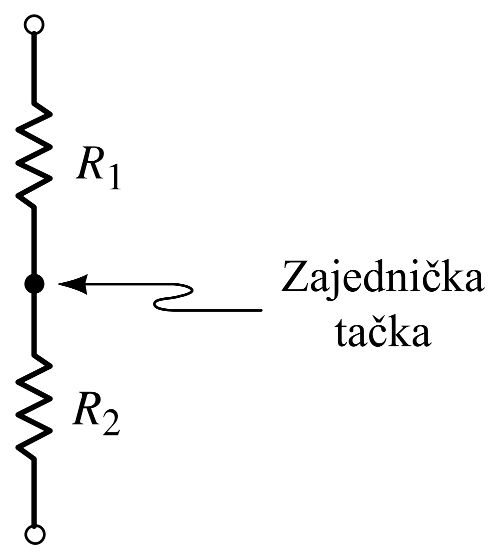
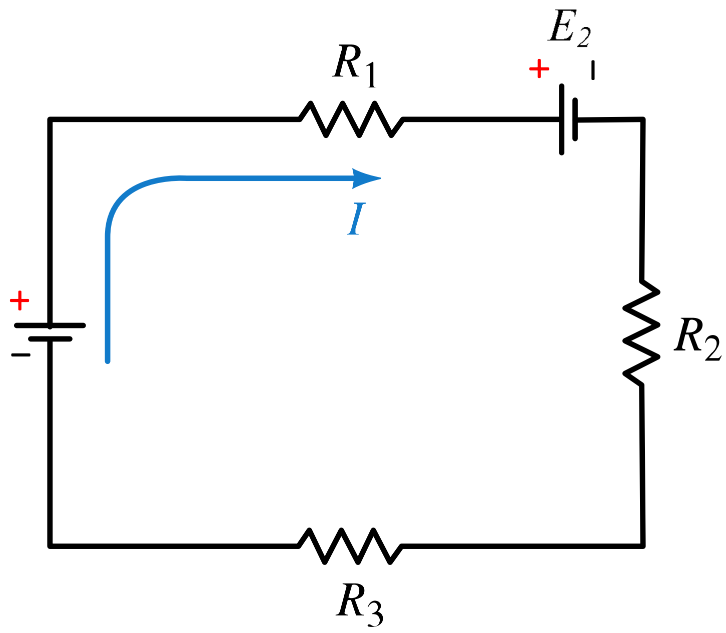
Serijska veza elemenata u strujnom kolu

- Kažemo da su dva elementa (otpornika) vezana u seriju ako imaju samo jednu zajedničku tačku
- Serijsko strujno kolo čine više izvora (baterija) i potrošača (otpornika) povezanih u seriju
- **U serijskom strujnom kolu jedna te ista struja protiče kroz sve elemente u serijskoj vezi**





II Kirhofov zakon (za napone u kolu)

- Najprostiju strujnu konturu čini serijsko strujno kolo sa više izvora (baterija) i potrošača (otpornika)
- **Drugi Kirhofov zakon:** U zatvorenoj strujnoj konturi **suma svih izvora (baterija)** jednaka je **sumi padova napona na otporima**

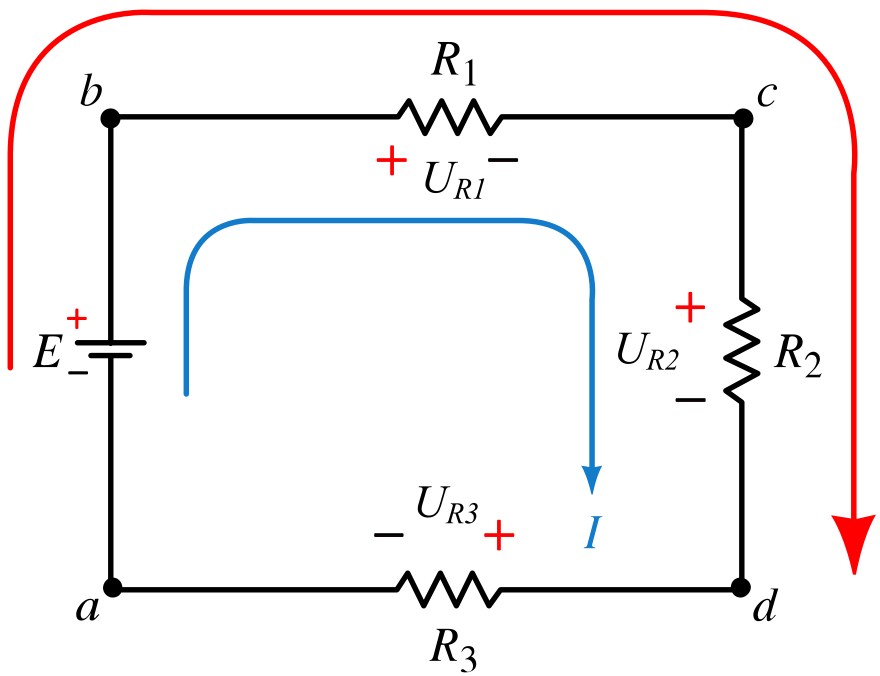
$$\sum_{i=1}^{n} E_i = \sum_{k=1}^{m} R_k \cdot I_k$$

$$\sum_{i=1}^{n} E_i - \sum_{k=1}^{m} R_k \cdot I_k = 0$$

$$\sum_{i=1}^{n} E_i = \sum_{k=1}^{m} U_{R_k}$$

II Kirhofov zakon (za napone u kolu)

- Usvojimo da se smjer obilaska konture podudara sa smjerom proticanja struje kroz konturu
- Izvori (baterije) će imati pozitivan znak ako smjer obilaska konture izlazi iz (+) pola a uvire u (-) pol izvora (baterije)
- Padovi napona na otpornicima su pozitivni ako se smjer struje kroz otpornik podudara sa smjerom obilaska konture



$$E - U_{R1} + U_{R2} + U_{R3} = 0$$

$$E = U_{R1} + U_{R2} + U_{R3}$$

$$E = I \cdot R_1 + I \cdot R_2 + I \cdot R_3$$

II Kirhofov zakon

Primjer:

EXAMPLE 5–2 Verify Kirchhoff's voltage law for the circuit of Figure 5–8.

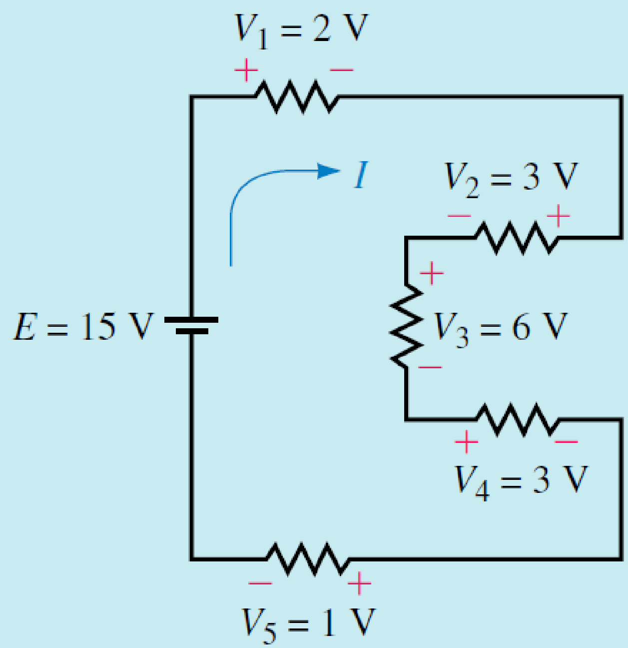


FIGURE 5–8

Solution If we follow the direction of the current, we write the loop equation as

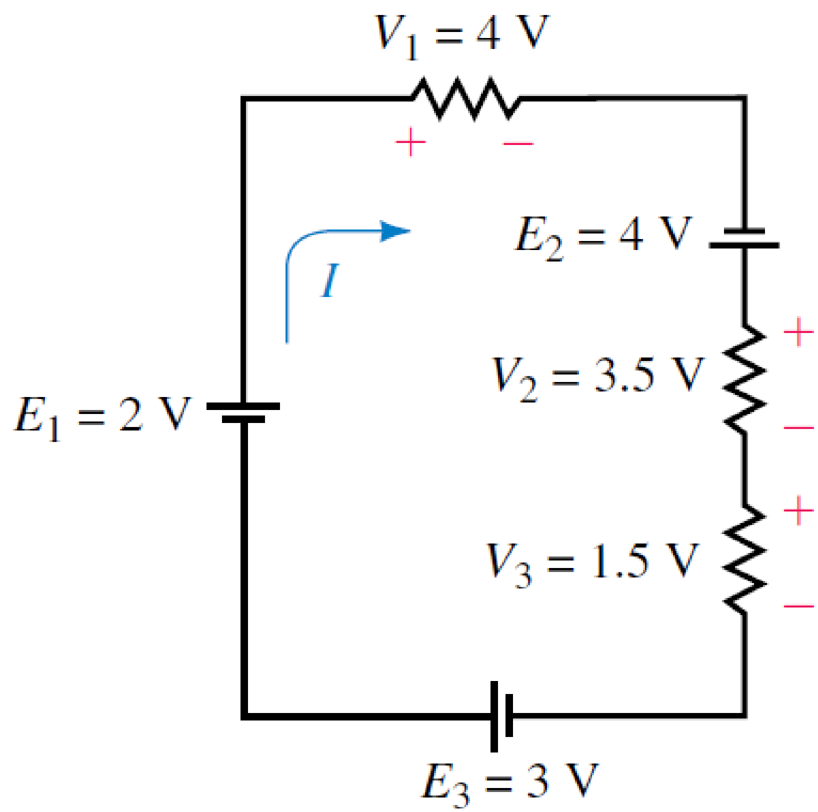
$$15\text{ V} - 2\text{ V} - 3\text{ V} - 6\text{ V} - 3\text{ V} - 1\text{ V} = 0$$

II Kirhofov zakon

Primjer:

Verify Kirchhoff's voltage law for the circuit of Figure 5–9.

FIGURE 5–9

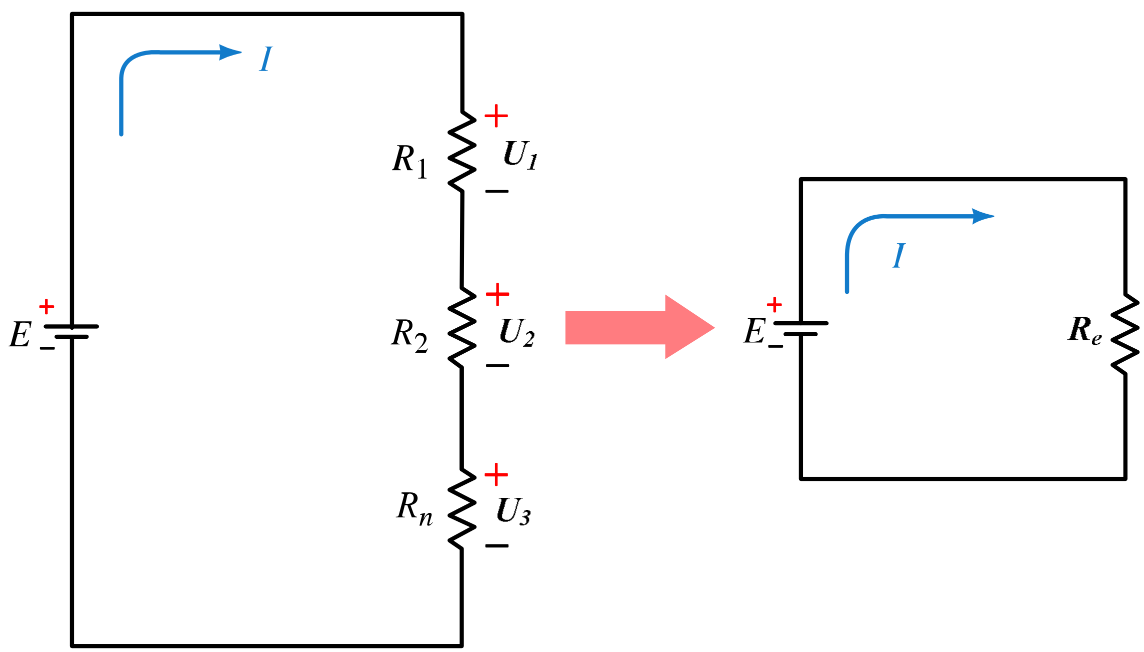


Answer: $2\text{ V} - 4\text{ V} + 4\text{ V} - 3.5\text{ V} - 1.5\text{ V} + 3\text{ V} = 0$

Serijska veza otpornika

- Kroz sve otpornike u serijskoj vezi teče jedna te ista struja I
- Na svakom otporniku pravi pad napona: $U_x = I \cdot R_x$
- Primjenom II Kirhofov zakona dobijamo:

$$E = U_1 + U_2 + \ldots + U_n$$
$$E = I \cdot R_1 + I \cdot R_2 + \ldots + I \cdot R_n$$
$$E = I \cdot \left(R_1 + R_2 + \ldots + R_n\right)$$



$$R_e = \left(R_1 + R_2 + \ldots + R_n\right)$$

Serijska veza otpornika

Primjer:

EXAMPLE 5–3 Determine the total resistance for each of the networks shown in Figure 5–12.

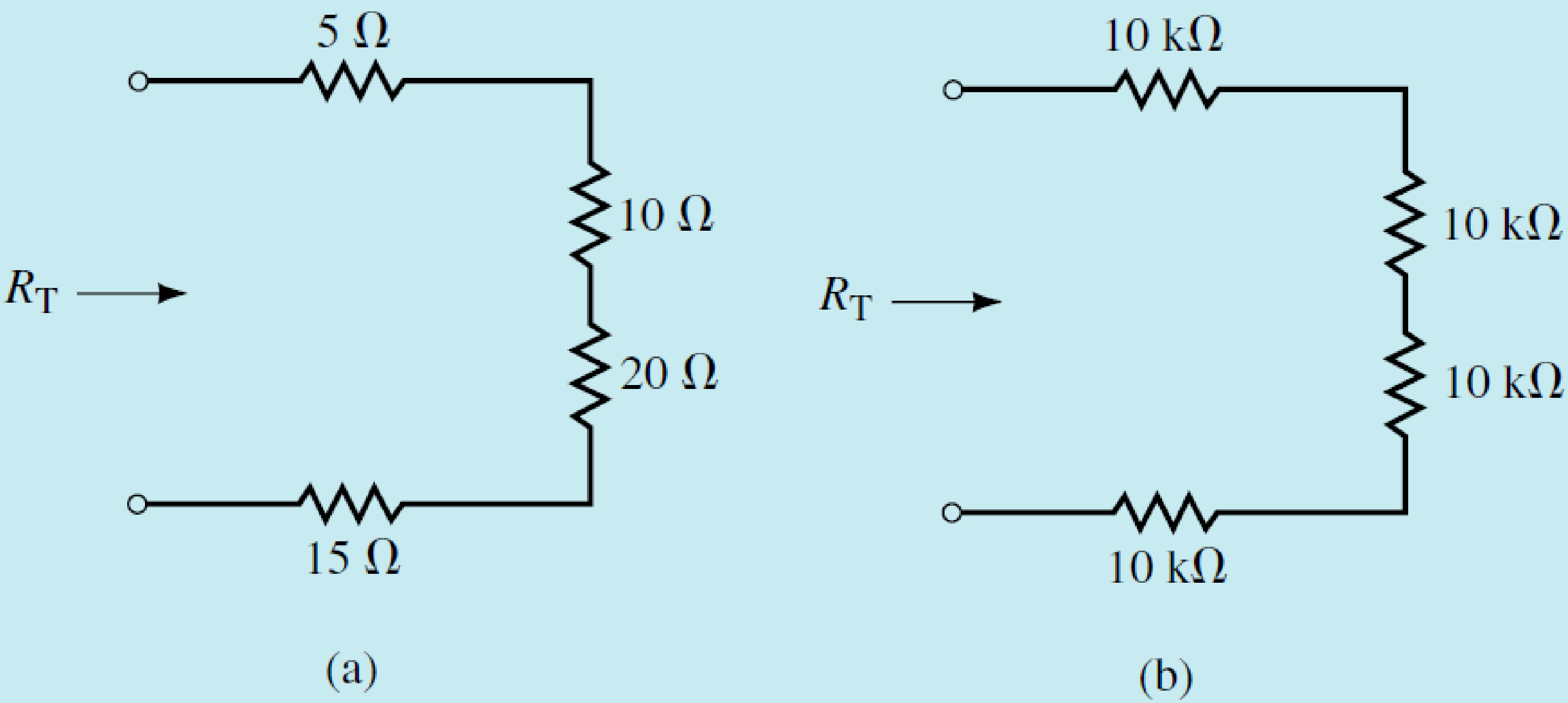


FIGURE 5–12

Raspodjela snaga kod serijske veze otpora

- Snaga koja se troši na pojedinim otpornicima u vezi data je izrazom:

$$P_1 = U_1 \cdot I = \frac{U_1^2}{R_1} = I^2 \cdot R_1$$

$$P_2 = U_2 \cdot I = \frac{U_2^2}{R_2} = I^2 \cdot R_2$$

$$P_n = U_n \cdot I = \frac{U_n^2}{R_n} = I^2 \cdot R_n$$

- Enaga koju izvor predaje potrošačima data je sa: $P_{izvora} = E \cdot I$
- Ukupna snaga u kolu jednaka je sumi snaga koje se triše na pojedinim otpornicima u serijskoj vezi

$$P_{ukupno} = P_1 + P_2 + \ldots + P_n$$

Raspodjela snaga kod serijske veze otpora

Primjer:

EXAMPLE 5–4

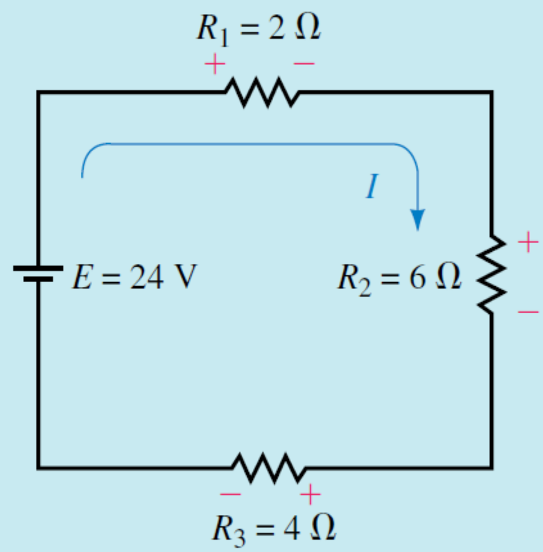


FIGURE 5–13

For the series circuit shown in Figure 5–13, find the following quantities:

a. Total resistance, R_T.

b. Circuit current, I.

c. Voltage across each resistor.

d. Power dissipated by each resistor.

e. Power delivered to the circuit by the voltage source.

f. Verify that the power dissipated by the resistors is equal to the power delivered to the circuit by the voltage source.

Raspodjela snaga kod serijske veze otpora

Primjer:

Solution

a. $R_T = 2\ \Omega + 6\ \Omega + 4\ \Omega = 12.0\ \Omega$

b. $I = (24\ V)/(12\ \Omega) = 2.00\ A$

c. $V_1 = (2\ A)(2\ \Omega) = 4.00\ V$

$V_2 = (2\ A)(6\ \Omega) = 12.0\ V$

$V_3 = (2\ A)(4\ \Omega) = 8.00\ V$

d. $P_1 = (2\ A)^2(2\ \Omega) = 8.00\ W$

$P_2 = (2\ A)^2(6\ \Omega) = 24.0\ W$

$P_3 = (2\ A)^2(4\ \Omega) = 16.0\ W$

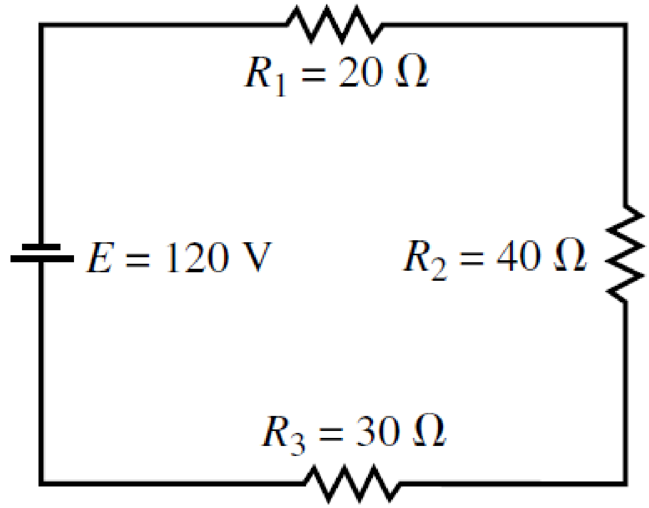
e. $P_T = (24\ V)(2\ A) = 48.0\ W$

f. $P_T = 8\ W + 24\ W + 16\ W = 48.0\ W$

Raspodjela snaga kod serijske veze otpora

Primjer:

FIGURE 5–14



For the series circuit shown in Figure 5–14, find the following quantities:

a. Total resistance, R_T.

b. The direction and magnitude of the current, I.

c. Polarity and magnitude of the voltage across each resistor.

d. Power dissipated by each resistor.

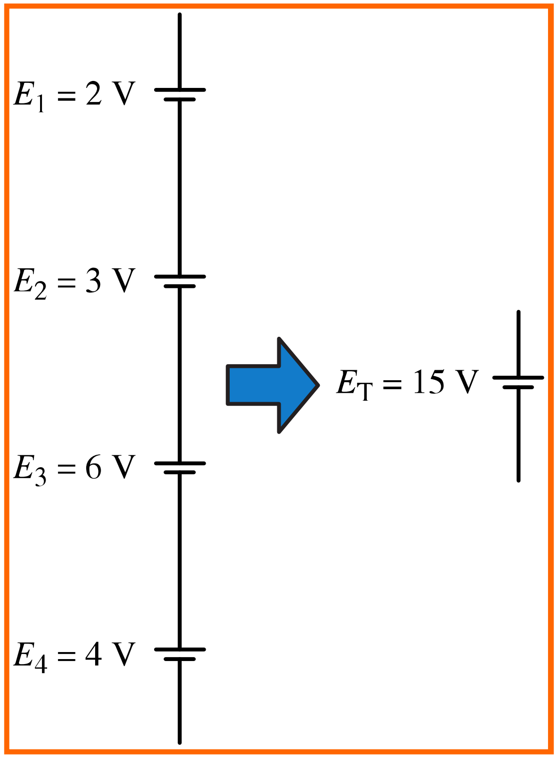
e. Power delivered to the circuit by the voltage source.

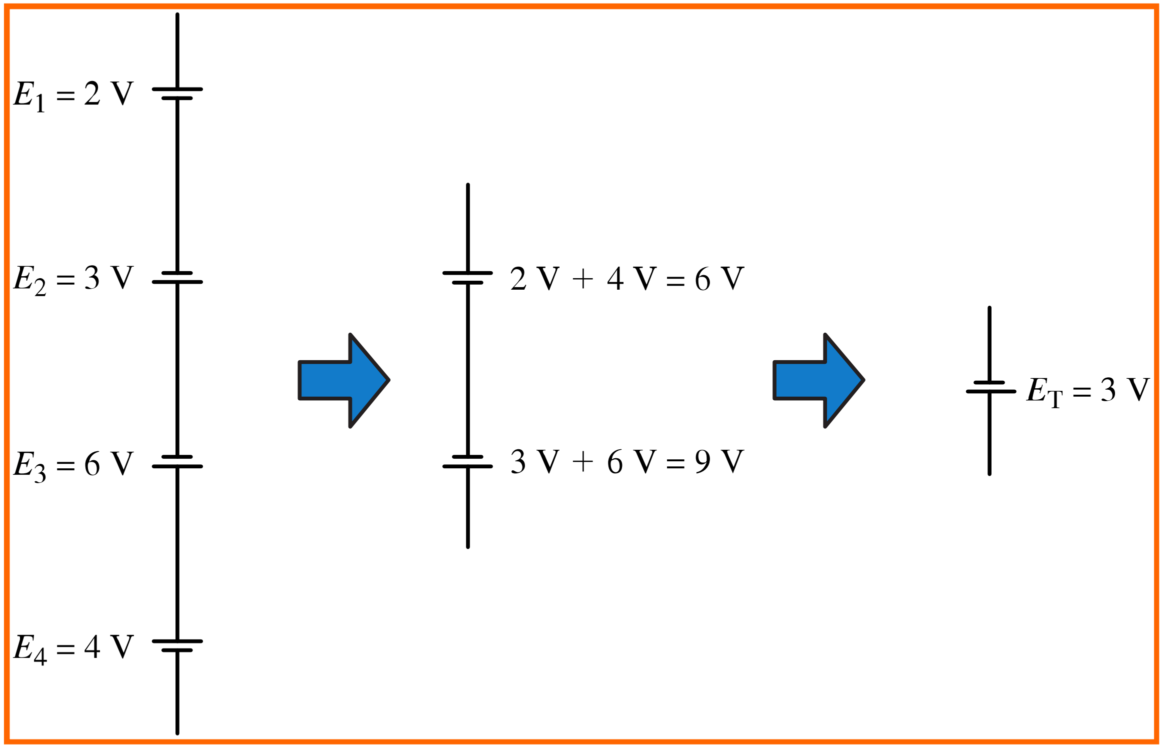
f. Show that the power dissipated is equal to the power delivered.

Serijska veza naponskih izvora

- Serijska veza više naponskih izvora može se zamijeniti jednim izvorom čija je vrijednost jednaka sumi ili razlici pojedinih izvora u serijskoj vezi

$$E = E_1 + E_2 + \ldots + E_n$$

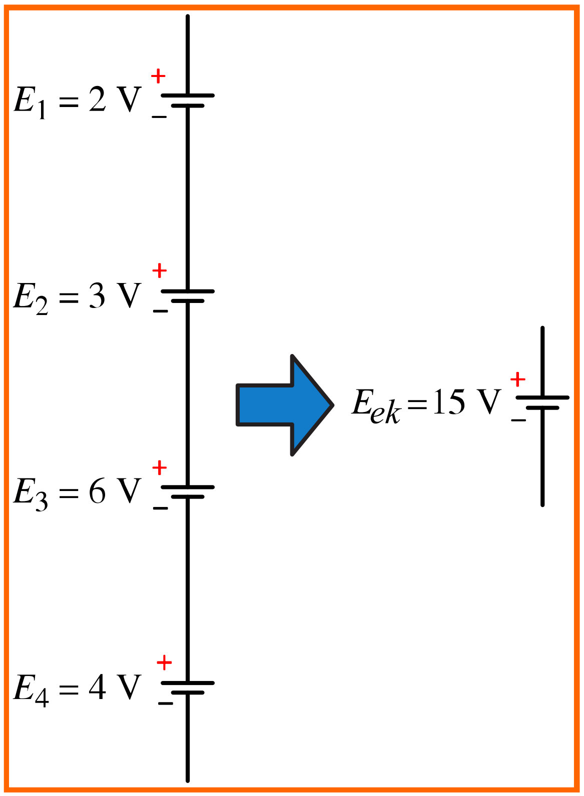


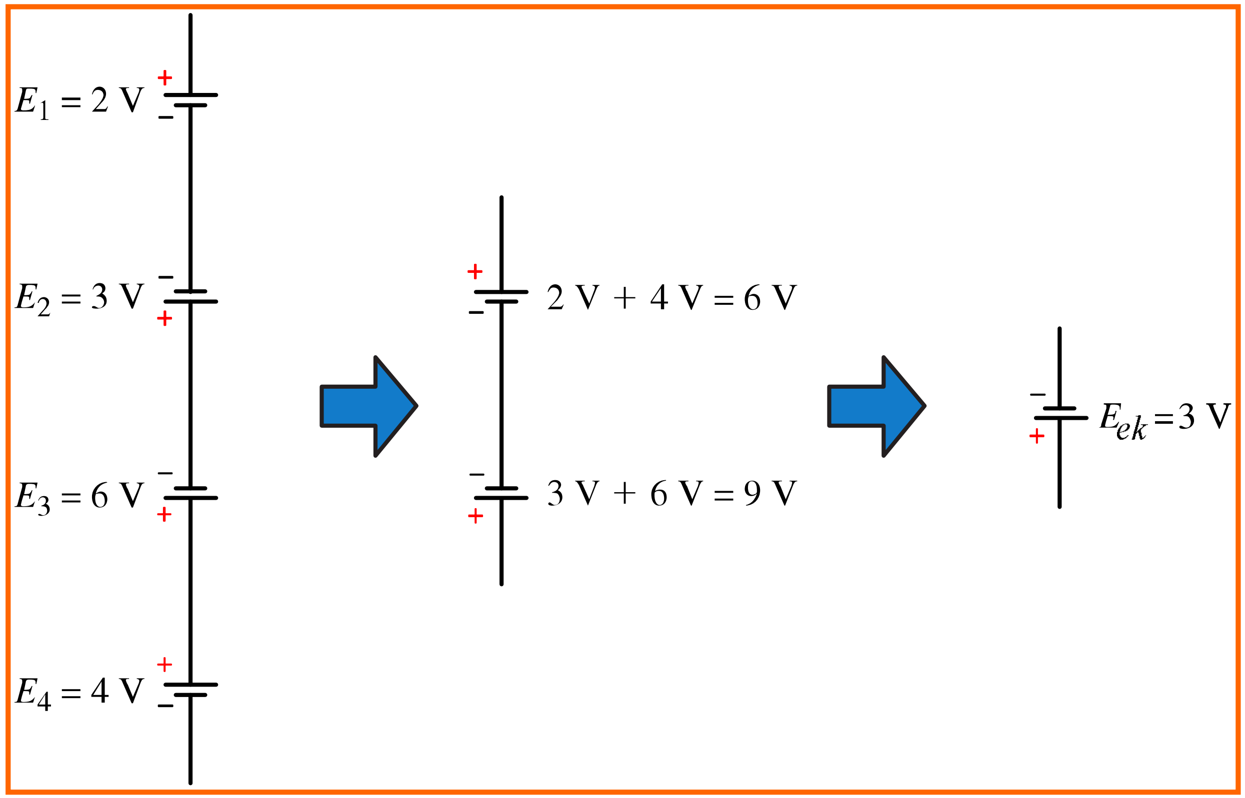


Serijska veza naponskih izvora

- Serijska veza više naponskih izvora može se zamijeniti jednim izvorom čija je vrijednost jednaka sumi ili razlici pojedinih izvora u serijskoj vezi

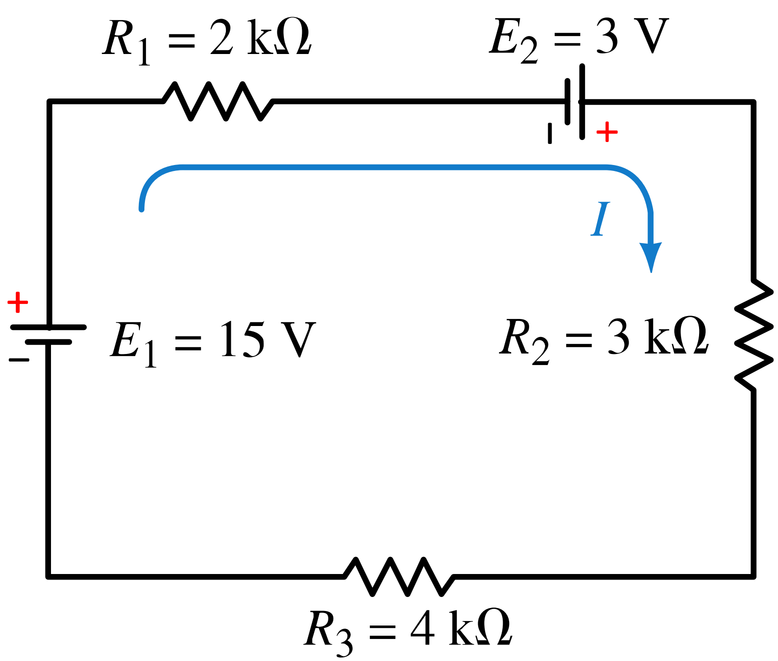
$$E_{ek} = E_1 + E_2 + \ldots + E_n$$

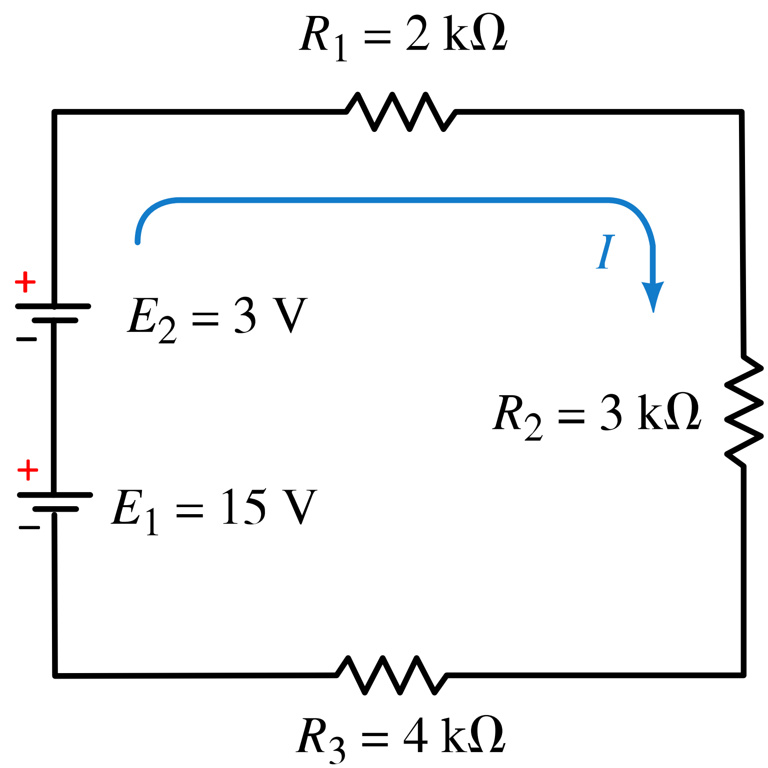




Premještanje komponenti u serijskoj vezi

- Redosljed komponenti u serijskij vezi može biti promjenjen bez ikakvog uticaja na rad strujnog kola
- Prikazana dva strujna kruga je ekvivalentna





Premještanje komponenti u serijskoj vezi

Primjer:

EXAMPLE 5–5 Simplify the circuit of Figure 5–18 into a single source in series with the four resistors. Determine the direction and magnitude of the current in the resulting circuit.

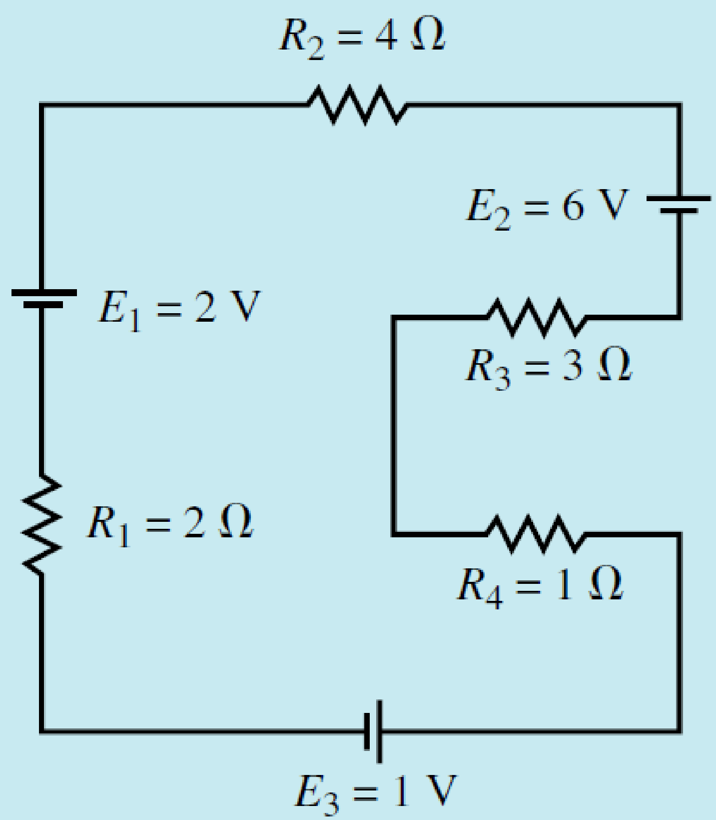


FIGURE 5–18

Premještanje komponenti u serijskoj vezi

Primjer:

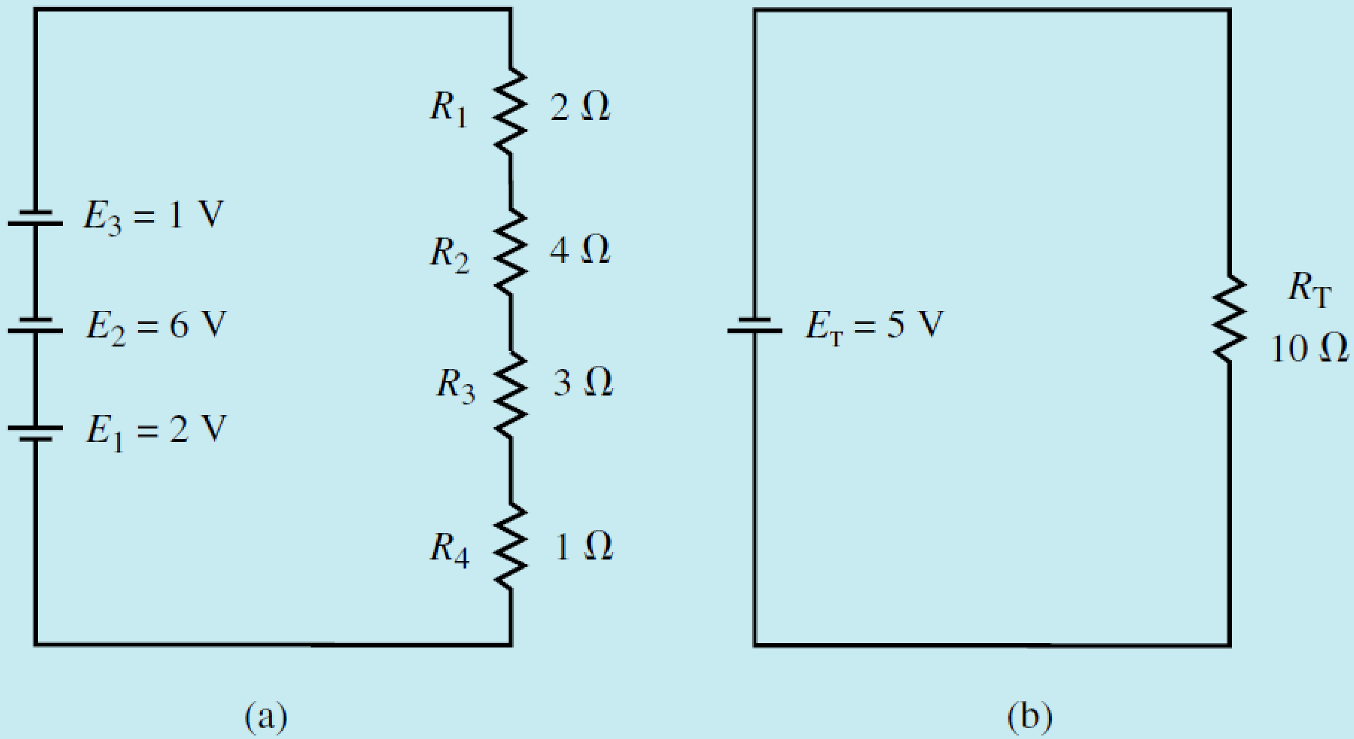


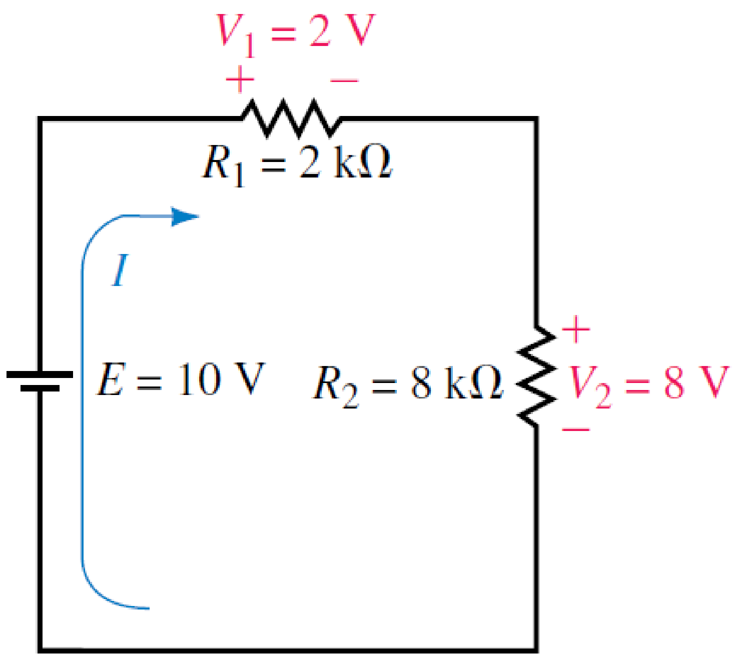
FIGURE 5–19

The current in the resulting circuit will be in a counterclockwise direction around the circuit and will have a magnitude determined as

$$I = \frac{E_T}{R_T} = \frac{6\text{ V} + 1\text{ V} - 2\text{ V}}{2\ \Omega + 4\ \Omega + 3\ \Omega + 1\ \Omega} = \frac{5\text{ V}}{10\ \Omega} = 0.500\text{ A}$$

Naponski djelitelj

- Veličina pada napona na otporniku direktno je proporcionalna je vrijednosti njegove otpornosti.
- Veća otpornost veći pad napona i obrnuto



$$I = \frac{E}{R_e}; \quad R_e = R_1 + R_2$$

$$U_{R1} = I \cdot R_1 \Rightarrow U_{R1} = \frac{E}{R_e} \cdot R_1 \Rightarrow U_{R1} = \frac{R_1}{R_1 + R_2} \cdot E$$

$$U_{R2} = I \cdot R_2 \Rightarrow U_{R2} = \frac{E}{R_e} \cdot R_2 \Rightarrow U_{R2} = \frac{R_2}{R_1 + R_2} \cdot E$$

$$U_{Rx} = I \cdot R_x \Rightarrow U_{Rx} = \frac{E}{R_e} \cdot R_x \Rightarrow U_{Rx} = \frac{R_x}{R_1 + R_2 + \ldots + R_x} \cdot E$$

Naponski djelitelj

Primjer:

EXAMPLE 5–6 Use the voltage divider rule to determine the voltage across each of the resistors in the circuit shown in Figure 5–21. Show that the summation of voltage drops is equal to the applied voltage rise in the circuit.

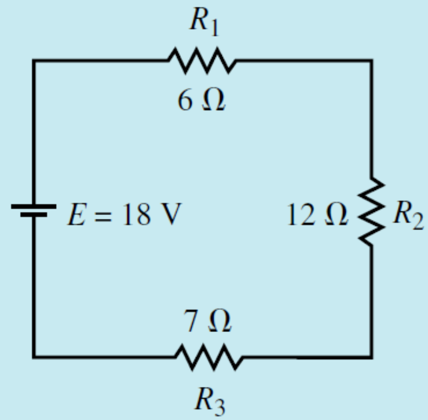


FIGURE 5–21

Solution

$$R_T = 6\ \Omega + 12\ \Omega + 7\ \Omega = 25.0\ \Omega$$

$$V_1 = \left(\frac{6\ \Omega}{25\ \Omega}\right)(18\ \mathrm{V}) = 4.32\ \mathrm{V}$$

$$V_2 = \left(\frac{12\ \Omega}{25\ \Omega}\right)(18\ \mathrm{V}) = 8.64\ \mathrm{V}$$

$$V_3 = \left(\frac{7\ \Omega}{25\ \Omega}\right)(18\ \mathrm{V}) = 5.04\ \mathrm{V}$$

The total voltage drop is the summation

$$V_T = 4.32\ \mathrm{V} + 8.64\ \mathrm{V} + 5.04\ \mathrm{V} = 18.0\ \mathrm{V} = E$$

Naponski djelitelj

Primjer:

EXAMPLE 5–6 Use the voltage divider rule to determine the voltage across each of the resistors in the circuit shown in Figure 5–21. Show that the summation of voltage drops is equal to the applied voltage rise in the circuit.

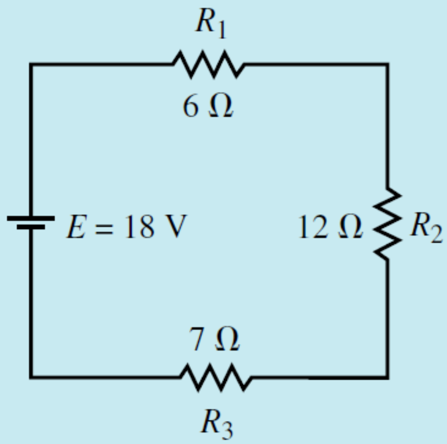


FIGURE 5–21

Solution

$$R_T = 6\ \Omega + 12\ \Omega + 7\ \Omega = 25.0\ \Omega$$

$$V_1 = \left(\frac{6\ \Omega}{25\ \Omega}\right)(18\ \text{V}) = 4.32\ \text{V}$$

$$V_2 = \left(\frac{12\ \Omega}{25\ \Omega}\right)(18\ \text{V}) = 8.64\ \text{V}$$

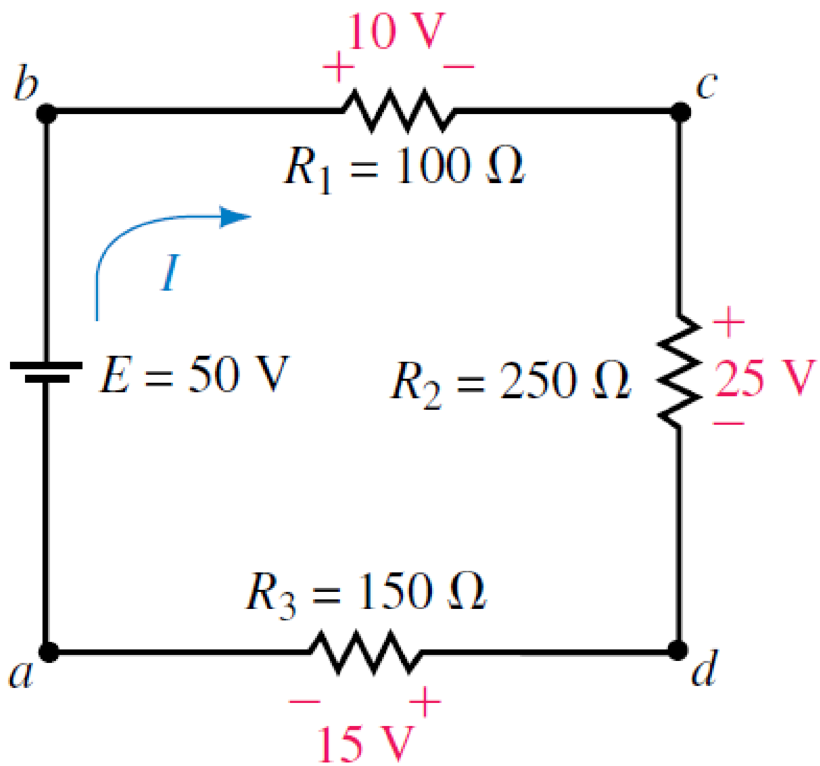
$$V_3 = \left(\frac{7\ \Omega}{25\ \Omega}\right)(18\ \text{V}) = 5.04\ \text{V}$$

The total voltage drop is the summation

$$V_T = 4.32\ \text{V} + 8.64\ \text{V} + 5.04\ \text{V} = 18.0\ \text{V} = E$$

Slovne oznake za padove napona u kolu

- Ponekad se za označavanje pojedinih tačaka u kolu koriste slovne oznake: a,b,c,d,...
- Usvajamo pravilo da je npr. napon Uab pozitivan ako je tačka b na većem potencijalu od tačke a, u suprotnom je negativan



$$U_{ba} = 50V; \quad U_{ab} = -50V; \Rightarrow U_{ba} = -U_{ab}$$
$$U_{bc} = 10V; \quad U_{cb} = -10V; \Rightarrow U_{bc} = -U_{cb}$$
$$U_{cd} = 25V; \quad U_{dc} = -25V; \Rightarrow U_{cd} = -U_{dc}$$
$$U_{da} = 15V; \quad U_{ad} = -15V; \Rightarrow U_{da} = -U_{ad}$$

Slovne oznake za padove napona u kolu

Primjer:

EXAMPLE 5–8 For the circuit of Figure 5–28, find the voltages V_{ac}, V_{ad}, V_{cf}, and V_{eb}.

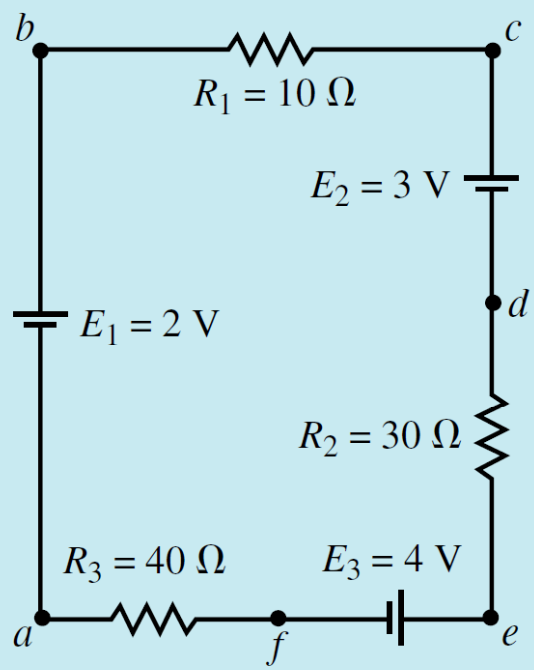


FIGURE 5–28

Solution First, we determine that the equivalent supply voltage for the circuit is

$$E_T = 3\text{ V} + 4\text{ V} - 2\text{ V} = 5.0\text{ V}$$

Slovne oznake za padove napona u kolu

Primjer:

$$V_1 = \frac{R_1}{R_T}E_T$$

$$= \left(\frac{10\ \Omega}{10\ \Omega + 30\ \Omega + 40\ \Omega}\right)(5.0\ \text{V}) = 0.625\ \text{V}$$

$$V_2 = \frac{R_2}{R_T}E_T$$

$$= \left(\frac{30\ \Omega}{10\ \Omega + 30\ \Omega + 40\ \Omega}\right)(5.0\ \text{V}) = 1.875\ \text{V}$$

$$V_3 = \frac{R_3}{R_T}E_T$$

$$= \left(\frac{40\ \Omega}{10\ \Omega + 30\ \Omega + 40\ \Omega}\right)(5.0\ \text{V}) = 2.50\ \text{V}$$

The voltages appearing across the resistors are as shown in Figure 5–29.

Slovne oznake za padove napona u kolu

Primjer:

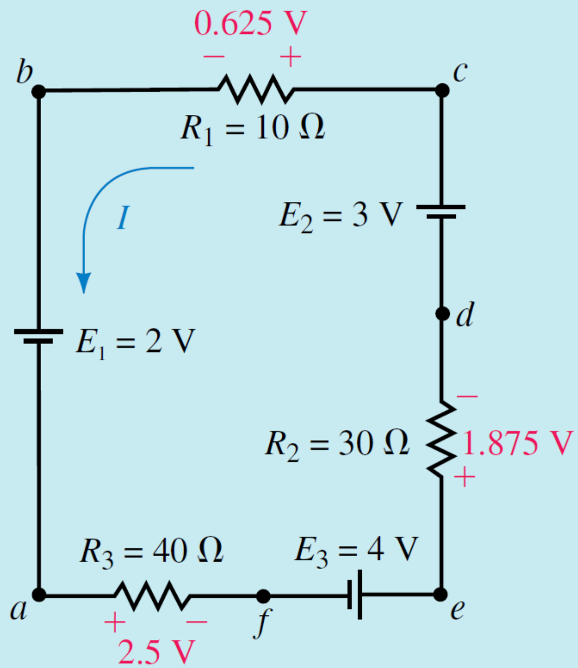


FIGURE 5–29

Finally, we solve for the voltages between the indicated points:

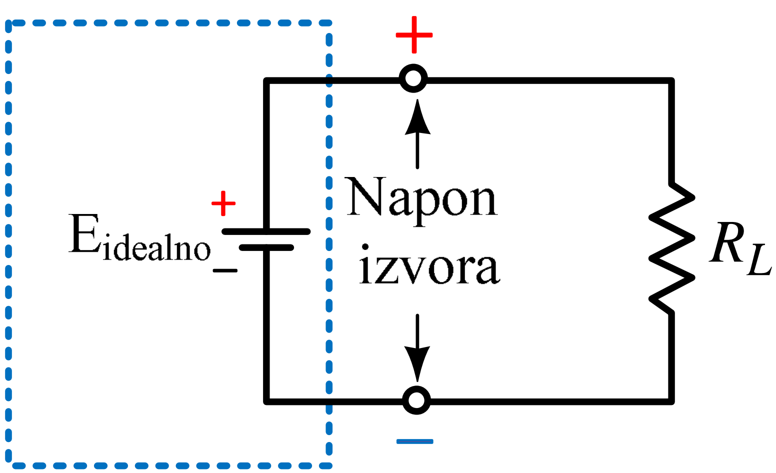
$$V_{ac} = -2.0\text{ V} - 0.625\text{ V} = -2.625\text{ V}$$
$$V_{ad} = -2.0\text{ V} - 0.625\text{ V} + 3.0\text{ V} = +0.375\text{ V}$$
$$V_{cf} = +3.0\text{ V} - 1.875\text{ V} + 4.0\text{ V} = +5.125\text{ V}$$
$$V_{eb} = +1.875\text{ V} - 3.0\text{ V} + 0.625\text{ V} = -0.500\text{ V}$$

Or, selecting the opposite path, we get

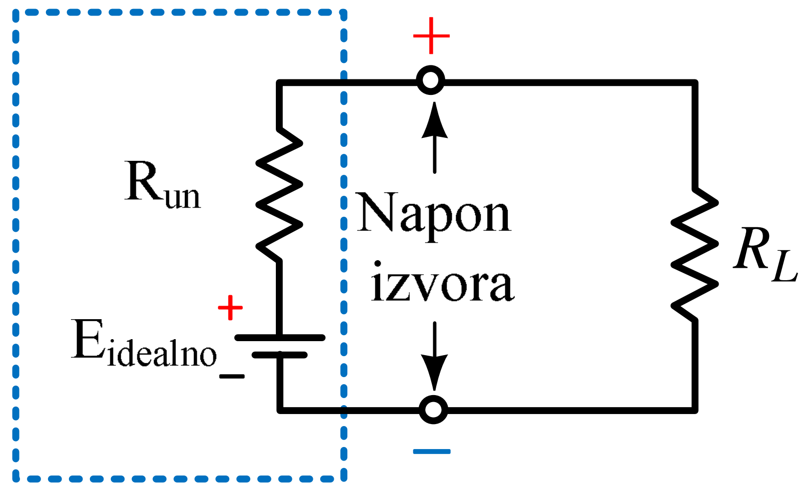
$$V_{eb} = +4.0\text{ V} - 2.5\text{ V} - 2.0\text{ V} = -0.500\text{ V}$$

Idealni i realni naponski izvori

- Kod idelanih naponskih izvora napon na krajevima izvora ostaje konstantan bez obzira na struju opterećenja.
- Vrijednost unutrašnje otpornosti idelanog naponskog izvora jednaka je nuli ($R_{un}=0$)
- Kod realnih naponskih izvora napon na krajevima izvora se mijenja sa strujom opterećenja
- Realni naponski izvori imaju unutrašnji otpor različit od nule ($R_{un} \neq 0$)



Idealni naponski izvor



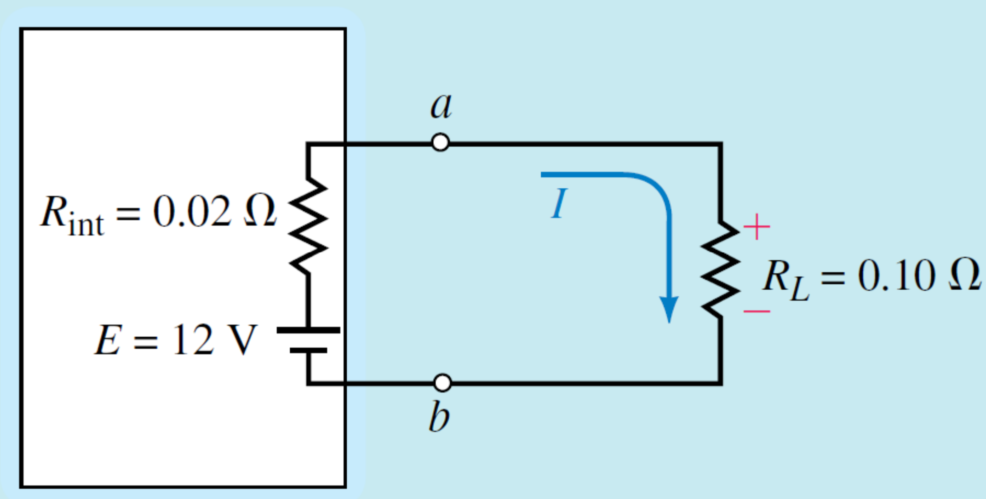
Realni naponski izvor

Idealni i realni naponski izvori

Primjer:

EXAMPLE 5–12 Two batteries having an open-terminal voltage of 12 V are used to provide current to the starter of a car having a resistance of 0.10 Ω. If one battery has an internal resistance of 0.02 Ω and the second battery has an internal resistance of 100 Ω, calculate the current through the load and the resulting terminal voltage for each of the batteries.

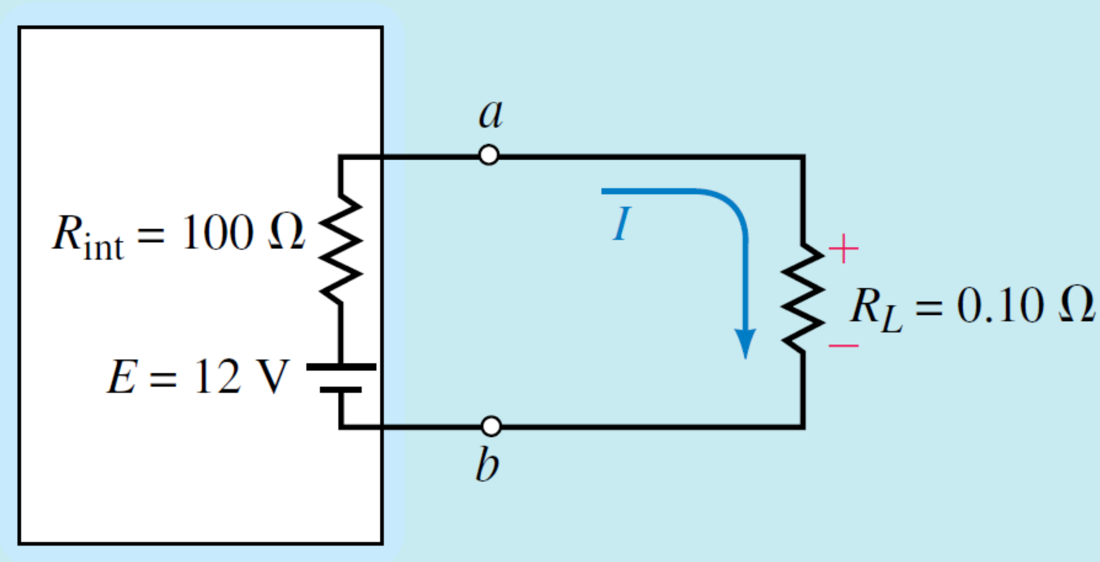
Solution The circuit for each of the batteries is shown in Figure 5–38.



(a) Low internal resistance

Idealni i realni naponski izvori

Primjer:



(b) High internal resistance

Idealni i realni naponski izvori

Primjer:

FIGURE 5–38

R_{int} = 0.02 Ω:

$$I = \frac{12\text{ V}}{0.02\ \Omega + 0.10\ \Omega} = 100.\text{ A}$$

$$V_{ab} = (100\text{ A})(0.10\ \Omega) = 10.0\text{ V}$$

R_{int} = 100 Ω:

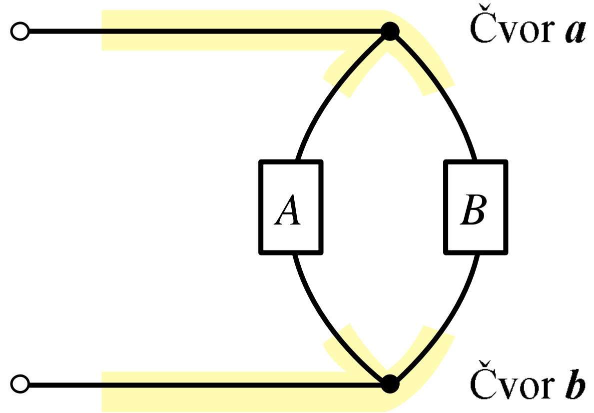
$$I = \frac{12\text{ V}}{100\ \Omega + 0.10\ \Omega} = 0.120\text{ A}$$

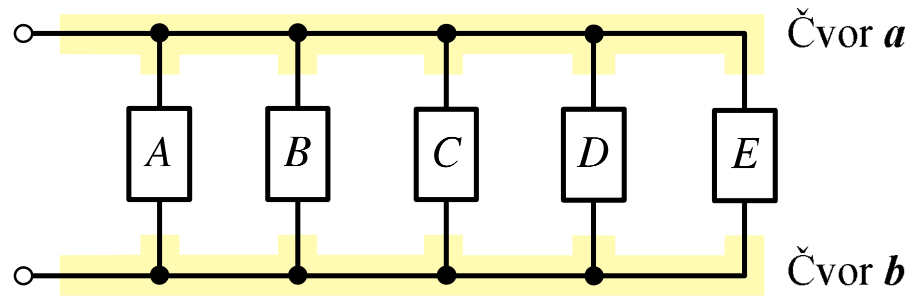
$$V_{ab} = (0.120\text{ A})(0.10\ \Omega) = 0.0120\text{ V}$$

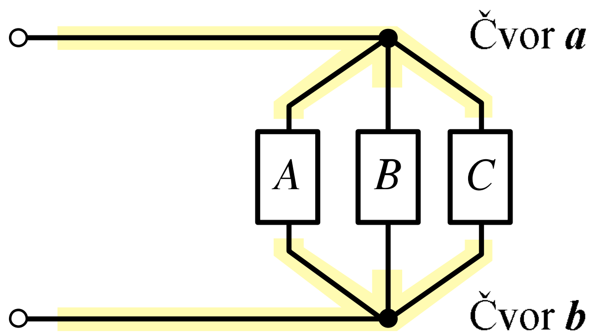
This simple example helps to illustrate why a 12-V automobile battery (which is actually 14.4 V) is able to start a car while eight 1.5 V-flashlight batteries connected in series will have virtually no measurable effect when connected to the same circuit.

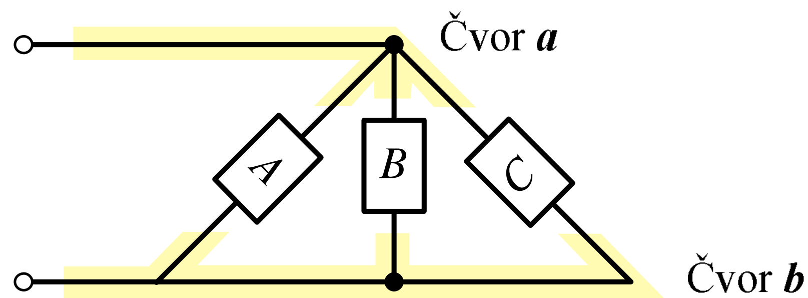
Paralelna veza elemenata u strujnom kolu

- Kažemo da su dva elementa (otpornika) vezana u paralelu ako su im krajevi zajedno povezani u dva čvora









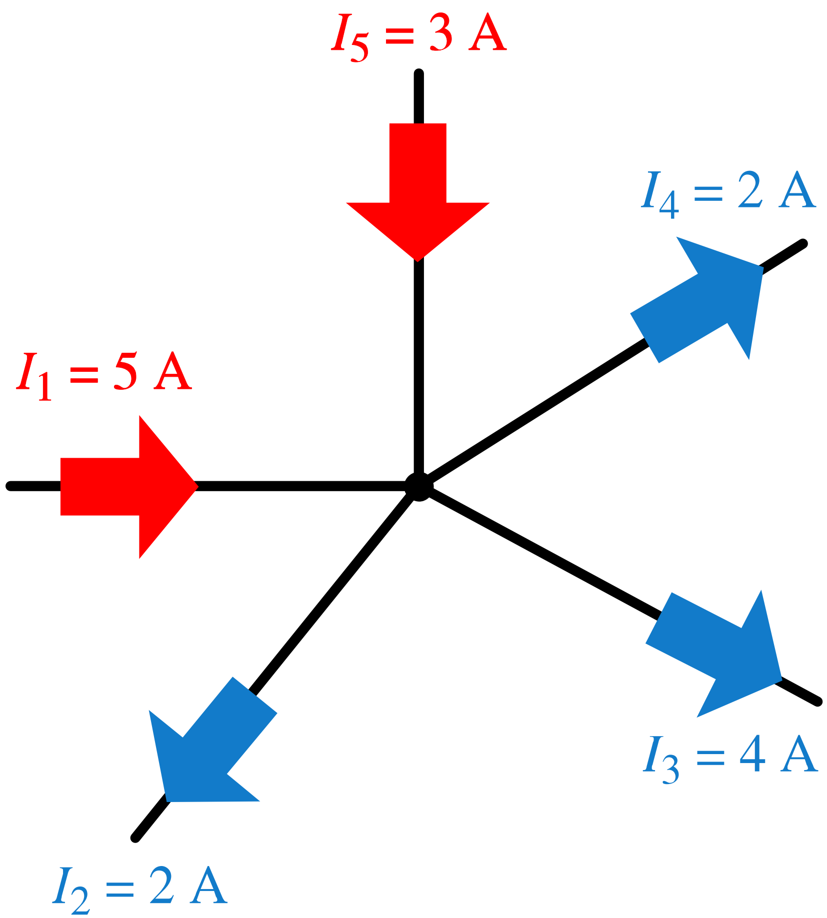
I Kirhofov zakon (za struje u čvorovima)

- Suma struja koja ulaze u čvor jednaka je sumi struja koje izlaze iz čvora:

$$\sum I_{ul} = \sum I_{izl}$$

$$\sum I_{ul} - \sum I_{izl} = 0$$

$$I_1 + I_5 = I_2 + I_3 + I_4$$



I Kirhofov zakon (za struje u čvorovima)

Primjer:

EXAMPLE 6–1 Determine the magnitude and correct direction of the currents I_3 and I_5 for the network of Figure 6–7.

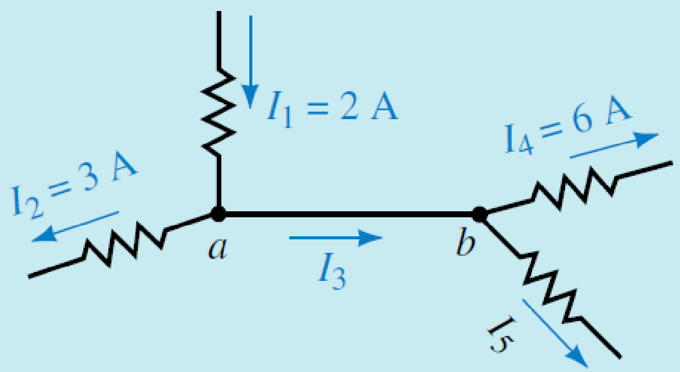


FIGURE 6–7

Solution Although points *a* and *b* are in fact the same node, we treat the points as two separate nodes with 0 Ω resistance between them.

Since Kirchhoff's current law must be valid at point *a*, we have the following expression for this node:

$$I_1 = I_2 + I_3$$

and so

$$\begin{aligned} I_3 &= I_1 - I_2 \\ &= 2\text{ A} - 3\text{ A} = -1\text{ A} \end{aligned}$$

I Kirhofov zakon (za struje u čvorovima)

Primjer:

EXAMPLE 6–2 Find the magnitudes of the unknown currents for the circuit of Figure 6–9.

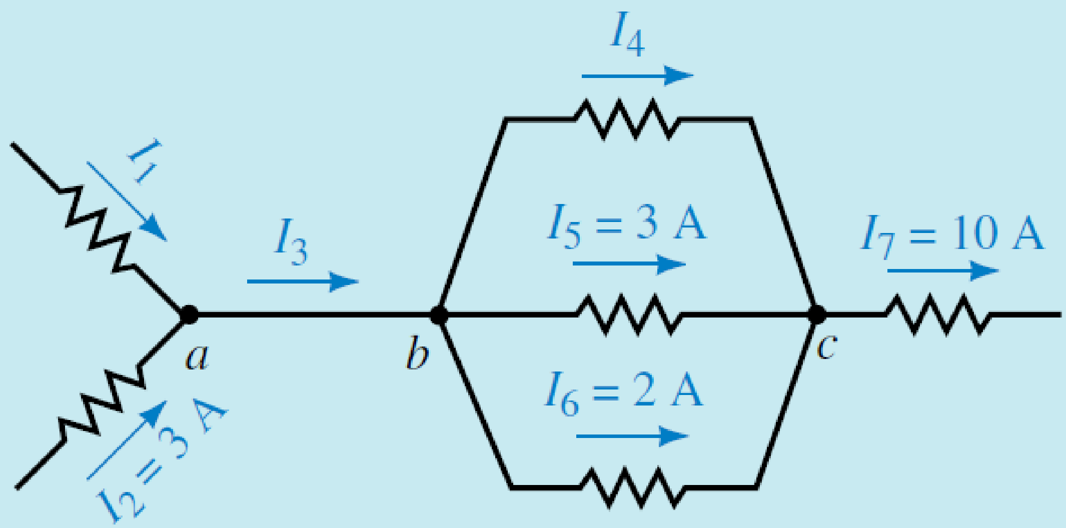


FIGURE 6–9

I Kirhofov zakon (za struje u čvorovima)

Primjer:

Solution If we consider point *a*, we see that there are two unknown currents, I_1 and I_3. Since there is no way to solve for these values, we examine the currents at point *b*, where we again have two unknown currents, I_3 and I_4. Finally we observe that at point *c* there is only one unknown, I_4. Using Kirchhoff's current law we solve for the unknown current as follows:

$$I_4 + 3\text{ A} + 2\text{ A} = 10\text{ A}$$

Therefore,

$$I_4 = 10\text{ A} - 3\text{ A} - 2\text{ A} = 5\text{ A}$$

Now we can see that at point *b* the current entering is

$$I_3 = 5\text{ A} + 3\text{ A} + 2\text{ A} = 10\text{ A}$$

And finally, by applying Kirchhoff's current law at point *a*, we determine that the current I_1 is

$$I_1 = 10\text{ A} - 3\text{ A} = 7\text{ A}$$

I Kirhofov zakon (za struje u čvorovima)

Primjer:

EXAMPLE 6–3 Determine the unknown currents in the network of Figure 6–10.

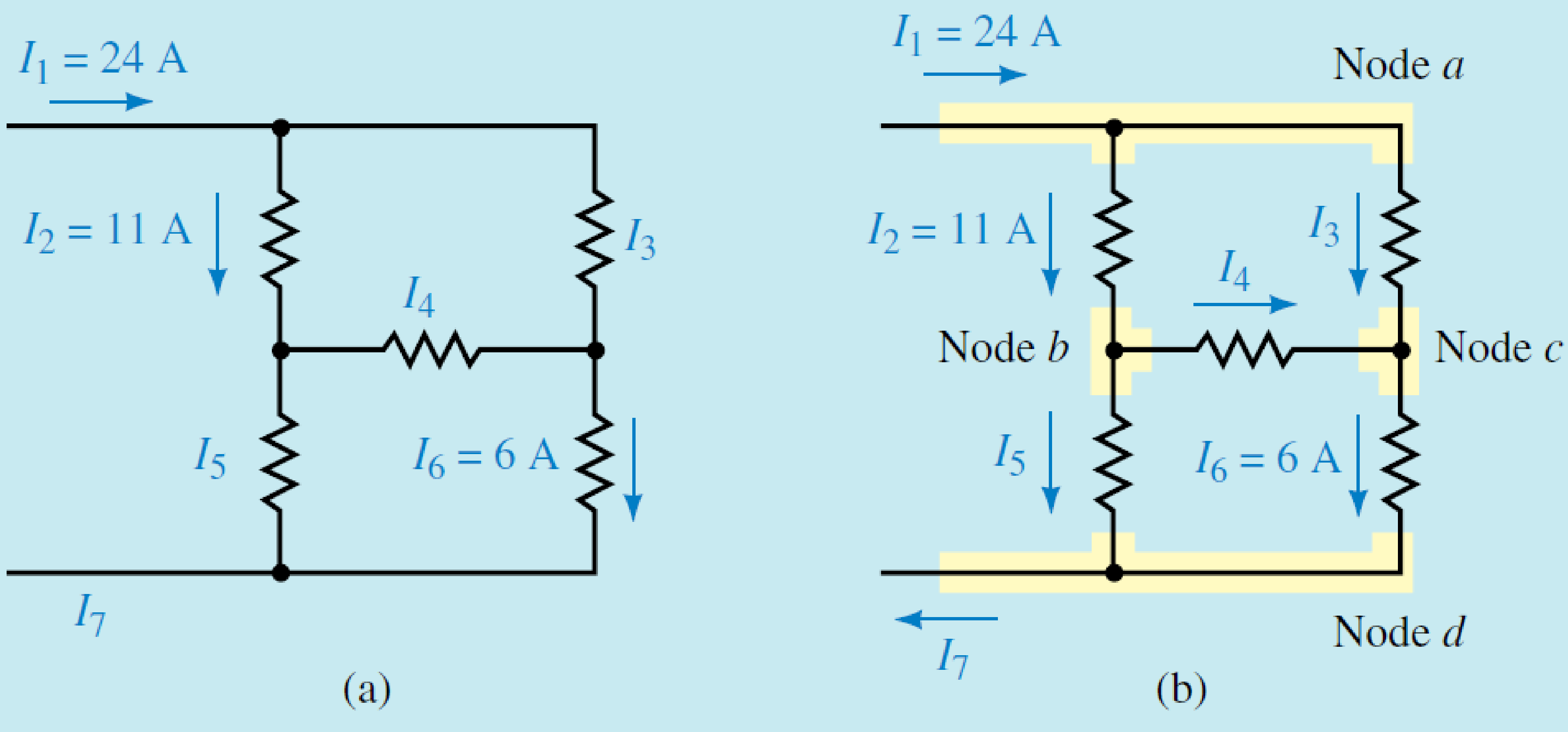


FIGURE 6–10

I Kirhofov zakon (za struje u čvorovima)

Primjer:

Now, applying Kirchhoff's current law to node *a*, we calculate the current I_3 as follows:

$$I_1 = I_2 + I_3$$

Therefore,

$$I_3 = I_1 - I_2 = 24\ \text{A} - 11\ \text{A} = 13\ \text{A}$$

Similarly, at node *c*, we have

$$I_3 + I_4 = I_6$$

Therefore,

$$I_4 = I_6 - I_3 = 6\ \text{A} - 13\ \text{A} = -7\ \text{A}$$

Paralelna veza otpornika

- Svi otpornici u paralelnoj vezi imaju isti pad napona:

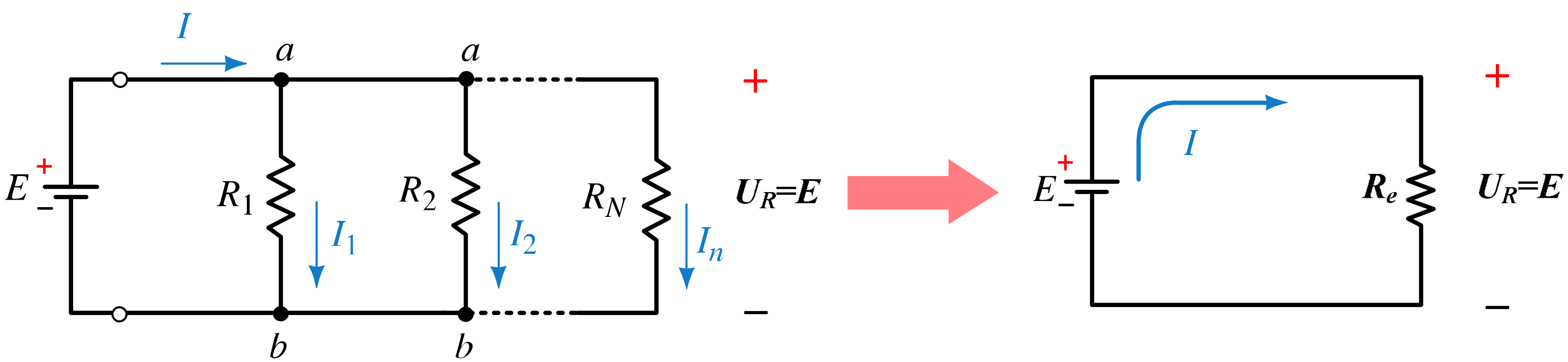
$$U_{R1} = U_{R2} = \ldots = U_{Rn} = E$$

- Primjenom I Kirhofovog zakona za struje dobijamo:

$$I = I_1 + I_2 + \ldots + I_n$$

- Primjenom Omovog zakona pojedine struje u kolu su:

$$I = \frac{U_{R1}}{R_1} + \frac{U_{R2}}{R_2} + \ldots + \frac{U_{Rn}}{R_n}$$



Paralelna veza otpornika

- Posljednja jednačina može sa napisati u formi:

$$I = \frac{E}{R_1} + \frac{E}{R_2} + \ldots + \frac{E}{R_n}$$

- Djeljenjem posljednje jednačine sa E dobijamo izraz za ekvivalentnu otpornost otpornika u paralelnoj grani:

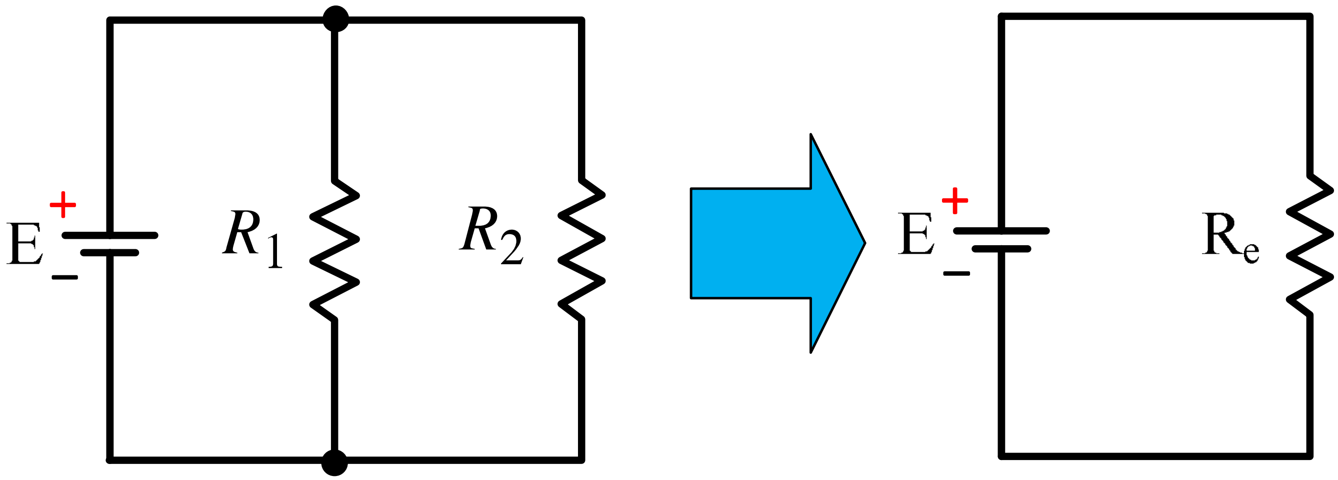
$$\frac{I}{E} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots + \frac{1}{R_n}$$

$$\frac{1}{R_e} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots + \frac{1}{R_n}$$

Recipročna vrijednost ekvivalentne otpornosti jednaka je sumi recipročnioh vrijednosti pojedinih otpornosti u kolu

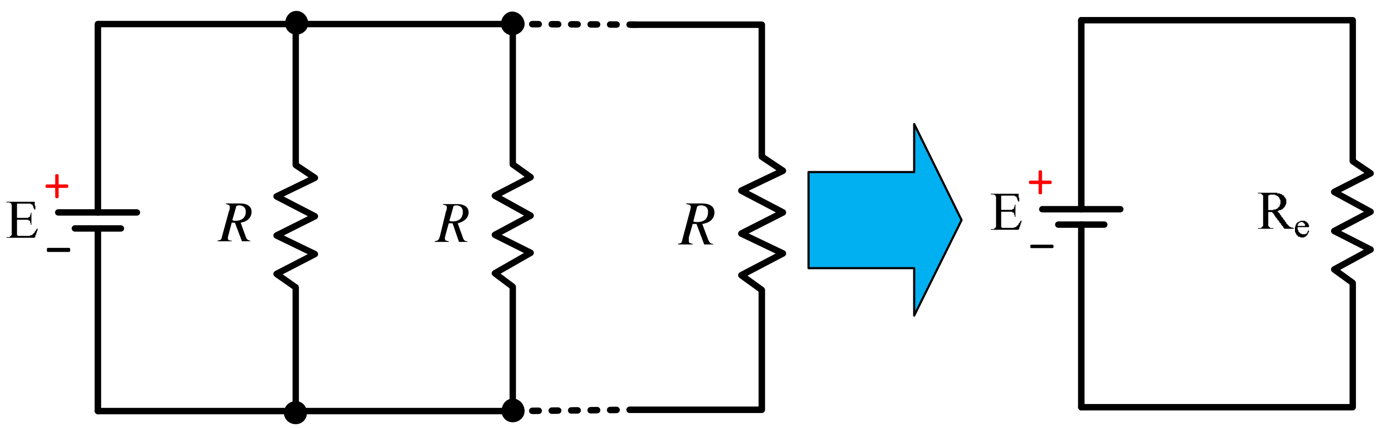
Paralelna veza otpornika – karakteristični slučajevi

Paralelna veza dva otpornika:



$$R_e = \frac{R_1 \cdot R_2}{R_1 + R_2}$$

Paralelna veza N jednakih otpornika:



$$R_e = \frac{R}{N}$$

Paralelna veza otpornika

Primjer:

EXAMPLE 6–4 Solve for the total conductance and total equivalent resistance of the circuit shown in Figure 6–13.

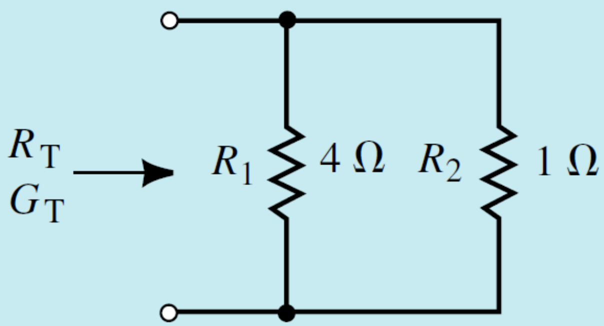


FIGURE 6–13

Solution The total conductance is

$$G_T = G_1 + G_2 = \frac{1}{4\ \Omega} + \frac{1}{1\ \Omega} = 1.25\ \text{S}$$

The total equivalent resistance of the circuit is

$$R_T = \frac{1}{G_T} = \frac{1}{1.25\ \text{S}} = 0.800\ \Omega$$

Notice that the equivalent resistance of the parallel resistors is indeed less than the value of each resistor.

Paralelna veza otpornika

Primjer:

EXAMPLE 6–5 Determine the conductance and resistance of the network of Figure 6–14.

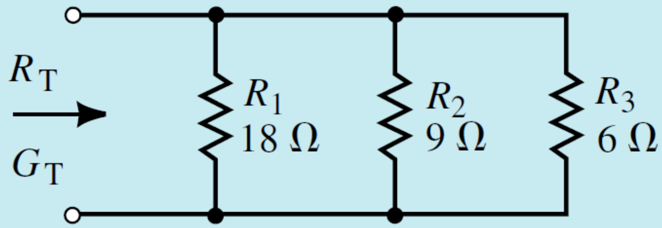


FIGURE 6–14

Solution The total conductance is

$$G_T = G_1 + G_2 + G_3$$
$$= \frac{1}{18\ \Omega} + \frac{1}{9\ \Omega} + \frac{1}{6\ \Omega}$$
$$= 0.0\overline{5}\ \text{S} + 0.1\overline{1}\ \text{S} + 0.1\overline{6}\ \text{S}$$
$$= 0.3\overline{3}\ \text{S}$$

where the overbar indicates that the number under it is repeated infinitely to the right.

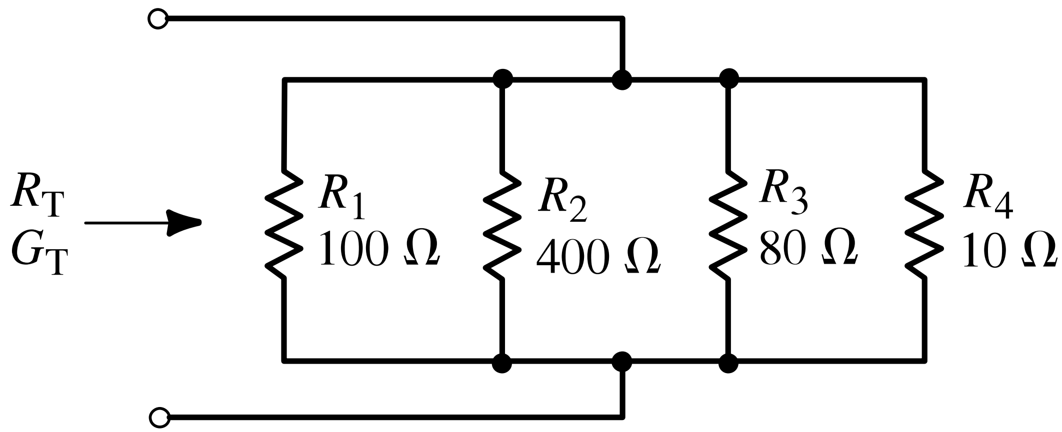
The total resistance is

$$R_T = \frac{1}{0.3\overline{3}\ \text{S}} = 3.00\ \Omega$$

Paralelna veza otpornika

Primjer:

For the parallel network of resistors shown in Figure 6–15, find the total conductance, G_T and the total resistance, R_T.

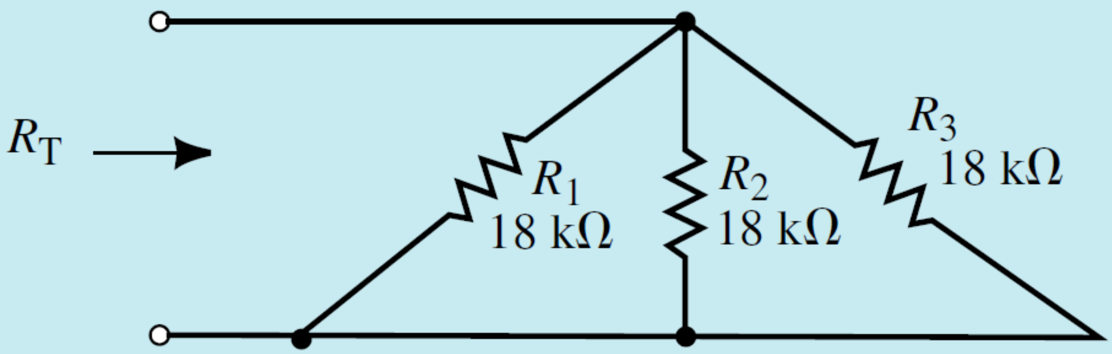


Answers: $G_T = 0.125$ S
$R_T = 8.00\ \Omega$

Paralelna veza otpornika

Primjer:

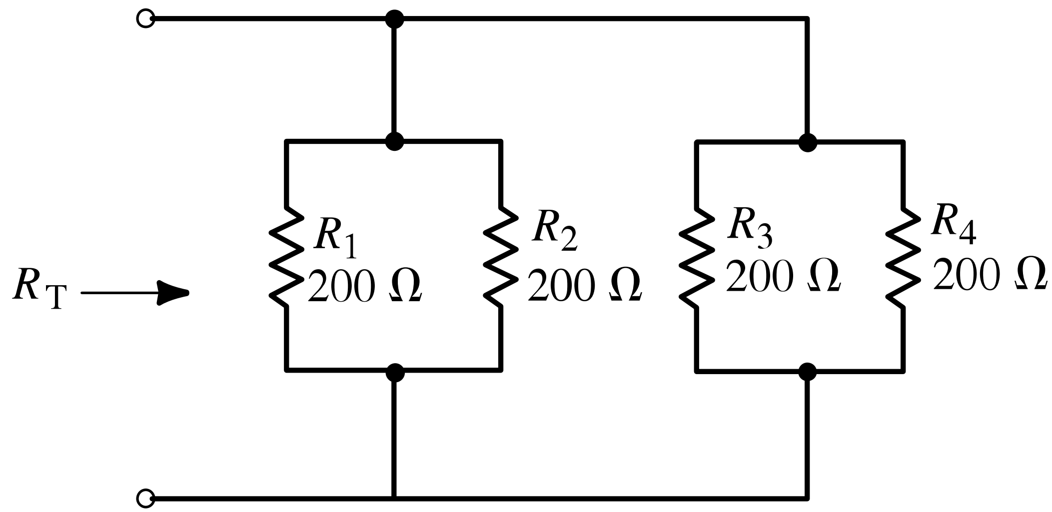
EXAMPLE 6–6 For the networks of Figure 6–16, calculate the total resistance.



(a)

Paralelna veza otpornika

Primjer:



(b)

FIGURE 6–16

Solution

a. $R_T = \dfrac{18\ \text{k}\Omega}{3} = 6\ \text{k}\Omega$

b. $R_T = \dfrac{200\ \Omega}{4} = 50\ \Omega$

Paralelna veza otpornika

Primjer:

EXAMPLE 6–7 Determine the total resistance of the resistor combinations of Figure 6–17.

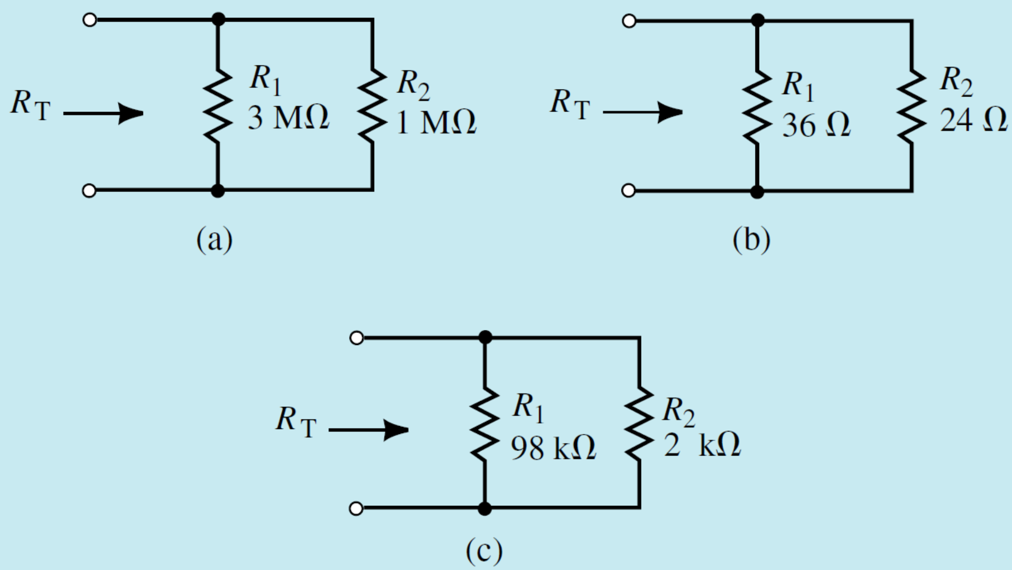


FIGURE 6–17

Solution

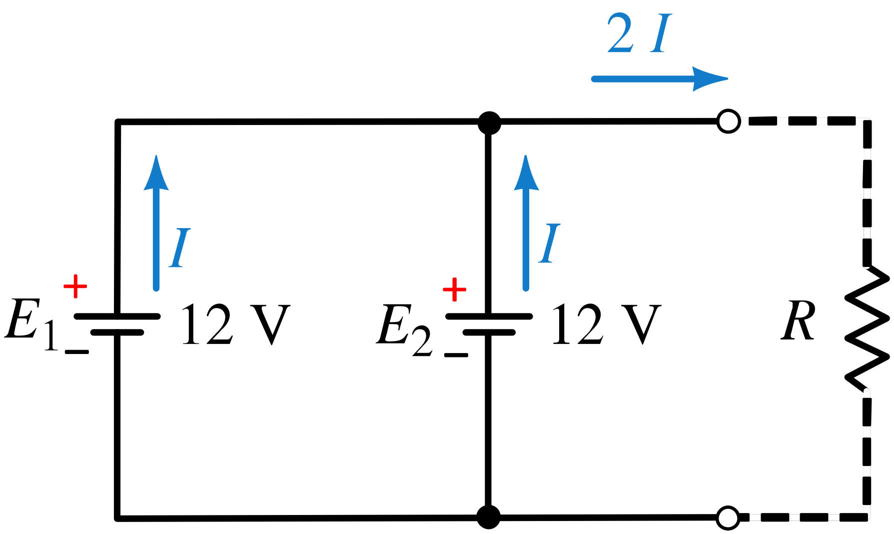
a. $R_T = \dfrac{(3\ \text{M}\Omega)(1\ \text{M}\Omega)}{3\ \text{M}\Omega + 1\ \text{M}\Omega} = 0.75\ \text{M}\Omega = 750\ \text{k}\Omega$

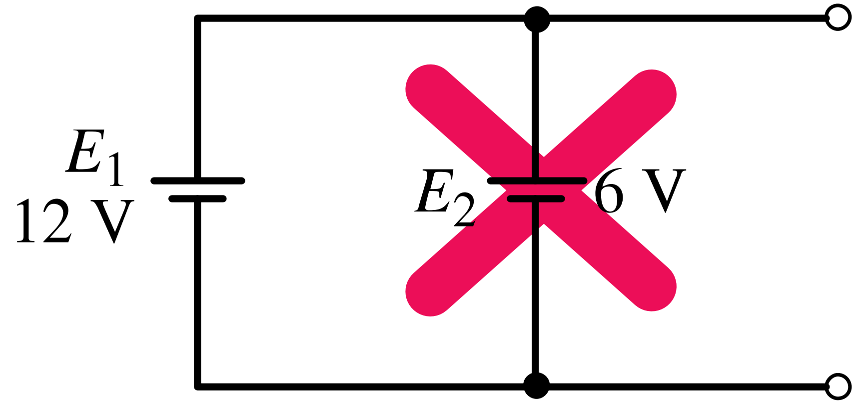
b. $R_T = \dfrac{(36\ \Omega)(24\ \Omega)}{36\ \Omega + 24\ \Omega} = 14.4\ \Omega$

c. $R_T = \dfrac{(98\ \text{k}\Omega)(2\ \text{k}\Omega)}{98\ \text{k}\Omega + 2\ \text{k}\Omega} = 1.96\ \text{k}\Omega$

Paralelna veza naponskih izvora

- Kod paralelne veze naponskih izvora ukupna struja jednaka je sumi struja koju daju pojedini izvori
- Paralelno je moguće vezivati samo naponske izvore istih karakteristika (napon, unutrašnji otpor)





Paralelna veza naponskih izvora

Primjer:

EXAMPLE 6–9 A 12-V battery and a 6-V battery (each having an internal resistance of 0.05 Ω) are inadvertently placed in parallel as shown in Figure 6–24. Determine the current through the batteries.

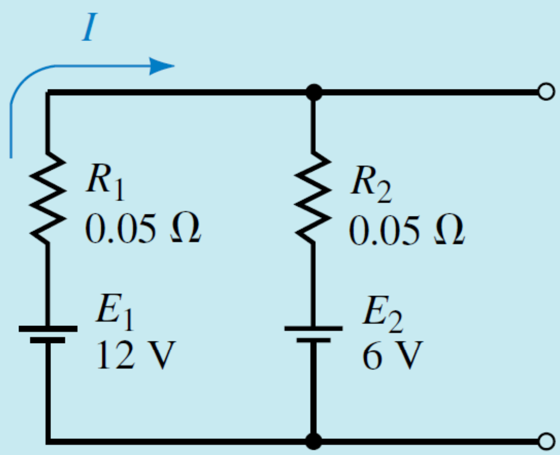


FIGURE 6–24

Solution From Ohm's law,

$$I = \frac{E_T}{R_T} = \frac{12\text{ V} - 6\text{ V}}{0.05\ \Omega + 0.05\ \Omega} = 60\text{ A}$$

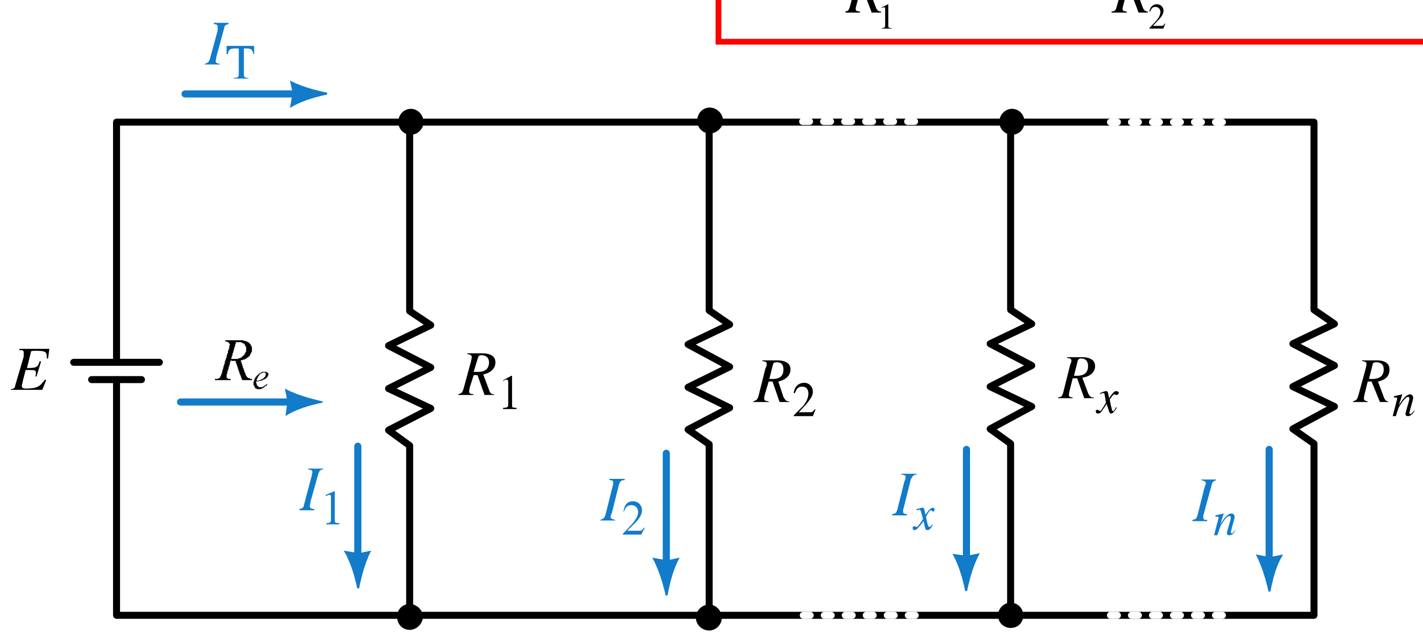
This example illustrates why batteries of different potential must never be connected in parallel. Tremendous currents will occur within the sources resulting in the possibility of a fire or explosion.

Strujni djelitelj

- Kod paralelnih kola napon na svim elementima je jednak
- Pravilo strujnog dijelitelja omogućava određivanje struje u pojedinim granama na osnovu poznavanja ukupne struje u kolu
- Kroz najmanju otpornost u paralelnoj vezi teče najveća struja
- Na osnovu omovog zakona važi:

$$I_1 \cdot R_1 = I_2 \cdot R_2 = \ldots = I_x \cdot R_x$$

$$I_1 = \frac{R_x}{R_1} I; \quad I_2 = \frac{R_x}{R_2} I; \ldots \quad I_n = \frac{R_x}{R_n} I$$

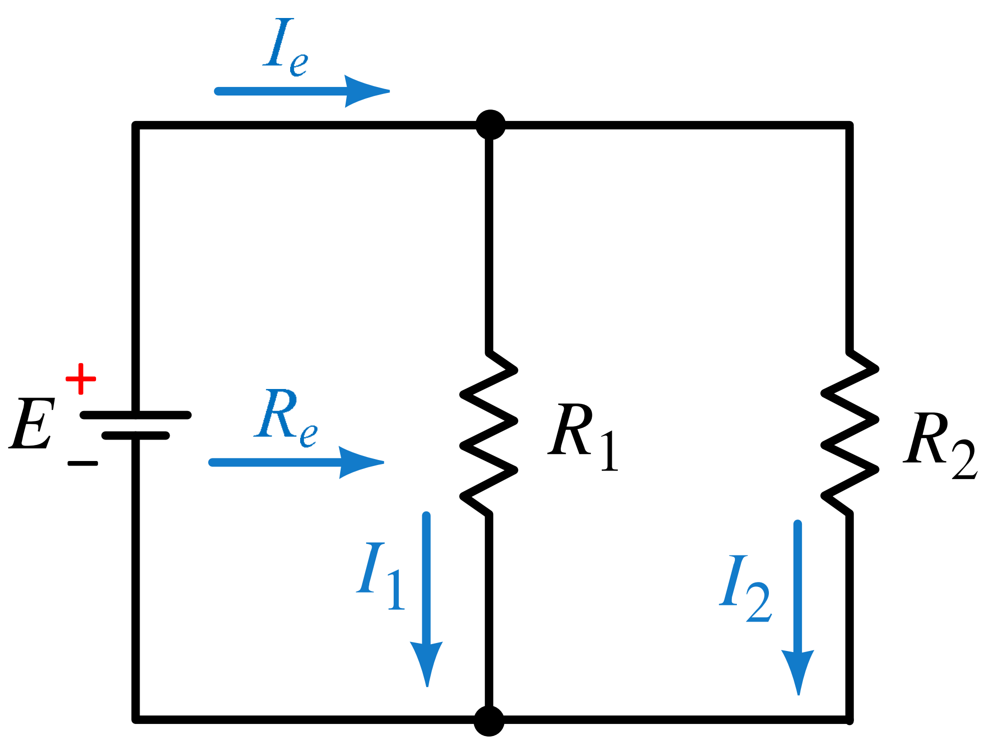


Strujni djelitelj – dva otpornika

- Za slučaj dva otpornika u paralelnoj vezi ekvivalentna otpornost i ukupna struja date su izrazom:

$$R_e = \frac{R_1 \cdot R_2}{R_1 + R_2}$$

$$I_e = \frac{E}{R_e} = \frac{E}{\dfrac{R_1 \cdot R_2}{R_1 + R_2}}$$



$$I_1 = \frac{R_2}{R_1 + R_2} \cdot I_e$$

$$I_2 = \frac{R_1}{R_1 + R_2} \cdot I_e$$

Strujni djelitelj

Primjer:

EXAMPLE 6–10 For the network of Figure 6–26, determine the currents I_1, I_2, and I_3.

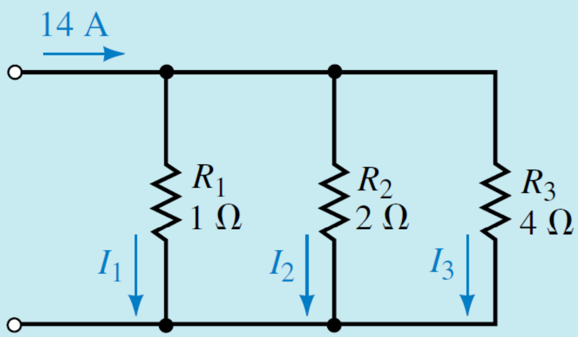


FIGURE 6–26

Solution First, we calculate the total conductance of the network.

$$G_T = \frac{1}{1\ \Omega} + \frac{1}{2\ \Omega} + \frac{1}{4\ \Omega} = 1.75\ \text{S}$$

Now the currents may be evaluated as follows:

$$I_1 = \frac{G_1}{G_T} I_T = \left(\frac{1\ \text{S}}{1.75\ \text{S}}\right) 14\ \text{A} = 8.00\ \text{A}$$

$$I_2 = \frac{G_2}{G_T} I_T = \left(\frac{0.5\ \text{S}}{1.75\ \text{S}}\right) 14\ \text{A} = 4.00\ \text{A}$$

$$I_3 = \frac{G_3}{G_T} I_T = \left(\frac{0.25\ \text{S}}{1.75\ \text{S}}\right) 14\ \text{A} = 2.00\ \text{A}$$

Strujni djelitelj

Primjer:

EXAMPLE 6–10 For the network of Figure 6–26, determine the currents I_1, I_2, and I_3.

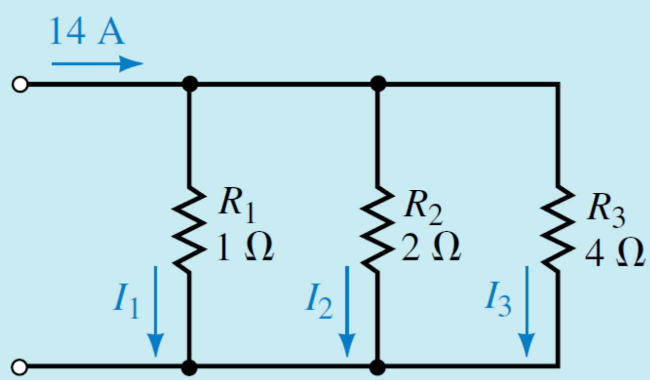


FIGURE 6–26

An alternate approach is to use circuit resistance, rather than conductance.

$$R_T = \frac{1}{G_T} = \frac{1}{1.75\ \text{S}} = 0.571\ \Omega$$

$$I_1 = \frac{R_T}{R_1} I_T = \left(\frac{0.571\ \Omega}{1\ \Omega}\right) 14\ \text{A} = 8.00\ \text{A}$$

$$I_2 = \frac{R_T}{R_2} I_T = \left(\frac{0.571\ \Omega}{2\ \Omega}\right) 14\ \text{A} = 4.00\ \text{A}$$

$$I_3 = \frac{R_T}{R_3} I_T = \left(\frac{0.571\ \Omega}{5\ \Omega}\right) 14\ \text{A} = 2.00\ \text{A}$$

Strujni djelitelj

Primjer:

EXAMPLE 6–11 For the network of Figure 6–27, determine the currents I_1, I_2, and I_3.

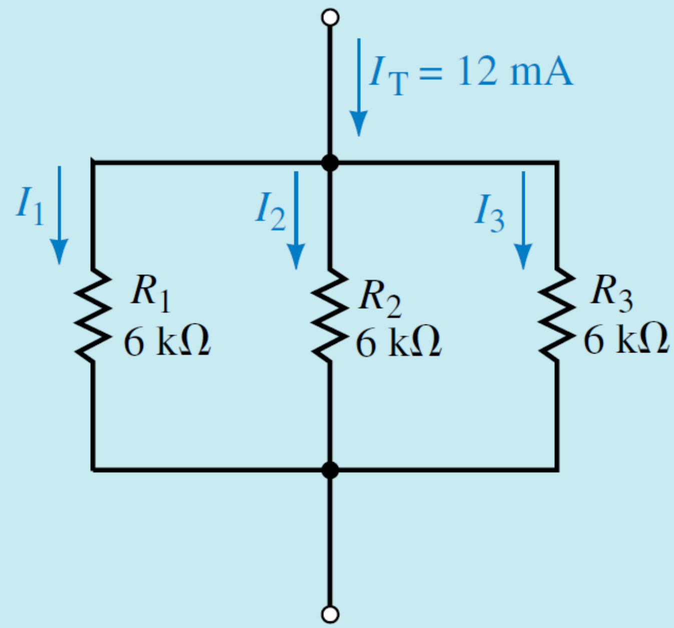


FIGURE 6–27

Solution Since all the resistors have the same value, the incoming current will split equally between the resistances. Therefore,

$$I_1 = I_2 = I_3 = \frac{12\ \text{mA}}{3} = 4.00\ \text{mA}$$

Strujni djelitelj

Primjer:

EXAMPLE 6–12 Determine the currents I_1 and I_2 in the network of Figure 6–28.

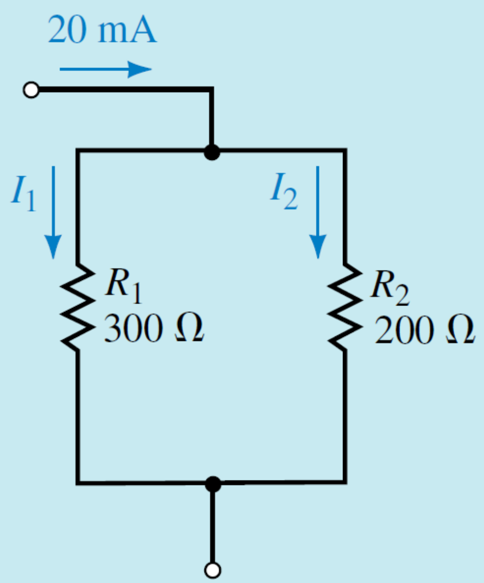


FIGURE 6–28

Solution Because we have only two resistors in the given network, we use Equations 6–12 and 6–13:

$$I_1 = \frac{R_2}{R_1 + R_2} I_T = \left(\frac{200\ \Omega}{300\ \Omega + 200\ \Omega}\right)(20\ \text{mA}) = 8.00\ \text{mA}$$

$$I_2 = \frac{R_1}{R_1 + R_2} I_T = \left(\frac{300\ \Omega}{300\ \Omega + 200\ \Omega}\right)(20\ \text{mA}) = 12.0\ \text{mA}$$

Strujni djelitelj

Primjer:

EXAMPLE 6–13 Determine the resistance R_1 so that current will divide as shown in the network of Figure 6–29.

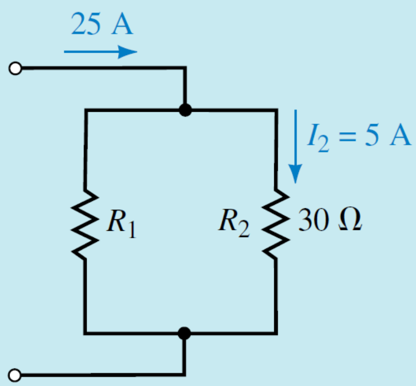


FIGURE 6–29

Solution There are several methods which may be used to solve this problem. We will examine only two of the possibilities.

Method I: Since we have two resistors in parallel, we may use Equation 6–13 to solve for the unknown resistor:

$$I_2 = \frac{R_1}{R_1 + R_2} I_T$$

$$5\text{ A} = \left(\frac{R_1}{R_1 + 30\ \Omega}\right)(25\text{ A})$$

Using algebra, we get

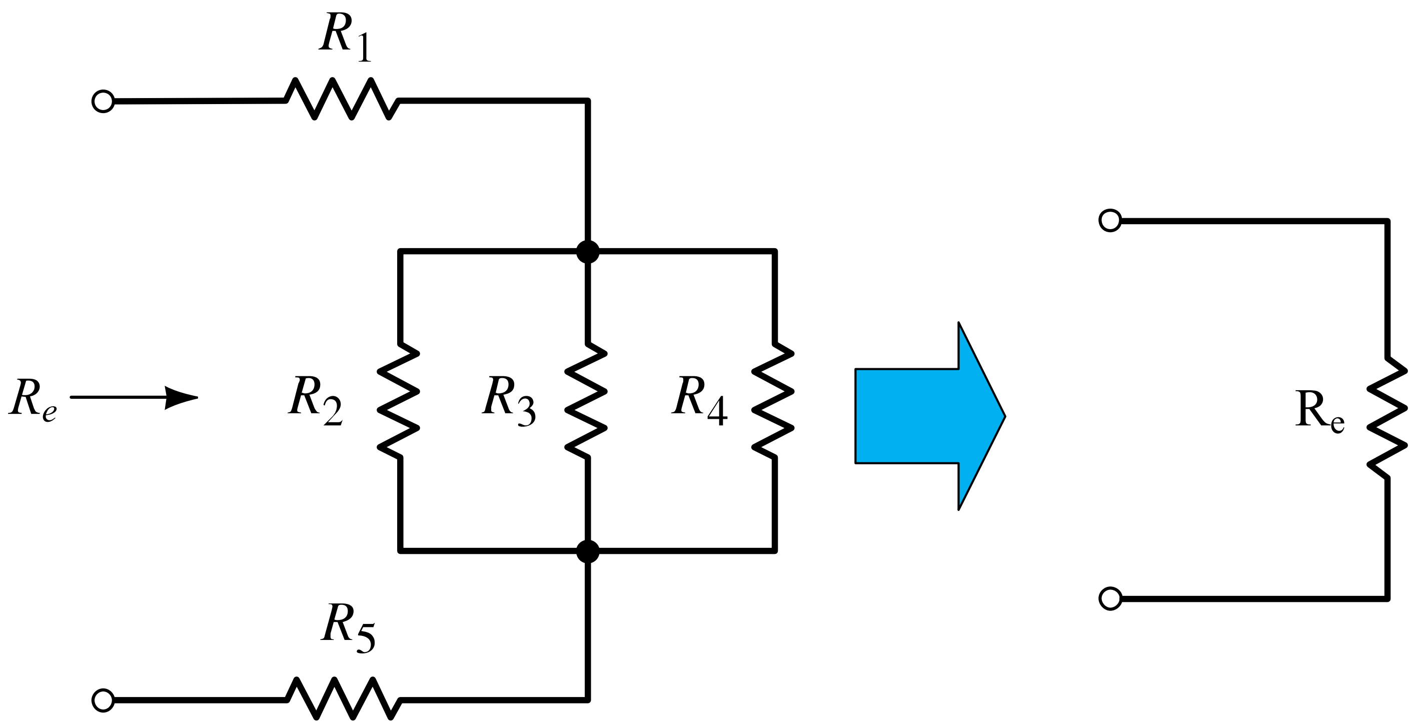
$$(5\text{ A})R_1 + (5\text{ A})(30\ \Omega) = (25\text{ A})R_1$$

$$(20\text{ A})R_1 = 150\text{ V}$$

$$R_1 = \frac{150\text{ V}}{20\text{ A}} = 7.50\ \Omega$$

Mješovita veza otpornika

- Komponente između čvorova mogu biti povezane kao različita kombinacija izvora, otpornika ili drugih komponenti
- Pri analizi složenih kola važno je da se prvo prepozna koji su elementi povezani u paralelu, a koji elementi u povezani u seriju



$$R_e = R_1 + R_2 \,||\, R_3 \,||\, R_4 + R_5$$

Mješovita veza otpornika

Primjer:

EXAMPLE 7–1 For the network of Figure 7–2, determine which resistors and branches are in series and which are in parallel. Write an expression for the total equivalent resistance, R_T.

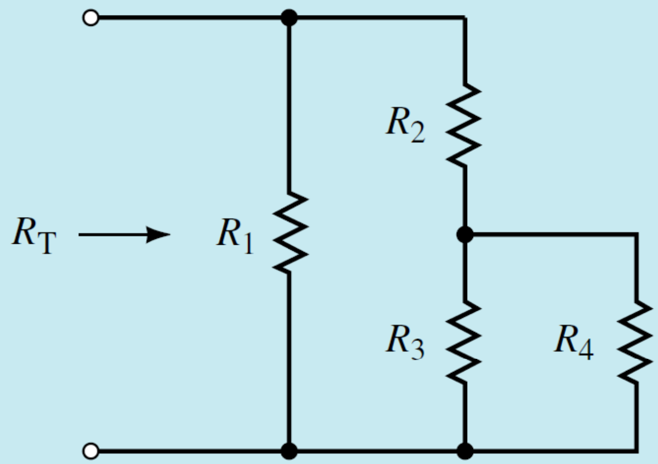


FIGURE 7–2

Solution First, we recognize that the resistors R_3 and R_4 are in parallel: $(R_3 \| R_4)$.

Next, we see that this combination is in series with the resistor R_2: $[R_2 + (R_3 \| R_4)]$.

Finally, the entire combination is in parallel with the resistor R_1. The total resistance of the circuit may now be written as follows:

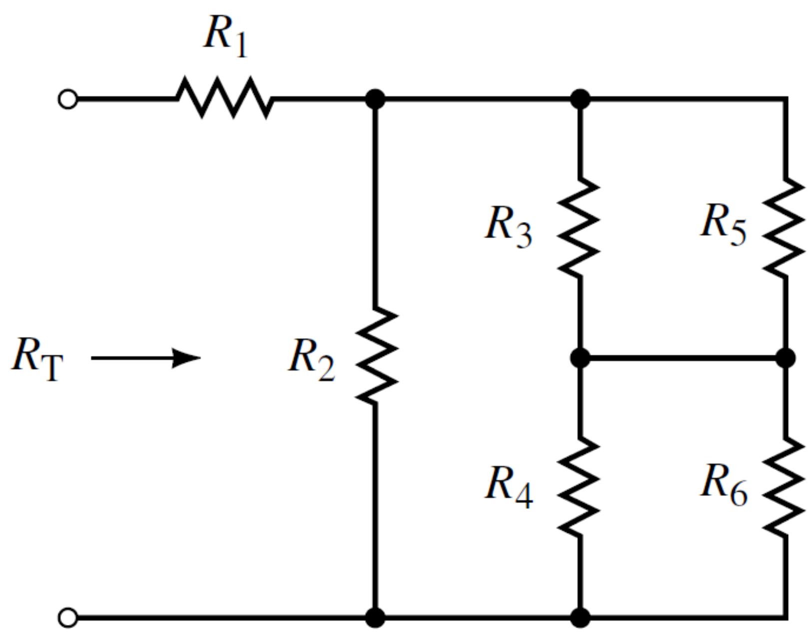
$$R_T = R_1 \| [R_2 + (R_3 \| R_4)]$$

Mješovita veza otpornika

Primjer:

For the network of Figure 7–3, determine which resistors and branches are in series and which are in parallel. Write an expression for the total resistance, R_T.

FIGURE 7–3

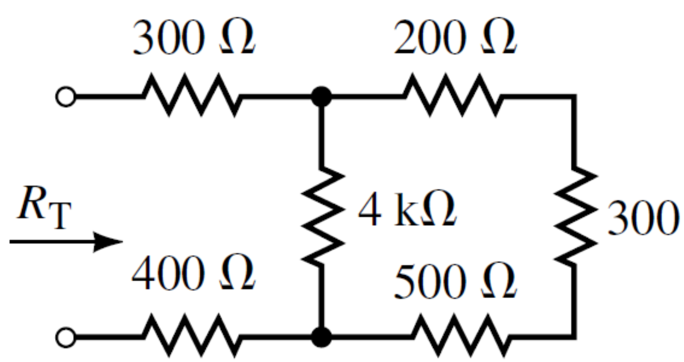


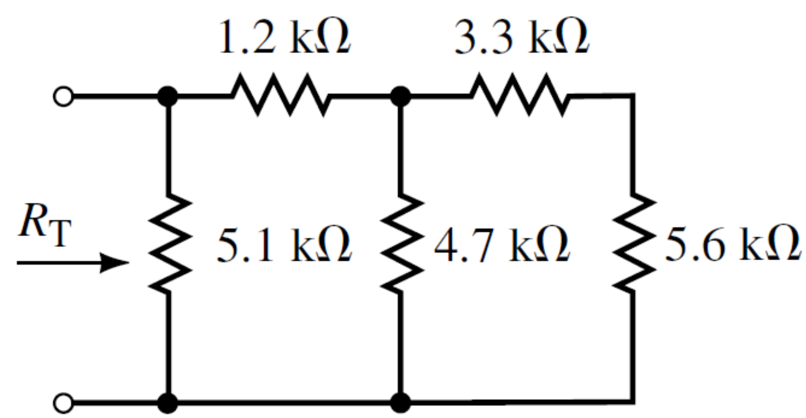
Answer: $R_T = R_1 + R_2 \| [(R_3 \| R_5) + (R_4 \| R_6)]$

Mješovita veza otpornika

Primjer:

7. Determine the total resistance of each network in Figure 7–50.





Analiza mješovitih kola

- Komponente između čvorova mogu biti povezane na različite načine kao kombinacija izvora, otpornika ili drugih komponenti
- Pri analizi složenih kola važno je da se prvo prepoznaju koji su elementi povezani u paralelu, a koji elementi u povezani u seriju
- Ako je potrebno precrtati kolo tako da izvori budu sa desne strane i označiti sve čvorove kola
- Označiti sve smjerove struja i padove napona na otpornicima
- Pojednostaviti kolo rješavanjem paralelne i serijske veze otpornika
- Odrediti ekvivalentnu otpornost kola R_e
- Odrediti ukupnu struju u kolu I_e
- Odrediti struje pojedinih grana i padove napona na otpornicima

Analiza mješovitih kola

Primjer:

EXAMPLE 7–2 Consider the circuit of Figure 7–4.

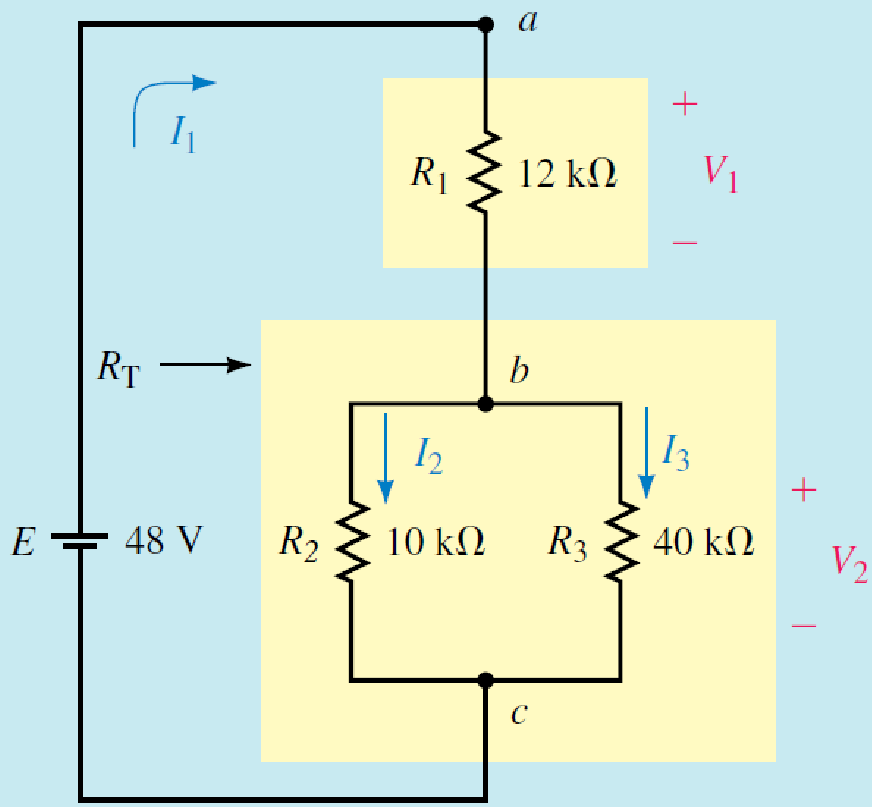


FIGURE 7–4

a. Find R_T.

b. Calculate I_1, I_2, and I_3.

c. Determine the voltages V_1 and V_2.

Analiza mješovitih kola

Primjer:

Solution By examining the circuit of Figure 7–4, we see that resistors R_2 and R_3 are in parallel. This parallel combination is in series with the resistor R_1.

The combination of resistors may be represented by a simple series network shown in Figure 7–5. Notice that the nodes have been labelled using the same notation.

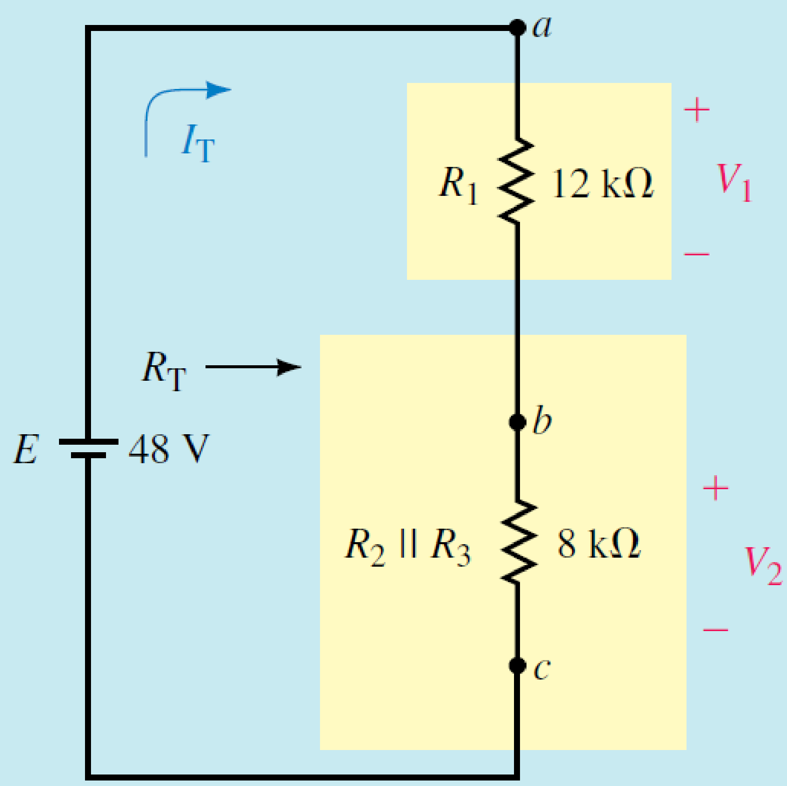


FIGURE 7–5

Analiza mješovitih kola

Primjer:

a. The total resistance of the circuit may be determined from the combination

$$R_T = R_1 + R_2 \| R_3$$

$$R_T = 12\ \text{k}\Omega + \frac{(10\ \text{k}\Omega)(40\ \text{k}\Omega)}{10\ \text{k}\Omega + 40\ \text{k}\Omega}$$

$$= 12\ \text{k}\Omega + 8\ \text{k}\Omega = 20\ \text{k}\Omega$$

b. From Ohm's law, the total current is

$$I_T = I_1 = \frac{48\ \text{V}}{20\ \text{k}\Omega} = 2.4\ \text{mA}$$

The current I_1 will enter node b and then split between the two resistors R_2 and R_3. This current divider may be simplified as shown in the partial circuit of Figure 7–6.

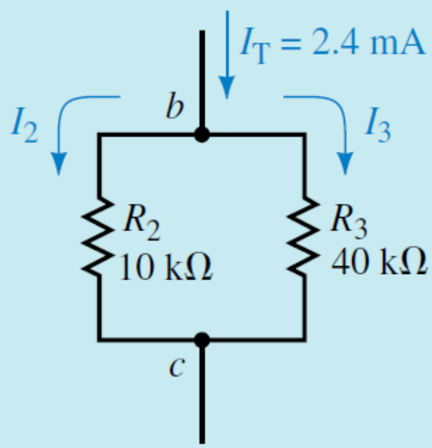


FIGURE 7–6

Analiza mješovitih kola

Primjer:

Applying the current divider rule to these two resistors gives

$$I_2 = \frac{(40\ \text{k}\Omega)(2.4\ \text{mA})}{10\ \text{k}\Omega + 40\ \text{k}\Omega} = 1.92\ \text{mA}$$

$$I_3 = \frac{(10\ \text{k}\Omega)(2.4\ \text{mA})}{10\ \text{k}\Omega + 40\ \text{k}\Omega} = 0.48\ \text{A}$$

c. Using the above currents and Ohm's law, we determine the voltages:

$$V_1 = (2.4\ \text{mA})(12\ \text{k}\Omega) = 28.8\ \text{V}$$

$$V_3 = (0.48\ \text{mA})(40\ \text{k}\Omega) = 19.2\ \text{V} = V_2$$

In order to check the answers, we may simply apply Kirchhoff's voltage law around any closed loop which includes the voltage source:

$$\begin{aligned}\sum V &= E - V_1 - V_3 \\ &= 48\ \text{V} - 28.8\ \text{V} - 19.2\ \text{V} \\ &= 0\ \text{V (checks!)}\end{aligned}$$

The solution may be verified by ensuring that the power delivered by the voltage source is equal to the summation of powers dissipated by the resistors.