

task_6tqttque1e2nf2c7_with_calculation

Student Group

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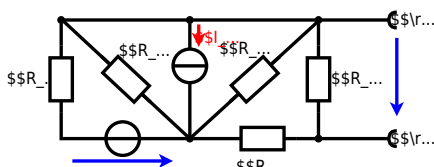
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dc network analysis, pure resistor network simplification, delta wye transformation, exam ee1 WS2022

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.
 Result

$$\begin{aligned} U_{\text{S}} &= U_{\text{AB}} = 4.5 \text{ V} \\ R_{\text{i}} &= R_{\text{AB}} = 6 \text{ } \Omega \end{aligned}$$



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

Solution

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 :
$$R_{135} = R_1 || R_3 || R_5$$

$$I_{24} = I_2 - I_4 = \frac{U_{24}}{R_1} - I_4$$
 The resulting circuit can again be transformed:



Here, the U_{24} is calculated by I_{24} as the following:
$$U_{24}$$

$$U_{24} = R_{135} \cdot I_{24} \quad \&= \left(\frac{U_2}{R_1} - I_4 \right) \cdot R_1 \parallel R_3 \parallel R_5$$

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:

$$U_{AB} = U_{24} \cdot \frac{R_7}{R_6 + R_7 + R_1 \parallel R_3 \parallel R_5} \quad \&= \left(\frac{U_2}{R_1} - I_4 \right) \cdot \frac{R_7 \cdot R_1 \parallel R_3 \parallel R_5}{R_6 + R_7 + R_1 \parallel R_3 \parallel R_5}$$

For the internal resistance R_i the ideal voltage source is substituted by its resistance ($\mathcal{E} = 0 \text{ V}$, so a short-circuit):

$$R_{AB} = R_7 \parallel (R_6 + R_1 \parallel R_3 \parallel R_5)$$

with $R_1 \parallel R_3 \parallel R_5 = 5 \text{ } \Omega \parallel 10 \text{ } \Omega \parallel 10 \text{ } \Omega = 5 \text{ } \Omega \parallel 5 \text{ } \Omega = 2.5 \text{ } \Omega$:

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

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