Wrocław University of Science and Technology

ELECTRIONIC MEASUREMENTS
LABORATORY REPORT

Chair of Electronic and Photonic Metrology
ELECTRIONIC MEASUREMENTS LABORATORY

Theme of class: DC VOLTAGE MEASUREMENT

Group no: 1

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1 Introduction

In the last laboratory we were learning about DC voltage measurement with an analogue and digital multimeter. We explored their parameters and calculated measurement errors and found out their sources.

First Experiment

In the first experiment we connected voltmeter parallel to the circuit which consists of power source and resistor. From the lecture we know that proper way to measure voltage is to connect voltmeter with infinite internal resistance, so current does not flow through, but in real world meter is not ideal and it's changes the measured value. During this experiment we observe the influence of internal voltmeter resistance on the accuracy of measurement.

Second Experiment

In the second experiment we are using two voltmeters power supply and voltage divider. We learned how how voltage dividers work and how load on output changes output voltage. We will consider 4 different configurations: 2 with internal resistance of 1 k Ohm and two with 1 M Ohm using different k coefficients.

2 Experiment

2.1 Output voltage of a voltage source

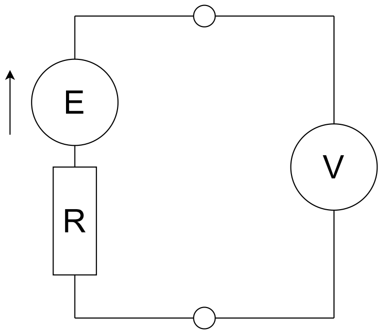

Figure 1: Voltage measurement schematic

Analog measurement

For analogue measurements we used an LM-3 meter, characterized by an accuracy class of 0.5 and an internal resistance of 1 $\frac{k\Omega}{V}$.

$R_c[\Omega]$	α	α_{max}	V_r[V]	V[V]	ΔV[V]	δV%	$V \pm \Delta V$[V]
0	40	75	7.5	4.0	0.037500	0.937500	4.00 ± 0.04
10	40	75	7.5	4.0	0.037500	0.937500	4.00 ± 0.04
100	39.5	75	7.5	3.95	0.037500	0.949367	3.95 ± 0.04
1000	35	75	7.5	3.5	0.037500	1.071429	3.50 ± 0.04
5000	56	75	0.15	0.112	0.000750	0.669643	0.1120 ± 0.0008
10000	30	75	0.15	0.06	0.000750	1.250000	0.0600 ± 0.0008

Table 1: Analog voltage measurement for $E \sim 3.9\,\mathrm{V}$ (R_c – circuit resistance, α – actual needle swing, α_{max} – maximal swing, V_r – range, V – calculated voltage, ΔV – absolute error, δV – relative error)

$R_v[\Omega]$	$\Delta_m V$[V]	$\delta_m V$	c[V]	V_c[V]	$V_c \pm \Delta V$[V]
7500	0	0	0	4	4.00 +- 0.04
7500	-0.005333	-0.001332	0.005333	4.005333	4.01 ± 0.04
7500	-0.052667	-0.013158	0.052667	4.002667	4.01 ± 0.04
7500	-0.466667	-0.117647	0.466667	3.966667	3.97 ± 0.04
150	-3.733333	-0.970874	3.733333	3.845333	3.8453 ± 0.0008
150	-4	-0.985222	4	4.06	4.0600 ± 0.0008

Table 2: Analog voltage measurement for $E \sim 3.9\,\mathrm{V}$ (R_v – internal voltmeter resistance, $\Delta_m V$ – systematic error, $\delta_m V$ – ?, c – correction factor, V_c – ?

Example calculations for $R_c = 100\,\Omega$ are shown in Equations 1, 2, 3, 4, 5, 6, 7, 8.

$$V = \frac{\alpha \cdot V_r}{\alpha_{max}} = \frac{39.5 \cdot 7.5\,\mathrm{V}}{75} = 3.95\,\mathrm{V} \tag{1}$$

$$\Delta V = \frac{V_r \cdot cl}{100\%} = \frac{7.5\,\mathrm{V} \cdot 0.5\%}{100\%} = 0.0375\,\mathrm{V} \tag{2}$$

$$\delta V = \frac{\Delta V}{V} \cdot 100\% = \frac{0.0375}{3.95} \cdot 100\% \approx 0.949367\% \tag{3}$$

$$R_v = V_r \cdot 1\,\frac{\mathrm{k\Omega}}{\mathrm{V}} = 7.5\,\mathrm{V} \cdot 1000\,\frac{\Omega}{\mathrm{V}} = 7500\,\Omega \tag{4}$$

$$\Delta_m V = -V \cdot \frac{R_c}{R_v} = -3.95\,\mathrm{V} \cdot \frac{100\,\Omega}{7500\,\Omega} \approx -0.052\,667\,\mathrm{V} \tag{5}$$

$$\delta_m V = -\frac{R_c}{R_c + R_v} = -\frac{100\,\Omega}{100\,\Omega + 7500\,\Omega} \approx -0.013158 \tag{6}$$

$$c = -\Delta_m V = -(-0.052\,667\,\mathrm{V}) = 0.052\,667\,\mathrm{V} \tag{7}$$

$$V_c = V + c = 3.95\,\mathrm{V} + 0.052\,667\,\mathrm{V} = 4.002\,667\,\mathrm{V} \tag{8}$$

Digital measurement

$R_c[\Omega]$	Accuracy	V_r[V]	V[V]	ΔV[V]	δV[%]	$V \pm \Delta V$[V]
0	0.0035 ± 0.0005	10	3.9996	0.000190	0.004750	3.9996 +- 0.0002
10	0.0035 ± 0.0005	10	3.99953	0.000190	0.004750	3.9995 +- 0.0002
100	0.0035 ± 0.0005	10	3.99964	0.000190	0.004750	3.9996 +- 0.0002
1000	0.0035 ± 0.0005	10	3.99931	0.000190	0.004750	3.9993 +- 0.0002
5000	0.0035 ± 0.0005	10	3.99791	0.000190	0.004752	3.9979 +- 0.0002
10000	0.0035 ± 0.0005	10	3.99593	0.000190	0.004751	3.9959 +- 0.0002

Table 3: Digital voltage measurement for $E \sim 3.9\,\mathrm{V}$ (R_c – circuit resistance, Accuracy: $\pm$ (a% of reading + b% of range), V_r – range, V – measured voltage, ΔV – absolute error, δV – relative error)

R_v[MΩ]	$\Delta_m V$[V]	$\delta_m V$	c[V]	V_c[V]	$V_c \pm \Delta V$[V]
10	0	0	0	3.9996	3.9996 +- 0.0002
10	-0.000003	-0.000001	0.000004	3.999534	3.9995 +- 0.0002
10	-0.000040	-0.000010	0.000040	3.999680	3.9997 +- 0.0002
10	-0.000400	-0.000100	0.000400	3.999710	3.9997 +- 0.0002
10	-0.001999	-0.000500	0.001999	3.999909	3.9999 +- 0.0002
10	-0.003996	-0.000999	0.0039969	3.999926	3.9999 +- 0.0002

Table 4: Digital voltage measurement for $E \sim 3.9\,\mathrm{V}$ (R_v – internal voltmeter resistance, $\Delta_m V$ – systematic error, $\delta_m V$ – ?, c – correction factor, V_c – ?

Example calculations for $R_c = 5000\,\Omega$ are shown in Equations 9, 10, 11, 12, 13, 14.

$$\Delta V = \frac{a}{100\%} \cdot V + \frac{b}{100\%} \cdot V_r = \frac{0.0035\%}{100\%} \cdot 3.997\,91\,\mathrm{V} + \frac{0.0005\%}{100\%} \cdot 10\,\Omega = \\ = 0.000\,14\,\mathrm{V} + 0.000\,05\,\mathrm{V} = 0.000\,19\,\mathrm{V} \tag{9}$$

$$\delta V = \frac{\Delta V}{V} \cdot 100\% = \frac{0.000\,19\,\mathrm{V}}{3.997\,91\,\mathrm{V}} \cdot 100\% = 0.004752\% \tag{10}$$

$$\Delta_m V = -V \cdot \frac{R_c}{R_v} = -3.997\,91\,\mathrm{V} \cdot \frac{5000\,\Omega}{10\,000\,000\,\Omega} \approx -0.001\,999\,\mathrm{V} \tag{11}$$

$$\delta_m V = -\frac{R_c}{R_c + R_v} = -\frac{5000\,\Omega}{5000\,\Omega + 10\,000\,000\,\Omega} \approx -0.000500 \tag{12}$$

$$c = -\Delta_m V = -(-0.001\,999\,\mathrm{V}) = 0.001\,999\,\mathrm{V} \tag{13}$$

$$V_c = V + c = 3.997\,91\,\mathrm{V} + 0.001\,999\,\mathrm{V} = 3.999\,909\,\mathrm{V} \tag{14}$$

2.2 Voltage divider

3 Conclusions

At this laboratory we learned that measuring devices are not ideal and have own resistance which shouldn't come as a surprise and we have to take this fact into account while making measurements.