Wrocław University of Science and Technology

ELECTRIONIC MEASUREMENTS
LABORATORY REPORT

Chair of Electronic and Photonic Metrology
ELECTRIONIC MEASUREMENTS LABORATORY

Theme of class: DC CURRENT MEASUREMENT

Group no: 1

Students:
1. Paulina Nowak 251002
2. Ivan Melnyk 275510
3. Stanislav Kustov 275512

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Lab assistant: mgr inż. Krzysztof Adamczyk

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1 Introduction

1.1 Theory

Electric current can be measured in two ways: directly and indirectly. To make a direct measurement, the meter must be connected to the circuit in series. An ideal meter should have a zero internal resistance as not to impact the current flowing through; in reality, meters will always have a non-zero resistance creating a voltage drop.

The systematic error of current measurements $\Delta_m I$ can be calculated using formulas shown in Eq. 1, 2 (for: I_A – measured current, R_A – internal ammeter resistance, R_C – circuit resistance).

$$\Delta_m I = -I_A \cdot \frac{R_A}{R_C} \tag{1}$$

$$\delta_m I = -\frac{R_A}{R_A + R_C} \tag{2}$$

1.2 Equipment

The following devices were used during the laboratory:

- power supply: DF1730SB3A;
- analog ammeter: LM-3;
- digital meter: Agilent 34401A;
- decade resistor: DR4b-16;
- resistance standard: product name unknown.

2 Experiments

2.1 Direct current measurements

For direct measurements the meter was connected to the circuit in series (Figure 1). Measurements were taken for varying circuit resistances.

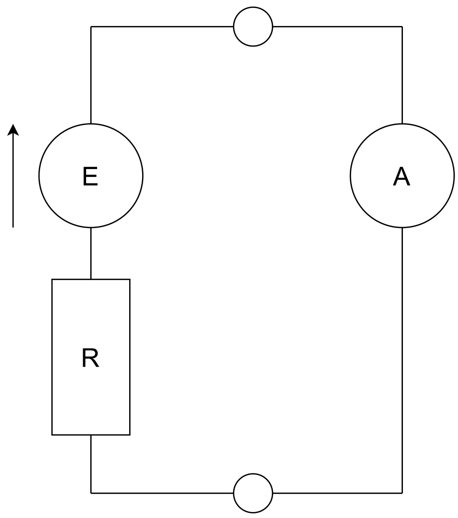

Figure 1: Direct current measurements schematic

2.1.1 Analog measurements

The ammeter which we used for analog measurements is was of a 0.5 accuracy class and had $\frac{23}{I_R[\text{mA}]} + 0.004[\Omega]$ internal resistance (for: I_R – range).

The measurements along with the results are split into Tables 1 and 2; Tab. 1 contains the measurement results with only the limiting error applied, whereas Tab. 2 shows the final results which include the systematic error.

$R_C[\Omega]$	α	α_{max}	$I_r[\text{mA}]$	$I[\text{mA}]$	$\Delta_I[\text{mA}]$	$\delta_I[\%]$	$I \pm \Delta_I[\text{mA}]$
10	66	75	150.0	132.00	0.7500	0.56819	132.0 ± 0.8
30	45	75	75.0	45.00	0.3750	0.83334	45.0 ± 0.4
100	67	75	15.0	13.40	0.0750	0.55971	13.40 ± 0.08
300	45.5	75	7.5	4.55	0.0375	0.82418	4.55 ± 0.04
1k	34	75	3.0	1.36	0.0150	1.10295	1.360 ± 0.016
3k	12	75	3.0	0.48	0.0150	3.12501	0.480 ± 0.016
10k	5	75	3.0	0.20	0.0150	7.50001	0.200 ± 0.016

Table 1: Current measurements for $E \sim 1.3\,\text{V}$ (for: R_C – circuit resistance, α – actual needle swing, α_{max} – maximal swing, I_r – range, I – measured current, Δ_I –absolute error, δ_I – relative error)

$R_A[\Omega]$	$\Delta_m I$[mA]	$\delta_m I$	c[mA]	I_C[mA]	I_{exp}[mA]	$I_C \pm \Delta_I$[mA]
0.15734	-2.07681	-0.01550	2.07681	134.07681	130.00	134.1 ± 0.8
0.31067	-0.46601	-0.01025	0.46601	45.46601	43.33	45.5 ± 0.4
1.53734	-0.20601	-0.01515	0.20601	13.60601	13.00	13.61 ± 0.08
3.07067	-0.04658	-0.01014	0.04658	4.59658	4.33	4.60 ± 0.04
7.67067	-0.01044	-0.00762	0.01044	1.37044	1.30	1.370 ± 0.016
7.67067	-0.00123	-0.00256	0.00123	0.48123	0.43	0.481 ± 0.016
7.67067	-0.00016	-0.00077	0.00016	0.20016	0.13	0.200 ± 0.016

Table 2: Current measurements for $E \sim 1.3\,\mathrm{V}$ (for: R_A – internal ammeter resistance, $\Delta_m I$ – systematic error, $\delta_m I$ – relative error, c – correction factor, I_C – calculated current, I_{exp} – expected current)

Example calculations for $R_C = 300\,\Omega$ are shown in the equations below.

$$I = \frac{\alpha \cdot I_r}{\alpha_{max}} = \frac{45.5 \cdot 7.5\,\mathrm{mA}}{75} = 4.55\,\mathrm{mA} \tag{3}$$

$$\Delta_I = \frac{I_r \cdot cl}{100\%} = \frac{7.5\,\mathrm{mA} \cdot 0.5\%}{100\%} = 0.0375\,\mathrm{mA} \tag{4}$$

$$\delta_I = \frac{\Delta_I}{I} \cdot 100\% = \frac{0.0375\,\mathrm{mA}}{4.55\,\mathrm{mA}} \cdot 100\% \approx 0.82418\% \tag{5}$$

$$R_A = \frac{23}{I_R[\mathrm{mA}]} + 0.004[\Omega] = \frac{23}{7.5\,\mathrm{mA}} + 0.004\,\Omega \approx 3.070\,67\,\Omega \tag{6}$$

$$\Delta_m I = -I_A \cdot \frac{R_A}{R_C} = -4.55\,\mathrm{mA}\frac{3.070\,67\,\Omega}{300\,\Omega} \approx -0.046\,58\,\mathrm{mA} \tag{7}$$

$$\delta_m I = -\frac{R_A}{R_A + R_C} = -\frac{3.070\,67\,\Omega}{3.070\,67\,\Omega + 300\,\Omega} \approx -0.01014 \tag{8}$$

$$c = -\Delta_m I = -(-0.046\,58\,\mathrm{mA}) = 0.046\,58\,\mathrm{mA} \tag{9}$$

$$I_C = I + c = 4.55\,\mathrm{mA} + 0.046\,58\,\mathrm{mA} = 4.596\,58\,\mathrm{mA} \tag{10}$$

$$I_{exp} = \frac{V}{R_C} = \frac{1.3\,\mathrm{V}}{300\,\Omega} \approx 0.004\,33\,\mathrm{A} = 4.33\,\mathrm{mA} \tag{11}$$

2.1.2 Digital measurements

Digital measurements were made using a multimeter. Its internal resistance and accuracy are available in the device manual; for our calculations we chose the least precise accuracy value that is guaranteed to work for one year after device calibration.

The measurements along with the results are split into Tables **??** and **??**; Tab. **??** contains the measurement results with only the limiting error applied, whereas Tab. **??** shows the final results which include the systematic error.

2.2 Indirect current measurement

3 Conclusions