

# dummy\_with\_calculation

## Student Group

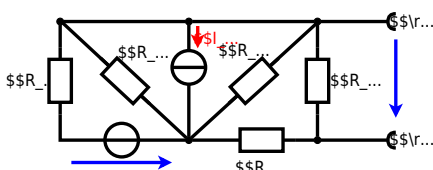
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**Exercise E1.1 Power loss and efficiency II**  
**(written test, approx. 14 % of a 60-minute written test, WS2022)**

The circuit in the following has to be simplified.



Calculate the internal resistance  $R_i$  and the source voltage  $U_s$  of an equivalent linear voltage source on the connectors  $A$  and  $B$ .  $R_1=5.0 \Omega$ ,  $U_2=6.0 \text{ V}$ ,  $R_3=10 \Omega$ ,  $I_4=4.2 \text{ A}$ ,  $R_5=10 \Omega$ ,  $R_6=7.5 \Omega$ ,  $R_7=15 \Omega$ . Use equivalent sources in order to simplify the circuit!

The best thing is to re-think the wiring like rubber bands and adjust them:



The linear voltage source of  $U_2$  and  $R_1$  can be transformed into a current source  $I_2 = \frac{U_2}{R_1}$  and  $R_1$ :



Now a lot of them can be combined. The resistors  $R_1$ ,  $R_3$ ,  $R_5$  are in parallel, like also  $I_2$  and  $I_4$ : 
$$R_{135} = R_1 || R_3 || R_5$$
 
$$I_{24} = I_2 - I_4 = \frac{U_2}{R_1} - I_4$$
 The resulting circuit can again be transformed:



Here, the  $U_{24}$  is calculated by  $I_{24}$  as the following: 
$$U_{24} = R_{135} \cdot I_{24} = \left( \frac{U_2}{R_1} - I_4 \right) \cdot R_{135} \parallel R_3 \parallel R_5$$

On the right side of the last circuit, there is a voltage divider given by  $R_{135}$ ,  $R_6$ , and  $R_7$ .

Therefore the voltage between  $A$  and  $B$  is given as: 
$$U_{AB} = U_{24} \cdot \frac{R_7}{R_6 + R_7 + R_{135} \parallel R_3 \parallel R_5} = \left( \frac{U_2}{R_1} - I_4 \right) \cdot \frac{R_7 \cdot R_{135} \parallel R_3 \parallel R_5}{R_6 + R_7 + R_{135} \parallel R_3 \parallel R_5}$$

For the internal resistance  $R_i$  the ideal voltage source is substituted by its resistance ( $= 0 \Omega$ , so a short-circuit): 
$$R_{AB} = R_7 \parallel (R_6 + R_{135} \parallel R_3 \parallel R_5)$$

with  $R_{135} \parallel R_3 \parallel R_5 = 5 \Omega \parallel 10 \Omega \parallel 10 \Omega = 5 \Omega \parallel 5 \Omega = 2.5 \Omega$ :

$$U_{AB} = \left( \frac{6.0 \text{ V}}{5.0 \Omega} - 4.2 \text{ A} \right) \cdot \frac{15 \Omega \cdot 2.5 \Omega}{7.5 \Omega + 15 \Omega + 2.5 \Omega} \parallel R_{AB} = 15 \Omega \parallel (7.5 \Omega + 2.5 \Omega)$$

Final result

$$U_{AB} = 4.5 \text{ V} \parallel R_{AB} = 6 \Omega$$

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