Lab01 - Resistors

Student Group

First Name	Surname	Matrikel Nr.

Table of Contents

Lab01 - Resistors 2
Challenge description 2
Resistance measurement 2
Background Information 2
Experimental Tasks 2
Direct resistance measurement 3
Indirect resistance measurement 3
Test Questions - Resistors 4
Mesh set 4
Set of nodes 5
Voltage divider as voltage source 7
Nonlinear resistors 8

Lab01 - Resistors

Challenge description

An automotive engineer is testing the electrical system of a passenger car. The vehicle has a **12 V battery**, interior lighting, a temperature sensor, and a rear window heater. During vehicle development, the engineer must verify electrical components using resistance measurements, Ohm's law, series and parallel circuits, Kirchhoff's laws, and the behavior of a non-linear load.

Resistance is defined by voltage and current:
$$ R = \frac{U}{I} $$

A constant supply voltage is available for the experiment. This raises the following questions:

- How will the different values of U and I influence R?
- How can the set of nodes help to understand the current flow?
- How will the voltage be affected from nonlinear resistors?

To answer these questions, different circuits are investigated: the Mesh-set, Set of nodes and a light bulb circuit for nonlinear resistors.

2026/07/31 15:13 · feharst

Resistance measurement

Background Information

Procedure for resistance measurement: * Set the measuring device to resistance measurement * Connect the resistance to be measured to the corresponding sockets on the measuring device (the measuring device sockets labeled COM and Ω * Read the measured value There are different types of resistance measurement: * **direct** resistance measurement * **indirect** resistance measurement The resistances can also be determined by measuring the current/voltage. **Ohm's law: In an electrical circuit, the current increases with increasing voltage and decreases with increasing resistance.**
$$ I=\frac{U}{R} $$

Experimental Tasks

Direct resistance measurement

Determine the nominal and measured values of the resistance for $R_{\rm 1}$ (brown, green, orange), $R_{\rm 2}$ (yellow, violet, red), $R_{\rm 3}$ (red, violet, red) and the incandescent lamp $R_{\rm L}$. Also measure the approximate resistance $R_{\rm K}$ of your body from your right to your left hand.

	R_1	R_2	R_3	$R_{\rm L}$	$R_{\rm K}$
nominal value					
measured value					

Tab. 1: Direct resistance measurement

How do you explain the deviation between $R_{\rm L,nominal}$ and $R_{\rm L,meas}$?
What consequences can $R_{\rm K}$ have?
Now determine the series and parallel connections of resistors $R_{\rm 1}$, $R_{\rm 2}$ and $R_{\rm 3}$.
Specify the formulas used:
$R_{\rm serial}$ =
$R_{\rm parallel}$ (= $R_{\rm a}$ || $R_{\rm b}$) =

	R1+R2	R1+R3	R2+R3	R1 || R2	R1 || R3	R2 || R3
calculated						
measured						

Tab. 2: Series and parallel connections

Indirect resistance measurement

Build the measuring circuit shown in figure 1 for each of the three resistors and set the voltage on the power supply to $~{\rm 12} ~{ V}$.

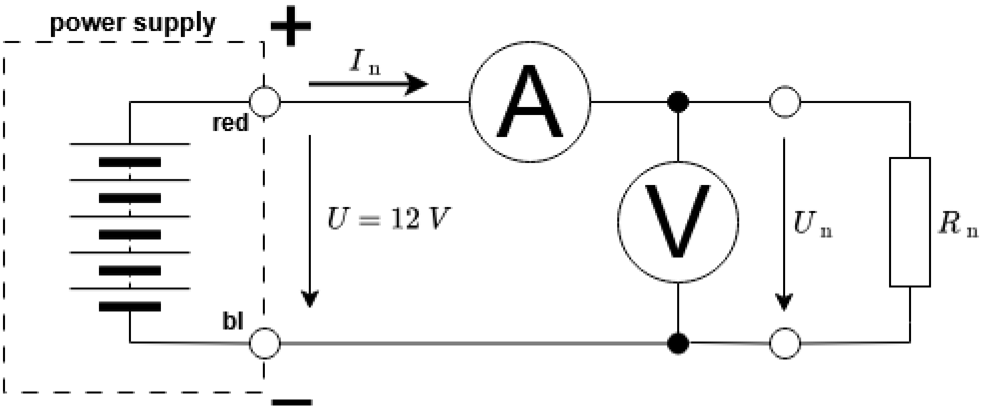


Fig. 1: Indirect resistance measurement

Measure $U_{\rm n}$ [V] and $I_{\rm n}$ [mA]. Calculate $R_{\rm n}$ [kΩ]

from these values.

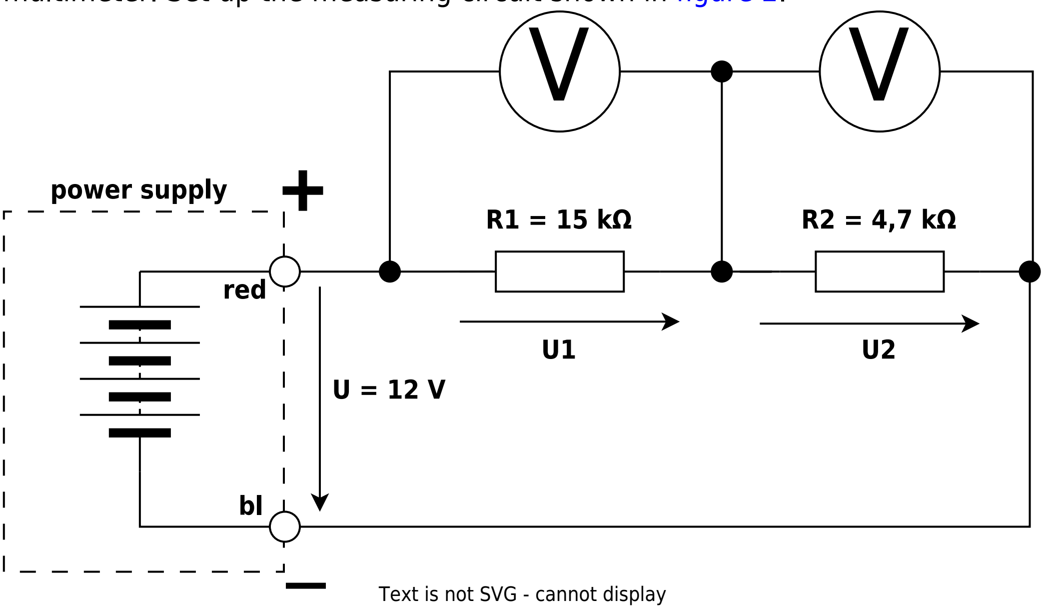
I_1	U_1	R_1	I_2	U_2	R_2	I_3	U_3	R_3

Tab. 3: Indirect resistance measurement

Test Questions - Resistors

Mesh set

In every closed circuit and every mesh of the network, the sum of all voltages is zero!
Set the voltage on the power supply to $12~\rm V$ and measure this voltage precisely using a multimeter. Set up the measuring circuit shown in figure 2.



Text is not SVG - cannot display

Fig. 2: Mesh-set Add the voltage arrows and measure U, $U_{\rm 1}$ und $U_{\rm 2}$:

$$U$$	$$U_{~\rm 1}$$	$$U_{~\rm 2}$$

Tab. 4: Mesh set voltage mesurement

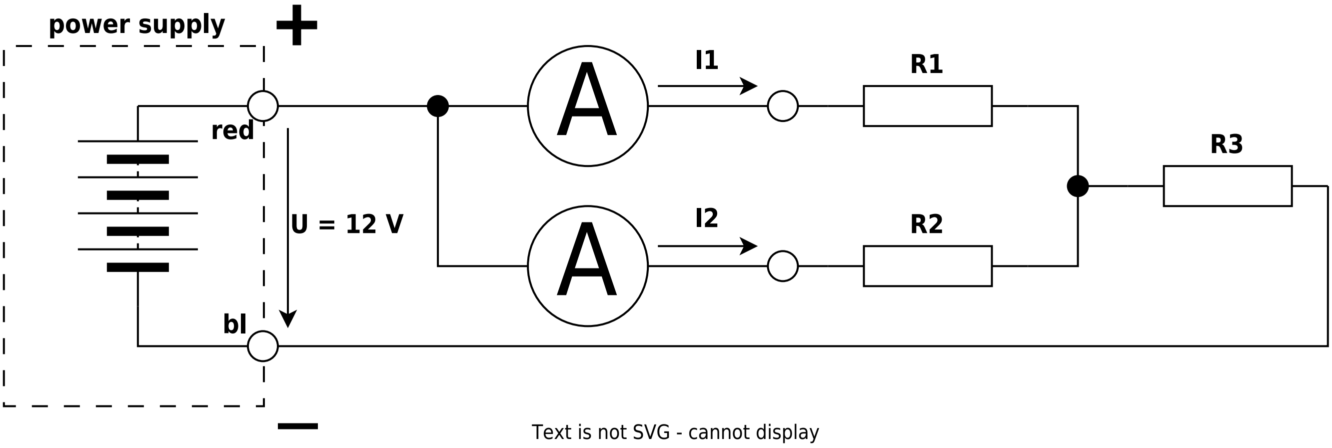
What is the mesh set here?

Check the formula with the measured values:

The resistors $R_{\rm 1}$ and $R_{\rm 2}$ connected in series form a voltage divider. What is the ratio between the voltages $U_{\rm 1}$ and $R_{\rm 2}$? $$ \frac{U_1}{U_2} = $$

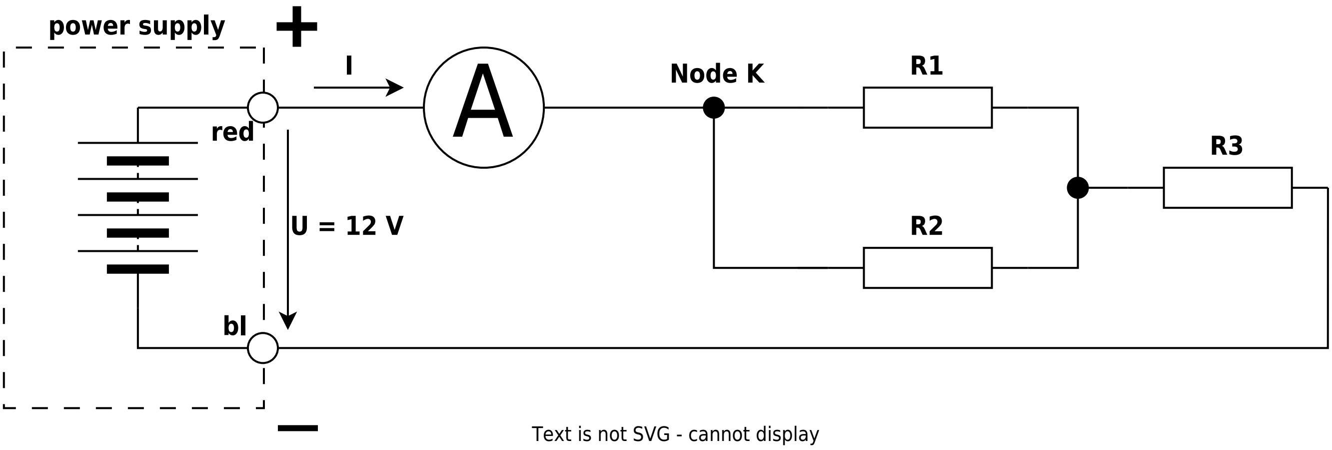
Set of nodes

At each junction point, the sum of all incoming and outgoing currents is equal to zero!
Set the voltage on the power supply to $12~\rm V$ and measure the voltage accurately with a multimeter. In the first step, set up the measuring circuit shown in figure 3:



Text is not SVG - cannot display

Fig. 3: Node-set circuit 1 Draw the arrows for the directions of currents $I_{\rm 1}$ and $I_{\rm 2}$ in figure 4. The DC current measurement range must be set on both multimeter using the rotary switch. Then measure currents $I_{\rm 1}$ and $I_{\rm 2}$ and enter the measured values in table 5.



Text is not SVG - cannot display

Fig. 4: Node-set circuit 2 What is the relationship between currents $I_{\rm 1}$ and $I_{\rm 2}$? $$\frac{I_1}{I_2} = $$ Switch the power supply back on and measure the current I. Enter its value in table 5.

$$I$$	$$I_{~\rm 1}$$	$$I_{~\rm 2}$$

Tab. 5: Node set current mesurement

Determine the node set for node K and check its validity.

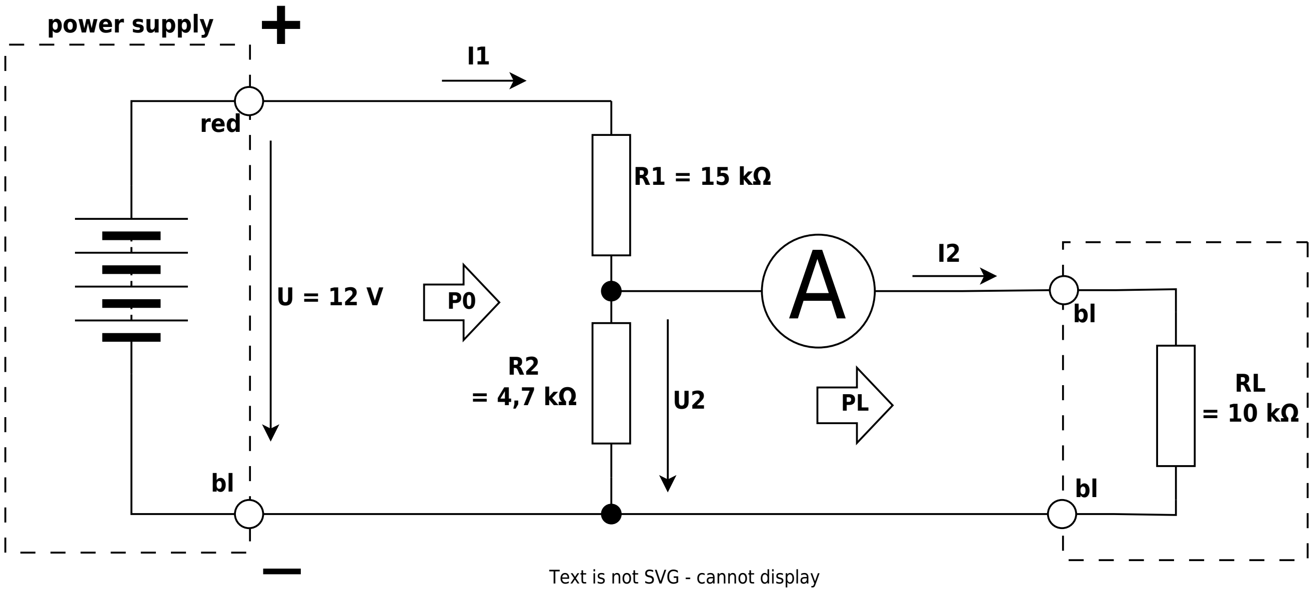
Using the measured values for resistors $R_{\rm 1}$, $R_{\rm 2}$, and $R_{\rm 3}$, calculate the total resistance $R_{\rm KP}$:

Using the calculated value $R_{\rm KP}$, check the measured value of the total current:
$$ I=\frac{U}{R_{KP}} = $$

Voltage divider as voltage source

The voltage divider shown in figure 5 is in an unloaded state, as the entire current supplied by the power supply flows through the resistors $R_{\rm 1}$ and $R_{\rm 2}$ connected in series. A resistor parallel to $R_{\rm 2}$ loads the voltage divider. Set the voltage on the power supply to $12 ~\rm V$ and measure the exact voltage with a multimeter. Set up the measuring circuit shown in figure 5. For the connected load $R_{\rm L}$ = ${\rm 10} ~{\rm k\Omega}$, the voltage divider represents a voltage source. Like any voltage source, it has a source voltage (also called the original voltage) $U_{\rm 0}$ and an internal resistance $R_{\rm i}$. The internal resistance of a voltage divider considered as a voltage source results from the parallel connection of the divider resistors $R_{\rm

1}$ and $R_{\rm 2}$:
$$ R_i = R_1 || R_2 = \frac{R_1\cdot R_2}{R_1+R_2} $$
Use the measured values of resistors $R_{\rm 1}$ and $R_{\rm 2}$ to calculate the internal resistance $R_{\rm i}$ of the voltage source: $$ R_i = $$ $$ U_0 = $$
The power $P_{\rm 0}$ supplied by the power supply can be calculated using the following equation:
$$ P_0 = U\cdot I_1$$
The power consumed by the load resistance can be determined using the following formula: $$ P_L = R_L\cdot {I_2}^2$$



Text is not SVG - cannot display

Fig. 5: Voltage divider
Draw the equivalent voltage source of the voltage divider:

What would be the value of $U_{\rm 2}$ without $R_{\rm L}$?
$$ U_{2, zero} = $$ Calculate $U_{\rm 2,L}$ and $I_{\rm 2}$ for $R_{\rm L}$ = ${\rm 10} ~{\rm k\Omega}$ using the values of the equivalent voltage source: (Provide formulas!) $$ U_{2L} : $$ $$ I_2 : $$
Check the values by measuring:
$$ U_{2L, Meas} : $$
$$ I_{2, Meas} : $$ Check the values using Kirchhoff's rules: (Provide formulas!)
$$ U_{2L} : $$ $$ I_2 : $$

Nonlinear resistors

All resistors examined so far are linear resistors, for which the characteristic curve $I=f(U)$ is a straight line, s. figure 6. The resistance value of a linear resistor is independent of the current I flowing through it or the applied voltage U.

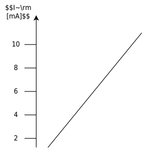


Fig. 6: Characteristic curve of a linear resistor

With nonlinear resistors, there is no proportionality between current and voltage. The characteristic curve of such a resistor is shown in figure 7. With these resistors, we talk about static resistance (R) and dynamic (or differential) resistance (r). The static resistance is determined for a specific operating point: at a specific voltage, the current is read from the resistance characteristic curve. The calculation is performed according to Ohm's law: $$ R = \frac{U}{I} $$ The differential resistance around the operating point is calculated from the current difference caused by a change in the applied voltage: $$ r = \frac{\Delta U}{\Delta I} $$

Fig. 7: Characteristic curve of a nonlinear resistor A light bulb is examined as an example of a nonlinear resistor. Set up the measuring circuit shown in figure 8.

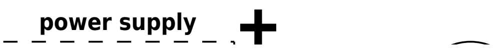


Fig. 8: Measuring circuit light bulb

Set the voltage on the power supply to the voltage values from table 6. Measure the corresponding current values and enter them in table 6.

$U \rm~[V]$	0,5	1,0	2,0	3,0	4,0	5,0	6,0	7,0	8,0
$I \rm~[mA]$									

Tab. 6: Values characteristic curve light bulb

Create the characteristic curve $I = f(U)$, s. figure 9

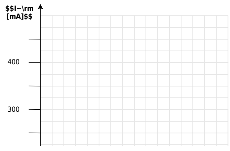


Fig. 9: Characteristic curve light bulb Calculate the static resistance R at the operating point $U = \rm 7.0 ~V$:

Calculate the dynamic resistance r at the operating point $U = \rm 7.0 ~V$:

Compare the values with the values from table 1 (direct resistance measurement)