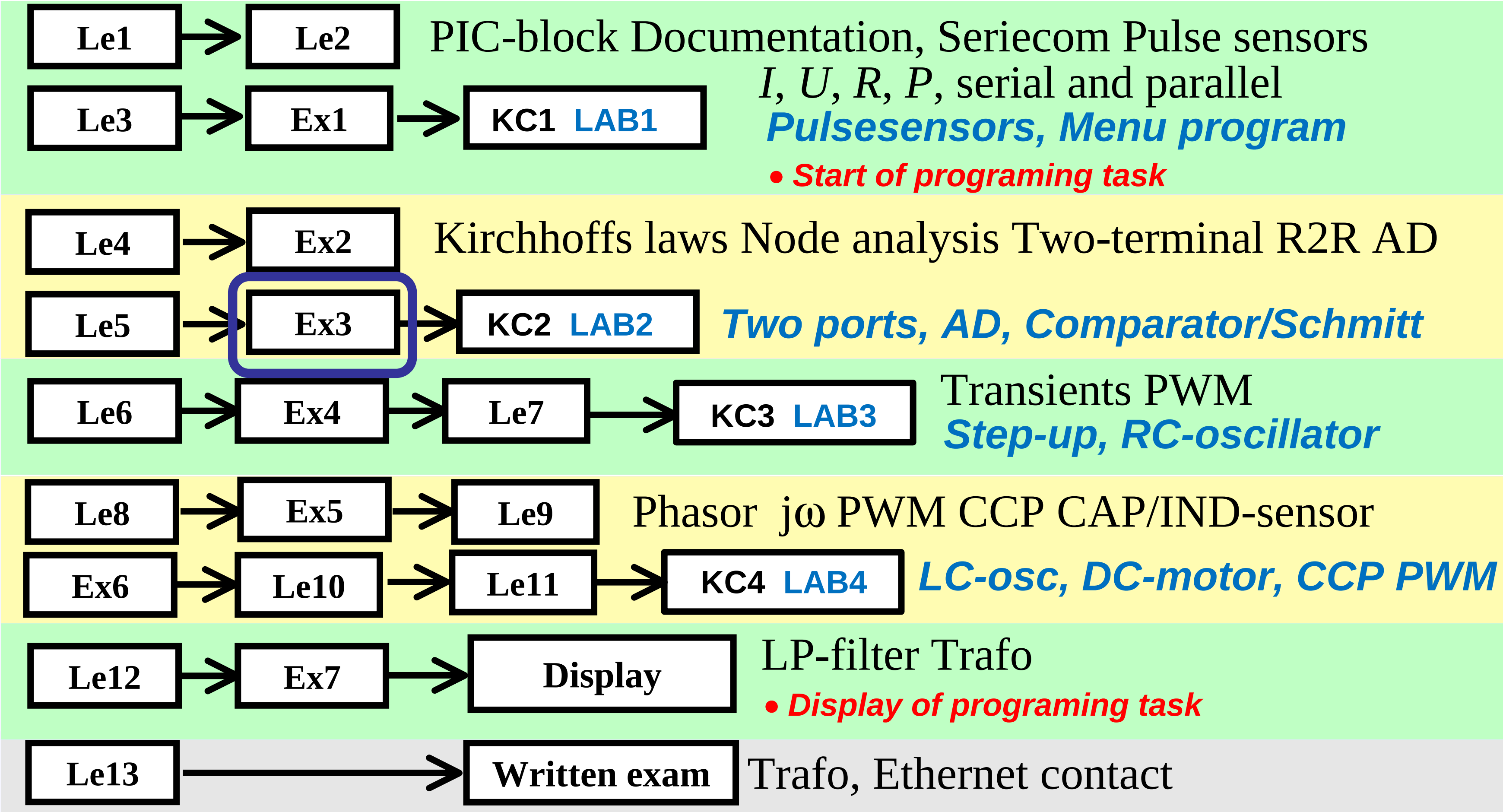
IE1206 Embedded Electronics



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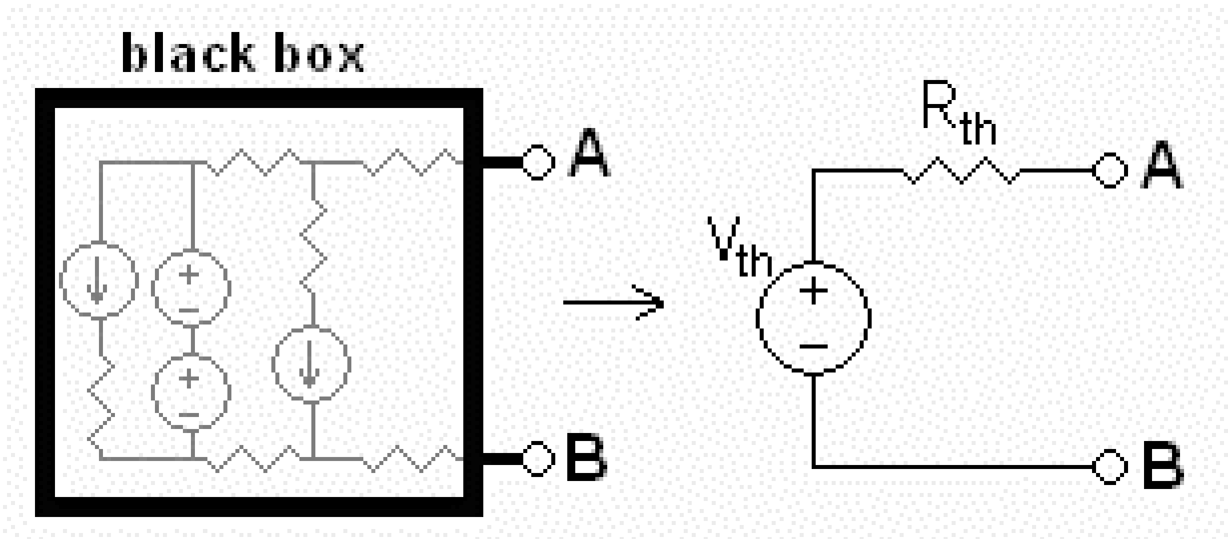
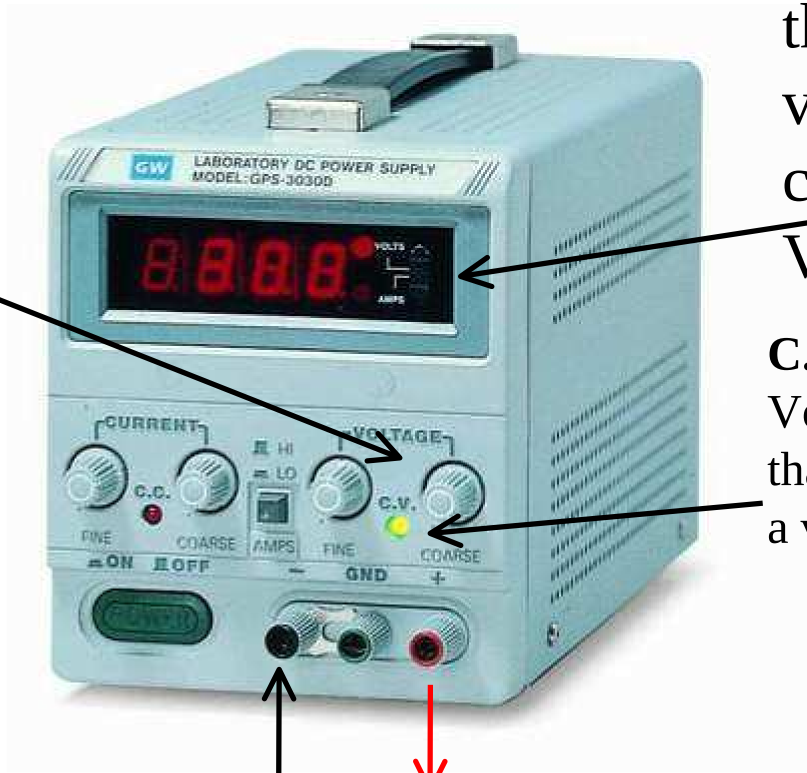
Two port circuits – Black box



? **=** **!**

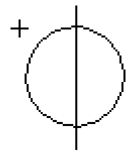
The power supply

VOLTAGE knob to set the constant voltage. Coarse and fine adjustments.



Buttons to select the display of voltage or current.
Voltage / Amps

C.V. Continuous Voltage. Led indicating that the unit operates as a voltage generator.



\+ and – poles

\-

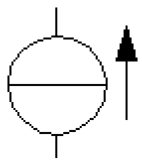
\+

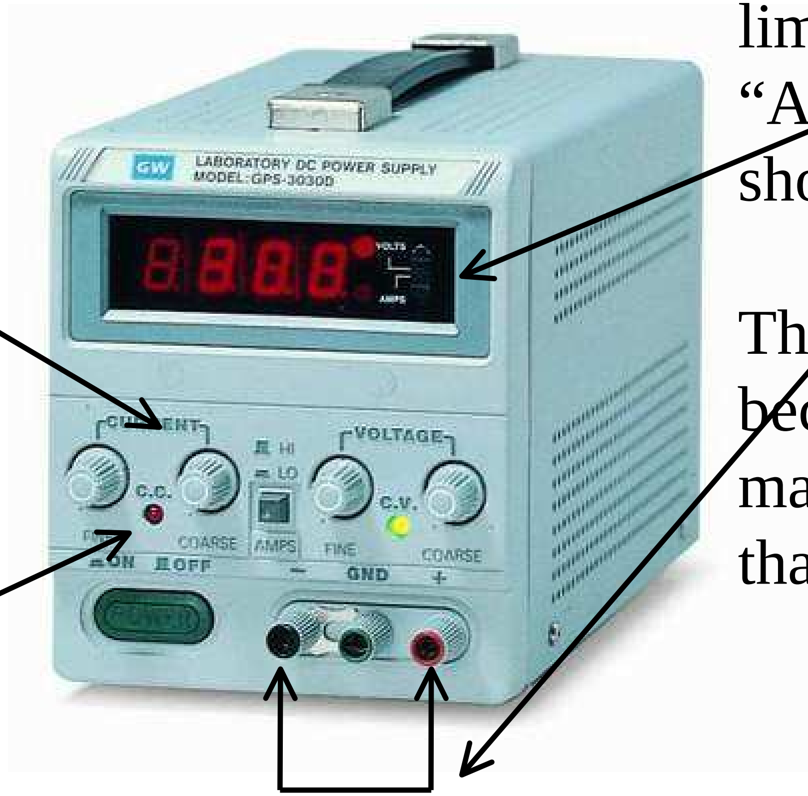
(GND is to connect the metal casing to +/- to suppress interference).

The power supply

CURRENT knob to set the current limit. Coarse and fine adjustments.

C.C. Continuous Current. Led indicating that the unit operates as a current generator.



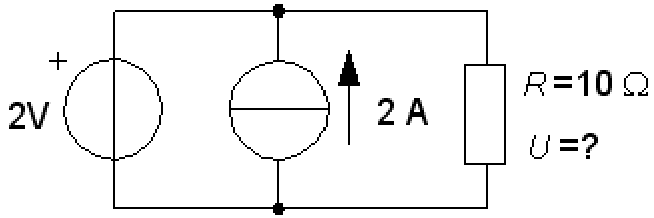


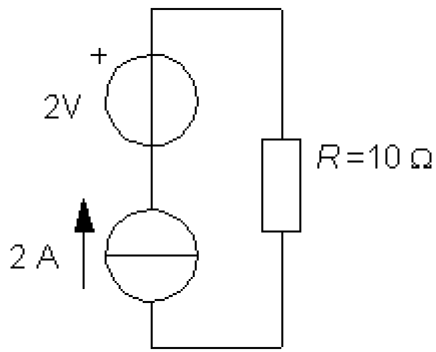
To set the current limit you show "Amps" and then short voltage poles.

The set current then becomes the maximum current that can occur.

Voltage and Current generator

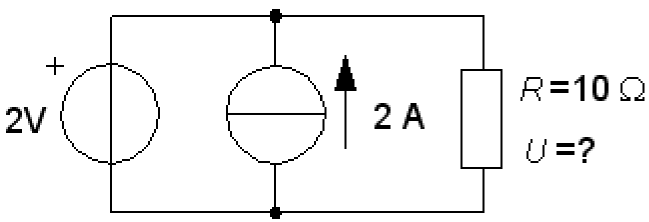
(Ex. 8.1) What value will the U get in these idealized and usually unrealistic circuits?

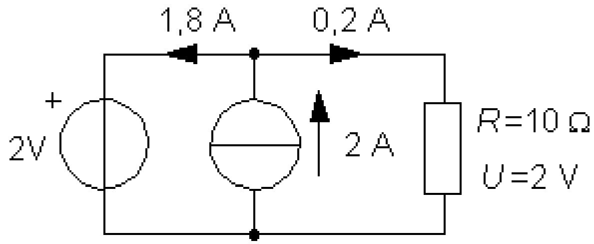


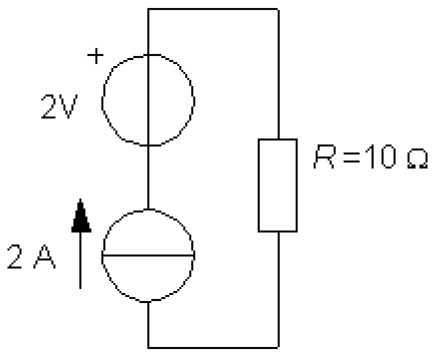


Voltage and Current generator

(Ex. 8.1) What value will the *U* get in these idealized and usually unrealistic circuits?







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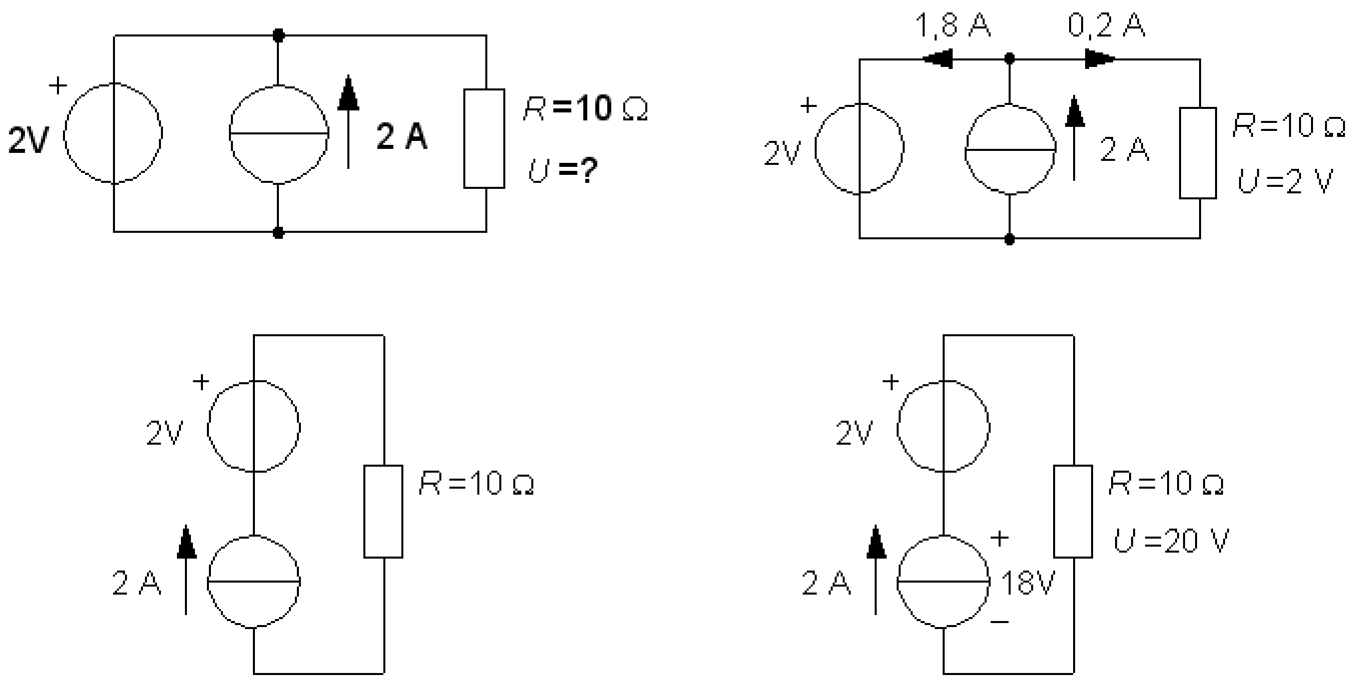
Voltage and Current generator

(Ex. 8.1) What value will the *U* get in these idealized and usually unrealistic circuits?



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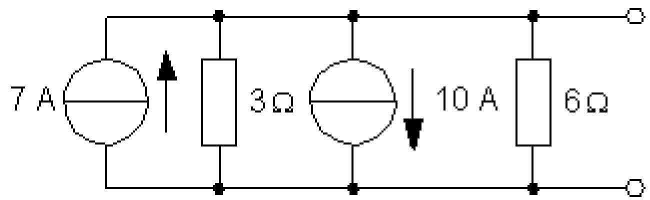
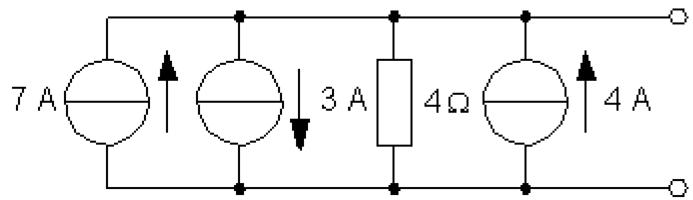
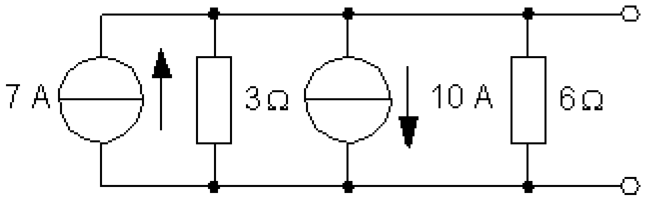
Simplify … (8.2)



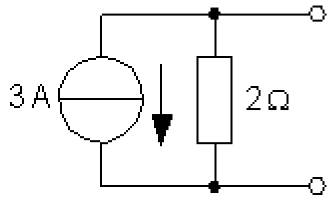


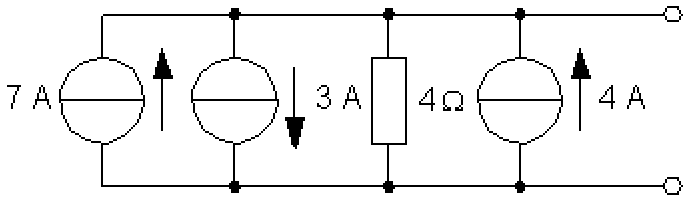
Simplify … (8.2)



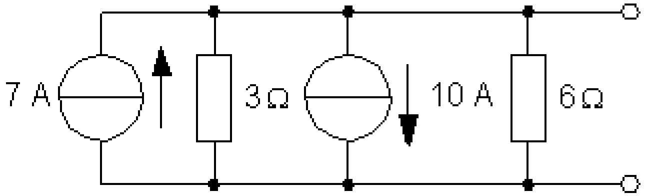
$$7-10=-3$$

$$\frac{3\cdot 6}{3+6}=2$$



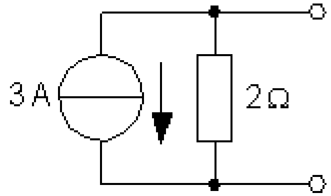


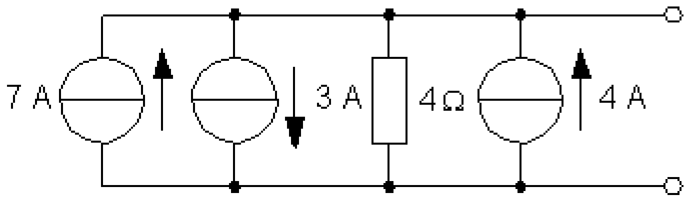
Simplify … (8.2)

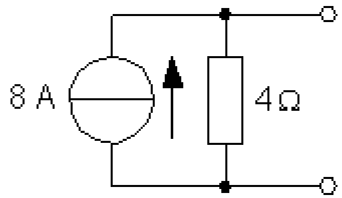


$$7 - 10 = -3$$

$$\frac{3 \cdot 6}{3 + 6} = 2$$







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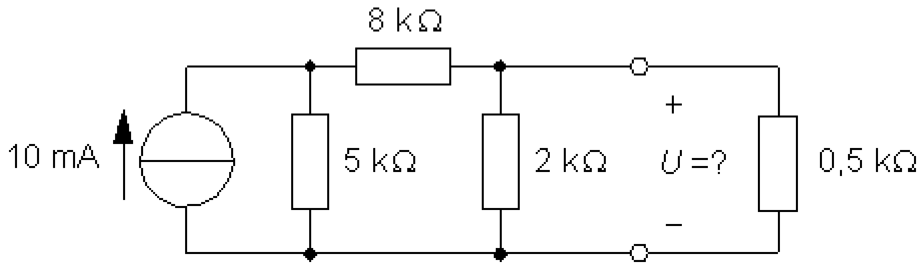
Equvalents step by step …

(8.4) Electronics prefix [V] [kΩ] [mA]



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Equvalents step by step …

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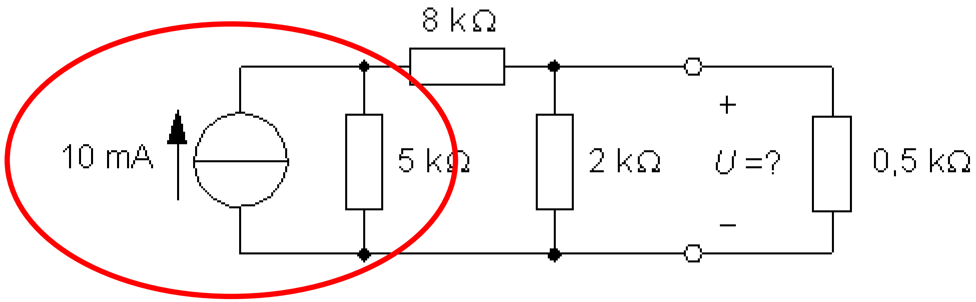
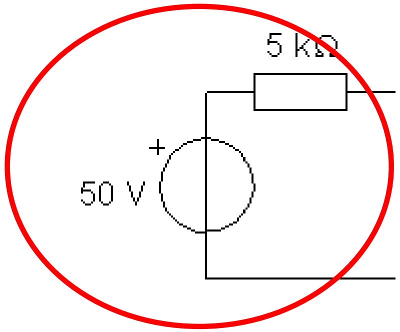


10·5=50



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Equivalents step by step …

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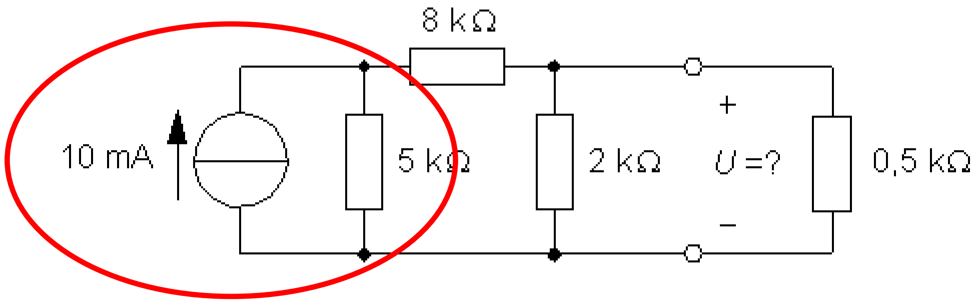

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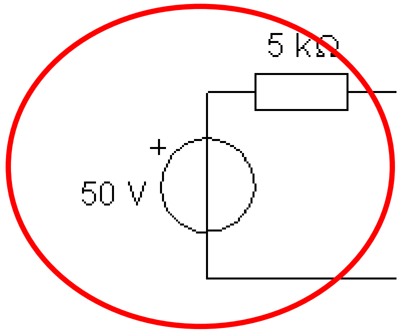
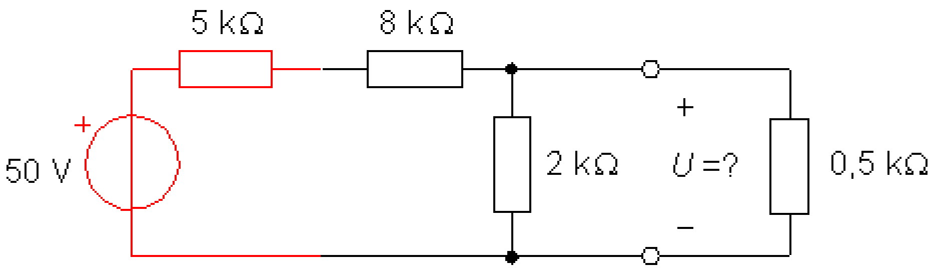
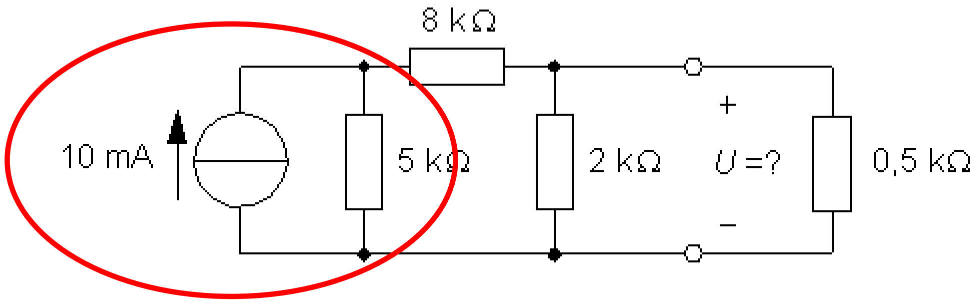


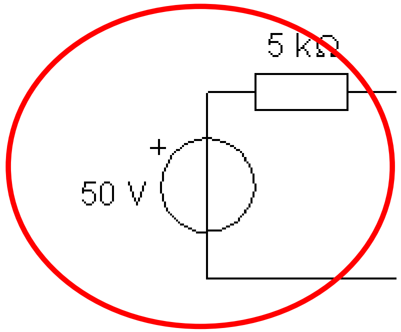


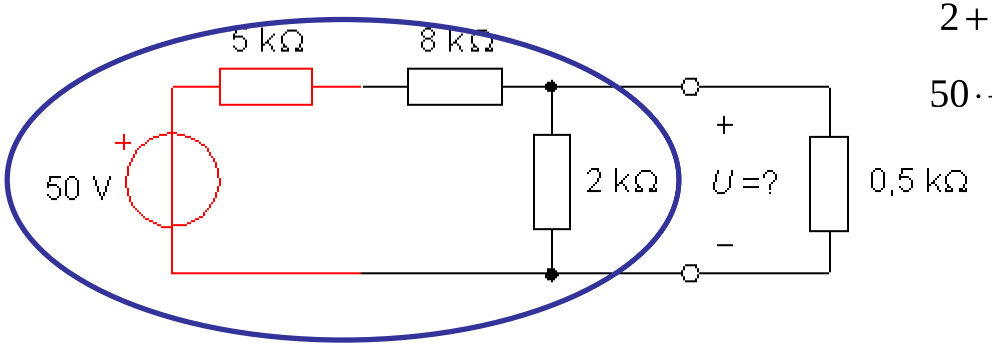
Equvalents step by step …

(8.4) Electronics prefix [V] [kΩ] [mA]



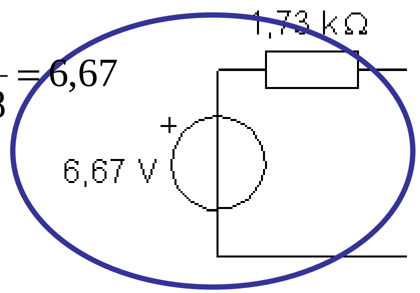
$10 \cdot 5 = 50$





$$\frac{2 \cdot (5+8)}{2+5+8} = 1{,}73$$

$$50 \cdot \frac{2}{2+5+8} = 6{,}67$$



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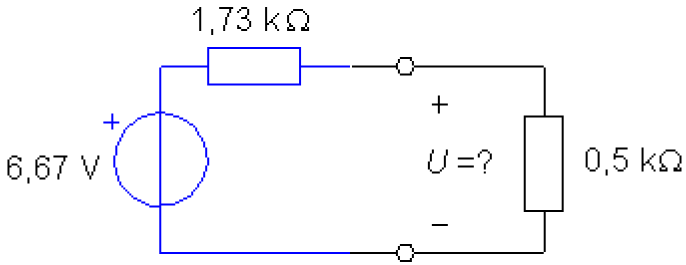
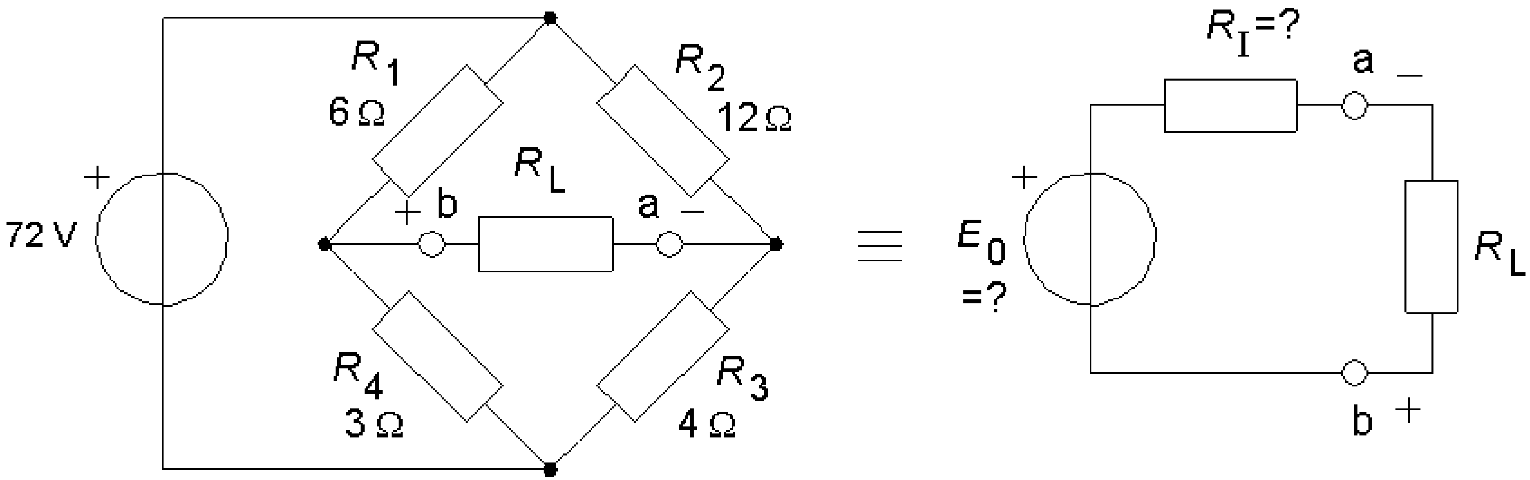
At last …



Voltage divider:

$$U = 6{,}67 \cdot \frac{0{,}5}{0{,}5 + 1{,}73} = 1{,}49 \text{ V}$$

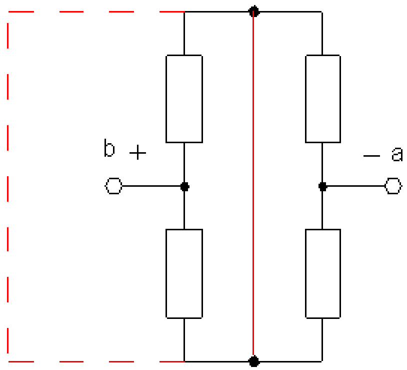
(Wheatstone bridge equivalent)

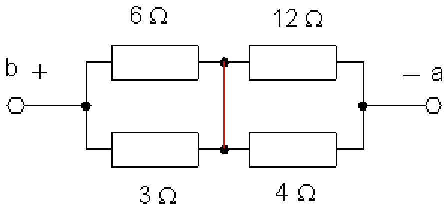


Determine the Wheatstone bridge Thevenin equivalent.

(Determine R_I)

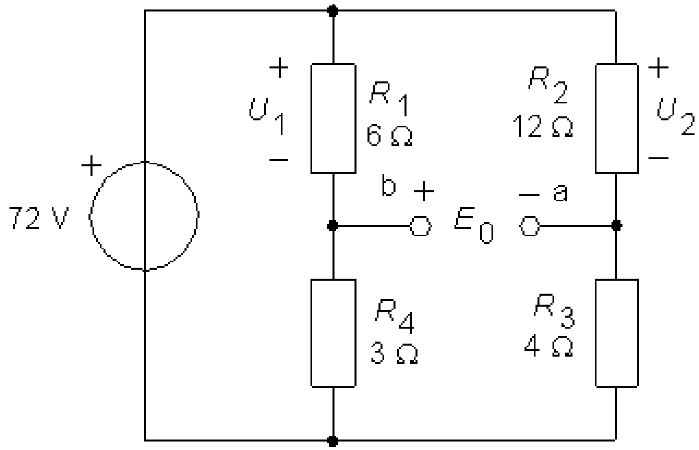
Voltage turned down to zero





$$R_I = \frac{6 \cdot 3}{6+3} + \frac{12 \cdot 4}{12+4} = 5\ \Omega$$

(Determine E_0)

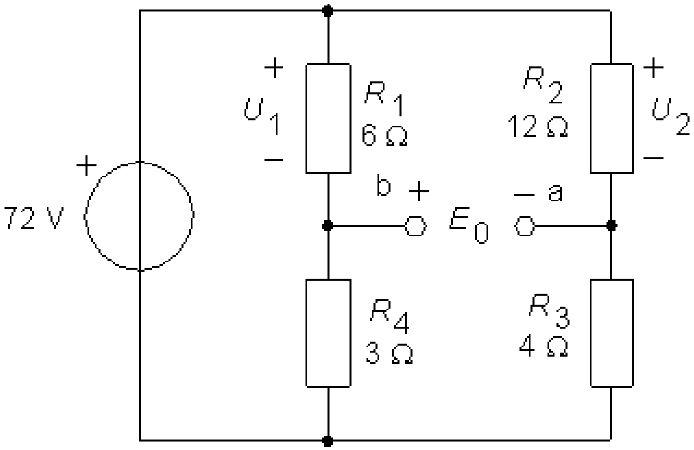


$$U_1 = 72 \cdot \frac{6}{6+3} = 48$$

$$U_2 = 72 \cdot \frac{12}{12+4} = 54$$

$$E_0 = 54 - 48 = 6 \text{ V}$$

(Determine R_I E_0)

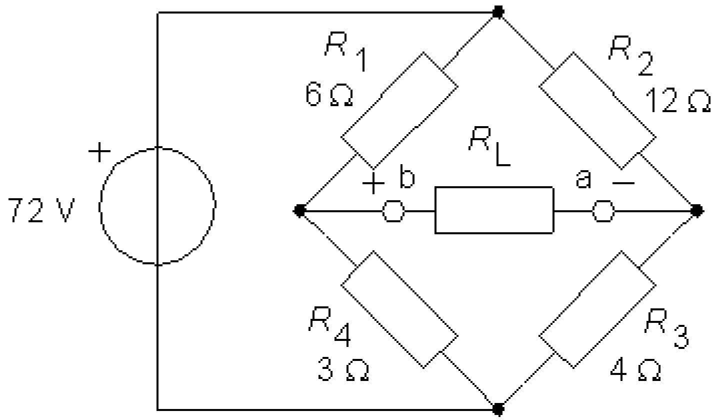


$$U_1 = 72 \cdot \frac{6}{6+3} = 48$$

$$U_2 = 72 \cdot \frac{12}{12+4} = 54$$

$$E_0 = 54 - 48 = 6 \text{ V}$$

Done!



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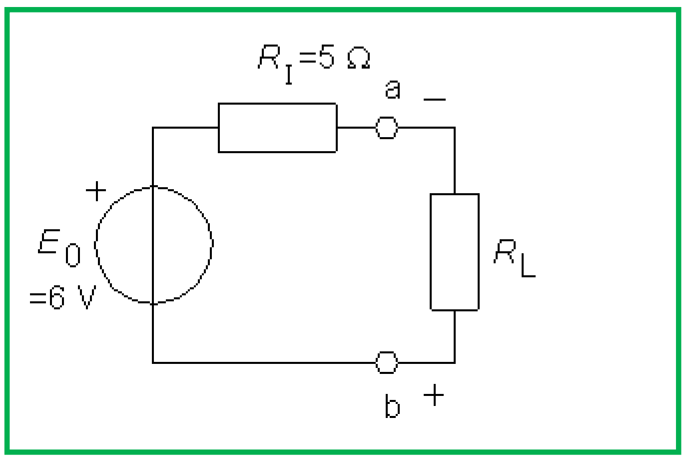

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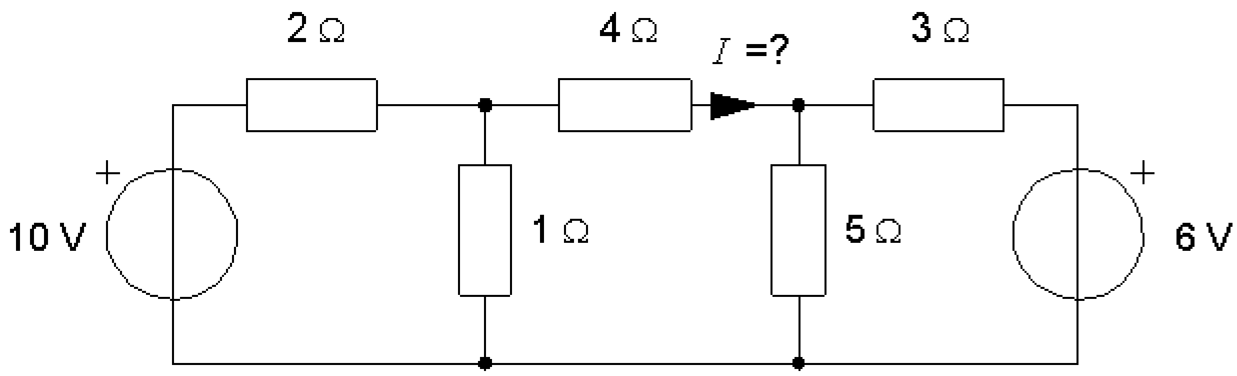
Equivalent circuits (instead of mesh analysis)!



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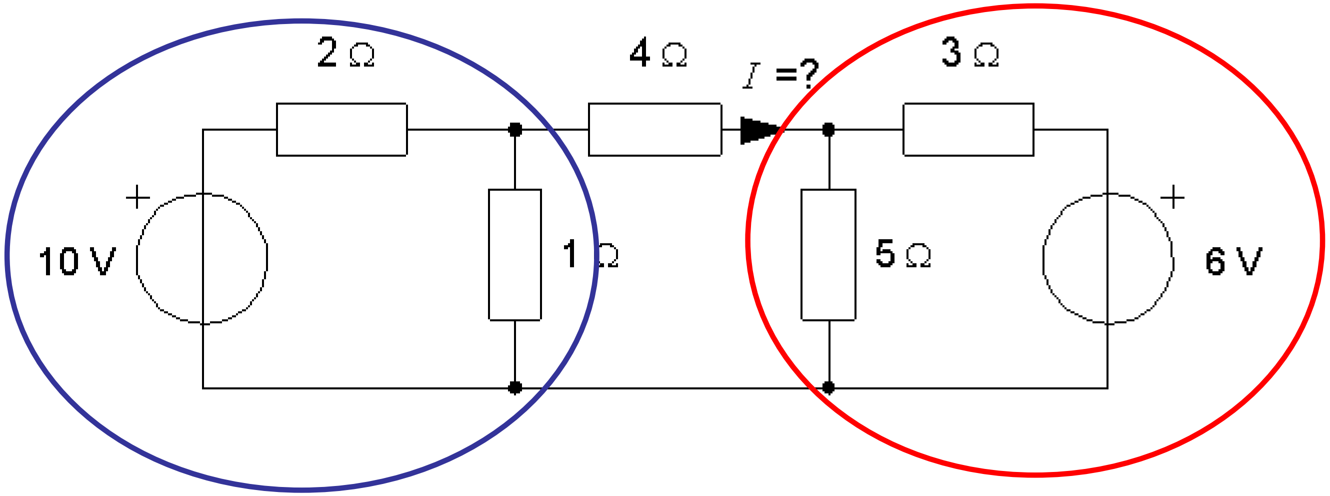

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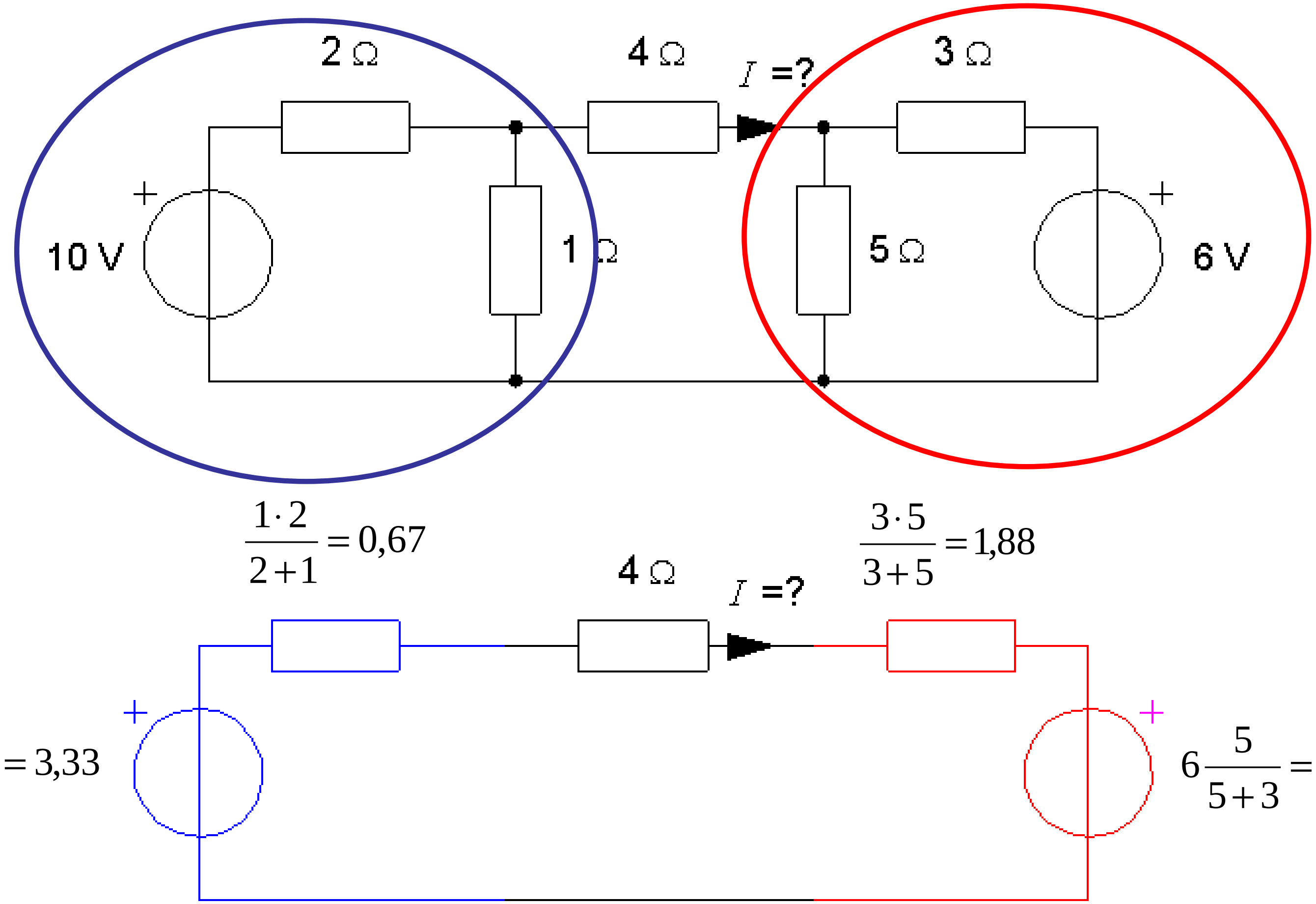


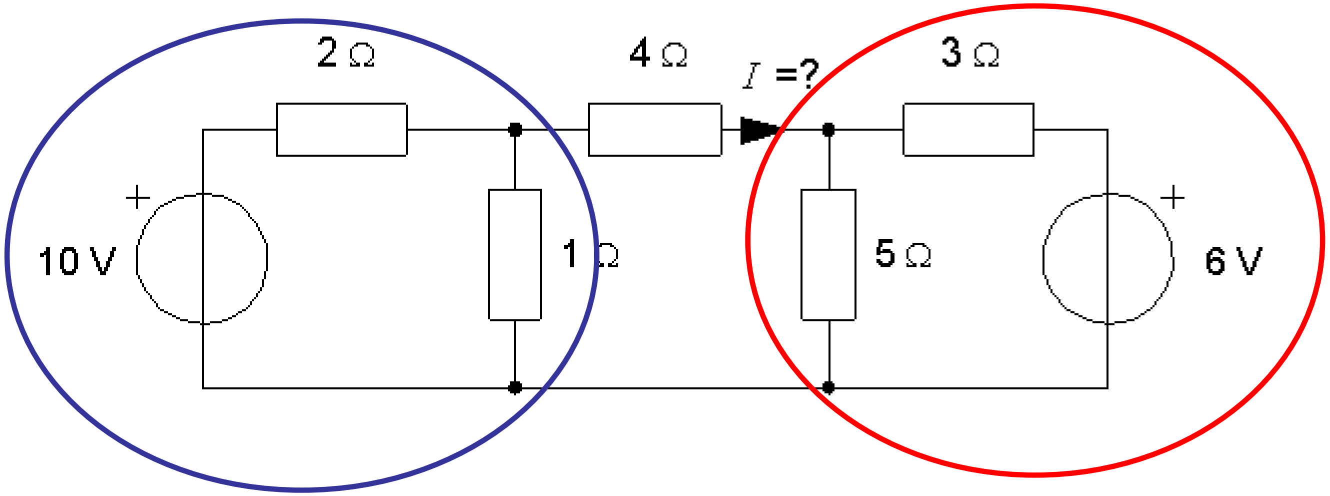
$$\frac{1\cdot 2}{2+1}=0{,}67$$

$$\frac{3\cdot 5}{3+5}=1{,}88$$

$$10\frac{1}{1+2}=3{,}33$$

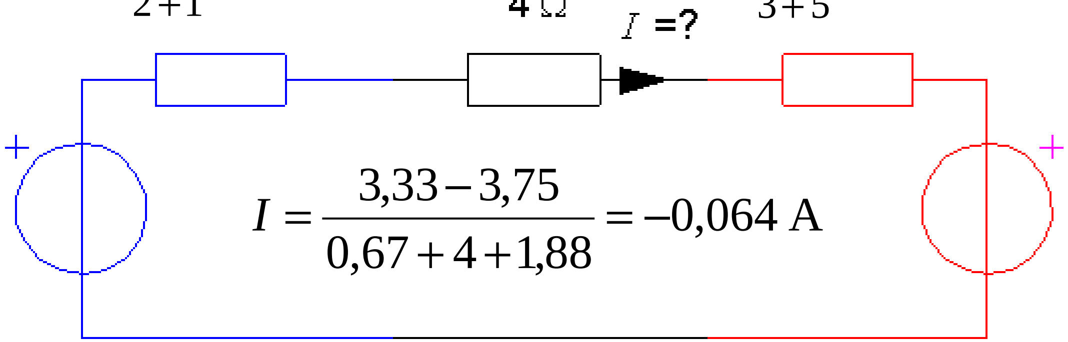
$$6\frac{5}{5+3}=3{,}75$$

Equivalent circuits (instead of mesh analysis)!



$$\frac{1 \cdot 2}{2+1} = 0{,}67$$

$$\frac{3 \cdot 5}{3+5} = 1{,}88$$



$$10\frac{1}{1+2} = 3{,}33$$

$$I = \frac{3{,}33 - 3{,}75}{0{,}67 + 4 + 1{,}88} = -0{,}064 \text{ A}$$

$$6\frac{5}{5+3} = 3{,}75$$

Ex. current generator at node analysis

(7.2)

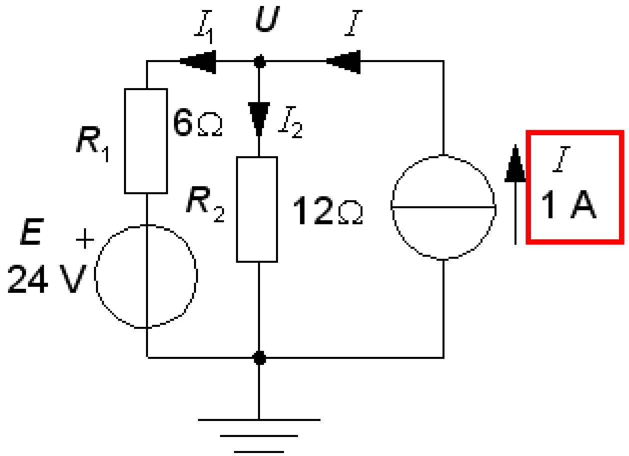
$$-I_1 - I_2 + 1 = 0 \quad I_1 + I_2 = 1$$

$$I_2 = \frac{U}{R_2} = \frac{U}{12}$$

$$I_1 = \frac{U - E}{R_1} = \frac{U - 24}{6}$$

$$1 = \frac{U}{12} + \frac{U - 24}{6} = \frac{2 \cdot U - 48 + U}{12} \quad \Leftrightarrow \quad 12 = 3 \cdot U - 48$$

$$U = 20 \text{ V}$$

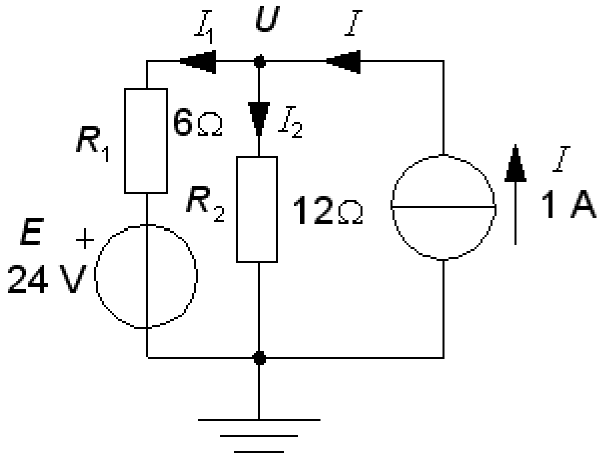


Node analysis – the currents

$$I_2 = \frac{20}{12} = 1{,}67$$

$$I_1 = \frac{20-24}{6} = -0{,}67$$

$$I_1 + I_2 = 1 \quad \Rightarrow \quad -0{,}67 + 1{,}67 = 1$$



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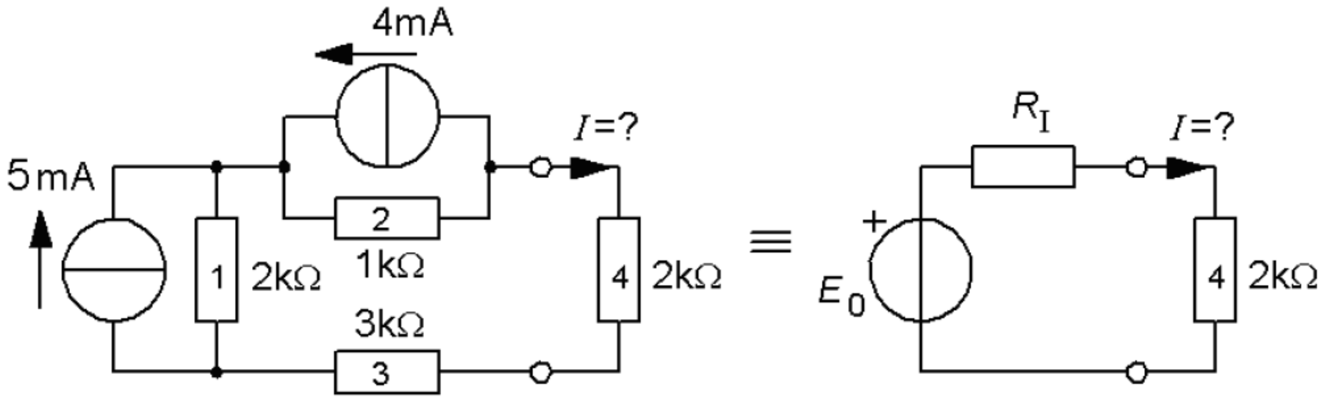
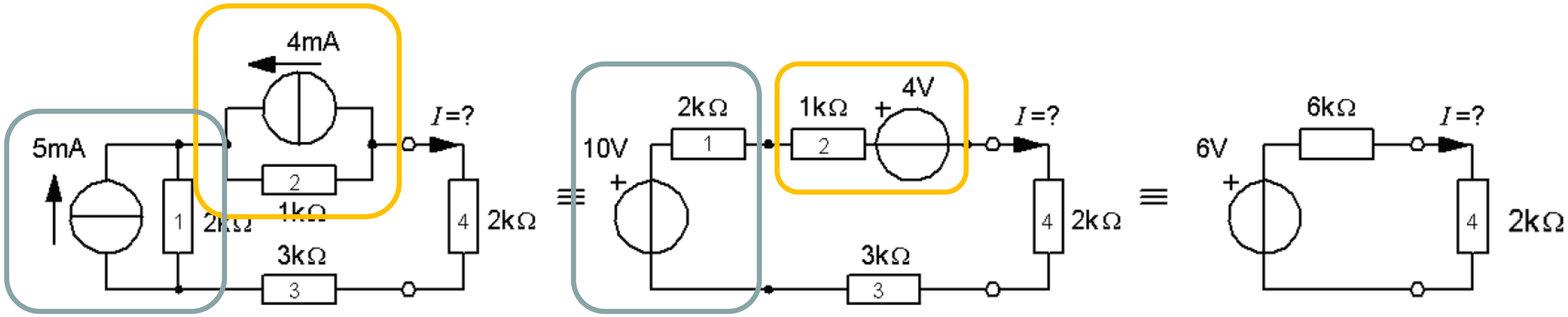
Example (8.9)



a) Derive a Thevenin's equivalent, E_0 R_I, to the circuit with the two current sources.

b) Calculate how big the current I would be if you connected a resistor R_4 = 2 kΩ to the circuit (or it's equivalent).

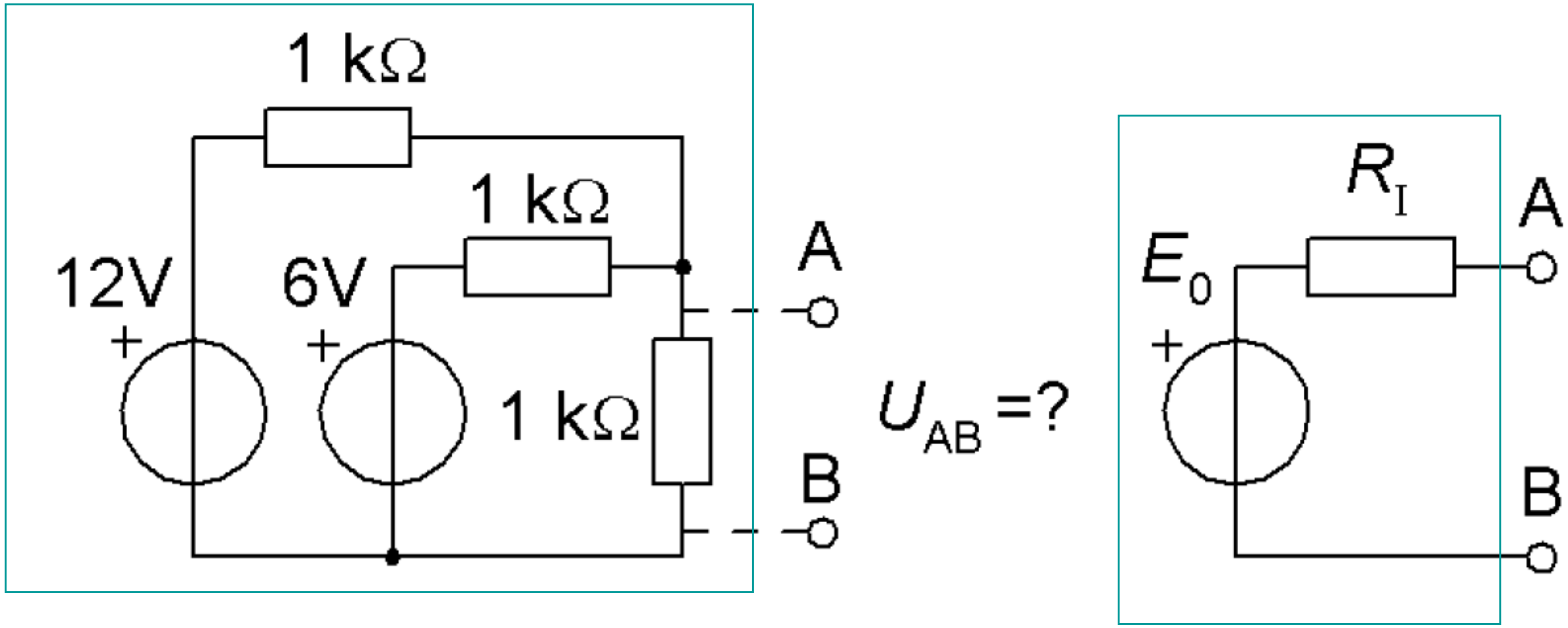
Example (8.9)



$$5\text{mA}||2\text{k}\Omega \;\Leftrightarrow\; 10\text{V}+2\text{k}\Omega,\;\; 4\text{mA}||1\text{k}\Omega \;\Leftrightarrow\; 4\text{V}+1\text{k}\Omega \;\Rightarrow\; 6\text{V}+6\text{k}\Omega$$

$$I = \frac{E_0}{R_I + R_L} = \frac{6}{6+2} = 0{,}75\text{ mA}$$

Example (8.10)

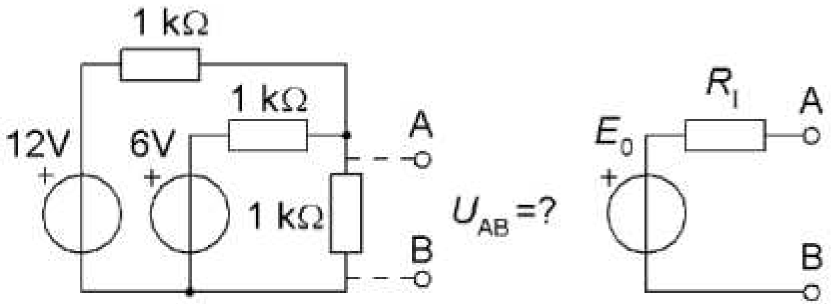


a) Derive a Thevenin's equivalent, E_0 R_I, to the circuit with the two voltage sources and the three resistors.

b) How big is the voltage drop U_{AB} over 1 kΩ resistor in the original circuit?

Example (8.10)

Let's calculate the voltage drop U_{AB} over the 1 kΩ resistor in the circuit, from the Thevenin's equivalent, as then U_{AB} will be the same as the E_0!



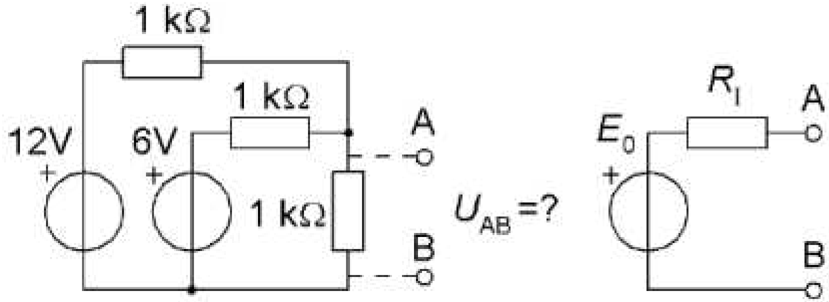
R_I is the equivalent resistance when the both voltage sources are turned down to zero:

$$R_I = \frac{1}{\frac{1}{1\text{k}\Omega} + \frac{1}{1\text{k}\Omega} + \frac{1}{1\text{k}\Omega}} = \frac{1}{3}\text{k}\Omega$$

Suppose A and B short circuited. The third 1 kΩ resistor will then be without current and can be ignored. The short cicuit current will come from the two votage sources through their 1k Ω resistors:

$$I_K = \frac{12\text{V}}{1\text{k}\Omega} + \frac{6\text{V}}{1\text{k}\Omega} = 18\text{ mA}$$

Example (8.10)

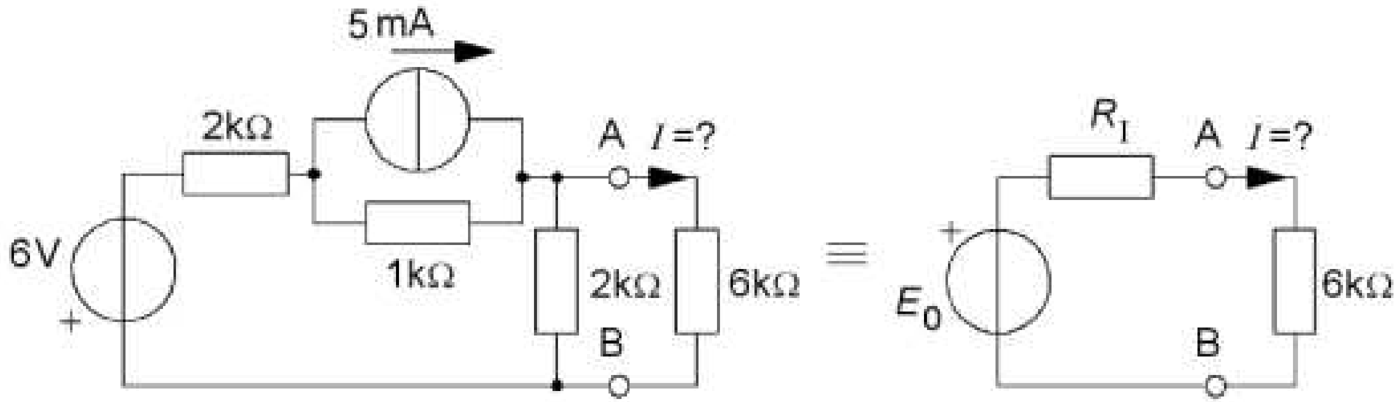


The Thevenin equivalent will have the same short circuit current I_K = 18 mA. This makes it easy to calculate E_0:

$$I_K = \frac{E_0}{R_I} \quad \Rightarrow \quad E_0 = I_K \cdot R_I = 18 \cdot \frac{1}{3} = 6 \text{ V}$$

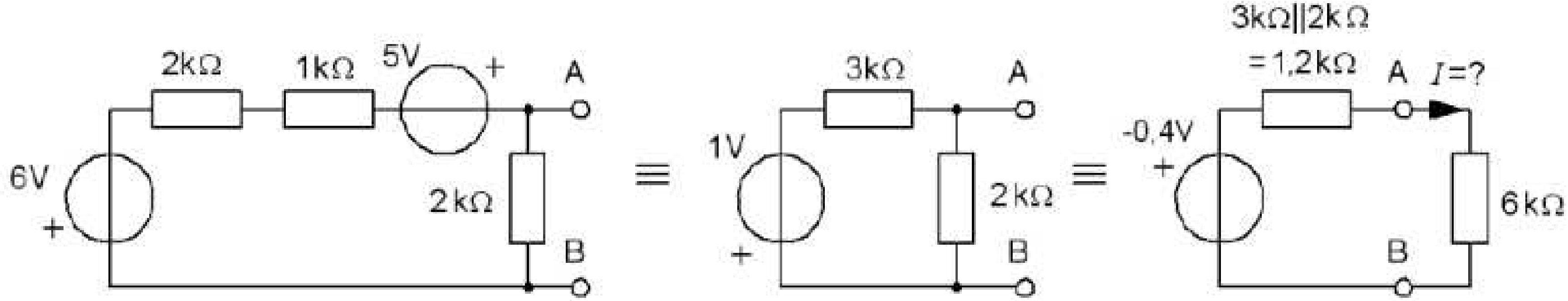
And the voltage drop U_{AB} is the same E_0. U_{AB} = 6 V.

Example (8.11)



a) Derive a Thevenin's equivalent, E_0 R_I, to the circuit with the voltage source and the current source and the three resistors. (The 6 kΩ resistor is not includes in the circuit).
b) Calculate how big current I would flow in a resistor R = 6 kΩ connected to A-B? What direction will the current have?

Example (8.11)



The current source with the 1 kΩ resistor can be transformed to a voltage source. The circuit then becomes a 1 V voltage source with a voltage divider.

$$E_0 = 1\frac{2}{3+2} = 0{,}4 \text{ V} \quad R_I = \frac{3 \cdot 2}{3+2} = 1{,}2 \text{ k}\Omega$$

The open circuit voltage is 0,4 V, and the internal resistance 3kΩ||2k Ω = 1,2 k Ω. Note. The voltage source 0,4V is opposite to the definition of the figure.