The computer laboratory Workshops "The Bases of Electronics"

Zhukov A. A., Dotsenko O. A., Kochetkova T. D., Novikov S. S., Pavlova A.A.

Department of Radioelectronics, Faculty of Radiophysics

Tomsk State University, TSU

Tomsk, Russian Federation

apr@mail.tsu.ru

Abstract—**Computer Laboratory Workshops are used to introduce students into the basics of electronics. The students are provided with five laboratory works to be done. These laboratory works are aimed to introduce into the analysis of electrical signals, processes in linear, nonlinear circuits and in semiconductor devices, in circuits of gain, generation and electrical signal shaping. Also, the students are encouraged to study the possible applications of operational amplifiers. The tasks are carried out on NI ELVIS II + platform. LMS MOODLE is used for information support of the course.**

Keywords—*radioelectronics, ELVIS, MOODLE, MULTISIM, computer laboratory.*

I. INTRODUCTION

Life in modern society has imposed new requirements on the educational process in higher school establishments. Firstly, the increasing pace of life puts forward the problem of time management for young people and teaching staff of universities. Independent work of students is becoming increasingly important and requires a methodological support and study guide from teachers. Software products that enable students and teachers to share teaching materials such as assignments and tests remotely, have become a convenient and useful tool for organizing this work. The programs of this kind are widely used in many universities and schools [1-5]. Secondly, the development of certain areas of knowledge has reached such a level that multidisciplinary research is becoming inevitable. Modern science needs specialists with a wide range of knowledge, allows them to see the problem in all its manifold aspects. This necessitates higher school establishments to include certain disciplines of related fields into their curricula.

The students of the National Research Tomsk State University receive a broad education and learn a lot of scientific disciplines. Philologists, biologists, lawyers, historians learn the basics of the exact sciences. Physicists, mathematicians, economists study the core courses of humanities.

"The Bases of Electronics" is one of the common subjects in teaching the students at Tomsk State University. The students of the Faculty of Physics, the Faculty of Physical Engineering, the Faculty of Geology and Geography, the Biology Institute and the Faculty of Applied Mathematics and Cybernetics study this course although Electronics and electrical engineering will not be a major of those students in the future.

In this course, the students are introduced into the basic concepts of electronics, with linear and nonlinear circuits, semiconductor devices. This information may be useful in further work.

A very handy tool for staging such works is NI ELVIS II + platform. Solutions in the field of education from National Instruments are well known [6-12]. Laboratory practical work presented in this paper is also based on the application of NI platform. Schemes studied devices are assembled on the breadboard and the students get it in accordance with the task.

II. COURSE CONTENT

The course "The Bases of Electronics" consists of the following parts: lectures, tutorials and laboratory workshops.

Tutorials are given in the following order:

- study of the program of circuit simulation MULTISIM,
- study of sets of virtual instruments NI Elvis II +,
- simulation of various electronic components and circuits
- computer simulation of these components and circuits.

Students learn the simplest schemes at tutorials. Fig. 1 shows the NI ELVIS II + platform with laboratory prototyping board. The circuit of a multivibrator is assembled on this prototyping board.

A computer laboratory workshop is used for experimental studies of electronic circuits. The students learn at these classes:

- Conversion of signals by linear circuits,
- Rectification,
- Multivibrator,

- Amplifier based on bipolar transistor,
- Electrical circuit on operational amplifier.

LMS Moodle for information support of the course is used. The Hypertext Transfer Protocol of the computer laboratory workhops of Faculty of Radiophysics are located on http://info.rff.tsu.ru/course/index.php?categoryid=21.

A. LMS Moodle for information support of the course

Methodological instructions at laboratory workshops
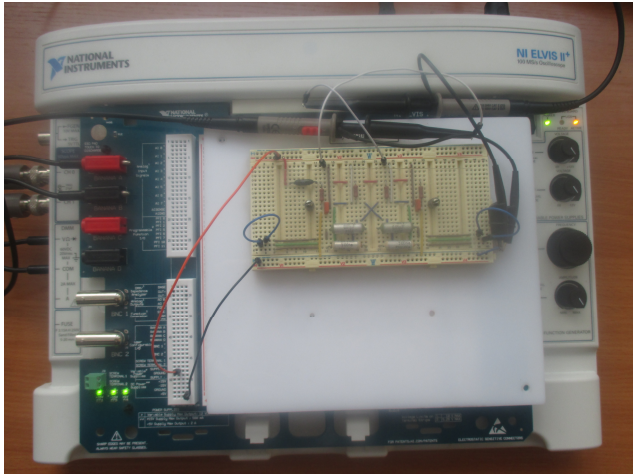
Fig. 1. NI ELVIS II + platform with laboratory prototyping board

contain a minimum of theoretical training material. It is necessary for preparing and doing laboratory work. The students are supposed to study the appropriate material given in the textbook when preparing for laboratory work. The textbook is available on the site of LMS Moodle.

The theoretical material in the form of lectures, the intermediate questions for self-examination included, is set in the LMS Moodle system.

To gain admission to the lesson the student must answer the questions given in the input test. The test is in the Moodle system. The students write reports on home assignment and laboratory work on the computer. After that, they e-mail reports for the teacher to control within the LMS Moodle. Next, the students are given a score as the assessment of their work. The students are allowed to view the assessment.

B. The order of classes

Laboratory work is done by each student independently.

Option number of initial data is given by the teacher.

Laboratory studies are carried out according to the following rules:

At the opening lesson, the students will become familiar with the internal regulations and safety of laboratory station NI Elvis II + and its virtual instrumentation.

Prior to performing the lab the teacher checks student's knowledge of the objectives, the result of their preliminary calculations and computer simulations. Before the students start the experiments, they should carefully examine the circuit diagram.

The assembling of the circuit is made with power off in strict accordance with the scheme shown in laboratory practice.

Any changes to the scheme are made when the power supply voltage is turned off. The turning on of laboratory equipment is possible only after verification of scheme by the teacher.

C. Lab «Circuits on the operational amplifier»

As the first example, let us consider the execution of laboratory work «Circuits on the operational amplifier».

The purpose of this work is to study the various schemes using the unique properties of the operational amplifier.

Work assignments include calculations and experimental study of the inverting amplifier, the digital-to-analog converter, analog differentiator, the analog integrator, the relaxation oscillator. It is necessary to compare the results of calculations with experimental data, discuss the reasons of the discrepancies, estimate the error signal transformations.

The students have to calculate the gain of inverting amplifier K for different values of feedback resistance, to measure K on the model with the help of instruments, to analyze the reasons for discrepancies between the results of measurements and calculations. They should take the frequency response of the amplifier K (f) using the Bode analyzer and the amplitude response U_{out} (U_{in}) for applying to the input harmonic signal, to observe the distortion of the output signal.

In one more task various 3-bit binaries should be fed to the input of the digital-to-analog converter and then the output voltage should be measured, and the expected and the obtained results are to be compared.

The students use three waveforms: harmonic, rectangular and triangular pulses at the analysis of the analog differentiator and integrator. Shown in Fig. 2 is a deviation of the phase difference between the output and the input signals from − 90º. This deviation is a measure of the phase error of a real
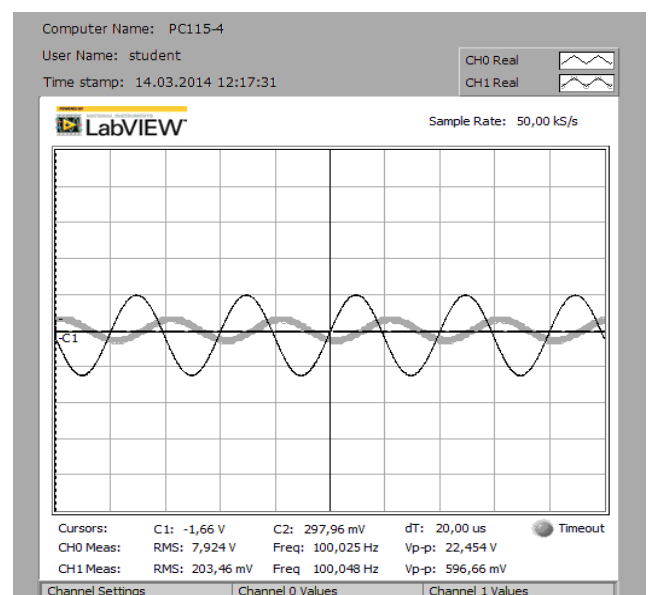

Fig. 2. Integration of the harmonic signal. Grey lines – input signal, black lines – output signal.

differentiator.

They must estimate the condition of the ideal of integration and differentiation at a given frequency or pulse duration, as shown in Fig. 3, 4.
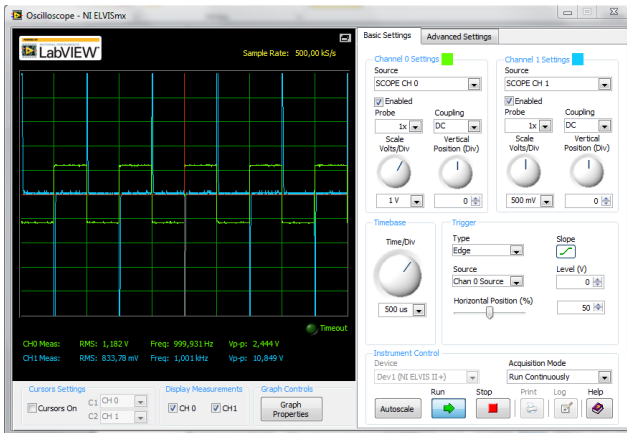

Fig. 3. Example of work window the scope. Differentiation of rectangular pulses under the condition of differentiation Green lines – input signal, blue lines – output signal.
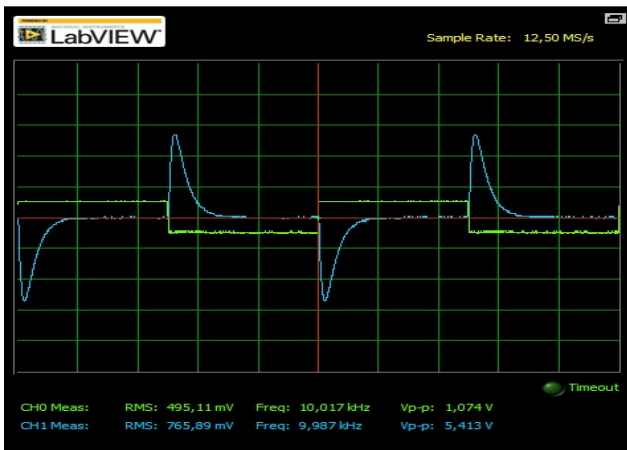

Fig. 4. Example of work window the scope. Differentiation of rectangular pulses with a significant error. Green lines – input signal, blue lines – output signal.

The students must calculate and measure the period of oscillation and compare the results obtained (Fig. 5).

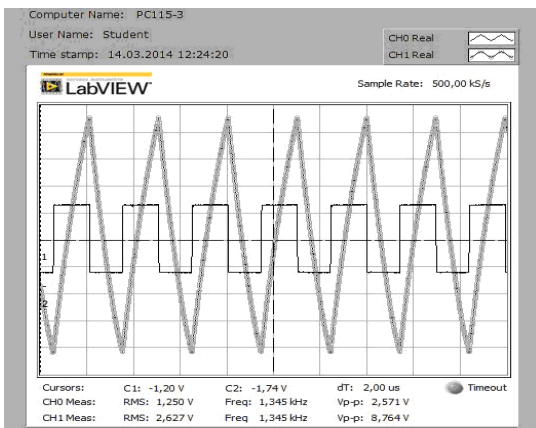Using ELVIS platform in this work facilitates work with

Fig. 5. The output signals of generator of relaxation oscillations: grey line – from capacitor, black line – from resistor.

the scheme and allows more accurate measurements to be made. The presence of the function generator makes it possible to explore various forms of signal.

Students are actively using the option to save the oscilloscope images in the laboratory work report.

D. Lab «Linear signal conversion circuits»

As a second example, let us consider the execution of laboratory work « Linear signal conversion circuits».

The purpose of this work is to study of low-pass, high-pass and band-pass electrical filters. The students should measure characteristics of input and output electric signals. After that, the students are to compare those signals.

In this paper, we consider the passage of signals through simple passive filters. Fig. 6 shows the waveform of the input signal – rectangular pulses – and output signal after low-pass filter. We can see decline harmonic amplitudes at low frequencies by the spectrum analyzer.
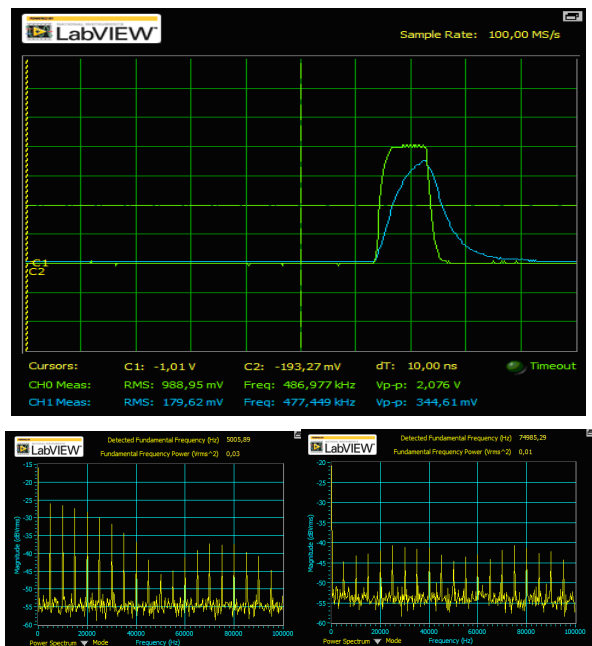

Fig. 6. Rectangular pulse before (green lines) and after (blue lines) low-pass filter and spectra of input and output signals.

Periodic square shape signal at a frequency of 25 kHz with a duty cycle equal to 10 was fed on a band pass filter (Fig. 7). The number of fill periods of the output signal for one period of the input signal is about 16. Therefore, the resonant frequency of the band pass filter approximately equals to 25 kHz × 16 ~ 400 kHz, which coincides with the data obtained by Bode analyzer.

The ELVIS platform allows us to monitor signals in the temporal and spectral representation at the same time. You can very clearly demonstrate changes in the spectrum of the signal by band-pass filter. The amplitude-frequency characteristic of the filter "cuts" spectrum of an output signal from the input signal spectrum is shown in Fig. 8.
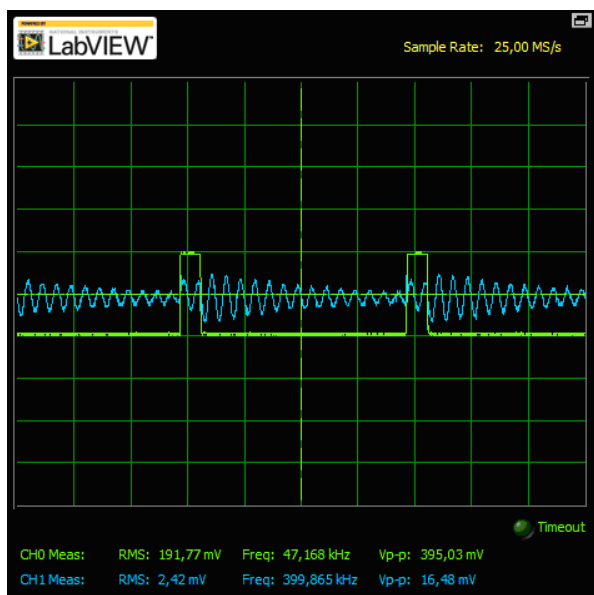
Fig.7. Example of work window the scope. Rectangular pulses before (green lines) and after (blue lines) band pass filter and spectra of pulse.
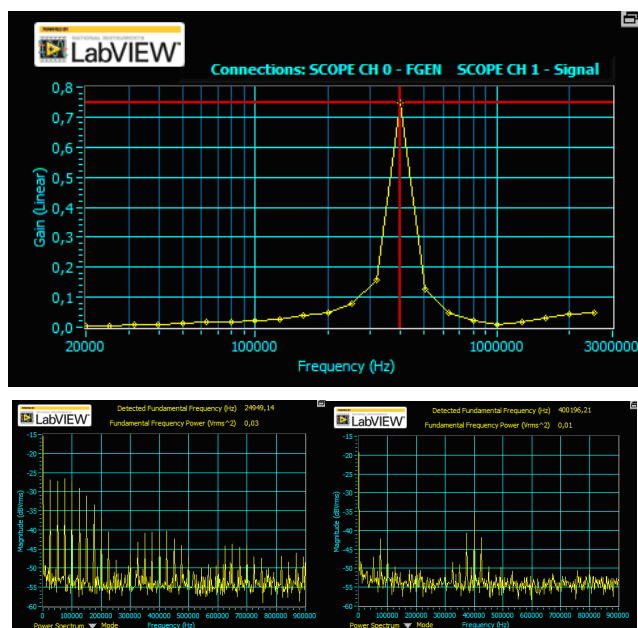

Fig. 8.The amplitude-frequency characteristicof band-pass filter and spectra of rectangular pulse before (on the left) and after (on the right) band-pass filter.

III. CONCLUSION

This article provides a description of the course «Bases of electronics». Practical and laboratory classes using the platform NI Elvis II + have been held at the Radiophysics Department for the last two years. Our experience shows that the use of modern means of measurement and the analysis of experimental data improve the quality of education, and motivate students' learning.

IV. REFERENCES

[1] L.M. Regueras, E. Verdú, M.J.0 Verdú, J.P. de Castro, "Design of a Competitive and Collaborative Learning Strategy in a Communication Networks Course," Trans. Educ., vol. 54, no. 2, pp. 302–307, May 2011.

[2] J.A. Macías, "Enhancing Project-Based Learning in Software Engineering Lab Teaching Through an E-Portfolio Approach," IEEE Trans. Educ., vol. 55, no. 4, pp. 502–507, Nov. 2012.

[3] F. Martinez, L.C. Herrero, S. de Pablo, "Project-Based Learning and Rubrics in the Teaching of Power Supplies and Photovoltaic Electricity," IEEE Trans. Educ., vol. 54, no. 1, pp. 87–96, Feb. 2011.

[4] S. Bogarra Rodriguez, M. Corbalan Fuertes, A. Font Piera, I. Plaza Garcia, F.J.A. Solsona, "Lessons Learned in the Use of WIRIS Quizzes to UpgradeMoodle to Solve Electrical Circuits," IEEE Trans. Educ., vol. 55, no. 3, pp. 412–417, Aug. 2012.

[5] M.A. Trenas, J. Ramos, E.D. Gutierrez, S. Romero, F. Corbera, "Use of a New Moodle Module for Improving the Teaching of a Basic Course on Computer Architecture," IEEE Trans. Educ., vol. 54, no. 3, pp. 222–228, May. 2011.

[6] L. de la Torre, R. Heradio, C.A. Jara, J. Sanchez, S. Dormido, F. Torres, F.A. Candelas, "Providing collaborative support to virtual and remote laboratories," IEEE Trans. Learning Technologies, vol. 6, no. 4, pp. 312-323, Oct.-Dec. 2013.

[7] C. Mwikirize, A.T. Asiimwe, L. Musasizi, V. Namuswa, M.D. Nakasozi, C. Mugga, A. Katumba, S.S. Tickodri - Togboa, J. Butime, P.I. Musasizi., "Development of Online Laboratories for Modulation and Combinational Logic Circuit Analysis Using NI ELVIS II™ Platform," Proc. 7th Int'l Conf. Information Technology: New Generation - ITNG2010, pp. 159-162, Apr. 2010

[8] M. Tawfik, E. S. Cristobal, A. Pesquera, R. Gil, S. Martin, G. Diaz, et al., "Shareable educational architectures for remote laboratories," Proc. Int'l Conf. Technologies Applied to Electronics Teaching (TAEE), pp. 122-127, Jun 2012.

[9] S. Mahata, A. Maiti,and C. K. Maiti,"Cost-Effective Web-Based Electronics Laboratory using NI MultiSim, LabVIEW and ELVIS II", Proc. Int'l Conf. Technology for Education (T4E), pp 242-243, July 2010.

[10] J. Butime, R. Besiga, A. Bwonyo, V. Nakanwagi, T. Togboa, A. Katumba, "Design of online Digital Electronics laboratories based on the NI ELVIS II platform," Proc. 9th Int'l Conf. Remote Engineering and Virtual Instrumentation (REV), pp 1-3, July 2012

[11] Naddami, A. Fahli, M. Gourmaj, M. Moussetad, "Online laboratory in digital Electronics using NI ELVIS II+," Proc. 2014 Int'l Conf. Interactive Mobile Communication Technologies and Learning (IMCL), pp 120-124, Nov. 2014

[12] P.A. Cotfas, D.T. Cotfas, L. Floroian, D. Floroian, "General physics remote laboratory based on the NI ELVISplatform and Moodle," Proc. 11th Int'l Conf. Remote Engineering and Virtual Instrumentation (REV), pp. 159-162, Feb. 2014.