RESISTANCE MEASUREMENTS

Electronic Measurements Lab

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Team

Team no.

Student	Last name	First name	Signature
1			.....
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1 Assignment

This lab is about resistance measurements with the ammeter-voltmeter method and with multimeters.

Fill the PDF form and upload it on Portale della Didattica (Homework/Elaborati section), one upload for each team, by May 5, 2024.

Equipment

You need the following laboratory equipment:

- Bench DC power supply
- Handheld digital multimeter
- Bench digital multimeter (Agilent/Hewlett-Packard HP34401A)
- Resistor box with 4.7 Ω, 10 Ω, 470 Ω and 10 kΩ resistors (figure 1)
- A 100 kΩ resistor, 5 % tolerance
- A 1 kΩ resistor, 5 % tolerance
- Banana plug to banana plug cables
- Banana plug to spade adapters (figure 2)

Figure 1: Resistor box.

Figure 2: Banana plug to spade adapters.

2 Resistor box measured by the bench digital multimeter

1 Configure the multimeter for 4-wire resistance measurements (Shift + Ω 4W) and a resolution of 6 digits (Shift + 6 Digit).

2 Connect the first resistor of the resistor box to the multimeter with a 4-wire connection, as shown in figure 3. In this kind of measurement, two wires, carrying negligible current, are used to directly measure the voltage across the unknown resistance (figure 4), such that no measurement error arises from the wire resistances.

3 Measure the resistance of the first resistor and report its value in table 1 on page 12.

4 Repeat points **2** and **3** for the remaining resistors.

5 From the multimeter specifications evaluate the measurement uncertainty of the four resistance values and report the uncertainties in table 1.

6 Repeat the four resistance measurements and the evaluation of the uncertainties with the multimeter configured for 2-wire resistance measurements (Ω 2W). Report the results in table 1. Which measurements are more affected by the wire resistances?

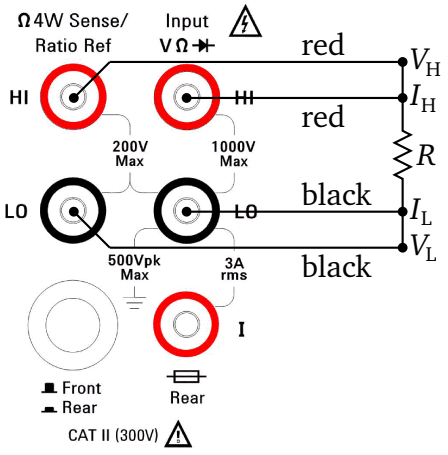

Figure 3: Connection of the Agilent 34401A for 4-wire resistance measurements.

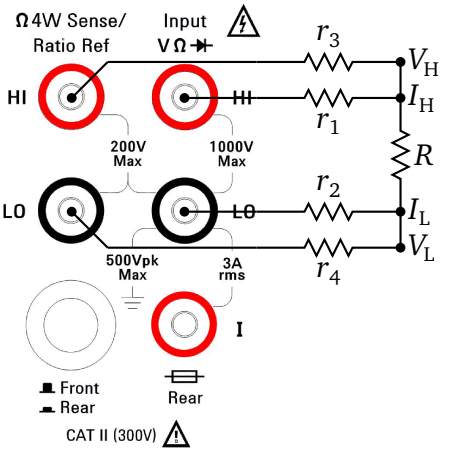

Figure 4: In this diagram $r_1, \ldots, r_4$ represent the wire resistances. In a 4-wire resistance measurement, the multimeter uses the *Input* terminals to inject a current through r_1, R and r_2, and uses the *Sense* terminals to measure the voltage directly across R. The voltage drop across the wire resistances r_3 and r_4 is negligible because the current crossing the *Sense* terminals is virtually zero.

3 Resistor box measured by the handheld multimeter

The handheld multimeter can only make 2-wire resistance measurements.

1. Measure the four resistors of the resistor box with the handheld multimeter.
2. From the multimeter specifications evaluate the measurement uncertainty of the four resistance values.
3. Report the results in table 1.
4. Are the results obtained with the handheld multimeter compatible with those obtained with the bench multimeter?

4 Resistor box measured by the ammeter-voltmeter method, voltmeter downstream

You here measure the resistances of the resistor box with the ammeter-voltmeter method (*IV* method), voltmeter downstream.

1. Set the power supply output voltage to 0 V.
2. Assemble the measurement circuit as reported in figure 5, connecting one of the resistors of the resistor box. Use the handheld multimeter as ammeter and the bench multimeter as voltmeter, connecting the voltmeter downstream of the ammeter with 4-wire connection. The additional 1 kΩ resistor is used to limit the power supply output current.
3. Increase the power supply voltage to get a current of 1 mA for the 470 Ω and 10 kΩ resistors, and a current of 10 mA for the 4.7 Ω and 10 Ω resistors.
4. Determine the resistance reading $R^{\text{read}} = V^{\text{read}}/I^{\text{read}}$.
5. Correct the resistance reading for the voltmeter loading, as described during the lectures, and evaluate the measurement uncertainty. The voltmeter input resistance and its uncertainty are reported in the multimeter specifications.
6. Report the result in table 1.
7. Repeat the above points for the remaining resistors.
8. Are these measurements compatible with those obtained with the other multimeters?

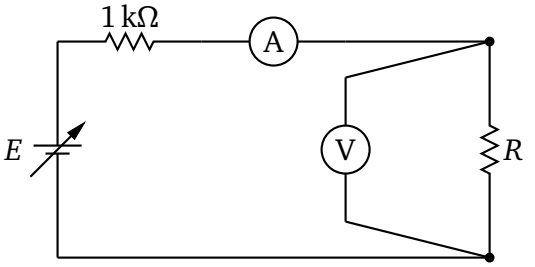

Figure 5: Measurement circuit for the *IV* method with the voltmeter downstream and 4-wire connection: E represents the bench power supply; R represents the resistor under measurement. The additional 1 kΩ resistor limits the power supply output current.

5 100 kΩ resistor

1. Measure the 100 kΩ resistor with the bench multimeter, both in 2-wire and 4-wire configurations, and with the handheld multimeter. Evaluate the uncertainties and report the results in table 1.
2. Measure the 100 kΩ resistor with the *IV* method, ammeter downstream, according to the schematic of figure 6. Determine the resistance reading $R^{\text{read}} = V^{\text{read}}/I^{\text{read}}$, correct the resistance reading for the ammeter voltage burden, as described during the lectures, and evaluate the measurement uncertainty. Report the result in table 1.

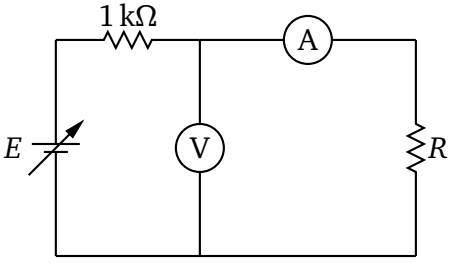

Figure 6: Measurement circuit for the *IV* method with the ammeter downstream.

Table 1: Resistor measurements.

Nominal value	Bench multimeter				Handheld multimeter		*IV* method	
	2-wire		4-wire					
	R/Ω	$\delta R/\Omega$	R/Ω	$\delta R/\Omega$	R/Ω	$\delta R/\Omega$	R/Ω	$\delta R/\Omega$
4.7 Ω								
10 Ω								
470 Ω								
10 kΩ								
100 kΩ								