

MATHEMATICAL MODEL OF LOCAL INDUCTION HEATING OF PETROLEUM PRODUCTS IN A PIPELINE

A.A. Khvostov, I.G. Drozdov, E.A. Soboleva, D.A. Konovalov, A.A. Zhuravlev

Annotation: the synthesis of a mathematical model of a thermal marker generator, formalizing the processes of heat and mass transfer in a non-Newtonian fluid moving in a cylindrical steel pipeline with dynamic viscosity specified by the Carreau rheological model, is considered. To ensure invariance to contamination of the pipeline surface and the presence of non-metallic thermal insulation, it is proposed to supply thermal energy to form a thermal mark locally by induction. The mathematical model includes a description of the turns of a coil with a conductor through which electric current flows, the steel wall of the pipeline and the flow of non-Newtonian fluid. The model is formalized on the basis of Ampere's law, equations of conservation of momentum, mass and energy. The solution of equations for the electromagnetic field in the frequency domain is used to specify the source term in the heat conduction equation for a steel wall. The results of modeling the evolution of electromagnetic, velocity and thermal fields under different regimes of fluid flow and electromagnetic pulse of an induction generator are presented. The following model media were used: air for the environment, structural steel for the pipeline, copper for the conductor of the heat tag generator, crude oil for the medium transported through the pipeline. A qualitatively correct description of the main patterns of heat and mass transfer occurring in a model environment when a thermal disturbance is introduced by induction is shown

Key words: induction heating, non-Newtonian fluid, Carreau model

ALGORITHMISATION OF DATA PROCESSING AND PREPARATION FOR BUILDING PREDICTIVE ANALYTICS MODELS

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Abstract: the paper presents the problem of algorithmizing of data processing for further use in predictive analytics models. The advantages of using predictive analytics models, such as increased productivity, risk reduction and cost optimization, are shown, as well as the difficulties that arise, in particular the labor-intensive processing of raw data. To solve this problem, an algorithm is presented in the form of a flowchart, which is roughly divided into three levels. The first level involves the initial obtaining of information and its translation into the available language of software tools. The operations of the second level are aimed at reducing the influence of factors that negatively affect the quality of the final model. At the third level, data is transformed and modified for more convenient use. For each level, the most common operations with data are given and examples of their use are shown. An example of the implementation of the proposed algorithm for the predictive analytics model training system on the example of an electric generator is considered. In practice, it is shown that it is possible not to strictly follow the rules, but to select operations for a specific problem, which allows to achieve greater flexibility and efficiency in work. After the necessary preparations, emission research has been carried out to study the abnormal system operation modes that are of interest according to the problem statement

Key words: predictive analytics, data processing, data analysis, forecasting

OPTIONS FOR MODIFYING THE DETR ALGORITHM FOR DETECTING OBJECTS IN A VIDEO STREAM

A.I. Parshin, V.F. Barabanov, N.I. Grebennikova, M.N. Aralov, S.A. Kovalenko

Abstract: despite the remarkable progress that has taken place in recent years, the task of detecting objects in a video stream remains one of the most difficult and requires large computing resources. The convolutional neural networks that have already become classical, on which almost all modern algorithms are based, to one degree or another, are characterized by a large number of variable parameters, such as the dimension of the convolution core for each of the layers, the number of these layers, the parameters of the subdescriptization layers, etc. On the other hand, an increase in the requirements for the quality of object recognition leads both to an increase in the complexity of the structure of the convolutional networks used, and to a constant complication of the final algorithms based on these networks. Currently, an important task is the task of upgrading existing algorithms, one of which is DETR (DEtection TRansformer). The article describes some possible ways and methods of upgrading this algorithm, and estimates the impact on the final result. The proposed modification option contains both optimization of the decoder layers using a neural network, and modification of the influence mechanism to reduce the mathematical complexity of calculations and increase the total accuracy

Key words: object recognition, DETR, artificial neural network, image analysis, convolutional neural network

LOSSLESS RASTER IMAGE COMPRESSION ALGORITHM

M.S. Voitenko, A.S. Voitenko, Yu.N. Fedenko, A.I. Antonov

Abstract: the article is devoted to the issue of efficient compression of raster images without loss of digital data. The relevance of the conducted research is due to the need for effective data compression, which contributes to saving storage resources and saving bandwidth. The paper proposes a new compression algorithm, which is based on the idea of splitting the image into separate color channels and counting the number of consecutive repetitions of the same color value in each channel. The described approach can significantly reduce the amount of image data, thus saving storage space. The paper also presents the results of experiments comparing the proposed algorithm with the standard PNG image compression algorithm and the results of compression based on sequential recording of color channels. The comparison was carried out on the example of raster images without gradient elements. The article contains a description of the proposed algorithm, visual representation of its operation, comparative tables of approaches to the organization of image data and graphics, graphs with the data of experiments on raster image compression: comparison of the data volume of sequential recording of color channels based on a pixel grid and separate recording by color channels

Key words: compression algorithm, lossless data compression, color channel separation, bitmap images

THE ARCHITECTURE OF A DBMS USING A METAGRAPH DATA MODEL

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Abstract: in today's information society, data processing has become an important tool for making informed decisions and achieving success in many areas of activity. There are different types of database management systems (DBMS) used to store data, each with its own unique features, benefits, and use cases. The problem of effective data modeling in conditions of constant growth is considered, the limitations of existing graph models are presented, and a DBMS architecture with a metagraph data model is proposed. The architecture of a metagraph DBMS is described, including subsystems for user input/output, data access, interaction with data storage, and object storage. The proposed metagraph data model and the DBMS developed on its basis will make it possible to fill the need for semantically complete and optimal modeling of complex processes and processing of large volumes of complex network data. Implementation-specific aspects such as attribute management, query optimization, and transaction management are covered. Current achievements in the development of a metagraph DBMS and plans for the future are highlighted, including the development of a prototype storage and software interface, which will allow further research and development of the most optimal DBMS models

Key words: graph DBMS, metagraph, metagraph DBMS, DBMS architecture

RESEARCH OF THE FIELD IN A SYNCHRONOUS MACHINE WITH ELECTROMAGNETIC EXCITATION IN THE REGION OF SELF-OSCILLATIONS

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Abstract: it is known that with an increase in the intensity of the magnetic field in the air gap, a synchronous machine with electromagnetic excitation can enter a mode of self-oscillations of varying degrees of intensity. Many works have been devoted to the study of self-oscillations, but the magnetic field in this area has not been studied. The initial direction of research is the division of areas of operation of a synchronous machine into areas of stable operation, areas of self-oscillation and creep when the synchronous machine goes into asynchronous mode. In addition to the design of the machine, the stability areas depend on the parameters of both the machine itself and the mode. The most influential parameters are: the active resistance of the stator winding and the current in the field winding. The current in the field winding determines the induction and strength of the magnetic field, which in turn affects the electromagnetic torque and the ability of the machine to operate stably. However, a synchronous machine with electromagnetic excitation has a peculiarity in its operation: when the current in the excitation winding increases beyond a certain limit, spontaneous self-oscillations begin to develop in it. Their amplitude can increase until the synchronous machine either continues to operate with oscillations of a certain amplitude and frequency, or falls out of synchronism. To study the electromagnetic field in the self-oscillation mode, the numerical finite element method is most suitable. With its help, it is easy to calculate the amplitude and frequency of self-oscillations, as well as the electromagnetic torque in the mode under consideration. In addition, the saturation level of the machine's magnetic circuit in any computational domain becomes known. The finite element method allows you to do this clearly, quickly and quite accurately

Key words: synchronous machine, electromagnetic excitation, boundaries of stable operation, parameters of the substitution circuit, finite element analysis, electromagnetic field, low frequency oscillations, stroboscopic method

DESIGNING OF A UNIVERSAL SERVICE FOR VIEWING STUDENT SCHEDULES OF DIFFERENT UNIVERSITIES

D.L. Sashchenko, S.A. Oleinikova

Abstract: the article is devoted to the development of an online service designed to view student class schedules. The relevance of the development is due to the ability to view the schedule at any time from both a mobile and a stationary device, as well as promptly respond to any changes. In addition, such services are usually updated in real time, which allows students to be aware of class changes or cancellations and avoids missing classes. The developed application includes a database, client and server parts. The Vue web framework and its Quasar add-on will be used as the client part of the web service for a richer user interface, and the Spring Boot framework and PostgreSQL database will be used to implement the server part. The server part of the project implements receiving schedule files, extracting data from them with subsequent processing and saving into its own database, as well as further work with data, namely their receipt and aggregation. The application architecture will be depicted on UML and AIA diagrams, which will show how the user interacts with the service, as well as the application integration architecture. The novelty lies in providing users with the ability to view content from any device. The practical significance is confirmed by the implementation of the application in the activities of the Voronezh State Technical University

Key words: student timetable, online service, UML diagram, AIA diagram, PostgreSQL

INTELLIGENT TRAFFIC FLOW CONTROL SYSTEM AT INTERSECTIONS WITH TRAFFIC LIGHT REGULATION

M.A. Strizhko, V.V. Chervinskiy

Abstract: the paper proposes a system of intelligent traffic flow control at intersections with traffic light regulation as one of the possible solutions to the problem of traffic delays in a megacity. This solution makes it possible to reduce the periods of idle time for cars at red light when there is no traffic in the direction of green light by dynamically changing the duration of the control phases based on information about the parameters of traffic flows. The purpose of the study is to increase the efficiency of vehicles passing through intersections with traffic light regulation. The proposed control system is based on fuzzy logic. The principle of its operation is similar to the actions of the police officer. Due to the use of technical means of traffic detection, the amount of information about the parameters of the traffic flow has been significantly expanded, which makes it possible to improve the quality of control. The article describes the structure of the proposed control system, the configuration of the fuzzy logic controller and the choice of the main parameters and limitations of the system. The assessment of the control quality of the developed system was carried out using computer simulation of traffic lights on a section of the city's road network. The results of modeling and comparing the developed system with existing traffic flow control systems at intersections showed that the application of the proposed system made it possible to increase the efficiency of road regulation by 13% and 39 % compared with existing "flexible" and "rigid" control systems, respectively. The proposed traffic flow control system demonstrates the greatest efficiency in conditions of high dynamics of changes in the intensity of traffic flows at intersections, which is quite common in modern megacities

Key words: intersection, traffic flow, intelligent control system, fuzzy logic, traffic light regulation

BAYESIAN NETWORK OF TRUST IN A DECISION MAKING SYSTEM WHEN CONTROLLING A UAV

V.A. Malinovkin, O.S. Mordvinkina, K.N. Reznikov, A.V. Barabanov

Abstract: the range of unmanned aerial vehicles (UAVs) is expanding in today's world. A distinction is made between controlled control (via a control panel) and uncontrolled control of UAVs. The task of automation includes the exclusion of human influence from the main process. Thus, uncontrolled control of UAVs is an actual task. Earlier, the main systems of support and decision making based on: machine learning, deep learning, Bayesian networks, game theory were considered. As a result of comparison the choice was made in favor of Bayesian networks, as in this case it is not required to carry out preliminary training, achieves high speed of calculations and realizes the possibility of working with different input information affecting the event at a point. In the current work we analyzed the following algorithms for finding the shortest distance: Floyd-Worshell algorithm, Ford-Bellman algorithm, Dijkstra algorithm. The comparative analysis showed that the Ford-Bellman algorithm is optimal for solving the problem of finding the shortest path in an urban environment (the number of edges is less than the number of vertices, since the existence of edges is limited by knowledge of the terrain). The use of Bayesian trust networks in a decision support system using d-separation has also been demonstrated. Optimality criteria for choosing the optimal path were formulated: presence of the minimum distance between the initial points, presence of the largest average confidence coefficient

Key words: Bayesian networks, d-partitioning, Floyd-Warshell algorithm, Dijkstra algorithm, Ford-Bellman algorithm

FLAT MOTION SIMULATION OF A TWIN-ENGINE LIGHTER-AIR FLIGHT VEHICLE

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

Abstract: the article discusses the modeling of the plane motion of a disc-shaped unmanned aerial vehicle with positive buoyancy. Perspective aircraft of this type have solar panels on the surface of the shell and allow the use of a fuel-free power plant, which ensures the operation of the device at altitudes of 20,000 - 22,000 meters. The flying devices that have the ability to operate in hovering mode at a certain point in space during a long flight time allow the use of only electric power plants. Theoretically, the duration of the flight time is determined by the uptime of the batteries. One of the significant disadvantages inherent in airships is high windage and low maneuverability. The disc-shaped shape of the aircraft successfully combines the high energy capabilities provided by the solar battery, reduced windage and allows for increased maneuverability of the device. However, it is known that flying devices of this shape are extremely unstable in flight and exposed to wind loads. The electric power plant has a particularly valuable quality - good controllability. Brushless DC motors are ideal for operation at high altitudes at ambient temperatures as low as 50°C. To control the engines, modern control and navigation systems are used, which stabilize the fundamentally unstable flight. To assess the maneuverability of an airship, it is necessary to simulate the plane motion of the aircraft along a given trajectory. Controlling movement along a given trajectory in manual mode is a rather difficult task. But even in automatic mode, flight along a given trajectory has certain speed restrictions: the higher the speed the less controllable the device, unlike an airplane. In this case, the principles of constructing a control system also used in quadcopters with some systematic error give quite acceptable flight trajectories. The results of modeling the plane motion of an aircraft along a given trajectory are presented

Key words: modeling, plane motion, motion control along a given trajectory, unmanned aerial vehicle

ROBUST REPLICATION METHODS AND PROTOCOLS IN DISTRIBUTED SYSTEMS AND ENVIRONMENTS

A.D. Danilov, M.O. Savvin, A.E. Karachevtsev

Abstract: the volume of data generated by different devices, sensors, applications, and users of web services and social networks has significantly increased. This increase has prompted the need to transition to a new architecture for storing and processing data. The existing centralized local solutions have become inefficient, and further increase in computing power required significant financial investments. In addition, the need to store the original "raw" data has further increased the need for disk space. The solution to this problem is based on the use of distributed architectures controlled by special distributed data storage and processing systems. Nodes in such systems may consist of simple components that do not always have high reliability and fault tolerance. In this article, the authors have shown that in such conditions, data consistency and system resilience to failures come to the fore. The analysis of modern replication methods and protocols in distributed environments conducted in the article showed that data replication is a key strategy for ensuring the reliability and availability of information in systems where data is stored and processed on multiple nodes. The classification of replication protocols into two categories is considered: the update strategy and the method of distributing updates. In the end, it is concluded that centralized approaches to replication with eager distribution of updates are currently an indispensable mechanism for improving the efficiency of highly loaded and distributed systems

Key words: data replication, distributed computing, software and hardware, transaction management

METHODS OF DATA TRANSMISSION USING LINEAR FREQUENCY MODULATED SIGNALS

L. A. Senatorov

Abstract: various approaches to data transmission using linear frequency modulated (chirp) signals are studied. The purpose of the work is to study methods of modulation and demodulation of chirp signals to select the most suitable one for the case of data transmission over a radio channel. The author has explored two main approaches - the transmission of individual bits and the transmission of groups of bits for additional spectrum expansion. When considering these approaches, the work examines four methods of transmitting data using chirp signals: processing using matched filters, processing using the correlation method, processing using analysis of the parameters of the analytical signal, as well as a method for searching for a phase break in the transmitted signal. For each of the considered methods, a simulation model was compiled and studied in Matlab R2018b. The study of models made it possible to identify the main advantages and disadvantages of using each method. Separately, we consider the method of generating a chirp signal from the spectrum using the inverse Fourier transform using Newman phases. The method of modulating a chirp signal using a phase break was recognized as the most promising for use in radio communication systems. Depending on the chosen algorithm for searching for a phase break, this method may lose in processing speed, however, due to its algorithmic simplicity and good noise immunity, it can be successfully used in real communication systems

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

DIELECTRIC LEAKY-WAVE ANTENNA WITH TRANSVERSE RADIATION

A.V. Ostankov, D.Yu. Kryukov

Abstract: leaky-wave antennas have become widespread due to their relatively simple designs small transverse dimensions and high efficiency. Dielectric periodic leaky-wave antennas which convert the slow surface wave of a dielectric waveguide into a spatial radiated wave using a periodic grating are used in oblique radiation mode when excited on one side. However, in some cases the transverse radiation mode is preferable. However, the implementation of such a regime is associated with a catastrophic deterioration in emissivity due to Bragg diffraction. The paper discusses ways to eliminate the normal effect. In relation to an antenna with a radiating aperture in the form of a planar dielectric waveguide loaded with a periodic comb grating, a method has been implemented for introducing an additional groove on a period at a distance of a quarter of the wavelength from the main groove. It has been established that when an additional groove appears during the period, equivalent in size to the main groove, the increase in the emissivity of the antenna is not so significant. Two options have been proposed for increasing the efficiency of an antenna with a modified aperture by optimizing the position of the additional groove relative to the main one or selecting the depth of the additional groove. It has been established that the increment in emissivity and radiation efficiency of the leaky-wave antenna when optimizing the depth of additional grooves is higher than in the case of selecting the distance between the additional and main grooves. The results are obtained on the basis of electrodynamic modeling, implemented on the basis of the author's projection model, which has received wide recognition

Key words: dielectric antenna, comb grating, groove, transverse mode of electromagnetic radiation, emissivity, efficiency

COMPREHENSIVE COMPARISON OF CONTROL DEVICES IN TELECODE AND VOICE COMMUNICATION SYSTEMS

Ya.S. Motyleva , Yu.G. Khrenova, V.Z. Tsikolia, A.Yu. Chernyshev

Abstract: the features of control in telecode and voice communication systems are considered. Certain requirements for the speed and volume of data transfer in modern equipment have been identified. Methods used to verify the integrity and authenticity of data are considered. For practical implementation, the MD5 algorithm was chosen since it is one of the most common. The task was set to select programmable devices to solve specific problems. To assess the performance of occupied resources, a functional device was taken and tested on various programmable devices, for each of which code was written in the corresponding programming languages. Based on the test results, we can conclude that the use of user-programmable gate arrays makes it possible to successfully perform several parallel tasks at a lower clock frequency along with popular microcontrollers, which indicates a possible reduction in the cost of telecode and voice communication systems. The use of digital signal processors is justified only for solving highly specialized problems associated with digital processing of analog signals and real-time control systems

Key words: programmable control devices, microprocessors, user-programmable valve matrices (UPVCs)

JOINT UPLINK ARCHITECTURE OF MASSIVE MIMO AND OFDM RADAR SYSTEMS

O.N. Chirkov, A.V. Bashkirov, Yu.M. Pshenitsyna

Abstract: the article proposes a joint uplink architecture of massive MIMO and OFDM radar systems using the same hardware and time-frequency resources. An uplink and short-range radar sensing are considered, when data from user equipment is received at the BS base station, and at the same time radar signals from targets. The signal received by each BS antenna consists of radar signals and communication channel data, which must be processed separately for detection and data transmission. Signal detection is achieved by using channel separation between user equipment and targets, as in mass MIMO communication systems. The signal from the user is detected and demodulated, then subtracted from the received signals to obtain radar data. Symbol-based radar processing is used for the radar, since it provides a significant gain in processing, and the effectiveness of its detection does not depend on the shape of the transmitted radar signal. Thus, a two-functional massive OFDM radar communication system is obtained over the MIMO uplink. In addition, the analysis of intrinsic interference that occurs between simultaneously operating transmitting and radar antennas (i.e. in full-duplex mode) is considered. The study shows that it is possible to develop a transmitter architecture that can satisfactorily interact with several subscribers simultaneously using time-frequency resources for radar sensing of the data transmission environment without significantly increasing the cost or complexity of the system

Key words: signal, system, uplink, base station, bandwidth, radar, channel diversity, MIMO, OFDM

DESIGN METHODOLOGY FOR DIGITAL IP-BLOCKS OF INTEGRATED CIRCUITS

I.R. Chekaldin, A.V. Rusanov, V.A. Smerek, A.I. Sukachev

Abstract: this paper considers the main stages of the development of complex-functional digital IP-blocks as part of ultra-large integrated circuits (ULSI) and systems on chip (SoC). Formulated the main advantages and disadvantages of the integrated circuits (IC) design concept using standard cells and IP-blocks are outlined, and the main objectives of the application of this concept. The place of IP-blocks in the SoC design route is determined, on basis of which the hierarchy of priority of some stages of the design of custom IP-blocks is highlighted. Some aspects of standardization in design at the model level are considered in order to avoid conflict situations when placing and connecting cells. The composition of the final topological, circuit design and description files is analyzed, which is necessary and sufficient for the delivery of the developed block to the customer, and its subsequent application in the design route. The methods of protecting commercial information when transferring topology files to enterprises producing IC crystals are given. Software capabilities (verification, synthesis of digital automata, topology design using automation tools) in the design of IP-blocks were described within the framework of the functionality of software tools provided by Cadence, Mentor Graphics, Synopsis. The relevant actions of the IP-block customer after receiving the necessary modeling, topology, description and documentation files are briefly touched

Key words: digital IP-blocks, integrated circuit, Verilog, design methodology, license GPL/LGPL, complex-functional blocks

DEVELOPMENT HARDWARE FOR OPTICAL DEFECT INSPECTION SYSTEM TOPOLOGY OF ELECTRONIC COMPONENTS

M.A. Romashchenko, D.V. Vasilchenko

Abstract: the article discusses one of the stages of a project aimed at developing, manufacturing, and testing a prototype of a software-hardware complex for optical defect inspection of electronic component topology. The problem justifying the need for such an optical inspection complex is formulated. The task for this stage involves selecting hardware and determining the approach for its integration with software modules, as well as developing principles for automated control of the movement of the inspection microscope's stage. The selection of the hardware used is conducted and the application of the industrial inspection microscope Nexcope NX1000 and the digital camera Dahemg imaging MER2-2000-19U3C is justified. The designed structural scheme of the software-hardware complex for optical defect inspection of electronic components is presented. The proposed system for automated movement of the microscope stage is described, and its functional diagram is provided. The main requirements for the components of the automated movement system, as well as the method of its integration into the inspection microscope Nexcope NX1000, are specified. The work was carried out with financial support from the Federal State Budgetary Institution "Foundation for Assistance to Small Innovative Enterprises in Science and Technology" within the framework of the Start-23-1 competition (Queue II) (contract No. 5049GS1/89569 dated 24.10.2023)

Key words: electronic component, machine vision, defectoscopy, optical inspection, non-destructive testing

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THE POSSIBILITY OF ATTENUATION OF THE MAIN LOBE OF THE REFLECTED WAVE BY MEANS OF A SPIRAL TRIANGULAR METASTRUCTURE

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Abstract: this work presents metastructures in the form of unclosed spiral triangles, as well as their diffraction characteristics, namely scattering diagrams, the distribution of the electric field and current over the surface of the samples. This type of structure makes it possible to obtain a number of practically important characteristics that are difficult to achieve using conventional weakening coatings. Such properties are achieved by changing the direction of propagation of the electromagnetic wave when it is reflected from the surface of the object, as well as due to the destructive interference of the reflected wave from specially designed resonators located on the surface of the sample. Thus, the above structures can form negative dielectric and magnetic permittivity in a certain frequency band, in our case, the range of 16-25 GHz. The work also includes computer modeling of the impact of an electromagnetic field of the specified range on the samples presented in the CST Studio software package. Then, the obtained data were compared with the results of experimental researches. Based on the data obtained, it can be concluded that the presented structure has high attenuation rates of the main lobe of the reflected electromagnetic wave. Thus, this property makes possible the further development of frequency-selective surfaces, which will be based on the above-described meta-coating

Key words: Reflection attenuation, scattering diagram, S-band, frequency dependences

INDICATOR OF STRUCTURAL EFFICIENCY OF INFORMATION INTERACTION MANAGEMENT IN HETEROGENEOUS DATA TRANSMISSION NETWORK OF SPATIALLY DISTRIBUTED MONITORING SYSTEM

V.A. Shevtsov, A.M. Kazantsev, A.V. Timoshenko, R.A. Kochkarov, S.V. Prokopchina

Abstract: at present, the increasing complexity of operating conditions and the increasing volume of transmitted data in spatially distributed monitoring systems (SDMS) with a dynamic topology of the data transmission network make it difficult to achieve the specified requirements for efficiency, stability and security of information exchange, including in the conditions of failures of its subsystems of different levels. The paper considers the graph-theoretical model of SDMS and the formulation of optimization problems with different criteria: weight and topological. It is noted that in order to reduce the consequences of possible destructive influences, as well as to predict the behavior of SDMS, it is necessary to metric the efficiency of information interaction of information means (IM) within the system. It is proposed to use an aggregated topological index, which is a linear convolution of structural and topological metrics and realizes the main requirements of operational management and control of structural stability of SDMS. Based on the solved problems of SDMS, the main structural-topological metrics are proposed. It is noted that by studying each metric and applying the proposed criterion to the analysis, it is possible to evaluate the mechanism of information interaction between IM of SDMS, both in terms of structure and its quality, and in terms of the nature of information exchange in time

Key words: information interaction, heterogeneous network, graph, destructive influences, basic structural and topological metrics, aggregated topological index

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A METHOD FOR PROCESSING PULSE SIGNALS WITH ORTHOGONAL FREQUENCY DIVISION USING LOW-DENSITY CODING

M.V. Khoroshailova

Abstract: in this article, a method is proposed to increase the stability of the system to distortions in the data transmission channel by integrating a cyclic prefix, which is redundant information, and a virtual carrier into a composite signal. In addition, to reduce the error rate, we introduce low-density parity checking (LDPC) into this system. On the receiver side, channel estimation performance is improved by estimating symbol synchronization offset, estimating carrier frequency offset, and channel estimation methods aided by a priori information obtained from radar data. During radar detection, a joint estimation of the distance and velocity of a radar target is achieved by using consistent filtering, pulse compression, and window processing to obtain delay and Doppler frequency. To obtain more reliable data, we use an estimate of the minimum standard error based on the discrete Fourier transform to estimate the channel. Simulation modeling shows that the proposed system not only implements transmission and detection functions, but also improves the performance of the integrated signal, such as the bit error rate (BER) 6×10^{-5} , the peak side lobe ratio is -12.73 dB and the integrated side lobe ratio is -8.56 dB with a signal-to-noise ratio (SNR) of 10 dB

Key words: cyclic prefix, low-density encoding, multiplexing with orthogonal frequency division of channels, symbol synchronization offsets

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MICROSTRIP CROSSOVER FOR THE UHF RANGE BASED ON COMPACT LOOP MODIFICATIONS

A.V. Ostankov, N.N. Schetinina, S.A. Slinchuk

Abstract: microstrip multi-beam phased array antenna systems may include crossovers that enable the transmission of useful signal power in mutually intersecting directions in a single plane. Classical microstrip crossovers consist of a cascade connection of two co-directional dividers, each of which, when implemented based on quarter-wave loops, has significant dimensions in the UHF range. The aim of this work is to minimize the size of the crossover by replacing the quarter-wave loops, which form the crossover topology, with their equivalent compact modifications. Combinations of T- and Pi-shaped loop sections combined with back-to-back structures and meander lines are taken as alternatives to the original transmission line segments, the analysis and synthesis of which were carried out by the authors in earlier publications. This proposed configuration allows for the efficient use of free space within the crossover and thus significantly reduces the dimensions of the device. The frequency properties of the classical microstrip crossover and the original crossover implemented on modified loops were studied based on rigorous electromagnetic modeling using the method of moments. The amplitude-frequency characteristics of the classical and modified crossovers are presented and compared. It was found that the area occupied by the modified device is more than 80 % smaller compared to the traditional construction. However, the fivefold reduction in the dimensions of the crossover is accompanied by a narrowing of the operating frequency band by one and a half times

Key words: crossover, topology, modification, T-section, Pi-section, passband

FORECASTING THE YIELD PERCENTAGE OF SUITABLE ICS

A. V. Bashkirov, A.B. Antilikatorov, A.S. Kostyukov, P.I. Podmarkov

Abstract: forecasting yield percentage is a critical aspect in integrated circuit design. The successful determination of this percentage is important both at various stages of development and during the production stage. It is determined for each batch of products separately using simple calculations, which include counting the number of valid integrated circuits that meet the technical requirements, as well as the number of rejected ones after each technological operation or group of operations, including control stages. In the process of assessing the percentage of yield of suitable integrated circuits, two main categories are distinguished: the yield of suitable integrated circuits on the wafer (substrate) during the formation of crystals (boards) and the yield of suitable ones after the full assembly stage, which together makes it possible to assess the efficiency of the production process and the technological reliability of the system production of integrated circuits in general. Mathematical models are presented that are intended to describe the occurrence of random failures of integrated circuits. The presented models are based, in turn, on the analysis of statistical data, namely the Poisson distribution and the binomial distribution. The models presented in the article are adapted to various conditions for the occurrence of failure situations of integrated circuits

Key words: ICS, technological process probability of failures, type of defects, number of failures, test control, percentage of output of suitable IS

IMPROVING NOISE IMMUNITY IN WIRELESS COMMUNICATION SYSTEMS WITH OFDM MODULATION BY REDUCING THE PEAK FACTOR OF THE SIGNAL

O.N. Chirkov, E.A. Kushchev

Abstract: this article describes the technology OFDM signal modulation in broadband communication systems, identifies the features of the organization of the OFDM channel, the advantages and disadvantages of this type of signal processing, as well as its scope. The peak factor of the signal is described as the main characteristic of the OFDM communication channel and the main problem in the development of a communication system with this type of modulation. Here, the question of the influence of the peak factor of the signal on both the efficiency of data transmission in a wireless communication system and the complexity and cost of the design of receiving and transmitting devices is raised. After the designation of the peak factor problem of the signal, the article considers the question of effective methods of reducing the peak factor applicable to the OFDM channel. The analysis of distorting and non-distorting methods of peak factor reduction is carried out and at the end a comparative characteristic of the presented methods is given in terms of data transmission efficiency, noise immunity of the OFDM channel and the expediency of the areas of application of these methods in the design of a wireless communication system

Key words: OFDM modulation, peak factor, time-frequency grid, fast Fourier transform, inverse discrete Fourier transform, clipping, companding, suboptimal method

STUDY OF NEAR-FIELD ELECTRICAL AND MAGNETIC COMPONENTS FOR STRIPE ANTENNA

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Abstract: in the field of microwave technology, strip antennas are often used, usually manufactured using printed circuit board or integrated circuit technology. Analysis of the level of their radiation and the influence of the housing material is very important at the development stage of this device to assess electromagnetic compatibility. In the modern world, the issue of correct assessment of electromagnetic compatibility plays a significant role in the design and development of electronic equipment. To save time and money, many developers strive to analyze their devices at the early stages, including electromagnetic compatibility. A powerful software package for analyzing the electrical and magnetic components from a radiating source is Ansys HFSS. The article presents a description of the algorithm for analyzing the magnetic and electrical components of the near field in relation to a strip antenna. A comparison of the radiation level in a housing made of different materials is also carried out. The electric and magnetic components of the near field of the strip antenna were analyzed. A comparison was also made of the electrical and magnetic components of the antenna strip in closed structures - in a housing

Key words: magnetic field, electric field, radiation, housing, software

ON THE ISSUE ABOUT MICROSTRIP BANDPASS FILTERS PROTOTYPING IN THE LABORATORY CONDITIONS (Part 2)

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Abstract: when designing microstrip bandpass filters, prototyping is often required to refine the calculation results. There are several ways to model in the laboratory. An important issue when choosing a layout method is the degree to which the parameters of the manufactured layout correspond to the calculated parameters. The achievable degree of parameter compliance determines the applicability of a particular layout method. Within the framework of this work, a qualitative assessment of the applicability of milling the topology of a microstrip filter on a numerical control machine (CNC) for the purposes of layout in laboratory conditions is given. The method under consideration consists in generating a control program for a CNC machine based on the calculated topology of a microstrip bandpass filter, taking into account the features of the tool used. After that, the foil dielectric material is milled. For the layout made in this way, measurements of the parameters were carried out: the geometric dimensions of the topology and the amplitude-frequency response of the filter (frequency response). The figures showing the geometric dimensions of the calculated filter and the milled layout are given. Additionally, microstrip resonators of the resulting layout are magnified under a microscope to assess the manufacturing quality. Based on a comparison of the calculated geothermal parameters and the calculated frequency response with the corresponding parameters of the manufactured microstrip strip filter layout, a qualitative assessment of the applicability of milling for layout in laboratory conditions was made. Additionally, a comparison of deviations in geometric dimensions and frequency response of a microstrip bandpass filter layout manufactured using photolithography technology followed by chemical etching is presented

Key words: microstrip filter, bandpass filter, prototyping

DETECTING THE SIZE OF NEOPLASMS ON THE BASIS OF RADIO WAVES

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Abstract: the paper considers the possibility of detecting cancerous neoplasms using a microwave system of two antennas of millimeter range, as well as determining the size of neoplasms based on changes in the characteristics of the channel. The determination of the characteristics of the passing electromagnetic waves is based on the amplitudes of the received signal, its Fourier spectrum, the S_{21} -parameter matrix, and the dielectric characteristics of the system based on the scattering matrix. An electrodynamic model simulating the interaction of electromagnetic waves with a stratified tissue structure including skin, fat, and muscle layers with unique dielectric constants, magnetic permeability, and electrical conductivity is presented. The essence of the technology is the use of bilayer patch radiators in the frequency range of 23.97 to 28.88 GHz, chosen for their sensitivity to the smallest neoplastic changes due to their short wavelengths. Tumors with radii ranging from 1 mm to 10 mm are evaluated in the model, and the effect of tumor size on radio wave propagation, as determined by S_{21} transmission coefficient parameters, is studied. The results show a direct correlation between increasing tumor size and a decrease in the amplitude of the signal received by the antenna, indicating the ability of the method to detect tumors in their initial stages, which is necessary for effective treatment

Key words: electrodynamic modeling, disease detection, wave scanning, scattering matrix, spectral analysis, dielectric characteristics

APPLICATION OF THE PARTICLE SWARM METHOD IN THE TASK OF OPTIMIZING THE PID CONTROL SYSTEM OF A PROGRAMMABLE DC ELECTRONIC LOAD

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Abstract: currently, the DC electronic load control circuit is mainly based on analog control, that is, the control circuit is controlled by an operational amplifier. Thus, in the process of increasing the current, it is easy to cause low response speed and overvoltage, and improving the response speed is of great importance for the test line. Dynamic response is important when testing the load of power supplies and batteries. Therefore, this article examines the digital control of a DC electronic load. The digital DC load control system has non-linearity characteristics, which makes it difficult to theoretically model it. Therefore, to obtain a mathematical model, the State Flow toolset of the domestic SimInTech dynamic modeling environment is used. The traditional method of setting up a PID requires a lot of time and has a bad effect. This article uses a self-tuning PID controller based on a particle swarm optimization algorithm. Two control schemes were modeled and compared using SimInTech modeling: traditional PID control and PID control with particle swarm optimization (PSO-PID control). The results show that the optimized PID controller demonstrates a faster response compared to the traditional PID control algorithm, and the system performance is significantly improved. The developed electronic load control system will ensure resistance to interference and minimize their impact on control.

Key words: electronic load, PID regulation, particle swarm optimization, instrumentation, dynamic modeling, transfer function

EXPANDING OF THE SCOPE OF USE OF COMBINED HIGH-TECH TECHNOLOGIES IN MECHANICAL ENGINEERING

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Abstract: the paper considers the issues of expanding the scope of use of combined high technology technologies used at the final finishing stages of processing. As a result of research, over 40 processing methods have been systematized and schemes for their implementation have been considered. A method for solving the problem is proposed based on the use of an electronic bank of design and technological solutions. The results of systematization and unification of schemes and methods of combined physical-chemical, ultrasonic and radiation finishing methods obtained during the creation of a bank of technological solutions are presented. Promising methods for combined finishing of internal surfaces, in particular, channels of various cross-sections with straight and curved axes, due to anodic dissolution of the allowance, have been established. A brief description of the dialogue environment through which access to information from the technological solutions bank is organized is provided. Using the example of the combined processing method, methods for the practical application of research results in the design of finishing technologies for machine parts of an expanded range of various branches of mechanical engineering and related branches of technology are shown. In particular, the emerging possibilities of using the shown logical connections for the purpose of automating research and applied technologies in the field of medicine have been studied, which expands the capabilities of combined processing methods

Key words: combined methods, bank of design and technological solutions, technologies, design, scope of use

MODELING OF THE PRODUCING SURFACES OF MILLING CUTTERS FOR HIGH-PERFORMANCE MACHINING OF CURVED GEARS ECCENTRIC-CYCLOIDAL ENGAGEMENT

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Annotation: in this paper, a fundamentally new method of processing curved gears of eccentric-cycloidal engagement with a curved profile using a special tool is considered. The surfaces of wheels of eccentric-cycloidal engagement with a curved profile for small and large wheels are simulated. The scheme of forming a small wheel of eccentric-cycloidal engagement using a shaped milling cutter with a constructive radial feed is shown. The producing surface of the milling cutter is obtained, which allows to fulfill all the conditions of shaping when implementing the proposed scheme for shaping a small wheel of eccentric-cycloidal engagement with a curved profile. For a large wheel, a shaping scheme using the rolling method using a worm wheel is proposed. Modeling of the producing surface of a worm mill for shaping the surface of a large wheel of eccentric-cycloidal engagement using the rolling method is performed. This milling cutter producing surface also allows you to fulfill all the shaping conditions when implementing the proposed shaping scheme. This approach can be used in the design of milling cutters designed for working curved gears of eccentric-cycloidal engagement of various sizes. The use of such special tools will make it possible to make the transition to serial and mass production of gears with this eccentric-cycloidal engagement

Key words: eccentric-cycloidal engagement, milling cutter, modeling, producing surface

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APPLICATION OF THREE-DIMENSIONAL SCANNING TECHNOLOGY TO CREATE DIGITAL TWINS OF MACHINING FACILITIES

O.A. Ryabinina, A.I. Boldyrev, A.A. Boldyrev, D.Yu. Levin

Abstract: the paper describes the possibility of using three-dimensional scanning technology to create a digital twin of the machining facilities and its further use in the process of technological manufacturing preparation. A digital twin is a tool to optimize the work of specialists, it allows to recreate the infrastructure and logic of operations of a physical object. Digital models obtained in this way can be used in the future in automated enterprise management systems, as well as in the competent design of production area and production flows in three-dimensional space, where the twin will act as a 3D template of equipment for more optimal organization of the manufacturing process. These are software and hardware complexes designed for training in the skills of working on CNC machine. Such systems can use a digital twin to create and simulate CNC programs on a computer. Being a complete virtual prototype of a real machine, it allows not only to teach how to work with CNC systems, but also, without working time of the machine, to debug previously developed machining programs, eliminating with its help possible collisions of machine units, eliminating defects and inaccuracies of programs, optimizing operating modes. The article presents the algorithm of three-dimensional scanning of machining facilities and explanations to it. The application of these technologies is aimed at reducing the time of technological preparation of production by creating a digital library of machining facilities

Key words: digital twins; 3D scanning; machining facilities; digital manufacturing procedure; jigs, fixtures and tools; technological tooling