

# aufgabe\_4.5.2\_mit\_rechnung

## Student Group

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### Aufgabe 4.5.2: open circuit voltage via superposition (exam task, approx. 12 % of a 60-minute exam, WS2020)



A circuit is given with the following parameters

$$R_1 = 5 \, \Omega$$

$$U_1 = 2 \, \text{V}$$

$$I_2 = 1 \, \text{A}$$

$$R_3 = 20 \, \Omega$$

$$U_3 = 8 \, \text{V}$$

$$R_4 = 10 \, \Omega$$

Determine the open circuit voltage between A and B using the principle of superposition.

Tips

- What do the individual circuits look like, by which the effects of the individual sources can be calculated?  
Which equivalent resistor must be used to replace a current or voltage source when calculating the individual effects?
- Where are the open-circuit voltages applied when looking at the individual components?

Solution

First, the individual circuits must be created, from which the effect of the individual sources between points A and B can be determined.

#### (Voltage) source $U_1$

- substitute the current source  $I_2$  with a short-circuit
- substitute the voltage source  $U_3$  with an open circuit



The components can be moved in order to understand the circuit s bit better.



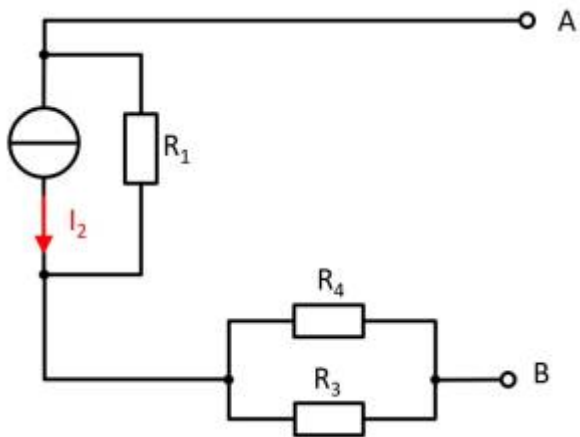
For the open circuit, no current is flowing through any resistor. Therefore, the effect is:  
 $U_{AB,1} = U_1$

**(current) source  $I_2$**

- substitute the voltage source  $U_1$  with an open circuit
- substitute the voltage source  $U_3$  with an open circuit



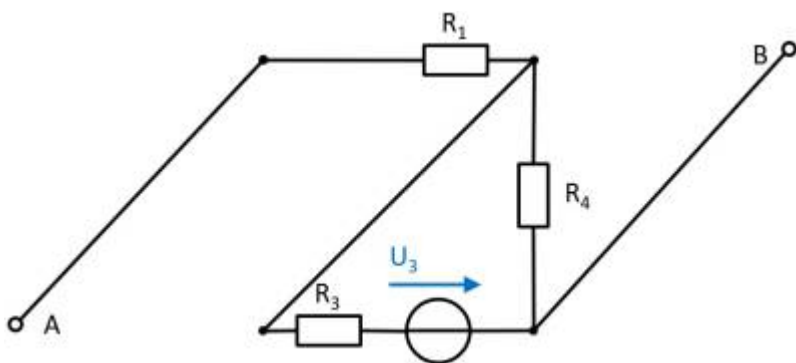
Also here, the components can be shifted for a better understanding:



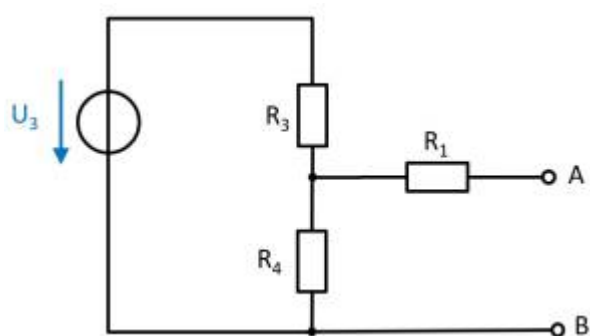
Here, the current source  $I_2$  creates a voltage drop  $U_{AB,2}$  on the resistor  $R_2$  :  
 $U_{\text{AB},2} = - R_1 \cdot I_2$

**(Voltage) source  $U_3$**

- substitute the voltage source  $U_1$  with an open circuit
- substitute the current source  $I_2$  with a short-circuit



Again, rearranging the circuit might help for an understanding:



In this case, between the unloaded outputs  $\text{A}$  and  $\text{B}$  there will be an unloaded voltage divider given by  $R_3$  and  $R_4$ . On  $R_1$  there is no voltage drop since there is no current flow out of the unloaded outputs.

Therefore:

$$\begin{align*} U_{\text{AB},3} &= \frac{R_4}{R_3 + R_4} \cdot U_3 \end{align*}$$

**resulting voltage**

$$\begin{aligned} U_{\text{AB}} &= U_1 - R_1 \cdot I_2 + \frac{R_4}{R_3 + R_4} \cdot U_3 \\ \end{aligned}$$

Final value

$$\begin{aligned} U_{\text{AB}} &= 2 \text{ V} - 5 \Omega \cdot 1 \text{ A} + \frac{10}{20 \Omega + 10 \Omega} \cdot 8 \text{ V} \\ U_{\text{AB}} &= 0.333 \text{ V} \end{aligned}$$

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