

MEASURING THE CHARACTERISTICS OF VOLTAGE SOURCE – REMOTE PHYSICAL EXPERIMENT CONTROLLED VIA INTERNET

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Abstract: The article describes the incorporation of pilot experiment of remotely controlled laboratory task into physical education at the Faculty of Materials Science and Technology. It deals with the measurements of the basic characteristics of electrical voltage source. The individual parts of arrangement were realized by the ISES-kit that is capable to command the measuring procedures and to transform the corresponding values via computer. We present an evaluation of the test, completed by students included to the process. It has been realized in the mentioned laboratory experiment by two different methods – via classical measurement and via internet. Relevant results have been evaluated by Kolmogorov’s-Smirnov’s statistical method.

1 Introduction

Remote real laboratory is a modern device of current cognition, representing a new strategy of current e-learning [1]. Therefore, there exists a growing application of it in education, including the teaching process at the universities, too.

Also our department participates in the preparation of remote experiments – in the framework of international cooperation. We have prepared the experiment “Measurements of the Characteristics of DC-Voltage Source”. The complete device had been connected to the internet network so that users can remotely control the experiment. In this article we describe the principle of operation of such device when operating over this way. This task is usually being a part of common education in other technical and natural-science faculties, and at the secondary level, too. It is also contained in the contents of our teaching programme. The article describes a comparison of both methods of measurement – the classical one and through local computer - and the expression of students.

2 Physical Theory and Technical Description of Measurements

The voltage U_s being applied to the external resistor R_z is always less than the electrical voltage on the vacant source of U_0 . If we should use the connection as in Figure 1, the competent relationship between these quantities has the form

$$U_0 = r \cdot I + R_z \cdot I_A = r \cdot I + U_s. \quad (1)$$

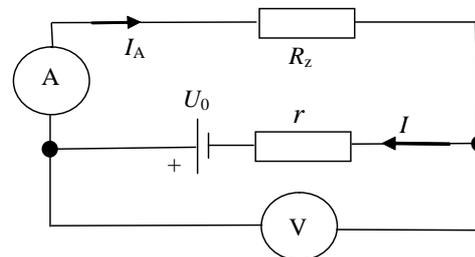


Figure 1 Basic classical connection for measuring of the characteristics of the DC- electrical source

Here $U_s = R_z I_A$ and I_A is the current that runs by resistor R_z . (It is not necessary to take to account the resistances of measuring instruments because of the resistance of ammeter is considered to be equal to zero, and similarly, the resistance of voltmeter is considered to be infinite). On the basis of this relationship, it is possible to measure the internal resistance r of the source.

The measurements of basic characteristics of the voltage source can be done either by using a classical involvement (that is in principle identical with Figure 1), or by the computer-supported experiment, respectively. The corresponding scheme of it in the block representation is depicted below (Figure 2).

It consists of the following parts: DC-voltage source with the internal resistance r , ammeter A, voltmeter V, load resistance R_z , ohmmeter Ω and switching relay. In our experiments they had been realized by modules ISES [2], [3], [4], that are controlled directly by computer

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(Figure 2). The load resistance R_z has been changed in continuous steps by the switching relay.

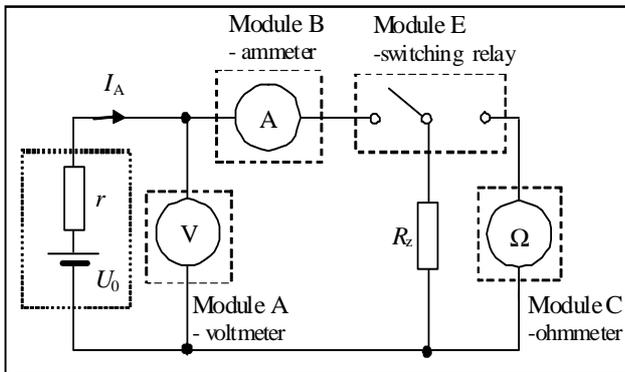


Figure 2 Block scheme of the measuring arrangement, suitable for computer cooperation, realized by ISES-components (indicated by dashes)

The arrangement and integration of individual modules and other components of the experiment, corresponding to this scheme, is presented on photo (Figure 3). We have investigated the characteristics of voltage source LABORATORY POWER SUPPLY, where the set point of 2 V has been fixed (this value is equal to the electromotive voltage).



Figure 3 Look at the layout of the experiment.

The electrical source (gray-coloured box on the left hand) being measured is located between the keyboard and the computer monitor. Motherboard and the retracted ISES modules are on the right side of monitor. Resistance decade with the remote switching resistors is located in the black box on the right side a web camera is imaged by red arrow. White arrow shows the red control light of switching relay. The time traces of voltage, current, load resistance and switching relays are imaged in monitor, simultaneously.

3 Measuring Procedures

The task has been located in the world-wide internet network for six years (2008 – 2014), in present it is allowed in our local school network.

The installation of the compilation language Java is necessary for user for correct compatibility of the computer with experiment (as it is warned in the title-page). Web page is presented in three languages – Slovak, Czech and English. Now we are dealing with English mutation. After clicking on the address, the following sub-page will appear (Figure 4):

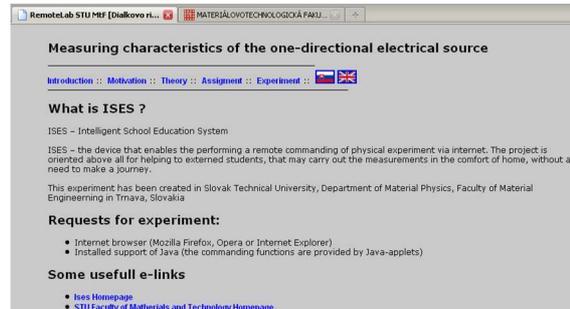


Figure 4 Title page

This window is identical with the sub-page *Introduction*, too. The dealing with the site *Theory* is not necessary, because of it has been described above. The following items *Motivation* and *Assignment* have the forms which are imaged in the next sites (Figure 5, Figure 6).



Figure 5 The page Motivation

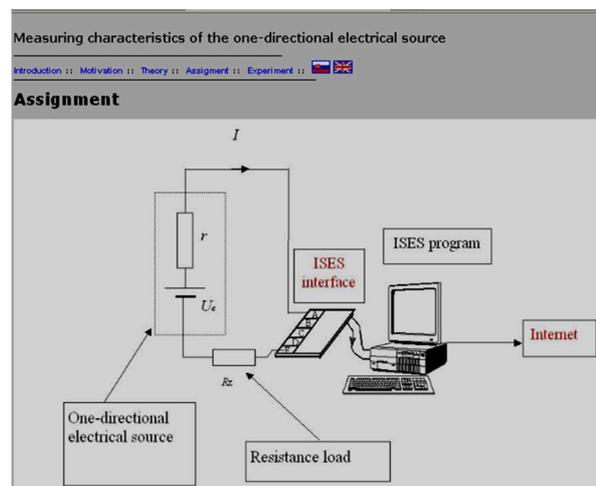


Figure 6 The page Assignment

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The page *Assignment* also offers guidance on the measurement procedure:

1. Learn more about the experiment, aimed at determining the characteristics of DC- electrical source.
2. Perform the measurements of electromotive and terminal voltage of source with various resistive sizes of load resistance R_z .
3. Using the measured values of ε , U_s , R_z and I determine - on the basis of the formula (1) - the value of internal resistance r of the source for each measurement, with following determining of the arithmetic average.
4. Draw the graphical records of terminal voltage and current in the circuit on the load resistance. Identify the approximate value of the internal resistance of the source from the current dependence.
5. Discuss the size of power and efficiency of the source on the size of a resistive load.
6. Draw up a paper with the following points:
 - a. Physical introduction
 - b. Description of the experiment and layout
 - c. Measurement procedure
 - d. Table of measured values of ε , U_s , I and R_z with the relevant calculation of the resistance r , including the arithmetic average
 - e. Graphical dependences:
 - terminal voltage U_s as a function of load resistance R_z ,
 - current in the circuit I as a function of load resistance R_z , with the extrapolation of estimate r
 - power P_e as a function of load resistance R_z
 - efficiency η as a function of load resistance R_z .

The actual process of measurement can be made through site *Experiment*. When you click on it, the next sub-page will appear (Figure 7):

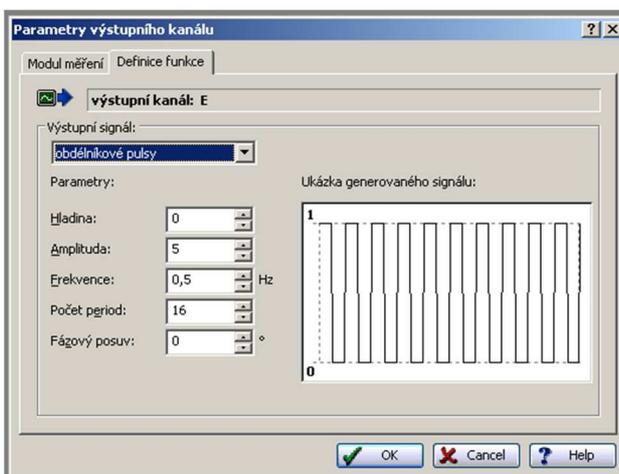


Figure 7 A dialogue window after the activation of relay; the rectangle pulses being commanding the experiment are imaged in right white window (the description in the picture is made in Czech language, given by producer of an ISES-kit)

We had chosen the following parameters:

Rectangular pulses in the role of commanding signal (appointed by relay). The total measurement time could be in interval of 32 sec. It is appropriate value because of the fact, that there are the kit of 16 resistors (totally), included in measurement and a duration of each simple pulse is 2 sec. (it represents the opposite value of frequency). In the same time period, the rolling of relay happens, too.

The automatic measuring procedure is activated by the clicking on the item *Start* and it is directed by switching of the relay. The time operation of the circuit can be presented as a set of four courses - voltage, current, resistance load and switching pulses. Their shapes are – in case that all the four modules are activated simultaneously - illustrated in Figure 8 (they are identical with the pictures on the monitor in the background in Figure 3).

The first graph represents the electromotive voltage (in the 1st, 3rd, 5th...etc, i.e. the odd intervals, when the load resistance has been disconnected from the source by means of relay), and the applied voltage (in the 2nd, 4th, 6th...etc, i.e. in the even intervals, when the load has been connected to the source).



Figure 8 The time courses for the quantities being measured, as they were recorded and imaged in the screen of local computer (it is visible on the background in Figure 3, too).

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In the second graph we can see the change of current passing through the resistance load; the single steps are synchronized with the previous case.

The third graph reflects the size of load resistance being used (the corresponding values are laying in the bottoms of rectangular pulses in each odd interval, when the load has been disconnected from the source; it is true a small value, but by means of enlargement of graph it is possible the corresponding determination to make easy).

The fourth graph shows the switching of relay. The odd and the even steps have the same sense as in the cases mentioned above.

The results having obtained have confirmed the known fact that the current is declining with increasing load resistance, while the accompanied applied voltage is growing. The time courses also show the expected result, that the applied voltage increases with increasing size of the load resistance, and that the current, in turn, decreases. As we found from the measured values, the size of the internal resistance is equal to 10Ω . It is possible to calculate an internal resistance of source, and to plot the dependences of the performance of consumer and the efficiency of source to the size of the load resistor - from relevant numerical results. It would be a task for students to conclude experimental procedure.

4 Pedagogical View

The pilot implementation into education at technical university has been realized in Faculty of Materials Science and Technology of Slovak University of Technology in Trnava, Slovakia. Fifty students were measuring the internal resistance of the source in the framework of laboratory exercises. Students were able to measure the physical quantity by both of methods, by classical way (using their own connection and hand controls) and also by mentioned manner with using a computer. Students have expressed their opinions considering these methods in a questionnaire after absolving the measurements. Related answers were processed and evaluated statistically using the Kolmogorov's-Smirnov's correlation test [5].

Students were asked by following question:

“Does the remote-controlled method present a better possibility for understanding of the theory like classical method?”

The percentage distribution of responses to this question is depicted on the pie chart (Figure 9).

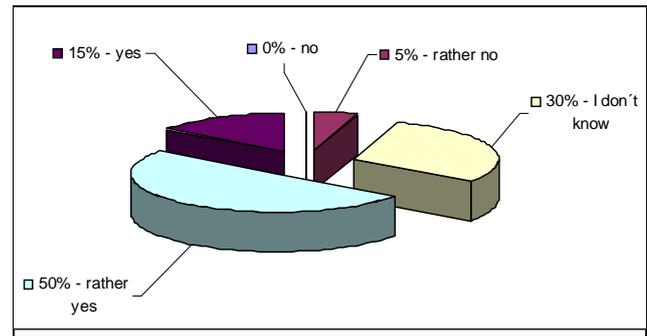


Figure 9 Graphical illustration of responses distribution corresponding to the question

As we can see, the most numerous part of students would prefer to measure the internal resistance of resource by means of computer. As it results from these examinations, the value of the test criterion $D_1=0,35$ and critical value of $D_{1;0,05}= 0,294$. Because of $D_1 \geq D_{1;0,05}$, we reject the null hypothesis (it supposed that the amount of students preferring some of both methods will be divided equally on all five possible responses) at the significance level of 0,05.

Conclusions

The experiment being presented above belongs to the file of Czech and Slovak physics tasks, controlled via internet, which set is constantly replenished. The filling of this task can be applied in teaching on physics lectures concerned with the topics on power supplies, as so as in the labs. The pilot implementation into the education, that has been realized in our faculty and it is described here, confirms the fact that this form of practical exercises is attractive and suitable for students. It can be applied as a filling work for student groups being interested in physics in secondary schools, too.

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