aufgabe_4.5.2_mit_rechnung

Student Group

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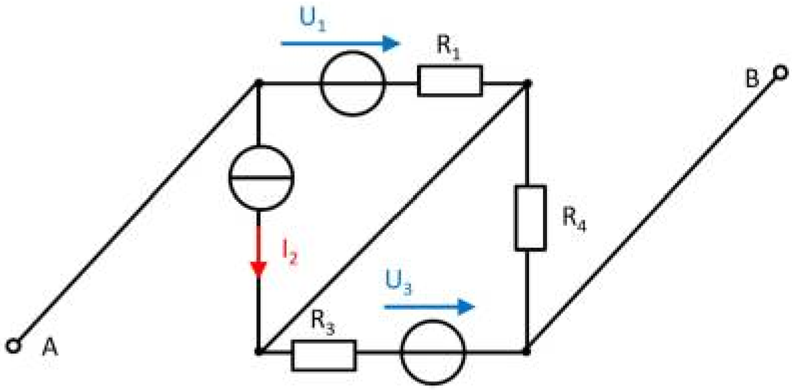
Aufgabe 4.5.2: Leerlaufspannung über Superposition (Klausuraufgabe, ca 12% einer 60minütigen Klausur, WS2020)



A circuit is given with the following parameters
$R_1=5 ~\Omega$
$U_1=2 ~V$
$I_2=1 ~A$
$R_3=20 ~\Omega$
$U_3=8 ~V$
$R_4=10 ~\Omega$

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

Tips

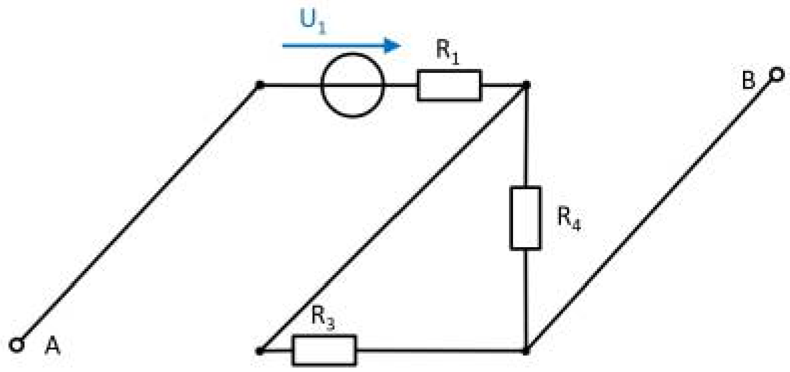
- What do the individual circuits look like, by which the effects of the individual sources can be calculated?
  Which equivalent resistor must be used to replace a current or voltage source when calculating the individual effects?
- Where are the open-circuit voltages applied when looking at the individual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

Solution

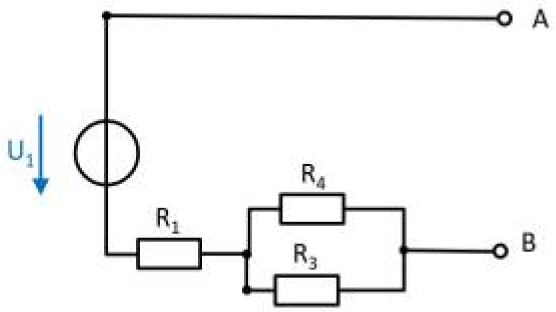
First, the individual circuits must be created, from which the effect of the individual sources between points A and B can be determined.

(Voltage) source U_1

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



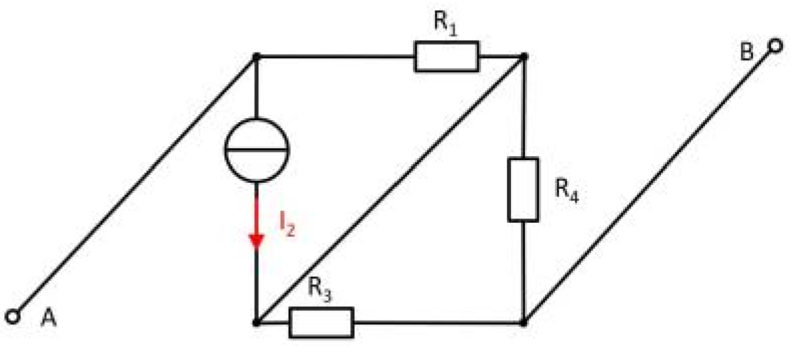
The components can be moved in order to understand the circuit s bit better.



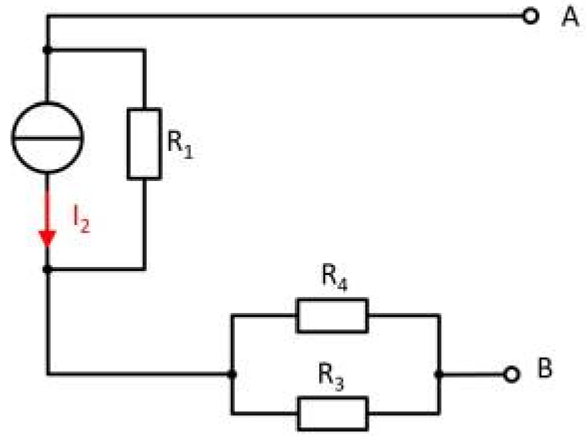
For the open circuit, no current is flowing through any resistor. Therefor the effect is:
$U_{AB,1} = U_1$

(current) source I_2

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



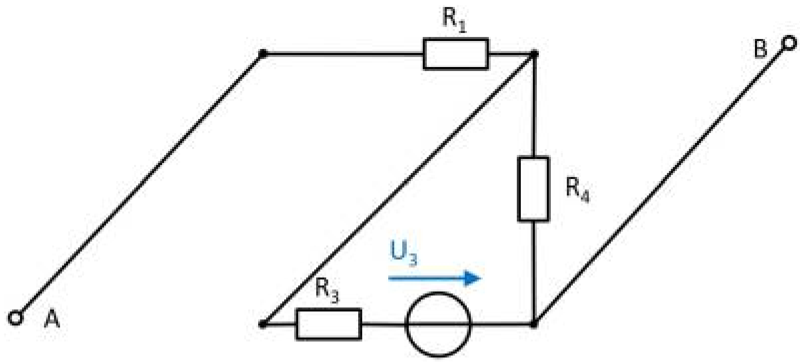
Also here, the components can be shifted for a better understanding:



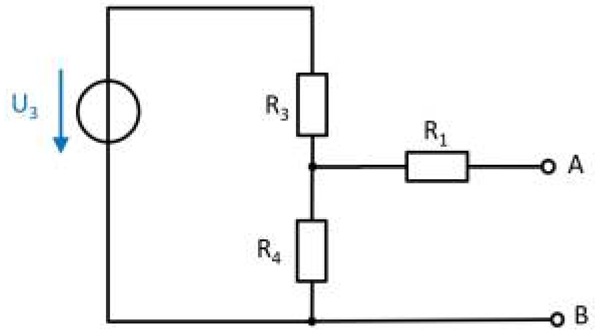
Here, the current source I_2 creates a voltage drop U_{AB_2} on the resistor R_2 :
$U_{AB,2} = - R_1 \cdot I_2$

(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 A and 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_{AB,3} = \frac{R_4}{R_3 + R_4} \cdot U_3 \end{align*}

resulting voltage

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

Final value

$$\begin{align*} U_{AB} &= 2 ~V - 5 ~\Omega \cdot 1 ~A + \frac{10 ~\Omega}{20 ~\Omega + 10 ~\Omega} \cdot 8 ~V \\ \\ U_{AB} & = 0.333... ~V \rightarrow 0.3 ~V \\ \end{align*}$$

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