DISTANCE LEARNING WITH LabVIEW

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Abstract:
This article presents a set of the remotely controlled real and simulated physics experiments accessible via the Internet. There are presented three types of the remote access to the real or simulated physics experiments installed at Faculty of Physics of the Warsaw University of Technology. Described experiments have been elaborated by using LabVIEW graphical programming. With its Remote Panel the LabVIEW applications can be turned into a remote laboratory. Users can open a link with their web browser to a remote application, to control it using the Remote Panel, observe how an experiment runs and collect experimental data. This kind of experiments can be useful for distance learning using the Internet.

Keywords: distance learning; remote laboratory; Socrates; Comenius 2.1; VccSSe; LabVIEW;

1. Introduction

As a rule, universities have well-organized classic student laboratories but, for instance, secondary level schools are usually devoid of real experimental equipments and pupils learn selected subjects mainly from books only. However, some experiments are also not available in student labs because of some reasons, for instance, because the instruments are expensive, or the maintenance of them can be difficult. On the other hand, in the same time similar experimental equipment is used in university research labs, and could support teaching, but generally, research laboratories are not prepared to didactic needs. Building the remote laboratories available via Internet can solve the listed above problems. There are several types of remote laboratories accessed via Internet, which could be used for distance learning. For example:

- remote laboratory with access to real student laboratory existed in selected university;
- remote laboratory with access to real research laboratory;
- remote laboratory equipped with simulated experiments, which model real experiments.

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Common characteristic of the listed above remote laboratories is that they base on the set of the real computer controlled experiments or simulated experiments, which can be accessed and controlled externally through some communication medium, for example, through the Internet.

2. Remote nuclear physics laboratory

The Nuclear Physics Laboratory (NPL - see also Fig. 2 in the article *LabVIEW in Education*) is a part of the Central Physics Laboratory at the Faculty of Physics at the Warsaw University of Technology. Laboratory exercises are an essential part of the education experience in the nuclear physics. They not only demonstrate nuclear physics ideas and concepts, but also bring the course theory alive so students can observe how nuclear particles affect real-world measurements.

The NPL is very well equipped with instruments to perform basic nuclear physics experiments. All experiments are computer controlled. As a rule, nuclear physics experiments need very expensive equipment and qualified maintenance. On the other hand some high level schools, colleges, and secondary level schools are completely devoid of such experimental set-ups. This is a reason why the NIP was turned into commonly accessible laboratory.
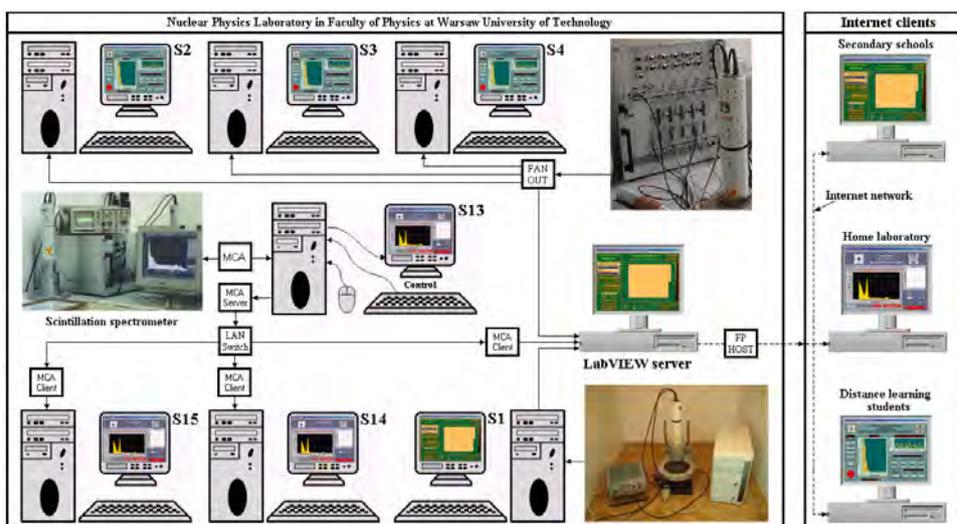

Fig. 1 *Nuclear Physics Laboratory with extended access, via the Internet, for remote users.*

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Real nuclear physics experiments on the Internet. The Nuclear Physics Laboratory offers remote users three nuclear physics experiments reflecting, on the elementary level, all the characteristic features of the nuclear radiation.

In the experiment devoted gamma rays energy determining the standard spectra of ^{137}Cs and ^{60}Co are recorded first, and then used to calibrate scintillation spectrometer. For this purpose the total gamma absorption peaks, observed in the standard source spectra, are used. The spectrometer calibration curve is then used to determine the energy of "unknown" radiation source (^{22}Na) and identify it. All measurements are performed with the virtual spectra analyser (VSA). It is used for spectra recording, spectrometer calibrating, and finally preparation identifying.

In the experiment used for the examining of the attenuation of gamma radiation, when it passes through the solid matter, the virtual intensity analyser (VIA) allows user to verify the gamma absorption law and determine absorption coefficients for lead, cooper and aluminium.
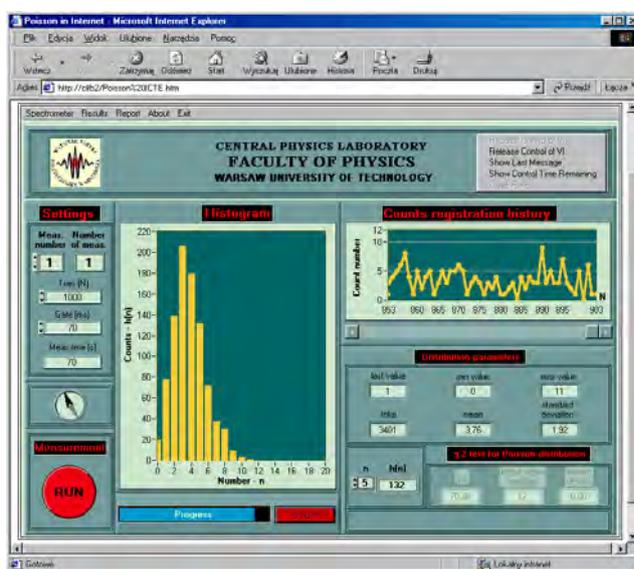

Fig. 2 *The remote panel of the statistics distribution analyser opened with Web browser and used to perform measurements.*

Figure 2 shows the remote panel of the Poisson's distribution experiment, published on the Internet, which allows users to compare the experimental distributions of radioactive decay with the theoretical distribution for small number of events. For each individual particle in the radioactive source, it is a matter of coincidence whether it will decay over a

given time interval Δt. The probability that any particular particle will decay in the time interval Δt is extremely low. The aim of this experiment is to show that the number of output pulses from the radiation detector during identical time interval Δt corresponds to Poisson's distribution. An important feature of the Poisson's distribution is that it depends on only the mean value μ, and the variance $P(n)$ is equal to μ, so that the standard deviation is $\sigma = sqrt (\mu)$. A special characteristic of the Poisson's distribution is its unsymmetrical shape. It can be observed in the case of a small number of events, $n < 20$.

3. Experiment accessible remotely from the research laboratory

The gamma spectroscopy experiments based on the Mössbauer effect are in practice not available in student labs because of some reasons: Mössbauer spectrometers are very expensive and their maintenance can be difficult, sources used in experiments are high intensity sources, and therefore can be dangerous for experimenters (students and lecturers). Also the reasonable data acquiring needs to run experiment during several hours or even several days. Building multi-user virtual instrumentation system, which allows remote access from student lab via the LAN to the research lab with installed Mössbauer spectrometer, can solve the listed problems. This system allows also remote users access to the Mössbauer experiment by Internet.

The virtual measurement systems based on the LabVIEW allow establishing easy communication between computers using the *Transmission Control Protocol* (TCP) or by publishing the front panel of a LabVIEW application for use in a standard Web browser.

The first method is used for communication between the research and student labs using the LAN (Fig. 3). In establishing TCP connection it is needed to specify both the Internet address and a port at that address. The address identifies a computer on the network. The port is an additional number that identifies a communication channel on the computer that the server program uses to listen for communication requests. When a connection is established one can read and write data to the remote application. In presented application there are used two ports, the *Command Port* for command sending and the *Data Port* for data transferring. The type of the command depends on the type of data to be transferred. The data can be the currently measured data or can be the data collected earlier and stored on the disk of the server computer. The last possibility is important and should be taken into account because the reasonable data acquiring in the Mössbauer experiment needs to run it during several hours or even several days. So the spectra collected earlier (before student work in the lab) in determined time intervals can be available for students after entering the lab for analyzing how the shape of the recorded spectra depends statistics (data time acquiring). The student computers equipped with the *Virtual Mössbauer Recorder* (VMR) allows spectra recording, then analyzing them with the *Virtual Mössbauer Analyzer* (VMA) – the LabVIEW application developed for the spectra folding and the spectrometer calibrating. The Mössbauer spectrometer can be remotely controlled exclusively from the operator or lecturer computer.
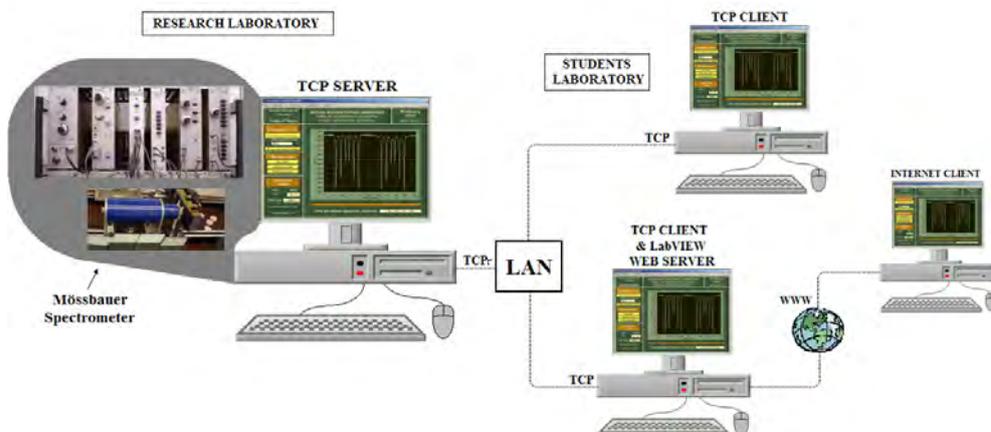
Fig. 3 *The remote access via the LAN and Internet to the Mössbauer spectrometer installed in the research lab.*

For publishing the front panel of the VMR on the Internet, one of the computers installed in the student lab is simultaneously the TCP Client and the LabVIEW Web server. Before transforming the VMR into the remote VMR, available with the Web browser, some operations have to be performed for creation and publishing the application. There are the following operations: at first in the selected window (opened using the LabVIEW *Web Publishing Tool*) the operator has to activate the LabVIEW Web server, then create and save the HTML document with the VMR front panel, and finally create the URL address of the enabled application.

To operate an application by means of remote panel, it is necessary to install on the client computer the LabVIEW *Run-Time Engine*. When a remote user logs onto the Mössbauer experiment with the appropriate URL address, the VMR panel appears in the browser and automatically is in a monitor state. A remote user can request control of the program.

After data acquiring, the Mössbauer spectrum recorded with the VMR can be written to an output file, and then used for spectrometer calibrating with the VMA installed on the remote computers.
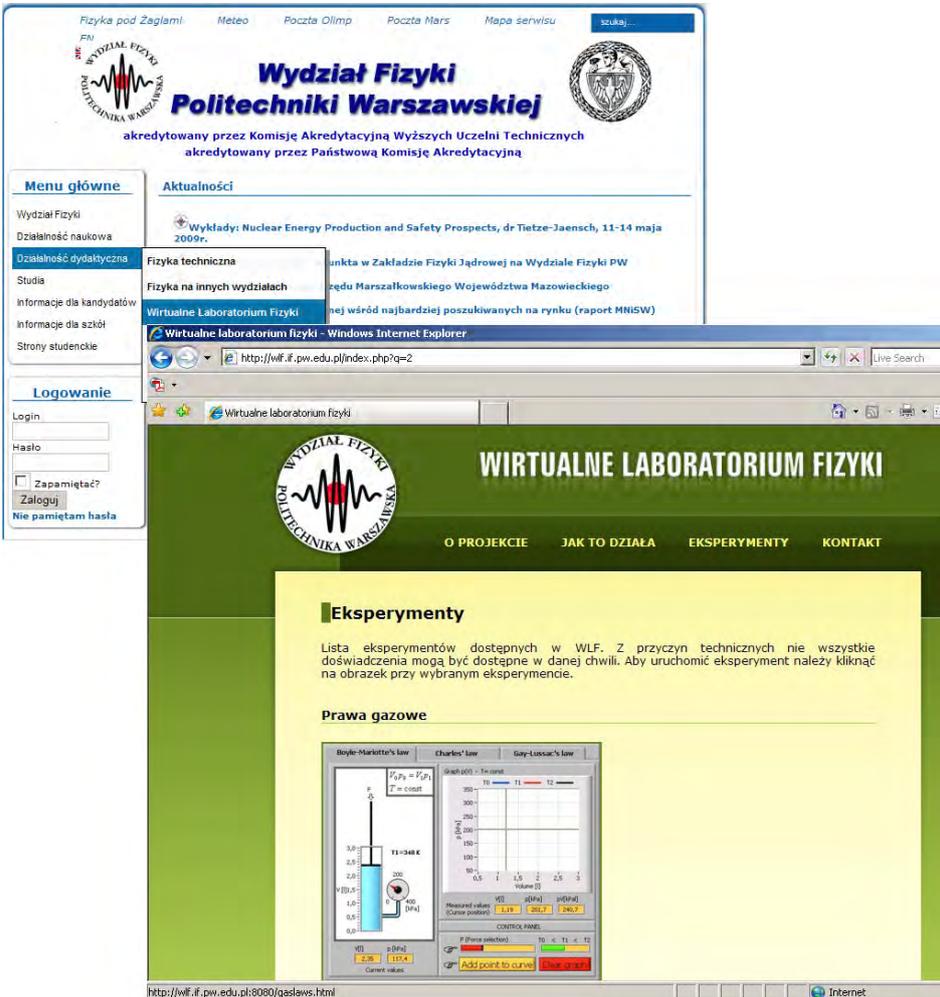
4. Remote physics laboratory with simulated experiments

For remote users, who want to perform measurements in different but convenient for them time, there are developed virtual experiments, which are equivalents of the real experiments. Such experiments can be available 24 hours a day on the Internet, without any

technical support, by connecting the remote PC to the LabVIEW server equipped with simulated experiments.

Fig. 4 *Web site of the WUT Faculty of Physics with opened Virtual physics laboratory page.*

The main purpose of the simulated experiments is to familiarize pupils with physical phenomena without using any special equipment. Due to simulated experiments they can work even at home at their own speed, repeating the experiment as many times as they

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need. Such solutions are also highly appreciated by secondary school teachers, who can introduce to their pupils more sophisticated experiments without having access to a real laboratory. In this chapter there are described five simulated experiments: three devoted to gases laws, one to the heat transportation and the last one to the electrical resonance, accessible from the home site of the Faculty of Physics of the WUT (Fig. 4).

The only thing, which is required to perform a simulated experiment, is a popular personal computer with the MS Windows and the *LabVIEW Run-Time Engine.* After opening virtual laboratory using web browser, and following enclosed instruction, one can download the RTE 8.6, from National Instruments web site, needed to run experiments, and than perform them independently.

4.1 Ideal gases laws

Figure 5 shows front panels of the set of three simulated experiments devoted to ideal gases laws:

- pressure (p) dependency of the volume (V) of a gas at constant temperature (T) – *Boyle-Mariotte's law*
- temperature (T) dependency of the volume (V) of a gas at constant pressure (p) – *Gay-Lussac's law*
- temperature (T) dependency of the pressure (p) of a gas at constant volume (V) – *Charles's law*
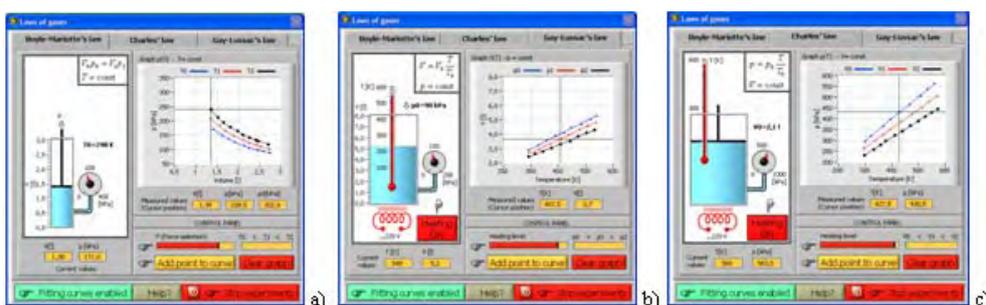

Fig. 5 *Front panels of the simulated experiments devoted to ideal gases laws: Boyle-Mariotte's law a), Charles's law b), and c), accessible via Internet.*

Performing experiments a user can set as constant one of three parameters: the pressure (p), volume (V) and temperature (T) and check relationships between two others depending on selected experiment. During virtual measurements a user can collect data, place them on the graphs, and fit curves to points placed on the graphs.

In the first experiment (Fig. 5a) the air column is maintained at constant room temperature T. At an external pressure p_0, it has a volume V_0. During experiment

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performing, the pressure p in the air column is reduced, and the increased volume V of the air column is determined for different pressure values. The experiment confirms the *Boyle-Mariotte's law*.

In the second experiment (Fig. 5b), the thermometer measures the specific temperature of the air in the column, in which the pressure is constant. This experiment measures the volume V of the air column as a function of the temperature T. The experiment confirms the relationship *Charles's law*.

In the third experiment (Fig. 5c), the pressure p in the air column is reduced in the way, which allows keep the volume V constant as the temperature drops. This experiment measures the pressure p of the air column as a function of the temperature T. The experiment confirms the relationship *Gay-Lussac's law*.

4.2 Heat transportation

In the *Heat transportation* experiment (Fig. 6) one measures the thermal conductivity coefficient λ for a metallic rod. It has the meaning of the quantity of heat ΔQ transferred through the material in unit time Δt, with the cross-section S, and unit gradient of the temperature grad T.

Main goals of this experiment performing are:
- become familiar with thermodynamics experiment;
- study mechanism of heat conduction in solids;
- understand the temperature gradient idea;
- become familiar with temperature measurements performed with RTDs sensors;
- become familiar with measurements, devoted to determination of the thermal conductivity coefficient λ, based on the Ängstrom method.

The value of the thermal conductivity coefficient is different for different materials and characterizes, for instance, the isolation characteristics of materials. For iron $\lambda = 79$ [SI units], for water $\lambda = 0,6$ etc.

Presented here experiment is based on the Ángström method and demonstrates the damping of temperature values in a rod. The temperature changes are generated by repeatedly switching on/off the heating system installed on the one end of the rod. This process produces a temperature "wave", which penetrates the rod. These changes propagate through the whole sample, but with the amplitude decreasing (exponentially) with increasing distance x from the source of heat. The temperature T is then described by a function typical for all damped waves.

4.3 Electrical resonance

The current and voltage as a function of the frequency can be observed in the series and parallel tuned *RLC* circuits.
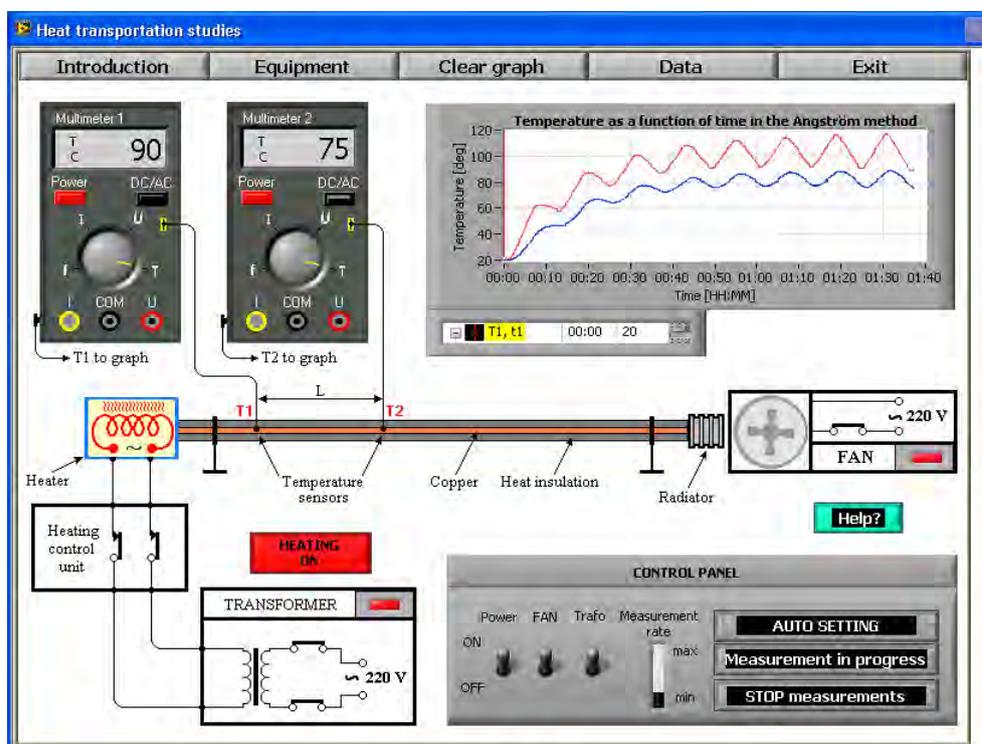
Fig. 6 *Front panel of the Heat transportation simulated experiment accessible via Internet.*

The virtual experimental set-up (Fig. 7) for resonance phenomena studies simulates the real one, which consists of the function generator, the digital oscilloscope, two digital multimeters (DMM), and RLC circuit.

Main goals of the experiment are as following:
- become familiar with RLC circuits;
- understand the operation of the series-tuned circuit;
- understand the operation of the parallel - tuned circuit;
- study voltage resonance observed in a series - tuned circuit;
- study current resonance observed in parallel -tuned circuit;
- study properties of RLC circuits; resonance frequency – f_r, phase displacement – φ, Q-factor, bandwidth, loss resistance, and damping.

The software used in described simulated experiments was prepared in a user-friendly way. Due to the on-line help reference, that covers the introduction to the physical theory

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and the usage of software as well, there is no need to have any additional experience to run and perform the selected experiment.
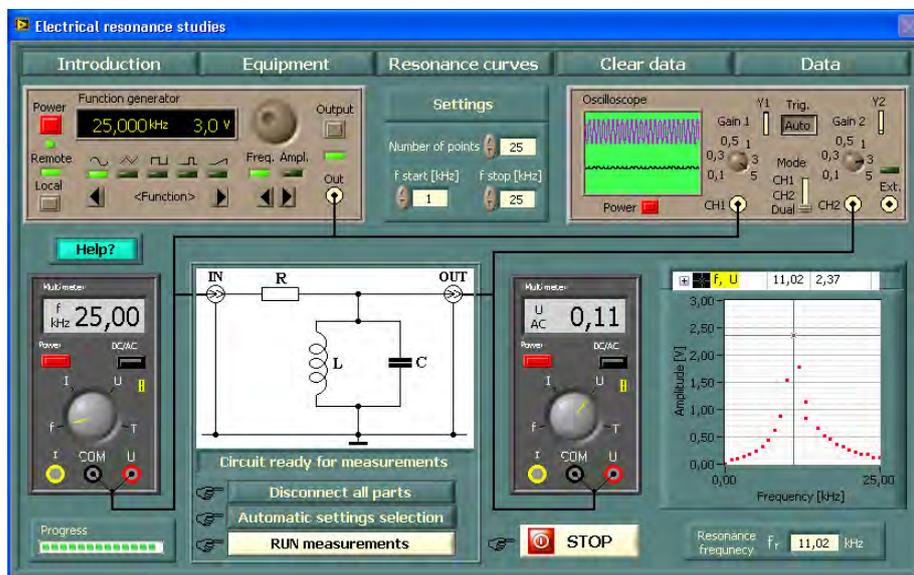

Fig. 7 *Front panel of the Electrical resonance simulated experiment accessible via Internet.*

5. Conclusions

The examples of the remotely accessible experiments presented in this article show that they can be a very attractive support of the teaching process.

The virtual instruments used in the experiments not only allow users to conduct measurements, but also give information about physics fundamentals. They instruct a user, a teacher or pupil, how to switch on electronics, how to set correct values of parameters, run experiment, collect and analyze data. This information can be selected remotely by pressing the corresponding button available on the top of the front panel of the web publish instrument. Before starting data acquiring, the user has to prepare virtual instruments to work. He must switch on, for instance, power supplies, digital multimeters, heating and cooling systems.

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References

[1] SOCRATES - Program Edukacyjny Wspólnoty Europejskiej, Informator, Fundacja Rozwoju Systemu Edukacji, ANPS, Warszawa 2004.

[2] W. Tłaczała, Modeling with LabVIEW™, *Handbook of Measuring System Design*, edited by Peter Sydenham and Richard Thorn, © 2005 John Wiley & Sons, Ltd., pp. 685-694.

[3] W. Tłaczała, Virtual Instrumentation in Physics, *Handbook of Measuring System Design*, edited by Peter Sydenham and Richard Thorn, © 2005 John Wiley & Sons, Ltd., pp. 695-701.

[4] D. Halliday, R. Resnick, J. Walker, *Fundamentals of Physics*, ©2001 John Wiley & Sons, Ltd.

[5] W. Tłaczała, G. Gorghiu, A. Glava, P. Bazan, J. Kukkonen, W. Mąsior, J. Użycki and M. Zaremba, Computer simulation and modeling in virtual physics experiments, *Proceedings of IV International Conference on Multimedia and Information & Communication Technologies in Education*, November 22-25th 2006, Seville, Spain.

[6] W. Tłaczała, G. Gorghiu, A. García de la Santa, M. Kordaki, J. T. Rodriguez and J. Użycki, Modeling of the D/A and A/D conversion techniques based on virtual instrumentation, *Proceedings of IV International Conference on Multimedia and Information & Communication Technologies in Education*, November 22-25th 2006, pp. 564-568, Seville, Spain.

[7] W. Tłaczała, M. Zaremba, A. Zagórski and G. Gorghiu, Virtual physics laboratory for distance learning developed in the frame of the VccSSe European Project, *Proceedings of V International Conference on Multimedia and Information & Communication Technologies in Education*, April 22-24th 2009, pp. 467-471, Lisbon, Portugal.

[8] http://www.ni.com/labview/