

Exam Winter Semester 2022

Student Group

First Name	Surname	Matrikel Nr.

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Exam Winter Semester 2022

Additional permitted Aids

- non-programmable calculator,
- formulary (2 DIN A4 pages)

Hits

- The duration of the exam is 60 min.
- Attempts to cheat will lead to exclusion and failure of the exam.
- Withdrawal is no longer possible after these exam has been handed out.
- Please write down intermediate calculations and results on the assignment sheet. (when more space is needed also on the reverse side. In this case: Mark it clearly).
- Always use units in the calculation.
- Use a document-proof, non-red pen.

Only EEE1-relevant Part

This part is only for about 25 minutes !

Exercise E1 Resistance of a Wire by Resistivity

(written test, approx. 6 % of a 60-minute written test, WS2022)

2. Heating elements are used to heat wire with a temperature of 180°C . An electric power dissipation (= heat flow) of $P=40\text{ W}$ is necessary.

Determine the current I needed to operate for heating elements.

The Nichrome wire has a resistivity of $1.10 \cdot 10^{-6}\ \Omega\text{m}$.

The heating element is 3 m long and has a diameter of 3.57 mm .

∴ Calculate the resistance R of the heating element.

Solution

$$\begin{aligned} P &= U \cdot I = R \cdot I^2 \quad \rightarrow \quad I = \\ &= \sqrt{\frac{P}{R}} = \sqrt{\frac{40\text{ W}}{0.33\ \Omega}} \end{aligned}$$

$$\begin{aligned} R &= \rho \cdot \frac{l}{A} \quad \& \quad | \text{with } A = r^2 \cdot \pi = \\ &= \frac{1}{4} d^2 \cdot \pi \quad \& \quad R = \rho \cdot \frac{4 \cdot l}{d^2 \cdot \pi} \quad \& \quad R = \\ &= 1.10 \cdot 10^{-6}\ \Omega\text{m} \cdot \frac{4 \cdot 3\text{ m}}{(3.57 \cdot 10^{-3}\text{ m})^2 \cdot \pi} \end{aligned}$$

Exercise E1 Temperature-dependent Resistance
(written test, approx. 6 % of a 60-minute written test, WS2022)

2. A refrigerator, which has a temperature coefficient of resistance α and a temperature coefficient of resistance β , has a resistance of R_0 at T_0 . Calculate the resistance of the thermistor at T_1 .

Its temperature coefficients are: $\alpha = 0.01 \cdot 10^{-6} \text{ K}^{-1}$ and $\beta = 71 \cdot 10^{-6} \text{ K}^{-2}$.

The temperature inside the refrigeration system can reach down to $-40 \text{ }^\circ\text{C}$.

$$R = 6.5 \cdot 10^4 \cdot \Omega \text{ at } -40 \text{ }^\circ\text{C}$$

The power transfered to the load is $P = \frac{U^2}{R}$. Therefore, a solution is to increase the resistance.

Therefore, with constant U and increasing R the power decreases. Ten times more resistance decreases the heat flow to one-tenth.

$$R = R_0 \cdot (1 + \alpha \cdot \Delta T + \beta \cdot \Delta T^2)$$

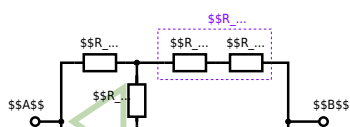
$$R = 10 \cdot 10^4 \cdot \Omega \cdot (1 + 0.01 \cdot 10^{-6} \cdot (-40 - 25) + 71 \cdot 10^{-6} \cdot (-40 - 25)^2)$$

Exercise E2 Pure Resistor Network Simplification
(written test, approx. 13 % of a 60-minute written test, WS2022)

The following shall be solved: $R_1 = 20 \text{ } \Omega$, $R_2 = 10 \text{ } \Omega$, $R_3 = 10 \text{ } \Omega$, $R_4 = 10 \text{ } \Omega$, $R_5 = 10 \text{ } \Omega$, $R_6 = 10 \text{ } \Omega$, $R_7 = 10 \text{ } \Omega$, $R_8 = 10 \text{ } \Omega$, $R_9 = 10 \text{ } \Omega$, $R_{10} = 10 \text{ } \Omega$, $R_{11} = 10 \text{ } \Omega$, $R_{12} = 10 \text{ } \Omega$, $R_{13} = 10 \text{ } \Omega$, $R_{14} = 10 \text{ } \Omega$, $R_{15} = 10 \text{ } \Omega$, $R_{16} = 10 \text{ } \Omega$, $R_{17} = 10 \text{ } \Omega$, $R_{18} = 10 \text{ } \Omega$, $R_{19} = 10 \text{ } \Omega$, $R_{20} = 10 \text{ } \Omega$, $R_{21} = 10 \text{ } \Omega$, $R_{22} = 10 \text{ } \Omega$, $R_{23} = 10 \text{ } \Omega$, $R_{24} = 10 \text{ } \Omega$, $R_{25} = 10 \text{ } \Omega$, $R_{26} = 10 \text{ } \Omega$, $R_{27} = 10 \text{ } \Omega$, $R_{28} = 10 \text{ } \Omega$, $R_{29} = 10 \text{ } \Omega$, $R_{30} = 10 \text{ } \Omega$, $R_{31} = 10 \text{ } \Omega$, $R_{32} = 10 \text{ } \Omega$, $R_{33} = 10 \text{ } \Omega$, $R_{34} = 10 \text{ } \Omega$, $R_{35} = 10 \text{ } \Omega$, $R_{36} = 10 \text{ } \Omega$, $R_{37} = 10 \text{ } \Omega$, $R_{38} = 10 \text{ } \Omega$, $R_{39} = 10 \text{ } \Omega$, $R_{40} = 10 \text{ } \Omega$, $R_{41} = 10 \text{ } \Omega$, $R_{42} = 10 \text{ } \Omega$, $R_{43} = 10 \text{ } \Omega$, $R_{44} = 10 \text{ } \Omega$, $R_{45} = 10 \text{ } \Omega$, $R_{46} = 10 \text{ } \Omega$, $R_{47} = 10 \text{ } \Omega$, $R_{48} = 10 \text{ } \Omega$, $R_{49} = 10 \text{ } \Omega$, $R_{50} = 10 \text{ } \Omega$, $R_{51} = 10 \text{ } \Omega$, $R_{52} = 10 \text{ } \Omega$, $R_{53} = 10 \text{ } \Omega$, $R_{54} = 10 \text{ } \Omega$, $R_{55} = 10 \text{ } \Omega$, $R_{56} = 10 \text{ } \Omega$, $R_{57} = 10 \text{ } \Omega$, $R_{58} = 10 \text{ } \Omega$, $R_{59} = 10 \text{ } \Omega$, $R_{60} = 10 \text{ } \Omega$, $R_{61} = 10 \text{ } \Omega$, $R_{62} = 10 \text{ } \Omega$, $R_{63} = 10 \text{ } \Omega$, $R_{64} = 10 \text{ } \Omega$, $R_{65} = 10 \text{ } \Omega$, $R_{66} = 10 \text{ } \Omega$, $R_{67} = 10 \text{ } \Omega$, $R_{68} = 10 \text{ } \Omega$, $R_{69} = 10 \text{ } \Omega$, $R_{70} = 10 \text{ } \Omega$, $R_{71} = 10 \text{ } \Omega$, $R_{72} = 10 \text{ } \Omega$, $R_{73} = 10 \text{ } \Omega$, $R_{74} = 10 \text{ } \Omega$, $R_{75} = 10 \text{ } \Omega$, $R_{76} = 10 \text{ } \Omega$, $R_{77} = 10 \text{ } \Omega$, $R_{78} = 10 \text{ } \Omega$, $R_{79} = 10 \text{ } \Omega$, $R_{80} = 10 \text{ } \Omega$, $R_{81} = 10 \text{ } \Omega$, $R_{82} = 10 \text{ } \Omega$, $R_{83} = 10 \text{ } \Omega$, $R_{84} = 10 \text{ } \Omega$, $R_{85} = 10 \text{ } \Omega$, $R_{86} = 10 \text{ } \Omega$, $R_{87} = 10 \text{ } \Omega$, $R_{88} = 10 \text{ } \Omega$, $R_{89} = 10 \text{ } \Omega$, $R_{90} = 10 \text{ } \Omega$, $R_{91} = 10 \text{ } \Omega$, $R_{92} = 10 \text{ } \Omega$, $R_{93} = 10 \text{ } \Omega$, $R_{94} = 10 \text{ } \Omega$, $R_{95} = 10 \text{ } \Omega$, $R_{96} = 10 \text{ } \Omega$, $R_{97} = 10 \text{ } \Omega$, $R_{98} = 10 \text{ } \Omega$, $R_{99} = 10 \text{ } \Omega$, $R_{100} = 10 \text{ } \Omega$.

$$R_{\text{eq}} = 132.8 \text{ } \Omega$$

Now a wye-delta transformation is necessary.

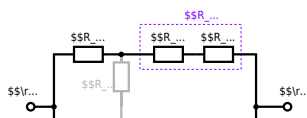


Since $R_2=R_3$ and based on the equations for the transformation, the transformed R_Y is given as:
$$R_Y = \frac{R_2 \cdot R_2}{R_2 + R_2 + R_2} = \frac{(100 \sim \Omega)^2}{3 \cdot 100 \sim \Omega} = \frac{1}{3} \cdot 100 \sim \Omega = 33.33 \sim \Omega$$

The equivalent resistor is given by a parallel configuration of resistors in series:
$$R_{\text{eq}} = R_Y + (R_Y + R_1 + R_1) \parallel (R_Y + R_2) \parallel R_{\text{eq}} = 33.33 \sim \Omega + (33.33 \sim \Omega + 400 \sim \Omega) \parallel (33.33 \sim \Omega + 100 \sim \Omega) \parallel$$

1. The switch shall now be open. Calculate the equivalent resistance R_{eq} between A and B .

Solution



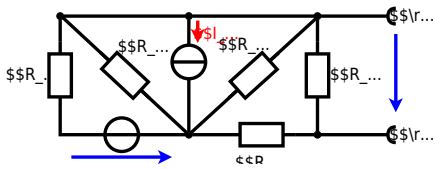
The equivalent resistor is given by a parallel configuration of resistors in series:

$$R_{\text{eq}} = (R_2 + R_1 + R_{-1}) \parallel (R_2 + R_2) \parallel R_{\text{eq}} = (100 \Omega + 200 \Omega + 200 \Omega) \parallel (100 \Omega + 100 \Omega) \parallel R_{\text{eq}} = \{500 \Omega \parallel (200 \Omega) \parallel R_{\text{eq}} = \{500 \Omega \cdot 200 \Omega \over 500 \Omega + 200 \Omega\} \parallel$$

**Exercise E3 Equivalent linear Source
(written test, approx. 14 % of a 60-minute written test, WS2022)**

The circuit in the following has to be simplified.
Result

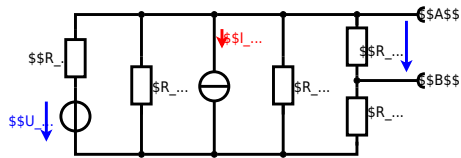
$$U_{\text{s}} = U_{\text{AB}} = 4.5 \text{ V} \quad R_{\text{i}} = R_{\text{AB}} = 6 \Omega$$



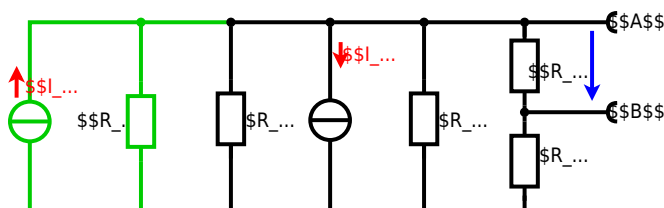
Calculate the internal resistance R_i and the source voltage U_s of an equivalent linear voltage source on the connectors A and B . $R_1=5.0 \Omega$, $U_2=6.0 \text{ V}$, $R_3= 10 \Omega$, $I_4=4.2 \text{ A}$, $R_5=10 \Omega$, $R_6=7.5 \Omega$, $R_7=15 \Omega$ Use equivalent sources in order to simplify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

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

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



Here, the U_{24} is calculated by I_{24} as the following:
$$U_{24} = I_{24} \cdot R_6$$

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

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:

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

For the internal resistance R_i the ideal voltage source is substituted by its resistance ($=0\Omega$, so a short-circuit):

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

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

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

$$R_{AB} = 15\Omega \parallel (7.5\Omega + 2.5\Omega)$$

Full Exam

These is the full exam

Full exam

Exercise E1 Resistance of a Wire by Resistivity (written test, approx. 6 % of a 60-minute written test, WS2022)

The heating element made of nichrome wire with a cross-section of 1.80mm^2 . Each cm^3 of the nichrome wire has a power dissipation (= heat flow) of $P=40\text{W}$ is necessary. Calculate the current I needed to operate for heating elements. The Nichrome wire has a resistivity of $1.10 \cdot 10^{-6}\Omega\text{m}$. The heating element is 3m long and has a diameter of 3.57mm . Calculate the resistance R of the heating element.

Solution

$$P = U \cdot I = R \cdot I^2 \quad \rightarrow \quad I = \sqrt{\frac{P}{R}} = \sqrt{\frac{40\text{W}}{0.33\Omega}}$$

$$R = \rho \cdot \frac{l}{A} \quad | \quad A = r^2 \cdot \pi = \frac{1}{4} d^2 \cdot \pi \quad | \quad R = \rho \cdot \frac{4 \cdot l}{d^2 \cdot \pi} \quad | \quad R = 1.10 \cdot 10^{-6}\Omega\text{m} \cdot \frac{4 \cdot 3\text{m}}{d^2 \cdot \pi}$$

$$3 \cdot 10^{-3} \cdot (3.57 \cdot 10^{-3} \cdot R)^2 \cdot \pi$$

[electrical_engineering_and_electronics:task_rj0r6j4apumukrj6_with_calculation](#)
[resistivity, power, exam ee1 ws2022](#)

Exercise E1 Temperature-dependent Resistance
(written test, approx. 6 % of a 60-minute written test, WS2022)

A refrigerator is explained with the effect of temperature on the resistance of a resistor. The resistance of a resistor is given by $R = R_0 (1 + \alpha \Delta T + \beta \Delta T^2)$ for T in $^{\circ}\text{C}$. Its temperature coefficients are: $\alpha = 0.01 \text{ K}^{-1}$ and $\beta = 71 \cdot 10^{-6} \text{ K}^{-2}$.

The temperature inside the refrigeration system can reach down to $-40 \text{ }^{\circ}\text{C}$.

Result

Calculate the resistance of the thermistor at $-40 \text{ }^{\circ}\text{C}$.

The power transferred to the resistor $P = U \cdot I$ and the heat $Q = P \cdot t$ is solution for resistive flow might heat up the refrigeration system. Therefore, with constant U and increasing R the power decreases. Ten times more resistance decreases the heat flow to one-tenth.

$$R = R_0 (1 + \alpha \Delta T + \beta \Delta T^2) \quad | \text{with } \Delta T = T_{\text{end}} - T_{\text{start}}$$

$$R = 10 \text{ k}\Omega \cdot (1 + 0.01 \text{ K}^{-1} \cdot (-40 \text{ }^{\circ}\text{C} - 25 \text{ }^{\circ}\text{C}) + 71 \cdot 10^{-6} \text{ K}^{-2} \cdot (-40 \text{ }^{\circ}\text{C} - 25 \text{ }^{\circ}\text{C})^2)$$

[electrical_engineering_and_electronics:task_70jg4yzznocarsq_with_calculation](#)
[temperature dependent resistance, power, heat, exam ee1 ws2022](#)

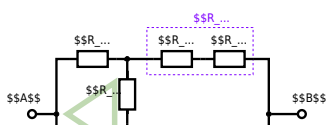
Exercise E2 Pure Resistor Network Simplification
(written test, approx. 13 % of a 60-minute written test, WS2022)

The following shall hold: $R_1 = 20 \text{ }\Omega$, $R_2 = 10 \text{ }\Omega$, $R_3 = 10 \text{ }\Omega$, $R_4 = 10 \text{ }\Omega$, $R_5 = 10 \text{ }\Omega$, $R_6 = 10 \text{ }\Omega$, $R_7 = 10 \text{ }\Omega$, $R_8 = 10 \text{ }\Omega$, $R_9 = 10 \text{ }\Omega$, $R_{10} = 10 \text{ }\Omega$, $R_{11} = 10 \text{ }\Omega$, $R_{12} = 10 \text{ }\Omega$, $R_{13} = 10 \text{ }\Omega$, $R_{14} = 10 \text{ }\Omega$, $R_{15} = 10 \text{ }\Omega$, $R_{16} = 10 \text{ }\Omega$, $R_{17} = 10 \text{ }\Omega$, $R_{18} = 10 \text{ }\Omega$, $R_{19} = 10 \text{ }\Omega$, $R_{20} = 10 \text{ }\Omega$.

Solution

$$R_{\text{eq}} = 132.8 \text{ }\Omega$$

Now a wye-delta transformation is necessary.

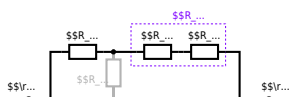


Since $R_2=R_3$ and based on the equations for the transformation, the transformed R_Y is given as:
$$R_Y = \frac{R_2 \cdot R_2}{R_2 + R_2 + R_2} = \frac{(100 \Omega)^2}{3 \cdot 100 \Omega} = \frac{1}{3} \cdot 100 \Omega = 33.33 \Omega$$

The equivalent resistor is given by a parallel configuration of resistors in series:
$$R_{eq} = R_Y + (R_Y + R_1 + R_1) \parallel (R_Y + R_2) \parallel (R_Y + R_2 + 100 \Omega)$$

1. The switch shall now be open. Calculate the equivalent resistance R_{eq} between A and B .

Solution



The equivalent resistor is given by a parallel configuration of resistors in series:

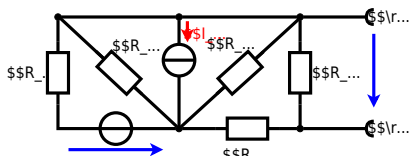
$$R_{\text{eq}} = (R_2 + R_1) \parallel (R_2 + R_2) \parallel R_{\text{eq}} = (100 \Omega + 200 \Omega + 200 \Omega) \parallel (100 \Omega + 100 \Omega) \parallel R_{\text{eq}} = (500 \Omega) \parallel (200 \Omega) \parallel R_{\text{eq}} = \frac{500 \Omega \cdot 200 \Omega}{500 \Omega + 200 \Omega}$$

[electrical_engineering_and_electronics:task_x357drkaqv84jnsc_with_calculation_network_simplification,_exam_ee1_ws2022](#)

**Exercise E3 Equivalent linear Source
(written test, approx. 14 % of a 60-minute written test, WS2022)**

The circuit in the following has to be simplified.
Result

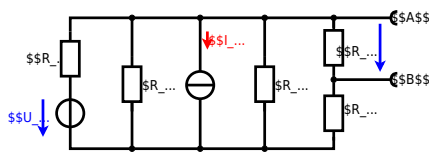
$$U_{\text{S}} = U_{\text{AB}} = 4.5 \text{ V} \parallel R_{\text{i}} = R_{\text{AB}} = 6 \Omega$$



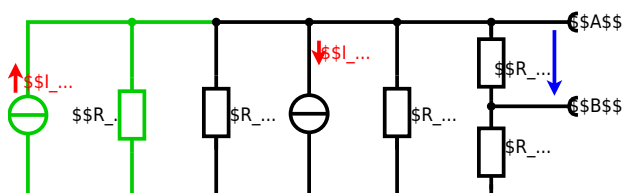
Calculated the internal resistance R_{int} and the source voltage U_{src} of an equivalent linear voltage source on the connectors A and B. $\begin{aligned} R_1=5.0 \text{ } \Omega, \quad U_1=6.0 \text{ V}, \quad R_3= 10 \text{ } \Omega, \quad I_4=4.2 \text{ A}, \\ R_5=10 \text{ } \Omega, \quad R_6=7.5 \text{ } \Omega, \quad R_7=15 \text{ } \Omega \end{aligned}$
 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:



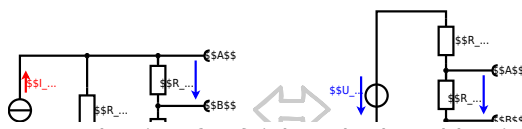
The linear voltage source of U_2 and R_1 can be transformed into a current source $I_2 = \frac{U_2}{R_1}$ and R_1 :



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

$$I_{24} = I_2 - I_4 = \left\{ \frac{U_2}{R_1} \right\} - I_4$$
 The resulting circuit can again be transformed:



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

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:
$$U_{\text{AB}} = U_{24} \cdot \frac{R_7}{R_6 + R_7 + R_1 || R_3 || R_5} = \left(\frac{U_2}{R_1} - I_4 \right) \cdot \frac{R_7 \cdot R_1 || R_3 || R_5}{R_6 + R_7 + R_1 || R_3 || R_5}$$

For the internal resistance R_i the ideal voltage source is substituted by its resistance ($=0\Omega$, so a short-circuit):
$$R_{\text{AB}} = R_7 || (R_6 + R_1 || R_3 || R_5)$$

with $R_1 || R_3 || R_5 = 5 \Omega || 10 \Omega || 10 \Omega = 5 \Omega || 5 \Omega = 2.5 \Omega$:

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

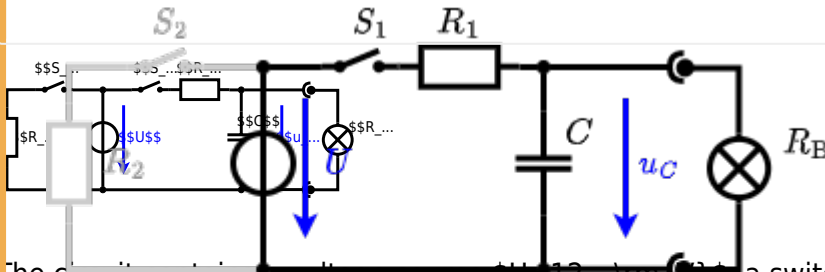
[electrical_engineering_and_electronics:task_6tqtque1e2nf2c7_with_calculation](#)
 dc network analysis, pure resistor network simplification, delta wye transformation, exam ee1 ws2022

Exercise E1 Charging Capacitors (written test, approx. 16 % of a 60-minute written test, WS2022)

The capacitor becomes fully charged) dissipation of power in the circuit is again 0 W. The voltage across the capacitor is again 0 V at the moment $t_0=0$ s when the switch S_1 is closed. Calculate the voltage $u_c(t_2)$ across the capacitor at $t_2=1$ ms after closing the switch.

Hint: To solve this, first create an equivalent linear voltage source from U , R_1 , and R_B .

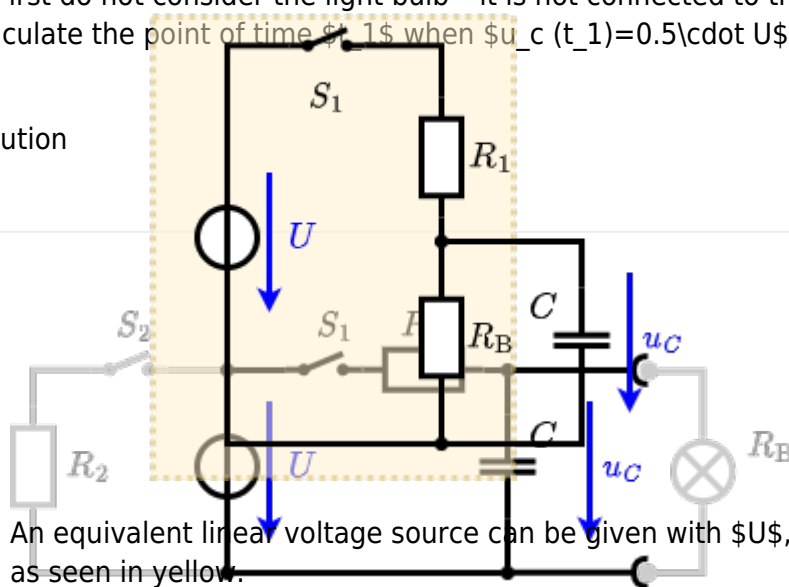
The internal voltage of the equivalent source is $U_{eq} = U \cdot \frac{R_B}{R_1 + R_B}$ and the internal resistance is $R_{eq} = R_1 \parallel R_B = \frac{R_1 \cdot R_B}{R_1 + R_B}$. The voltage across the capacitor is $u_c(t) = U_{eq} \cdot (1 - e^{-t/\tau})$ where $\tau = R_{eq} \cdot C$.
 Solution: $U_{eq} = \frac{12 \text{ V} \cdot 12 \text{ } \Omega}{12 \text{ } \Omega + 12 \text{ } \Omega} = 6 \text{ V}$ and $R_{eq} = \frac{12 \text{ } \Omega \cdot 12 \text{ } \Omega}{12 \text{ } \Omega + 12 \text{ } \Omega} = 6 \text{ } \Omega$.
 On an alternative view, one can try to create an equivalent linear voltage source again. Then, the internal resistance is given by substituting the ideal voltage source is again short-circuiting R_2 .



The circuit contains a voltage source $U=12$ V, a switch S_1 , a resistor of $R_1=20$ Ω and a capacitor of $C=100$ μF . The switch S_2 to an additional consumer R_2 will be considered to be open for the first tasks. At the moment $t_0=0$ s the switch S_1 is closed, the voltage across the capacitor is $u_c(t_0)=0$ V.

... First do not consider the light bulb - it is not connected to the RC circuit. Calculate the point of time t_1 when $u_c(t_1)=0.5 \cdot U$.

Solution



An equivalent linear voltage source can be given with U , R_1 , and R_B as seen in yellow.

Therefore, the voltage of the equivalent source is $U_{eq} = U \cdot \frac{R_B}{R_1 + R_B} = \frac{1}{2} \cdot U$. The internal resistance is given by $R_{eq} = R_1 \parallel R_B = \frac{R_1 \cdot R_B}{R_1 + R_B} = 6 \text{ } \Omega$. The following formula describes the time course of $u_c(t)$ which has to be $u_c(t) = U_{eq} \cdot (1 - e^{-t/\tau})$ with $\tau = R_{eq} \cdot C$. It has to be rearranged to $(1 - e^{-t/\tau}) = 0.5$ $\Rightarrow e^{-t/\tau} = 0.5$ $\Rightarrow -t/\tau = \ln(0.5)$ $\Rightarrow t = -\tau \cdot \ln(0.5) = 6 \text{ } \Omega \cdot 100 \text{ } \mu\text{F} \cdot \ln(2) \approx 0.416 \text{ ms}$.

$$\frac{1}{2} \cdot U \cdot (1 - e^{-\frac{1}{\tau}}) \cdot I \cdot \mu F$$

electrical_engineering_and_electronics:task_tb6pi8dgh0m2e2pw_with_calculation charging capacitors, dc network analysis, pure resistor network simplification, delta wye transformation, exam ee1 ws2022

Exercise E4 Analyzing complex Impedances (written test, approx. 14 % of a 60-minute written test, WS2022)

2. Calculate the effective value of the current $i(t)$ and the average power P in the circuit. The voltage $u(t)$ and the current $i(t)$ are given by $u(t) = 50 \sin(\omega t)$ V and $i(t) = 0.24 \cos(\omega t - \varphi_i)$ A. The effective value I_{eff} of the current $i(t)$ and the average power P shall be given.

After analysis, the following information can be extracted: $Z = 4.68 \angle -20^\circ \Omega$. The effective value I_{eff} of the current $i(t)$ and the average power P shall be given.

.. Calculate the physical values of the two components. $R = 4.68 \cos(20^\circ) \approx 4.38 \Omega$, $X_L = 4.68 \sin(20^\circ) \approx 1.60 \Omega$

Solution

$$\underline{I} = \frac{\underline{U}}{\underline{Z}} = \frac{50 \angle 0^\circ}{4.68 \angle -20^\circ} = 10.68 \angle 20^\circ$$
 The effective value I_{eff} is $I_{eff} = \frac{10.68}{\sqrt{2}} \approx 7.54$ A. The average power P is $P = I_{eff}^2 \cdot R = 7.54^2 \cdot 4.38 \approx 250$ W. With the complex part comes the physical value $i(t) = 7.54 \sqrt{2} \sin(\omega t + 20^\circ)$ A.

electrical_engineering_and_electronics:task_jti0uzudcmg4u22t_with_calculation complex impedance, exam ee1 ws2022

Exercise E1 Impedances at different Frequencies

(written test, approx. 18 % of a 60-minute written test, WS2022)

2. A series circuit contains a resistor with $R = 1.00 \text{ k}\Omega$ and a capacitor with $C = 40 \text{ nF}$. The voltage source is $v(t) = 4.7 \sin(2\pi \cdot 150 \text{ kHz} \cdot t) \text{ V}$.
 Result: $I = 1.00 \text{ mA}$ and $V_C = 16.0 \text{ V}$.
 The resistor R_1 shall have the same absolute value of the impedance as a capacitor $C_1 = 40 \text{ nF}$ at $f = 4 \text{ MHz}$.

Solution

$$R_1 = 1.00 \text{ k}\Omega$$

$$R_2 = 10.0 \text{ k}\Omega$$

A series circuit means that the current is constant on every component.
 The equivalent impedance for R and C combined is given by $Z = R - jX_C$

$$Z = R - j \frac{1}{\omega C} = 1.00 \text{ k}\Omega - j \frac{1}{2\pi \cdot 150 \text{ kHz} \cdot 40 \text{ nF}} = 1.00 \text{ k}\Omega - j 26.5 \text{ }\Omega$$

 The voltage across the resistor is $V_R = I \cdot R$ and the voltage across the capacitor is $V_C = I \cdot X_C$.
 The power is perpendicular to the voltage $P = I^2 R$. (It has to, since R is perpendicular to X_C)

$$P = I^2 R = (1.00 \text{ mA})^2 \cdot 1.00 \text{ k}\Omega = 1.00 \text{ mW}$$

 Therefore, the resulting current of the parallel circuit is given as:

$$I_{total} = I_R + I_C$$

 This can be re-arranged to get $I_C = \sqrt{I_{total}^2 - I_R^2}$

$$I_C = \sqrt{(1.00 \text{ mA})^2 - (1.00 \text{ mA})^2} = 0 \text{ mA}$$

 Back to the first formula: $R_1 \cdot I_{total} = X_{C1} \cdot I_{total}$

$$R_1 = X_{C1} = \frac{1}{\omega C_1}$$

$$R_1 = \frac{1}{2\pi \cdot 4 \text{ MHz} \cdot C_1}$$

[electrical_engineering_and_electronics:task_pdkgtyexxy1ktu3_with_calculation](#)
[complex impedance, exam ee1 ws2022](#)

Exercise E1 Complex Impedance Circuit

(written test, approx. 15 % of a 60-minute written test, WS2022)

1. Consider the circuit below. The voltage source is $v(t) = 3.0 \sin(2\pi \cdot 15 \text{ kHz} \cdot t) \text{ V}$ and the resistor is $R = 10 \text{ }\Omega$. The voltage source is $v(t) = 3.0 \sin(2\pi \cdot 15 \text{ kHz} \cdot t) \text{ V}$.
 Choose ω and ϕ in the voltage source $v(t) = 3.0 \sin(2\pi \cdot 15 \text{ kHz} \cdot t) \text{ V}$.
 This linear source is connected with an inductor of $L = 330 \text{ }\mu\text{H}$ and a capacitor of $C = 0.22 \text{ }\mu\text{F}$, all in series.

Solution

Result

$$Z = 19.8 \text{ }\Omega$$

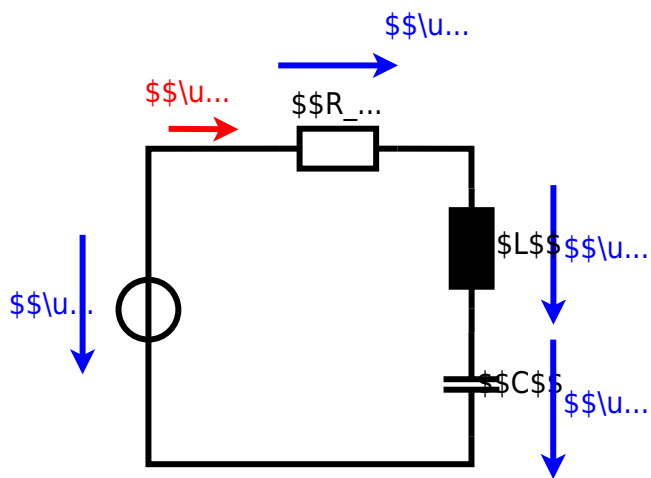
Draw the circuit diagram of the given circuit.
 Label all components, voltages, and currents.

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

$$Z = \sqrt{10^2 + (2\pi \cdot 15 \text{ kHz} \cdot 330 \text{ }\mu\text{H} - 2\pi \cdot 15 \text{ kHz} \cdot 0.22 \text{ }\mu\text{F})^2}$$

$$Z = 19.8 \text{ }\Omega$$

$$I = \frac{V}{Z} = \frac{3.0 \text{ V}}{19.8 \text{ }\Omega} = 0.15 \text{ A}$$



electrical_engineering_and_electronics:task_kricv9fh7haauo6q_with_calculation
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