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UDC 377.8.00:18

Integrated Laboratory System

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This paper presents an integrated laboratory system, which enables to conduct laboratory work in “Electrical Engineering with the Basics of Industrial Electronics”, “Electronics”, “Electrical Work” and others in the course of teaching complex electrical and electronic professions. The design of the system enables to perform physical simulation of laboratory work by integrated plug-in units and also electronic simulation by a personal computer.

Key words: integrated laboratory system, laboratory work, physical simulation, electronic simulation.

Formulation of the problem

The age of technological advances, the intensive development of science, technology and their integration result in complication of nature and structure of professional work. The emergence of new technologies requires more serious training of engineers from specialists of technical institutions. This also concerns future teachers related to vocational education, who are being prepared at teacher training institutions.

Rapid implementation of scientific achievements in production, especially in electrical- and radioengineering, leads to the expansion of educational material in programmes and, as a consequence, to the increase in the period of study. Due to the rapid development of electronic production, i.e. the application of new materials, the implementation of new technologies, changes in hardware components of electrical and radio equipment, it can be said that the society sees a technological challenge, which affects training in educational institutions [3, p. 228].

Because the volume of knowledge, skills and abilities in these professions is so large and constantly growing, it is required to change the professional training content of engineers. On the one hand, there are inconsistencies between rapid technological

progress, constantly changing range of electronic manufacture, and on the other hand, operational difficulties in displaying this amount of information in teaching- and programme documentation, textbooks, teaching aids and textbooks. This impacts the training quality of specialists of higher- and vocational education.

Analysis of current research activities and publications

Due to high rates of science and technology progress, the entire education system and professional education in particular, are faced with the efficiency improvement of learning process. The changes in question must be primarily reflected in the curricula, academic programmes, textbooks, manuals and other literature. This is particularly important for specialists in the sphere of complex electrical and electronic professions. Today, they account for approximately 30% of all professions. Workers and engineers associated with these activities have to perform much practical work on assembly, connection, disassembly and adjustment of various electrical and electronic circuits. Correct execution of these operations is achieved by long training during various practical and laboratory work.

It must be noted that currently there is a large range of equipment to perform laboratory work in electrical- and radio-



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engineering disciplines. Some authors, such as A.I. Bashmakov, A.P. Balashov, I.T. Bogdanov, A.I. Bugayov, M.I. Zhaldak, B.T. Kaminsky, S.S. Kizim, D.I. Panfilov, D.Ya. Tamarchak propose to use in their studies foreign software of electronic versions of laboratory equipment.

Almost in all the laboratory equipment the principle is the same. To perform the specific group of laboratory work, there exists a physical test bench, on which this activity is executed. For example, one test bench is used for the subject "Electrical Equipment", section "Direct Current", another test bench is used for section "Alternating Current", etc. [1, 2, 7, 8, 9].

Purpose of the article.

Justification of the existing technology state of laboratory equipment for complex electrical- and electronic professions and presentation of the existing integrated laboratory system.

Presentation of basic material.

Thus, the relevance and practicability of laboratory- and practical work with unified laboratory equipment are driven by the increased requirements of modern society to the training of qualified engineers-teachers in their current and future activities.

Long-term studies conducted in the Laboratory of Vocational Education and Training (VET) of the International Academy of Human Problems in Aerospace Systems and in the Laboratory of Vocational Education and Training of the Institute of Pedagogy and Psychology of Vocational Education of the Academy of Education of Ukraine have revealed, that to improve the quality of practical training in these professions, fundamentally new laboratory equipment is required. These activities began in 1986 and resulted in manufacturing fundamentally new laboratory equipment [3, p. 371; 8]. Further studies, which continued since 2000, allowed to develop electronic versions of laboratory work.

The unified laboratory system includes unified laboratory equipment [3, p. 371; 8]; teaching materials, which consist of textbooks, manuals and educational

software to support training process. This system enables to perform laboratory and practical work, and also to conduct simulated and practical activities, both in small and large classrooms using multimedia equipment. Since it is an integrated system, it can be used to execute work in various disciplines [4, p. 7-18; 5, p. 17-35; 6, p. 5-13]. During production of multimedia versions, copyright software products were developed.

Tablets of laboratory benches, being original development, belong to the basic laboratory equipment [3, p. 189; 8]. A sloping panel, which is a tablet, with the slope angle of 70° to the horizon, is mounted to the top cover on the left-hand side of the bench [3, p. 189].

The colour range of the bench, removable elements, wires and other items are selected according to the requirements of engineering psychology. The tablet for assembly and study of electrical circuits during laboratory work includes five toggle switches (1) to connect and disconnect power supply, ten sockets (2) to connect power source socket (3) and to wire and connect various circuit elements (fig. 1).

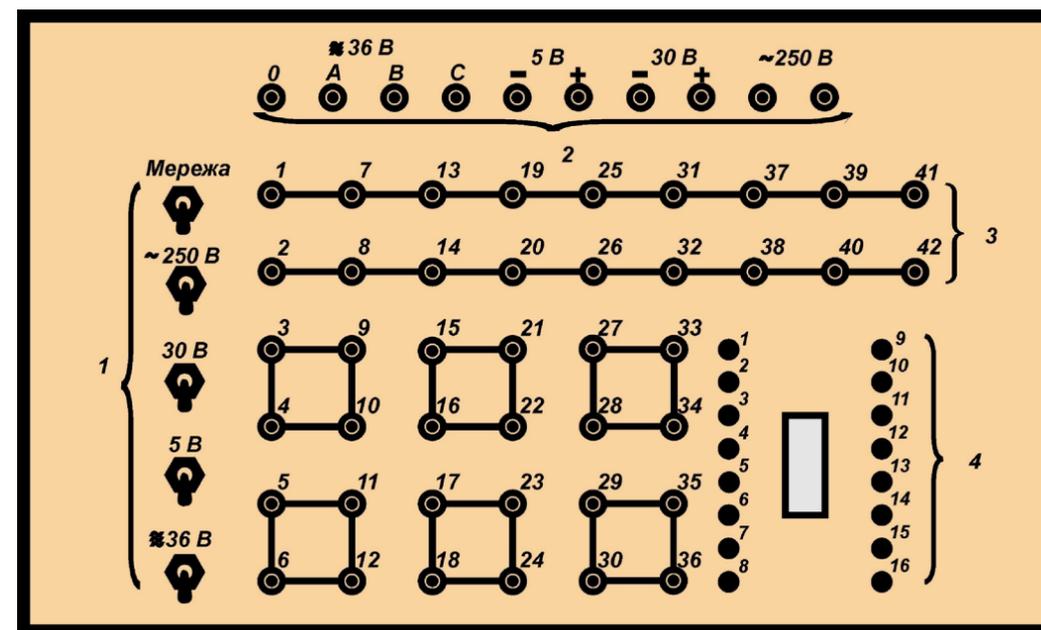
For assembly of electrical circuits using algorithmic instructions, all socket contacts on the perfbord are numbered from 1 to 42.

The socket contacts are interconnected in a certain way from the back side of the panel. These connections are shown on the front side of the panel by the engraving with numbers of socket contacts. The panel for study of integrated circuits (4) is located on the right-hand side of the tablet.

The integrated laboratory equipment uses removable elements (fig. 2), which consist of resistors (fig. 2, a), capacitors (fig. 2, b, c), semiconductor diodes (fig. 2, d) and other elements, which are fastened to dielectric base and soldered to forks in 4 mm diameter [3, p. 191; 4, p. 17].

Since all the elements are integrated, they can be used for assembly of various electrical circuits, i.e. in Laboratory Work No1, which is "Series-, Parallel- and Mixed Connection of Resistors" and other types

Fig. 1. Perfbord with integrated laboratory equipment sockets



of laboratory work. Incandescent lamps of different power are used as the load (resistors) [4, p. 25, 130]. These lamps are screwed in the socket and can be quickly interchanged.

Circuit assembly is performed on the mock-up field of the laboratory bench, and is simultaneously shaped on the PC monitor screen (fig. 1, 3, 4). The installation result of the physical element and its connection

Fig. 2. Removable integrated elements of electrical circuits:

a) resistors; b, c) capacitors; d) semiconductor diodes

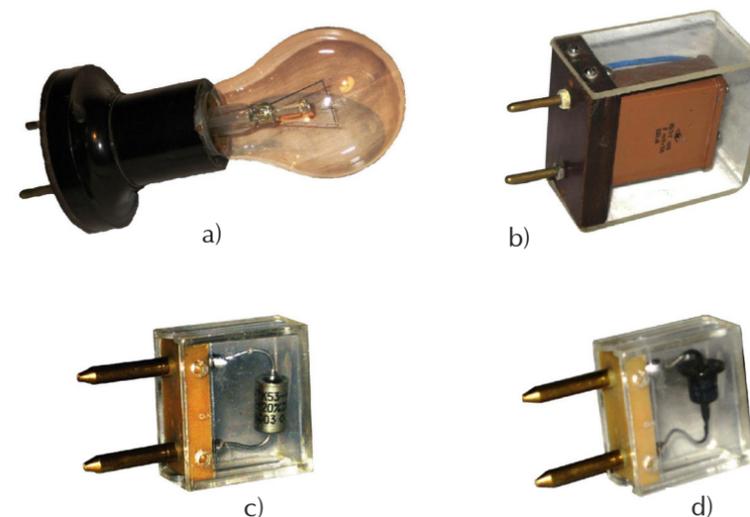
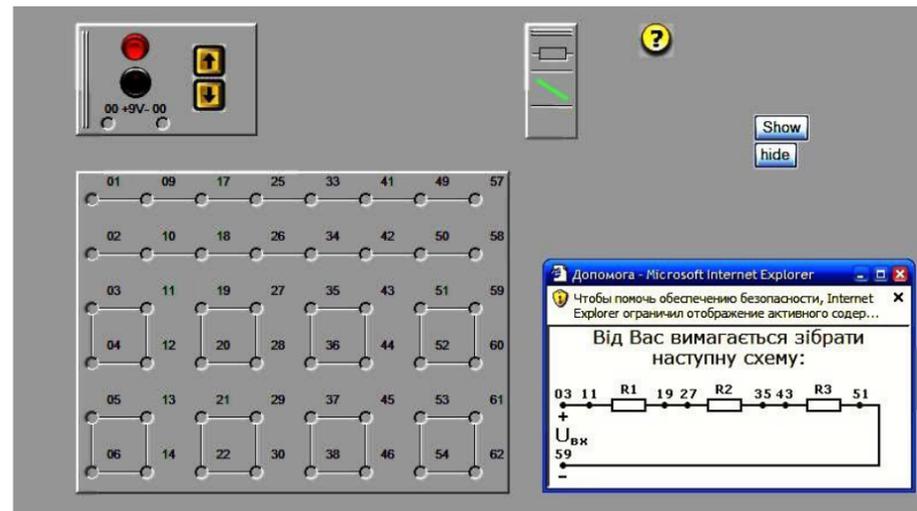


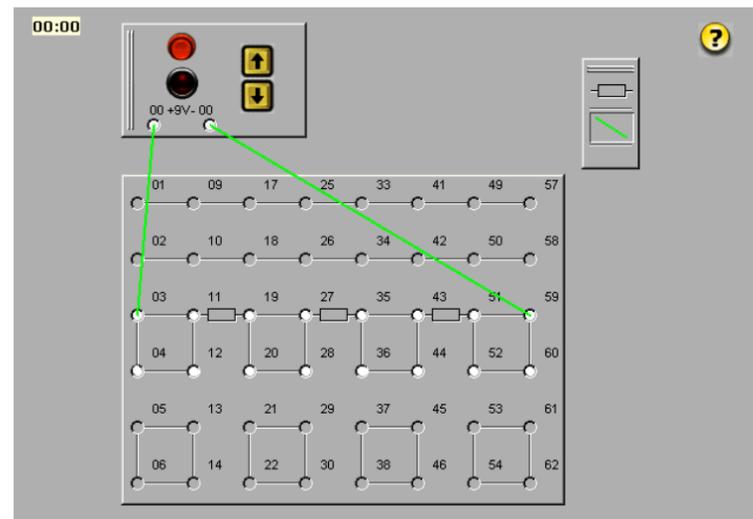
Fig. 3. Mock-up field of laboratory equipment generated by special programme on PC monitor screen



to another one immediately appears on the computer monitor in the form of the electrical circuit, which is the task card analogue (Appendix 1) [4, p. 130]. Therefore, it is possible to visually follow the drawing of the electrical circuit on the screen. It must be noted, that assembly of all electrical circuits is performed as per specially developed algorithms [4, p. 16; 5, p. 29; 7, p. 126].

All the resistors need to be inserted in the sockets, and the wires need to be connected to the power source. If the circuit has been assembled correctly, the socket and the wires actuate. The sockets turn white, and the wires turn green (fig. 4). After power has been supplied to the electrical circuit, the sockets are actuated and turn yellow, and the wires turn red and blue. At that, the resistors

Fig. 4. Panel of laboratory bench with inserted resistors and actuated sockets



are actuated, and electric current begins to run through them by way of changing colours: red – white. At the same time, the window with the circuit is displayed (fig. 5).

Next step includes results actuation of instrumental gauging and also table actuation with experiment-and calculation results (fig. 6).

During the final step of laboratory work, through the use of formulae students must calculate values of resistors and insert results into the table (fig. 7).

We have adopted a special subprogramme to perform calculations for all types of laboratory work. The arrangement of circuits through the use of range of colours (red, yellow, green) and their application during calculation of relevant programmes made it possible to call these teaching operations “the principle of traffic lights”.

Laboratory equipment must comply with several requirements. First of all, it must provide the possibility to perform all types of specified laboratory work, and those which exceed its limits. The second indispensable condition for the system development is

the possibility to perform laboratory work in various subjects. And thirdly, which we have been tasked with, is the possibility to use this system as a simulator. This was required because future engineers-teachers had to perform certain techniques of assembly of electrical circuits, until they became automatic. At that, “trial and error method” had to be excluded.

Conclusions

The inspection of the unified system, which has been performed from 2006 to the present time, has revealed its high efficiency revealed its high efficiency. This made it possible:

- to minimize disadvantages of traditional teaching in the course of obtaining knowledge, to acquire certain professional skills and abilities and apply them in practice;
- to reduce preparation time of laboratory equipment prior to performing laboratory work;
- to reduce duration of laboratory work, and thereby increase their amount;

Fig. 5. Elements panel with electrical circuit under study

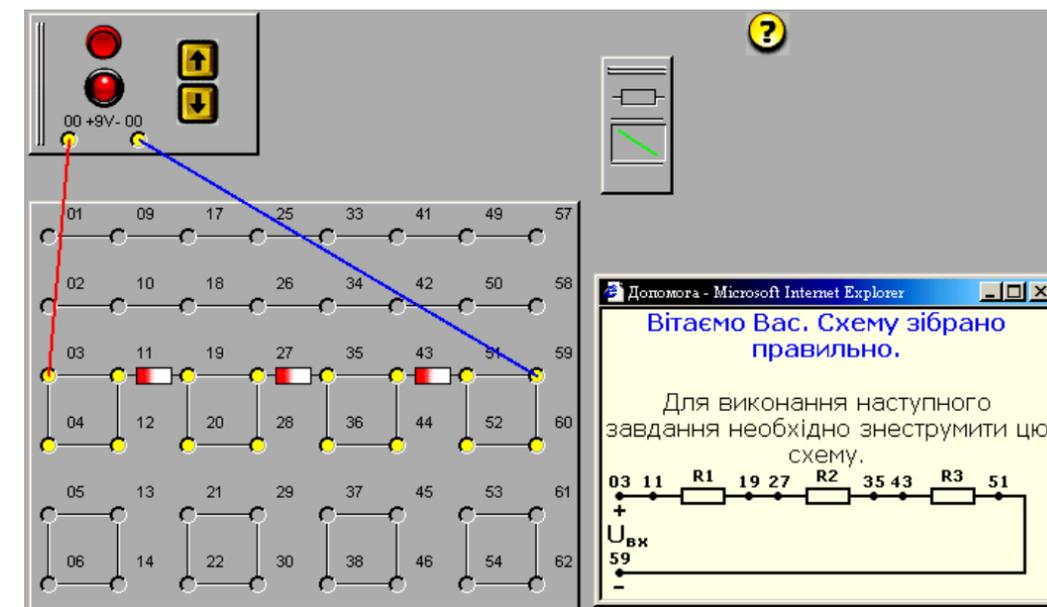


Fig. 6. Actuated panel with measuring instruments and table

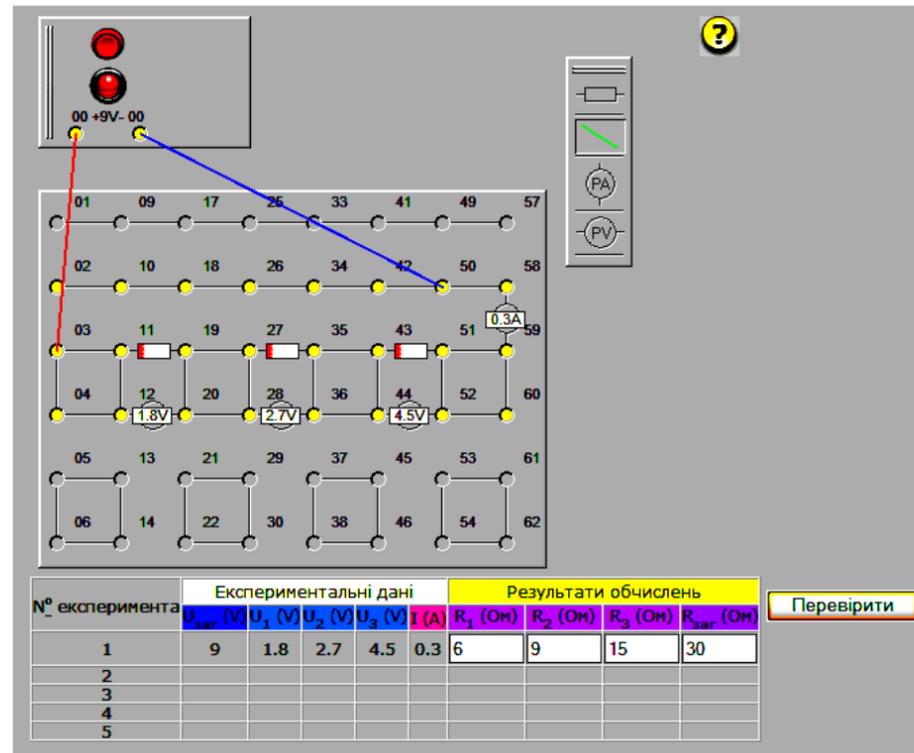
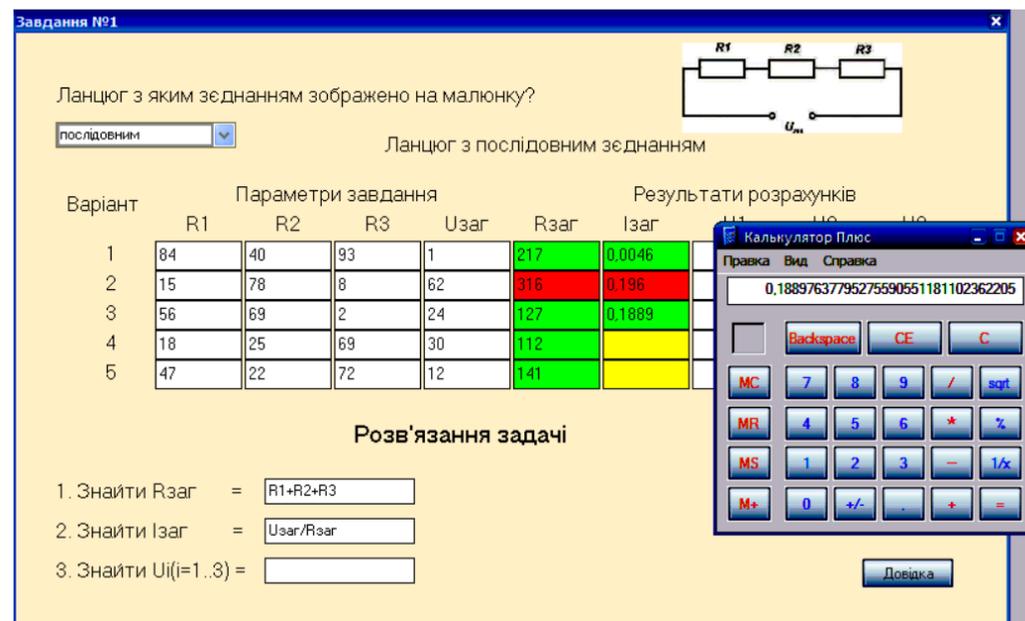


Fig. 7. Reflection of lab work calculation results in boxes and



- to reduce time required for assembly of electrical circuits during laboratory work;
- to exclude "trial and error method" during assembly of electrical circuits in the course of laboratory work;
- to increase the amount of tasks in each subject, in order to test various activities of students;
- to focus training of students on intellectual development by reducing

reproductive part and reinforcing creative and search activity.

Further research will be aimed at testing and endorsing practical and laboratory work on the integrated laboratory equipment in the course of other subjects, such as "Electrical Works", "Instrumentation" and also during generation of material content based on these disciplines.

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