

## DEVELOPMENT OF AN ALGORITHM FOR MONITORING THE STATE OF A COMPUTER SYSTEM

**A.V. Barabanov, V.F. Barabanov, M.A. Belykh**

**Abstract:** this article analyzes the tools for monitoring the performance of a computer system, identifies the internal mechanisms of their operation and ways to interact with them. Based on the mechanisms of operation, an algorithm for monitoring the state of the computer system was developed, designed for operational control and analysis of the operability of various components of the system. The algorithm allows for continuous collection of data on performance, load, resources and other system parameters, and also provides the ability to predict possible failures and deterioration of performance. Based on the algorithm, a resource monitoring program has been implemented. The information about the processes and CPU utilization of the system obtained by the algorithms described in the article allows discrepancies with the task manager of up to 5% in CPU utilization due to different calculation algorithms and is absolutely identical in calculating RAM utilization. The use of the described algorithms is advisable in cases where there are no built-in counters or there is a need to analyze specific system parameters. As a result, an algorithm for monitoring resources was developed and implemented, which is available in most systems, but does not require additional user rights for its use

**Key words:** computer system monitoring, control and analysis of system components, health forecasting systems, performance counters

## THERMAL PROCESSES DURING IR IRRADIATION OF WATER: EXPERIMENT AND MODEL

**D.S. Saiko, D.G. Andreev, S.A. Titov, V.I. Korepanov**

**Abstract:** the paper presents an experimental study of infrared absorption by the water, and temperature versus time and immersion depth curves of the two thermal sensors were obtained. The sensors were placed on floats so that the upper sensor was 0.5 mm from the surface. The distance between the thermocouples was fixed at 3 mm. Modeling of thermal processes in the sample was carried out. To describe heat flows in the liquid, a standard model is used - the heat conduction equation with Newton-Richman boundary conditions. For an inhomogeneous heat conduction equation with boundary conditions of the third type for a semi-infinite medium with exponential inhomogeneity, the authors previously obtained an exact solution, which is used to describe processes in the near-surface region with a relatively short duration of the experiment. The model is compared with the experiment by means of the optimization procedure of the input parameters of the model. It is shown that the use of the model leads, at high intensity of IR irradiation of the water surface, to the observed dependence of temperature on time and coordinate, if we assume the thermal conductivity coefficient to be several times greater than the tabulated value. In this case, the model shows that in the near-surface region with a thickness of the order of a micrometer at high intensity of irradiation of the sample, an inverse heat flow directed to the surface occurs. The results of modeling and the limits of application of the model are discussed

**Key words:** thermal properties of water, infrared absorption in liquid, modeling of heat transfer in liquid, one-dimensional heat equation, inhomogeneous parabolic equation, third boundary value problem, Robin problem, analytical solution, exponential inhomogeneity, error function

## MATHEMATICAL MODEL OF THE PROBLEM OF NON-NEWTONIAN INCOMPRESSIBLE FLUID FLOW STEADY BETWEEN TWO ROTATING CYLINDERS

**V.S. Kuptsov, A.A. Katrakhova**

**Annotation:** in this work, a mathematical model is constructed that considers the problem of rotation of two cylinders in a non-Newtonian flow of incompressible fluid. To solve this problem, a cylindrical coordinate system was used for partial differential equations (in stresses) and the continuity equation for a given flow. When solving the problem, the convective part of the equations describing fluid flows was taken into account. A model of a non-Newtonian fluid with nonlinear stress components was considered. The fluid flow was steady. Taking into account the nonlinearity of the stress field of a given fluid flow, the components of strain rates and stresses were calculated, and the moment of the milestone forces relative to the axis of symmetry along any circle of arbitrary radius was calculated. A variant of solving the problem is considered, which coincides with the classical one, but for a non-Newtonian stationary flow of incompressible fluid. In this formulation of the problem, analytical formulas are obtained for calculating the hydrodynamic parameters of the flow of a non-Newtonian fluid. The formulas can be applied to specific non-Newtonian fluids analytically and numerically, depending on the type of fluid and the conditions of the technical problem. A special case of this result coincides with the formulas for a problem in a similar formulation for a Newtonian stationary flow of a viscous incompressible fluid

**Key words:** mathematical model, partial differential equation system, cylinders, cylindrical coordinates, stationary flow, non-Newtonian incompressible fluid

## DIGITAL SHIP TRAFFIC CONTROL SYSTEM ON INLAND WATERWAYS

V.I. Plyushchaev

**Abstract:** at present, information exchange in the implementation of dispatch regulation of fleet movement on inland waterways is mainly based on radiotelephone communications. This type of communication distracts the navigator from vessel control, does not guarantee the delivery of messages, requires manual recording and archiving of received information, and seriously complicates the creation of databases on vessel movement and cargo transportation. The creation of a complete and effective information system for inland waterways requires a major modernization of the existing dispatch control system. The article discusses approaches to creating a digital supervisory control system. The structure of the dispatching system of the Inland Waterways Basin Administration is proposed. The variant of organization of information exchange on the basis of automatic identification stations (AIS) network and Internet is substantiated. The results of AIS channels loading research are given, the possibility of additional information transfer using AIS is proved. The composition and structure of messages in data exchange between the objects of the information network on inland waterways are defined. Variants of messages formalization and automation of their generation are proposed. The technical platform for realization of the digital information network is presented, the composition and structures of the automated workplace of the dispatcher and the automated workplace of the ship's watch officer are considered, the variants of the workplace interface are given. The technical platform of the information system allows receiving, archiving, printing messages from dispatch centers and other vessels, forming, editing, archiving and transferring messages both to coastal dispatch centers and between vessels. The implementation of the automated information system, along with improving the safety of navigation, will allow to form databases on the movement of ships and cargo flows on inland waterways to optimize the transport process

**Key words:** inland waterways, dispatch control, information systems, automatic identification system, data transfer, automated workplace

## METHOD FOR MONITORING THE CONDITION (THRUST) OF A TURBOJET ENGINE IN FLIGHT AT FIXED OPERATING MODES

S.V. Nikolaev, A.P. Tupitsyn, D.S. Merentsov

**Abstract:** this paper considers the improving the flight safety of aviation complexes. The analysis of aviation accidents at modern and promising aviation complexes, the cause of which was the failure (damage) of the power plant elements, was carried out. The directions of development of on-board flight safety improvement tools and crew information about a dangerous situation are shown. The known methods of monitoring the condition and identification of high-altitude and high-speed characteristics of engines in flight and their disadvantages are analyzed. The reasons for the difference in the actual altitude and speed characteristics of turbojet engines (as part of an aviation complex) from those obtained in bench tests are shown. The tasks of the information management system of the aviation complex are considered. A method for monitoring the state (thrust) of a turbojet engine in flight is proposed, based on an experimental calculation method for determining an inductive excess of thrust. The claimed result of the proposed method is achieved by: introducing into the information and control system a mathematical model of the flight characteristics of the movement of the aviation complex as a material point; correcting the mathematical model by identifying the altitude and speed characteristics of the engine (taking into account the interference of airframe elements); calculating engine thrust deviations from the standard (reference); the introduction of additional information elements into the crew's intellectual support system on a multifunctional indicator in the cockpit, showing the crew the current characteristics of each engine and the capabilities of the aviation complex in terms of flight performance directly in flight. Examples of identification of high-altitude and high-speed characteristics of the engine performed in the framework of flight tests of modern aviation complexes are demonstrated

**Key words:** aviation complex, turbojet engine, non-indicated failures, high-speed characteristics, flight safety, flight tests, crew information support, multifactor regression analysis

# COMPARATIVE ANALYSIS OF THE WORK OF EVOLUTIONARY ALGORITHMS FOR SOLVING A MULTI-CRITERIA TRANSPORT PROBLEM WITHOUT RESTRICTIONS

**M.A. Belykh, D.A. Baranov, V.F. Barabanov**

**Abstract:** this paper presents a computational experiment on solving a multicriteria transportation problem using a set of evolutionary algorithms, including a genetic algorithm, an ant colony algorithm, and a bee colony algorithm. The study uses 10,000 different problem statements, each consisting of a square adjacency matrix with dimensions from 10x10 to 20x20. Each of these statements was solved using 39 variations of each algorithm. Each algorithm performed 60 iterations with 60 individuals in its composition. The main goal of the computational experiment was to evaluate the performance and quality of solutions provided by these algorithms, as well as to identify their advantages and disadvantages of their application in various conditions within the framework of solving a multicriteria transportation problem without constraints. The experimental results show that each of the algorithms has unique characteristics and can be preferable depending on the specifics of the problem and the requirements for computing resources. The conducted analysis provides valuable information for further research and practical application of metaheuristic methods in solving, in particular, combinatorial optimization problems

**Key words:** metaheuristic methods, evolutionary algorithms, ant algorithm, genetic algorithm, bee algorithm

# MODELING OF HEAT EXCHANGE OF A THERMOELECTRIC MODULE WITH A TURBULENT FLOW IN THE FRAMEWORK OF THE $k-\omega$ TURBULENCE MODEL

**O.A. Dorokhova, I.L. Bataronov, T.A. Nadeina, N.A. Yuyukin**

**Abstract:** a two-dimensional problem of heat exchange between a turbulent flow and a thermoelectric cooling module is considered. The physical properties of the thermoelectric element and the coolant are considered constant, equal to the average values of the physical parameters. The calculation is carried out in the  $k-\omega$  turbulence model, which makes it possible to obtain a solution in the wall zone. The analysis within the framework of similarity theory showed that the profiles of the normalized temperature difference depend on the Reynolds and Prandtl numbers and the parameter  $\Upsilon$  of the thermoelectric element. It is found that the coordinate dependence at the initial section of the profile is represented by a cubic root, and the main part of the profile is a fractional irrational function supplemented by a linear asymptotic dependence. Due to the strong correlation of the coefficients of the model, the calculation was carried out in two stages. At the first stage, two parameters of the main part of the profile are determined. It is shown that they linearly depend on the criterion ratio  $\Upsilon$ , and the dependence on  $Re$  and  $Pr$  is similar to the formula of M.A.Mikheev. At the second stage, the correction factor of the initial section is found, which was approximated by exponential functions. It is established that the correction factor depends only on the numbers  $Re$  and  $Pr$ . Based on the one-dimensional energy balance equation, an expression for the local Nusselt number is obtained, which differs from that without a thermoelectric element by subtracting the parameter  $\Upsilon$  multiplied by a coefficient depending on the number  $Pr$ . Detected the existence of a critical regime that occurs when the values of the numbers  $Nu$  and  $\Upsilon$  approach

**Key words:** heat transfer, thermoelectric coolers, temperature field, finite element method, correlations

# INVESTIGATION OF FLIGHT STABILITY OF A HYBRID TWIN-ENGINE VEHICLE

**V.B. Fursov, Yu.V. Pisarevsky, Zh.A. Gen**

**Abstract:** the evaluation of the movement of a hybrid aircraft is defined by the necessity to create promising types of air vehicles. Currently, aircraft of a new design, hybrid-type vehicles can be developed — the aircrafts of a new design, which are differing in their construction and functionality. The shape of a hybrid airship is close to that of a wing of an airplane. Such a shape allows you to get additional lifting force and speed during the flight. The huge potential of such an aircraft in their small version is not used. The creation of such an aircraft is impeded by the absence of research in the field of flight dynamics. Ensuring the flight stability of any aircraft is the most important factor determining the promise of the new aircraft's design. For lighter-than-air aircraft, static stability is but this article is about dynamic instability associated with a stable state in hover mode, which is observed only during movement and, as a rule, depends on the speed. In such a case longitudinal instability presents the greatest dangers. This article describes the dynamic stability of an aircraft with positive buoyancy of an elliptical shape. Research shows that with a certain stability, the stability of flight resistance slows down, and without a reserve power reserve, the flight is already unstable at low speeds. The simulation used a quasi-dynamic method — the flight resistance functions for different positions of the aircraft were obtained numerically for stationary motion, which at low speeds should not lead to a large modelling error

**Keywords:** hybrid twin-engine vehicle, simulation, flight instability, angle of attack, oscillations

## MODELING OF CONTROL SYSTEM UAV ELECTRIC DRIVE

**I.A. Boldyrev, A.S. Kozhin, A.V. Burkovsky, A.V. Tikunov, T.E. Chernykh**

**Abstract:** Currently, unmanned transport systems are increasingly being used all over the world to solve various tasks, unmanned aerial vehicles (UAVs) have become particularly widespread. The analysis of the information shows that in our country there are a number of problems in the field of UAV development and production. One of the most important problems is that until recently, components and assemblies for UAVs in our country were not actually produced, but imported from abroad, but now there is an urgent need to organize the production of these components at Russian enterprises in a short time. However, for this it is necessary to have techniques that allow for the design of components and assemblies, taking into account the purpose of the UAV. In the field of development of control systems for contactless electric motors of propeller-driven groups, taking into account such characteristics as efficiency and weight and size indicators of electric motors that are part of the propeller-driven groups of UAVs, in our country there is a serious lag behind European competitors, which is largely due to the long-term lack of need for such systems, despite the fact that the development of control systems for contactless machines. The equipment used in automation systems in our country is at a very high technical and technological level. The article describes one of the possible methods for constructing an electric motor control system for a propeller-driven UAV group based on PMSM vector control with improved robust properties in relation to the parameters of the electric motor, which can serve as the basis for designing a control system for UAV electric motors with improved energy and weight and size indicators, and will also increase the maneuverability of the device as a whole.

**Key words:** unmanned aerial vehicles, contactless DC motor; synchronous motor with permanent magnets, vector control

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## FLASH MEMORY-BASED DATA STORAGE OPTIMIZATION TECHNIQUE TAKING INTO ACCOUNT THE THRESHOLD VOLTAGE ANALYSIS

**A.V. Bashkirov, M.V. Khoroshailova, A.S. Demikhova**

**Abstract:** in this article, a method for regulating data storage has been developed, taking into account the analysis of threshold voltage to increase the service life of flash memory. The main idea is that during the reading operation, the modulation of the bias conditions allows you to analyze the threshold voltage level ( $V_{th}$ ). Low-charge batteries can be detected using error correction codes (ECC), operational redundancy and  $V_{th}$  analysis. For this purpose, a memory array model has been developed that uses cells to ensure reliability when using a standard error correction code. This technique allows you to divide the pages stored in flash memory into two groups depending on the frequency of page recording and apply the most appropriate access controls to two different groups of flash pages/blocks. This technique eliminates a significant number of unnecessary updates and significantly increases the service life of flash memory. An architecture is provided that increases the reliability of the memory cell, and allows you to replace an erroneous page with a redundant page as soon as an error is detected. The simulation shows that using a parity code that can detect only one error, error correction with threshold voltage analysis can correct up to one error, which improves the average operating time to memory failure by 4.7 times in a 2-megabit array with 32 bits per word.

**Key words:** flash memory, error correction codes, data storage, memory array, write frequency, extended service life

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## RESEARCH OF MODERN MULTIPATH LENS ANTENNAS

**D.A. Shershov, S.M. Fedorov, E.A. Ishchenko**

**Abstract:** the article discusses multipath antennas based on dielectric lenses using modern 3D printing methods. Dielectric lens antennas are of increased interest for applications on millimeter and submillimeter waves, where they become compact, especially in configurations with an integrated power supply, which are commonly referred to as integrated lens antennas. The lenses are very flexible and easy to design and manufacture, being a reliable alternative to reflective antennas at these frequencies. The output signal of the lens can range from a simple collimated beam (increasing the directivity of radiation) to more complex multi-purpose devices. The main types of lenses are presented, such as: Luneberg lens, Maxwell lens. It has been shown that the Maxwell Fisheye lens (MFEL) with positive refraction allows for perfect visualization, but requires additional drainage costs. MFEL embedded in the outer coating, inspired by the solid immersion concept, allows for high-resolution images without leaks. It was found that the full reflection on the external solid-state immersion interface and the natural ideal focusing of MFEL synthetically contribute to obtaining a high-resolution image formed in the air. An innovative antenna design is presented, which uses a cylindrical Luneberg dielectric lens designed specifically for Internet of Things (IoT) applications with a frequency of 60 GHz. To optimize the V-band coupling, the dielectric constant of the dielectric medium is strategically regulated by precisely regulating the physical porosity. The measurement results demonstrate exceptional antenna performance, exceeding the standards of the Internet of Things deployment. This paves the way for the creation of an improved Internet of Things infrastructure, characterized by enhanced detection capabilities and improved connectivity

**Key words:** antenna, Lens antennas, Luneberg lens, Maxwell lens, millimeter waves, Internet of Things, 3D printing

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## INVESTIGATION STABILITY A COMMUNICATION CHANNEL OF UNMANNED AERIAL VEHICLES TO NOISE-LIKE INTERFERENCE

**M.A. Romashchenko, D.V. Vasilchenko, A.Yu. Aralov**

**Abstract:** the issue of studying the noise immunity of radio communication channels based on Long Range (LoRa) technology used in unmanned aerial vehicles to the impact of noise-like interference with frequency modulation of noise is considered. The rationale for choosing noise-like interference as the most common and effective for suppressing communication channels is given. An algorithm for generating frequency-modulated noise-like interference and its mathematical implementation in the MatLab modeling environment are presented, and the corresponding spectrograms are given. The signal quadratures obtained using a vector generator were used for the experimental implementation of the interference effect. A structural diagram of an experimental stand for practical suppression of the LoRa communication channel has been developed and the necessary equipment has been selected. As part of the experiment, an assessment of the relationship between the power of the interference and useful signal under communication suppression conditions and under stable operation of the LoRa receiver has been performed. Spectral data and signal-to-noise ratio levels at different stages of the experiment are presented. Based on the data obtained, conclusions have been made about the low energy efficiency of noise-like interference for suppressing a LoRa-based communication system. Recommendations are given for further research in the field of interference-resistant communication and control systems for ground and air unmanned robotic vehicles using LoRa technology

**Key words:** noise-resistant communication, communication channel, UAV, noise-like interference, LoRa

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## INVESTIGATION OF THE EFFECT OF COMPOUNDS ON THE CHARACTERISTICS OF A PLANAR TRANSFORMER IN A POWER SUPPLY MODULE

I.S. Bobylkin, A.A. Kuzyomkin, E.M. Ivashkina, A.M. Bezrukavay

**Annotation:** in the modern world of electronics and electrical engineering, compact and efficient solutions for power supply systems are becoming increasingly important. Planar transformers, due to their flat design, represent a promising direction for reducing the size and weight of power supply modules. However, their manufacture requires special attention to the selection and use of compounds, which play a key role in ensuring the reliability, safety, and efficiency of transformers. Compounds perform several important functions: sealing, electrical insulation, explosion protection and influence on thermal characteristics. The study of the influence of compounds on the characteristics of a planar transformer in a power supply module is considered, an analysis of various types of compounds and their effects on transformer parameters such as inductance, losses, temperature regime and reliability is given. The results of experimental studies are presented, which allow us to assess the effectiveness of using various compounds to improve the characteristics of the transformer. The prospects of applying the results obtained in the development of modern power supply modules are also discussed. It will be useful for specialists in the field of electrical engineering, electronics, and design of electronic devices to familiarize themselves with the results when studying data and recommendations for optimization and modernization of transformer modules

**Key words:** planar transformer, compound, power supply module, transformer characteristics

## DESIGNING A MULTIPLICATION AND ACCUMULATION UNIT FOR APPLICATIONS DIGITAL SIGNAL PROCESSING

M.V. Horoshailova, A.V. Turetskiy, A.S. Demikhova

**Abstract:** this article presents the implementation of an analog-to-digital converter (ADC) unit with a sequential approximation register. Based on the developed sequential approximation algorithm, which helps to reduce the number of conversion steps, an improved design of an ADC with a sequential approximation register (SAR) using several parallel comparators and a binary-weighted capacitive matrix of a digital-to-analog converter (DAC) with charge distribution was presented. The two-stage converter circuit was built using additional pMOS and RMOs transistors. The bit cycle logic was developed using D-triggers and inverter elements available in Multisim 14.0. This logic requires two-phase non-overlapping clock pulses for its operation. Therefore, the clock frequency generation scheme was also developed using triggers and inverters with an appropriate delay. The simulation results show that the proposed ADC reduces the conversion time from 16% to 5%. It is also shown that the 5-bit operation reduces the conversion time by about 16.25%. In addition, a capacitive DAC with built-in sampling and retention functions consumes less energy and time, and causes fewer misalignment errors compared to a resistive DAC

**Key words:** ADC with sequential approximation register, capacitive DAC matrix, conversion time, comparator, shift register

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## PRINTED LOGOPERIODIC ANTENNA FOR WIDE-BAND DIRECTION FINDING SYSTEM

E.D. Egorova, E.A. Ishchenko, A.E. Medvedev, D.V. Patsev, S.M. Fedorov

**Abstract:** the paper considers a printed broadband antipodal logoperiodic antenna, which is designed to implement a broadband direction finding system. The proposed antenna design has simplicity of implementation, repeatability, as well as stability of characteristics over a wide range of operating frequencies. The operating frequency range 900-1400 MHz was selected for implementation, which allows for the widest possible overlap of the range in which automated robotic complexes operate. The article presents the results of electro-dynamic modeling of the antenna, as well as measurements of the characteristics of the layout. The layout was made on the basis of a double-sided foil dielectric Fr-4 with a thickness of 1 mm, which makes it possible to ensure the small size of the antenna, as well as greater strength. The resulting layout was used to measure the operating frequency range using a vector circuit analyzer, as well as to measure the radiation pattern. The obtained results show a high correlation of measurement and simulation results, which is especially important for antenna systems of direction finding complexes. Also, special attention was paid to the position of the phase center of the antenna, since it affects the measurement of the characteristics of the electromagnetic field, which is especially important in the problems of direction finding of electromagnetic radiation sources

**Key words:** printed antenna, logoperiodic antenna, direction finding antenna, wide-field antenna

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# STUDY OF THE INFLUENCE OF INTERSYMBOL INTERFERENCE ON THE TRANSMISSION OF COMPLEX SIGNALS

**L.A. Senatorov**

**Abstract:** the paper studies the influence of external interference on the quality of signal transmission over a radio channel. The aim of the paper is to study the stability of linear-frequency-modulated and nonlinear-frequency-modulated signals to interference arising from the operation of other radio transmitting devices. Increasing the density of radio-electronic devices in limited areas leads to a gradual deterioration of the interference situation, which can often lead to the emergence of deliberate or accidental interfering effects that can worsen the quality of communication or completely block it. Mutual installation of blocking interference is considered a case of intersymbol interference. To study the stability of linear-frequency-modulated and quadrature nonlinear-frequency-modulated signals, a simulation model of complex signal transmission under the influence of intersymbol interference was compiled in Matlab R2023a. The experiments showed high noise immunity of complex signals, the probability of bit error did not exceed 10%. The study showed that complex signals are highly resistant to external interference, but the linear frequency-modulated signal is the most noise-resistant of those considered, and therefore can be used in advanced radio communication systems intended for use in large cities or when operating critical communication nodes in the event of an incident

**Key words:** chirp signals, Matlab, signal processing, signal modulation, signal demodulation

# REDUCING THE SIZE PARAMETERS OF RADIO ENGINEERING DEVICES TAKEN INTO ACCOUNT OF REDUCING LOSSES IN THE POWER SUPPLY TRANSFORMER

**N.Yu. Veretennikov**

**Abstract:** the main way to reduce the overall dimensions of radio engineering devices is to optimize the dimensions of the magnetic component of the switching power supply by increasing the frequency of operation of the converter. However, with an increase in the operating frequency of the magnetic component, its efficiency may suffer due to the occurrence of high-frequency losses in the core and copper conductors. In this paper, the main mechanisms of occurrence of high-frequency losses in the windings of magnetic components with energy accumulation are considered, as well as a method for analytical modeling of high-frequency losses in windings caused by the proximity effect. The most popular way to reduce losses in power transformers is to alternate windings using wires of optimal thickness. However, in the reverse-way converter, the windings work alternately. At the same time, losses in the passive layers of the windings can significantly exceed losses in the windings conducting current. It is shown that despite the impossibility of compensating the field in a reverse current transformer, alternating windings can redistribute eddy currents in the windings, and, as a result, reduce losses associated with the proximity effect

**Keywords:** eddy current, proximity effect, skin-effect, modeling of magnetic components, high-frequency magnetic components, flyback transformer

# RESEARCH OF MODERN ANTENNA SYSTEMS BASED ON ROTMAN LENSES

**D. A. Shershov, S. M. Fedorov, E.A. Ishchenko**

**Abstract:** the article considers an antenna system based on a Rotman lens for the formation of multi-element phased array antennas by changing the phase distribution of the Ka-band signal. The design and experimental verification of an all-metal double-sided 10x10 Rotman waveguide lens manufactured in an additive manner as a single part is described. The broadband operation of this quasi-optical beam shaper allows us to cover the uplink and downlink frequencies allocated for satellite communications in the K/Ka band, from 17.3 GHz to 30 GHz. The design of the loading opening has been modified to allow vertical printing, which has minimized the use of auxiliary structures. A prototype was manufactured and tested. The presented results indicate losses in the range of 0.5 dB in the low-pass band and 0.8 dB in the high-pass band, including waveguide transitions added for testing purposes. The measured reflection and coupling coefficients remain below  $\approx 11.5$  dB in the operating band. The standard deviation of the residual phase error along the matrix ports is less than 5 in modeling and less than 10 in measurements. The matrix coefficients synthesized using scattering parameters confirm the good stability of the beam formation functionality in a wide analyzed frequency range. This monolithic design is a promising step towards creating more integrated antenna systems, such as a compact two-stack configuration for the design of flat antenna arrays

**Key words:** Rotman lens, K/Ka band, Rotman Waveguide lens, 30GHz

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## OPTIMIZING THE ALLOCATION OF WIRELESS NETWORK RESOURCES SENSOR NETWORK

**M.V. Khoroshailova, A.A. Pirogov, A.V. Turetskiy**

**Abstract:** a method for planning high-density data transmission in a wireless sensor network based on Wi-Fi is proposed. This method creates a node interaction model, a network structure model, and a power consumption model before sending high-density data, takes into account the process of generating and transmitting packets in a wireless sensor network, and optimizes the execution time of a node task, thereby reducing node latency. The nodes in the network are fully planned in such a way as to control the time of packet generation in the network, which further reduces energy consumption. An energy optimization algorithm based on clusters is proposed, which allows choosing the main node of the cluster by comprehensively influencing factors on the energy balance of a wireless sensor network. In the proposed algorithm, an energy density function is first introduced, taking into account the velocity and density of residual energy in the radius of the neighborhood of nodes, in order to reduce the randomness of choosing the main node of the cluster. The control nodes of the signals are arranged in several orders according to the total amount of data, thereby reducing the waiting time required during the optimization process. The motion performance function was developed based on the variable motion parameters of the mobile receiver, which effectively balanced the network load and reduced data latency

**Key words:** wireless sensor network, power consumption, delay time, data transmission, clustering

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## IDENTIFICATION OF AN INCREASED OR DECREASED INPUT VOLTAGE IN A DC/DC SWITCHING POWER SUPPLY

**I.S. Bobylkin, A.V. Ivanov, A.A. Kuzyomkin, D.A. Kislenkov**

**Annotation:** limiting the input voltage in a pulse secondary power supply (PSS) (also called a power supply module) is necessary to ensure its stable and reliable operation. The input voltage limiting unit protects the source from voltage surges at the input, which may occur due to network instability or transient processes. Input voltage limiting is usually used in low-power DC/DC converters that use batteries as the primary power source (PPS). This is due to the fact that the battery voltage decreases during its operation under load. A low voltage value at the input of the power supply may not be enough to start the microcircuit that controls the power circuit of the module using a pulse-width modulation (PWM) signal. In other cases, when the supply voltage at the input exceeds the permissible value, this may lead to incorrect operation of the power supply, one of the signs of which is the occurrence of short-term voltage fluctuations at the output. As a rule, at this moment the internal protection circuit of the module from overvoltage or overcurrent is triggered. It will operate until the input voltage enters the permissible operating range. In this article, a method for identifying the voltage value using a simple functional unit consisting of several electrical circuits based on common electronic radio products is proposed to protect the power supply from increased or decreased input voltage. Theoretical calculations were performed and simulation was performed in the SPICE simulator Multisim. By applying various pulses, type 5 according to the ISO7637 standard (conductive noise immunity tests), the effective operation of the protection circuit was demonstrated both from short pulses with a voltage of up to 80 V and a duration of 120 ms, and from longer ones, with an amplitude of up to 70 V and a duration of 500 ms. The use of a combination of a protection device and a pulse PSS allows saving space and reducing the cost of implementing the product

**Key words:** voltage limitation, protection circuit, voltage range, power supply module, direct current, comparator, power source, electrical power



## METHODS OF RECEIVING, PROCESSING AND RECOGNIZING RADIO SIGNALS IN THE TASKS OF DETECTING UNMANNED AERIAL VEHICLES

**M.A. Romashchenko, A.Yu. Mantula**

**Abstract:** one of the options for detecting the operation of an unmanned aerial system is considered for the purpose of its subsequent identification and determining the legality of the presence of an unmanned aerial vehicle (UAV) in the airspace. The problem is formulated that justifies the need for rapid and timely counteraction to illegal activities of unmanned aerial systems for the purpose of safety of industrial facilities, infrastructure and civilians. The task is to develop a methodology that allows automating the process of obtaining and processing data for detecting UAV and their subsequent identification. A review of the main existing approaches to detecting UAVs is conducted, among which radio and radar detection are considered separately. A structural diagram of the method for receiving, processing and recognizing radio signals is described and provided, allowing for the detection of UAV. An experimental study of the proposed method is conducted, consisting in simulating the presence of a drone in the airspace by emitting characteristic signatures. Having consistently performed the steps of the methodology for analyzing the radioether, adaptive adjustment of the detection threshold, digital filtering, a spectral image was obtained characterizing the presence of the UAV. Subsequent identification of the received signal by the high-frequency and low-frequency range allowed us to successfully determine the type of UAV

**Key words:** unmanned aircraft system, unmanned aerial vehicle, radio detection, radar

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## SETTING THE RANGE OF ACCEPTABLE VALUES OF THE AVERAGE THE RADIUS AND NUMBER OF TEETH OF THE ENCLOSING MILLING CUTTER WITH A CONSTRUCTIVE RADIAL FEED PROVIDING THE REQUIRED ERROR FOR THE FORMATION OF THE RC PROFILE SHAFTS

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**Annotation:** the establishment of the range of permissible values of the average radius and the number of teeth of the enclosing milling cutter with a constructive radial feed is considered, providing the required error in the shaping of RC-profile shafts, namely, the study of the effect on the error in the shaping of RC-profile shafts of the structural parameters of the enclosing milling cutter with a radial constructive feed. The proposed method of forming RC profile shafts using a covering milling cutter with a constructive feed is described, the equation of the profile of the producing surface of the milling cutter is given, ensuring the fulfillment of all shaping conditions. The values were obtained and the dependence was established for the minimum average radius of the profile of the enclosing cutter, which ensures the fulfillment of the shaping conditions. The discrepancy between the angular positions of the milling cutter teeth given by the parametric angles to their actual (geometric) angular position is shown. A method is proposed for calculating the value of the parametric angle of the teeth of the enclosing cutter through the values of their actual (required) angular position. A study has been performed and a regression equation has been established describing the effect on the shaping error of the average radius of the enclosing mill and the number of teeth with their uniform arrangement. The use of this equation made it possible to establish the areas of acceptable values of the design parameters of the designed cutters that ensure the required accuracy of shaping

**Keywords:** encompassing milling cutter, RC-profile shaft, error, shaping, constructive radial feed

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## **IMPROVING THE CONTACT WELDING SYSTEM IN THE CASE OF MANUFACTURING INTEGRATED CIRCUITS**

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**Abstract:** the article presents a study of the process of ultrasonic micro-welding of conductors by the "wedge - wedge" method. A technique for investigating the micro-connection of a wire with crystal contact pads and external terminals is presented. A comparison of the strength of the compounds obtained at the two capacities used (on the traverse and on the crystal) is determined. The parameters were obtained at which the greatest strength of micro-welded joints was observed at various ultrasound capacities at the standard frequency of ultrasonic vibrations. In this work, the ultrasound method is used only "wedge-wedge". Ultrasonic wedge-wedge welding with Au or Al wire is an advanced welding technology that ensures strong connections. It is used for welding various materials, including metals, plastics and composites. This method has a high welding speed and eliminates the need for adhesive joints. Separation testing guarantees reliability and compliance with the standards of welded joints. It is determined what effect the power of the ultrasonic circuit has on the strength characteristics of welded joints. The assessment of the quality of welded joints in 3 modes is implemented: with increased, normalized and with reduced power parameter. The optimal contact welding mode has been fixed, which ensures the strength of the micro-connections

**Keywords:** power, ultrasonic generator, ultrasonic welding, wedge-wedge, welding, strength, micro-connections