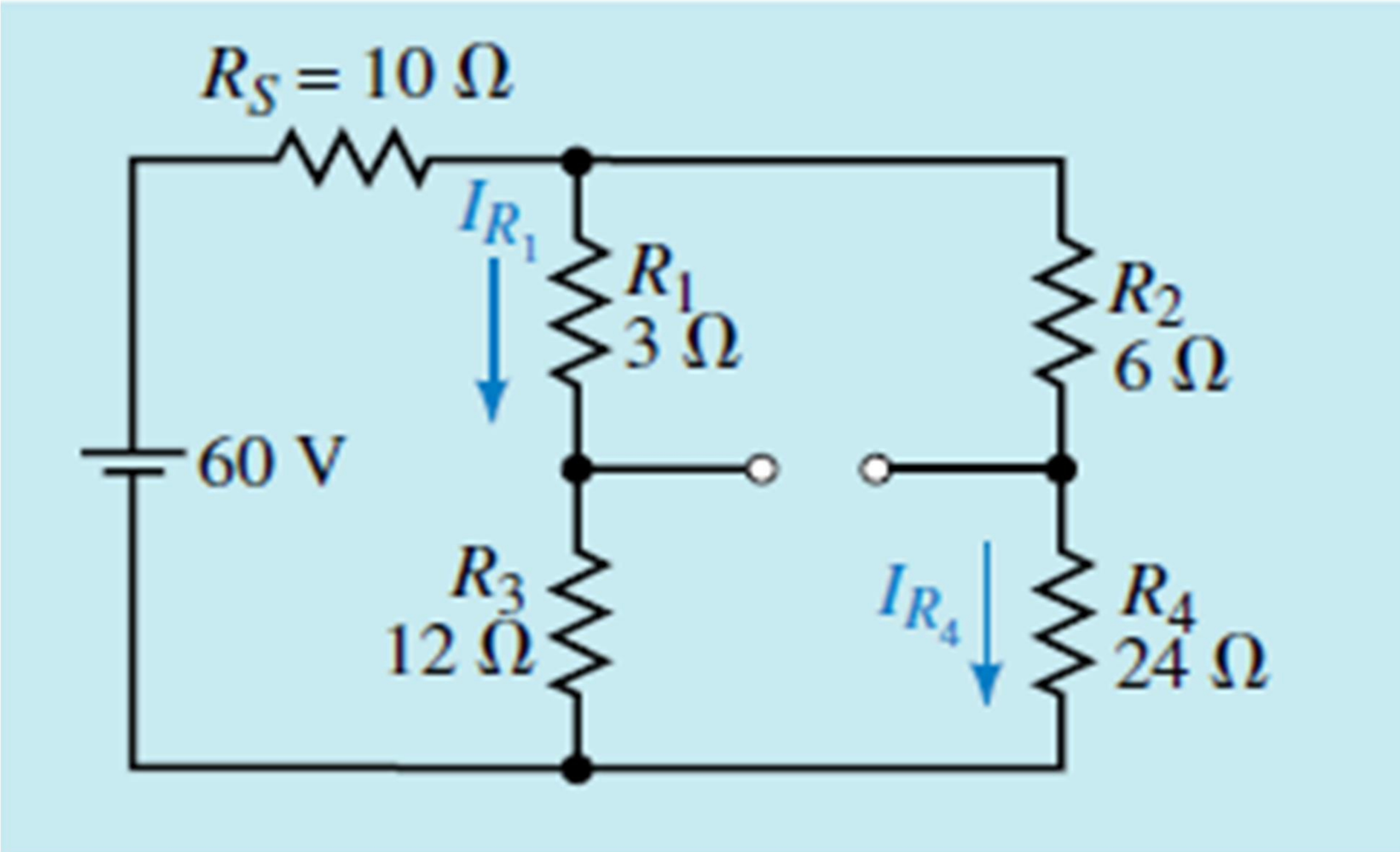
This results in a circuit current of

$$I = \frac{30\ \text{V}}{11.09\ \Omega} = 2.706\ \text{A}$$

Example :5- find the total current



Since the bridge is balance so VR5=0



The total circuit resistance is found as

$$\begin{aligned} R_T &= 10\ \Omega + (3\ \Omega + 12\ \Omega)\|(6\ \Omega + 24\ \Omega) \\ &= 10\ \Omega + 15\ \Omega\|30\ \Omega \\ &= 20\ \Omega \end{aligned}$$

The circuit current is

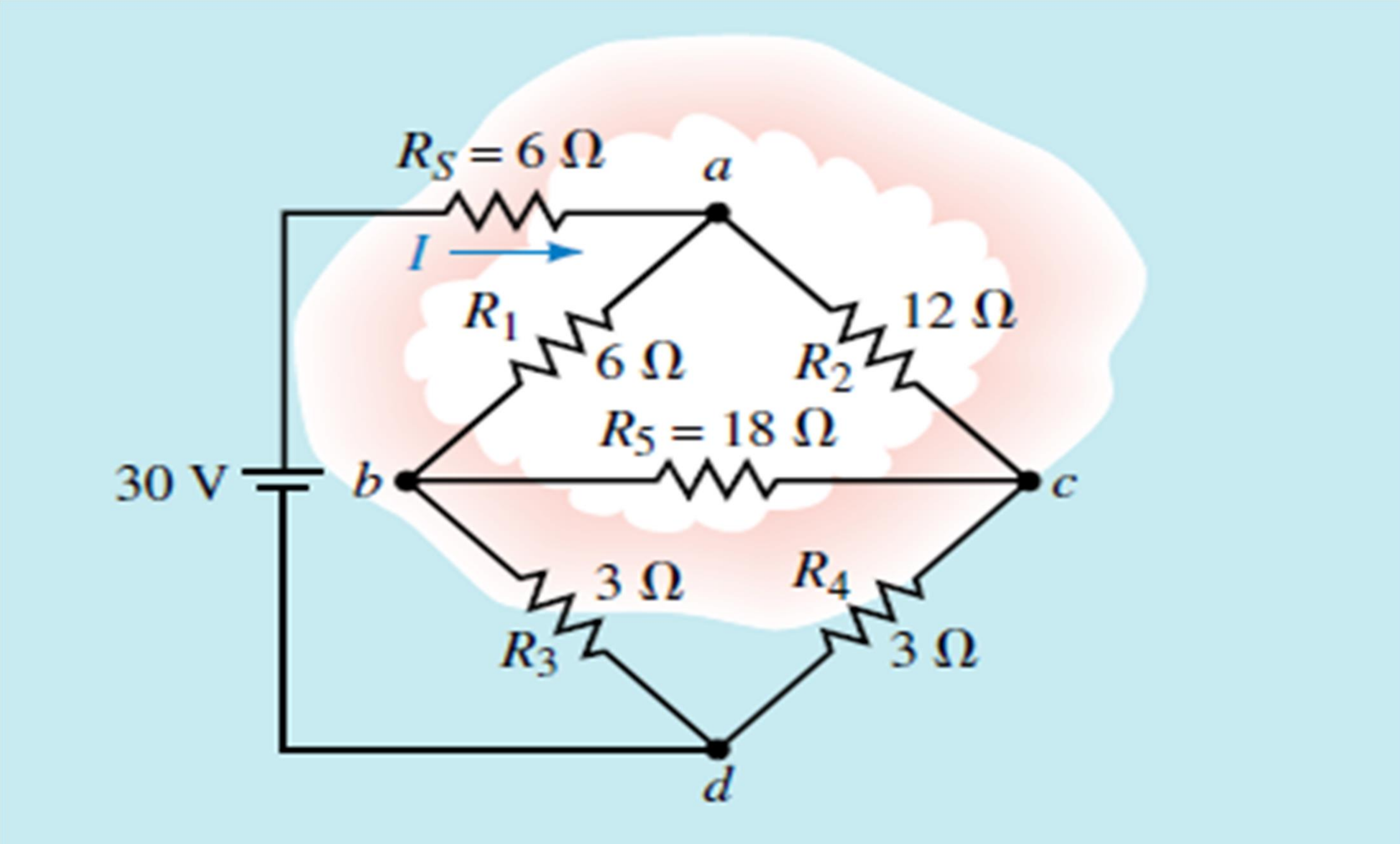
$$I_T = \frac{60\ \text{V}}{20\ \Omega} = 3.0\ \text{A}$$

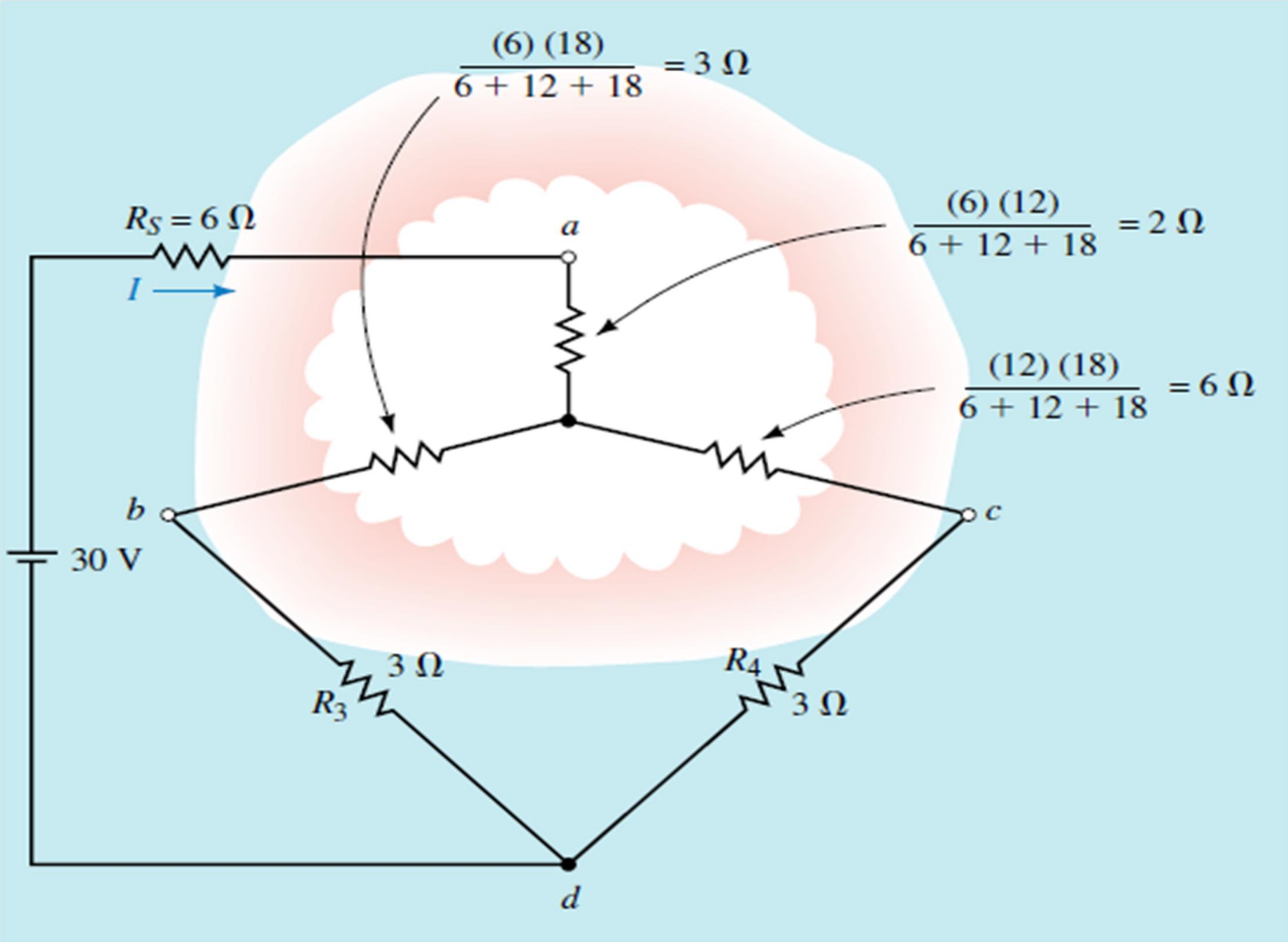
The current in each branch is then found by using the current divider rule:

$$I_{R_1} = \left(\frac{30\ \Omega}{30\ \Omega + 15\ \Omega}\right)(3.0\ \text{A}) = 2.0\ \text{A}$$

$$I_{R_4} = \frac{10\ \Omega}{24\ \Omega + 6\ \Omega}(3.0\ \text{A}) = 1.0\ \text{A}$$

Example :6- find the total current





(6) (18) / 6 + 12 + 18 = 3 Ω
(6) (12) / 6 + 12 + 18 = 2 Ω
(12) (18) / 6 + 12 + 18 = 6 Ω
R_S = 6 Ω
I
a
b
c
d
30 V
3 Ω
R_3
R_4
3 Ω

By combining resistors, it is possible to reduce the complicated circuit to the simple series circuit shown in Figure 8–58.

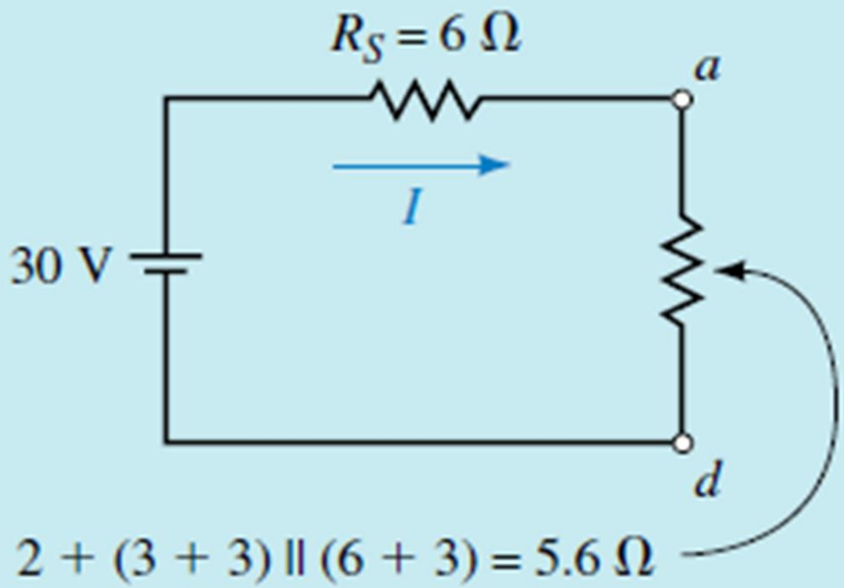


FIGURE 8–58

The circuit of Figure 8–58 is easily analyzed to give a total circuit current of

$$I = \frac{30\text{ V}}{6\ \Omega + 2\ \Omega + 3.6\ \Omega} = 2.59\text{ A}$$

Using the calculated current, it is possible to work back to the original circuit. The currents in the resistors R_3 and R_4 are found by using the current divider rule for the corresponding resistor branches, as shown in Figure 8–57.

$$I_{R3} = \frac{(6\ \Omega + 3\ \Omega)}{(6\ \Omega + 3\ \Omega) + (3\ \Omega + 3\ \Omega)}(2.59\ \text{A}) = 1.55\ \text{A}$$

$$I_{R4} = \frac{(3\ \Omega + 3\ \Omega)}{(6\ \Omega + 3\ \Omega) + (3\ \Omega + 3\ \Omega)}(2.59\ \text{A}) = 1.03\ \text{A}$$

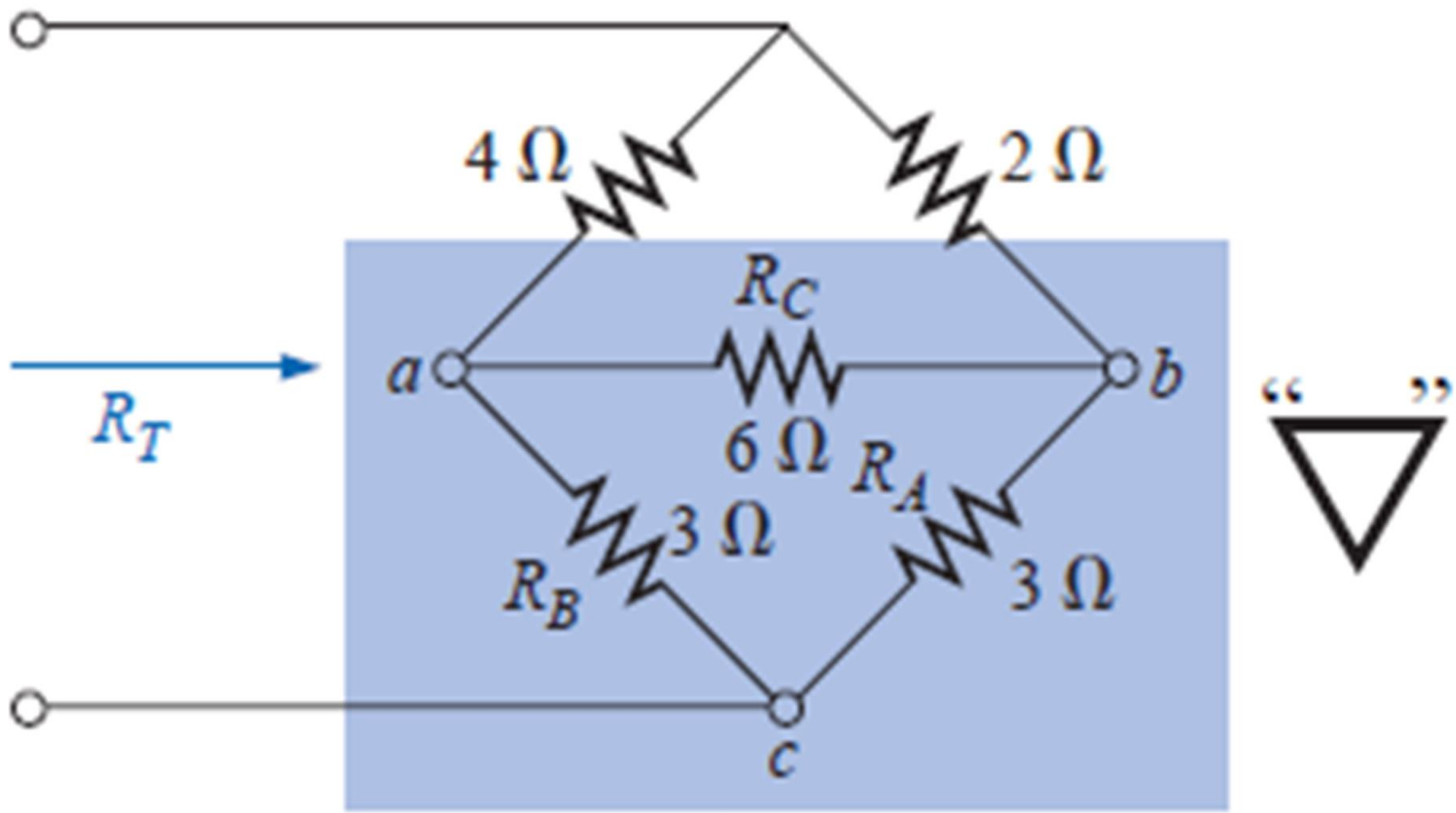
These results are exactly the same as those found in Examples 8–21 and 8–22. Using these currents, it is now possible to determine the voltage V_{bc} as

$$\begin{aligned} V_{bc} &= -(3\ \Omega)I_{R_4} + (3\ \Omega)I_{R_3} \\ &= (-3\ \Omega)(1.034\ \text{A}) + (3\ \Omega)(3.103\ \text{A}) \\ &= 1.55\ \text{V} \end{aligned}$$

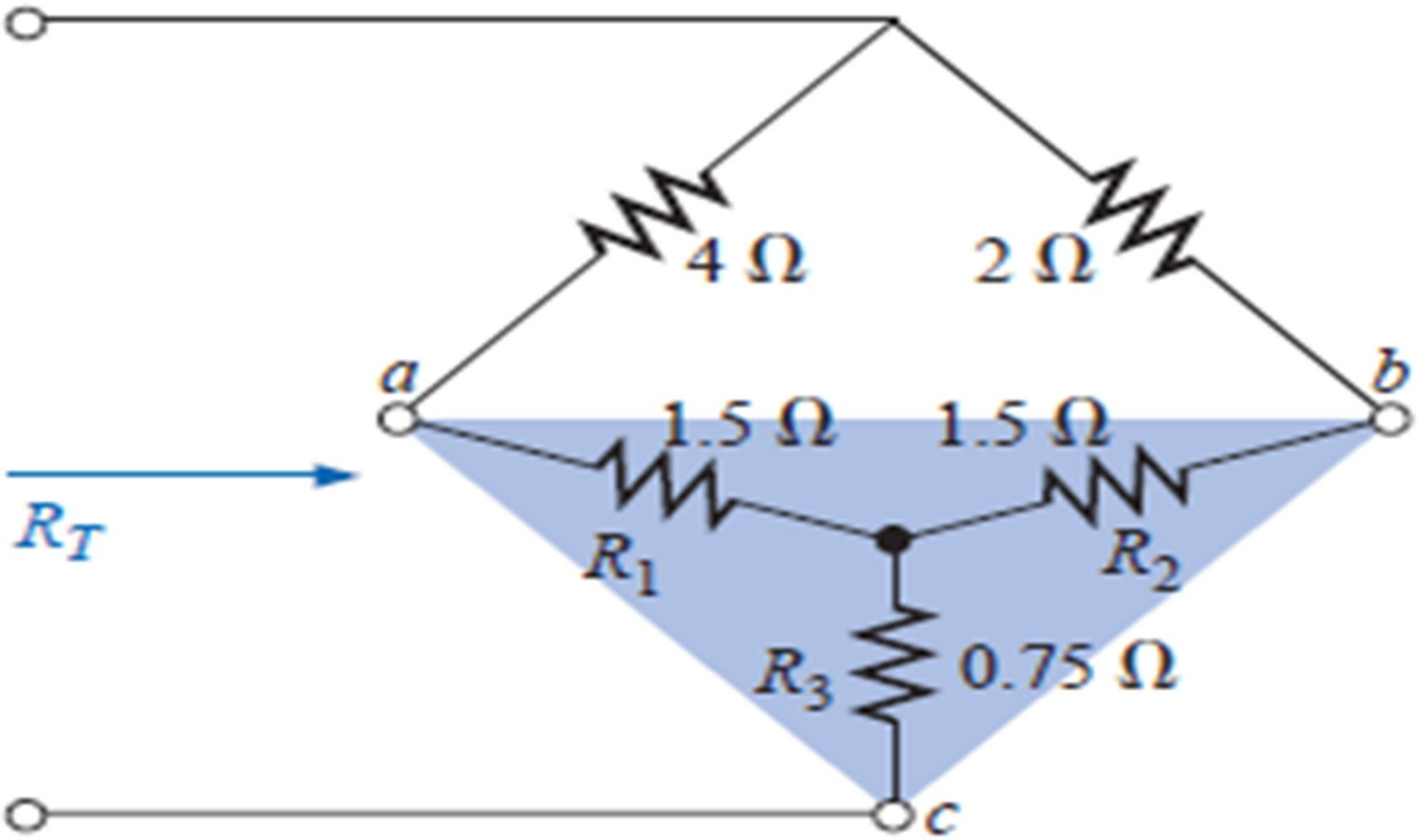
The current through R_5 is determined to be

$$I_{R5} = \frac{1.55\ \text{V}}{18\ \Omega} = 0.086\ \text{A} \quad \text{to the right}$$

Example :7- find Total Resistance



Convert delta (abc) to star



Solution:

Two resistors of the Δ were equal; therefore, two resistors of the Y will be equal.

$$R_1 = \frac{R_B R_C}{R_A + R_B + R_C} = \frac{(3\ \Omega)(6\ \Omega)}{3\ \Omega + 3\ \Omega + 6\ \Omega} = \frac{18\ \Omega}{12} = \mathbf{1.5\ \Omega}$$

$$R_2 = \frac{R_A R_C}{R_A + R_B + R_C} = \frac{(3\ \Omega)(6\ \Omega)}{12\ \Omega} = \frac{18\ \Omega}{12} = \mathbf{1.5\ \Omega}$$

$$R_3 = \frac{R_A R_B}{R_A + R_B + R_C} = \frac{(3\ \Omega)(3\ \Omega)}{12\ \Omega} = \frac{9\ \Omega}{12} = \mathbf{0.75\ \Omega}$$

Replacing the Δ by the Y, as shown in Fig. 8.81, yields

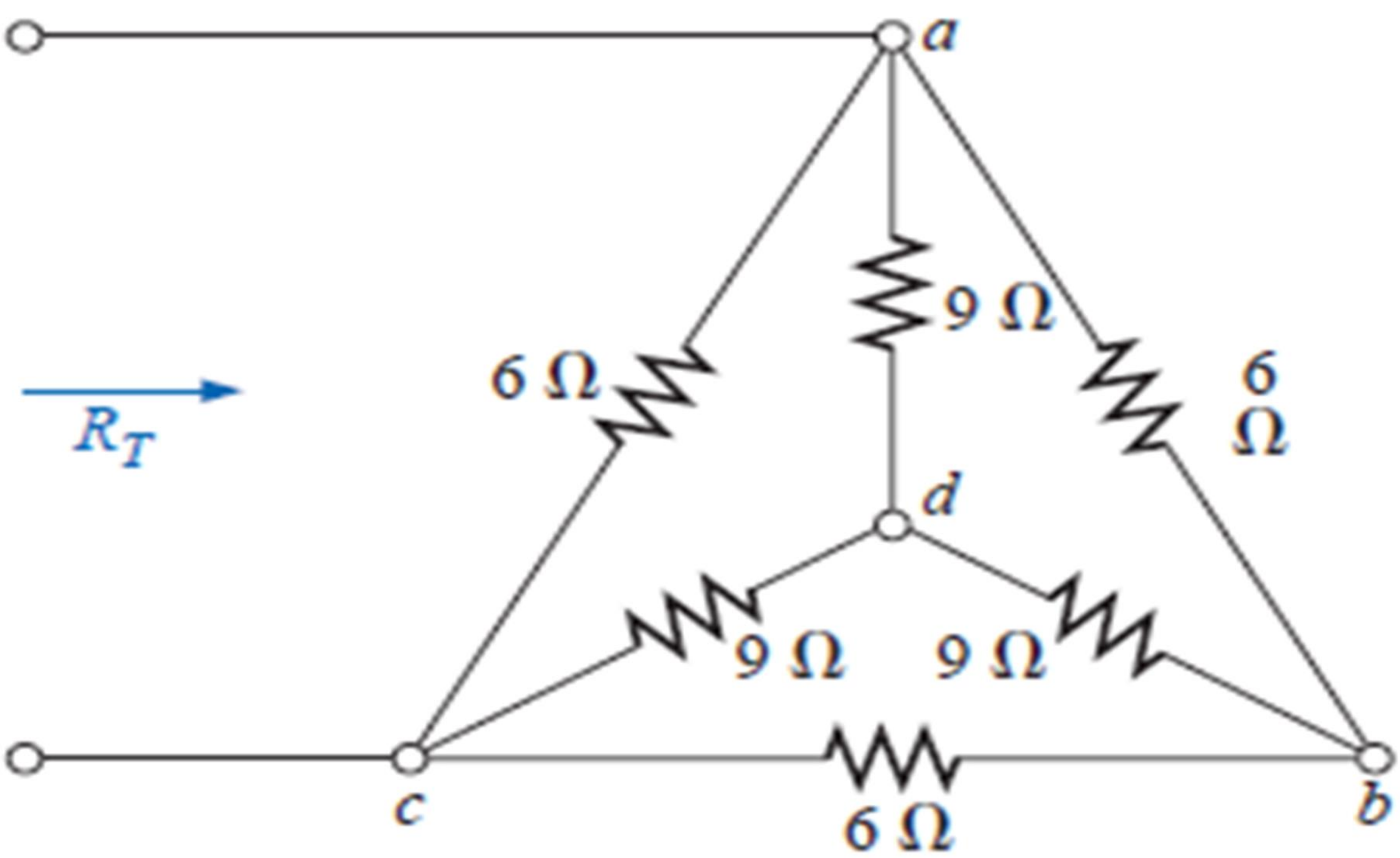
$$R_T = 0.75\ \Omega + \frac{(4\ \Omega + 1.5\ \Omega)(2\ \Omega + 1.5\ \Omega)}{(4\ \Omega + 1.5\ \Omega) + (2\ \Omega + 1.5\ \Omega)}$$

$$= 0.75\ \Omega + \frac{(5.5\ \Omega)(3.5\ \Omega)}{5.5\ \Omega + 3.5\ \Omega}$$

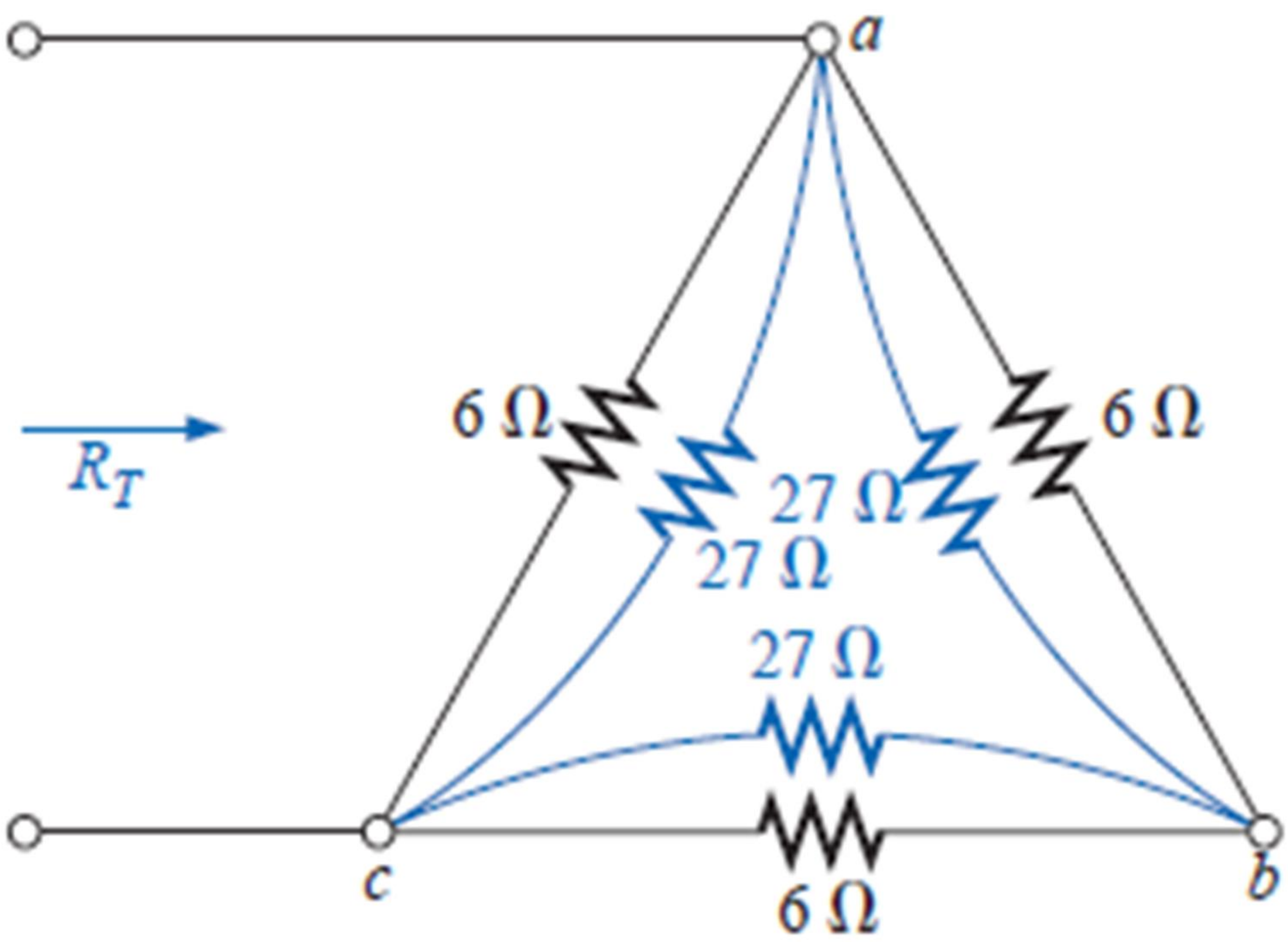
$$= 0.75\ \Omega + 2.139\ \Omega$$

$$R_T = \mathbf{2.889\ \Omega}$$

Example :8- find Total Resistance



Covert star to delta as shown below



b. *Converting the Y to a Δ:*

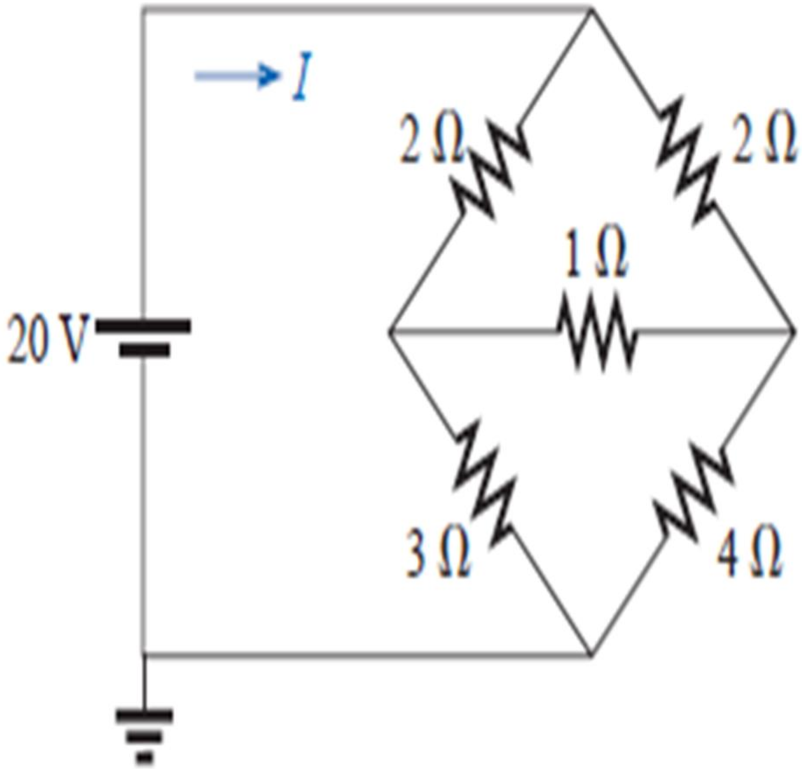
$$R_\Delta = 3R_Y = (3)(9\ \Omega) = 27\ \Omega \qquad \text{(Fig. 8.85)}$$

$$R'_T = \frac{(6\ \Omega)(27\ \Omega)}{6\ \Omega + 27\ \Omega} = \frac{162\ \Omega}{33} = 4.9091\ \Omega$$

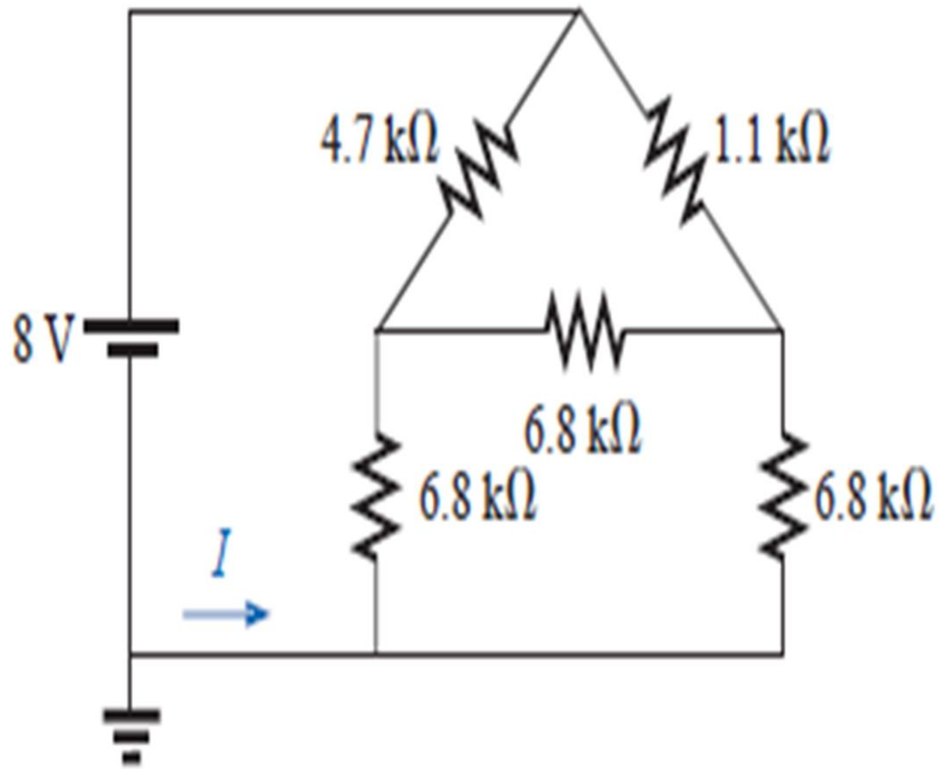
$$R_T = \frac{R'_T\,(R'_T + R'_T)}{R'_T + (R'_T + R'_T)} = \frac{R'_T 2R'_T}{3R'_T} = \frac{2R'_T}{3}$$

$$= \frac{2(4.9091\ \Omega)}{3} = \mathbf{3.2727\ \Omega}$$

Example :9- for the circuits shown find the current (I)   (H.W   )

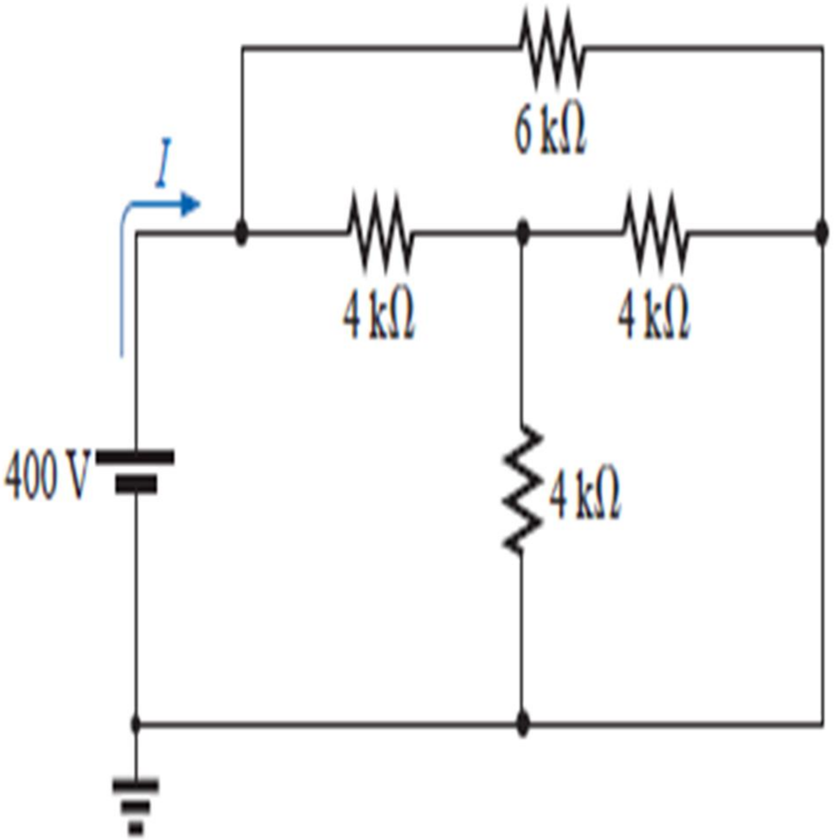


(a)

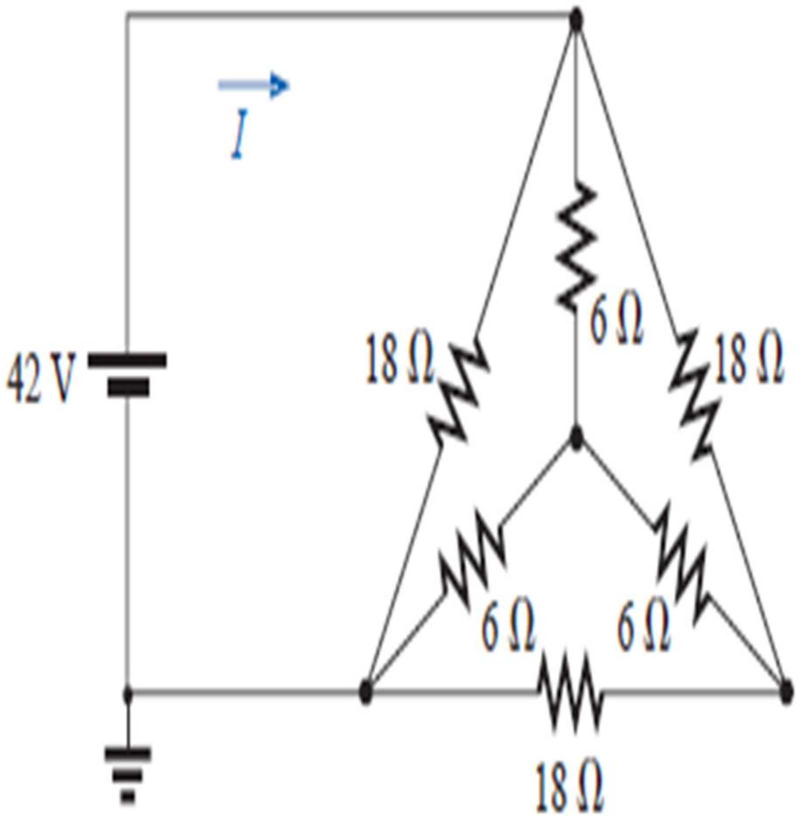


(b)

Example :10- for the circuitS shown find the current (I) (H.W)

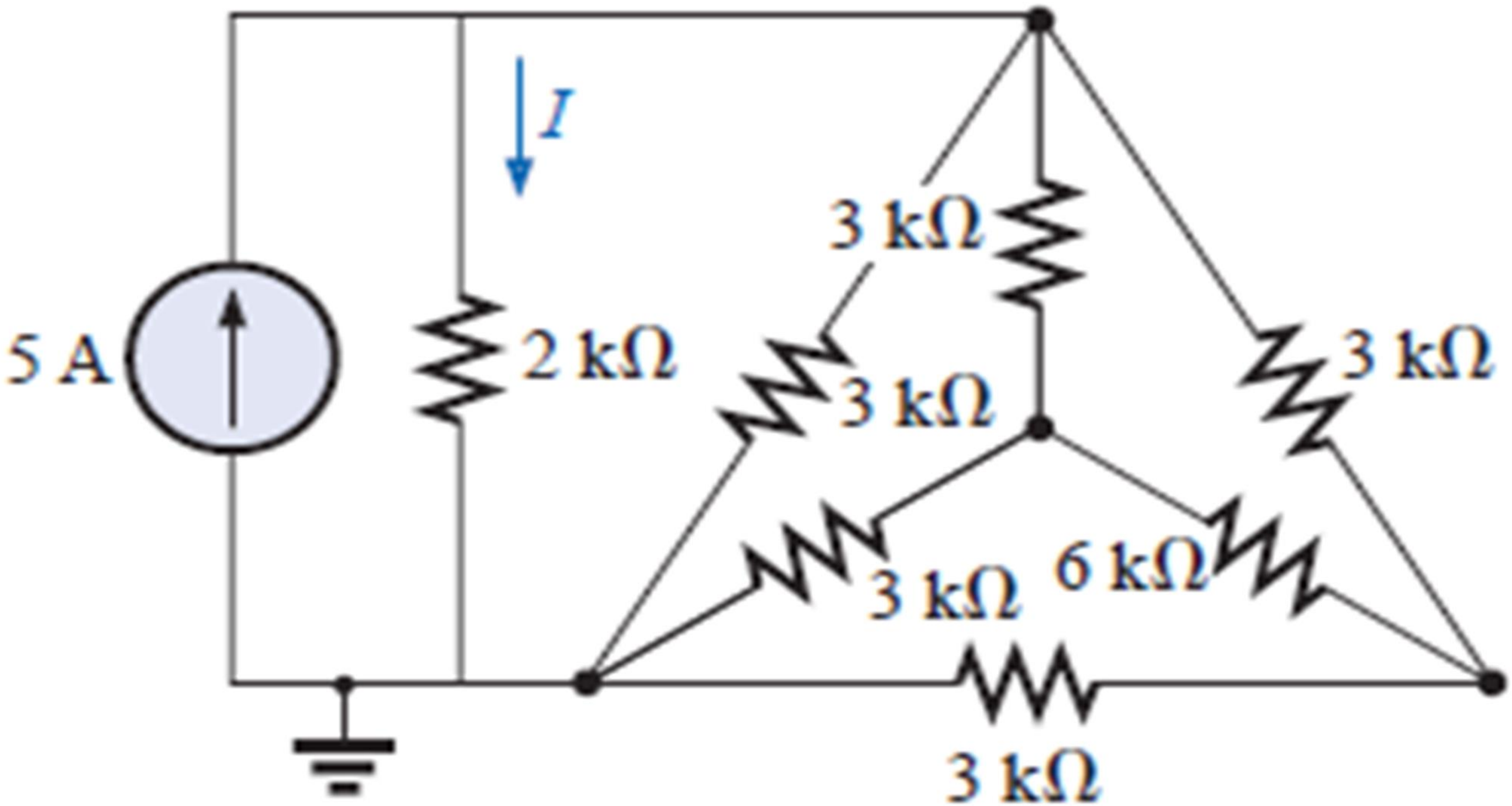


(a)



(b)

Example :11- for the circuit shown find the current (I) (H.W)



Example : 12 - find the total current (HW)