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Methods of converting digital signals to analog (continuous) signals and their essence" to link teaching to pedagogical technologies.

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Annotation: A scientific article on the topic “Circuit design and microprocessor systems” is devoted to the issues of “Methods for converting digital signals into analog (continuous) signals and their essence”, advanced interactive methods and the use of innovative educational technologies in teaching.
Based on the potential and capabilities of students, a teaching methodology for this course has been developed. An attempt has been made to highlight examples of pedagogical technologies that can be used during lectures, laboratory classes and practical exercises.
The results achieved with the help of the methods used ensure deepening of students' knowledge, expanding their thinking abilities, the ability to work in a team, the ability to process and analyze the information received, the complete and lasting assimilation of the information provided, and the critical habituation of students to thinking. , learns to work with technology, gets acquainted with devices and elements, learns to independently design based on the task at hand, learns to build static and dynamic characteristics of the device.

Keywords: DAC, ADC, converter, adjustment, two-weighted resistance, resistor matrix, zero and one, static parameters DAC, dynamic parameters DAC.

Introduction

The relevance of the topic of the article and its rationale. The renewal of society is the development and prospects of our life, the prosperity of our Republic as an independent state, its recognition in the world, the formation of

economic and social policies with a socially active, creative and strong civic position typical of the market. economy. in society. It is necessary to create a structure for the integration of pedagogical and psychological education that ensures the effectiveness of this process through a correct understanding of oneself and actions.

Currently, the development of technology stimulates the further development of science in the practical sphere. This plays an important role in the automation of process devices used in various industries. In particular, one of the main places is occupied by the application of information technology achievements in production and their development.

As the President of the Republic of Uzbekistan Shavkat Mirziyoyev determined in the priority areas of development of the social sphere "Strategy of action in the five priority areas of development of Uzbekistan for 2017-2021", on the development of the sphere of education and science", "Continuing the path of further improving the system of lifelong education, increasing the opportunities for providing quality educational services, training of highly qualified personnel in accordance with modern needs of the labor market.

1.1. Digital and analog signal.

We all live in two worlds: the analogue world is the real world, our real world, and the world of computers and smartphones is the digital world. Therefore, it is important to understand the difference between an analog signal and a digital signal.

The signal can be analog or digital. An **analog signal** is a continuous signal that can take on any value within the maximum and minimum range of its amplitude. Its disadvantage is the presence of noise, which sometimes leads to complete loss of data. Situations often arise when it is impossible to determine where the critical information is in the code and where the typical errors are.

A **digital signal** is a signal that takes on a finite number of values (0 or 1). That is, any information is encoded using 0 and 1.

Its amplitude can have a certain value from already established values. Although an analog signal can contain a lot of noise, a digital signal filters out most of the received noise. In addition, several codes can be sent simultaneously over one channel. Figure 1 shows a graphical representation of analog and digital signals.

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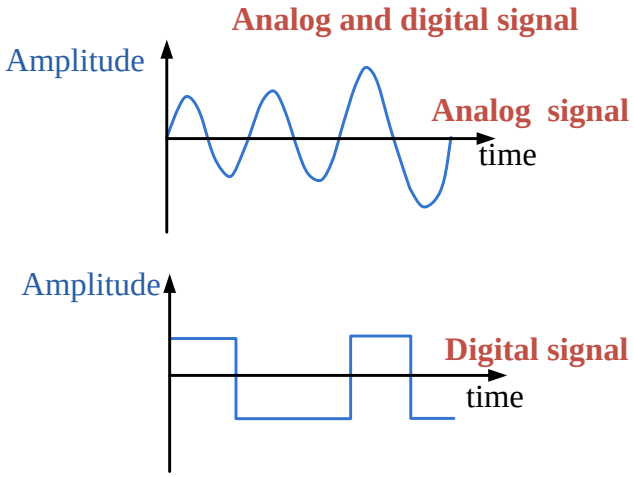


Figure 1. Analog and digital signal

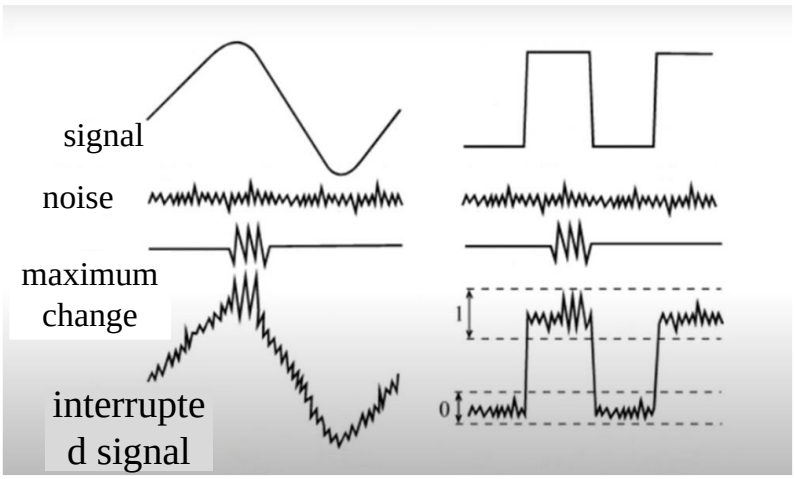


Figure 2. Protection against interference of analog and digital signals

1.2. DAC concept.

Application area A DAC-to-digital-to-analog converter is a device for converting digital (usually binary) code into an analog signal (current, voltage, or charge). DAC is an interface (bridge) between discrete digital and analog circuits. The scope of application of radioactive waste is very wide. These include audio amplifiers, audio encoders, video processing devices, display devices, data acquisition systems, calibration of sensors and other measuring instruments, motor control circuits, data distribution systems, digital potentiometers, programmable radio (SDR), etc.

DACs are used for exposure matching with analog devices, as internal nodes in AROs, and in digital metering devices.

Digital-to-analog converters (DACs) and analog-to-digital converters (ADCs) are used in measuring equipment (digital oscilloscopes, voltmeters, signal generators, etc.), in medical equipment, in radar instruments, in computer technology (audio input and output to a computer , video monitors, printers, etc.), are used in household appliances (TVs, stereos, car electronics, etc.), telephones and other various fields.

DAC chips decode digital information equivalent to the value of the output quantity (current, voltage). Digital information is represented by the corresponding code. The magnitudes of the bits in such a code are determined by the presence or absence of electrical voltage or high and low voltage levels.

A numeric code is expressed as a sequence of ones and zeros, for example (1100010100). In this case, it consists of 10 digits, known as digits.

The number of maximum bits that can be supplied to the input of the DAC and which can vary to the output value depends on the design and circuitry of the particular IC, which is proportional to the code value. The number of bits is a general characteristic that determines the nominal functionality of the IC. There are two RAO methods:

a) two-weighted resistive matrix;

b) resistor matrix R-2R.

1.3. DAC with two weighted resistors

The digital-to-analog converter (Fig. 3) is made of a resistor matrix that generates standard currents; from switches (K_i) connecting standard currents to the common point of aggregation in accordance with the access road code; From a practical amplifier (PA), which converts the current I_x into the voltage of the output path (U_{output}); I_t consists of a base voltage source (U_{base}). In the diagram in Fig. 3, a resistor with binary-weighted resistances of the form $R \square 2R \square \ldots \square 2^{n \square 1}R$ is used; a matrix is used. For example, if the current value for the first, largest chamber is taken I_1 = 1 mA, for the second chamber I_2 = 0.5 mA, for the third chamber I_3 = 0.25 mA and h. will.

Keys K_1 – K_p are controlled by voltage levels, which reflect the “zero” and “one” digits of the corresponding input path code numbers. PA access road since the potential is always zero, the summation of room currents is expressed by the following relationship.

$$I_x = \frac{U_m}{R} X_1 + \frac{U_m}{2R} X_2 + \frac{U_m}{4R} X_3 + \ldots + \frac{U_m}{2^{n-1}R} X_n =$$

$$= \frac{U_m}{R}\left(X_1 + 2^{-1} X_2 + 2^{-2} X_3 + \ldots + 2^{-(n-1)} X_n\right) = \frac{U_m}{R} \sum_{i=1}^{n} X_i 2^{-(i-1)} .$$

The voltage on the DAC output path is calculated using the following formula:

$$U_{chiq} = -I_x R_{t.b} = -U_T \sum_{i=1}^{n} X_i \cdot 2^{-i} \qquad 2$$

Here $R_{t.b.}$ = R/2 – resistance in the feedback circuit of the amplifier.

1.3. Resistor R-2R matrix DAC

A practical amplifier with several input path resistors (Fig. 4) allows the voltage applied to the resistors to be summed. The voltage at the input path (point “a”) of a

practical amplifier is close to zero. The input path voltage U_j creates a current $i = \frac{U_j}{R_j}$ in the corresponding resistor R_j.

The magnitude of this current is independent of the magnitude of the current flowing through other resistors. The op-amp directs the following current into the feedback loop.

$$i_{t.b} = -\sum_{j=1}^{n} i_j$$

Expressing the currents through the corresponding voltages, we obtain the following

$$U_{chiq} = -\sum_{j=1}^{n} \frac{R_{t.b}}{R_j} U_j$$

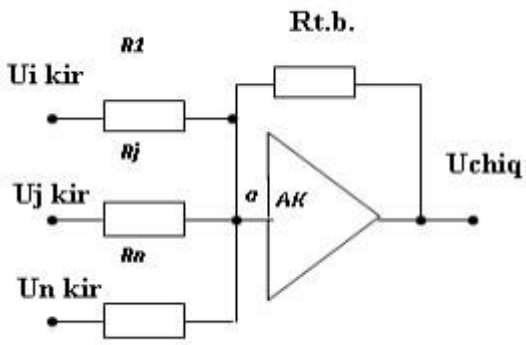


Figure 4. Adder circuit.

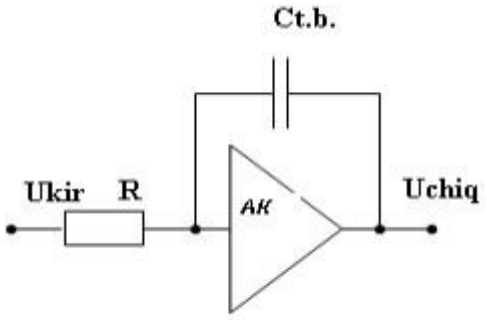


Figure 5. Integrator diagram.

The practical amplifier also allows integration operations.

In Fig. Figure 5 shows a circuit (integrator) that performs the integration operation. The voltage of the output path of the circuit is equal to

$$U_{chiq}(t) = -\int_{0}^{1} U_{kir}(t)dt$$

The switches in the digital-to-analog converters discussed above can be made according to the circuit shown in Fig. 7. "a".

The input path signal, reflecting the number in the code number of the input path, is bipolar (Fig. 7. “b”): the positive level (logical “1”) closes diode D1 and the reference current Ii is supplied to the input path PA through diode D2; a negative level (logical “0”) closes diode D2, and the reference current I_i is connected to the input signal source of path $U_{x,i.}$

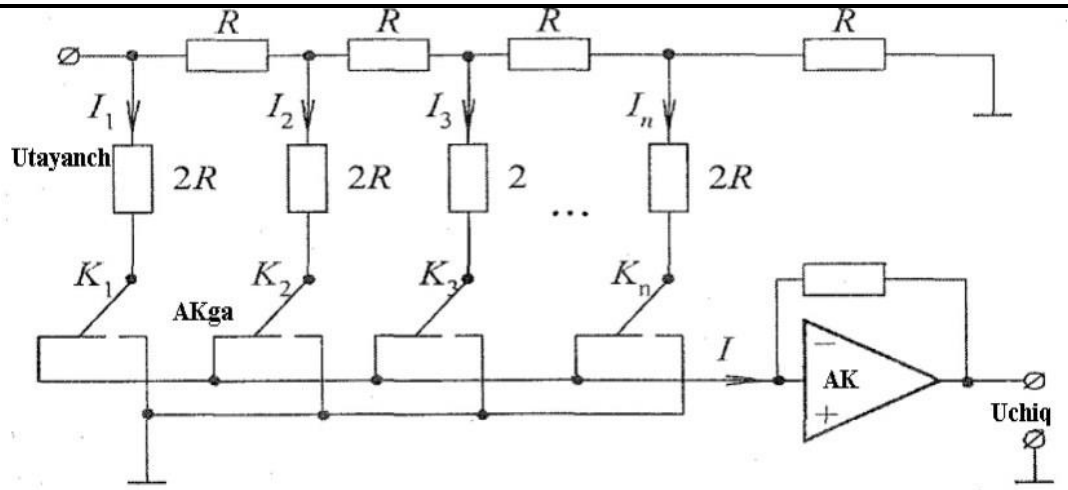
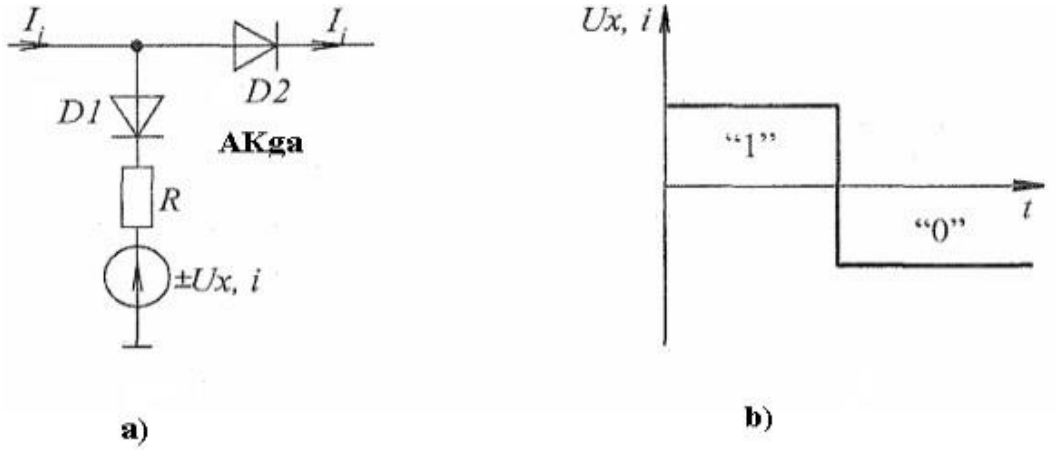


Figure. 6. Digital-to-analog converter circuit

Figure. 7. Key diagram.



2. Development of interactive educational methods on the topic "Methods for converting digital signals into analog (continuous) signals and their essence"

2.1. Blitz survey method

This method is used in the introductory part of the lesson to remember and consolidate the previous topic, as well as to increase the activity of students and study their initial knowledge before starting a new topic.

***Sample* Blitz survey questions**

Questions to remember and reinforce the previous topic:

1. How many steps was taken to convert an analog signal to a digital signal?

2. What is discretization?

3. What is quantization?

4. What is the signal code?

Questions to increase student engagement and explore their initial knowledge before starting a new topic

1. What is an analog-to-digital converter?

2. What is the structure and working principle of the sequential calculation DAC?

3. What is the structure and working principle of integrated ARO?

4. How is DAC, which converts voltage to frequency, constructed?

5. What is the structure and principle of operation of parallel conversion DACs?

2.2. "BOOMERANG" method

We will consider working in groups based on the **"BUMERANG" method.**

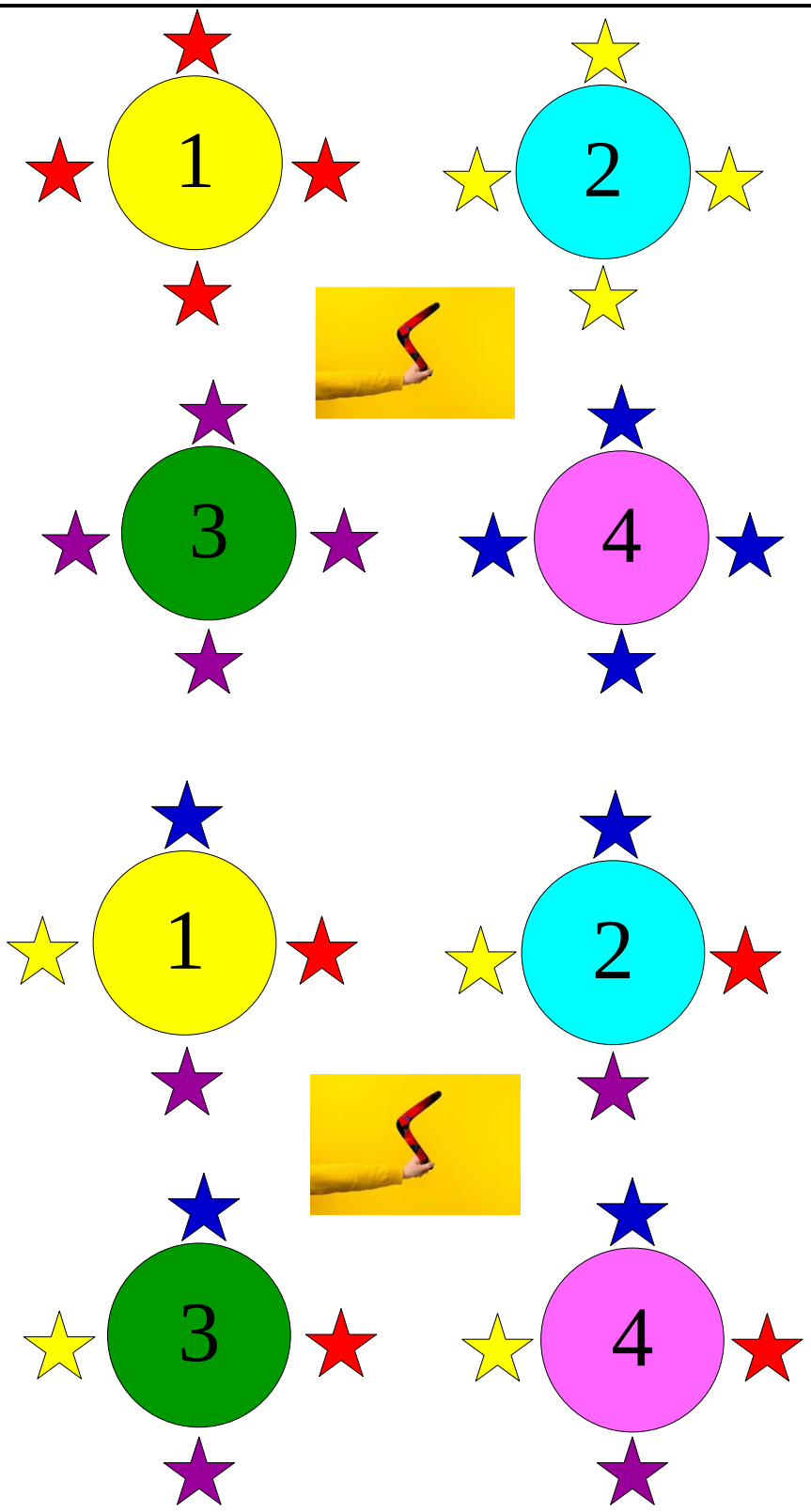
Stages of transfer of the "Boomerang" method

1. Small groups are formed and the rules for using technology are introduced.
2. A digital text is distributed to each group for independent study.
3. Groups master the educational material based on the assignment given to them.
4. Small groups are reorganized.
5. Pupils in small groups take turns informing each other about the texts they have studied independently, and learn the texts studied by their peers; internal control is conducted on the basis of questions and answers to determine whether students have effectively mastered the educational material.
6. Group members return to their "initial groups".
7. A "Group Accountant" is appointed to calculate the points collected by the groups.
8. The teacher determines whether the students (listeners and cadets) have effectively mastered the topic by asking questions and asking questions.
9. Based on the answers to the questions, the points collected by the groups are summarized and distributed equally among the group members.

In this way, information on the subject is studied independently in a short period of time. In Boomerang method, along with the ability of each student to understand, the ability to explain what they understand to others is formed.

Assignment for the "BUMERANG" method

Group 1. Structure and working principle of DAC with two weighted resistors
Group 2. R-2R resistor matrix DAC
Group 3. DAC static parameters
Group 4. DAC dynamic parameters



2.3. "PROJECT" method

We will consider working in groups based on the **"PROJECT" method**, for this we will look at one practical example.

Group work rules

1. Everyone should listen to their comrades and show respect.
2. Everyone should work actively, together, with responsibility for the assigned task.
3. Everyone should ask for help when needed.
4. Everyone must help when asked for help.
5. Everyone must participate in the evaluation of the result of group work.
6. Everyone must clearly understand:
7. We learn by teaching others.
8. The soul of the one who got into the ship is the same: either we will escape together or we will sink together.

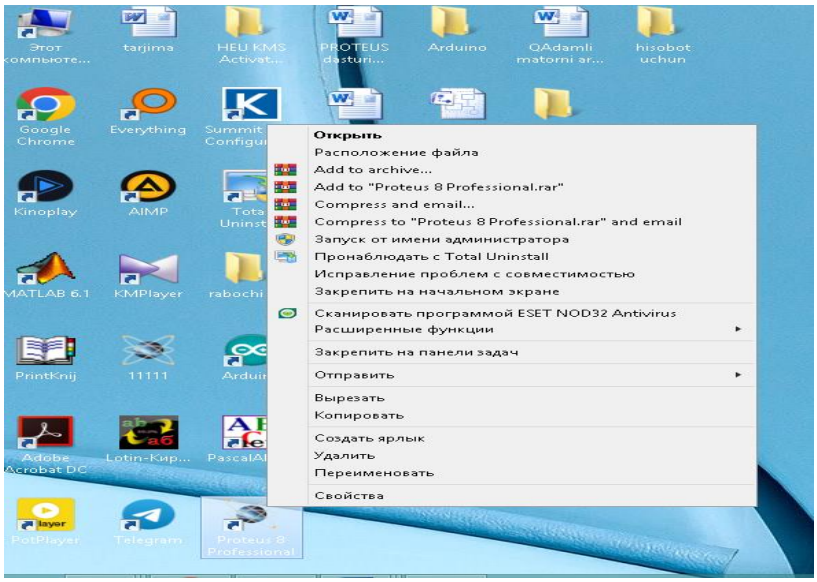
Group assignment

Task 1: based on Figure 3 presented in the lecture text, create a DAC project in Proteus 8.6. build through the program.

Task 2: build a DAC project using the PROTO mobile application based on Figure 6 presented in the lecture text.

Task 3: Construct the dynamic characteristics of the DAC using the PROTO mobile application (Fig. 6).

1. Task 1 execution procedure through the Proteus 8.6 program
2. To start the program, right-click on the program.
3. From the resulting menu, we launch Zapusk using the administrator command.



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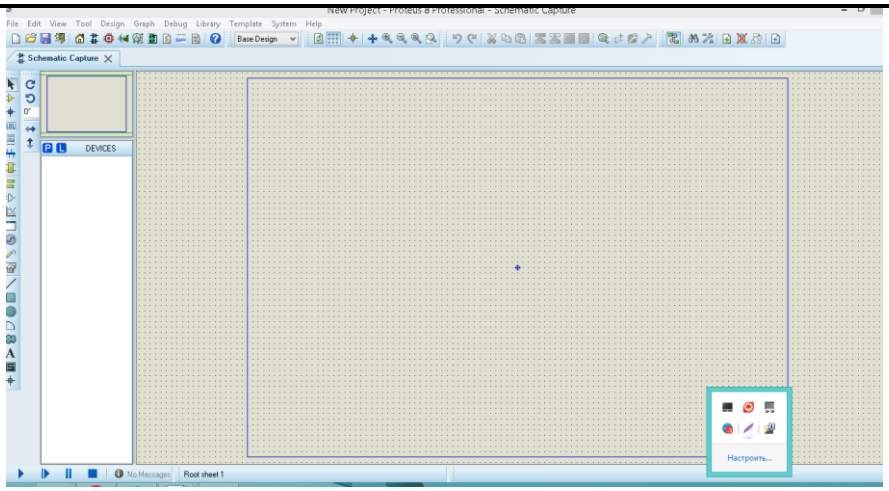
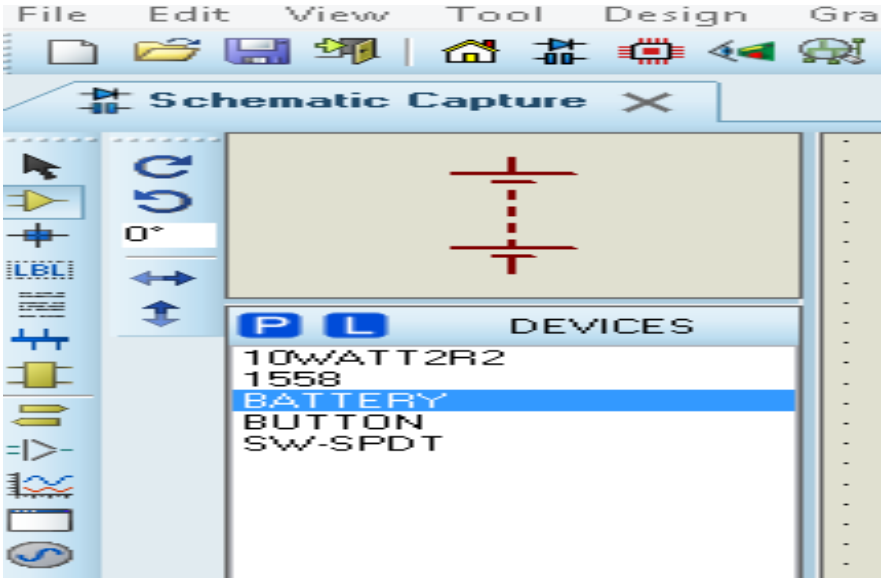
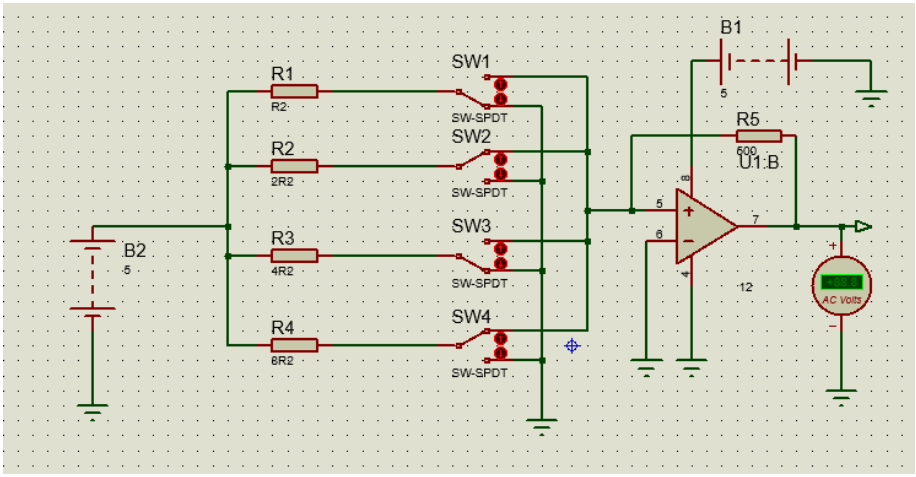


4. From the opened working window, we select the elements we need using the P icon.



5. We will assemble the given scheme based on the selected elements.



2.4. The results achieved through the used methods ensure students' in-depth knowledge, expand their thinking ability, students' teamwork, the ability to process and analyze the acquired information, the complete and solid assimilation of the given

information, students' critical gets used to thinking, learns to work with technologies, gets acquainted with devices and elements, learns to design independently based on a given task, learns to build static and dynamic characteristics of the device.

2.5. Subject control questions, independent work topics, test assignments

2.5.1. Control tasks, test questions and independent work topics

1. General information about analog signals.
2. General information about digital signals.
3. Disadvantages and advantages of analog and digital signals.
4. Fields of use of DACs and their role in everyday life.
5. Analysis of the principle scheme of the DAC, the output of which is voltage.
6. Analysis of the principle scheme of the DAC with the output magnitude being the current.

2.5.2 Test questions

	Test questions	Test answers
1.	What are the types of digital-to-analog converters according to the input data?	A. Analog, digital. B. *Series and parallel C. Series, parallel and mixed
2.	A continuous signal that can take any value in the maximum and minimum amplitude range...	A. *Analog signal B. Digital signal C. Analog-to-digital signal
3.	A signal that accepts a finite number of values (0 or 1) is	A. Analog signal B. *Digital signal C. Analog-to-digital signal
4.	What is an analog signal?	A. To a signal that accepts a finite number of values (0 or 1). B. *To a continuous signal that can take any value in the maximum and minimum range of its amplitude. C. To all signals on the network
5.	What is a digital signal?	A. To a continuous signal that can take any value in the maximum and minimum range of amplitude. B. To all signals in the network C. *Accepts limited numeric values (0 or 1)signalga.
6.	What is a DAC?	A. *Digital-analog converter B. Analog-digital converter C. Study of digital automation
7.	What is a ADC?	A. Digital-analog converter B. *Analog-digital converter C. Study of digital automation

8.	In what number system are the signals entering the digital-analog converter transmitted?	A. Ten B. Eight C. *Binality

2.5.3. Subjects of independent work

1. Calculation of the principle scheme of RAO', where the output signal is a voltage.
2. Creating an analog signal table of three-bit RAO' signals (corresponding voltage 5 V) for the RAO' principle circuit, where the output signal is a voltage.

Conclusion

The essence of pedagogical technological methods and the features of their application in technical sciences are considered, in which a number of pedagogical technological methods: Blitz survey method, "BUMERANG" method, "PROJECT" method are used to improve the educational process. 'l-hearts are given.

In the process of teaching the topic "Methods of converting digital signals to analog (continuous) signals and their essence", using the innovations in technology, the methodology of using interactive methods in the course of the lesson was developed, in which lectures on science were taught on a technological basis. Features of teeth, interactive methods used in them, and options for using interactive methods are presented in lectures based on advanced pedagogical technologies. It is recommended to be used in the training of students of higher educational institutions in the field of "Mechatronics and robotics".

Based on the above conclusions, the following suggestions were made.

Improvement of educational and methodological support of the subject "Schematic engineering and microprocessor systems" based on modern requirements and formation of electronic educational module development of the subject.

To ensure the integration of education, science and production in the teaching of "Schematic engineering and microprocessor systems", to ensure that practical and laboratory trainings are held in production enterprises and technological parks with high technological support.

Preparation and publication of scientific articles on the importance and essence of innovative educational technologies that serve to ensure the effectiveness of education in the teaching of specialized subjects

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