Computerized systems for physics laboratory

Author [1] Emilia Păuşan, Tudor Vladimirescu Theoretic High school, Bucharest

Author [2] Monica Iliescu, Tudor Vladimirescu Theoretic High school, Bucharest

Abstract— More than for other studying disciplines, for physics the most important is laboratory experiment. Because of this reason, adding new components to classic case, which offers another dimension of study for physics systems, this represents an important item. In this documentation are presented some of the advantages of acquisition and computerized processing of experimental data, being presented first experiments, simple for the beginning, realized by students of "Tudor Vladimirescu" Theoretic High school, there are also presented qualities of Labview programming, Romanian high schools are licensed since 2002-2003 with this software.

Key words—computerized monitoring, LabView, National Instruments, educational software, CSC, Connectus, NI-DAQ 6013.

1 Introduction

For physics teachers but not only for them, computers are important because this allows us a new kind of approaching: conversion of analogical quantity into a digital quantity. Using different sensors and an Analogical – Digital Converter it could be obtained a measuring system which can "see" beyond our senses, in infrasound, in infrared or ultraviolet, could interpret and present in different shapes the experimental data. With help of acquisition boards, data flow could be analyzed and processed. With regard to the measuring instrumentation based on calculation technique, the most important advantage of these, comparing with a classic measuring instrument, is that virtual instrumentation could be easily transformed with help of programming.

Using LabView (Laboratory Virtual Instrument Engineering Workbench) program, programming speed is increased because of introduction of an intuitive graphic interface. Interface of a virtual instrument contains different devices, measuring and control equipments realized in a graphic form mostly the same as real apparatus and equipments, users of LabView program using the virtual instruments in the same way they using the real instruments.

2 Computerized acquisition and processing of experimental data

We'll remember since the beginning that we could realize computerized data acquisitions, for different kind of laboratory experiments, having the support of National Instruments Company, who offered us an acquisition board, NI-DAQ 6031 (may, 2003) and also support of Centre of Complex Studies, through "Connectus" case which they gave us (2002-2003).

These new components of physic's case drove us to a new dimension of laboratory investigations, students of "Tudor Vladimirescu" high school of Bucharest, Romania, having today the possibility to practice modern techniques of investigation and monitoring of real systems. Further more, it will be presented new solutions for classic laboratory experiments, examples being three of experiments done by us: determining the friction factor at slipping, studying of linear oscillator, respective determining the electric resistance of a resistor and plotting his characteristic.

2.1 Determining the friction factor at slipping

This experiment has been elaborated for the students of the first year of high school, having as first objective determining the friction factor at slipping. Also, based on this experiment could be realized the study of linear oscillation, through processing of experimental data could be obtained characteristics of these oscillations.

Components of the experimental device:

- Wood board, on which we could put different materials;
- Fixed pulley, bodies with marking mass, pulling systems;
- Transparent rule on which have been put equidistant narrow slices made of non-transparent material;
- Sensitive sensor at light intensity variations;
- Acquisition board;
- Computer.

Figure 1. Experimental device used to study the linear oscillation

The experimental device, equivalent to the inclined plan from the laboratory case, its sensor is fixed in the central area of the wood board, the transparent rule slipping on the ramp realized by fixing and positioning of the wood board in which the sensor has been mounted.

Method principle

Obtaining the information regarding time periods when different items, which have been equidistant, arranged along the rule, passing by close to the sensor of the device, could be obtained the moving law of the body. Studying the movement through a reference system tied by the rule, is the same when this will be rested, and the sensor will move along the rule with his acceleration equal from the value point of view with the rule acceleration from the earth. Distance between those two successive items is known (the non-transparent slices have been mounted at the 4 cm distance between them) and this way the values of different coordinates are very well determined:

$$x_i = i*dx \ (i=0,1,2,3\ldots).$$

Making the graphic diagram x=x (t), could be obtained the value of system acceleration, and then it can be calculated the value of the friction factor at slipping.

Data processing

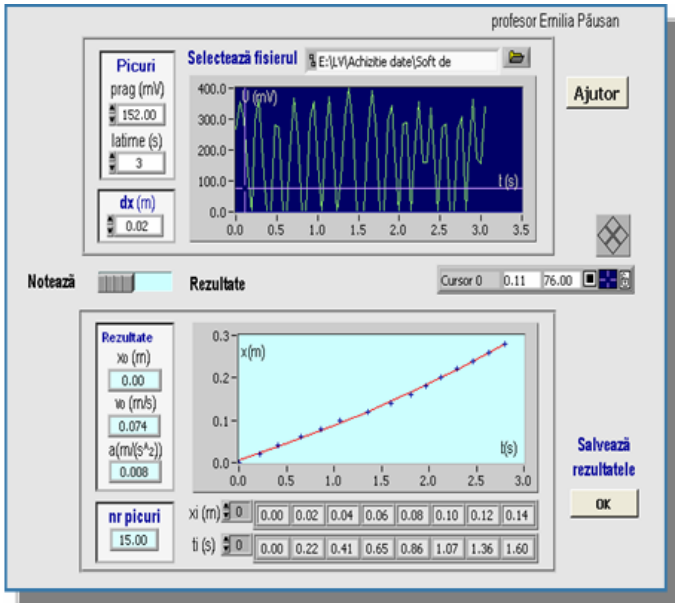

Figure 2. Software for data processing obtained through computerized acquisition (experiment made for studying the linear oscillation)

For data processing we used LabView; this software contains more sections.

The most important section present the signal obtained during the experiment, this has been remade based on the experimental data, saved in a file (for signal rendering it was used a xy diagram).

In the inferior side of the front panel, are displayed the results obtained by static processing, being necessary extraction the time periods which belongs to the recorded maximal value of the signal (when the opaque zones passing by the signal, the signal has a minimal value, and when the transparent zones of the rule are passing by close to the sensor, signal intensity increases, and the maxims are on the central part of these zones). Coordinates table, for which is already known the generation pitch, together with the timetable of the peaks, are transferred in a xy diagram, using points representation.

Using the smallest squares method, the LabView allows to determine the curves who describes the sequential order of the experimental points, could be calculated function coefficients that belongs to the sequential order. This way could be obtained the characteristics and moving law of the movement, the most important information being the value of the system acceleration. This information is displayed to the user by pressing "Results", being activated this way the most important section of the software.

By selecting the sequence "Note", by clicking the control with the same name, the user can record different values which will be useful for studying the linear oscillation, but also for determining the friction factor at slipping. Here will be written also different remarks regarding the experiment, or regarding the data processing. Also, in this sequence the student will take note regarding the experiment conclusion, and also the calculation algorithm used to determine the friction factor at slipping, starting by studying of the system interactions and the value of the acceleration, obtained through the statistic processing of the experimental data. It can be observed that it was realized a didactic projection of this application, optimizing the interaction between student and software, being proposed to the user a working action.

Although, software algorithm could be easily developed in order to be calculated the value of the friction factor at slipping, we wanted that this action to be made by the student, being included also the request to present all the necessary steps for obtaining the solution of the proposed problem.

Presenting all the projection items of the educational software we can take into discussion an important issue: also the applications for experimental data processing could be realized didactic, which recommends that this type of software to be realized by the teacher himself, starting with a specific didactic strategy.

Section "Help" presents information regarding the correct use of the software; being indicated also the working actions. Results obtained by processing could be saved in a file, being also saved the registered data in "Note" section. For this will be pressed "OK" button positioned under the message "Save data", button which is visible also for the section "Results" and "Note".

2.2 Studying the linear oscillator

Another experiment, made 2 years ago and remade this school year using the NI-DAQ acquisition board, have as objective studying the linear oscillator, acquired data being loaded in a processing software.
The realized arrangement is simple, using components from the laboratory case:

- Coil,
- Resort,
- Magnetic bar,
- Acquisition board
- Computer.

In figure no. 3 is presented a sequence during the experiment, for realizing this being necessary signal gain.

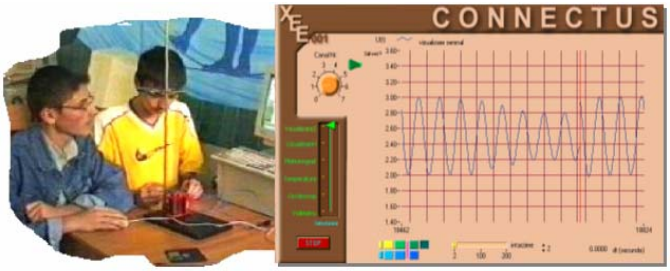

Figure 3. Experimental device used for studying the linear oscillation

One of the main aspects in the realized study was determining the damping coefficient which could offer information regarding his dependence and the body shape.

Obtained data, offered through the variation curve during time of the induced voltage in the coil, have been processed in order to be possible extraction of the registered signal amplitude and time periods, which belongs to these maxims. The two tables obtained are used to represent in a xy diagram of a time variation of the amplitude, existing an exponential decrease.

Statistic processing of the experimental data allows determining the physics measures, which describes the functioning of the studying system (period, frequency, pulsation, attenuation coefficient, etc). Using, as in the previous experiment, he offered facilities by LabView, could be determine function which describes sequential order of the experimental data, and based on the value of this function could be obtained the value of damping coefficient.

Although it's presented the way how the laboratory experiments have been projected using this new components which allows computerized acquisition of the experimental data, and also software projection items for data processing, we consider important to remind you that for each of these themes have been realized also simulation software, being important to compare functioning of the models created with real systems, theoretical aspects being easily understood.

A very important aspect is identification of the limits of these models, to realize the laboratory experiment, followed by the processing and analyze of the experimental results, which offers the possibility to make a detailed study. Could be proposed also settlement of corrections, which could be applied to a simple model, students solutions will be put under validation through laboratory investigations. Depends on students abilities that work on this; it could be proposed also the implementation of these solutions in the simulation software algorithm, studying of the model being a stage who offers useful information.

For processing of the obtained data from the presented experiment have been realized a similar software with the one realized to determine the friction factor at slipping, in figure 4 being presented the main sequence of this.

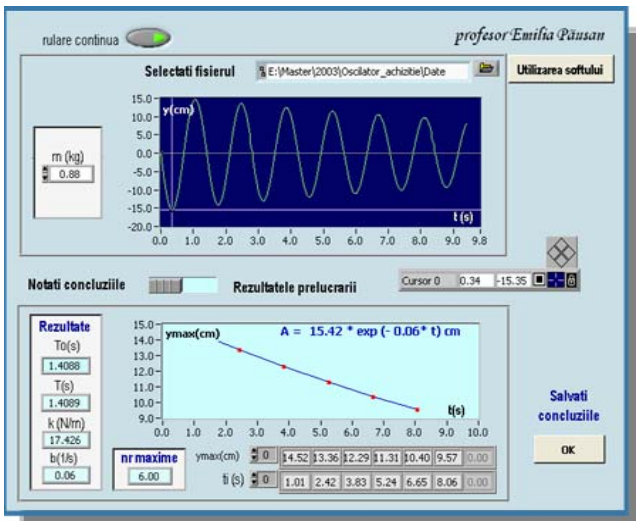

Figure 4. Software for data processing obtained based n the computerized acquisition (experiment made for linear oscillation study)

2.3 Determining the electric resistance of a resistor. Resistor characterization

Virtual instruments, offered by LabView (voltage-meter and oscilloscope) allow projection of mane laboratory experiments, being necessary sensor acquisition. There are also experiments for which is not necessary this procedure, the components of the experimental device are in the laboratory cases from school. Let me remind you in this way that the first experiment in this year using the NI-DAQ acquisition board: determining the electric resistance of a resistor.

Method principle is as follows: it will be measured the electric voltage at terminals of two resistors serial connected, for one of these two being known the value of

the electric resistance (named R1). The two signals are acquired from different channels, for each of them being used a differential module. Using the value of the electric resistance from the terminals of the resistor 1 and the value of the electric resistance of the resistor, will be determined the electric current intensity, which is the same for the two resistors serial connected.

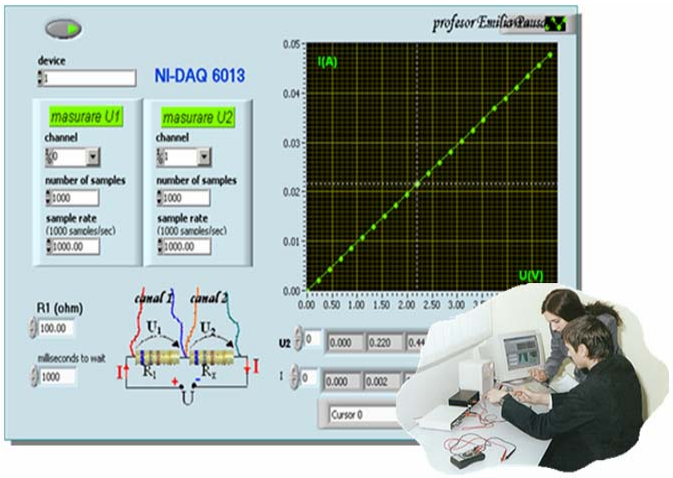

Figure 5. Drawing the resistor characteristics

To realize this experiment it was made simple software for data acquisition (figure 6). Values of the two pictures, describes the voltage at the resistor's terminals Rx and the intensity of the electric current, are transferred to an xy diagram, being obtained this way the resistor characteristic (at the electric circuit terminals it was applied an adjustable voltage, which allows to obtain the points of the characteristic). Analyzing the experimental results allows also determining the value of the electric resistance of the resistor, and pointing out the quality of the measurements made with this new component of our case, the NI-DAQ acquisition board.

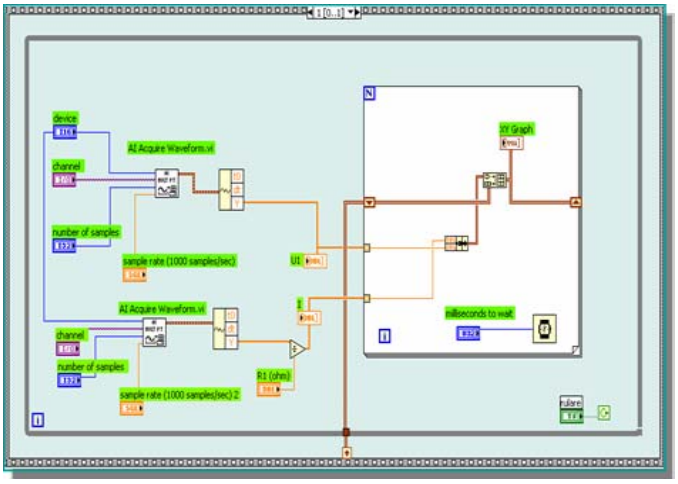

Figure 6. Software for experimental data acquisition (used to measure the electric resistance of a resistor)

3. CONCLUSIONS

We presented in this document few laboratory experiments in which the data have been acquired using the computer in order to point out that there are also simple solutions on which could be practice modern investigation techniques. In the meantime we also point out that the software on which the construction of virtual instruments is based, and the ones for data processing, could be realized by the teacher, their value being given by the didactic strategy used.

In conclusion, we propose, using the virtual instrumentation, enlargement of the physics case with this kind of component offering to the students the follows:

- Possibility to make a high quality investigation the real system;
- To get used with the modern techniques of measure and control;
- Made new competences, necessary to confront the new technologies.

Also, another component, which could be a useful didactic instrument, includes software for experimental data processing; the main arguments for this kind of proposal are as follows:

- Fast processing of experimental data;
- Possibility to analyze the obtained results due to the experiments, being important saving in the database the experimental results.

Realize new experiments that include systems for monitoring and control will be a future project for the nest years. Is important the cooperation with firms or companies which provide us with boards for data acquisition, so that our students to be able to project experiments interested for them. In the respective school years (2002-2003, and 2003-2004),our tries, teachers and students, showed us that the real chance to study physics in high school is refreshed by the modernization of laboratory cases, using the modern technologies to measure and control.
The effort for obtaining the financial sources will be rewarded by the success of our students. Do not forget that because of them the quality of our future life could be better.

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