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USE OF VIRTUAL MEASURING DEVICES IN METROLOGY, ELECTRONICS AND ELECTRICAL MACHINES FOR THE TRAINING OF ELECTRICAL ENGINEERING SPECIALISTS

Abstract. The work shows that a promising direction for the modernization of the educational laboratory base is the use of open systems methods together with the introduction of technologies for the use of virtual devices, based on the use of computer measurement methods. **The purpose of the work** is to analyze the possibilities of creating virtual laboratory work in various disciplines and their use in professional training of specialists in electrical engineering in higher educational institutions. As a result of the analysis of the most well-known application computer packages intended for the design of electronic units, the authors found that the ability to model both the simplest electrical circuits and power electronics circuits and rather complex control circuits for them, as well as various electrical machines is the main advantage of the Simulink package of the MATLAB environment in comparison with other software tools. Examples of constructing circuits for virtual laboratory work in the metrology course are given. It is shown that virtual laboratory work increases students' interest in the learning process, as well as the level of their skills and abilities.

Keywords: metrology, electronics, electrical machines, remote access, laboratory course, virtual measuring device.

Introduction

In these difficult times for Ukraine, when there are often air raids or there is no possibility to conduct classes in specialized laboratories, one of the most important areas of development of modern educational technologies is the development of remote access systems for learning and the implementation of open education standards on their basis [1].

The training of qualified specialists in electrical engineering is impossible without a modern laboratory base, on which students could not only consolidate the theoretical knowledge they have gained, but also acquire practical skills in research or production experiments, skills in designing and testing industrial systems. Today there is an intensive introduction of modern information technologies into the educational process, a large-scale modernization of the information infrastructure of the education system is being carried out, a unified educational environment is being formed. In such conditions, laboratory resources cannot remain at the old level, and a new approach to their formation is needed. A promising direction for the modernization of the educational laboratory base is the use of open systems technology together with the introduction of virtual device technology, based on the use of computer measurement methods [2, 3].

Today, many researches are devoted to the problems of informatization of vocational education. The works of the authors [3-8] consider the current state of formation and use in the professional training of specialists of new information and educational environments, however, despite the large number of diverse and large-scale studies concerning the informatization of education and the use of information and communication technologies of training, they did not find a thorough study of the development of virtual work.

The purpose of the work is to analyze the possibilities of creating virtual laboratory work in various disciplines and their use in professional training of specialists in electrical engineering in higher educational institutions.

Presentation of the main material

When studying electrical engineering specialties, an important component of the educational process is laboratory practice. Traditionally, educational laboratories are equipped with a certain set of technical means that allow for simple measurements. This applies, first of all, to such disciplines as physics, electrical engineering, electronics, electrical measurements, electrical machines. The set of measuring instruments here is usually very limited and includes an electrical signal generator, a voltmeter, an ammeter, a frequency meter and an oscilloscope, that is, measuring instruments of general use.

Until recently, all laboratory research and work, verification of the correctness of technical calculations could be performed only during the experimental study of real circuits and devices. This method has a number of significant drawbacks:

- for experimental study of the circuit, it is necessary to equip it with appropriate measuring equipment and full-scale samples of electrical machines and control devices;
- the errors of real measuring devices can be quite large;
- for the study of circuits, it is necessary to assemble their mock-ups from real elements, which leads to significant material costs.

Computer simulation of electrical circuits is devoid of these disadvantages, but there are some difficulties in accounting for the real parasitic parameters of circuit elements in the models: internal resistances and conductivities of sources; intrinsic inductances and capacitances of real resistors; losses in inductors and windings of electrical machines; nonlinearities caused by the presence of ferromagnetic cores; in addition, it is sometimes difficult to assess the accuracy of computer simulation.

Effective implementation of remote access technologies is possible only by creating a virtual information and educational environment of the university, uniting in a single information space various

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corporate management systems, electronic libraries, distance learning and training systems, corporate testing systems, automation of scientific research, etc. In such conditions, real experimental stands are replaced by models of installations, creating a system of virtual laboratories. Virtual measuring laboratories are a very important component of the virtual representation of an educational institution, providing, together with other systems, all the functions of learning and management of the educational process. As a typical option, we can offer a educational virtual measuring laboratory (EVML) with the following typical set of measuring instruments: a signal generator; a universal oscilloscope; electric motor; an electronic frequency counter; an ammeter, a voltmeter; a wattmeter; a multimeter.

Such a EVML can become the basis for organizing laboratory workshops in technical educational institutions on the disciplines of the electrical engineering cycle, especially for distance learning for students. The basic version of the hardware part of the complex can be expanded by adding special adapters that provide research on a wide range of processes and phenomena in relation to various disciplines. The software can be supplemented with modules for specialized analog and digital signal processing, graphical representation of the results obtained, etc.

We analyzed the most famous application computer packages designed for the design of electronic blocks: the Electronics Workbench package, which is essentially a virtual laboratory with quite wide capabilities; the Design Lab package - an integrated software complex of the MicroSim corporation for the design of analog, digital and analog-digital devices; the Micro-Cap package - a universal package of programs for modeling the circuitry of electronic circuits; the Simulink package of the MATLAB environment - a virtual laboratory that allows you to assemble and study the operation of many types of electrical circuits, electric machines and electric drive devices, power electronics circuits.

The comparison of the packages was carried out according to the possibility of modeling analog devices (the ability to create device models based on analog electronics elements); modeling digital devices (the ability to create device models based on digital electronics elements); modeling electric machines (the ability to create models of transformers, motors, generators); the possibility of graphically displaying the results of modeling (the availability of means of visual representation of the processes occurring in the model - graphs of transient processes, dependences of the characteristics of components on some varied parameter); in addition, the possibility of changing the characteristics of the elements of the device model (voltage, current, resistance, inductance, etc.) was analyzed.

According to the results of comparison and analysis, it was found that the ability to model both the simplest electrical circuits and power electronics circuits, rather complex control circuits for them (electric drive devices), as well as various electric machines is the main difference between the MATLAB system and other software tools. This package is based on building block diagrams by transferring blocks from the component library to the editing window of the user-created model. Then the model is launched for execution. To build a functional block diagram of the simulated devices, Simulink has a large library of block components and a convenient block diagram editor. When developing a set of virtual laboratory works for studying the metrology course, the Simulink package of the MATLAB software environment was used. Here are examples of works from the metrology course that can be performed both on your own computer at home and in the computer class of the university.

1. Laboratory work № 1. "Measuring parameters of electrical networks using a virtual measuring laboratory". In the process of work, students get acquainted with the method of using virtual tools when creating an electronic laboratory, build assigned virtual electrical circuits using virtual analog dial instruments, learn to measure active resistances, inductances and capacitances both directly and indirectly, and also evaluate measurement errors (Fig. 1).

Students study various systems of analog instruments, their advantages and disadvantages, methods of expanding the limits of measurements, and answer the given control questions.

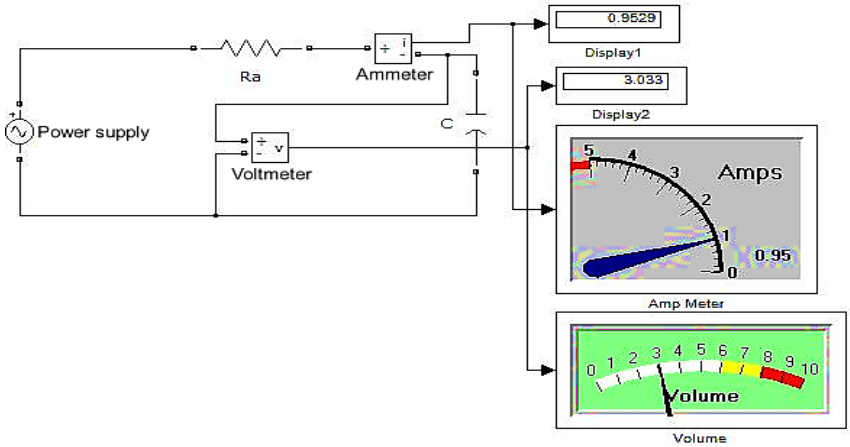

Fig. 1. An example of building a laboratory work № 1 scheme

2. Laboratory work №2. "Measurement of electrical network parameters by the bridge method using a virtual measuring laboratory". In the process of work, students study theoretical material on bridge circuits of direct and

alternating current, designs and principles of operation of comparison devices - bridges and compensators, get acquainted with the methodology for measuring electrical parameters by the bridge and compensation method using virtual devices, conduct measurements, and answer the given control questions (Fig. 2).

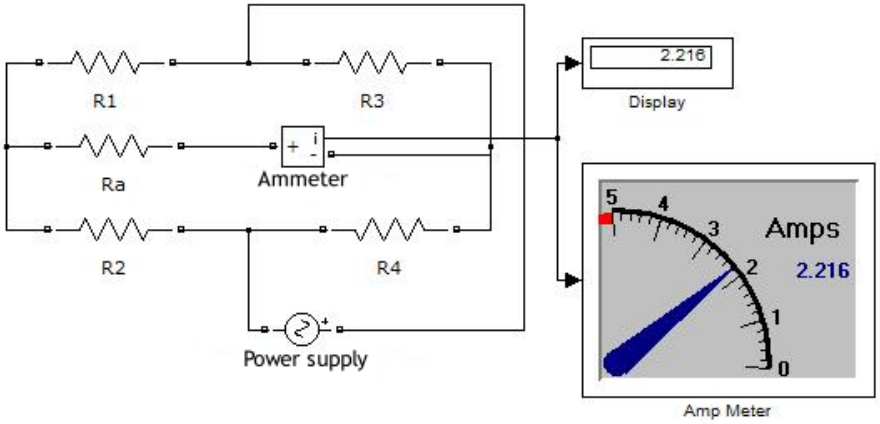

Fig. 2. An example of building a laboratory work № 2 scheme

3. **Laboratory work №3.** "Research of the parameters of periodic signals using a virtual oscilloscope". In the process of work, students study the structural diagrams and a typical set of blocks of both an electronic and a digital oscilloscope, get acquainted with the main characteristics of continuous and pulsed signals, acquire skills in working with a virtual oscilloscope and generator, learn to generate s ignals of various shapes, conduct measurements, calculate parameters of various signals, and answer the given control questions (Fig. 3).

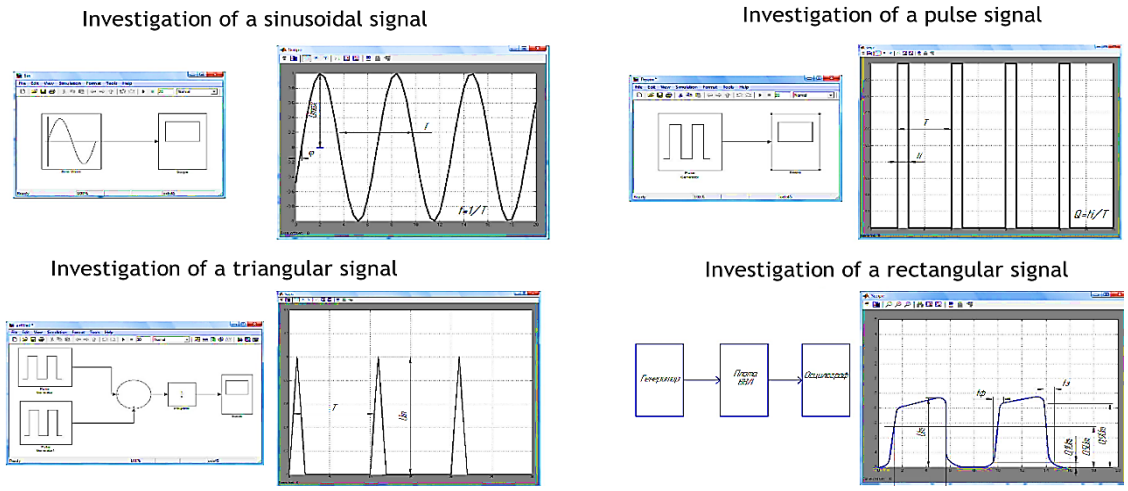

Fig. 3. An examples of obtaining and studying signals from laboratory work № 3

Such EVML laboratory can become a mandatory functional unit in collective use centers. In this case, the use of remote access mode will significantly improve the laboratory support of the educational process in the above-mentioned disciplines.

Conclusions

The particularity of this approach is the ability for students to practice experimental work skills on realistic models of dynamic objects with accurate reproduction of physical laws and high interactivity of research. It is possible to predict an increase in interest in the learning process in groups of students due to an innovative approach to the methodology of teaching engineering disciplines.

Virtual laboratory works in the professional training of future electricians ensure individuality and independence of students' activities, develop creative thinking and form the ability to make operational decisions, and, therefore, significantly increase the level of knowledge, skills and abilities. At the same time, the use of virtual laboratory work should be combined with the study of real equipment, real phenomena and processes.

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Використання віртуальних вимірювальних засобів в курсах метрології, електроніки та електричних машин у підготовці фахівців з електричної інженерії

О. В. Шефер, Н. В. Єрмілова, О. Г. Дрючко, М. К. Степанко, С. В. Пасічко

Анотація. В роботі показане, що перспективним напрямком модернізації учбової лабораторної бази є використання методик відкритих систем разом з впровадженням технологій застосування віртуальних приладів, заснованої на вживанні методів комп'ютерних вимірів. **Метою роботи є** аналіз можливостей створення віртуальних лабораторних робіт з різних дисциплін та їх використання у професійній підготовці фахівців з електричної інженерії у вищих навчальних закладах. В результаті аналізу найбільш відомих прикладних комп'ютерних пакетів, які призначені для проектування електронних блоків, авторами виявлено, що можливість моделювання як найпростіших електричних схем, так і схем силової електроніки та досить складних схем управління ними, а також різних електричних машин є головною перевагою пакета Simulink середовища MATLAB у порівнянні з іншими програмними засобами. Наведені приклади побудови схем для віртуальних лабораторних робіт з курсу метрології. Показано, що віртуальні лабораторні роботи підвищують інтерес студентів до процесу навчання, а також рівень їх умінь та навичок.

Ключові слова: метрологія, електроніка, електричні машини, віддалений доступ, лабораторний курс, віртуальний вимірювальний прилад.