## SEARCH FOR UNCERTAINTY REGIONS OF KINETIC CONSTANTS IN MODELING PROCESSES OF NON-BREAK POLYMERIZATION OF DIENES

**E.R. Gizzatova, A.S. Ismagilova, S.L. Podvalny**

**Abstract:** this paper considers the processes of polymerization on Ziegler-Natta catalysts. The question of the mechanism of the processes as a necessary set of elementary stages of the kinetic scheme is investigated. A general scheme of the permissible stages of the process is given, including the stages of initiation, chain growth, chain transfers and chain termination. It is indicated that part of the elementary reactions can be removed from the kinetic scheme due to the method of preparation of the catalyst itself, and part on the basis of the obtained kinetic dependences. However, the hypothesis about the presence or absence of elementary stages can be proved not only experimentally but also computationally. The tabular data presented in the work indicate a practically zero value of the rate constant of the elementary stage of material chain termination - deactivation of active centers, which, in turn, leads to optimization of the kinetic scheme. Then the processes under consideration can be attributed to the type of non-break polymerization. Compilation of kinetic and mathematical models for the processes under study makes it possible to pose direct and inverse kinetic problems. The solution of the latter can be obtained by the method of multiple solution of direct kinetic problems and comparison of the calculated values of molecular characteristics with their experimental counterparts. However, it is more expedient to carry out the preliminary stage of finding the regions of local minima by the optimized values of the constants by constructing the base surface. When searching for admissible sets of values of the rate constants, operate with the found areas of minima

**Key words:** polymerization, kinetical modeling, mathematical model, kinetic constants, method of moments

## DEVELOPMENT AND APPLICATION OF A GEOGRAPHIC INFORMATION SYSTEM FOR MONITORING THE WORK OF SALES REPRESENTATIVES IN THE “EFKO” GROUP OF COMPANIES

**V.S. Kudryashov, M.V. Alekseev, A.V. Ivanov, V.V. Portnov, E.V. Knyazeva, O.A. Orlovtseva**

**Abstract:** the article is devoted to solving the problems of developing a geographic information system (GIS), which allows the use of GPS data on pocket personal computers (PPC) of employees to generate a report of their visits to outlets specified according to the plan, and to view deviations from the route. In the structure of EFKO Management Company, the KPI system (based on 1C) is used for work in the sales and logistics department, which allows organizing the activities of its sales staff by collecting and analyzing various indicators. In particular, the work of supervisors, merchandisers, as well as territorial and regional managers was organized. In order to provide the work of territorial managers and supervisors not only at the computer but also directly during visiting the outlets, to place an order for the counterparty not on paper but immediately enter into the program, it is necessary to implement a connection between 1C KPI and the ST-Mobile application, developed specifically for this purpose. Employees should be able to record current data into the system on visited outlets, fill out documents for pre-orders of outlets for further delivery, check the filling of the shelves with the company's products. The purpose of the GIS development is to organize the operational data exchange between the accounting system and the employees' PPC. The GPS data from the employee's PPC is compared with the GPS data set in the “Outlets” directory to create the “Agent's actual route” report, from which it will be clear whether the employee visited the outlet from his route or not, and how large the deviation from the route was. The paper provides a brief description of the software correction in the 1C Configurator mode, the developed procedures and functions in java-script. The proposed solutions allow one to select a point of sale on the map, as well as form a task for an employee's route to points of sale, to draw on the map (according to GPS data) the actual route of the employee and indicators of attendance at retail outlets. The developed GIS was implemented at EFKO Management Company in the sales and logistics department

**Key words**: geographic information system, logistics, GPS data, employee performance monitoring

## ANALYSIS OF METHODS FOR CALCULATING HEAT TRANSFER IN THERMOELECTRIC COOLING SYSTEMS FOR HEAT-STRESSED ELEMENTS

**S.V. Borodkin, A.V. Ivanov, I.L. Bataronov, A.V. Kretinin**

**Abstract**: the article presents on the basis of the equations of heat transfer in a moving medium and the relations of heat transfer in a thermoelectric cooler, a comparative analysis of methods for calculating the temperature field in a heat-stressed element. We considered methods based on: 1) heat balance, 2) average heat transfer coefficient, 3) differential heat transfer coefficient, 4) direct calculation using the finite element method. We established that the first two methods do not provide an adequate distribution of the temperature field but can be useful for determining the principal possibility of a given cooling using thermoelectric elements. The last two methods allow us to correctly calculate the temperature field; but to use the third method, we need a differential heat transfer coefficient, which can be found from the calculation using the fourth method. We made a conclusion about the need for combined use of methods in a general case. The methods of thermal balance and average heat transfer coefficient allow us to determine the principal possibility of using thermoelectric cooling of a specific heat-stressed element. The actual parameters of the cooling system should be determined using a combination of the differential heat transfer coefficient and the finite element method. The first of them allows us to determine the heat-stressed areas and calculate the parameters of the cooling system that provide thermal discharge of these areas. The second method is used to perform numerical experiments to determine the heat transfer coefficient of a real structure

**Key words:** heat transfer, heat-stressed elements, thermoelectric coolers, temperature field, heat balance, heat transfer coefficient, finite element method

## SOLVING THE PROBLEM OF INTER-AIRCRAFT NAVIGATION TO ENSURE FLYING IN FORMATION USING A TECHNICAL VISION SYSTEM

**D.A. Smirnov, V.G. Bondarev, A.V. Nikolenko**

**Abstract:** the article provides a brief analysis of both domestic and foreign inter-aircraft navigation systems. In the course of the analysis, we found the shortcomings of inter-aircraft navigation systems and presented an up-to-date approach to improving the accuracy of the navigation system through the use of a technical vision system. To determine the location of the leading aircraft, we proposed to consider a technical vision system as a measuring complex, which is able to solve a large range of tasks at various stages, in particular, flight in formation. We proposed to install the technical vision system on the slave aircraft in order to measure all the parameters necessary for the formation of automatic flight control of the aircraft. We performed an image processing of the leading aircraft to determine the coordinates of three identical points on photosensitive matrices. Moreover, we selected optically contrasting elements of the aircraft structure as these points, for example, the end of the wing, tail, etc. To simplify the image processing procedure, it is possible to use semiconductor light sources in the infrared range (for example, with a wavelength of $\lambda = 1.54$ microns), which allows us to work even in difficult weather conditions. This approach can be used when automating a flight in formation of more than two aircraft, while it is only necessary to equip all the guided aircraft of the group with a technical vision system

**Key words:** technical vision system, automatic control system, inter-aircraft navigation, group flight, aircraft

## ALTERNATIVE COEFFICIENT OF CONCORDANCE IN CASE OF CONNECTED RANKS

**Yu.V. Lubenets**

**Abstract:** the article considers evaluation of expert opinion consistency when conducting an expert survey. The most commonly used score is Kendall's coefficient of concordance. However, this coefficient cannot be fully applied to establish good agreement of expert opinions, as it only shows deviations from cases of complete inconsistency. To eliminate this drawback, an alternative concordance coefficient can be considered, which estimates the proximity of the sums of the ranks of the alternatives to the case of complete consistency. The article gives the definition of this coefficient in the presence of connected ranks. The difficulty of this definition lies in the fact that in this case there are several cases of complete consistency with different sums of ranks. Definition of the alternative coefficient of concordance in the presence of tied ranks is carried out in two stages. First, its definition for ordered tables of a special kind is introduced and its coincidence with Kendall's coefficient of concordance in this case is shown. After that, the definition of the alternative coefficient of concordance in the general case is given and a simpler formula for its calculation is shown. Below are some examples of comparisons of the values of the considered concordance coefficients, their statistical characteristics, and histograms

**Key words:** coefficient of concordance, connected ranks, assessing agreement, expert evaluation

## STUDY OF THE INFLUENCE OF THE TILT ANGLE OF VERTICAL STABILIZERS OF AN AIRCRAFT ON THE EFFECTIVE SCATTERING SURFACE

**A.V. Volod'ko, S. M. Fyedorov, E. A. Ishchenko, M.A. Sivash**

**Abstract:** the article considers the dependence of the value of the effective scattering area (ESA) of the aircraft on the tilt angle of the vertical stabilizers. Modeling is performed using the method of the geometric theory of diffraction and physical optics since the dimensions of the object are many times larger than the dimensions of the wavelength. For irradiation, an X-band plane wave was used - a frequency of 10 GHz. Based on the results of the reflection of the electromagnetic wave from the object, backscatter diagrams were built, on the basis of which a table was formed containing the maximum values of the effective scattering area. It was noted that the maximum value of the effective scattering surface occurs in a situation where there is no inclination of the vertical stabilizers, while when the angle of inclination of the vertical stabilizers is changed by 5 degrees, a significant decrease in the maximum ESA level is observed. In this case, repeated reflections from horizontal tail stabilizers may occur, which, in turn, will lead to an increase in the level of the effective scattering surface. Competent optimization of the angle of inclination of the vertical stabilizers of the aircraft allows one to achieve a significant decrease in the ESA level while maintaining the aerodynamic characteristics of the aircraft, and the introduction of special composite stealth materials allows one to further reduce the ESA level

**Key words:** effective scattering area, monostatic ESA, method of geometric theory of diffraction and physical optics

## METHOD FOR CALCULATION OF RADIO FREQUENCY INTERFERENCE BASED ON THE TRANSFER FUNCTION

**A.V. Bashkirov, A.S. Demikhova, N.V. Astakhov, M.V. Dolzhenko, D.R. Elkin**

**Abstract**: a method for calculating the transfer function for assessing noise immunity and security (RFI) is proposed. Closed-form equations are analytically derived from Maxwell's equations and the reciprocity theorem. The RFI problem is decomposed into two parts: the dipole moments of the noise source and the transfer function of coupling to the antenna. Transfer functions can be obtained either from simulations or measurements. Simple S-parameter measurements can provide transfer functions. The proposed method was verified using numerical simulation and real experiments using a mobile phone. When simulating the source of interference, and the communication of the interference with the antenna-receiver, in the proposed work the problem is divided into two stages: the direct problem (the noise source emits, and the antenna is turned off) and the inverse problem (the antenna is activated, and the noise source is turned off). Engineers can use this method to diagnose and correct the effects of electromagnetic interference. A method for calculating the effect of interference based on the transfer function is also proposed to assess the degree of distortion of the transmitted signal. These equations allow us to clearly decompose the problem of radio interference into two components: the noise source and the effect of the transfer function on the antenna. In comparison with the conventional least-squares method, the proposed method has better accuracy (about 3 dB)

**Keywords:** electromagnetic environment, noise immunity of data transmission lines, selection and analysis of analytical and empirical methods for assessing noise immunity of radio electronic means and complexes, analytical method of assessment based on the transfer function

## AMPLITUDE DISTRIBUTION OF LINEAR ANTENNA SYSTEMS WITH CONTINUOUS APERTURES

**E.A. Rogozhina, O.A. Shiposha, K.A. Layko, A.S. Razumikhin, Yu.O. Filimonova**

**Abstract:** we carried out investigations of the known amplitude distributions for linear continuous apertures and obtained a number of new distributions with the best ratio of the utilization factor of the aperture surface for a given level of side lobes. Among the considered, there are the well-known amplitude distributions of the “cosine of the m-th degree” type. We note amplitude distributions from this class, the directional patterns of which have antiphase side lobes. We propose a new class of amplitude distributions for continuous apertures of the superposition type “cosine of the m-th degree” and “cosine of the m-2 degree” with different weight coefficients, the radiation patterns of which with antiphase side lobes give the resultant with a narrow main lobe, a lower value of the level of side lobes and a higher utilization of the aperture surface in comparison with the classical distribution “cosine of the m-th degree”. We present a comparative analysis of the obtained continuous distributions with the Dolph-Chebyshev amplitude distributions for discrete structures according to the criterion of the maximum utilization of the aperture surface for a given level of side lobes. We show that the utilization factor of the aperture surface of the compared amplitude distributions at a high level of side lobes differs by 35%. The proposed class of amplitude distributions allows one to obtain high values of the coefficient of use of the aperture surface for continuous structures and, therefore, a high coefficient of directional action

**Key words:** amplitude distribution, level of side lobes, directional pattern, utilization of the aperture surface, width of the main beam

## IMPROVING THE VARIOUS PROPERTIES OF THE UDA-YAGI ANTENNA

**S.M. Fedorov, E.A. Ishchenko, I.A. Zelenin, E.V. Papina, A.V. Bunina, L.V. Sopina**

**Abstract:** the article considers the Uda-Yagi antenna, which is designed to receive a terrestrial television signal in a 57-frequency channel. The most important characteristics for an Uda-Yagi antenna are directivity, front-to-back ratio, and these characteristics are highly dependent on the number of directors used in the antenna design. On the basis of the electrodynamic simulation, we determined how the characteristics of the antenna directivity patterns at a frequency of 762 MHz will change when using a different number of directors - from 1 (3-element Uda-Yagi antenna) to 12 (14-element Uda-Yagi antenna), at the same time, we determined the optimal number of directors for the situation when the achievement of maximum noise immunity is required (the maximum value of the front-to-back ratio). The article gives directivity patterns for different numbers of directors at a frequency of 762 MHz, dependencies of directivity coefficients on the number of directors and on the frequency, tables with comparative characteristics of directivity patterns. We carried out the simulation using the method of moments, since it achieves a high speed of calculations, as well as high accuracy of results. During simulation, the antenna had one reflector and an active element in the form of a half-wave dipole

**Key words:** Uda-Yagi dipole array, directivity, front-to-back ratio

## PULSE SIGNAL LOSS ESTIMATION TECHNIQUE IN SWITCHING EQUIPMENT AUTHENTICATION SUBSYSTEM

**O.A. Kulish**

**Abstract:** to authenticate L2 switches, you can use the authentication code transmitted by the sender of information to the recipient using the authentication module built into the switch. To generate the authentication code, an optical pulse is used, the energy of which is equal to the photon energy. When transmitting an optical pulse, it is important to estimate the energy losses in the optical devices of the authentication module. A technique was developed for assessing the loss of an optical pulse at bends in integrated optical waveguides. The new technique was obtained as a result of a modification of the calculation of optical energy losses at bends of waveguides for continuous laser radiation. The classical simulation of the propagation of a Gaussian optical pulse was used, while the conformal mapping method was used to replace a curved waveguide with an equivalent rectilinear waveguide. Using the conformal mapping method, the profile of the refractive index of a rectilinear waveguide was changed and the wave equation for the electric field was transformed. As a result of applying the new technique, a formula was derived for calculating the ratio of the energy power of an optical pulse to the power of a constant optical signal. On the basis of the plot of the obtained dependence, it was concluded that for pulses with a duration of 10 fs, the loss of an optical pulse differs greatly from the loss of continuous laser radiation; for pulses with a duration of 100 fs, this difference is insignificant. Thus, for short pulses, when calculating the loss of an optical signal in devices of authentication subsystems, it is necessary to use the method for solving the wave equation with the conformal mapping procedure

**Key words:** optical communication, authentication, switches, integrated optics, pulse signals, radiation loss

## MIXED CHARACTERISTIC OF S-PARAMETERS OF DIFFERENTIAL STRUCTURES

**T.S. Glotova, D.V. Zhuravlyev, V.V. Glotov**

**Abstract:** various types of microwave devices can be described using incident and reflected waves that propagate in the transmission lines connected to them. The relationship between these waves is described by the scattering wave matrix or the S-parameter matrix. Evaluation of differential structures is necessary to ensure optimal circuit performance. The combined differential and common-mode (mixed) scatter parameters (s-parameters) are well suited for accurate measurements of linear networks at radio frequencies. We present the transformation between standard s-parameters and mixed-mode s-parameters, and a graphical comparison of graphs of standard and mixed s-parameter losses is also described. S-parameters of the mixed mode, obtained using the described method, have good agreement for the pathogen and the reaction with the same mode (general or differential) and little variation with different modes. We fabricated and measured a differential structure with a two-port vector network analyzer and a four-port mixed-mode network analyzer. Mode conversion can be used to predict the behavior of mixed-mode parameters using a traditional 2-port vector network analyzer, but a four-port mixed-mode network analyzer is still required to accurately measure the effect of conversion mode on real integrated differential test structures

**Key words:** mixed mode s-parameter, differential structure, multiport vector network analyzer

## USING MACHINE LEARNING TO CALIBRATE ANALOG MICROCIRCUITS

**A.V. Bashkirov, N.V. Astakhov, N.V. Tsipina, A.B. Antilikatorov, A.S. Demikhova**

**Abstract:** we propose one of the machine learning methods that can be used to develop a neural network that predicts the dimensions of the elements of an analog integrated circuit using the example of two amplifiers, while taking into account their intended target characteristics. This scientific work shows that a properly trained neural network is able to learn design patterns and generate calibration schemes that are adequate and suitable for the requirements of the specifications, including those that were not contained in the training data. We present three options for organizing a neural network, based on the analysis of which it was concluded that neural networks showed themselves to be very flexible models capable of calculating the topology of analog integrated circuits. The method proposed in this work showed itself to be quite effective in overcoming the high nonlinearity of topology calculation problems and can be used by designers in practice. The use of this approach allows one to significantly reduce the design time (in individual tasks by 6 or more times) and provide a wider toolkit for the design automation of analog integrated circuits

**Key words:** operational amplifier design, machine learning, integrated circuit topology, analog integrated circuit design, deep learning of neural networks

## MINIMIZING THE EFFECTIVE AREA OF SCATTERING BY MEANS OF CHANGING THE RELATIVE MAGNETIC PERMEABILITY

**A.V. Volod'ko, S.M. Fyedorov, E.A. Ishchenko, M.A. Sivash, L.V. Sopina, A.V. Bunina**

**Abstract:** the article investigates the dependence of the effective scattering area (ESA) on the relative magnetic permeability of the material from which the structure is made. We chose a sphere as the modeling body, which is made of a dielectric material, in which it is possible to change the relative magnetic permeability. Based on the obtained simulation results, graphs of the dependence of the maximum value of monostatic ESA on frequency, as well as on the relative magnetic permeability of the medium, were constructed. It was shown that with an increase in the relative magnetic permeability of the material of manufacture, an increase in the value of the ESA of the object occurs, and the dependence of the effective scattering area on the ratio of the size of the ball and the wavelength was found, so when the threshold value is exceeded, after which the ball becomes a large object, ESA rises sharply. Based on the results of the study, a graph of the dependence of the effective scattering area of the sphere on the relative magnetic permeability of the material of manufacture was built. The possibility of using a material with a frequency-dependent relative magnetic permeability as a stealth coating was proven. The article contains the investigated model, graphs of the results obtained, by which it is easy to determine the dependence of the ESA on the frequency and on the relative magnetic permeability of the material of manufacture

**Key words:** effective scattering area of a ball, monostatic ESA, relative magnetic permeability of the medium

## COMBINED CHANNEL PROCESSING TECHNOLOGY BASED ON MULTI-LAYER TEMPLATES

**A.V. Shchednov, V.P. Smolentsev, N.S. Potashnikova**

**Abstract:** the article considers the technology of manufacturing additional elements of rocket engine cooling systems in the form of local recesses located on the existing milled channels on the outer surfaces of the combustion chambers and the jet nozzle. This problem requires solutions in promising products with high heat stress of the fuel combustion zone. We analyzed the design and processing capabilities of additional cooling elements in the bottom part and on the side surfaces of narrow channels with limited tool access to the allowance removal zone. We studied new tool designs for combined processing using templates of various designs and justified the possibility of their use for making recesses in channels. We propose new methods of combined local processing of recesses with an asymmetric cross-section geometry, the shape of which is justified in the process of testing the manufacturability of the design of the created engines, which was previously considered impossible or excessively labor-intensive. We investigated the possibility of multi-site processing of local recesses for additional cooling in channels in areas with a variable profile of the combustion chambers of modern and promising products using multilayer templates. Here, the developed combined technologies give the greatest effect and contribute to increasing the resource of new-generation engines to a level that provides a multiple increase in the number of trouble-free launches of space systems. This significantly reduces the cost of manufacturing new-generation rocket engines

**Key words:** engines, cooling, combined technology, multi-layer templates, multi-seat processing, resource

# ONE OF THE POSSIBLE APPROACHES FOR DESIGNING A HOB CUTTER FOR MACHINING A SMALL CYCLOIDAL CONE

**V.V. Kuts, A.A. Panin, D.N. Tyutyunov, K.V. Zhilina**

**Abstract:** the article provides an overview of the industrial production of hob cutters. We show that improving the quality and productivity of gear wheel manufacturing is a necessary condition for reducing the cost and expanding the production of gear wheels at domestic enterprises. The main requirement for the teeth of this cutter is that, as a result of sharpening on the front surface, which lies in the axial plane of the cutter, the profile of the teeth remains sharp until they are almost completely worn out. Therefore, we paid special attention to the choice of the relief curve, taking into account a number of factors that contribute to the improvement of the processing process. We note that relief has a number of advantages in comparison with sharpening of cutters. We give a new approach to the design of working equipment for processing small cycloidal wheels and investigate the theoretically permissible intervals of variation of the rear angles during relief. We established that despite the advantages of a cycloidal cutter over other types of undercut cutters in terms of speed and machining accuracy, it has one drawback - a rather small range of applicability on the cycloid arc. On the basis of existing approaches, we developed a variant of the relief of the teeth of the worm cutter along the cycloid

**Key words:** hob cutter, cycloidal transmission, screw relief