SECTION 4. ELECTRIC POWER ENGINEERING

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INTERDISCIPLINARY APPROACH TO TEACHING ELECTRICAL ENGINEERING THROUGH PROGRAMMING

МІЖДИСЦИПЛІНАРНИЙ ПІДХІД ДО ВИКЛАДАННЯ ЕЛЕКТРОТЕХНІКИ ЗАСОБАМИ ПРОГРАМУВАННЯ

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The theoretical foundations of electrical engineering are a core discipline in engineering education, providing fundamental knowledge of electrical circuits, their laws, and methods of analysis. Studying this subject requires students not only to understand physical processes but also to perform a significant number of mathematical calculations. At the same time, in the early stages of learning programming, students focus on mastering logic, syntax, and conceptual constructs, and often work with abstract examples that have no direct connection to their future professional activities, as noted in [1, p. 6456].

Modern research in the field of training students in engineering specialties indicates a growing need for competency-based approaches to teaching that promote the development of cognitive and practical skills in programming [2, p. 20350]. However, these approaches are often considered in the context of IT courses without close connection to specific technical disciplines, and do not show how to integrate programming directly with a technical subject, such as electrical engineering, in the curriculum. Other studies, for example [3, p. 8], demonstrate the positive impact of programming on the understanding of technical phenomena, in particular electromagnetic processes, but do not propose generalized models combining technical knowledge and programming skills.

This creates a need for an interdisciplinary approach that combines fundamental disciplines, in particular the theoretical foundations of electrical engineering, with information technologies. Modern trends in engineering education indicate a gradual transition to competency-based learning [4, p. 2], which presupposes the active integration of digital technologies and interdisciplinary practices. Educational programs should develop not only professional disciplinary knowledge but also broad competencies, including digital skills, critical thinking, the ability to solve real-world engineering problems, and the effective application of information technology in a technical context.

The interdisciplinary approach discussed in this paper addresses these limitations through the gradual integration of calculations in the course on the theory of electrical engineering and programming, the development of testing competencies, and the systematic verification of results. This is an important step toward improving the effectiveness of technical education.

At the initial stages of learning programming, it is advisable to combine the study of programming fundamentals with the calculation of DC electrical circuits, which are relatively simple and intuitive from an engineering perspective. Such problems allow students to become familiar with basic programming concepts, in particular data types, type casting, arithmetic operations, and the main control constructs of a programming language. As the course material becomes more complex and students move on to electrical circuit calculation methods, such as the nodal potential method and the loop current method, the need to work with systems of linear equations arises in programming. This, in turn, requires the use of matrix methods implemented using multidimensional arrays and corresponding mathematical operations. This ensures a natural transition from simple algorithms to more complex programming structures.

As their programming knowledge deepens and the complexity of the problems in the electrical engineering course increases, students gradually master the means of visualizing calculation results, particularly graphical output, and acquire basic knowledge of numerical methods. In this case, graphical representation of signals in the form of timing diagrams or vector diagrams provides a visual tool for analyzing processes in AC circuits. Figure 1 shows an example of software implementation for calculating a three-phase electrical circuit, combining a schematic representation, numerical results, and graphical visualization. The program calculates phase currents and voltages and constructs a vector diagram, which allows for a clear illustration of phase shifts and the symmetry of a three-phase system.

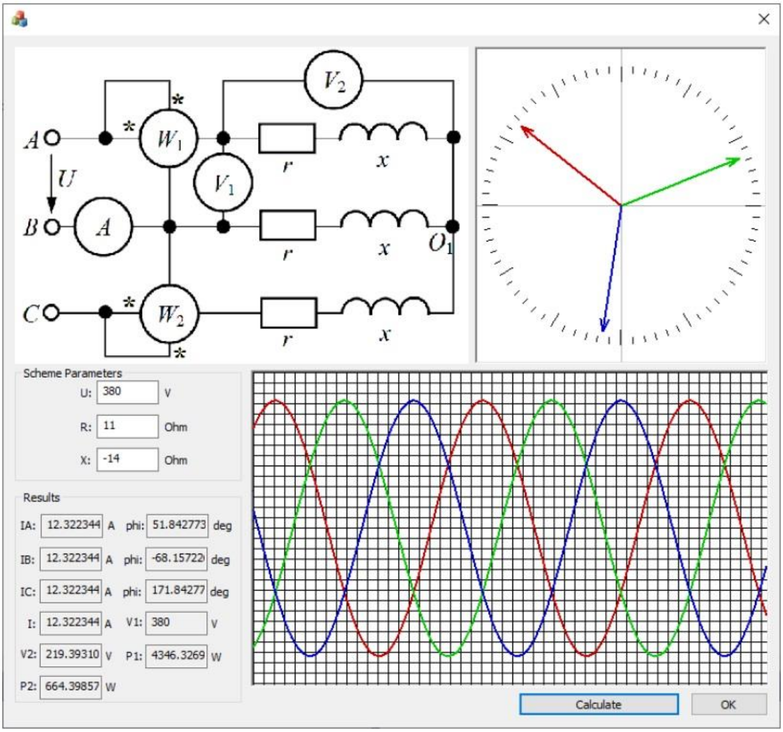

Fig. 1. Results of the software-based calculation of a three-phase circuit

The use of numerical methods is effective for calculating transient processes, performing parametric analysis of electrical circuits, and studying the impact of changes in component parameters on system operating modes. Implementing such methods in a software environment facilitates a deeper understanding of dynamic processes in electrical systems.

Particular attention should be paid to working with complex numbers, which are widely used in the analysis of AC circuits. During programming, it is advisable to create a custom class for representing complex numbers with overloaded arithmetic operators, allowing students to combine theoretical knowledge of electrical engineering with object-oriented programming approaches.

The presented methodology eliminates these shortcomings through a step-by-step approach:

– at the initial stages, students solve simple DC problems, which allows them to master data types, type casting, and basic operations;

– later, when studying nodal potential and loop current methods, systems of linear equations, multidimensional arrays, and mathematical operations are used;

– when analyzing AC circuits, signal visualization is used to clearly demonstrate phase shifts and transient processes;

– for working with complex numbers, the creation of a custom class with overloaded operators, integrating programming and mathematical modeling is proposed.

An analytical calculation of an electrical circuit, performed by a student in accordance with the theory of electrical engineering, should be considered a reference solution. The obtained results can be used to verify the correctness of the algorithms and software implementations. Comparing the results of manual and software calculations allows for the identification of possible errors in algorithms, the implementation of numerical methods, or the processing of input data, which develops students' basic skills in software testing and verification, as well as an understanding of the permissible errors inherent in numerical methods. The interdisciplinary approach proposed in the thesis is practically implemented in the textbook [5], which describes in detail the methods for the step-by-step integration of programming with electrical circuit calculations, numerical methods, and the visualization of results. Thus, the combination of programming and the theoretical foundations of electrical engineering provides an interdisciplinary link between academic disciplines, fosters professional, information technology, and analytical competencies, develops engineering thinking, and enhances the effectiveness of the educational process. In this approach, programming and the theoretical foundations of electrical engineering mutually support each other, creating a synergy focused on the practical training of future engineers.

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