CONTENTS AND ABSTRACTS

RADIO ENGINEERING AND COMMUNICATION SYSTEMS

Key words: mutual channel coupling, scaling method, multichannel receiving system, load impedances optimization, space-correlated noises, angular power spectrum.

The article considers a multi-channel receiving system with channel mutual coupling where antenna system external noises as well as low-noise amplifier internal noises are observed. Thermal noise changes in multichannel receiving system with mutual channel coupling leads to their spatial correlation. For noise matching in receiving system channels load impedances are optimized by numerical Nelder-Mead method according to the criterion of minimum noise variance. The aim of the article is to increase the efficiency of signal processing in the presence of spatially correlated noise in a coupled multichannel receiving system by optimizing load impedances. The research of noise angular power spectra in a coupled multichannel receiving system for various configurations of a receiving system is carried out. The optimization of load impedances is shown to be capable to reduce the power of spatially correlated noise.

Key words: low-frequency noise, flicker noise, phase noise, Gaussian model, non-Gaussian model, signal processing, field experiment, kurtosis coefficient, Internet of things.

The paper evaluates the parameters of low–frequency noise obtained by a full-scale experiment - digitization of op amp output signal. The aim of the work is to experimentally confirm the hypothesis for the presence of non-Gaussian properties in low-frequency noises with power spectral density inversely proportional to noise frequency. The task is considered to be relevant when converting carrier frequency of ultra-narrowband signals to a zero carrier, as well as in the process of demodulation. According to the experimental data, the calculation of non-Gaussian parameter, kurtosis coefficient, as well as constructing the dependence of kurtosis coefficient on the volume of experimental data is performed. According to the results of the study, non-Gaussian signal processing methods are proposed to be used in order to compensate for the influence of low-frequency noise and increase signal-to-noise ratio in ultra-narrowband signal processing systems.

Key words: an object with axial symmetry, electromagnetic waves scattering, scattering diagram, electrodynamic modeling program, boundary value problem of electrodynamics.

The scattering properties of dielectric and metallized objects with axial symmetry are estimated using CST MWS – Computer Simulation Technology Microwave Studio electrodynamic modeling software package. In order to study scattering diagrams for

various types of spatial distribution of reflective surfaces complex permittivity, secondary electromagnetic radiation was modeled by finite-length cylinders with regular cross-sectional radius for partial and complete metallization of side surfaces.

The distribution of surface currents on a cylinder was determined by FEM (Finite Element Method). The calculation of polarization components of the field and a cylinder scattering diagram was carried out by activating Frequency Domain Solver built into the structure of CST MWS program, which provides the determination of the coordinates in approximating grid with different types of cells.

In sampling zones, complex amplitudes of currents were determined by the method of MoM moments – Method of Moments with partial inversion of boundary value problems operators.

The results obtained show that the maxima of scattering diagrams of cylinders with perfectly conducting bands on side surfaces are concentrated in space sectors opposite to metallization region. The results also show that in the sector of 60° width angles the cylinder scattering diagrams of equal electrical dimensions with full and partial metallization are similar in shape.

The aim of the work is to study the patterns of secondary electromagnetic radiation of dielectric objects with different degrees of surface metallization.

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V. T. Dmitriev, M. S. Smirnov. STUDY OF NOISE-RESISTANT AND PROTECTED SPEECH SIGNAL TRANSMISSION SYSTEM BASED ON KHURGIN – YAKOVLEV REPRESENTATION

Key words: noise immunity, security, noise-correcting coding algorithms, cryptographic algorithms for symmetric and asymmetric encryption, primary coding, speech signal transmission, speech signal codecs.

The research of reconstructed speech quality at the output of noise-immune and protected speech signal transmission systems based on V.A. Kotelnikov theorem and Khurgin – Yakovlev representation under the action of various interferences in a communication channel is made. The task of the study is to determine the best combinations of encryption and primary coding algorithms to achieve the best quality of restored speech information at the output of primary decoder under the influence of interference in a communication channel, as well as to study the application of V.A. Kotelnikov and Khurgin – Yakovlev representations in the construction of primary codecs. The aim of the work is to select and justify the algorithms for primary coding and encryption of noise-resistant and protected system for transmitting speech signals, which provides the highest value for assessing the quality of speech at the output of transmission system in a given range of transmission rates and interference in a communication channel. As a result of study, the best combinations of primary coding and encryption algorithms were selected, and the use of Khurgin – Yakovlev representation was substantiated in order to improve restored speech quality, as well as noise immunity and security of transmitted information at the output of speech information transmission system.

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A. D. Koshelev, V. P. Fedorov. COMPARATIVE ANALYSIS OF MESSAGE TRANSMISSION METHODS IN UNDERWATER ENVIRONMENT

Key words: ultrasonic waves; transmission methods; coding; self-synchronization; signal-to-noise ratio.

The problem of constructing a hydroacoustic communication channel is considered. The aim of the work is to compare the known methods of encoding digital information with

the proposed transmission method by the combinations of quaternary system digits set by the chords of time-shifted parcels with ultrasonic waves filling four different frequencies. This method is compared with the transmission of digital information by continuous wave modulation and with the known bipolar transmission encodings adapted to a sonar channel. The considered method of information signal construction is shown to provide greater transmission reliability due to complete self-synchronization, larger signal-to-noise ratio and larger signal base.

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MATHEMATICAL AND COMPUTER SYSTEMS SOFTWARE AND COMPUTER NETWORKS

Key words: software defined networks, SDNLoadBalancer, intelligent multipath routing, OpenFlow protocol, swarm algorithms, bird migration algorithm.

Software defined networks (SDN) are a modern trend in building new generation computer networks. SDN provide flexibility and control in managing data flows in the network, as well as a given level of quality of service for applications. The purpose of the work is to develop a scientific approach of intelligent multipath routing in SDN based on bird migration algorithm. The article studies and analyzes the bird migration algorithm to solve the problem of multipath routing in SDN. A visual software system SDNLoadBalancer has been developed and an experimental topology of SDN has been designed, which makes it possible to study in detail the processes of multipath routing in SDN based on proposed approach. The paper compares the pro-posed approach with the results of the work of the classical genetic algorithm and the artificial bee colony algorithm. The results of experimental studies have shown the effectiveness of the application of bird migration algorithm in solving the problem of multipath routing in SDN, made it possible to obtain results close to optimal in an acceptable time, and also reduce the transmission delay jitter in the network.

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Key words: Software Defined Networks, controller, switch, OpenFlow, Flow Table , safety, DDoS attack, MITM attack, Petri Nets, CPN Tools.

Currently, large requirements are imposed on computer networks to increase speed, performance and fault tolerance. An important criterion of any network is network fault tolerance and protection against various attacks on the network. The article discusses the principles of security and the study of attacks in software defined networks (SDN). SDN can be subject to various types of attacks. One of the most common attacks are DDoS (Distributed Denial of Service) and MITM (Main in the middle) attacks. The aim of the research is to study the principles of security in SDN and to research various attack, such as DDoS and MITM using color Petri nets and CPN Tools modeling package. The objectives of the study are to detect attacks on each OpenFlow switch of any packet with fake data, to analyze the substitution of MAC address in a packet stream of the network. Hierarchical models on Petri nets made it possible not only to investigate the functioning and behavior of network control system and its security principles, but

INTELLIGENT INFORMATION SYSTEMS AND TECHNOLOGIES

Key words: neural networks, causal taxonomy, psychosomatic user identification, ICF ontology, hierarchical numbers, semantic proximity.

The article deals with the design of neural networks with knowledge. The designed networks are intended to solve the problem of classifying users according to their psychosomatic type. An original method of building networks using ICF-ontologies, structured in accordance with the causal taxonomy of the information needs of the Web site user, is presented.

To design an ontological causal taxonomy, elements of the theory of hierarchical numbers are used, which allow calculating the semantic similarity of ontology concepts for its optimization. The features used in the taxonomy are applied later in the formation of a set of basic features (S-elements) of neural network.

Software implementation of the approach proposed uses the subject area of current news site with many multidirectional information headings. The purpose of using a neural network is to classify users according to their psychosomatic type based on the analysis of visits to site materials by various users. As a practical part, experiments planned and delivered within the framework of Python v.3 software toolkit (Anaconda 3) are considered. The results obtained allow us to positively assess the effectiveness of the technology proposed.

The aim of the work is to create an original method for constructing neural networks for classification problems using causal taxonomies in ICF ontology format using hierarchical numbers.

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MATHEMATICAL AND COMPUTER MODELING

Key words: technogenic risk, Arctic zone, modeling, assessment, hazardous chemical, wind transport, wind speed field, cloud movement trajectory.

As part of the development and implementation of technogenic risk assessment method, three key tasks were solved: constructing the trajectory of a cloud saturated with vapors of dangerous chemical substance; modeling the dissipation of this cloud; assessing the technogenic risk along the trajectory of cloud movement. The aim of the work is to construct a new numerical method for assessing technogenic risk as a result of wind transport and dissipation of hazardous chemicals. The stages of implementing risk calculation algorithm are shown. The simulation of spatial distribution of dangerous consequences of a conditional man-made event that occurred in the Arctic zone was carried out. It is concluded that the proposed approach can be adapted to the model description of radioactive substances emissions into the atmosphere, environmental pollution of the area as a result of large-scale industrial and geological developments, geodynamic disasters.

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SYSTEM ANALYSIS, MANAGEMENT AND INFORMATION PROCESSING

a computational infrastructure for conducting experiments aimed at studying the characteristic of the technologies used for central bank digital currencies based on blockchain. A distributed computing infrastructure is being built to assess the effect of blockchain network parameters on the performance. The input data for conducting experiments are transactions for the transfer of digital resources from one user to another. The data obtained as a result of the experiment can show details of the load on infrastructure resources, reveal differences in system efficiency in different usage conditions.

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Key words: sociodynamic processes, activity of users of network mass media, time series, Hurst index, memory, self-similarity, fractality of time series.

The article analyzes the dynamics and characteristics of sociodynamic processes time series in comment networks of mass media users. There is a small amount of asymmetry in the distribution of amplitudes of changes in user activity when commenting on news and the distribution of amplitudes is almost symmetrical, but there is a so-called «heavy tail» – distribution density graphs lie above the normal distribution graph. The studies conducted allow us to draw a number of important conclusions that the time series studied are non-stationary, and the processes and systems described by them have short-term memory (the Hurst index is significantly less than 0.5). A significant difference between the Hurst indicators defined for them from 0.5 indicates that the processes or systems described by them not only have memory, but also that their structure has a fractal character. Fractality may be related to the fact that the observed processes are characterized by fractional measurement variables, which means that it is advisable to use fractional differential equations in the derivation of approximating density functions of their parameters distribution in order to build predictive models.

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Key words: digital twins, enterprise production system, architectural design, system engineering, digital twin management system, interoperability.

The international standard on digital twins of production systems ISO 23247 presents a typical architecture of a digital twin and an indication of the need to use generally recognized practices of architectural and system engineering design and various information standards for its development. However, the standard does not regulate how these practices and standards should be applied to develop the architecture of control systems for digital production twins. This paper discusses possible implementation of architectural and system engineering design practices, as well as international standards for data representation in the formation of the architecture for such systems.

The aim of the work is to identify methodological approaches to the development of the architecture of management system of digital twins of production systems, providing horizontal and vertical integration of participants in product lifecycle.

The paper defines the tasks of horizontal and vertical integration in the management of digital twins, the tasks of architectural design of digital twins control systems, explores possible approaches and tools for solving these problems based on the provisions of var-

PHYSICAL ELECTRONICS AND NANOELECTRONICS

layer barrier micro- and nanostructures properties. The aim of the work is to develop a complex approach to the study of multilayer barrier structures of micro- and nanoelectronics that means collaborated application of experimental techniques based on various physical properties of measurements and to make a measuring stand of complex diagnostics. The objects of the research is the structures of photoelectric converters on the basis of crystalline and hydrogenated amorphous silicon including HIT-structures and two-stage thin-film solar cells based on a-Si:H and a-SiC:H. Measuring and analytical complex to implement the informative techniques offered is developed. The results of the study allowed determining activation energies and layer concentration of three electrically active deep levels, refining the positions of Fermi levels in a-Si:H(p) layer as well as on the section border a-Si:H(i)/c-Si(n). High density of localized states found in a mobility gap of undoped a-Si:H (10^{16} – 10^{18} $eV^{-1}cm^{-3}$) leads to a tunnel-transparent SCR layer close to a-Si:H/c-Si border. Complex approach to research the properties of multilayer barrier structures of micro- and nanoelectronics elements allows us to verify experimental results and minimize instrumental and time costs for measurements.

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A. V. Ermachikhin, Yu. V. Vorobyov, E. P. Trusov, V. G. Litvinov. COMPARISON OF DEEP LEVEL TRANSIENT SPECTROSCOPY METHODS OF RELAXATION CURRENT ANALYSIS

Key words: DLTS, data processing, mathematical modeling, Laplace-DLTS, CONTIN, software.

Three different approaches to processing of current relaxation under square-wave depletion signal are considered on the simulated data. Three different cases are considered: including 1, 2 or 3 deep levels varying signal-to-noise ratio. The present work aims at establishing applicability of those methods to particular experimental conditions. The Laplace-DLTS method was implemented via CONTIN software. The DISCRETE program was used to approximate the relaxation curves by the sum of exponentials. The integration method was used for this purpose as well. Classical DLTS analysis was implemented using the «Lock-in» and «GS-4» weighting methods.

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S. M. Karabanov, D. V. Suvorov, E. V. Slivkin, D. Y. Tarabrin, A. S. Karabanov, G. P. Gololobov. EFFICIENCY ANALYSIS OF VARIOUS TYPES OF INDUCTOR GEOMETRIES FOR MAGNETOHYDRODYNAMIC MIXING OF SILICON MELT

Key words: multicrystalline silicon, magnetohydrodynamic mixing, traveling magnetic field, inductor, melt, mathematical modeling.

The aim of this work is a comparative efficiency evaluation of various systems for magneto-hydro-dynamic melt mixing in the application to industrial installation of directional crystallization type GT-DSS-450 with a form factor of crucible G5. In this work, using numerical simulations in the COMSOL Multiphysics® software, the efficiency of various types of inductor system geometries was analyzed for the application of magneto-hydro-dynamic mixing of a silicon melt for the conditions of industrial plants for growing multicrystalline silicon ingots. The main quantitative parameters of various configurations of inductor systems are presented, their advantages and disadvantages are compared. The results obtained can be used to create systems for magneto-hydro-dynamic mixing of silicon melt and electrically conductive melts of substances.

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Key words: LF noise, magnetically controlled contacts, measuring installation, contact resistance, power spectral density.

The results of an experimental study of the influence of switching conditions: the magnitude of currents and magnetic field sources of switching devices on the characteristics of magnetically controlled contacts are presented. To determine necessary parameters, the transfer characteristics obtained due to the inclusion of the reed contact studied according to a scheme of classical four-pole were used.

The analysis of a set of experimental conditions determining the magnitude and spread of resistance values of magnetically controlled contacts during repeated switching, as well as the influence of magnetic field sources of switching devices on the reproducibility of parameters calculated according to the developed program: shape index and spectral power density of LF noise is carried out. The experimental conditions under which the maximum reproducibility of the results is achieved are revealed.

The aim of this work is to study the factors affecting the spread of resistance value and the parameters of LF noise spectra during multiple repeated switching of reed contact using a magnetic field from different sources.

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