

Zachepa Iurii, Ph.D., Associate Professor, Department of Automatic Control Systems and Electric Drive, Tel. (050)4026212; E-mail: sm261245@gmail.com

Zachepa Nataliia, Ph.D., Associate Professor, Department of Automatic Control Systems and Electric Drive, Tel. (050)4026212; E-mail: sm261245@gmail.com

Ganzevich Ivan, doctoral student PhD, Tel. (050)4026212; E-mail: sm261245@gmail.com

Kremenchuk Mykhailo Ostrohradskyi National University, 39600, Kremenchug, st. Pervomayskaya, 20

Shokarov Dmytro, Ph.D., Associate Professor, Department of Power Plants, Tel. (050)4026212; E-mail: sm261245@gmail.com

National Technical University "Kharkiv Polytechnic Institute" 61002, Kharkiv, st. Kyrpychova, 2

Cherkashyna Halina, Ph.D., Associate Professor, Department of Power Supply, Tel. (050)4026212; E-mail: sm261245@gmail.com

National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute" 03056 Kyiv Peremohy Av., 37

THE PRINCIPLES OF CREATION AND APPLICATION OF COMPUTER SIMULATORS IN THE TASKS OF ELECTRIC POWER INDUSTRY

Abstract. *The work presents the structure and the necessary complex of elements that ensure the functioning of computer simulators-simulators in the tasks of electric power engineering. The organization of the system for ensuring work in the given computer simulator-simulator is proposed. On the basis of the formulated general technical requirements for simulator software, their tasks and functions, a computer simulator-simulator of an autonomous power-generating installation was developed to practice the skills of technical operation of electrical installations of consumers. Mathematical support for the formation of subprograms as independent elements capable of interacting with each other is proposed. On the basis of the formulated general technical requirements for the software of the simulator, its tasks and functions, a computer simulator of an autonomous power plant was created to form the skills of technical operation of the consumer of electrical equipment. An algorithm for software and hardware implementation of a computer simulator-simulator, identical to a real physical autonomous mini-power plant based on a diesel-generator unit, has been developed.*

Keywords: *virtual laboratory complexes, computer simulator, distance learning, automated learning systems.*

Зачепа Юрій Володимирович, к.т.н., доцент, кафедра систем автоматичного управління і електроприводу, Тел. (050)4026212; E-mail: sm261245@gmail.com

Зачепа Наталія Василівна, к.т.н., доцент, кафедра систем автоматичного управління і електроприводу, Тел. (050)4026212; E-mail: sm261245@gmail.com

Ганзевич Іван Павлович, докторант PhD, Тел. (050)4026212; E-mail: sm261245@gmail.com, Інститут електричної інженерії та інформаційних технологій

Кременчуцький національний університет імені Михайла Остроградського, 39600, м. Кременчук, вул. Першотравнева, 20

Шокар'єв Дмитро Анатолійович, к.т.н., доцент, кафедра електричних станцій, Тел. (050)4026212; E-mail: sm261245@gmail.com

Національний технічний університет «Харківський політехнічний інститут» 61002, м. Харків, вул. Кирпичова, 2

Черкашина Галина Ігорівна, к.т.н., доцент, кафедра електропостачання, Тел. (050)4026212; E-mail: sm261245@gmail.com

Національний технічний університет України «Київський політехнічний інститут імені Ігоря Сікорського» 03056 м. Київ, проспект Перемоги, 37

ПРИНЦИПИ СТВОРЕННЯ ТА ЗАСТОСУВАННЯ КОМП'ЮТЕРНИХ ТРЕНАЖЕРІВ-ІМІТАТОРІВ В ЗАДАЧАХ ЕЛЕКТРОЕНЕРГЕТИКИ

Анотація. *В роботі представлено структуру та необхідний комплекс елементів, що забезпечують функціонування комп'ютерних тренажерів-імітаторів в задачах електроенергетики. Запропоновано організацію системи забезпечення роботи в наведеному комп'ютерному тренажері-імітаторі. На основі сформульованих загальнотехнічних вимог, що висувуються до тренажерних програмних засобів, їх задач і функцій, для відпрацювання навичок технічної експлуатації електроустановок споживачів розроблено комп'ютерний тренажер-імітатор автономної енергогенеруючої установки. Запропоновано математичне*

забезпечення формуванні підпрограм як самостійних елементів, здатних взаємодіяти між собою. На основі сформульованих загальних технічних вимог до програмного забезпечення тренажера, його завдань і функцій створено комп'ютерний тренажер автономної електростанції для формування навичок технічної експлуатації споживача електроустаткування. Розроблено алгоритм програмно-апаратної реалізації комп'ютерного тренажера-імітатора, тотожного реальній фізичній автономній мініелектростанції на базі дизель-генераторної установки.

Ключові слова: віртуальні лабораторні комплекси, комп'ютерний тренажер-імітатор, дистанційне навчання, автоматизовані навчальні системи.

Зачепа Юрий Владимирович, к.т.н., доцент, кафедра систем автоматического управления и электропривода, Тел. (050) 4026212; E-mail: sm261245@gmail.com

Зачепа Наталья Васильевна, к.т.н., доцент, кафедра систем автоматического управления и электропривода, Тел. (050) 4026212; E-mail: sm261245@gmail.com

Ганзевич Иван Павлович, докторант PhD, Тел. (050) 4026212; E-mail: sm261245@gmail.com, Институт электрической инженерии и информационных технологий

Кременчугский национальный университет имени Михаила Остроградского, 39600, г. Кременчуг, ул. Первомайская, 20

Шокарев Дмитрий Анатольевич, к.т.н., доцент, кафедра электрических станций, Тел. (050) 4026212; E-mail: sm261245@gmail.com

Национальный технический университет "Харьковский политехнический институт" 61002, г. Харьков, ул. Кирпичева, 2

Черкашина Галина Игоревна, к.т.н., доцент, кафедра электроснабжения, Тел. (050) 4026212; E-mail: sm261245@gmail.com

Национальный технический университет Украины "Киевский политехнический институт имени Игоря Сикорского" 03056 г. Киев, проспект Победы, 37

ПРИНЦИПЫ СОЗДАНИЯ И ПРИМЕНЕНИЯ КОМПЬЮТЕРНЫХ ТРЕНАЖЕЛЕЙ-ИМИТАТОРОВ В ЗАДАЧАХ ЭЛЕКТРОЭНЕРГЕТИКИ

Аннотация. В работе представлена структура и необходимый комплекс элементов, обеспечивающих функционирование компьютерных тренажеров-имитаторов в задачах электроэнергетики. Предложена организация системы обеспечения работы в приведенном компьютерном тренажер-имитаторе. На основе сформулированных общетехнических требований, предъявляемых к тренажерным программным средствам, их задачам и функциям, для отработки навыков технической эксплуатации электроустановок потребителей разработан компьютерный тренажер-имитатор автономной энергогенерирующей установки. Предложено математическое обеспечение в формировании подпрограмм как самостоятельных элементов, способных взаимодействовать между собой. На основе сформулированных общих технических требований к программному обеспечению тренажера, его задачам и функциям создан компьютерный тренажер автономной электростанции для формирования навыков технической эксплуатации потребителя электрооборудования. Разработан алгоритм программно-аппаратной реализации компьютерного тренажера-имитатора, тождественного реальной физической автономной миниэлектростанции на базе дизель-генераторной установки.

Ключевые слова: виртуальные лабораторные комплексы, компьютерный тренажер-имитатор, дистанционное обучение, автоматизированные обучающие системы.

Introduction. Electric power industry is among the sectors of the national economy, in which the need for highly qualified specialists with practical experience is especially acute. The modern realities, the pandemic and the war imposed certain restrictions on the practical training of highly qualified specialists in the electricity industry of Ukraine. Moreover, it can be added that when performing a number of technological operations, the workers are forced to be in constant contact with working electrical equipment, which determines the high level of injuries

Results and Discussions. Currently, one of the effective directions for improving the efficiency of the process of offline training of specialists in the specialty 141 «Electric Power Engineering, Electrical Engineering and Electromechanics» are automated training systems (ATS) [1]. The most effective technical means of working out the safe and remote labor techniques is a computer simulator based on multimedia computer programs, which simulates real working conditions (specific operations of the technological process) [2] and implements a physical and functional model of the human-machine-production environment system, its interaction with the subject of work and the technological process.

Research materials. The general requirements for a computer simulator software [3]. The computer simulator should include the necessary set of elements in its structure that ensure its functioning. The composition of the simulator is shown in fig. 1.

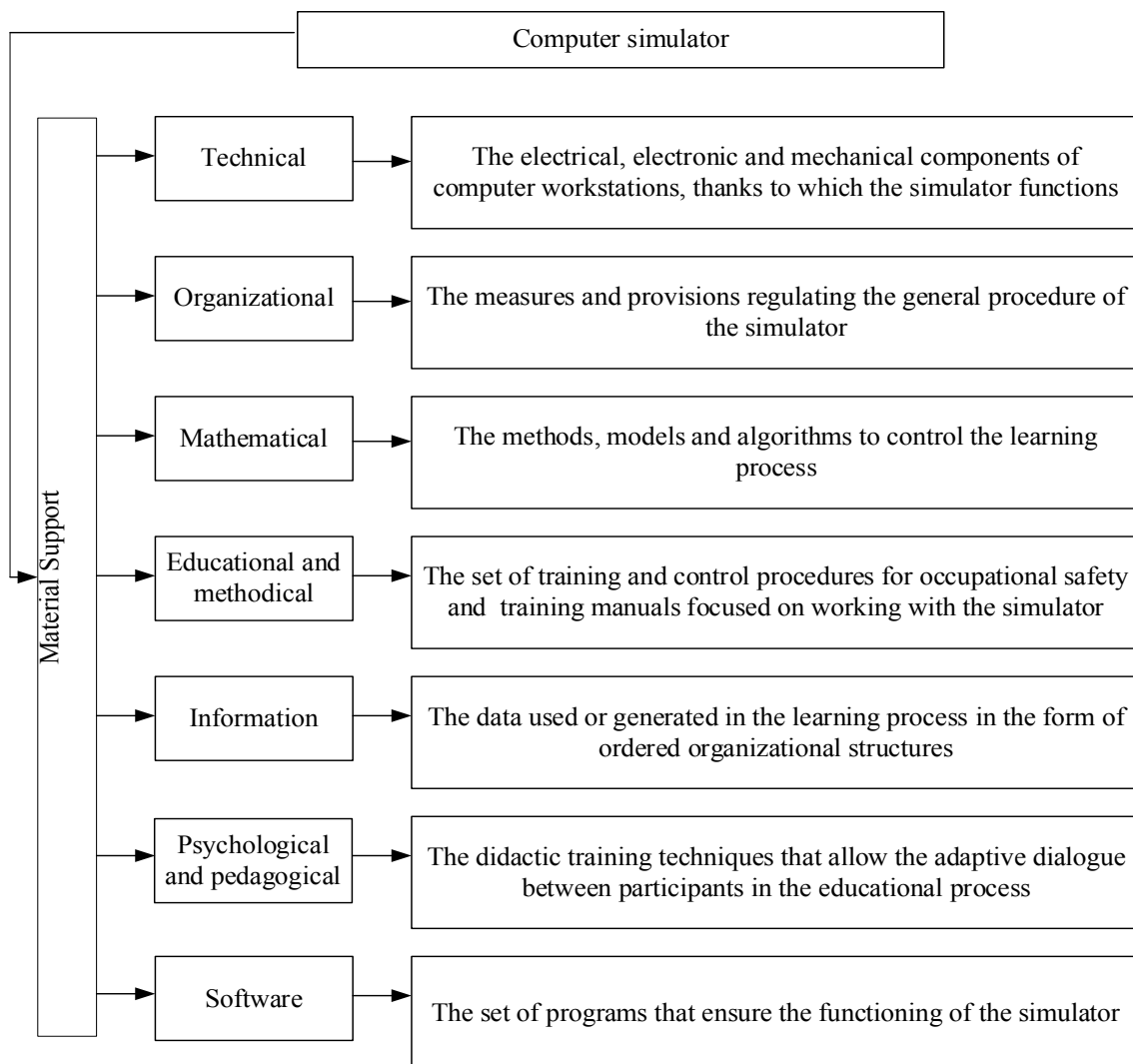


Fig. 1. Composition of computer simulator

The basis of the organization of the system for ensuring work in the given CS (Computer Simulator) is the block principle of building a mathematical support [4, 5], which consists in the formation of subroutines as independent elements capable of interacting with each other under the control of the organizing program. Such an aggregate principle of construction allows us to propose a systematic approach to ensure the proper level of healthy and safe working conditions for workers of different professions, to increase mathematical support, to create libraries of ready-made elements of the technological process [6], to configure CS on the development of various kinds of skills (speed of decision-making in a particular situation, working out a clear sequence of actions or operations in both regular and abnormal modes, etc.).

The following construction principles were used when creating the CS:

- the principle of conformity of the structure of skills formed with the help of a computer simulator with the structure of real labor skills in the execution of technological process operations, which means the simulation of the professional activity of the worker is fully carried out;

- the principle of target training, for which the main purpose of using the simulator is not to acquire knowledge, but to master the skills of safe performance of work;

- the principle of the active approach, which means that the computer simulator is necessary for the training of workers who need the skills of real production work.

The use of CS for the training of specialists in both the electric power industry and specialists in other industries allows: to improve the quality of training of employees from the electric power industry, to reduce the cost of professional training by reducing its terms, to conduct training in safe conditions, to increase the degree of objectivity of assessment of qualification of employees undergoing training (their knowledge and skills) due to the maximum realism of the task [7].

Therefore, based on the peculiarities of the activity, when preparing employees from the electric power industry, it is advisable to use CS as an addition to the adopted training system and form the basis of a systematic approach of training for ensuring the safe working conditions during technological operations [8, 9]. The ATS software for ensuring safe labor methods includes the corresponding software modules (Fig. 2.)

These software modules ensure compliance with all the requirements for CS and functions, as well as provide a full (network) version of the software. To implement this option, you need to have a local network. In this case, all data are stored on the central (server) PC. There should also be Module_2 and Module_3. There are interactive training modules - Module_1 on the workstations.

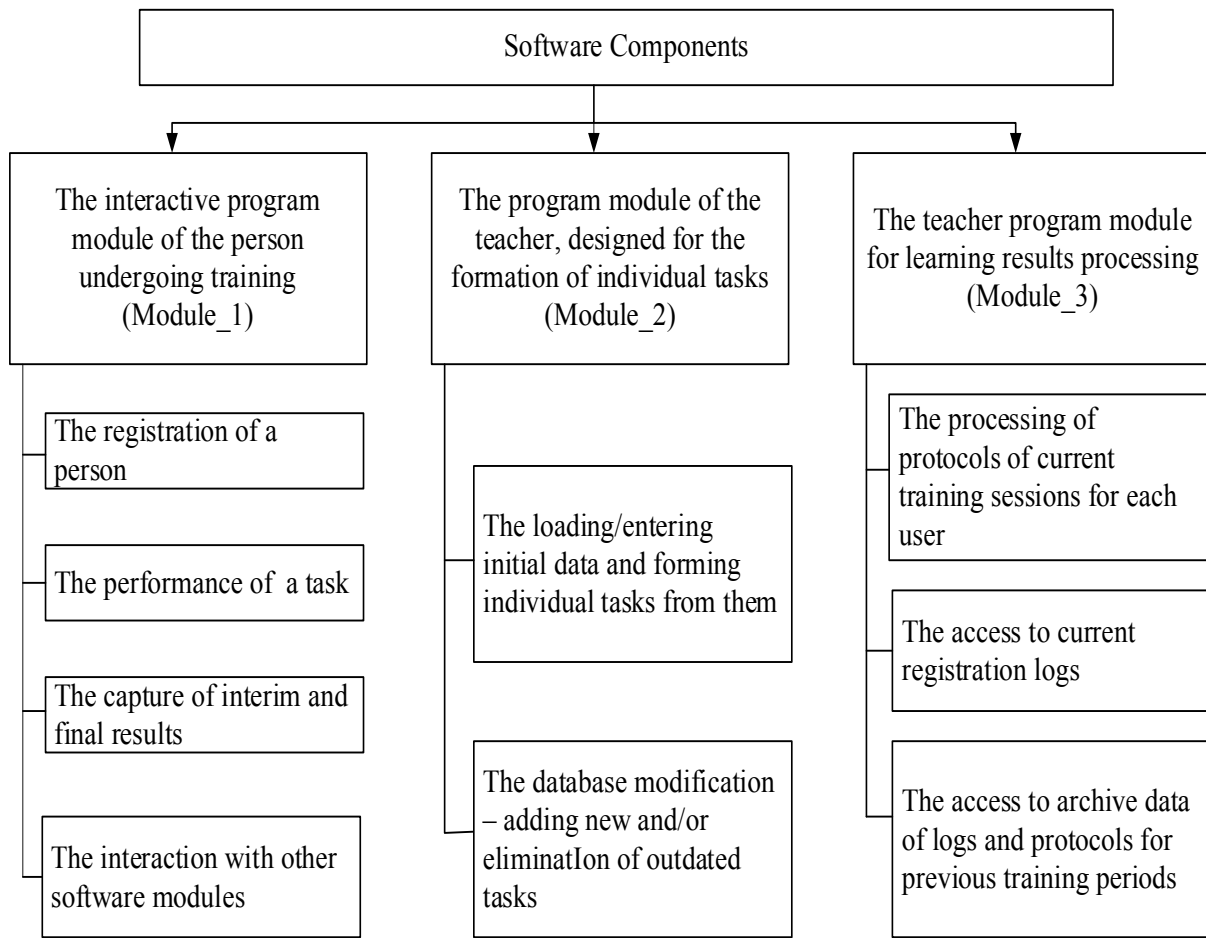


Fig. 2. Composition of CS software

The implementation of software and hardware part of computer simulator on the example of an autonomous power generating unit.

A real power generating plant compared to CS has a higher cost, more complex internal structure and voluminous technical documentation. This kind of equipment is difficult to upgrade and change the technical characteristics and purpose. Therefore, in order to train specialists in the development of safe work performance during production, increase labor productivity, prevent injuries, study of energy processes in autonomous power generating units (APG) based on diesel generator units (DGU) with an asynchronous generator (AG), CS was developed [10, 11]. In addition, the created simulator allows you to simulate different operating modes, change and test different characteristics of the equipment, analyze the factors of emergencies, etc.

The front panel of CS is shown in Figures 3 (a , b).

The basis of the organization of the labor support system in the given CS is a block principle of building mathematical support, lies in the formation of subroutines as the independent elements capable of interacting with each other under the control of the organizing program.

Such an aggregate principle of construction allows to provide an integrated approach to the professional training of workers from the electric power industry, to increase mathematical support, to create libraries of ready-made elements of the technological process, to set up CS for practicing various kinds of skills (speed of decision-making in a particular situation, working out a clear sequence of actions or operations, etc.).

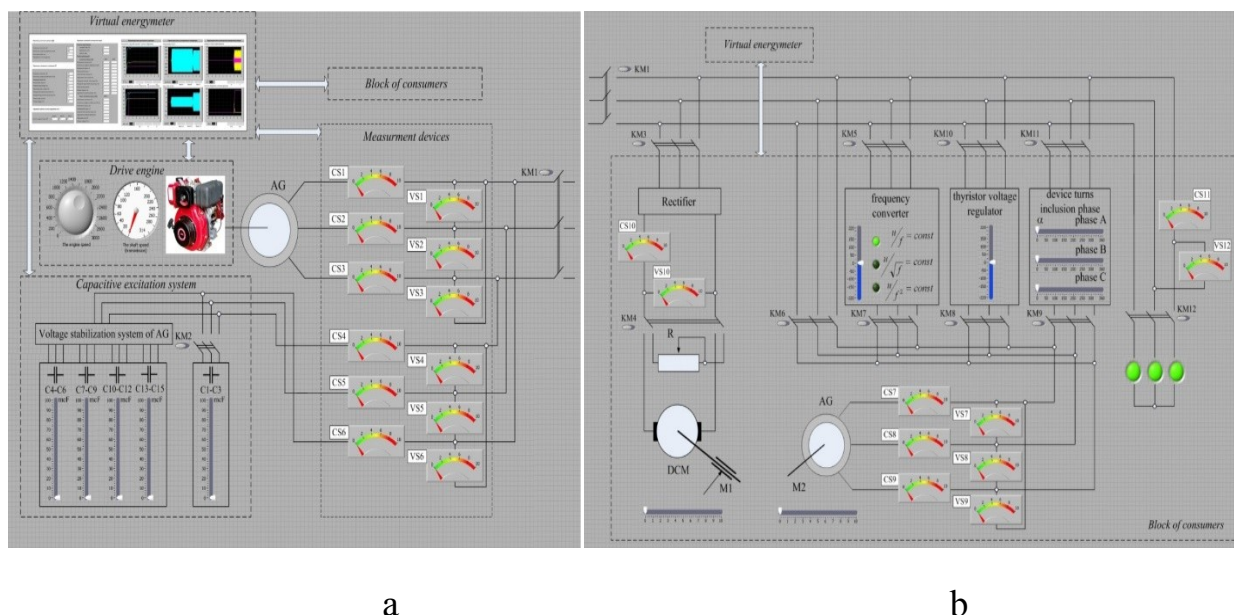


Fig. 3. CS front panel: typical power consumers

CS consists of the following main units:

- the "drive engine" unit - diesel internal combustion engine;
- the "electric energy converter" unit - asynchronous generator with capacitive excitation and stabilization systems of output voltage AG;
- the "consumers of electric energy" unit - includes AC consumers, both single-phase and three-phase. Thanks to the rectifier, the ability to connect DC consumers is realized;
- the "instrumentation" unit- contains current and voltage sensors, speed, torque, etc. These blocks form the basis of the interactive program module of the person undergoing training (Fig. 2, Module_1);
- the "virtual meter" unit - power signals are generated, then energy processes running in the system are determined with corresponding real-time implementation of all processes. The unit is also supplemented with an operator action retainer, which allows implementing various programs (Fig. 2, Module_2) for practicing the skills of safe execution of technological operations.

In addition to using the proposed virtual complexes in the educational process for the independent work of students and remote laboratory work, it is also possible to implement them in industry and in the field of scientific research. The

creation of mobile virtual complexes is especially interesting since it allows you to conduct the necessary research directly in the conditions of production, quickly receive and process the results of modeling and form the recommendations for improving the quality of management and the efficiency of using real equipment. The introduction of the developed systems in industrial enterprises is preceded by extensive research work. In this case, the developed CSs allow you to study the static and dynamic modes of operation of technological equipment visually, the study of its effective modes of operation.

Conclusion. The use of computer simulators is proposed to develop the skills for the training of specialists of the electrical profile and the implementation of technological operations.

On the basis of the formulated general technical requirements for the simulator software, their tasks and functions, a computer simulator of an autonomous power generating plant has been created to develop the skills of technical operation of the consumer of electrical equipment.

The algorithm for software and hardware implementation of a computer simulator, identical to a real physical autonomous mini-power plant based on a diesel-generator plant, has been developed.

The developed CS allows to solve a number of research problems: the analysis of technological capabilities and energy indicators of various methods of regulating technological parameters; the study of dynamic processes in the generator-motor system; the determination of regulatory and energy characteristics of systems, etc.

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Стаття надійшла до редакції 25.06.2022р.