On non-ideal voltage and current measurement tools

Latipov Vladimir &
& Onishenko Sergiy26.09.2020

Contents

1	1 Abstract 2 Experiments		2	
2			2	
	2.1	Experiment №1: Sequential plugging in	2	
	2.2	Experiment $N_{\underline{0}}2$: Only Voltmeter	3	
	2.3	Experiment №3: Only Ampermeter	4	
3	3 Solving equation system		4	
4	2.3 Experiment №3: Only Ampermeter		7	
5	The	e Answer	7	

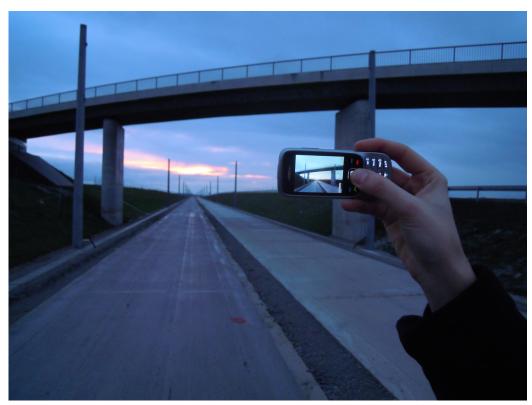
1 Abstract

The contents of this section should be too abstract for me to be able to write it.

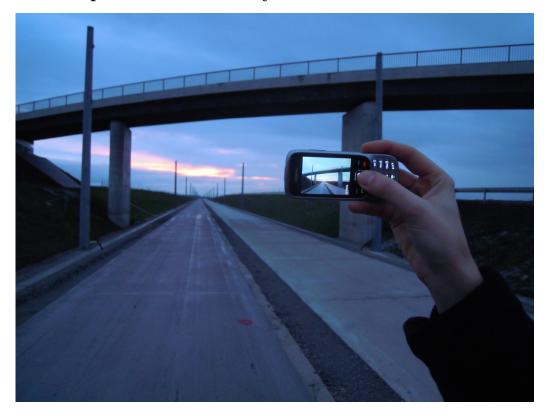
2 Experiments

There were 4 experiments arranged:

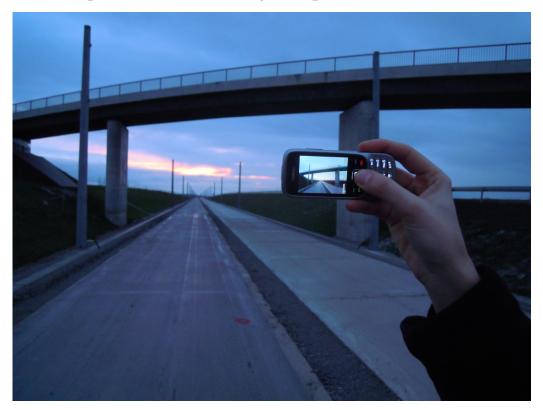
2.1 Experiment №1: Sequential plugging in



2.2 Experiment N_2 : Only Voltmeter



2.3 Experiment №3: Only Ampermeter



3 Solving equation system

Some bold, italic and underlined text here

$$A_1 = \frac{\varepsilon}{R_{all}} \tag{1}$$

$$V_1 = \varepsilon \cdot \frac{R_v}{R_{all}} \tag{2}$$

$$R_v = \frac{V_1}{A_1}$$

$$V_2 = \varepsilon \cdot \frac{R_v}{R_v + R_\varepsilon} \tag{3}$$

$$\varepsilon = V_2 + V_2 \cdot \frac{R_{\varepsilon}}{R_{v}}$$

$$A_3 = \varepsilon \cdot \frac{1}{R_A + R_{\varepsilon}} = \left(V_2 + V_2 \cdot \frac{R_{\varepsilon}}{R_v}\right) \cdot \frac{1}{R_A + R_{\varepsilon}} \tag{4}$$

$$A_3 \cdot R_A + A_3 \cdot R_{\varepsilon} = V_2 + R_{\varepsilon} \cdot \frac{V_2}{R_{v}}$$

$$R_{\varepsilon} \cdot \left(A_3 - \frac{V_2}{R_v} \right) = V_2 + A_3 \cdot R_A$$

$$R_{\varepsilon} = \frac{V_2 + A_3 \cdot R_A}{A_3 - \frac{V_2}{R}}$$

$$(1) \rightarrow A_1 = \frac{\varepsilon}{R_{all}} = \frac{\varepsilon}{R_v + R_A + R_\varepsilon} = \frac{\varepsilon}{R_v + R_A + \frac{V_2 + A_3 \cdot R_A}{A_3 - \frac{V_2}{R_v}}} = \frac{\varepsilon}{R_v + \frac{V_2}{A_3 - \frac{V_2}{R_v}} + R_A \cdot \left(1 + \frac{A_3}{A_3 - \frac{V_2}{R_v}}\right)}$$

$$\varepsilon = V_2 + V_2 \cdot \frac{\frac{V_2 + A_3 \cdot R_A}{A_3 - \frac{V_2}{R_v}}}{R_v} = V_2 + V_2 \cdot \frac{\frac{V_2}{A_3 - \frac{V_2}{R_v}} + \frac{A_3 \cdot R_A}{A_3 - \frac{V_2}{R_v}}}{R_v} = V_2 + \frac{V_2^2}{R_v \cdot A_3 - V_2} + R_A \cdot \frac{A_3 \cdot V_2}{A_3 \cdot R_v - V_2}$$

$$V_2 + \frac{V_2^2}{R_v \cdot A_3 - V_2} + R_A \cdot \frac{A_3 \cdot V_2}{A_3 \cdot R_v - V_2} = A_1 \cdot R_v + \frac{V_2 \cdot A_1}{A_3 - \frac{V_2}{R_v}} + R_A \cdot A_1 \cdot \left(1 + \frac{A_3}{A_3 - \frac{V_2}{R_v}}\right)$$

$$R_A \cdot \frac{A_3 \cdot V_2}{A_3 \cdot R_v - V_2} - R_A \cdot A_1 \cdot \left(1 + \frac{A_3}{A_3 - \frac{V_2}{R_v}}\right) = A_1 \cdot R_v + \frac{V_2 \cdot A_1}{A_3 - \frac{V_2}{R_v}} - V_2 - \frac{V_2^2}{R_v \cdot A_3 - V_2}$$

$$R_A \cdot \left(\frac{A_3 \cdot V_2}{A_3 \cdot R_v - V_2} - A_1 \cdot \left(1 + \frac{A_3}{A_3 - \frac{V_2}{R_v}} \right) \right) = A_1 \cdot R_v + \frac{V_2 \cdot A_1}{A_3 - \frac{V_2}{R_v}} - V_2 - \frac{V_2^2}{R_v \cdot A_3 - V_2}$$

$$R_A = \frac{A_1 \cdot R_v + \frac{V_2 \cdot A_1}{A_3 - \frac{V_2}{R_v}} - V_2 - \frac{V_2^2}{R_v \cdot A_3 - V_2}}{\frac{A_3 \cdot V_2}{A_3 \cdot R_v - V_2} - A_1 \cdot \left(1 + \frac{A_3}{A_3 - \frac{V_2}{R_v}}\right)}$$

$$R_{\varepsilon} = \frac{V_2 + A_3 \cdot R_A}{A_3 - \frac{V_2}{R_{v}}}$$

$$\varepsilon = V_2 + V_2 \cdot \frac{R_{\varepsilon}}{R_v}$$

4 Measurement Results

We're neglecting the inaccuracy of the pre-determined upper device measurement limit which is written on those devices. It's inaccuracy is pretty low!

$$A_{1} = ((0.6 \pm 0.07) \, Ampere) \times \frac{15.8}{2000} = (4.7 \pm 0.6) \, milliAmpere$$

$$V_{1} = ((3.25 \pm 0.1) \, Volt) \times \frac{6.1}{6} = (3.30 \pm 0.1) \, Volt$$

$$V_{2} = ((3.7 \pm 0.1) \, Volt) \times \frac{6.1}{6} = (3.76 \pm 0.1) \, Volt$$

$$A_{3} = ((1.8 \pm 0.07) \, Ampere) \times \frac{15.8}{2000} = (14.22 \pm 0.6) \, milliAmpere$$

5 The Answer

So, the impedance values are the following:

$$R_v=1\ R_e=1\ R_A=1\ \varepsilon=1$$