PHYSICAL CONTROL OF EXPERIMENT BY USING THE INTERNET SCHOOL EXPERIMENTAL SYSTEM - ISES

Karol KVETAN, Robert RIEDLMAJER, Marek MIZERA

Authors: **Karol Kvetan, PhD.,** * **Robert Riedlmajer, Assoc. Prof. PhD.,** *
**Marek Mizera, Bc. ** *

Workplace: * **Institute of Materials, Faculty of Materials Science and Technology, Slovak University of Technology, Trnava**

** ** **Division of Communication and Information Systems, Faculty of Materials Science and Technology, Slovak University of Technology, Trnava**

Address: * **J. Bottu 25, 917 24 Trnava, Slovak republic**

** ** **Paulínska 16, 917 24 Trnava, Slovak republic**

Tel.: **+421 33 5521007**

E-mail.: *karol.kvetan@stuba.sk*, *robert.riedlmajer@stuba.sk*, *mmizera@stuba.sk*

Abstract

The paper presents the first step to the building of a distant experiment, in the framework of remove physical laboratory directed via internet. 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 able to command the measuring procedures and to transform the corresponding values via computer.

Key words

physical experiment, electrical source, electromotive force, applied voltage, internal resistance, ISES kit

Introduction

We give here the examination of the perspective remote laboratory system (ISES), that has been developed and fabricated in Czech republic for the purposes of the integrated e-learning. This device enables to introduce the new strategy in teaching processes in all forms and all levels of education.

This system represents a complex tool for real time and remote data acquisition, data processing and control of experiments. It is an open system consisting of a basic ISES hardware and the controlling ISESWIN software [1].

Many real e-laboratories with remote experiments across the Internet had been published, based on a server-client approach [2],[3],[4]. Our exercise belongs to the works being under preparation for the network of remote-laboratory exercises, in the framework of Czech and Slovak cooperation; they will be a part of their contribution to the building of measurements controlled through the internet.

The name of our exercise is "Measurements of the Characteristics of One-Direction Voltage Source". This task deals with such terms as *electromotive* and *applied voltage, internal resistance, full power, efficiency of the source* etc.

Characteristics of one-direction voltage source

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_o. If we connect a voltmeter with large internal resistance R_v to the terminals of the source, its resistance is currently bigger than a source internal resistance r. In such case – due to the 2nd Kirchhoff´s law for closed circuit – we shall have

$$U_o = (R_v + r) \cdot I_v = R_v \cdot I_v = U_v \,, \tag{1}$$

where I_v is current passing voltmeter and U_v is the voltage on the voltmeter.

If we connect the external resistance R_z to the terminals of source (Fig. 1), the voltage at the terminals falls into the value of

$$U_s = R_z \cdot I_A \,, \tag{2}$$

where I_A is the current running resistor R_z. According to the 2nd Kirchhoff´s law, however

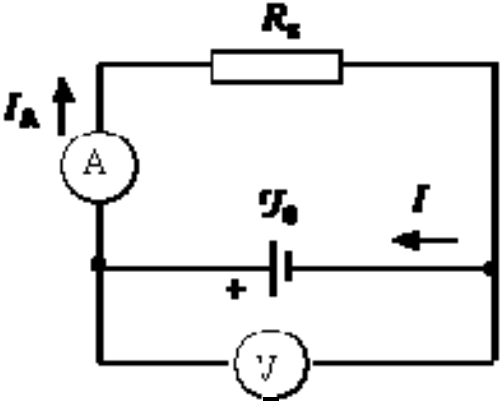$$U_o = r \cdot I + R_z \cdot I_A = r \cdot i + U_s \,. \tag{3}$$

Fig. 1. *The basic classical connection for measuring the characteristics of an one-direction electrical source*

An electrical voltage on the vacant source of U_o (when $I = 0$) can be considered as internal (electromotive) voltage (or electromotive force) of source, being indicated as ε.

The current, runing a source of internal resistance r, is roughly equal to the current I_A, because of the part of the current I_v, passing voltmeter, is negligibly small; the resistance of ammeter is negligible, too. After the adjustment (3) we can write:

$$r = \frac{U_0 - U_{\mathrm{z}}}{I} \quad , \text{ or} \quad r = \frac{\varepsilon - U_{\mathrm{z}}}{I} \quad . \tag{4}$$

On the basis of the relationship (4) it is possible to measure the internal resistance r of the source.

Realization of experiment

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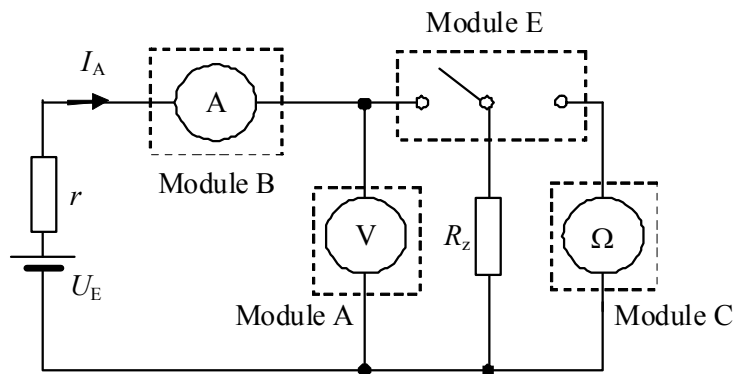

Fig. 2. *Block scheme of the measuring arrangement, suitable for computer cooperation*

It consist of the following parts: one-direction 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 (they are indicated by dashes in scheme), that are controlled directly by computer. The arrangement and integration of individual modules and other components of the experiment, corresponding to this scheme, is presented on photo in Fig. 3.

The total energy supplied by the source per unit of time (full power P) can be expressed as:

$$P = I^2 \cdot R_{\mathrm{z}} + I^2 \cdot r = P_{\mathrm{e}} + P_{\mathrm{i}} \quad . \tag{5}$$

The first member P_{e} reflects the performance released in the outer circumference (neglecting the resistance of wires): it is released on the load resistor R_{z} as a useful part, and the second member reflects the performance of P_{i} consumed in the own source. The usefulness of consumption of energy source is characterized by the efficiency η of the source, where

$$\eta = \frac{P_{\mathrm{e}}}{P} = \frac{U_{\mathrm{z}} \cdot I}{U_0 \cdot I} = \frac{U_{\mathrm{z}}}{U_0} = \frac{U_0 - r \cdot I}{U_0} = 1 - \frac{r \cdot I}{U_0} = 1 - \frac{r \cdot I}{\varepsilon} \quad ,$$

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or

$$\eta = \frac{P_z}{P} = \frac{I_A^2 \cdot R_z}{I^2 \cdot R_z + I^2 \cdot r} = \frac{R_z}{R_z + r} = \frac{1}{1 + \frac{r}{R_z}}$$.
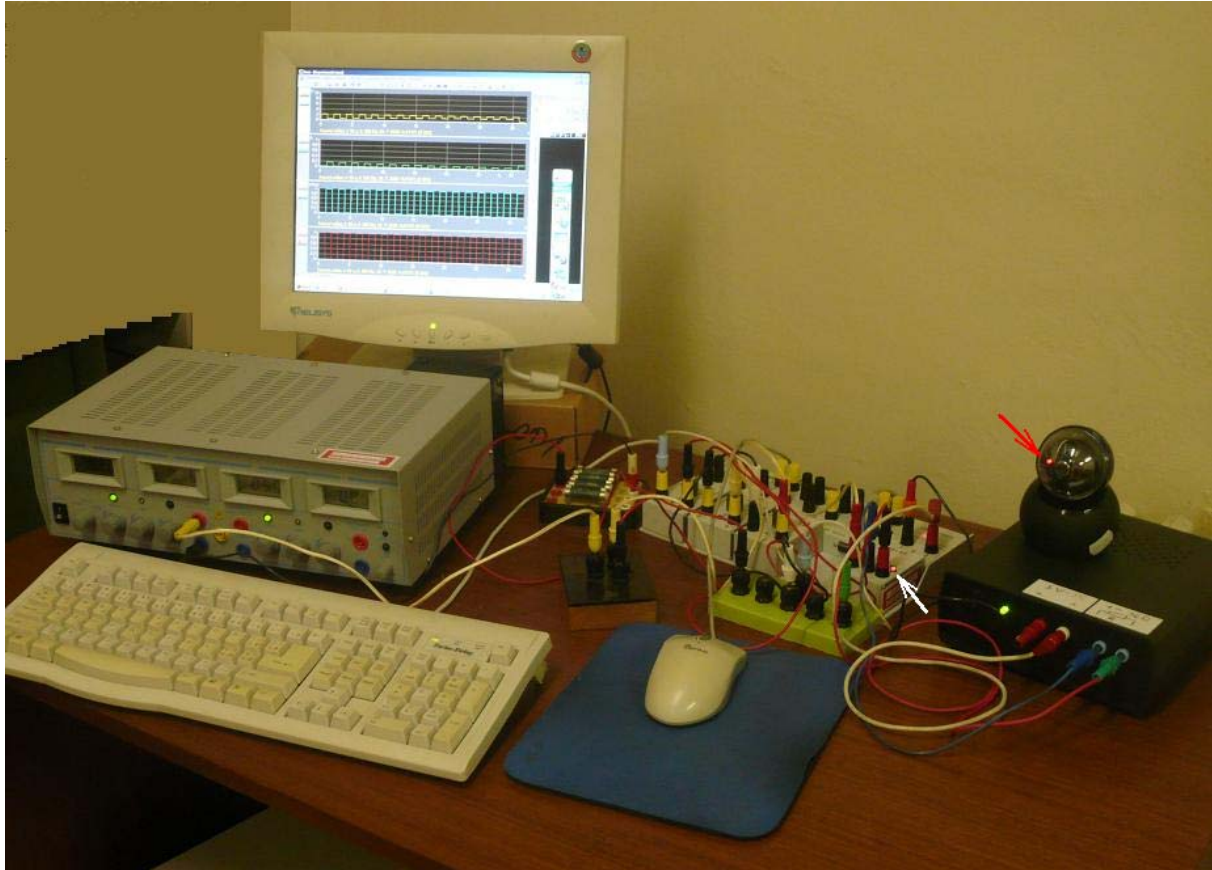
(6)

Fig. 3 *A look at the layout of the experiment. Measured electrical source of the gray colour is located between the keyboard and the computer monitor, motherboard and the retracted ISES modules are on the right hand of monitor. Resistance decade with the remote switching resistors is located in the black box on the right side, a web camera is a next two-balls black body with red control light marked with a red arrow. White arrow shows the red light relay control switching. The time traces of voltage, current, load resistance and switching relays are imaged in monitor, simultaneously*

By means of calculations or by experimental way, respective, we can find that the maximum power is handed over to the load when the size of the load resistance is equal to the internal resistance of the source, i.e when $R_z = r$. Then $U_s = \varepsilon / 2$, that is the terminal voltage at the load is equal to a half of electromotive voltage, the other half is exploiting by internal resistance of the source.

The efficiency of the transition of energy from a source within the appliance is also a function of the size of the external resistance R_z. The relationship (6) shows that an efficiency is equal to 0.5 at the size of this resistance $R_z = r$; maximum (100%) can be achieved with the infinitely large R_z.

Control of experiment by using the ISES-KIT

The advance of measuring procedure using the system ISES is as follow:
As the first, we define the participation of working modules and their parameters in the dialogue window (Fig. 4).
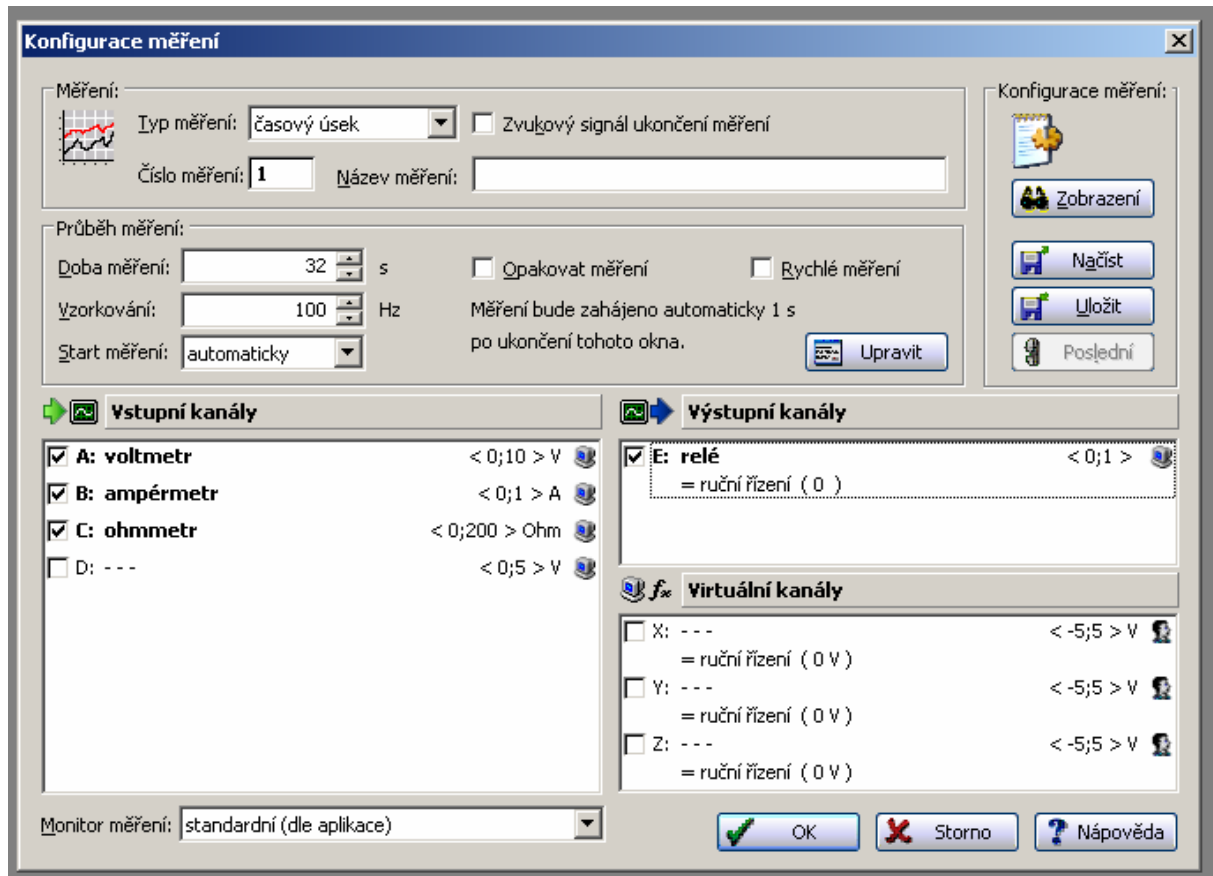

Fig. 4. *A dialogue window at the starting of measuring procedure*

The activated modules are indicated by a wedge mark in little squares.

In the role of commanding signal (appointed by relay) it will be acting the rectangular course (Fig.5). 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. In the same time period, the rolling of relay happens, too.
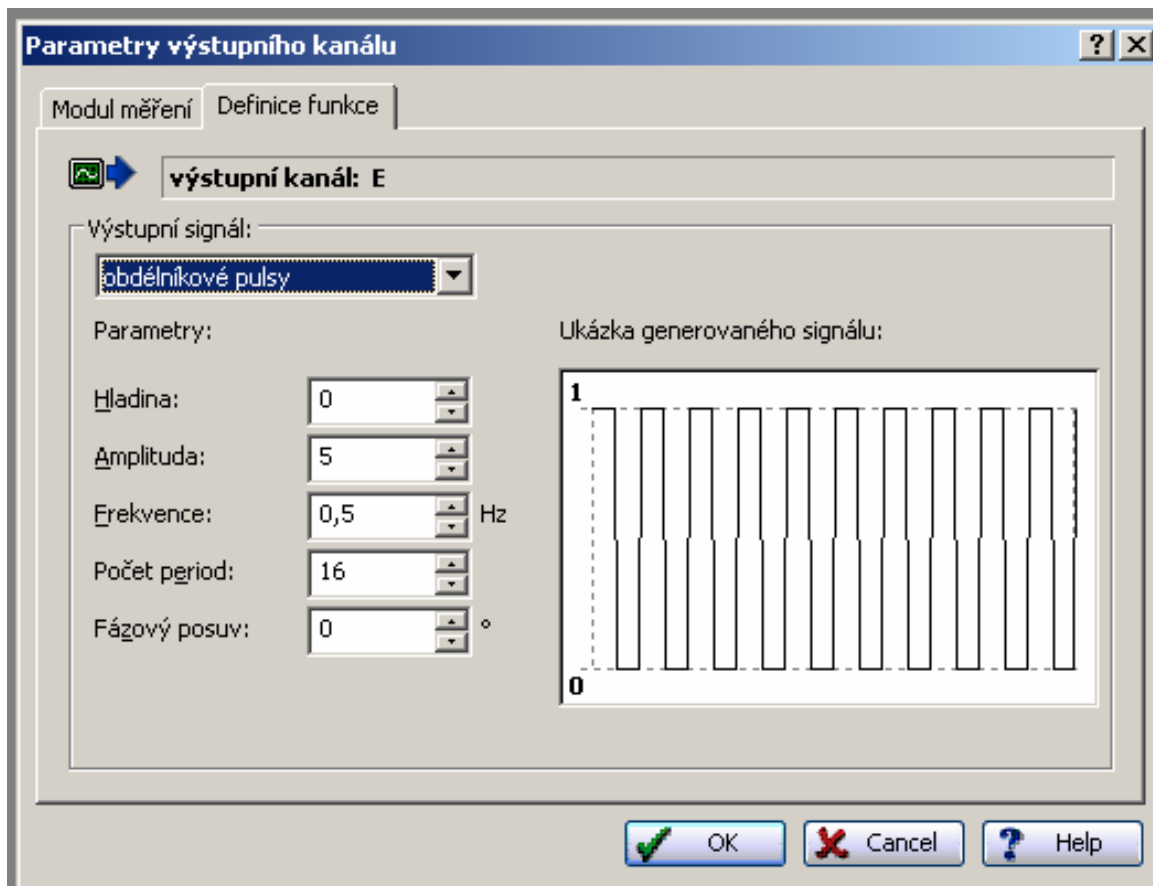
Fig. 5. *A dialogue window after the activation of relay; the rectangle pulses being commanding the experiment are imaged in right white window*

Time alone can pursue a set of four courses - voltage, current, resistance load and switching relay. They are - in case that all the four modules are activated simultaneously - illustrated in Fig . 6.

We can activate the single courses, too, owing to a better determination of the corresponding values. This is possible in connection with the relay modulus only. One of these graphs – a voltage course – is illustrated in Fig. 7. Here we can see the digital values, too, as determined by the position of cursor and as imaged in the right upper corner.
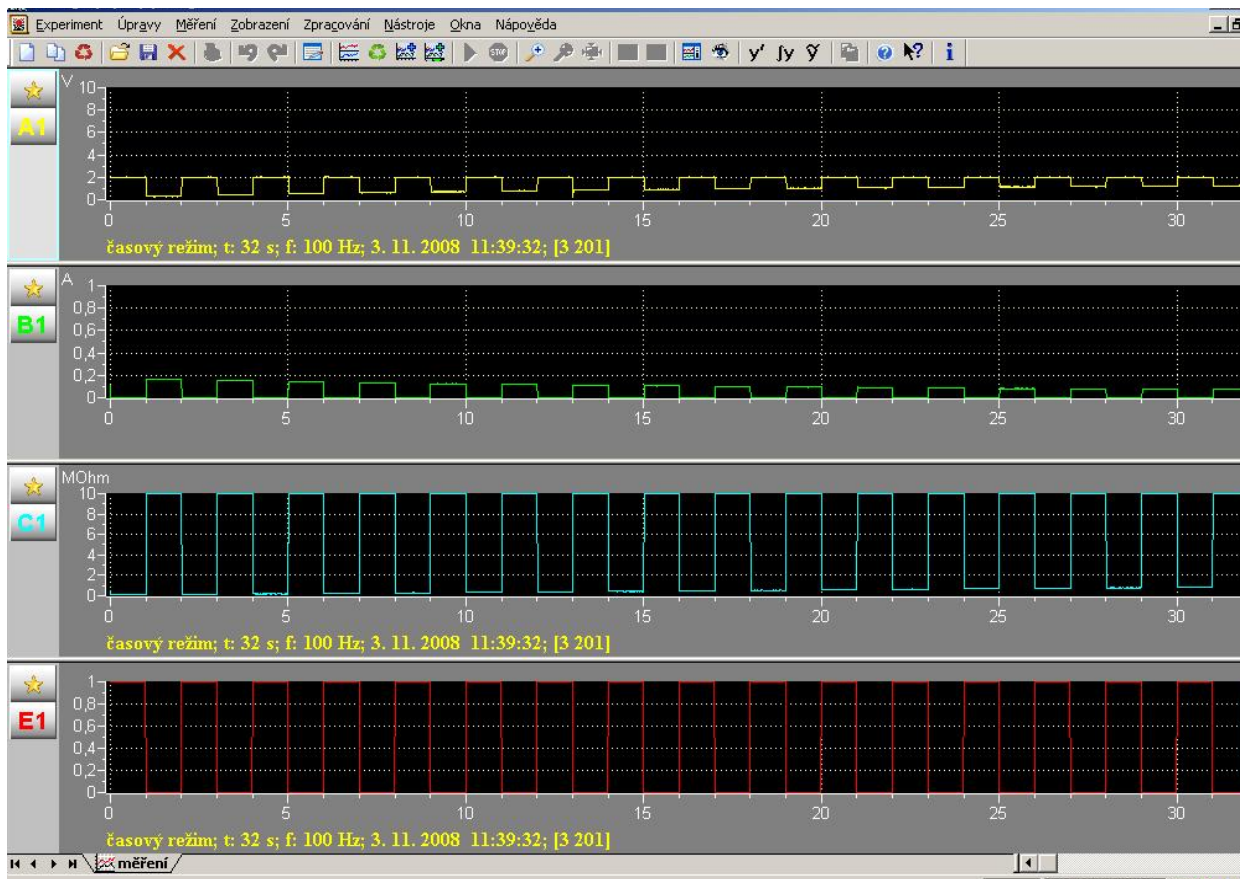
Fig. 6. *The time courses for the quantities being measured*
 1st graph: It represents the electromotive force (in the 1st, 3rd, 5th....etc, i.e. the odd
     intervals,when the load resistance has been disconnected from the source
     by means of relay), and the applied voltage (in the 2nd, 4th, 6th...etc, i.e. in
     the even intervals, when the load has been connected to the source)
 2nd graph: The current passing through the resistance load; the single steps are
     synchronized with the previous case
 3rd graph: The size of load being used (the corresponding values are laying in the
     lower part in each odd interval, when the load has been disconnected from
     a source; it is true a small value, but by means of enlargement of graph it
     is possible to make easy the corresponding determination)
 4th graph: The switching of relay. The odd and the even steps have sme 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, while the accompanied applied woltage is growing.
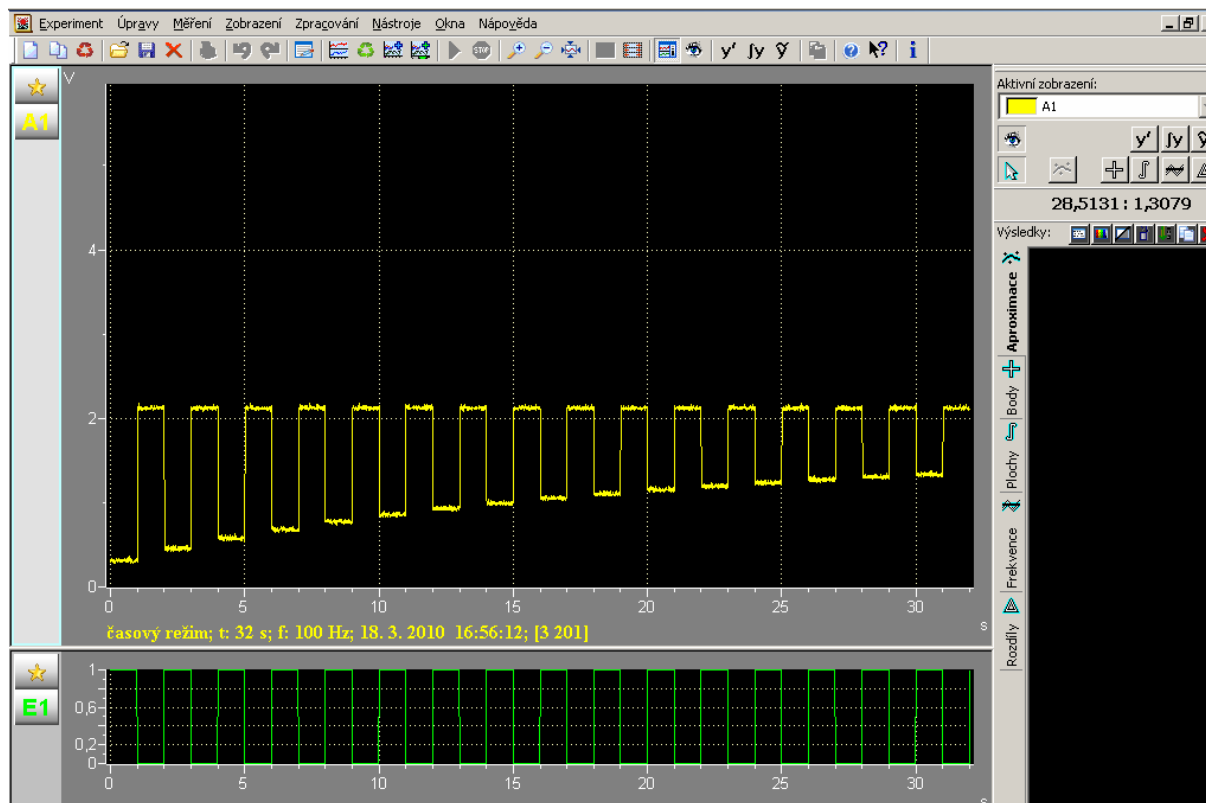
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Fig. 7. *The time course for voltage. The higher level corresponds to an electromotive force (in our measurements ε = 2.1 V = const.), the lower one to an applied voltage*

The measurements were taken with assistance of different values of resistant load – in the range of 1 – 16 Ω; they have been changing automatically, or in the regime of independent steps, respectively. We had calculated the value of internal resistance r of source from each measurement separately – according to the relation (4). The corresponding average value has been nominated to be equal 10 Ω, approximately (for example, for the values of $R_z = 15$ Ω and $ε = 2{,}1$ V we had determined $U_s = 1{,}3$ V and $I = 0{,}079$ A; it gives the result $r = 10{,}1$ Ω).

Conclusions

The procedures described above represent the preparatory phase to a realization of measurement directed via internet. It is possible to say that these "testing experiments" have been useful, the characteristics being measured have shown the assumed time courses and values. In present, the activities connected with the approach to the internet are carried out; the authors are preparing the presentations of them in future.

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