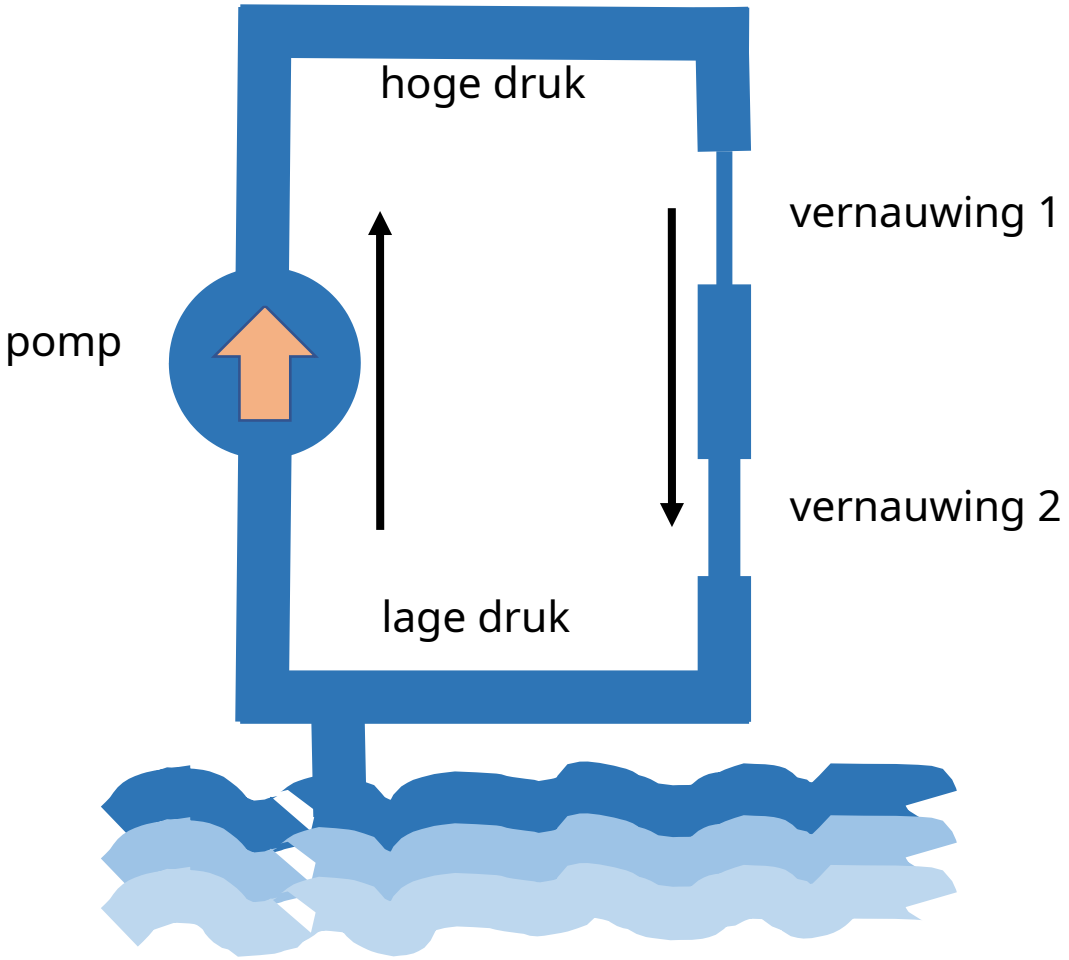
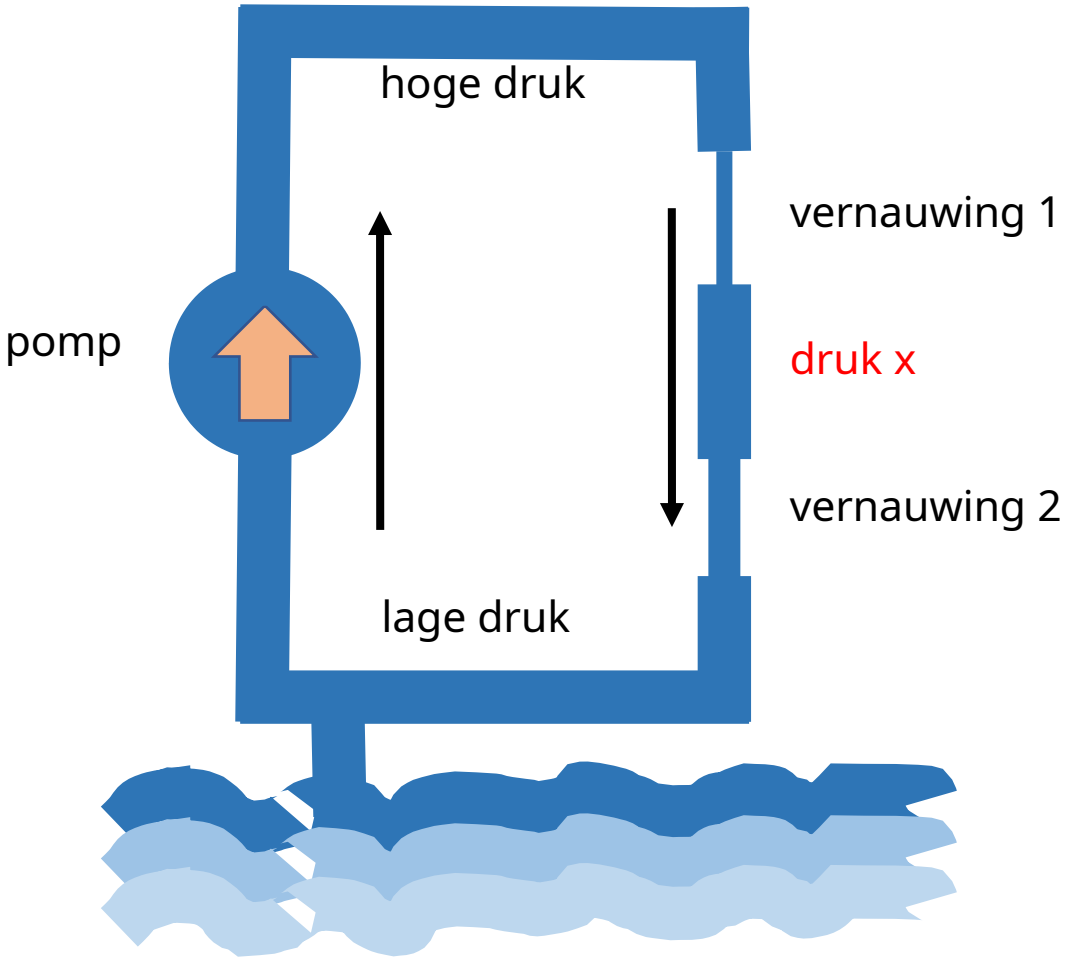
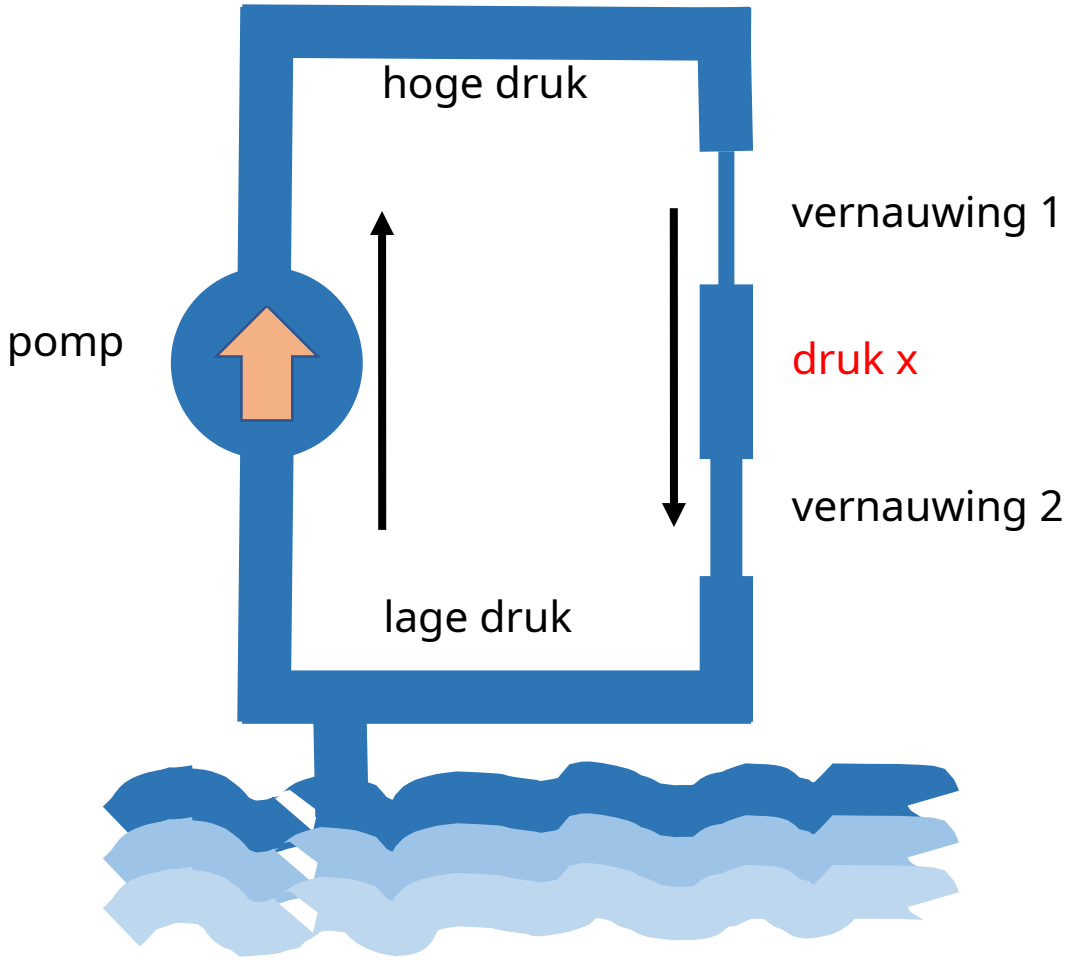
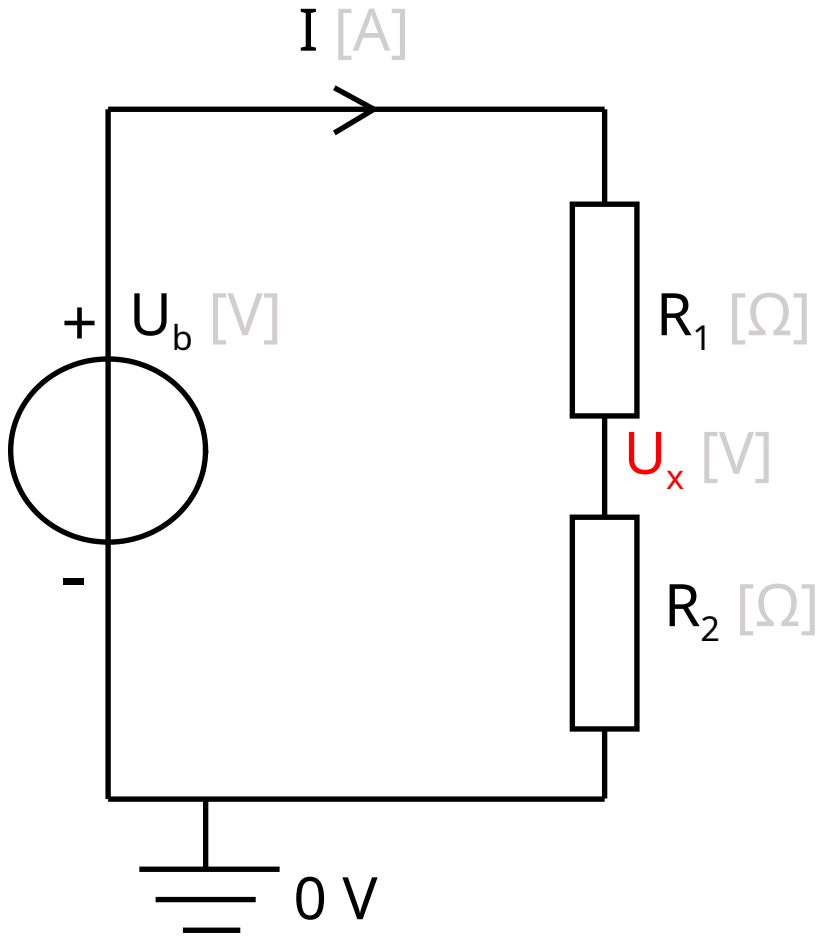
Uitgelegd met behulp van water

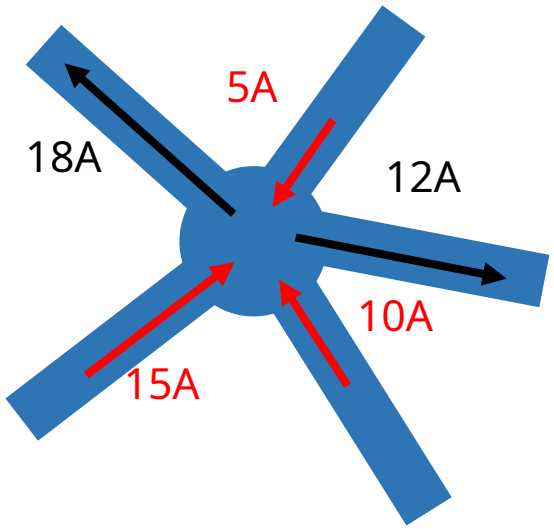
Spanning, stroom en weerstand

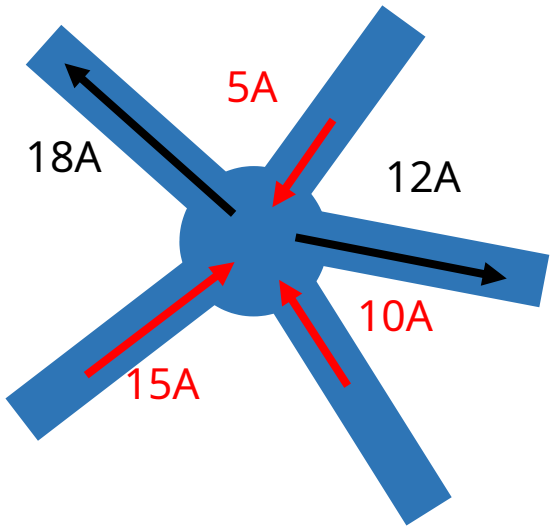

hoge druk
vernauwing 1
pomp
vernauwing 2
lage druk


hoge druk
vernauwing 1
pomp
druk x
vernauwing 2
lage druk

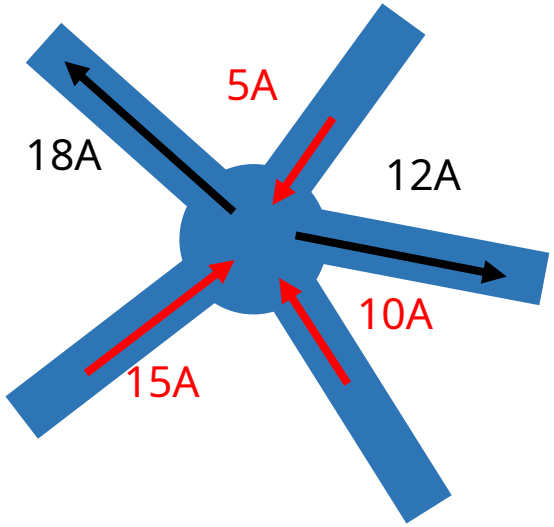

hoge druk
vernauwing 1
pomp
druk x
vernauwing 2
lage druk


I [A]
+
U_b [V]
-
R_1 [Ω]
U_x [V]
R_2 [Ω]
0 V

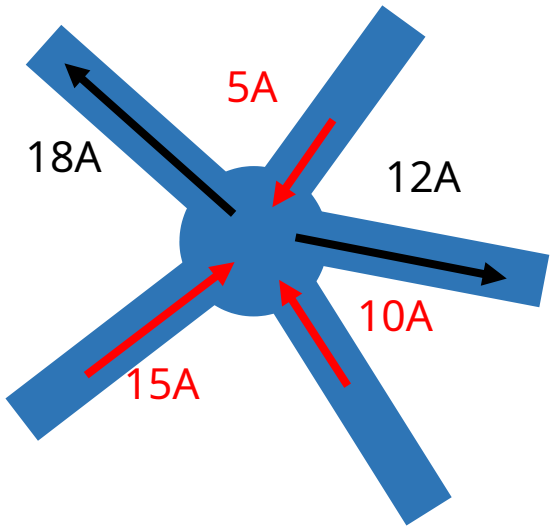

5A
18A
12A
10A
15A



$5 + 10 + 15 = 18 + 12$

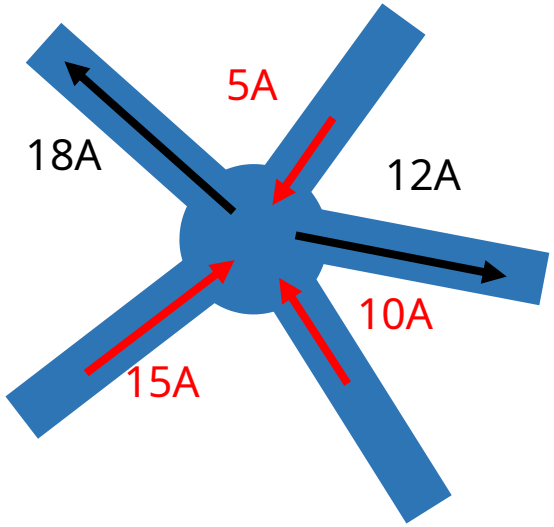


$5 + 10 + 15 = 18 + 12 \qquad | + -18 + -12$



$5 + 10 + 15 = 18 + 12 \quad | + -18 + -12$

$5 + 10 + 15 + -18 + -12 = 0$



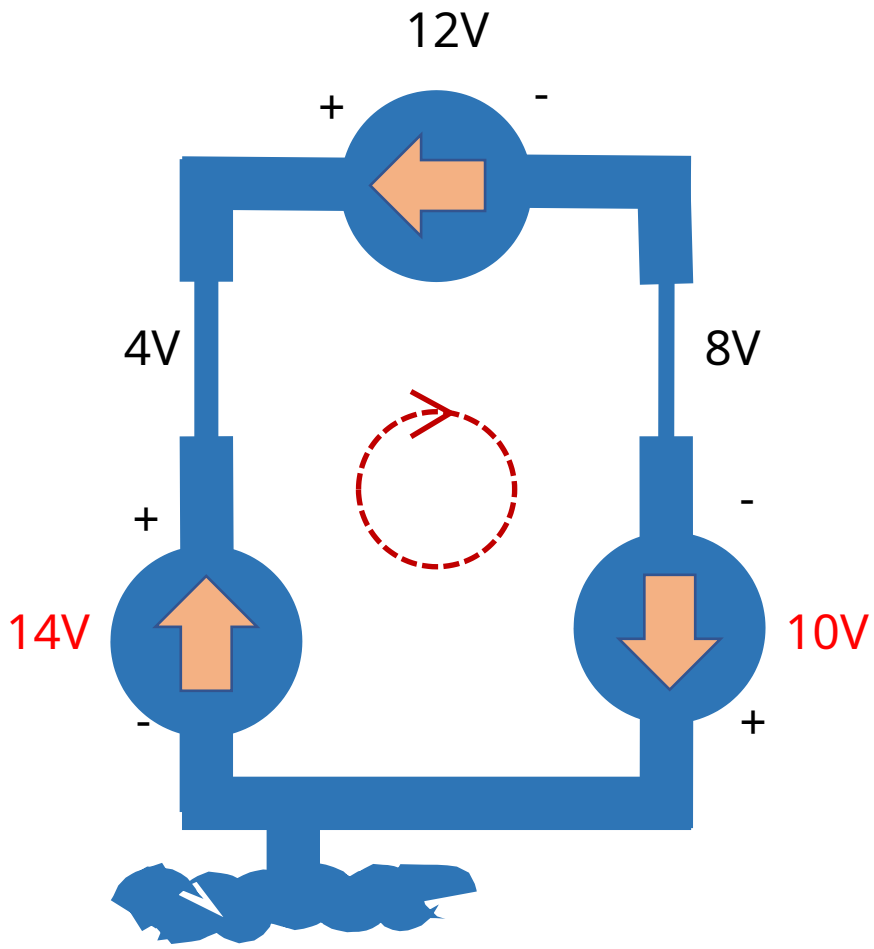
1e wet van Kirchhoff:

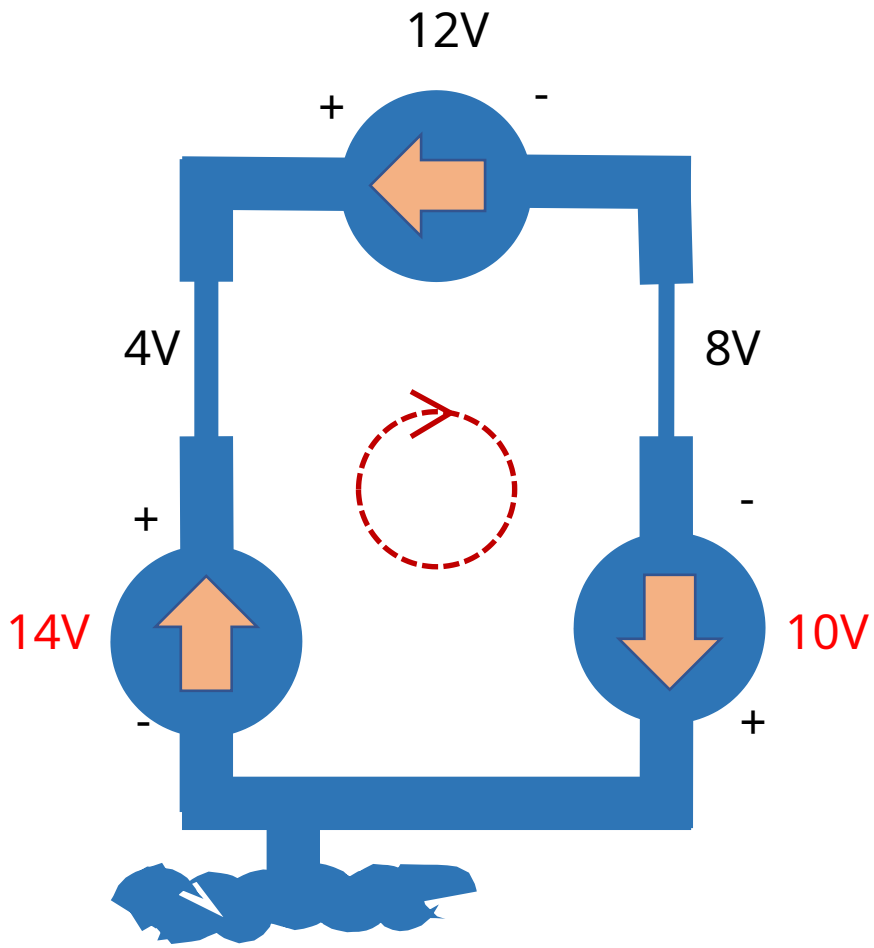
$$\sum I = 0$$

op elk knooppunt

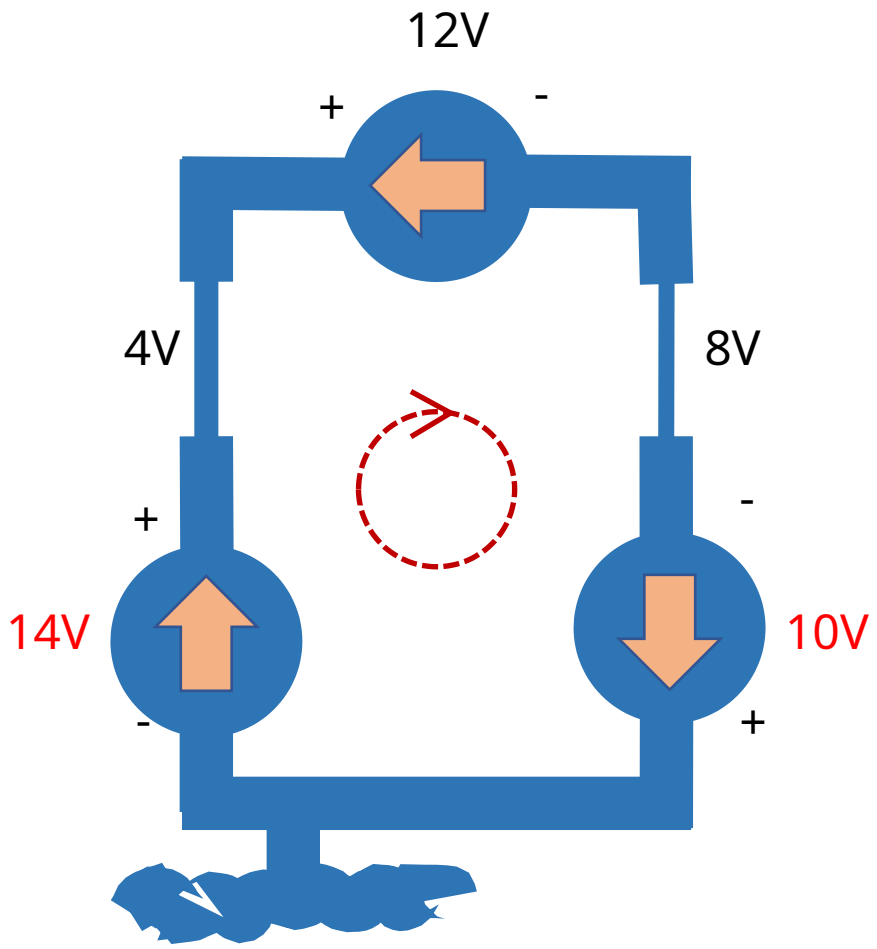
5 + 10 + 15 = 18 + 12 | + -18 + -12

5 + 10 + 15 + -18 + -12 = 0


12V
+
-
4V
8V
+
-
14V
10V
-
+



$$14 + 10 + -4 + -12 + -8 = 0$$

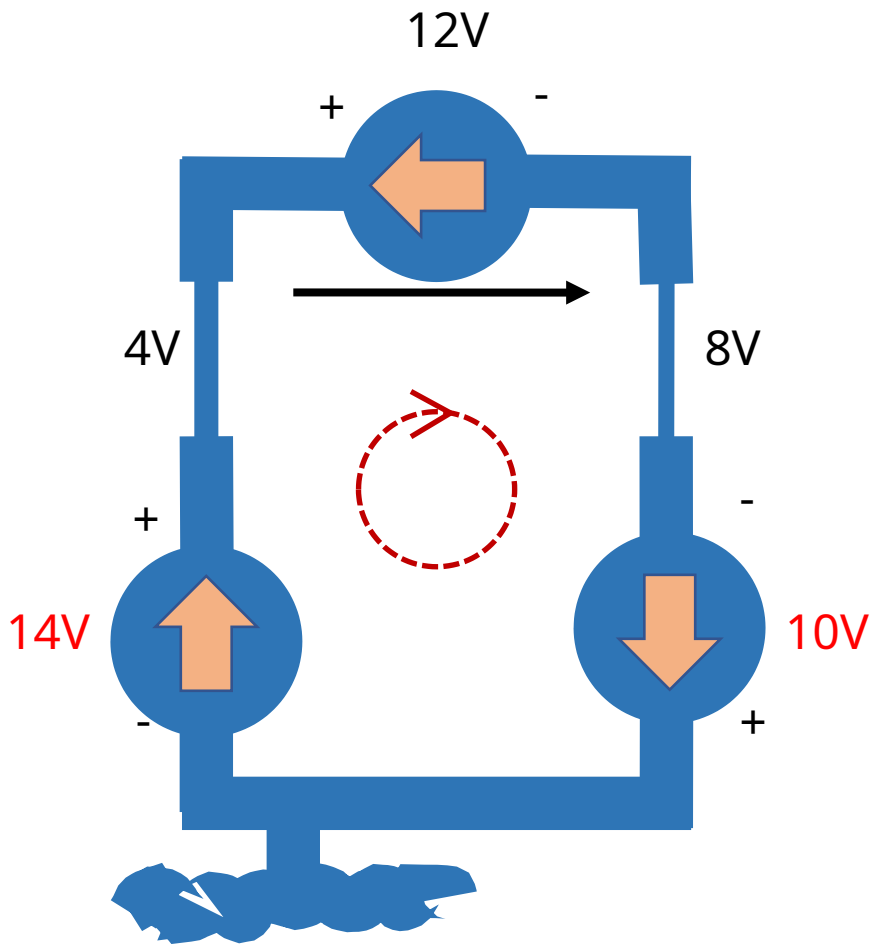


$14 + 10 + -4 + -12 + -8 = 0$

2e wet van Kirchhoff:

$$\sum U = 0$$

in elke lus

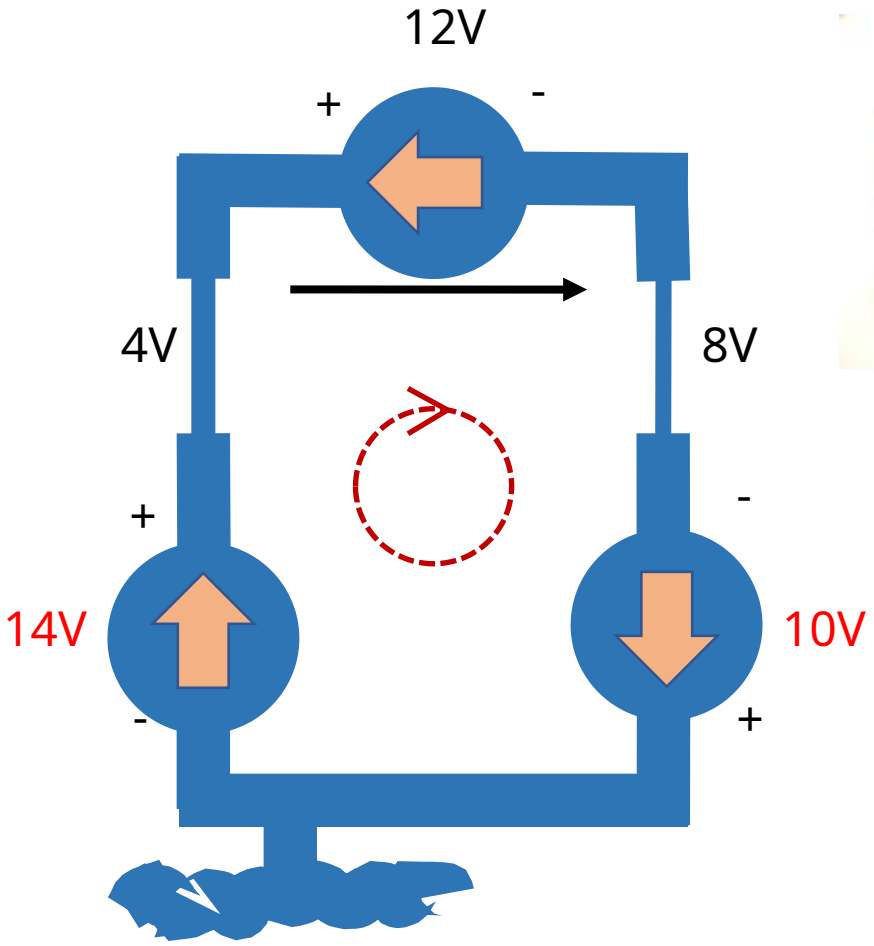


$14 + 10 + -4 + -12 + -8 = 0$

2e wet van Kirchhoff:

$$\sum U = 0$$

in elke lus

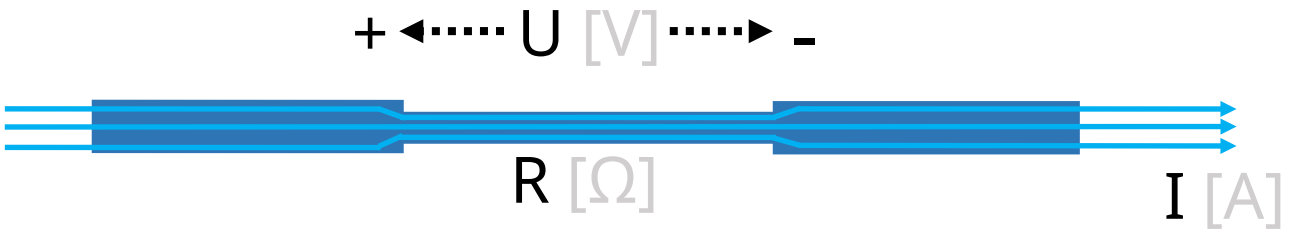


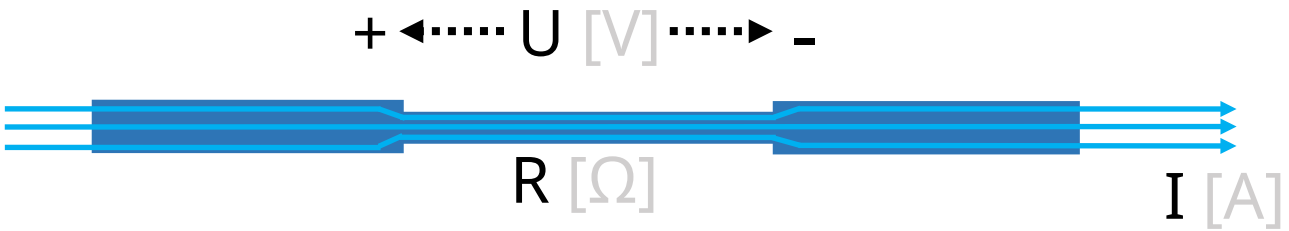
$14 + 10 + -4 + -12 + -8 = 0$

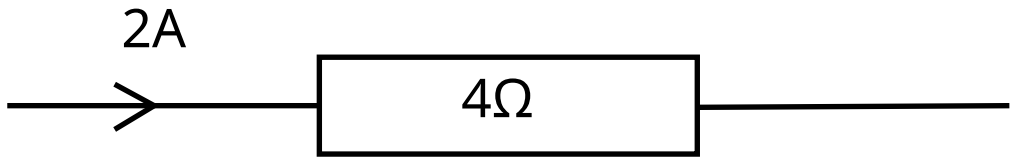
2e wet van Kirchhoff:

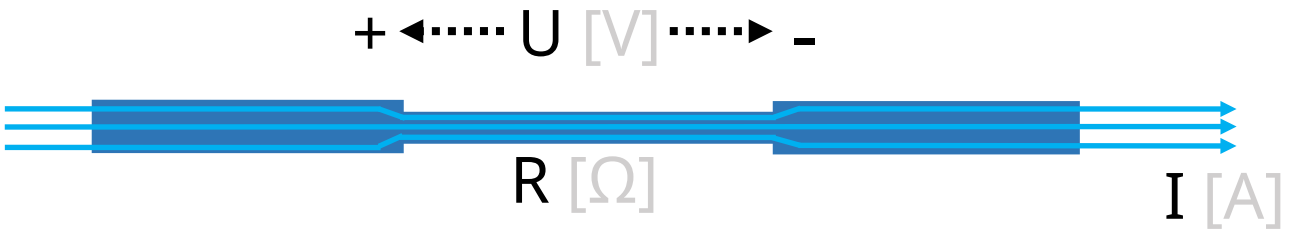
$$\sum U = 0$$

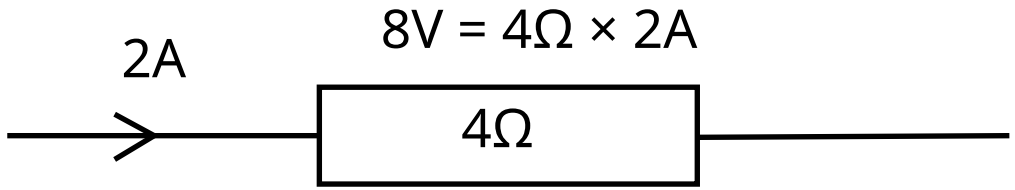
in elke lus

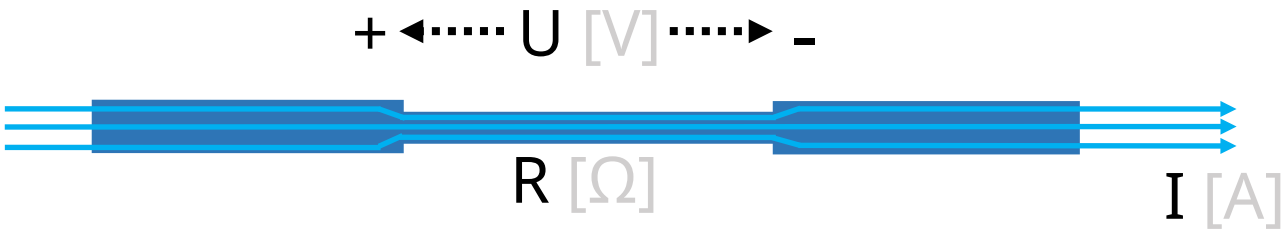

+
U [V]
-
R [Ω]
I [A]

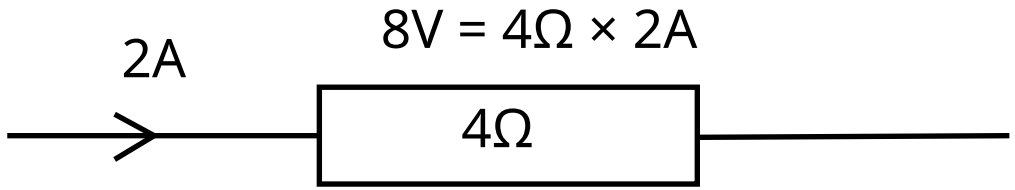

+
U [V]
-
R [Ω]
I [A]


2A
4Ω


+
U [V]
-
R [Ω]
I [A]


8V = 4Ω × 2A
2A
4Ω

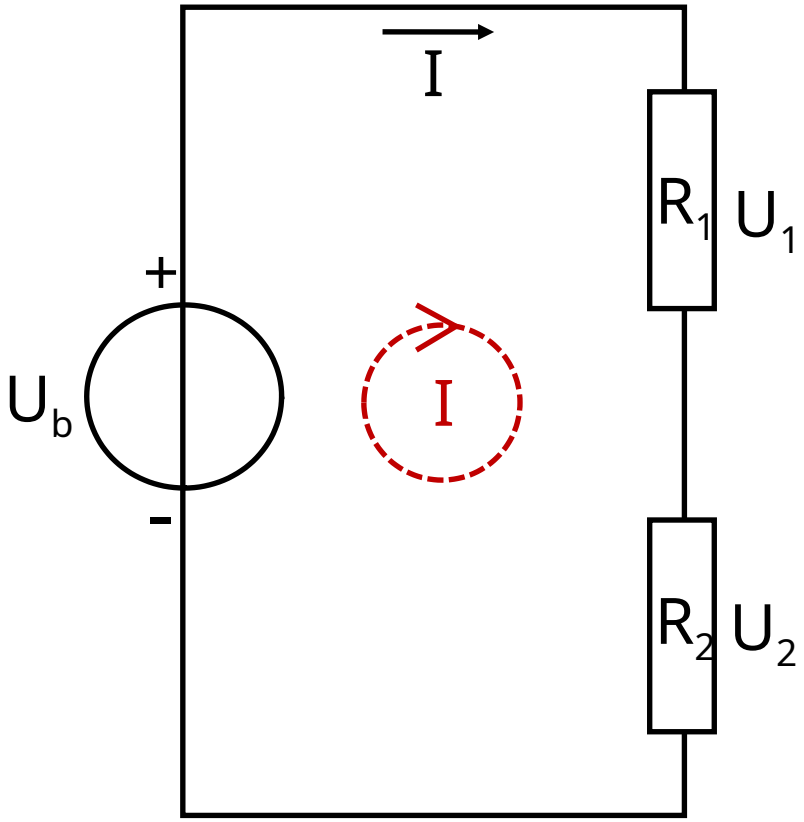


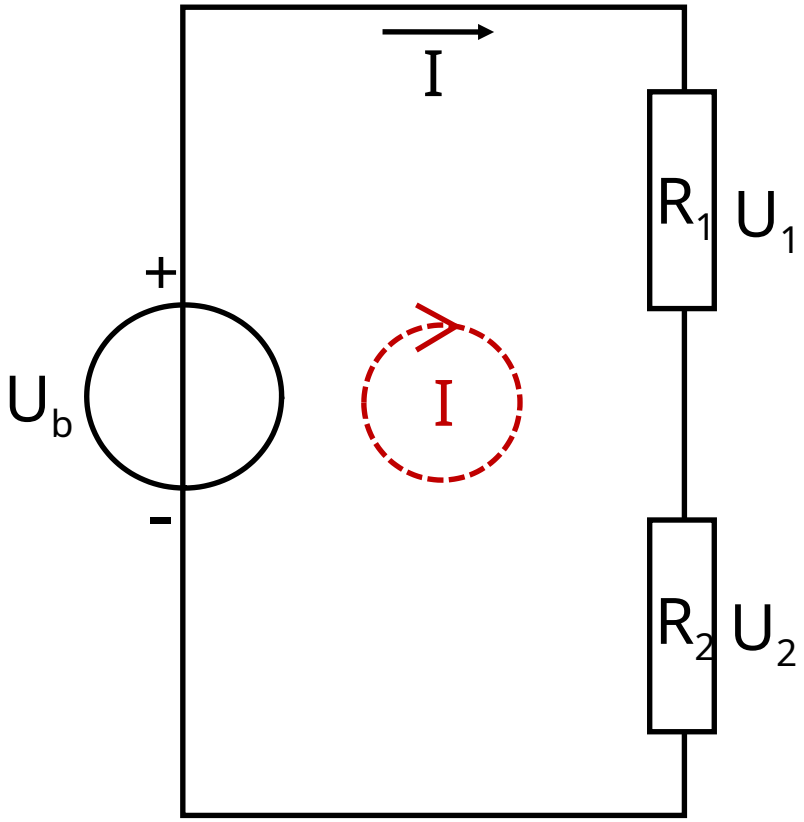


Wet van Ohm:

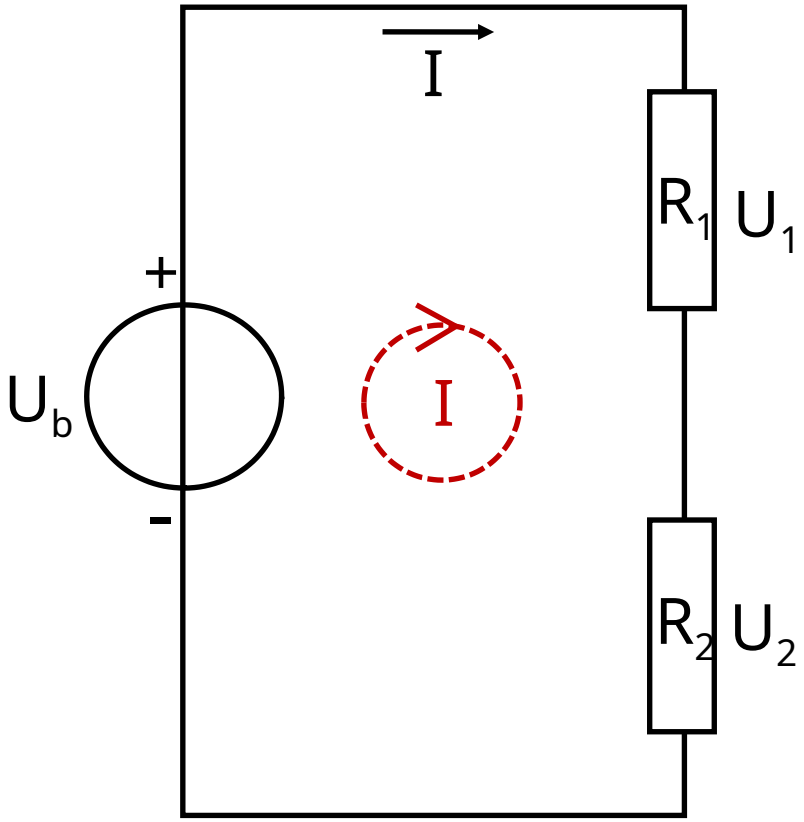
$$U = RI$$

voor elke weerstand


I
R1
U1
+
Ub
I
-
R2
U2

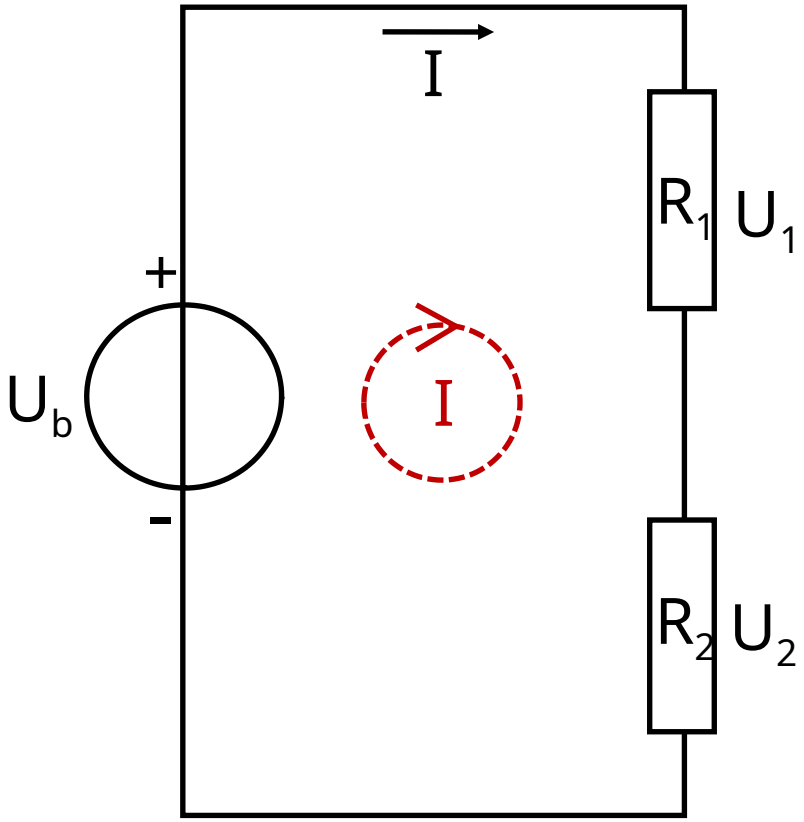


K2: $U_b + -U_1 + -U_2 = 0 \Rightarrow U_b = U_1 + U_2$



K2: $U_b + -U_1 + -U_2 = 0 \Rightarrow U_b = U_1 + U_2$

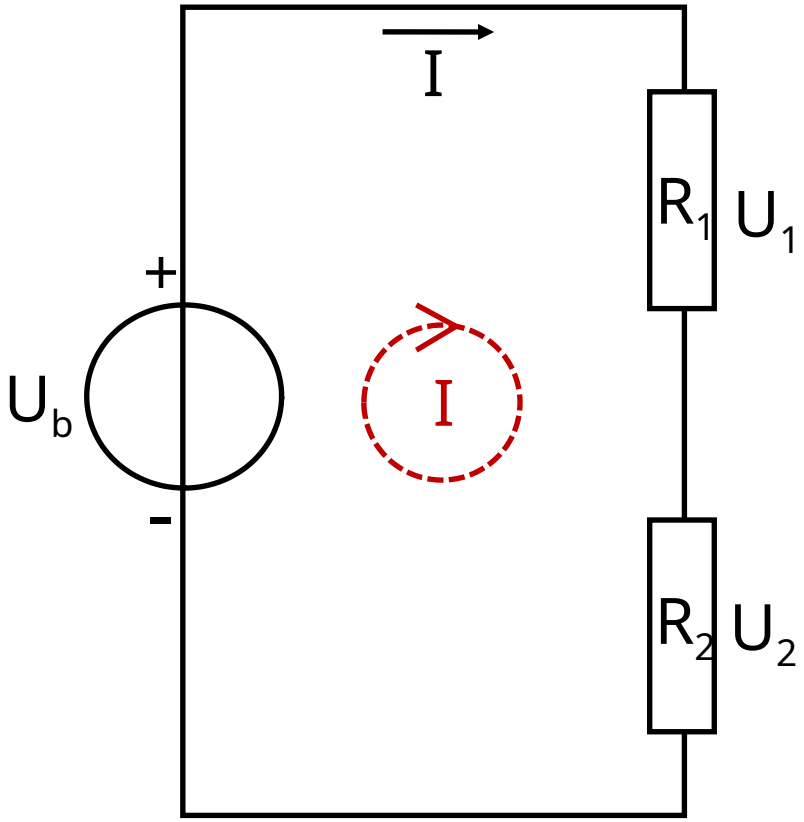
Ohm: $U_1 = R_1 I \quad \wedge \quad U_2 = R_2 I$



K2: $U_b + -U_1 + -U_2 = 0 \Rightarrow U_b = U_1 + U_2$

Ohm: $U_1 = R_1 I \wedge U_2 = R_2 I$

K2 $\wedge$ Ohm $\Rightarrow$ $U_b = R_1 I + R_2 I$

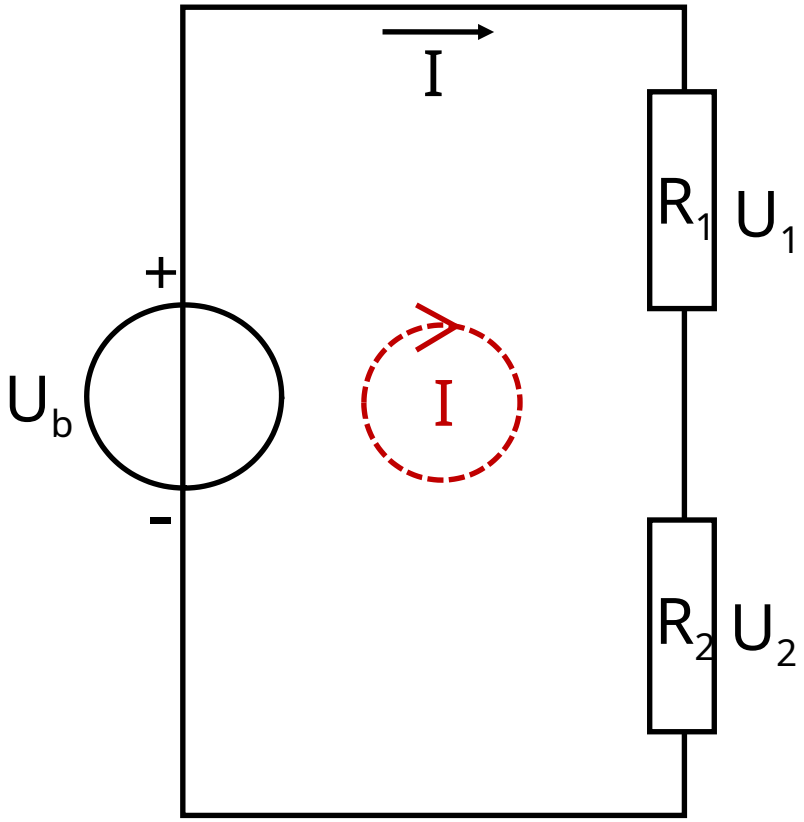


K2: $U_b + -U_1 + -U_2 = 0 \Rightarrow U_b = U_1 + U_2$

Ohm: $U_1 = R_1 I \wedge U_2 = R_2 I$

K2 $\wedge$ Ohm $\Rightarrow U_b = R_1 I + R_2 I$

$\Rightarrow U_b = (R_1 + R_2)\ I$

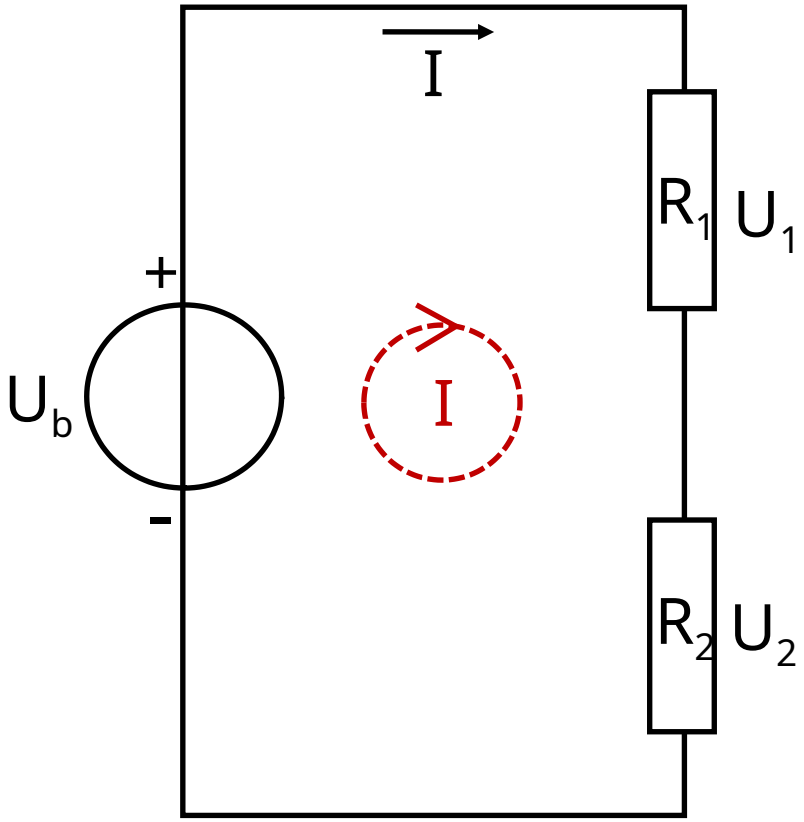


K2: $U_b + -U_1 + -U_2 = 0 \Rightarrow U_b = U_1 + U_2$

Ohm: $U_1 = R_1 I \quad \wedge \quad U_2 = R_2 I$

K2 $\wedge$ Ohm $\Rightarrow U_b = R_1 I + R_2 I$

$\Rightarrow U_b = (R_1 + R_2)\ I \quad \left| \times \frac{1}{R_1 + R_2} \right.$



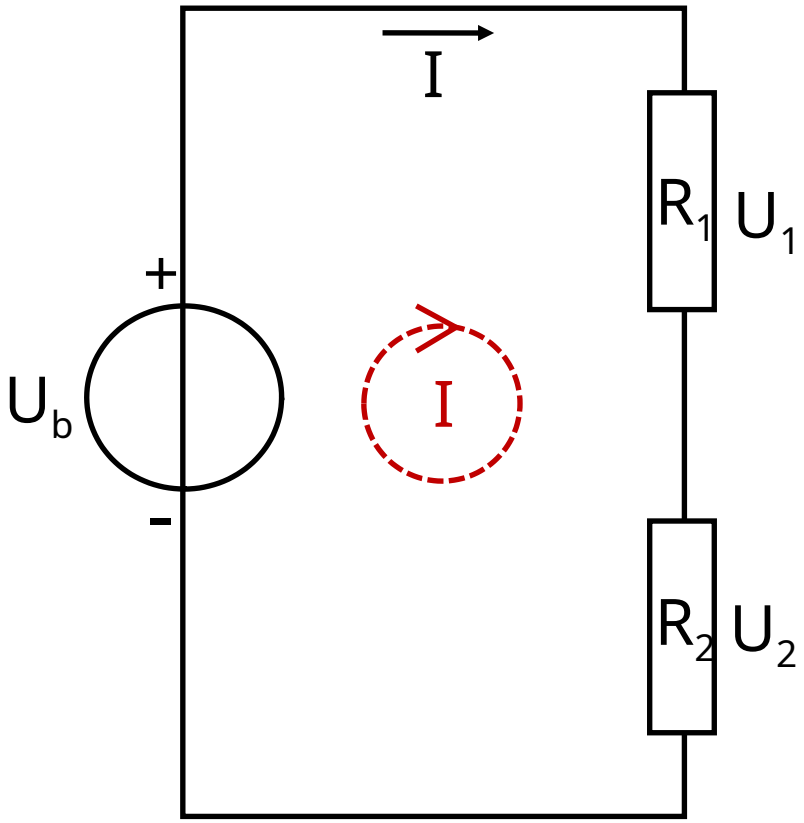
K2: $U_b + -U_1 + -U_2 = 0 \Rightarrow U_b = U_1 + U_2$

Ohm: $U_1 = R_1 I \quad \wedge \quad U_2 = R_2 I$

K2 $\wedge$ Ohm $\Rightarrow U_b = R_1 I + R_2 I$

$\Rightarrow U_b = (R_1 + R_2)\ I \quad \left| \times \frac{1}{R_1 + R_2} \right.$

$\Rightarrow I = \frac{1}{R_1 + R_2}\ U_b$



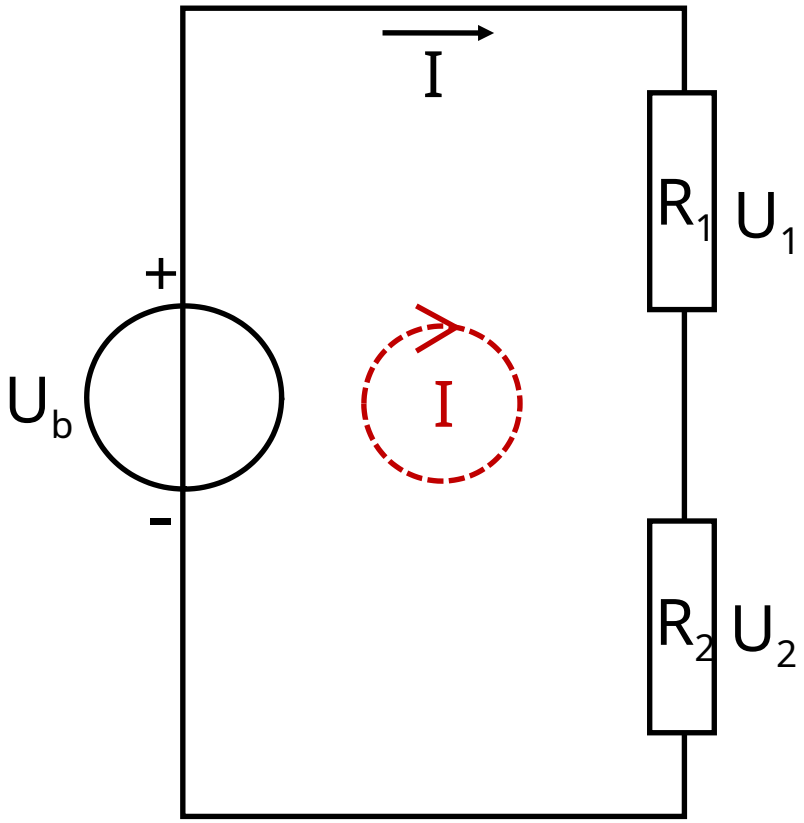
K2: $U_b + -U_1 + -U_2 = 0 \Rightarrow U_b = U_1 + U_2$

Ohm: $U_1 = R_1 I \quad \wedge \quad U_2 = R_2 I$

K2 $\wedge$ Ohm $\Rightarrow U_b = R_1 I + R_2 I$

$\Rightarrow U_b = (R_1 + R_2)\ I \quad \mid \times \frac{1}{R_1 + R_2}$

$\Rightarrow I = \frac{1}{R_1 + R_2}\ U_b \quad \mid$ Ohm



K2: $U_b + -U_1 + -U_2 = 0 \Rightarrow U_b = U_1 + U_2$

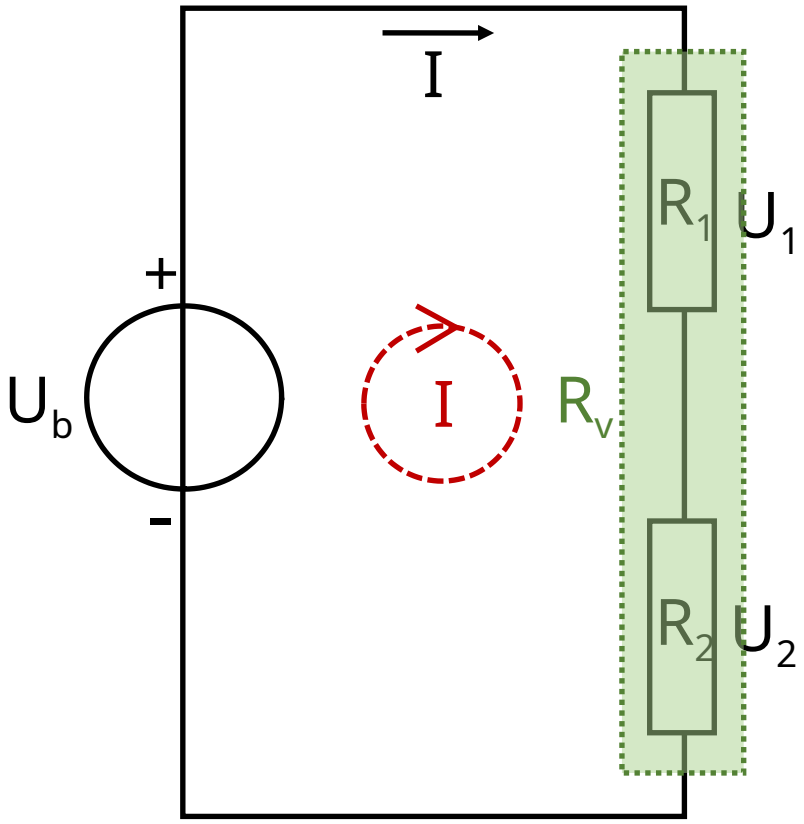
Ohm: $U_1 = R_1 I \quad \wedge \quad U_2 = R_2 I$

K2 $\wedge$ Ohm $\Rightarrow U_b = R_1 I + R_2 I$

$\Rightarrow U_b = (R_1 + R_2)\ I \quad | \times \frac{1}{R_1 + R_2}$

$\Rightarrow I = \frac{1}{R_1 + R_2} U_b \quad |$ Ohm

$\Rightarrow U_1 = \frac{R_1}{R_1 + R_2} U_b \quad \wedge \quad \mathbf{U_2 = \frac{R_2}{R_1 + R_2} U_b}$



K2: $U_b + -U_1 + -U_2 = 0 \Rightarrow U_b = U_1 + U_2$

Ohm: $U_1 = R_1 I \wedge U_2 = R_2 I$

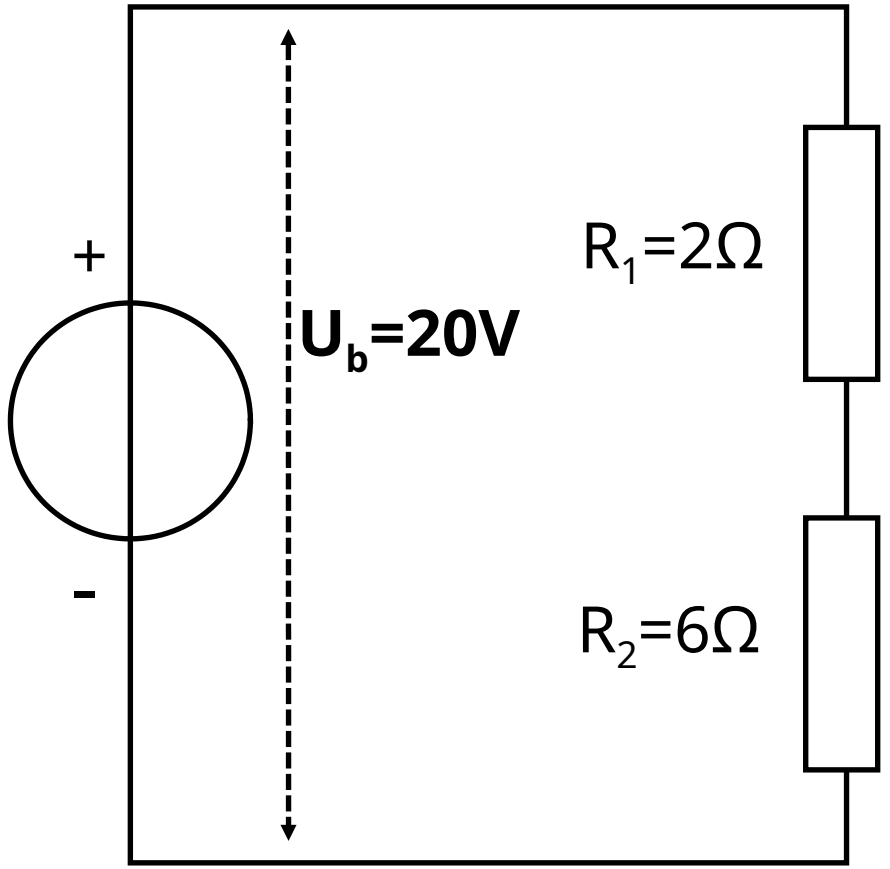
K2 $\wedge$ Ohm $\Rightarrow U_b = R_1 I + R_2 I$

$\Rightarrow U_b = \underbrace{(R_1 + R_2)}_{R_v} I \quad | \times \frac{1}{R_1 + R_2}$

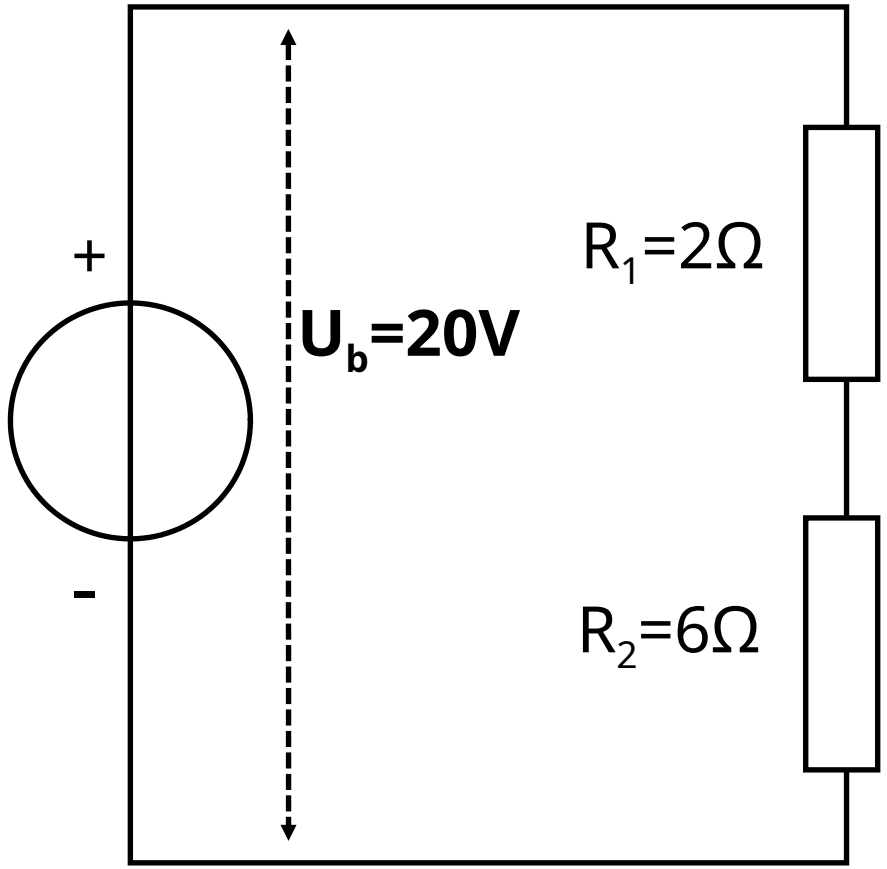
$\Rightarrow I = \frac{1}{R_1 + R_2} U_b \quad |$ Ohm

$\Rightarrow U_1 = \frac{R_1}{R_1 + R_2} U_b \wedge \mathbf{U_2 = \frac{R_2}{R_1 + R_2} U_b}$

Spanningsdeler

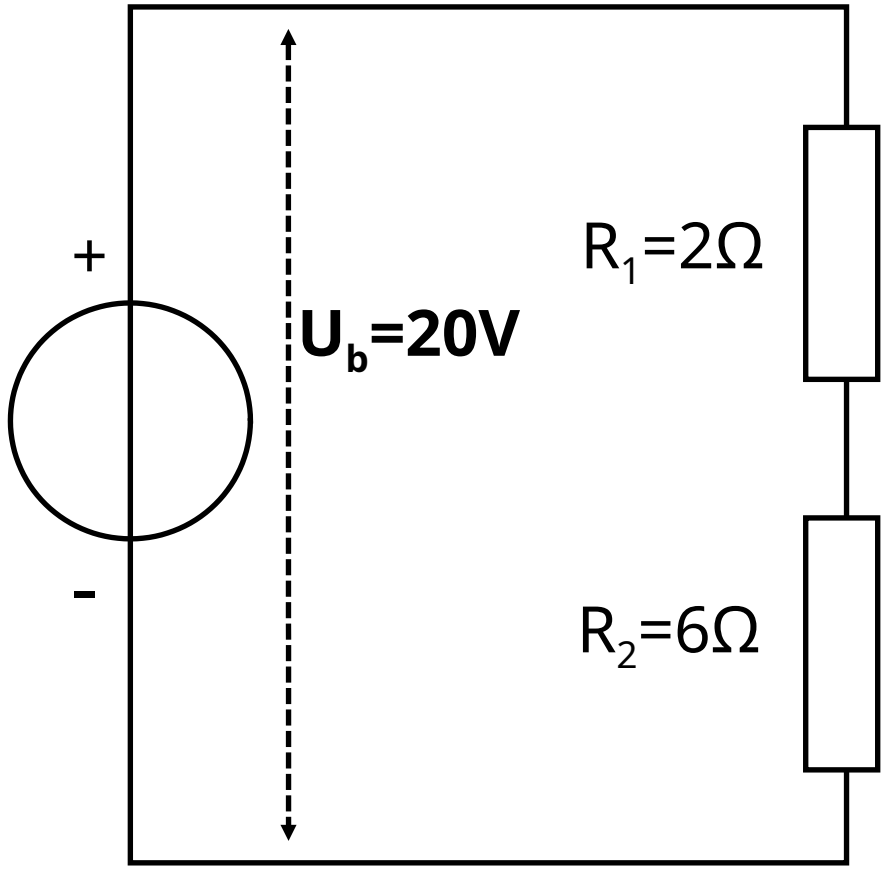


Spanningsdeler



$$U_2 = \frac{R_2}{R_1+R_2} U_b = \frac{6}{2+6} \times 20\ V = \mathbf{15V}$$

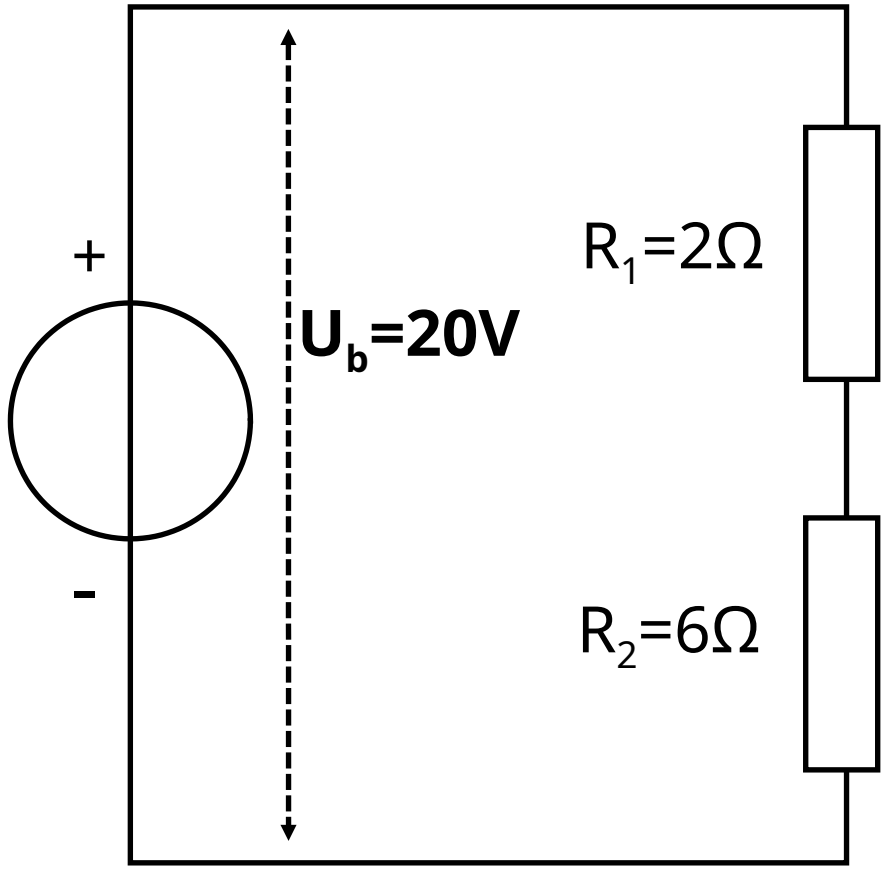
Spanningsdeler



$$\mathbf{U_1} = \frac{R_1}{R_1+R_2} U_b = \frac{2}{2+6} \times 20\ \text{V} = \mathbf{5V}$$

$$\mathbf{U_2} = \frac{R_2}{R_1+R_2} U_b = \frac{6}{2+6} \times 20\ \text{V} = \mathbf{15V}$$

Spanningsdeler

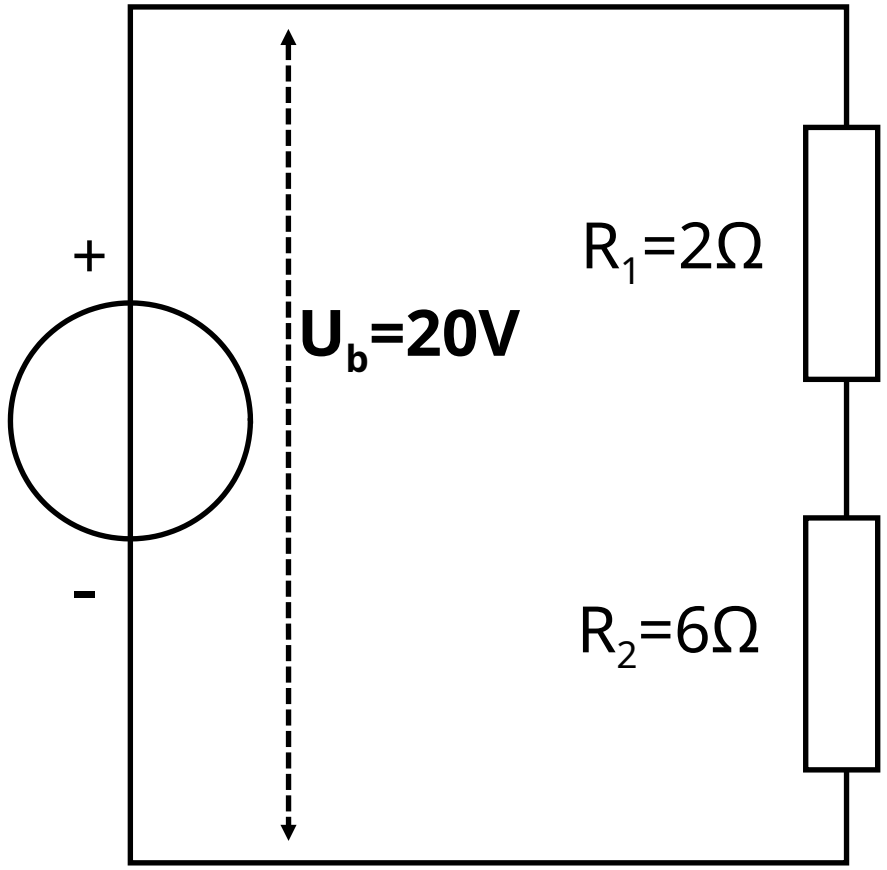


$$\mathbf{U_1} = \frac{R_1}{R_1+R_2} U_b = \frac{2}{2+6} \times 20\ \text{V} = \mathbf{5V}$$

$$\mathbf{U_2} = \frac{R_2}{R_1+R_2} U_b = \frac{6}{2+6} \times 20\ \text{V} = \mathbf{15V}$$

$$I = \frac{15\text{V}}{6\Omega} = 2\tfrac{1}{2}\ \text{A}$$

Spanningsdeler



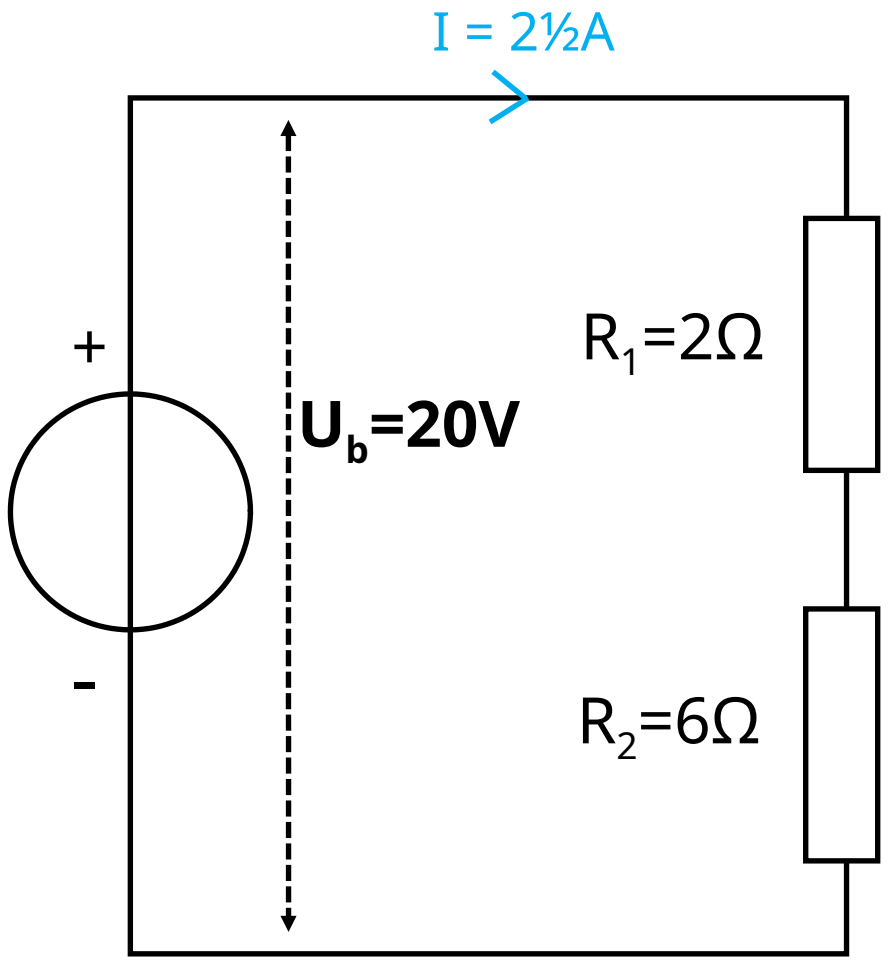
$$\mathbf{U_1} = \frac{R_1}{R_1+R_2} U_b = \frac{2}{2+6} \times 20\ \text{V} = \mathbf{5V}$$

$$I = \frac{5V}{2\Omega} = 2\tfrac{1}{2}\ \text{A}$$

$$\mathbf{U_2} = \frac{R_2}{R_1+R_2} U_b = \frac{6}{2+6} \times 20\ \text{V} = \mathbf{15V}$$

$$I = \frac{15V}{6\Omega} = 2\tfrac{1}{2}\ \text{A}$$

Spanningsdeler



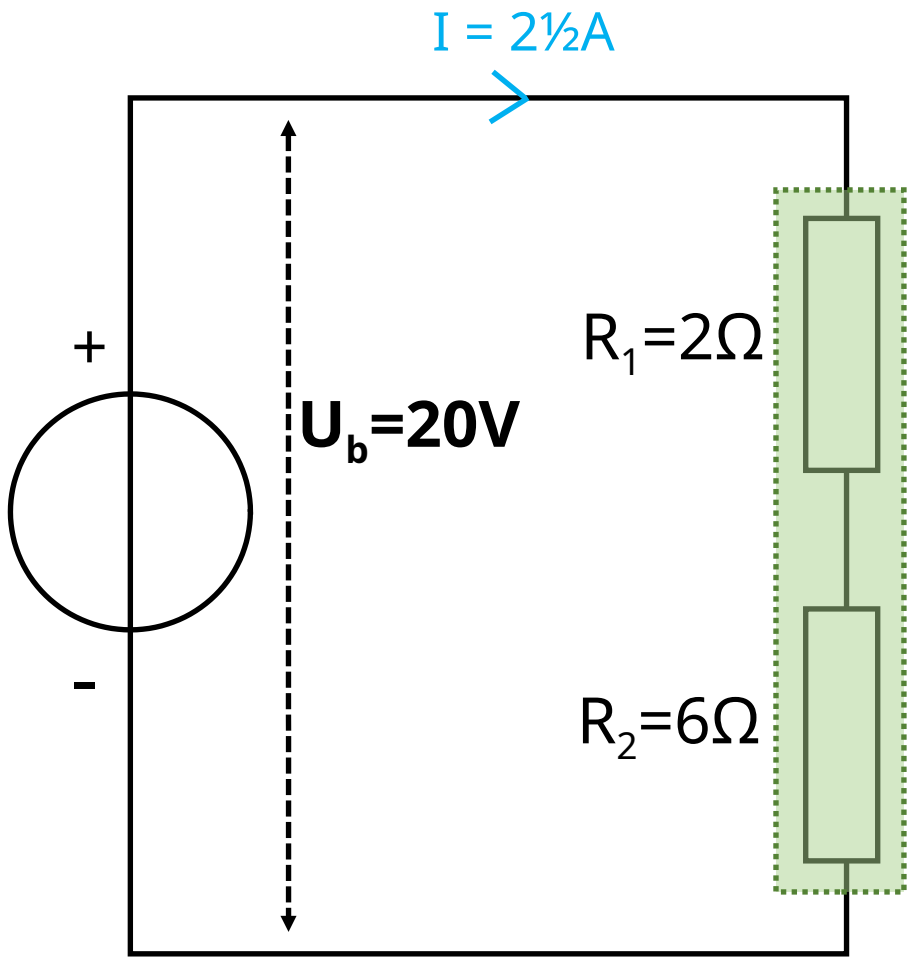
$$U_1 = \frac{R_1}{R_1+R_2} U_b = \frac{2}{2+6} \times 20\ V = \mathbf{5V}$$

$$I = \frac{5V}{2\Omega} = 2½\ A$$

$$U_2 = \frac{R_2}{R_1+R_2} U_b = \frac{6}{2+6} \times 20\ V = \mathbf{15V}$$

$$I = \frac{15V}{6\Omega} = 2½\ A$$

Spanningsdeler



$$U_1 = \frac{R_1}{R_1+R_2} U_b = \frac{2}{2+6} \times 20\ V = \mathbf{5V}$$

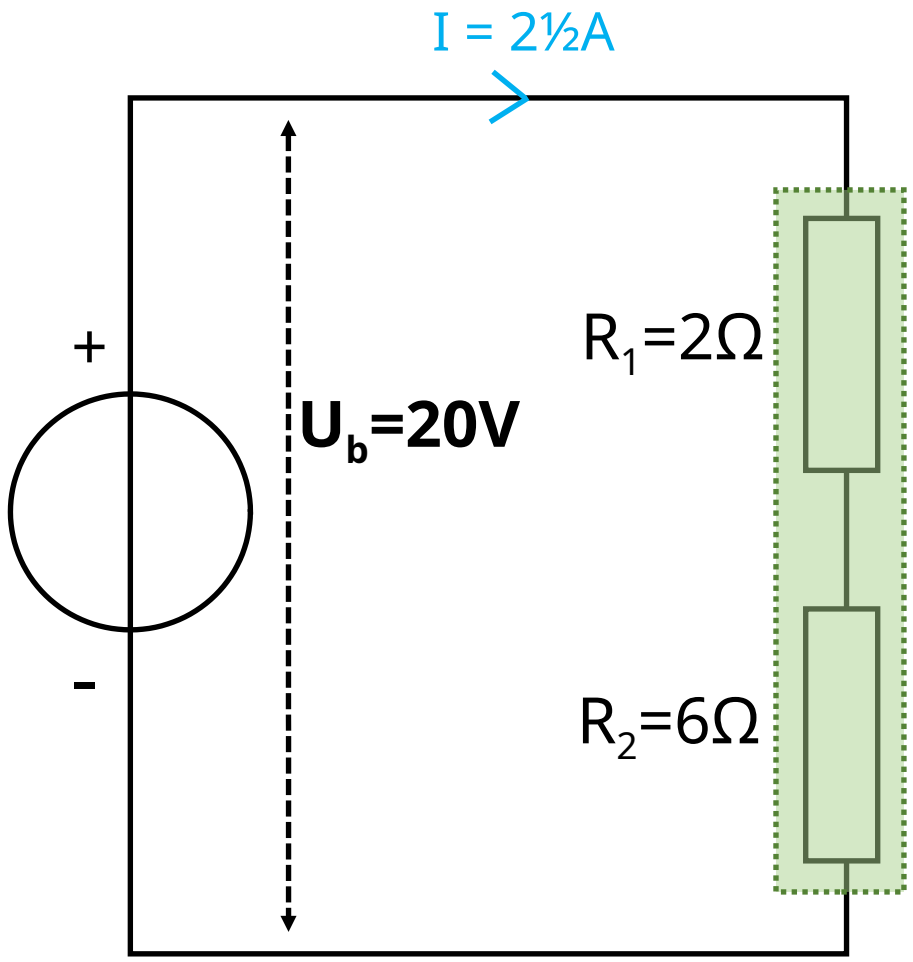
$$I = \frac{5V}{2\Omega} = 2½\ A$$

$$U_2 = \frac{R_2}{R_1+R_2} U_b = \frac{6}{2+6} \times 20\ V = \mathbf{15V}$$

$$I = \frac{15V}{6\Omega} = 2½\ A$$

$$R_v = (2+6)\Omega = 8\Omega$$

Spanningsdeler



$$U_1 = \frac{R_1}{R_1+R_2} U_b = \frac{2}{2+6} \times 20\ V = \mathbf{5V}$$

$$I = \frac{5V}{2\Omega} = 2½\ A$$

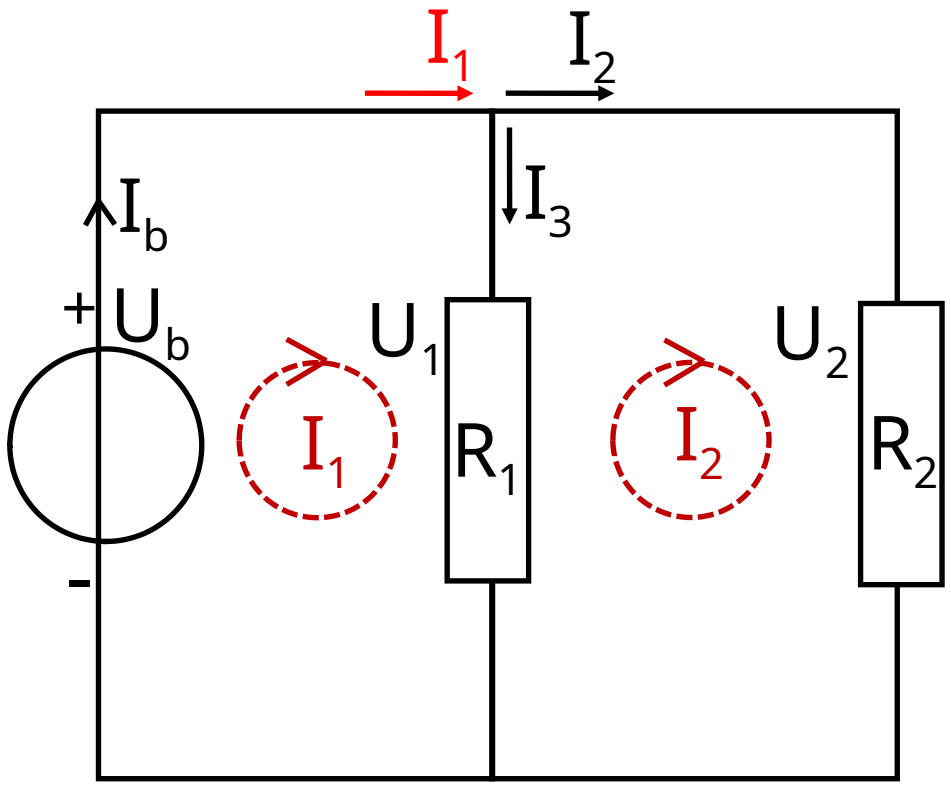
$$U_2 = \frac{R_2}{R_1+R_2} U_b = \frac{6}{2+6} \times 20\ V = \mathbf{15V}$$

$$I = \frac{15V}{6\Omega} = 2½\ A$$

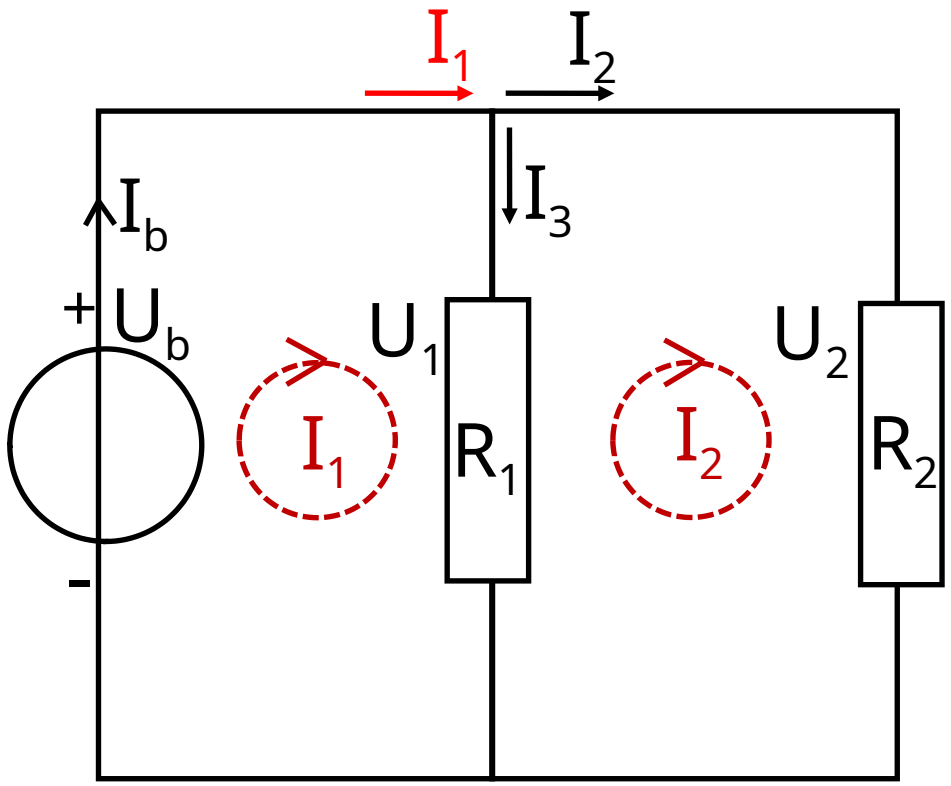
$R_v = (2+6)\Omega = 8\Omega$

Check: $U_b = R_v \times I = 8\Omega \times 2½A = 20V$

Stroomdeler

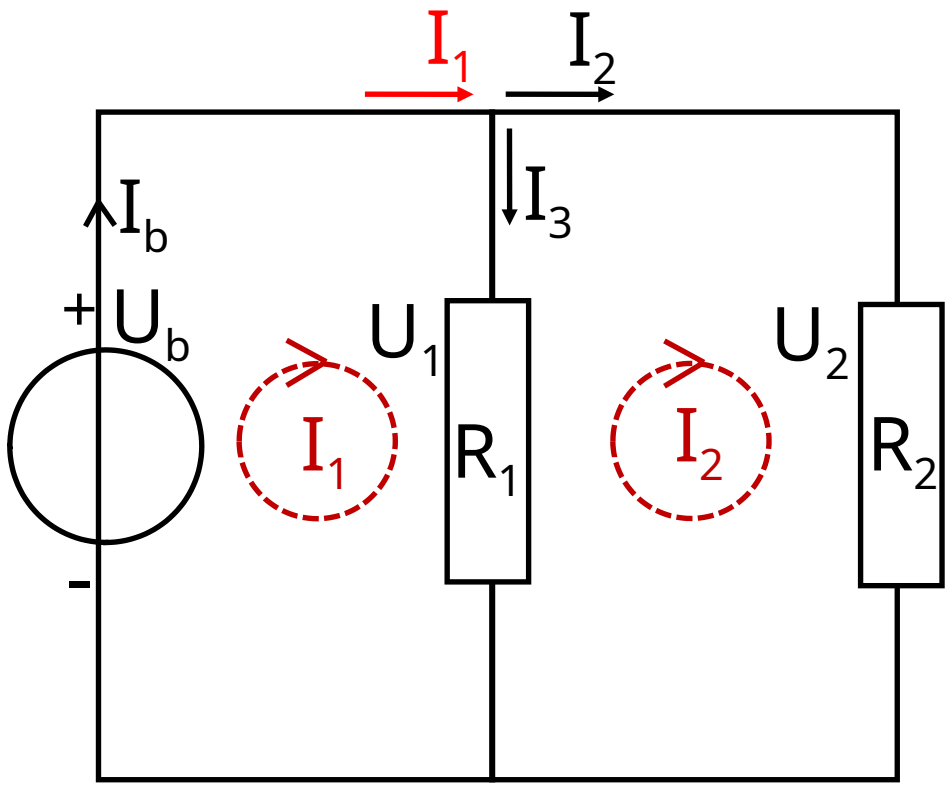


Stroomdeler



K2: $U_b + -U_1 = 0 \quad \Rightarrow \quad U_b = U_1$

Stroomdeler



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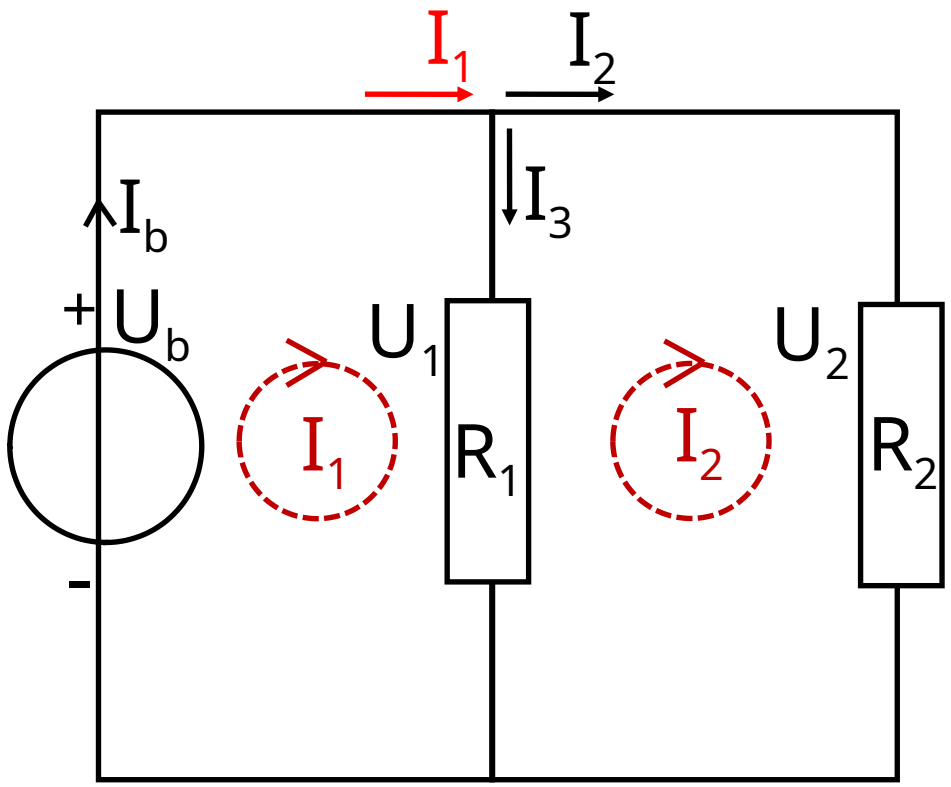
$U_1 + -U_2 = 0 \quad \Rightarrow \quad 0 = -U_1 + U_2$

Stroomdeler



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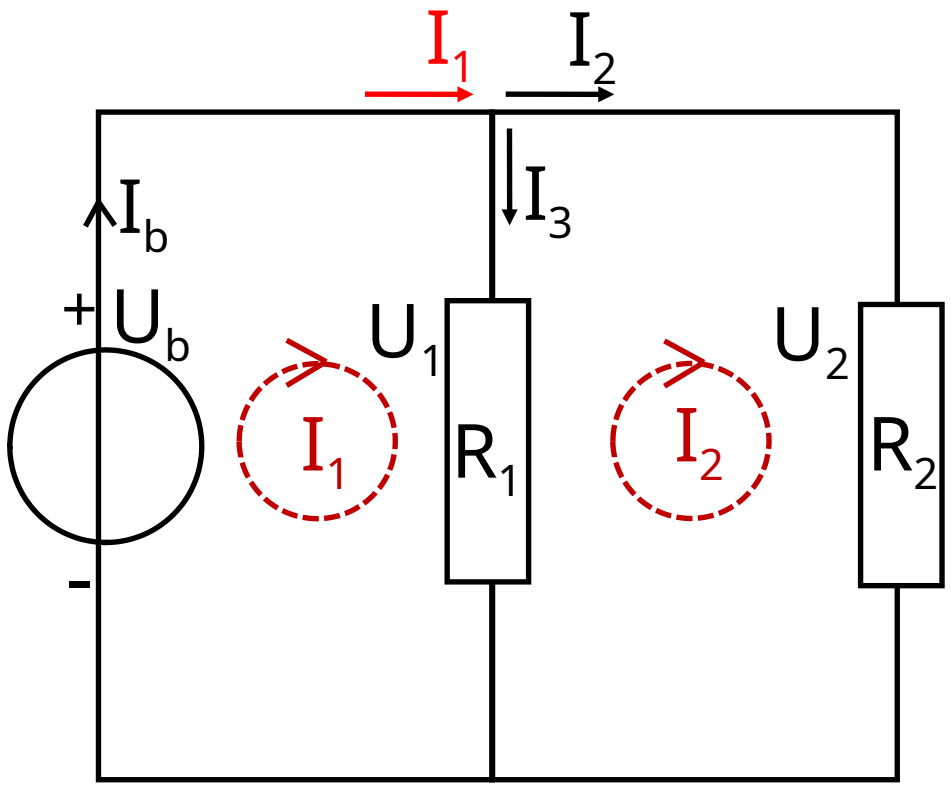
Stroomdeler



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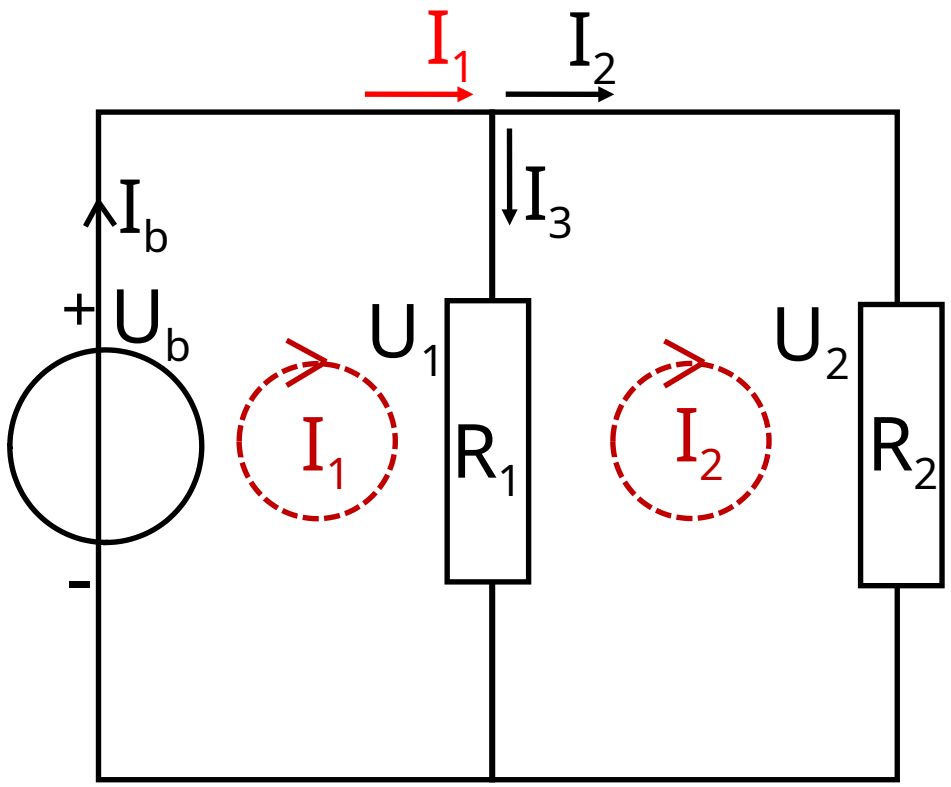
Stroomdeler



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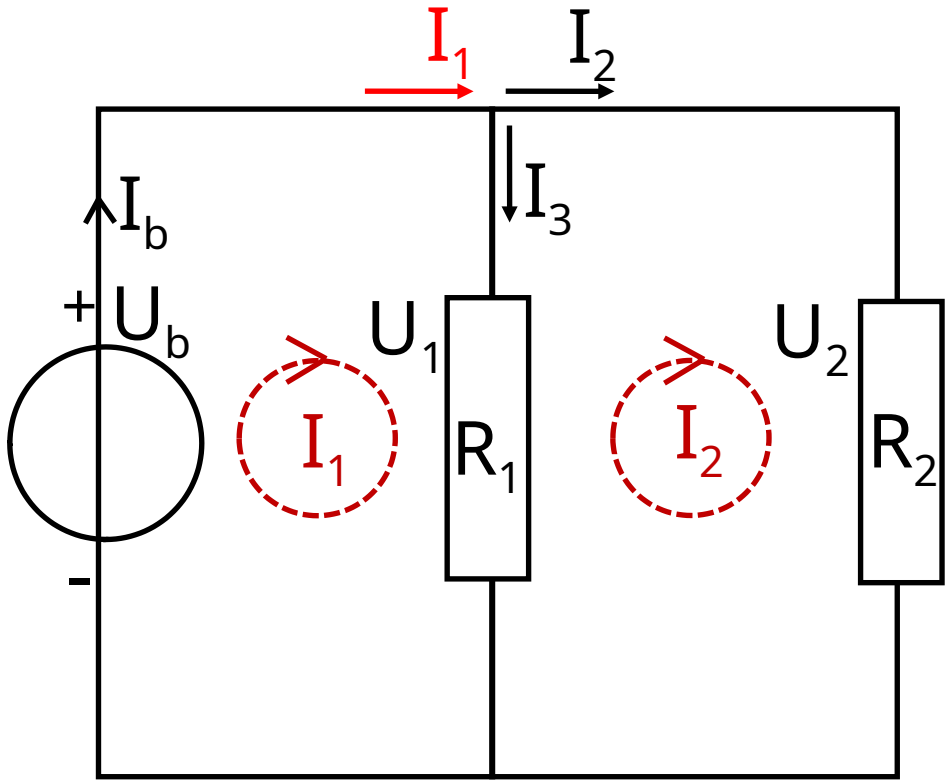
Stroomdeler



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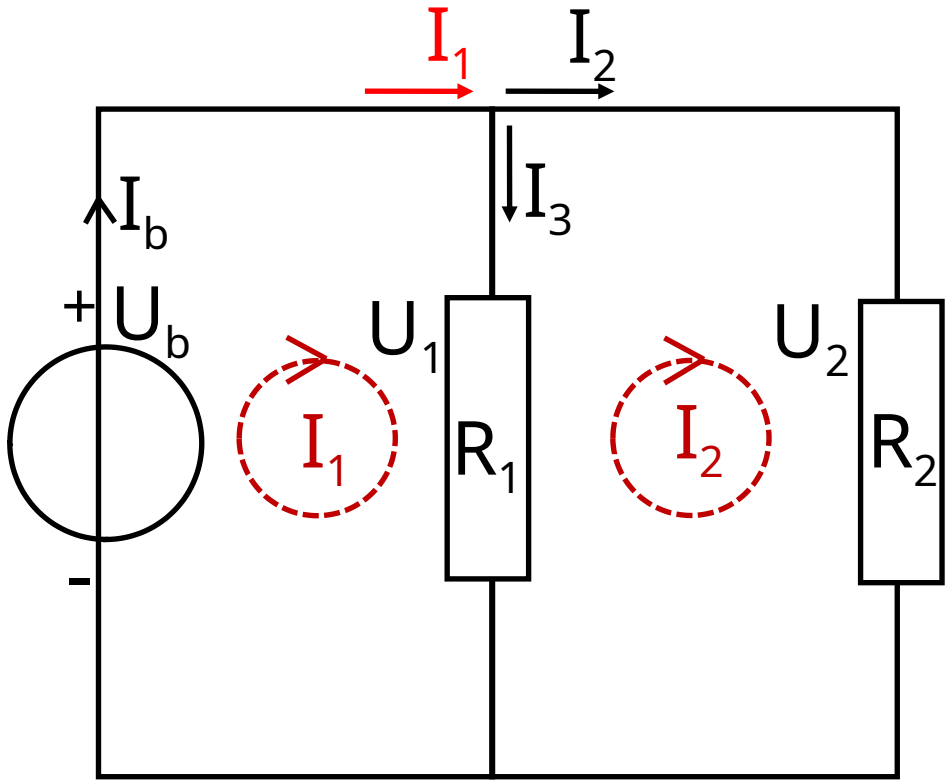
$$\left(\begin{array}{cc|cc} R_1 & -R_1 & 1 & 0 \\ -R_1 & R_1+R_2 & 0 & 1 \end{array}\right) \dashrightarrow \left(\begin{array}{cc|cc} R_1 & -R_1 & 1 & 0 \\ 0 & R_2 & 1 & 1 \end{array}\right) \dashrightarrow \left(\begin{array}{cc|cc} 1 & -1 & \frac{1}{R_1} & 0 \\ 0 & 1 & \frac{1}{R_2} & \frac{1}{R_2} \end{array}\right) \dashrightarrow \left(\begin{array}{cc|cc} 1 & 0 & \frac{1}{R_1}+\frac{1}{R_2} & \frac{1}{R_2} \\ 0 & 1 & \frac{1}{R_2} & \frac{1}{R_2} \end{array}\right)$$

Stroomdeler



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$$\left(\begin{array}{cc|cc} R_1 & -R_1 & 1 & 0 \\ -R_1 & R_1+R_2 & 0 & 1 \end{array}\right) \dashrightarrow \left(\begin{array}{cc|cc} R_1 & -R_1 & 1 & 0 \\ 0 & R_2 & 1 & 1 \end{array}\right) \dashrightarrow \left(\begin{array}{cc|cc} 1 & -1 & \frac{1}{R_1} & 0 \\ 0 & 1 & \frac{1}{R_2} & \frac{1}{R_2} \end{array}\right) \dashrightarrow \left(\begin{array}{cc|cc} 1 & 0 & \frac{1}{R_1}+\frac{1}{R_2} & \frac{1}{R_2} \\ 0 & 1 & \frac{1}{R_2} & \frac{1}{R_2} \end{array}\right)$$

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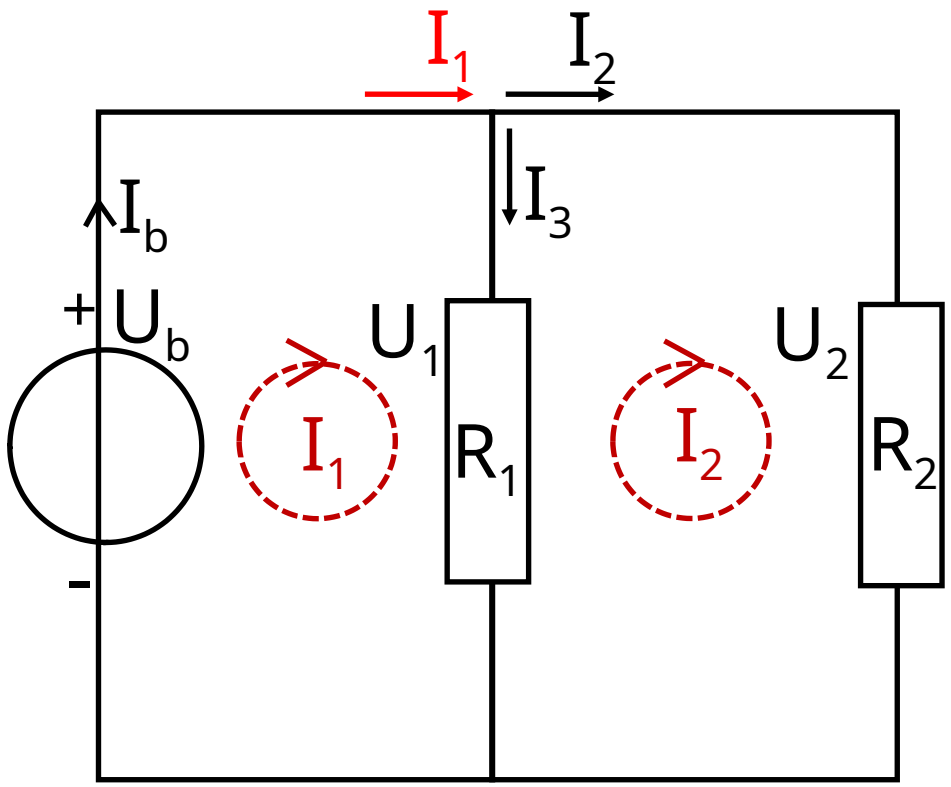
Stroomdeler



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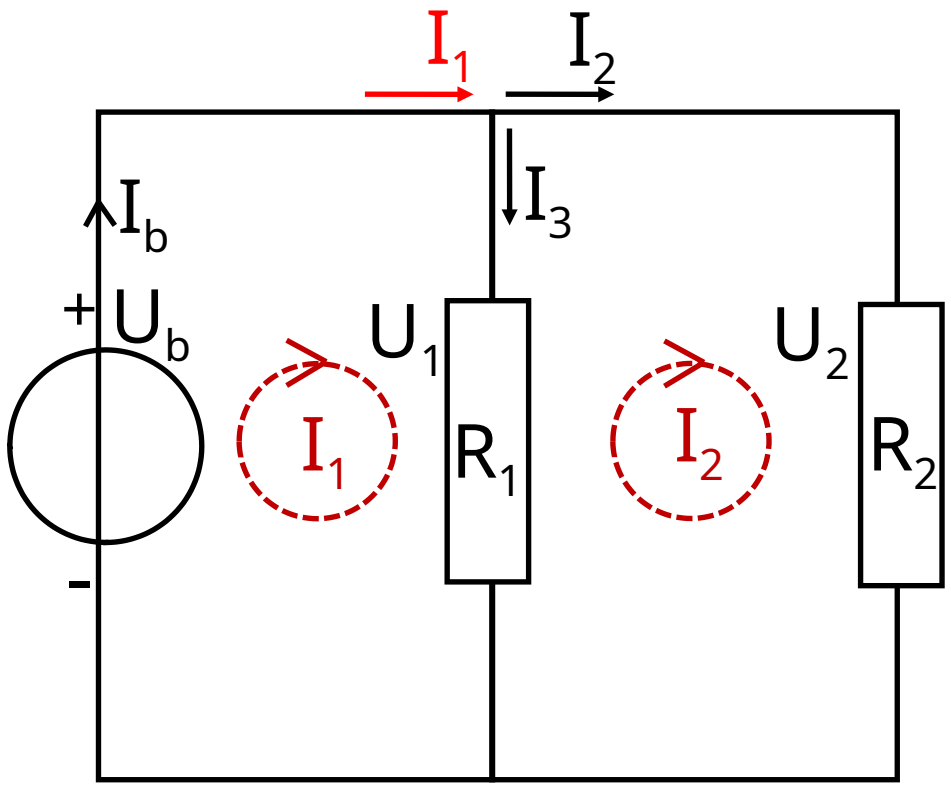
$G_v = G_1 + G_2$

Stroomdeler



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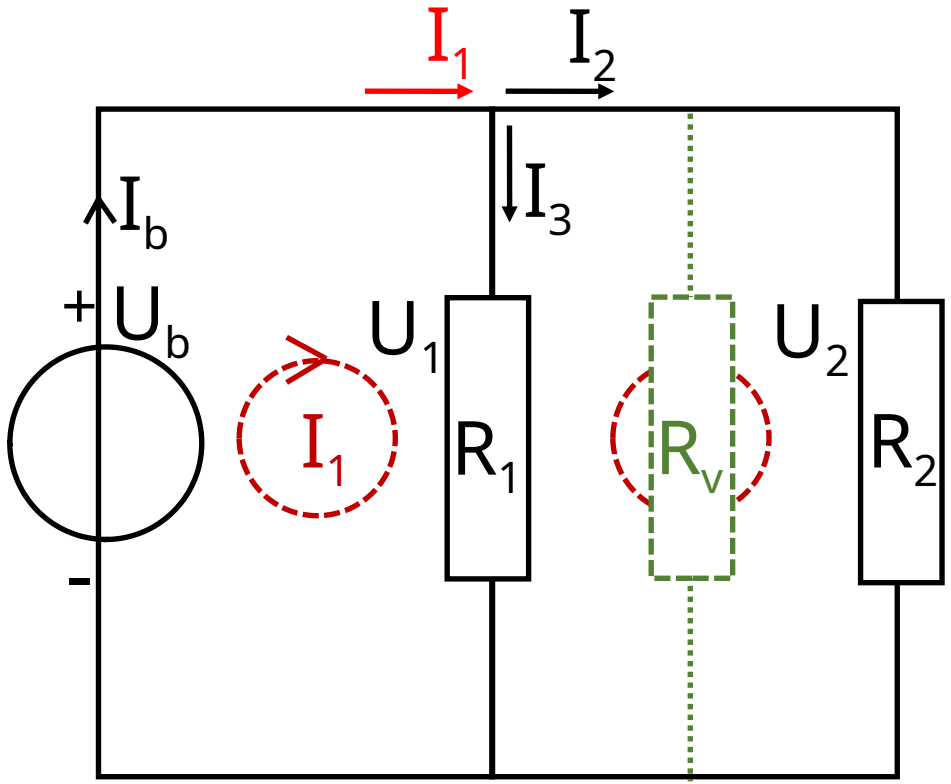
Stroomdeler



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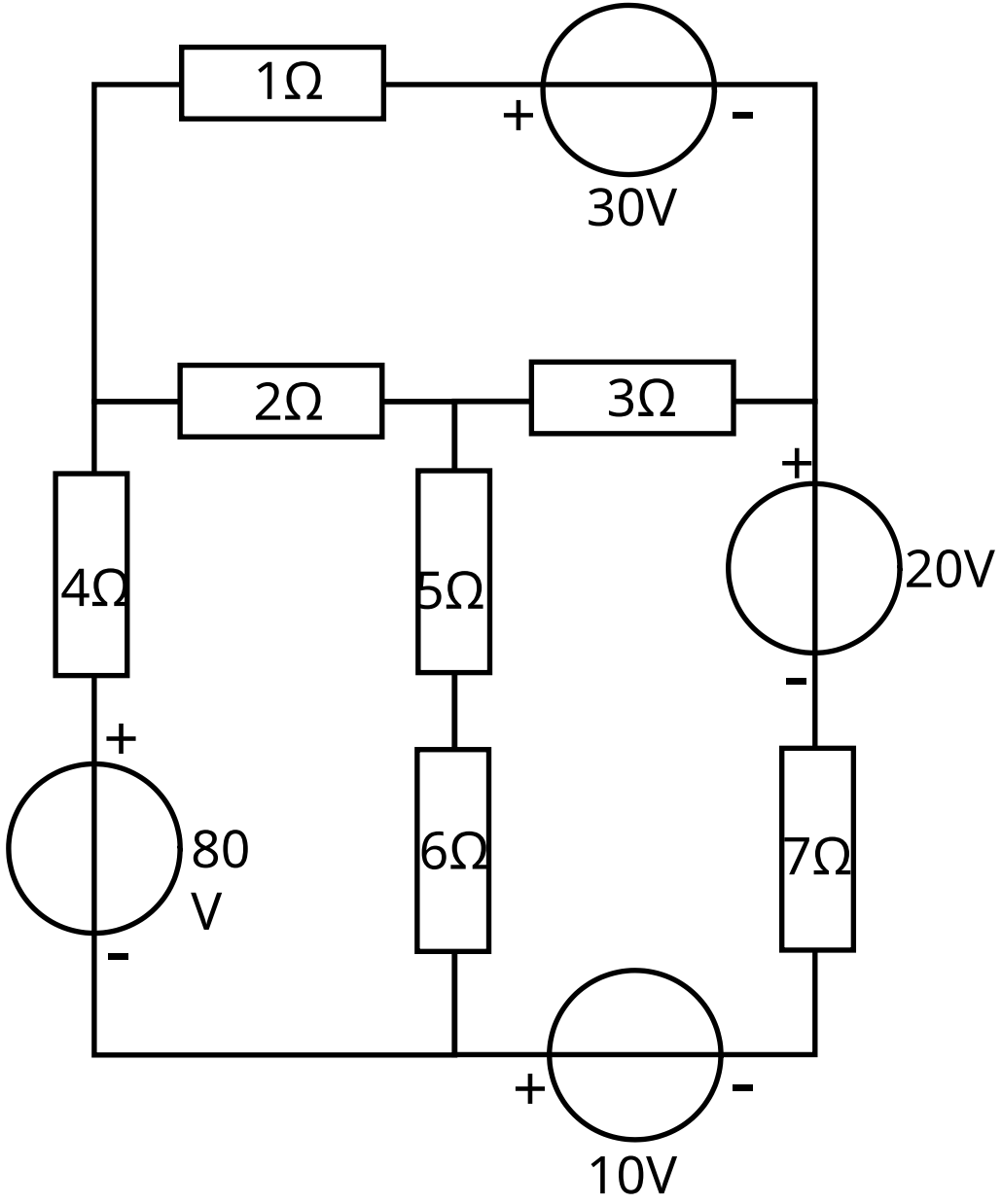
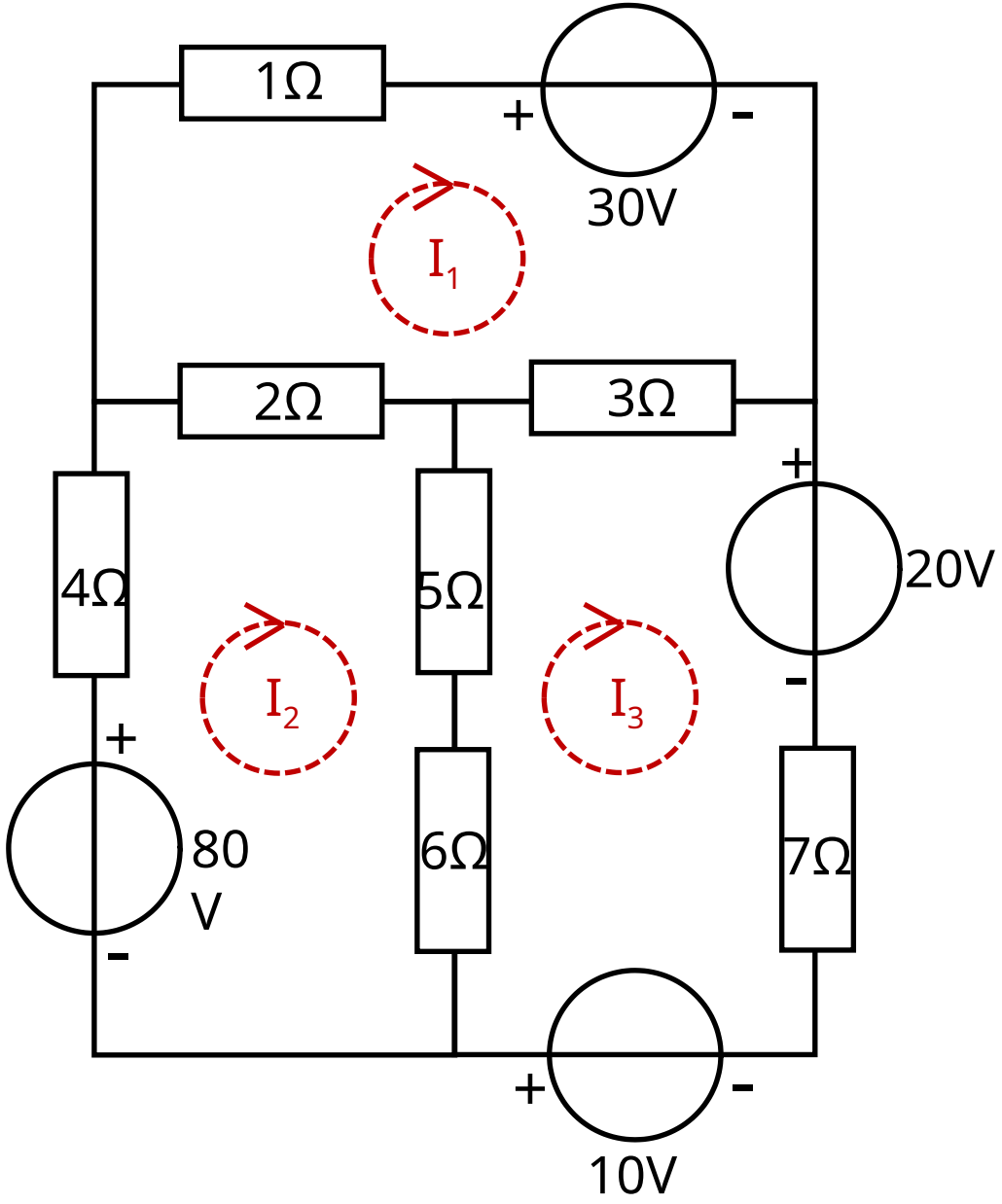
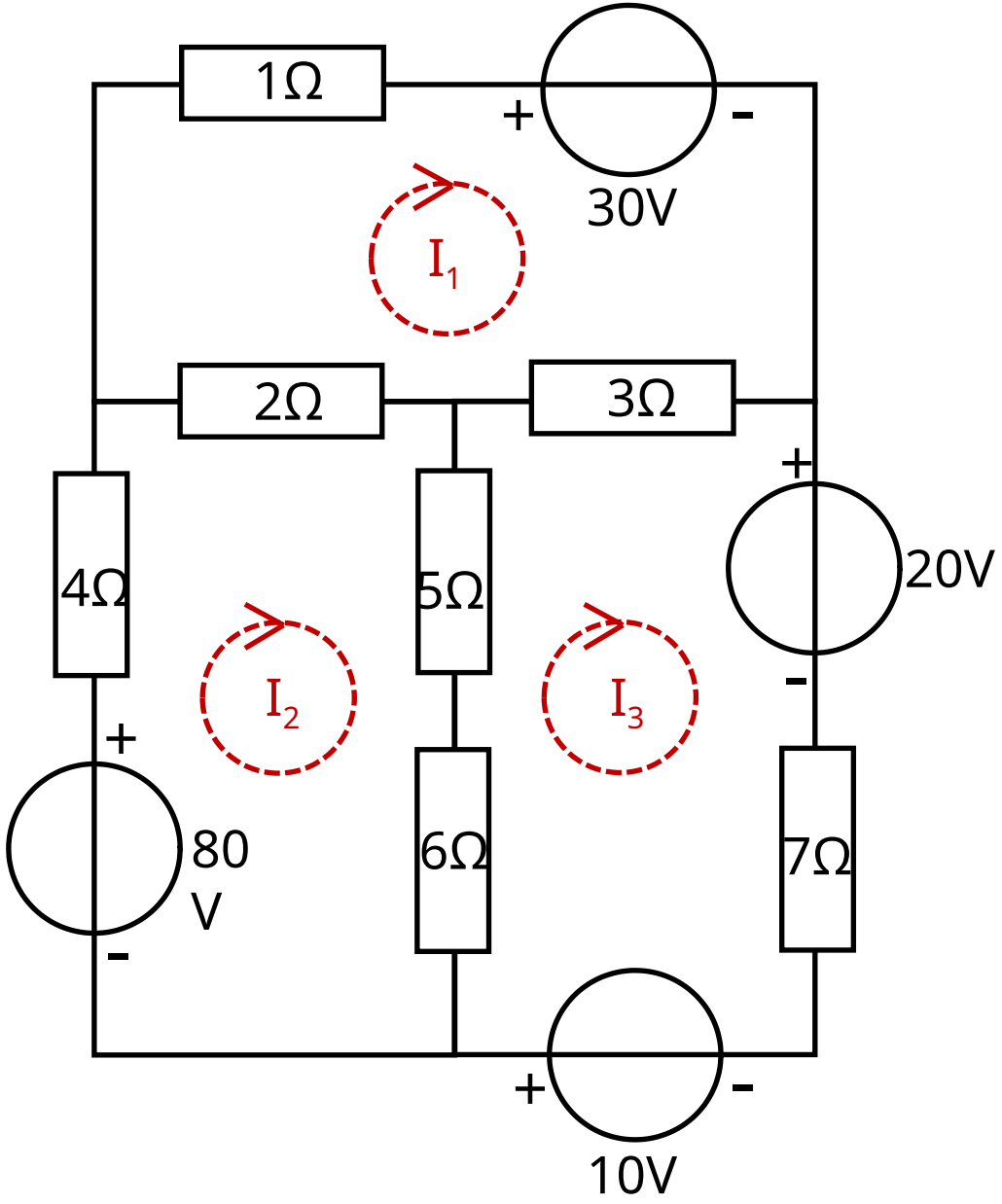
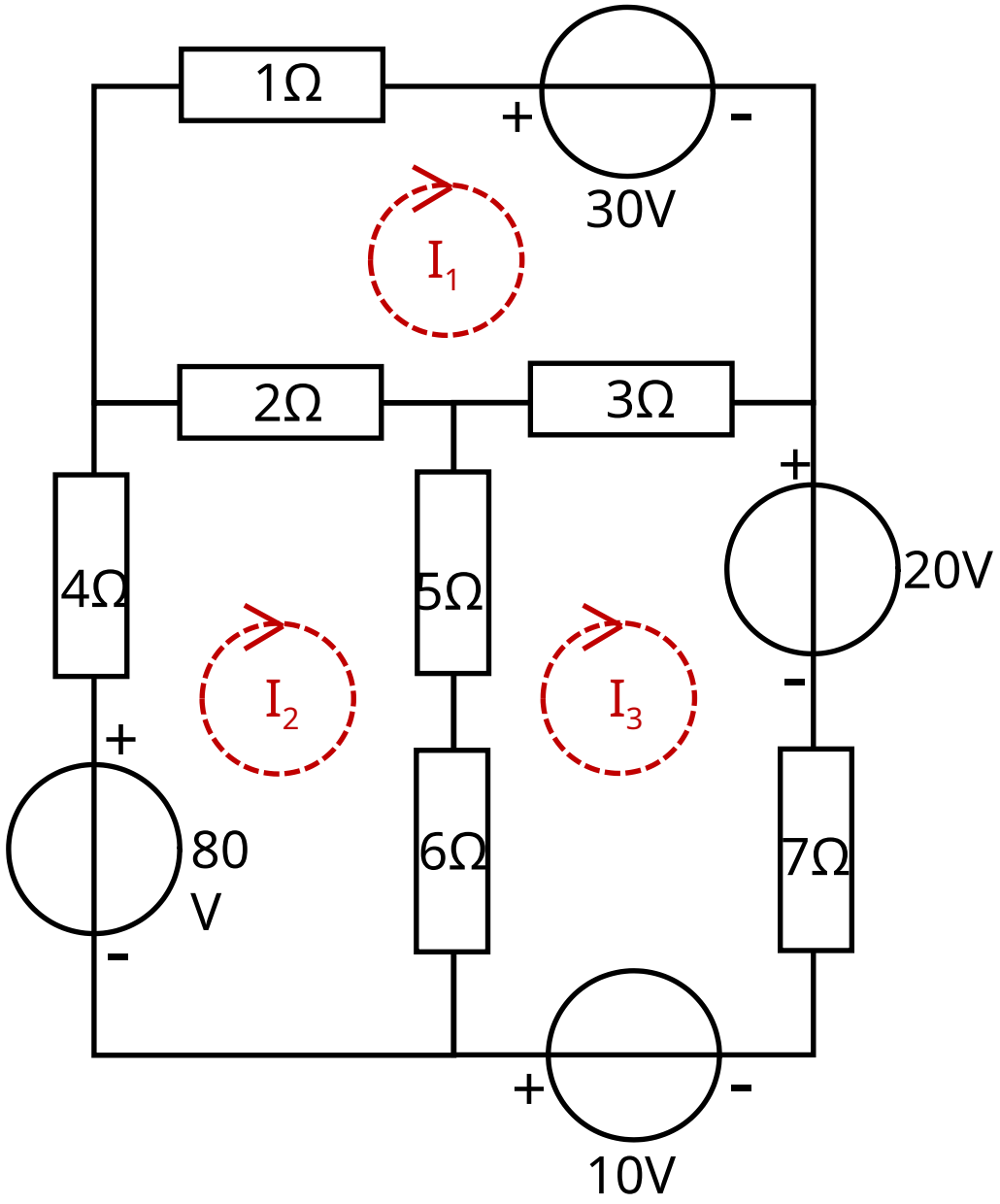

1Ω
+
-
30V
2Ω
3Ω
+
4Ω
5Ω
20V
-
+
80
V
6Ω
7Ω
-
+
-
10V


1Ω
+
-
30V
I1
2Ω
3Ω
+
20V
-
4Ω
5Ω
I2
I3
+
80
V
-
6Ω
7Ω
+
-
10V



$$
\begin{array}{rcrcrcrcr}
-30 & = & (1+3+2) & I_1 & + & -2 & I_2 & + & -3 & I_3 \\
80 & = & -2 & I_1 & + & (2+5+6+4) & I_2 & + & (-5-6) & I_3 \\
-20+10 & = & -3 & I_1 & + & (-6-5) & I_2 & + & (3+7+6+5) & I_3
\end{array}
$$



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\begin{aligned}
-30 &= (1+3+2)\,I_1 + (-2)\,I_2 + (-3)\,I_3 \\
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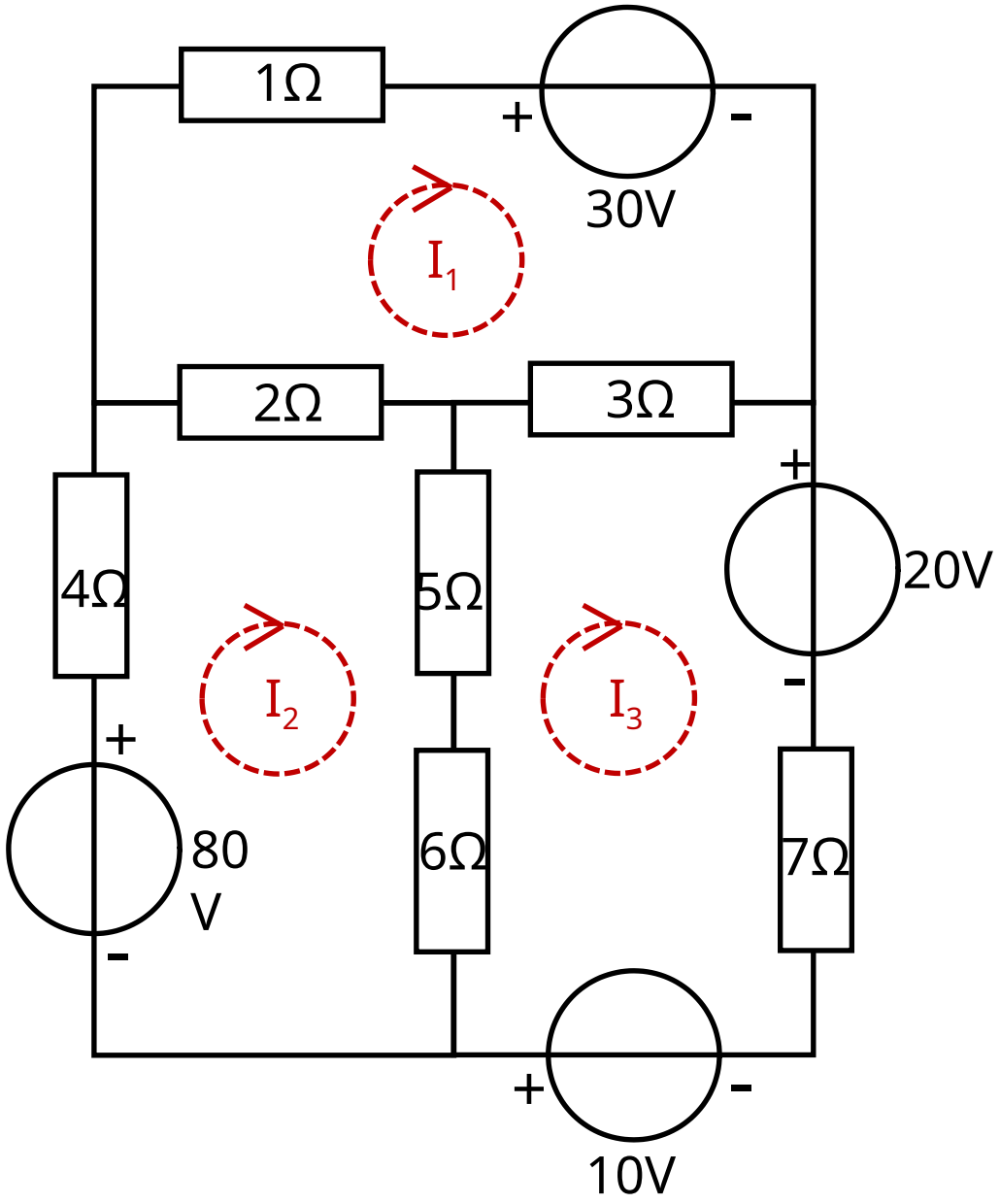
$$

$$
\Rightarrow \begin{pmatrix} -30 \\ 80 \\ -10 \end{pmatrix} = \begin{pmatrix} 6 & -2 & -3 \\ -2 & 17 & -11 \\ -3 & -11 & 21 \end{pmatrix} \begin{pmatrix} I_1 \\ I_2 \\ I_3 \end{pmatrix}
$$



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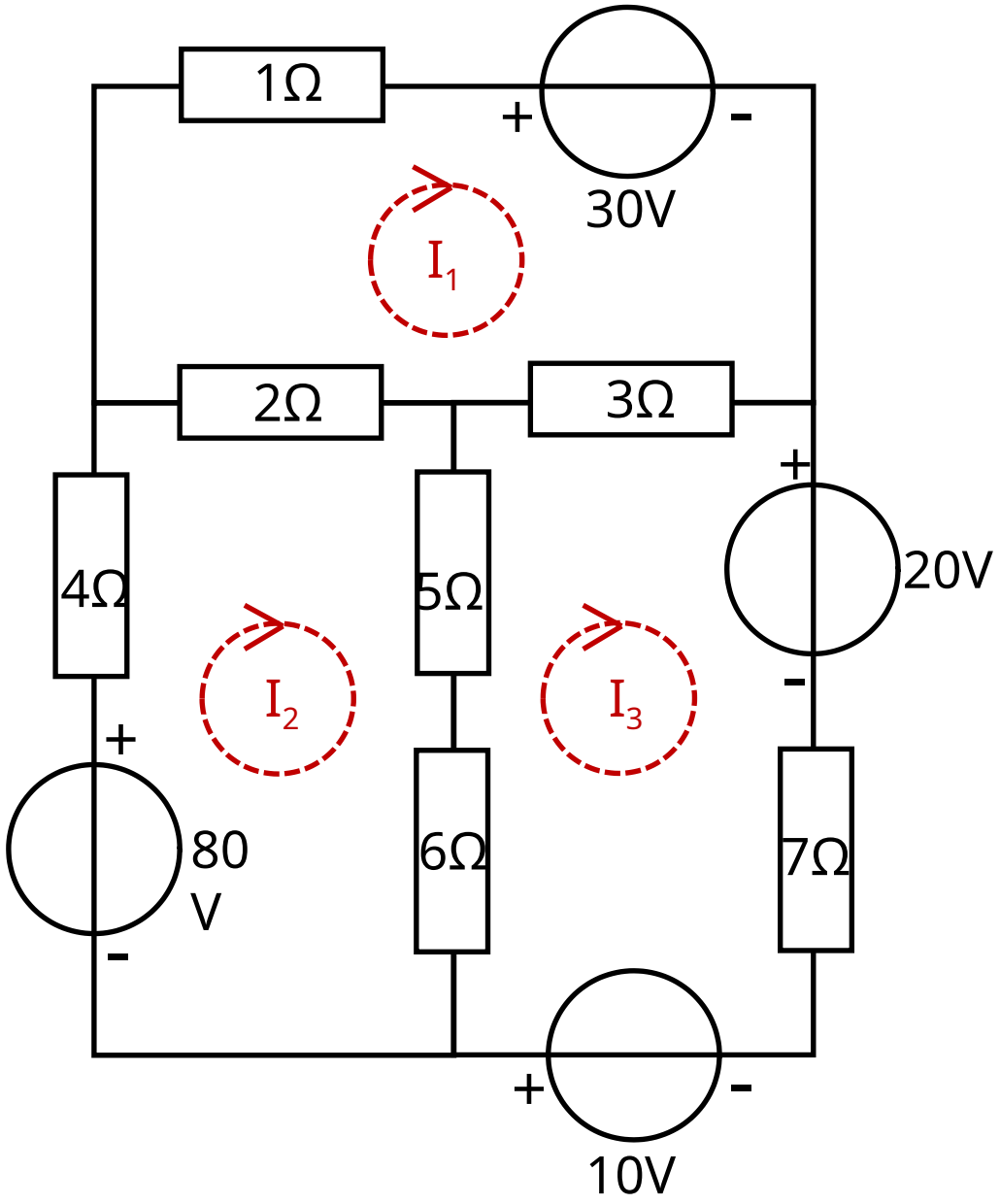
$$



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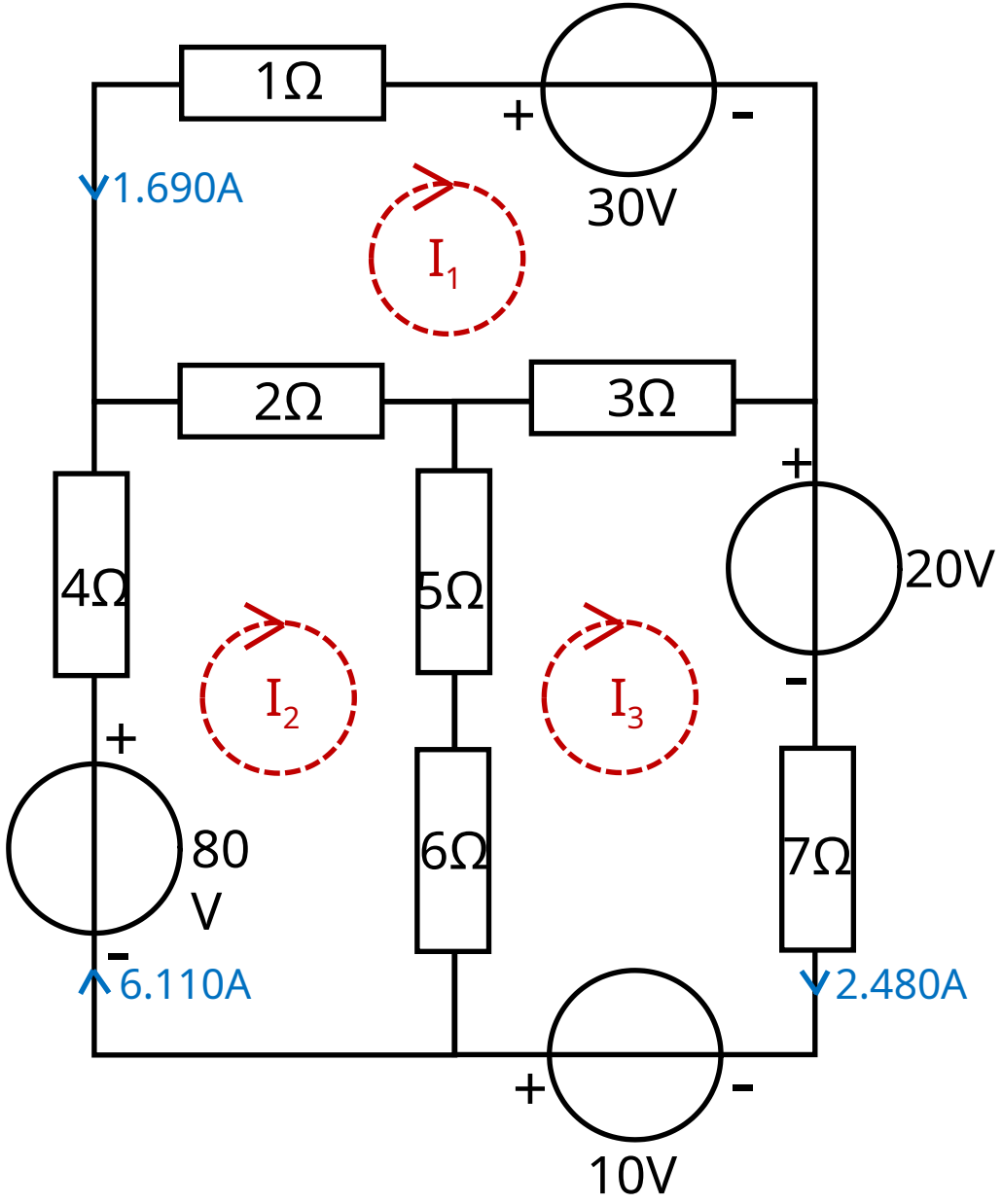
$$

$$
\begin{pmatrix} I_1 \\ I_2 \\ I_3 \end{pmatrix} = \begin{pmatrix} 0.225 & 0.072 & 0.070 \\ 0.072 & 0.112 & 0.069 \\ 0.070 & 0.069 & 0.094 \end{pmatrix} \begin{pmatrix} -30 \\ 80 \\ -10 \end{pmatrix} = \begin{pmatrix} -1.690 \\ 6.110 \\ 2.480 \end{pmatrix} \text{ [A]}
$$



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$$\Rightarrow \begin{pmatrix} -30 \\ 80 \\ -10 \end{pmatrix} = \begin{pmatrix} 6 & -2 & -3 \\ -2 & 17 & -11 \\ -3 & -11 & 21 \end{pmatrix} \begin{pmatrix} I_1 \\ I_2 \\ I_3 \end{pmatrix}$$

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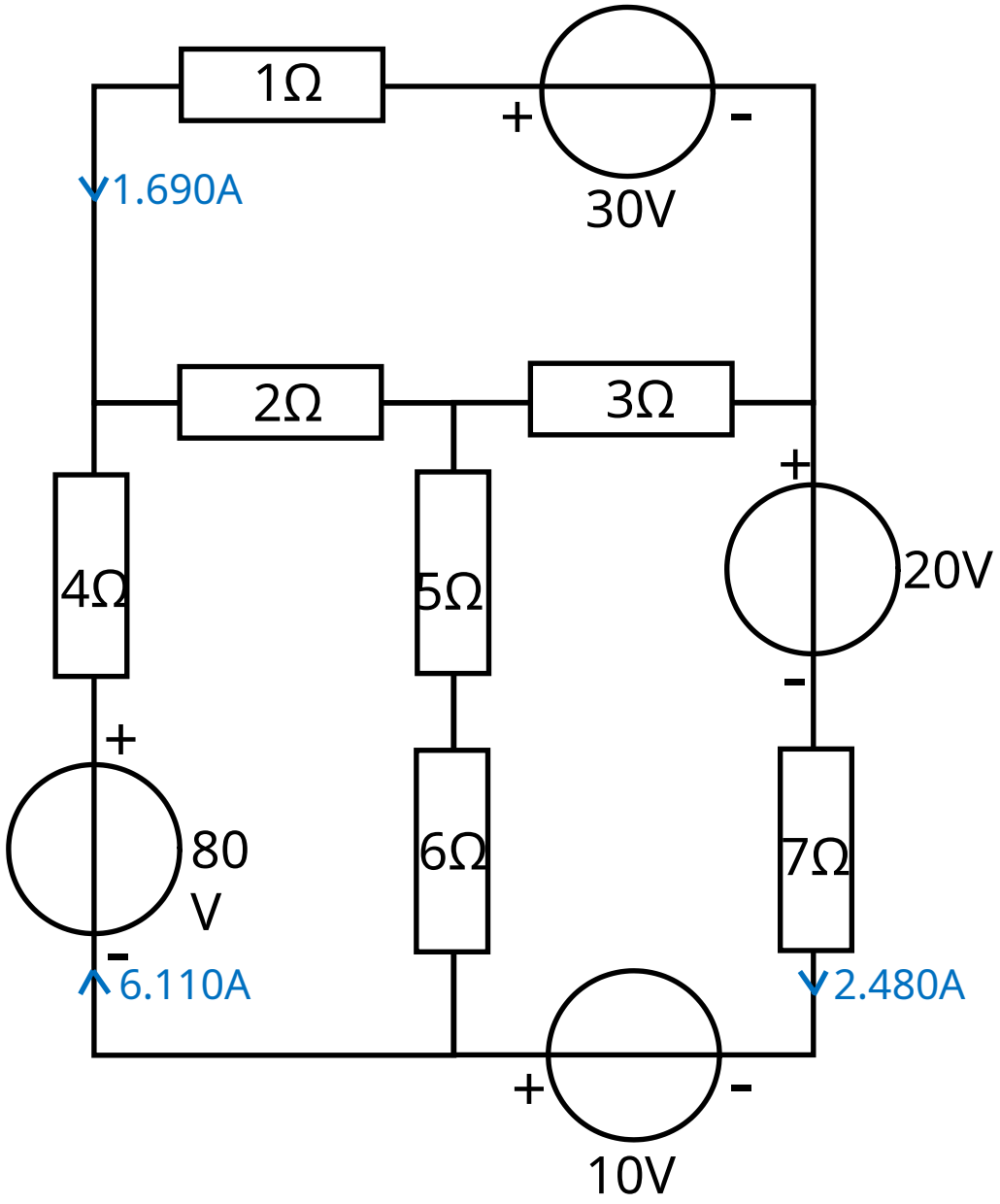
$$\begin{pmatrix} I_1 \\ I_2 \\ I_3 \end{pmatrix} = \begin{pmatrix} 0.225 & 0.072 & 0.070 \\ 0.072 & 0.112 & 0.069 \\ 0.070 & 0.069 & 0.094 \end{pmatrix} \begin{pmatrix} -30 \\ 80 \\ -10 \end{pmatrix} = \begin{pmatrix} -1.690 \\ 6.110 \\ 2.480 \end{pmatrix} [A]$$



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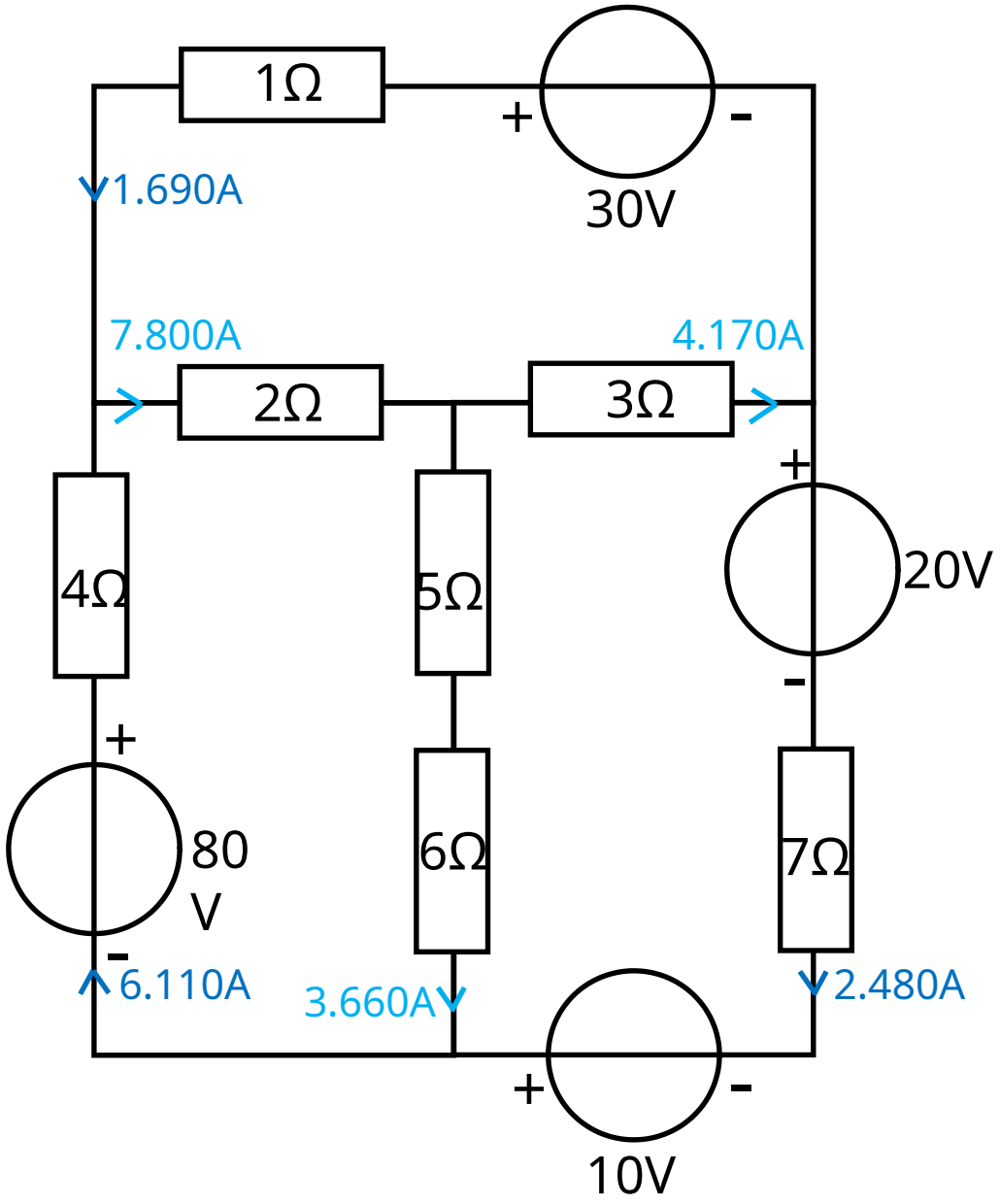
\end{array}
$$

$$
\Rightarrow \begin{pmatrix} -30 \\ 80 \\ -10 \end{pmatrix} = \begin{pmatrix} 6 & -2 & -3 \\ -2 & 17 & -11 \\ -3 & -11 & 21 \end{pmatrix} \begin{pmatrix} I_1 \\ I_2 \\ I_3 \end{pmatrix}
$$

$$
\Rightarrow \begin{pmatrix} I_1 \\ I_2 \\ I_3 \end{pmatrix} = \begin{pmatrix} 6 & -2 & -3 \\ -2 & 17 & -11 \\ -3 & -11 & 21 \end{pmatrix}^{-1} \begin{pmatrix} -30 \\ 80 \\ -10 \end{pmatrix}
$$

$$
\begin{pmatrix} I_1 \\ I_2 \\ I_3 \end{pmatrix} = \begin{pmatrix} 0.225 & 0.072 & 0.070 \\ 0.072 & 0.112 & 0.069 \\ 0.070 & 0.069 & 0.094 \end{pmatrix} \begin{pmatrix} -30 \\ 80 \\ -10 \end{pmatrix} = \begin{pmatrix} -1.690 \\ 6.110 \\ 2.480 \end{pmatrix} [A]
$$

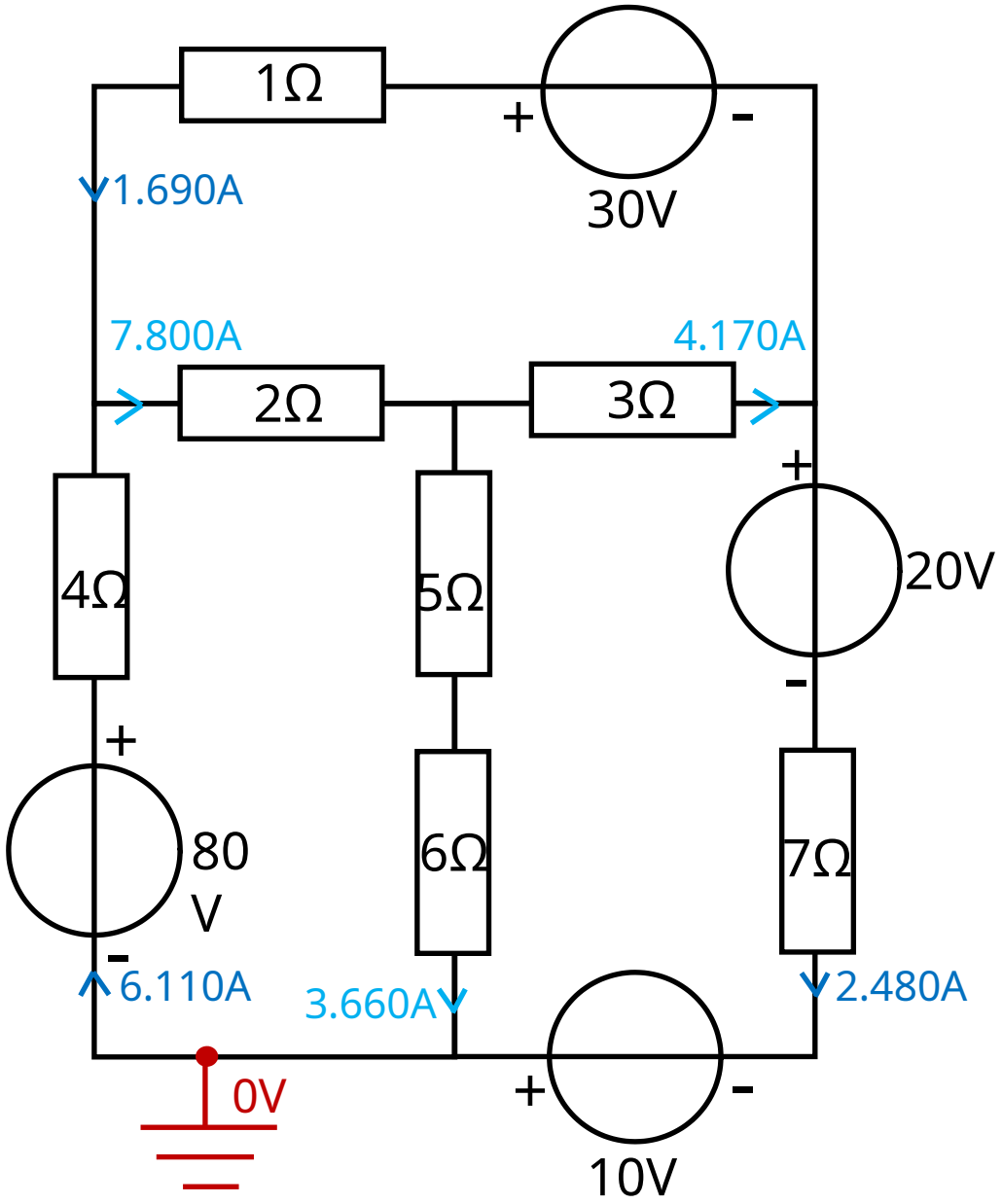


$$
\begin{array}{rcrcrcrcr}
-30 & = & (1+3+2) & I_1 & + & -2 & I_2 & + & -3 & I_3 \\
80 & = & -2 & I_1 & + & (2+5+6+4) & I_2 & + & (-5-6) & I_3 \\
-20+10 & = & -3 & I_1 & + & (-6-5) & I_2 & + & (3+7+6+5) & I_3
\end{array}
$$

$$
\Rightarrow \begin{pmatrix} -30 \\ 80 \\ -10 \end{pmatrix} = \begin{pmatrix} 6 & -2 & -3 \\ -2 & 17 & -11 \\ -3 & -11 & 21 \end{pmatrix} \begin{pmatrix} I_1 \\ I_2 \\ I_3 \end{pmatrix}
$$

$$
\Rightarrow \begin{pmatrix} I_1 \\ I_2 \\ I_3 \end{pmatrix} = \begin{pmatrix} 6 & -2 & -3 \\ -2 & 17 & -11 \\ -3 & -11 & 21 \end{pmatrix}^{-1} \begin{pmatrix} -30 \\ 80 \\ -10 \end{pmatrix}
$$

$$
\begin{pmatrix} I_1 \\ I_2 \\ I_3 \end{pmatrix} = \begin{pmatrix} 0.225 & 0.072 & 0.070 \\ 0.072 & 0.112 & 0.069 \\ 0.070 & 0.069 & 0.094 \end{pmatrix} \begin{pmatrix} -30 \\ 80 \\ -10 \end{pmatrix} = \begin{pmatrix} -1.690 \\ 6.110 \\ 2.480 \end{pmatrix} \text{ [A]}
$$



$$
\begin{array}{rcrcrcrcr}
-30 & = & (1+3+2) & I_1 & + & -2 & I_2 & + & -3 & I_3 \\
80 & = & -2 & I_1 & + & (2+5+6+4) & I_2 & + & (-5-6) & I_3 \\
-20+10 & = & -3 & I_1 & + & (-6-5) & I_2 & + & (3+7+6+5) & I_3
\end{array}
$$

$$
\Rightarrow \begin{pmatrix} -30 \\ 80 \\ -10 \end{pmatrix} = \begin{pmatrix} 6 & -2 & -3 \\ -2 & 17 & -11 \\ -3 & -11 & 21 \end{pmatrix} \begin{pmatrix} I_1 \\ I_2 \\ I_3 \end{pmatrix}
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$$
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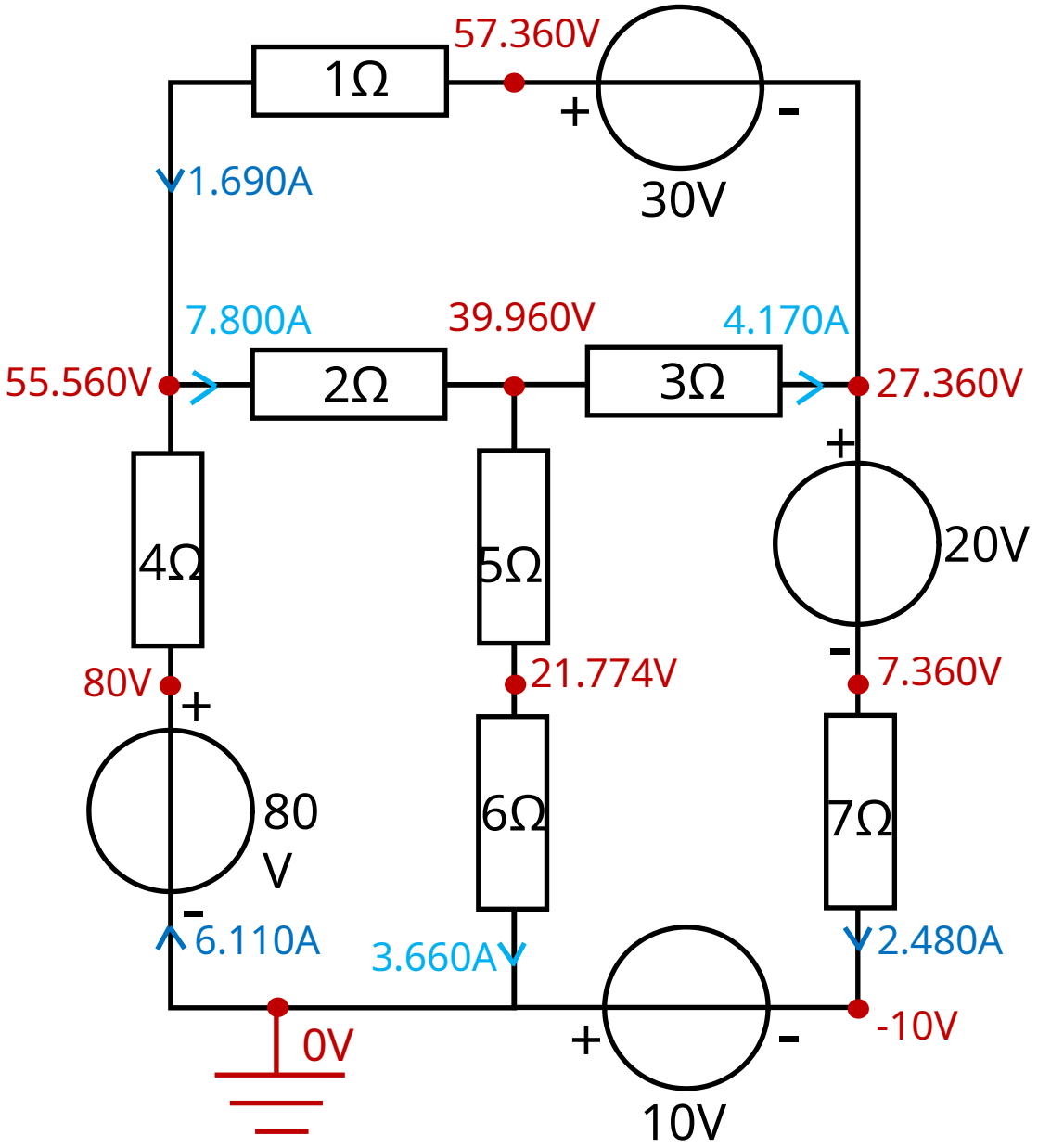
$$

$$
\begin{pmatrix} I_1 \\ I_2 \\ I_3 \end{pmatrix} = \begin{pmatrix} 0.225 & 0.072 & 0.070 \\ 0.072 & 0.112 & 0.069 \\ 0.070 & 0.069 & 0.094 \end{pmatrix} \begin{pmatrix} -30 \\ 80 \\ -10 \end{pmatrix} = \begin{pmatrix} -1.690 \\ 6.110 \\ 2.480 \end{pmatrix} \text{ [A]}
$$



$$
\begin{aligned}
-30 &= (1+3+2)\,I_1 + (-2)\,I_2 + (-3)\,I_3 \\
80 &= (-2)\,I_1 + (2+5+6+4)\,I_2 + (-5-6)\,I_3 \\
-20+10 &= (-3)\,I_1 + (-6-5)\,I_2 + (3+7+6+5)\,I_3
\end{aligned}
$$

$$
\Rightarrow \begin{pmatrix} -30 \\ 80 \\ -10 \end{pmatrix} = \begin{pmatrix} 6 & -2 & -3 \\ -2 & 17 & -11 \\ -3 & -11 & 21 \end{pmatrix} \begin{pmatrix} I_1 \\ I_2 \\ I_3 \end{pmatrix}
$$

$$
\Rightarrow \begin{pmatrix} I_1 \\ I_2 \\ I_3 \end{pmatrix} = \begin{pmatrix} 6 & -2 & -3 \\ -2 & 17 & -11 \\ -3 & -11 & 21 \end{pmatrix}^{-1} \begin{pmatrix} -30 \\ 80 \\ -10 \end{pmatrix}
$$

$$
\begin{pmatrix} I_1 \\ I_2 \\ I_3 \end{pmatrix} = \begin{pmatrix} 0.225 & 0.072 & 0.070 \\ 0.072 & 0.112 & 0.069 \\ 0.070 & 0.069 & 0.094 \end{pmatrix} \begin{pmatrix} -30 \\ 80 \\ -10 \end{pmatrix} = \begin{pmatrix} -1.690 \\ 6.110 \\ 2.480 \end{pmatrix} \text{[A]}
$$