

DEVELOPMENT OF A COMPONENT FOR ANALYZING THE INTERSECTION OF PART MODELS IN ASSEMBLIES BY MEANS OF GEOMETRIC KERNELS

A.N. Yurov

Abstract: when designing products, errors may be made due to the introduction of restrictions between parts in the overall layout of the assembly unit. Layout errors lead to mutual intersection of parts in digital format and may not be noticed in the engineering design system, but such errors are unacceptable in the production process. Methods for analyzing the intersections of models in assemblies using the functionality of the Open CASCADE geometric kernel were considered. The development is associated with the use of export formats and obtaining in them the composition of the structure of digital models of those parts in assembly units that have mutual intersections in the geometry of the location of these parts in the assembly. In software design, technologies are used that provide work with exchange data formats, solutions that allow obtaining model geometry and technical information from files. An algorithm for finding the intersections of parts in assemblies is proposed, classes of the geometric kernel are considered that are necessary for the implementation of the module for analyzing the assembly and identifying intersections, the results of working with imported assemblies are presented with an assessment of the performance time when using multi-core architectures of modern computing systems. An autonomous module has been created for working with export formats, data visualization, displaying the structure of models as part of an assembly unit with highlighting of those models that have mutual intersections of topological elements. The development is prepared for use in the Linux operating system based on 64-bit architecture.

Key words: export data formats, engineering data, digital product layouts, Open CASCADE geometric kernel, open source operating systems, model analysis as part of an assembly unit

ALGORITHM OF SCALAR DECOMPOSITION OF A NEIGHBORHOOD STRUCTURE

R.V. Popov

Abstract: the construction of a neighborhood model of the production process begins with the formalization of the technological scheme in the form of a neighborhood structure – a digraph with sets of variables at the vertices. The neighborhood structure defines for each vertex the variables included in the equations for this vertex and allows calculating, at least in the case of polynomial models, the number of coefficients for which parametric identification is required. As a rule, it is desirable to minimize this amount. Additional or new information about the modeled process in some cases makes it possible to reduce the number of coefficients after structural transformations of the neighborhood model. For example, for weakly coupled binary systems (two processes on the same neighborhood structure), an algorithm for decomposition and aggregation of the neighborhood structure was previously proposed, as a result of which the number of coefficients can be significantly reduced. This algorithm was implemented to optimize the ventilation system and air filtration in the clinker firing shop of cement production. This paper proposes an alternative algorithm that can be used in the case of any number (two or more) processes on one neighborhood structure. The proposed scheme of structural transformation of the neighborhood model is called in the work the algorithm of scalar decomposition of the neighborhood structure. The algorithm is described geometrically as a digraph transformation and algebraically as a transformation of the adjacency matrix of a digraph. The scalar decomposition algorithm of the neighborhood structure makes it possible to reduce the number of coefficients used in the model, which can simplify its analysis and increase efficiency.

Key words: neighborhood structure, scalar decasterization, scalar decomposition

DATA COLLECTION SYSTEM

G.V. Petrukhova, I.R. Boldyrev, M.O. Gorina, D.A. Gruzdev

Abstract: the relevance of automation of data collection (DCS) and the development of systems in this area is shown. The architecture of the DCS is presented. The formalization of the main processes supported by this system has been carried out. The DCS consists of functionally complete modules that support the execution of functions in the context of the main purpose of the system. A block diagram of the DCS is given. The system can be used autonomously or be a node of a distributed DCS. It is possible to manually control the electrical parameters of the communication circuits. The structure of the DCS is represented by a power supply module, a module for generating arbitrary signals, an indication module, and a module for direct data collection. The purpose and main functions of these structural units are presented in the article. The use of sensors to take measurements from objects is subject to the specifics of the task being performed. Various series of analog and digital sensors can be used. The system has 8 differential/16 unbalanced inputs and a 16-bit ADC resolution. An object management system can be developed on the basis of the DCS, and in this case the DCS will be used as a single-channel system to increase the speed of taking measurements. On a personal computer (PC) there are means of extracting, converting and storing data, as well as processing customer requests for access and obtaining operational information. The means of administration and management of the DCS allow for the distribution of user rights and do this using the role mechanism. DCS algorithms ensure the preservation of timestamps for all incoming measurement data. The presented DCS makes it possible to automate various processes of monitoring the condition of various equipment and production processes.

Key words: data acquisition, DCS, interface, device, analog signal, digital signal, ADC, DAC, server, Ethernet

HARDWARE AND SOFTWARE COMPLEX FOR CREATING A THREE-DIMENSIONAL MODELS OF PREMISES AND OBJECTS

D.V. Zhuravlev, N.A. Letov

Abstract: in the ever-evolving landscape of visual technologies, the demand for accessible and cost-effective tools for digitizing three-dimensional spaces and objects has become increasingly apparent. This study introduces a development that aims to serve as an affordable solution, offering an alternative to the more expensive technologies prevalent in the industry. The primary objective of this work is to devise a hardware and software solution that democratizes the creation of 3D models, making it more accessible to a wider audience. The device's design prioritises user convenience and portability, positioning it as an appealing option for a diverse user base engaged in three-dimensional modeling. This adaptability makes the envisaged complex suitable for applications across various sectors, including design, construction, research, and education. In essence, this work represents a significant stride towards creating more accessible and efficient solutions for the digitization of three dimensional objects. It contributes to the advancement and refinement of visual technologies in our contemporary information society

Key words: hardware and software complex, three-dimensional modeling, three-dimensional scanner, lidar, STM programming

DEVELOPMENT OF ALGORITHMS FOR EFFICIENT RESOURCE ALLOCATION IN A CLOUD ENVIRONMENT

S.A. Oleinikova, N.S. Kapustin, N.E. Evsyukov

Abstract: currently, more and more companies are using a variety of virtualization platforms located in a cloud environment. In this regard, the task of efficient resource allocation in the cloud arises. In particular, the task of distributing virtual machines across servers and their possible migration is urgent. When choosing the criterion of optimality and taking into account all constraints, this problem can be formulated as a discrete optimization problem. An analysis of possible methods for solving it has demonstrated the expediency of using heuristic approaches and genetic algorithms to solve it. In this regard, there is a need to develop appropriate heuristics and specify each stage of the genetic algorithm, taking into account the formulated objective function and constraints. Among the results obtained, which are characterized by scientific novelty, it is necessary to highlight a mathematical model that takes into account the resource limitations of servers and provides the possibility of distributing virtual machines in terms of the criterion of uniform loading across all types of resources. In addition, the operations of population formation, crossing and mutation of a genetic algorithm designed to solve the set optimization problem have been developed. As a result, characterized by practical significance, it is necessary to highlight a program implemented on the basis of an algorithm and designed to automatically determine the best host for each virtual machine

Key words: mathematical model, resource constraints, uniform loading criterion, genetic algorithm

INTELLIGENTIZATION OF DECISION MAKING IN THE SYSTEM MANAGEMENT OF THE TECHNOLOGICAL PROCESS OF ASPHALT CONCRETE MIXTURE PRODUCTION

I.N. Volkov, V.L. Burkovsky, V.P. Shelyakin

Abstract: highways are an important part of the country's industrial infrastructure. Moreover, their reliability and durability are determined by the quality of the road surface based on asphalt concrete mixtures. Reducing the costs of producing asphalt concrete mixtures requires the development of automation tools, including those based on the intellectualization of relevant control processes. The technology for the production of asphalt concrete mixtures includes the following stages: preparatory, main and final, within each of which processes are carried out that are interconnected. A large number of uncontrolled sources of external and internal disturbances in the process of controlling the technological process for the production of asphalt concrete mixtures, the high dynamics of changes in control parameters, significantly complicate their formalization. The article describes the main production stages of the technological process, as well as their algorithmization. In addition, the main stage associated with maintaining the temperature of the mixture when mixing materials using a gas burner, which is described in terms of fuzzy logic, is highlighted. The dependence was determined for a certain volume of gas supply per m³ and temperature, as a result, membership functions were formed, as well as transition matrices for different control options. This material may be useful to developers of tools for intellectualizing the control of technological processes with uncertain parameters

Key words: asphalt concrete mixture, algorithmization of technological processes, intellectualization, fuzzy logic, membership function, gas burner, transition matrix

RC OSCILLATOR FOR A DOMESTIC TECHNOLOGICAL PROCESS

A.V. Belyavtcev, A.V. Rusanov, T.S. Shaikina

Abstract: a functional block (IP) of RC oscillator is proposed. The oscillator is a clocking unit for a large number of electronic devices where frequency stability is not required, but small die size is important. This block is intended for use as part of integrated circuits of voltage regulators. The description of the electrical circuit of the oscillator with electrical specs as well as simulation results are presented. We obtained the following characteristics: oscillator frequency and current consumption plot versus temperature and supply voltage, frequency instability due to process, temperature and voltage variations. Then we have considered the relative stability of the oscillator characteristics under changes in external conditions and technological fluctuations. We present the RC oscillator IP block layout. The oscillator is designed in Russian 180 nm CMOS process. The circuit and layout design were carried out in a specialized IC design CAD system. The mathematical models of semiconductor devices provided by the manufacturer were used to simulate our circuit. The oscillator layout has been successfully verified for compliance with design rules (Design rule check, DRC) and comparing the layout with the schematic (Layout vs. Schematic, LVS)

Key words: oscillator, integrated circuit, microcircuit, analog IP block

THE EFFECT OF ANTENNA ARRAY GEOMETRY ON DATA TRANSMISSION IN MASSIVE MIMO

O.N. Chirkov, Yu.M. Pshenitsina

Abstract: the article examines the effect of the antenna array geometry on the performance of massive MIMO networks for indoor data transmission. Multi-user massive spatial signal encoding systems with multiple inputs and multiple outputs (systems of multiple MIMO antennas) will play a key role in future wireless communication networks. While spatial channel separation is a fundamental advantage of this encoding method, high channel correlation can significantly limit its capabilities and data transmission quality. The paper examines the effect of channel correlation on a prototyped MIMO network model in order to determine the geometry of the antenna array, which reduces the interconnection and correlation of channels. A highly efficient directional broadband single antenna element has been developed for antenna arrays and user equipment. The developed lattice geometry has been tested in an experimental broadband model for massive indoor MIMO. The following system parameters were analyzed in the channel: channel correlation, delay profiles and average power. In addition, based on the measured channel data, system-level modeling and calculations of network bandwidth with multiple inputs and multiple outputs are performed, as well as performance evaluation of the developed prototyped antenna arrays. A test matrix has been developed for comparative analysis. The results show that the modified geometry of the antenna array is superior to a homogeneous antenna array in terms of interconnection and channel capacity

Key words: antenna array, bandwidth, modulation, signal encoding, matrix, MIMO

MINIMIZATION OF DESIGN PARAMETERS OF PARTIALLY PRINTED LOGOPERIODIC VIBRATORY ANTENNAS FOR THE SYSTEM OF LOCAL SUPPRESSION OF CONTROL SIGNALS OF UNMANNED AERIAL VEHICLES 800 MHz – 900 MHz

A.A. Moiseenko, A.Yu. Chernyshev

Abstract: the results of the development of a logoperiodic UHF antenna; UHF band are considered. A brief analysis of the literature on this topic was carried out, promising types of antennas used in countering unmanned aerial vehicles were considered, the issue of constructing a logoperiodic antenna with piecewise linear vibrators and minimizing its characteristics at frequencies 800 MHz-900 MHz was raised. A method for calculating the main elements of logoperiodic antennas is given, vibrators are L-shaped to reduce the geometric dimensions of the antenna, to optimize antenna power, it is carried out by means of a printed circuit board. A simulation of a partially printed logoperiodic antenna obtained from the results of calculations is provided with a graph of the characteristics of the standing wave voltage coefficient at frequencies 700 MHz-1100MHz, directional diagrams at frequencies 800 MHz-900 MHz in the horizontal and vertical planes are obtained. Based on the data obtained, an experimental prototype of a logoperiodic antenna implemented on a dielectric substrate with L-shaped vibrators was assembled and its main characteristics were investigated, the result of measuring the standing wave coefficient was given. The problem of the influence of the accuracy of antenna manufacturing and the spread of parameters of the dielectric substrate on which the antenna is made is investigated. The design of the antenna is shown, in which the installation of an additional supply cable is not required due to the use of a dielectric substrate

Key words: logoperiodic antenna, radiation pattern, UHF band, modeling, experimental research

CORRECTION OF PHASE DISTORTIONS IN A PERIODIC LEAKY-WAVE ANTENNA WITH AN IRREGULAR DISTRIBUTION-RADIATING SYSTEM

D.Yu. Kryukov, A.V. Ostankov

Abstract: periodic leaky-wave antennas have a simple low-profile design, a significant efficiency and the ability to form a narrow beam of a radiation pattern in space, which makes them highly attractive and promising for use in wireless mobile communication networks. However, in practice it is not always possible to ensure the required amplitude-phase distribution of the field in the plane of the radiating aperture of antennas of this type. In the oblique radiation mode, we consider a leaky-wave antenna, which is an open radiating transmission line and contains a planar dielectric waveguide with an uneven profile, shielded by a comb-type metal resonant grating. An assessment was made of the degree of distortion of the phase distribution in the antenna aperture after optimizing the size of the gap between the dielectric waveguide and the grating. A relatively simple technique has been developed and tested for reducing phase distortions in a periodic leaky-wave antenna by varying the spacing of inhomogeneities in a comb array. It has been established that correction of the phase distribution in accordance with the developed technique makes it possible to reduce the maximum level of side lobes, correct the asymmetry of the radiation pattern, and also reduce the deviation of the maximum of the radiation pattern from the original radiation direction caused by distortions. The basic mathematical formulas underlying the developed methodology are given

Key words: leaky-wave antenna, periodic array, phase distortion, radiation pattern, modeling

MEMRISTORS. THE NEXT STEP IN THE DEVELOPMENT OF RADIO ENGINEERING

D.A. Shershov, S.M. Fedorov, A.V. Volod'ko, I.A. Zelenin

Abstract: the paper provides a review of scientific works on memristors, the history of proving the possibility of the existence and subsequent creation of this "missing" electrical element, as well as current prospects for setting up production and its commercial demand. Automated memristor design systems are considered with a description of the modeling process. Technical information about the structure of the memristor, its components, a circuit diagram and macrocircuit is presented, and the manufacturing process of the memristor is described in detail. Various types of memristors that are already in use or may be used in the future, their advantages and disadvantages, as well as the possibility of using memristors in various devices, such as adaptive antennas, phased array antennas, RF, microwave and UHF frequency filters are considered. (high, ultra-high, ultra-high frequencies) ranges or memory cells, both separately and in combination with a number of other devices and elements, the potential applications of memristors in the field of radio engineering and electronics are presented. The expected data of such a passive electrical element as a memristor open up great prospects for its use in dual-use devices and equipment. Despite the fact that at the moment the production of a memristor is a technologically complex and financially expensive process, its use in both the civilian and military segments is extremely promising

Key words: memristor, adaptive antenna, phased array antenna, PIN diode, COMSOL

PERFORMANCE IMPROVEMENT ERROR CORRECTION IN BLOCK LOW-DENSITY CODES USING CODEC COMPONENTS

M.V. Horoshailova, I.V. Sviridova, D.V. Lyalin

Abstract: this article presents a new class of combined codes with low density parity checks (LDPC) for transmission based on transport blocks (TB) based on the Markov chain superposition transmission method (BMST) in order to improve the efficiency of error correction. During encoding, the previous LDPC code words corresponding to TB (in the previous time interval) are alternated and superimposed on the current LDPC code words, resulting in transmitted code words. For decoding, an algorithm for decoding a sliding sum-product field or a minimum sum can be used, characterized by a relatively low decoding delay. To analyze the effectiveness of BMST LDPC codes at the error level, we use the lower bound of the packet transmission system using the random multiple access mechanism, which allows us to effectively predict the effectiveness of error correction. Numerical results show that the proposed codes can have a performance approaching throughput, with a margin of 0.007 dB from the corresponding Shannon limit. They also show that using the proposed BMST design, the error correction efficiency of the original 5G block LDPC codes can be significantly improved, achieving coding gains of up to 1 dB for channels with additive white Gaussian noise (AWGN) and up to 2 dB for channels with fast fading

Key words: Markov chain superposition transmission method, low-density parity check codes, transport blocks, transmission rate

HARDWARE IMPLEMENTATION OF AN INTEGRATED ALGORITHM FOR IDENTIFYING RADIO SIGNALS BY SPECTRUM SHAPE

A.G. Studenikin, V.A. Koz'min, A.B. Tokarev

Abstract: the development of wireless communication technologies, and, as a consequence, radio monitoring systems requires increasing speed in signal processing, in particular when identifying them in the sense of determining whether they belong to a communication standard. To ensure high performance when analyzing frequency ranges several gigahertz wide, identification procedures are divided into stages, the primary of which is based on assessments of the "external" characteristics of signals, one of which is the shape of the spectrum. A suitable hardware basis for implementing high-speed signal processing algorithms is programmable logic integrated circuits (FPGAs). At the same time, like many other signal processing algorithms, identification algorithms, as a rule, are sequential procedures focused on software implementation, that is, execution on a microprocessor. This also applies to the integrated identification algorithm based on spectral masks, which performs the primary identification of radio signals based on the shape of their spectrum. However, the approach to implementing signal processing algorithms on FPGAs has fundamental differences from software implementation, so a separate and very urgent task is the development of "hardware versions" of algorithms. This paper examines the features of the implementation on an FPGA of an integrated algorithm for identifying radio signals using spectral masks, which provides a frequency range analysis speed of 4.6 GHz/s on relatively low-performance FPGAs, for example, Xilinx Zync 7020

Key words: radio monitoring, signal identification, spectrum mask, FPGA

TECHNICAL CHARACTERISTICS AND PARAMETERS OF A TRANSMISSION LINE IN AN UNDERGROUND QUASI-ONE-DIMENSIONAL STRUCTURE

D.V. Fedosov, A.V. Kolesnikov, A.V. Nikolaev

Abstract: the article presents the results of a finite element simulation of a guide transmission line laid along a tunnel in solid semiconducting rock. The dependences of attenuation, velocity factor and impedance were obtained for different distances between the guide line and the tunnel wall for typical cases characteristic of a communication channel in the medium frequency range. The approximation of a flat semi-cylindrical tunnel with a radius of 2 meters, located in rocks with different electrical conductivity, was used. The guide line impedance is in the range of 500-700 ohms and decreases with decreasing distance, approaching 200 ohms for low-impedance rocks. As the transmission line approaches the rock, signal attenuation increases, with faster attenuation observed for rocks with lower electrical conductivity. Analytical expressions for the attenuation coefficient are given for several special cases. The analysis of the average signal velocity factor along the transmission line revealed a strong dependence of the signal phase on the distance between the line and the rock, the electrical parameters of the semiconducting rock and the range of the signal source. The technical characteristics and parameters of the transmission line are important when designing communication systems, information transfer and phase navigation in an underground structure

Key words: transmission line impedance, underground communication, attenuation in mines, guide line deceleration

MULTIBEAM ANTENNA BASED ON A SPHERICAL REFLECTOR AND A SYSTEM OF FEEDERS IN THE FORM OF SYMMETRICAL VIBRATORS WITH DIRECTORS

E.A. Ishchenko, Yu.G. Pasternak, V.A. Penduyrin, D.K. Proskurin, S.M. Fedorov

Abstract: the article discusses a multi-beam directional antenna with 7 beams, built on the basis of a spherical mirror and quasi-Uda-Yagi antenna elements. The resulting antenna is built on the basis of combining in a single design seven Uda-Yagi antenna elements and a single spherical mirror, which focuses electromagnetic waves in space. The use of the proposed design allows for multi-beam directional communication at a frequency of 2.4 GHz, which allows the antenna to be used for transmitting communications over long distances in one of the most common frequency ranges. The resulting antenna has a directivity coefficient of 21.8 dB and a lobe width of 15.9°. Thanks to these characteristics, it is possible to implement scanning of a sector of space of 102 degrees by forming seven independent rays. The resulting design makes it possible to increase the efficiency of using multibeam antennas, since the formation of additional beams does not require the use of expensive and complex phase shifters. The use of the resulting hemispherical antenna also makes it possible to significantly increase the streamlining of the structure, as well as the possibility of adding a second hemisphere made of polystyrene, which will form a spherical antenna that will have a minimal aerodynamic profile in all directions, which ensures wind stability of the resulting structure and also reduces windage in space

Key words: multibeam antenna, spherical reflector, optical principles

Acknowledgments: the work was carried out with financial support from the Ministry of Science and Higher Education of the Russian Federation as a part of the state assignment (project no. FZGM-2023-0013)

IMPROVING THE QUALITY OF LAYERED PANELS OF THE AIRCRAFT AIR INTAKE CHANNEL

V.I. Maksimenkov, M.V. Molod, V.V. Vyalykh, Yu.V. Molod

Abstract: the article discusses the issues of improving the efficiency of sound-absorbing two-layer structures. Three types of structures are considered: single-layer, double-layer and three-layer, which are used in the air intake ducts of the aircraft. Laminated panels consist of perforated and solid bearing layers of D16AM and a cellular filler made of SSP. The types of perforations used in the bearing layers of honeycomb panels are given. Perforation in the bearing layers obtained by punching in stamps. The direction of increasing the efficiency of layered structures for obtaining Chapter 14 of ICAO is given. This is achieved by developing new types and improving the technology of manufacturing layered structures. It is shown that during the manufacture of a laminated panel, glue flows into the hole of the perforated cladding above the permissible value determined by the technique. Which affects the acoustic characteristics of the panel. A technological process has been developed to eliminate glue leakage into perforated sheaths during gluing in an autoclave. A device has been developed to reduce the leakage of glue and a dependence has been obtained to estimate the pressure of hot air provided by a decrease in leakage. Experimental studies are presented, which confirmed the effectiveness of the developed method. This method is recommended for industrial implementation in the manufacture of an air intake duct

Key words: honeycomb structures, perforation, glue leakage, sheathing