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ADVANTAGES OF VIRTUAL MODELING FOR THE DEVELOPMENT OF MEASURING DEVICES

The relevance of using virtual modeling of devices for engineering design is considered. An analysis of the publication on the application of computerized design technologies in the processes of device development was made. The possibilities and ways of using computer modeling in the process of developing devices in the Proteus Design and SolidWorks software environments are indicated. In the Proteus Design software environment, you can simulate the operation of electrical circuits containing programmable devices: microcontrollers and microprocessors, as well as design a printed circuit board. A large number of virtual tools are used to simulate the circuits, which simulate the operation of measuring devices, which facilitates the development of electrical circuits. The ARES PCB design module has an autorouter that allows you to automate the design process. As a result of the design of the printed circuit board, a pattern of tracks is obtained, which is used for the manufacture of the printed circuit board by various methods. The article demonstrates all the stages of designing an electronic device. On the basis of the comparison of the simulation results and the operation of the manufactured device, conclusions are made about the effectiveness of the application of simulation in the engineering design of electronic measuring devices.

Key words: virtual device, three-dimensional model, electrical circuit, automated design system.

Introduction. The development of new devices is an important tool for the growth of companies [1]. Engineering design of electronic devices is a science-intensive activity. The application of various types of virtual simulation of devices with the help of computer software greatly facilitates engineering design. Virtual simulation has become a necessity these days. It saves time for the development of new devices, reduces the number of physical prototypes and experiments, reduces cost, and also increases the quality of final products, facilitates understanding of the design of a new device, improves management and automation processes [2] - [5]. Virtual modeling helps in planning and project management and ensures the quality of construction in compliance with standards and regulations [6]. Virtual modeling is the process of creating a complete model of a component, part, or assembly on a computer. A virtual model is a digital representation of a physical object and serves as the basis for modeling the manufacturing process and the structural behavior of the part. Virtual models are often used to create device prototypes [7].

Analysis of publications and formulation of the research task. Computerized design technologies have been used in the development of devices for a long time. A large number of scientific and scientific-methodological works and studies are devoted to the study of the problem of using information technologies for the design of devices. These works consider various aspects of the problem. The works [8-10] consider the concept of virtual and digital modeling, discuss the historical development and technologies, explore the consequences and advantages of this technology, describe in detail the specific branch applications of virtual modeling, and explore the advantages of analytical and virtual modeling. Approaches to the design of products and processes are investigated in [11]. These studies show how product data is used to analyze a variety of manufacturing activities in a virtual environment: product development, production planning, assembly analysis, work research, workplace design, work simulation, and production layout. It describes the methodology adopted and discusses the advantages and disadvantages of using the software.

The purpose of this work is to analyze the possibilities and use of computer modeling in the process of developing electronic measuring devices in Proteus Design and SolidWorks software environments.

Presenting main material. Proteus, NI Multisim, Micro-Cap and others are specialized software environments designed for automated design and simulation of electronic circuits. These software tools allow you to create electrical circuits using graphic editors, edit component parameters. Analog, digital, and analog-to-digital devices can be simulated in these environments. These software

products of computer modeling use "virtual" devices, by which we mean a mathematical model that imitates the structural and functional principles of the device.

The Proteus Design software package is a circuit modeling system based on electronic component models adopted in PSpice. A feature of the Proteus Design software package is the ability to simulate the operation of programmable devices: microcontrollers, microprocessor systems, DSP, etc. Proteus Design consists of two modules: ISIS (Intelligent Schematic Input System) - a graphic editor of electronic circuits and ARES (Advanced Routing and Editing Software) - a graphic editor of printed circuit boards with an autorouter. The presence of ARES makes Proteus Design an automated design system.

To create and edit electrical circuits in the ISIS module, the following actions must be performed: selection, placement of elements on the circuit and their connection. Elements for the scheme are selected from the program libraries. To place an element on the diagram, the orientation change commands - "Rotation" and "Reflection" are often used. The design of the electrical circuit is accompanied by the adjustment of the nominal values and properties of the components in the dialog boxes (Fig. 1)

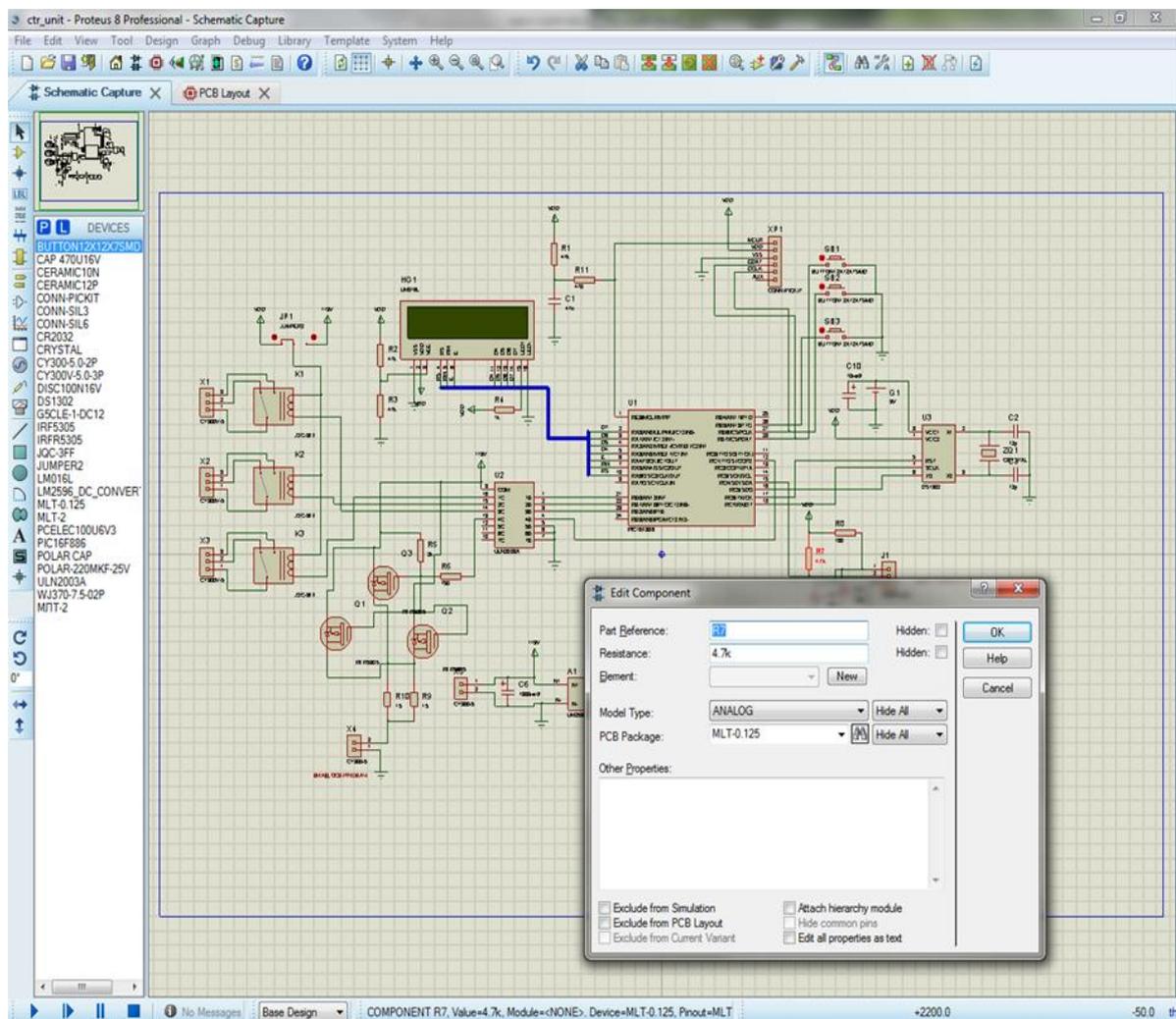


Figure 1 – View of the ISIS module window when designing a circuit diagram

In the ISIS module, you can simulate the operation of electrical circuits. Two types of simulation are used: Interactive Simulation and Graph Based Simulation. The use of real-time simulation strongly depends on the complexity of the circuit and the computing capabilities of the computer. With Graph Based Simulation, you can perform a more detailed analysis of circuits: construction of transmission, amplitude-frequency, voltage-current characteristics.

The advantage of performing Interactive Simulation is the ability to interact with the virtual circuit as with a real device. For this, special virtual devices, components and indicators are used. Such virtual devices include: voltmeter, ammeter, oscilloscope, counter/frequency meter, signal generator,

logic analyzer, etc. Virtual components are used to influence the scheme: switches, potentiometers, thermal and photoresistors, thermocouples, etc. Interaction with such components is possible by clicking with the mouse on the image of the component itself or on the red arrows next to the image of the component. Both in the real device and in the virtual one, there are also various models of indicators and boards: LEDs, seven-segment and liquid crystal symbol boards.

The ISIS module in interactive mode can simulate circuits of devices with microprocessors. To simulate the operation of the microprocessor, the compiled program file ("Program File"), processor clock frequency ("Processor Clock Frequency") and other settings ("Advanced Properties") are specified in the microprocessor model. The binary file of the program is created in the development environments or in the Source Code module of the Proteus Design package.

In interactive simulation, you can debug the microprocessor program step by step. Step-by-step execution of the program is enabled by pausing the interactive simulation or by adding a breakpoint to the program. In the interactive simulation pause, you can call up various windows with information about the current state of both microprocessor models and other microcircuits (Fig. 2). The "Source code" window is the main window for monitoring the progress of the program. The "Watch Window", "Variables", "Registers", "Data Memory", "EPROM Memory" windows are also used for debugging the microprocessor program. These windows display the state of the microprocessor's memory, which is used to analyze the correctness of the program execution.

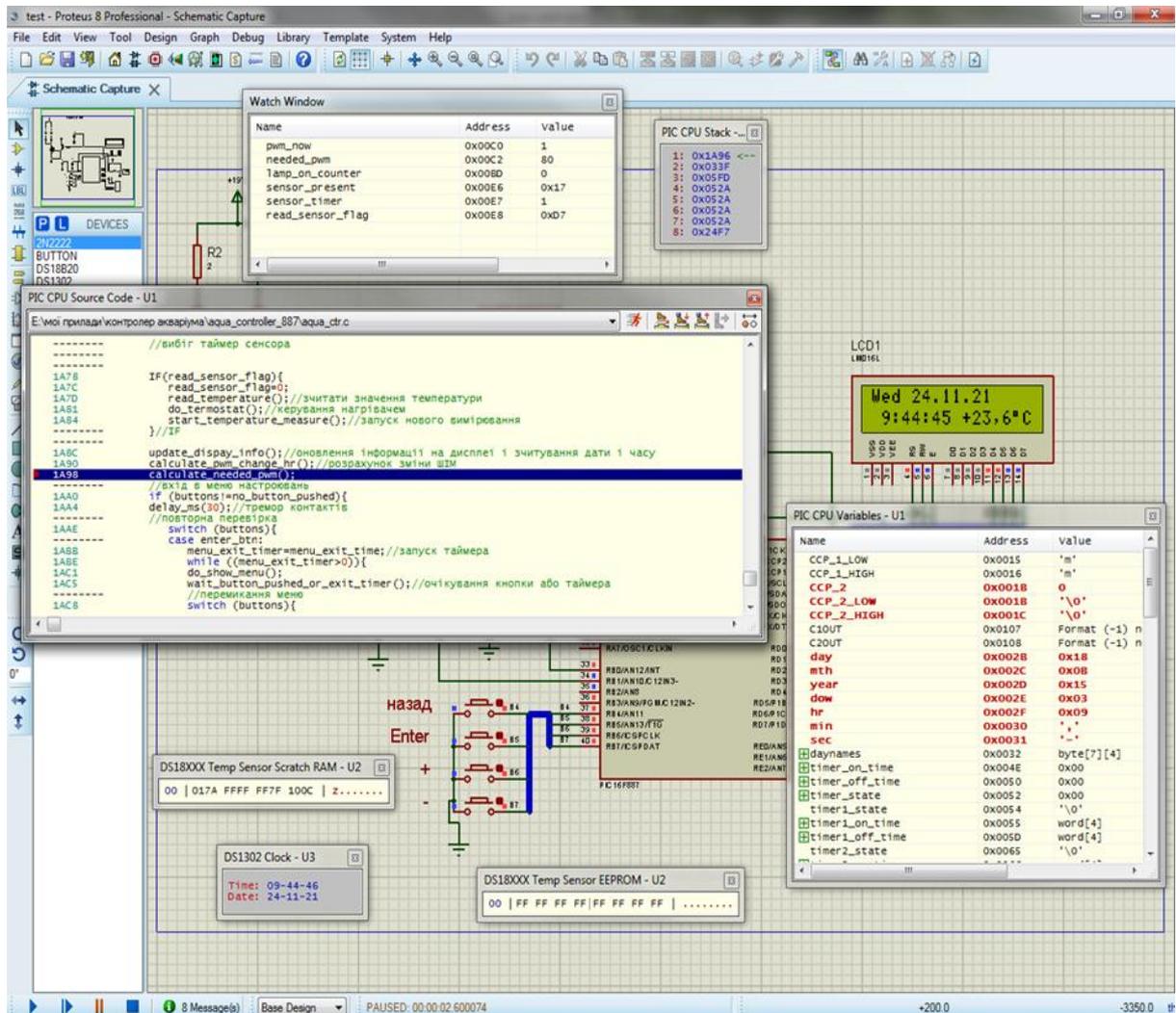


Figure 2 – View of the ISIS module window in the debugging mode of microprocessor equipment

The design of the electronic unit and printed circuit board is carried out by modeling the ARES module in two-dimensional space with the subsequent generation of a three-dimensional model (Fig. 3). In printed circuit board design environments, special layers are used to place 2-D graphics of radio elements, printed conductors, contact pads, etc.

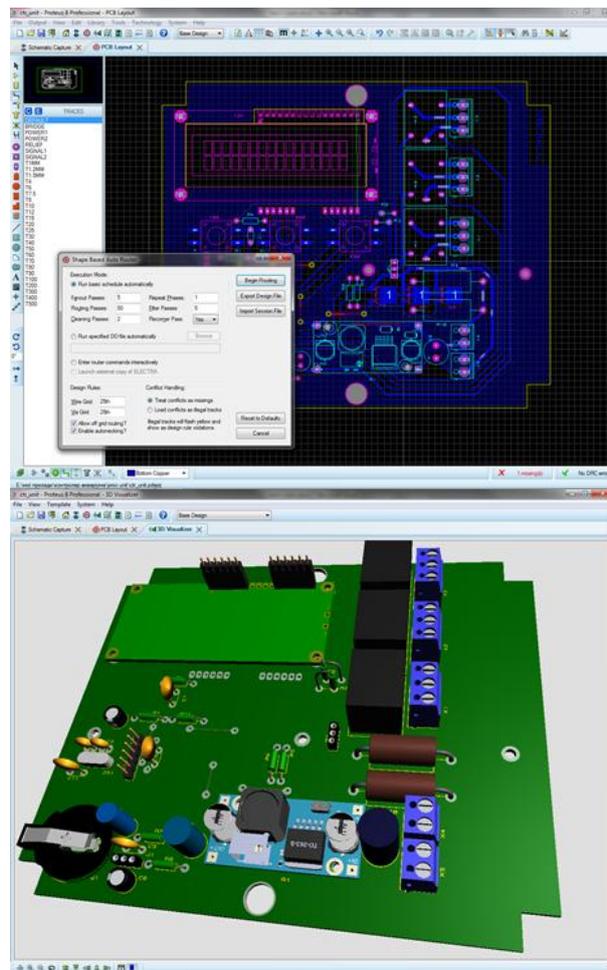


Figure 3 – View of the ARES module window in PCB editing mode and PCB 3D view

Modeling of the printed circuit board is done in two stages: placement of radio elements and tracing of printed conductors. The placement of radio elements depends on the features of the printed circuit board. Such elements as the liquid crystal screen, buttons, etc., must be in the specified places. Other elements can be placed in arbitrary places, taking into account electromagnetic compatibility and connections between them. Placement of elements on the printed circuit board model in the ARES module consists in indicating their location with the mouse pointer.

After placing the elements, trace the printed conductors. In ARES, printed conductors are traced manually or with the help of a special program - an autorouter. It is more convenient to first trace with an autorouter and then adjust the printed conductors manually. In the manual adjustment of printed conductors, the "Drag and Drop" technology, which is in graphic editors, is used.

The three-dimensional model of the printed block is further used for three-dimensional modeling of the device in the SolidWorks environment. This modeling involves the modeling of the case, the placement of the device parts in the printed block and it. A file of a three-dimensional model of a printed block in ARES is created using the "3D M-CAD Output" dialog box. A variety of 3D modeling software uses file formats that allow 3D models to be exchanged between them. Files in IGES, STL, and STEP formats are most widely used.

SolidWorks is one of the most popular environments for 3D modeling and automated design of complex products for various purposes. This program is a complete set for designing products in virtual form. The basic functionality of the program includes: 3-D modeling; design of welded structures; automated creation of drawings; design taking into account the material of the product; visualization; design of sheet metal products; animations of the finished product; data export in various formats. There are also calculations using the finite element method for strength, hydro- and aerodynamic flows, and bending. The use of additional extensions significantly increases the capabilities of the program.

Three-dimensional modeling of the device consists in the composition of models of parts in the assembly (Fig. 4) - their placement and the creation of geometric relationships between them.

Geometric connections between models of parts are called mates. In SolidWorks, the following combinations are most often used to compose part models: coincidence, parallelism, perpendicularity, tangent, concentricity, distance.

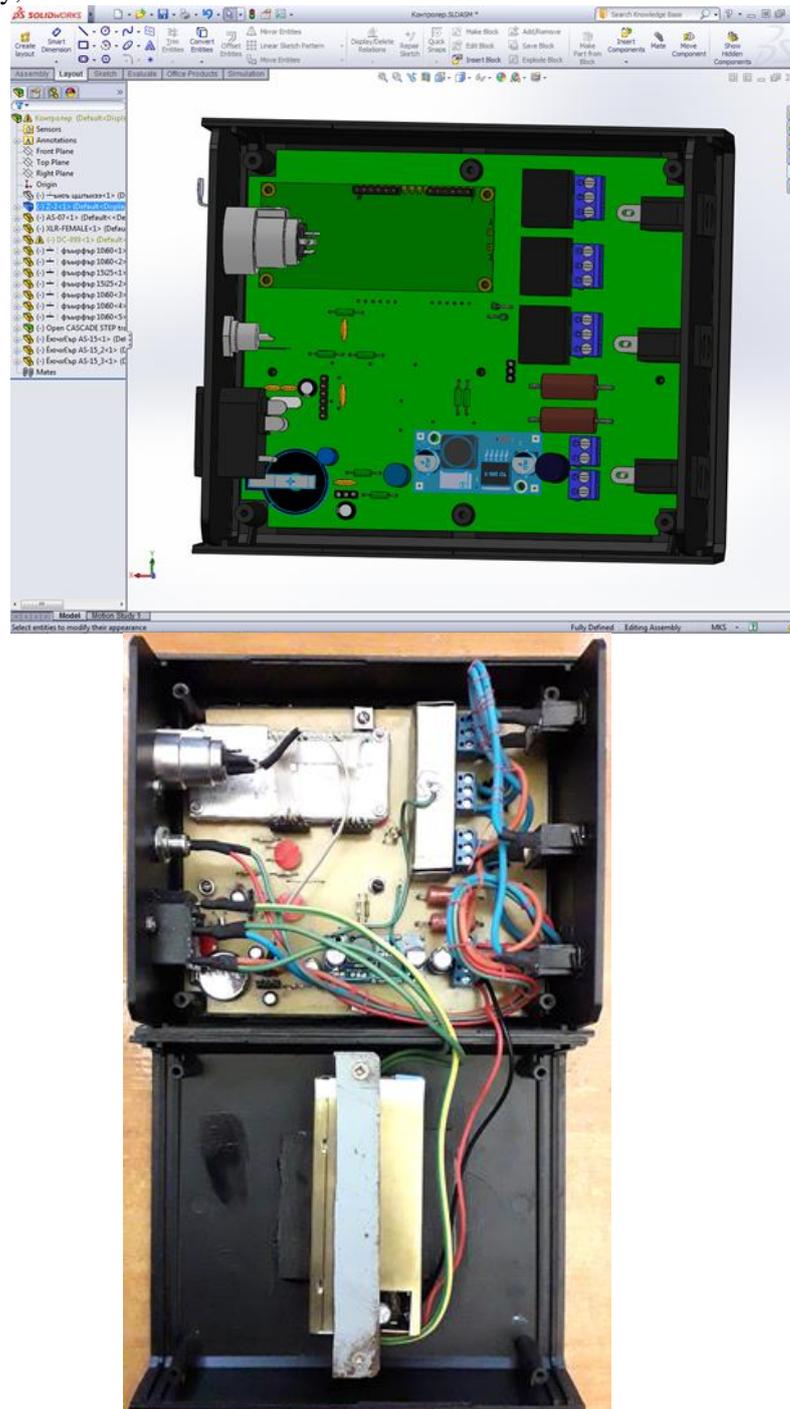


Figure 4 – A view of the SolidWorks window with a device model and a photo of the manufactured device

Conclusions. The conducted analysis makes it possible to conclude that virtual modeling has revolutionary prospects for increasing the efficiency of new product development processes, in particular measuring devices. The use of the Proteus Design and SolidWorks environments in the development of devices is promising both for the design of devices and for the study of subjects related to the study of the principles of device design by students of education. The combination of these environments is an effective tool both for designing devices as a whole and individual elements. The knowledge, skills and new experience acquired by students studying virtual modeling can play a significant role in the development and formation of a person both as a professional and as a person in general.

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ПЕРЕВАГИ ВІРТУАЛЬНОГО МОДЕЛЮВАННЯ ДЛЯ РОЗРОБКИ ЗАСОБІВ ВИМІРЮВАЛЬНОЇ ТЕХНІКИ

*Розглянуто актуальність застосування віртуального моделювання приладів для інженерного проектування. Зроблено аналіз публікації щодо застосування комп'ютеризованих технологій проектування в процесі розробки приладів. Вказано можливості і шляхи застосування комп'ютерного моделювання в процесі розробки приладів в програмних середовищах *Proteus Design* і *SolidWorks*. В програмному середовищі *Proteus Design* можна моделювати роботу електричних схем, що містять програмовані пристрої: мікроконтролери і мікропроцесори а також проектувати друковану плату. Для моделювання схем використовують велику кількість віртуальних інструментів, які імітують роботу вимірювальних приладів, що полегшує розробку електричних схем. Модуль проектування друкованих плат *ARES* має автотрасувальник, який дозволяє автоматизувати процес проектування. В результаті проектування друкованої плати отримують рисунок доріжок, який використовують для виготовлення друкованої плати різними методами. В статті продемонстровано усі етапи проектування електронного приладу. На основі порівняння результатів моделювання і роботи виготовленого приладу зроблено висновки про ефективність застосування моделювання в інженерному проектуванні електронних вимірювальних приладів.*

Ключові слова: віртуальний прилад, тривимірний модель, електрична схема, система автоматизованого проектування.