

APPLICATION OF ADAPTIVE OBSERVERS FOR SYSTEM IDENTIFICATION WITH BOUC-WEN HYSTERESIS

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Abstract: a method for adaptive identification of a system with Buck-Vienna hysteresis is proposed. It is based on the use of adaptive observers. This approach allows us to remove the stability problem of solving the hysteresis equation. It is shown that the input properties significantly affect the solution of the identification problem. A non-linear system with Buck-Vienna hysteresis should be structurally identifiable. It is shown that in order to fulfill the conditions of structural identifiability of the system, the input must be S-synchronizing. A selection of adaptive observer parameters is proposed. Adaptive algorithms for identifying processes in an adaptive system are synthesized. To obtain them, the second Lyapunov method was applied. Two subsystems are identified whose analysis of properties simplifies the analysis of system stability. The limited processes in subsystems of an adaptive system are shown. The accuracy of the estimates obtained depends on the value of the derivative of the output variable. A method is proposed for determining the current estimate of uncertainty in an adaptive system. The resulting uncertainty is the current benchmark for evaluating the hysteresis output. It is used to synthesize algorithms for tuning the parameters of the Buck-Vienna model. To identify the Buck-Vienna hysteresis, an adaptive model is used, which coincides with the equation of the adaptive observer. The simulation results are presented that confirm the operability of the proposed approach

Key words: hysteresis, Bouc-Wen model, adaptive observer, uncertainty

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ALGORITHMIZATION OF MANAGEMENT OF ERGATIC ELEMENT OF PRODUCTION SYSTEM IN EXTREME CONDITIONS

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Abstract: the article substantiates the urgency of the problem of ensuring the safety of the functioning of production systems. One of the possible directions for solving this problem with respect to a movable production system with an ergatic element is presented. Prerequisites for enhancing the intrinsic protective properties of a production system with an ergatic element by equipping it with complex functioning safety systems that implement hazard control and ensure that basic functions are performed with a minimum probability of system death are argued. The reasons are given for developing a method for preventing sudden loss by a human operator of an efficient state when the system is operating in extreme conditions. Arguments are presented in favor of introducing an additional parameter into the state vector — the rate of change of air pressure in the pressurized cabin of the facility, which will allow to indirectly determine the type of depressurization at an early stage of the development of a special situation and form appropriate control parameters to prevent the transition of a special situation from emergency to catastrophic. An algorithm is presented for determining the moment of occurrence of a special situation in a production system with an ergatic element caused by emergency or explosive depressurization by additionally measuring the rate of change of air pressure in the hermetic cabin of the facility, as well as a set of actions that exclude the loss by the human operator of operability at the initial stage of development special situation

Key words: production system, ergatic element, human operator, hermetic cabin, depressurization, hypoxia, absolute air pressure, air pressure change rate

MODEL OF RANDOM MULTIPLE ACCESS IN A LOCAL COMPUTER NETWORK WITH FLOWS OF VARIOUS INTENSITY AND PRIORITIES

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Abstract: a mathematical model of data transmission in a common channel with random multiple access is considered. It allows one to estimate the average data transmission time in flows, the probability of data transmission in flows, the average queue length in data transmission devices with asymmetric operation. The access algorithm is based on competition using fixed priorities with a given number of repetitions over a fixed time interval. It is believed that the system transmits codograms (messages) of a fixed duration. The message flows in the system are Poisson. The presented model includes a mathematical description of three interconnected random processes - the process of transmitting a separate communication, the process of forming a queue in the memory of individual devices and the process of occupying-releasing a common data transmission channel. Interconnected analytical expressions and a system of differential equations are obtained that allow one to evaluate the probability-time characteristics of the exchange process. The results of calculations using the proposed model for assessing the probability-time characteristics of information exchange in a microprocessor system using the I2C interface are presented. In contrast to the simulation models traditionally used in solving this kind of problem, the proposed analytical model is much simpler to implement. The main purpose of the model is to evaluate the parameters of the transmission process in the design of data transmission systems with a common channel

Key words: data channel, random multiply access, microprocessor system, data transmission probability, average data transfer time, queue length, message stream intensity, fixed message length

MODELING THE KNOWLEDGE BASE TO SUPPORT OPERATION OF TECHNOLOGICAL EQUIPMENT

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Abstract: a comprehensive approach is considered to provide support for maintainability, operation and fault tolerance of technological equipment of industrial enterprises, based on the development and implementation of an integrated logistics system based on knowledge. The formalization of expert knowledge will allow us to preserve and accumulate the results of practical and scientific work obtained in terms of ensuring the required reliability of equipment during its operation. The relevance of the study is due to the possibility of reducing total operating costs and, as a result, optimizing the cost of the equipment life cycle and extending its service life. The development of a knowledge base in the field of reliability, together with well-known mathematical methods of calculation, is of practical value for industrial enterprises. Implemented models for the representation of knowledge provide scenarios for the transformation of knowledge resources in the form of a sequence of invocation of operations between objects of a subject area implemented using classes. The categorization of data and knowledge, implemented using the ARIS methodology, allows one to determine the capabilities and limitations of the designed system. Using UML diagrams, a visual universal constructor was developed for constructing a knowledge base and a mechanism of logical inference on knowledge. Knowledge management provides the integration of the interaction of all participants in the equipment life cycle and the formation of objective prerequisites for the development and creation of a single information environment

Key words: integrated logistic support, operational reliability, diagnostics, operation support, knowledge base, classes

SIMULATION OF STATIONARY PROCESS OF THERMOELECTRIC GENERATOR MODULES OF RING GEOMETRY

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Abstract: a comparative analysis of the operational characteristics of thermoelectric generator modules with a given geometry of ring thermopiles using a universal mathematical model. Thermoelectric modules consisting of commercially available and experimental generator thermal batteries were used as an object of simulation. As the materials for the thermoelement legs, we used serial alloys produced by RIF Corporation with n-type conductivity ($\text{Bi}_2\text{Te}_{2.4}\text{Se}_{0.6}$ with the addition of 0.2% (mass.) Hg_2Cl_2) and p-type conductivity ($\text{Bi}_{0.5}\text{Sb}_{1.5}\text{Te}_3$ with an addition of 0.2% (mass.) Pb) obtained by cold pressing and subsequent hot pressing, as well as experimental ones with improved quality factor. For all thermoelectric materials, the temperature dependences of the thermoelectric power, thermal conductivity and electrical conductivity were known. The influence of the geometric characteristics of thermopiles on the operating parameters of the module was studied, as well as the analysis of the effectiveness of experimental materials compared to serial ones. The results of mathematical modeling are presented graphically in the form of dependences of the efficiency, electric power and the required heat flux along the hot side of the generator modules from the electrical resistance of the external load, and also the current-voltage characteristics and the dependences of the electric power of the generator modules on the operating current are obtained. The calculation results show that the new geometry of the battery allows one to increase the efficiency of the generator module by 20%. In turn, the use of new thermoelectric materials gives an additional increase in efficiency by 14.3%, and also increases the working range of economical operation. It is recommended to use new thermal batteries in conjunction with new materials for the development of autonomous current sources of a new generation

Key words: modeling, efficiency, thermoelectric generator, thermobattery of annular geometry, stationary process

INTERACTIVE METHOD OF NEURAL CONTROL OF PROCESS OF MILLING MIXTURE IN CEMENT PRODUCTION

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Abstract: an interactive method for the neurocontrol of the mixture grinding circuit is proposed for the production of cement for semi-automatic mills. In this case, the most important tasks of this system are to ensure a stable feed mode and energy saving. Neurocontrol is based on training a neural network with a teacher, the role of which is played by an experienced mill operator, which implements effective control of the grinding process. Neurocontrol calculates the optimal settings for distributed control loops based on an interactive computational procedure. This approach allows us to make effective decisions on controlling the grinding process based on the coordination of many conflicting technical conditions. The main advantage of the proposed method is that the decision-making method for choosing the values of control factors, taking into account the given technical and economic constraints, allows the operator to choose the optimal parameters for loading the mill according to many conflicting conditions, which allows one to get a quality product while minimizing the resources consumed. The controller developed on the basis of the proposed method was tested on the model of the grinding circuit for a real mill. The results confirmed the effectiveness of the proposed dispatch control system, which allowed to increase the mill productivity by 2.36% and at the same time reduce specific energy consumption by 2.29%

Key words: cement, clinker, neural network, charge, grinding process, operational control

OPTIMIZATION OF DESIGNING DECODERS OF LOW-DENSITY CODES BASED ON THE MODIFIED MIN-SUM ALGORITHM

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Abstract: the article shows how the result of modeling the performance of decoding algorithms can be used to optimize the algorithm parameters, and that processing using the parallelization method can not only dramatically increase the evaluation performance, but can also make the computational optimization of decoding algorithms feasible in practice. The presented parallelization method allows one to increase productivity and simplify the tasks of computational optimization of decoding algorithms. One way to solve decoding problems is to apply an integer linear program. The execution of linear programming for decoding substantially depends on the composition of linear programming used. Examples of modeling some low-density code algorithms are given, and simulation results using the modified min-sum algorithm are also shown. It is shown that the modified algorithm wins in error correction performance, especially in a high range of noise exposure. A parallelized method of accelerated design and optimization of low-density decoding algorithms is presented. Using the developed criteria for evaluating the efficiency of decoding algorithms, it turns out to optimize the selection of algorithm parameters using non-linear optimization methods. It is shown that all these actions aimed at optimization lead to a semi-automatic model of the algorithm

Key words: LDPC decoding, decoding algorithm, decoding efficiency, algorithm performance

ASSESSMENT OF THE MIMO-OFDM COMMUNICATION CHANNEL OF DATA EXCHANGE BETWEEN VEHICLES BASED ON A CELLULAR NETWORK WITH STRONG INTERFERENCE

O.N. Chirkov, I.M. Pashueva, E.E. Kagramanov

Abstract: the article investigates the construction of pilot signals for estimating the radio channel of a system for exchanging data between vehicles based on a cellular network with MIMO-OFDM with strong interference in the radio channel from spectrum reuse between different communication lines. The studied data exchange system between vehicles based on a cellular network is currently considered the most promising and feasible solution for automotive communications and networks with 5G support. A scheme for constructing pilot signals with increased noise immunity using a sequence of zones with zero correlation is obtained. A method for estimating the channel of a system for exchanging data between vehicles based on correlation in the time domain is derived. The obtained method uses a sequence of zones from the same family from which the pilot symbols from the time domain are selected. Noise in a multipath channel is effectively eliminated by using a correlation-based estimation. Simulation results show that proposed method for estimating channel of a system for exchanging data between vehicles based on a cellular network with strong interference shows the characteristics of the bit error from the signal-to-noise ratio close to the characteristics of the channel without interference

Key words: pilot signal, cellular network, channel estimation, sequence of zones, correlation, symbol, noise

TRAJECTORY SIMILARITY METHOD FOR DISAMBIGUATING PHASE MEASUREMENTS

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Abstract: the paper is devoted to solving the problem of phase measurement disambiguation in determining the angular coordinates of radio space crafts applying multi-position phase direction finders. For this purpose, we considered the principles of amplitude correlative and phase correlative direction finding of objects. The article describes the disadvantages of the common algorithms for phase measurement disambiguation. In order to overcome them, the method is developed based on identifying the similarity of the object trajectories obtained from the results of phase and amplitude measurements during the post-session processing. The consecutive stages of phase measurements using the introduced approach are described. The theoretical results obtained are confirmed by simulation. The implementation of the presented trajectory similarity method for phase measurements disambiguation is illustrated by the example of the phase correlative direction finder for which the amplitude correlative direction finding mode is activated without any hardware changes. The conclusion is drawn on the efficiency of the combined application of amplitude and phase direction finding for high-precision restoration of the examined object trajectory. Multi-position phase direction finders are used to solve the problem of high-precision measurement of the angular coordinates of radio-emitting spacecraft and other flying objects. The use of directional tracking antennas in phase direction finders can significantly alleviate the requirements for the magnitude of the unambiguity interval of phase measurements, the choice of which is carried out in accordance with the width of the directional diagram of the used antennas for a given range of angular measurements

Key words: phase measurements, multi-position direction finder, disambiguation

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APPLICATION OF STOCHASTIC CODING IN SOLUTION FEEDBACK SYSTEMS

A.V. Bashkirov, I.V. Sviridova, D.A. Pukhov, A.S. Demikhova

Abstract: this article describes a practical method of stochastic coding, which provides a sufficiently small probability of undetectable errors for a system of any binary channels. The purpose of the analysis are systems in which the communication channel provides the transmission of signals from the transmitting point to the receiving point with minimal distortion. Practical distortion of signals in real communication channels is inevitable, since the channels are exposed to various kinds of interference, the nature of which can often change. In this paper we consider a system of binary channels, which will carry out a replay of code blocks with detected errors to increase the quality of the signal. One of the most important conditions for data transmission is the transmission of high-definition signal, as errors in the code distorts the information and can lead to disruption of the device. This article discusses a binary channel setup in which all channel errors are additive. For transformations that will help to preserve the integrity of information, consider two stages. At the first stage, the stochastic coding method ensures that the signal is stored only for the channel with additive errors. The second step is a stochastic transformation that reduces an arbitrary binary channel to a channel with additive noise. Both of these transformations have to be mutually independent, otherwise they can be considered as one transformation, if these codes are used in a system with decisive feedback, then the additive channel will not reduce the average rate of information transfer

Key words: stochastic coding, binary channel with noise, system with decisive feedback, information integrity, signal, additive channel

DOUBLE-CHANNEL GENERATOR-MANIPULATOR OF RECTANGULAR PULSE

D.V. Zhuravlev, M.A. Sivash, A.S. Kostyukov, D.I. Naumov, V.A. Mal'tsev

Abstract: based on the analysis and research of the well-known circuitry of a rectangular pulse generator on the RS-trigger, a double-channel rectangular pulse manipulator-generator was developed with the ability to manipulate in amplitude and frequency. The principle of operation of a two-channel generator of the manipulator of rectangular pulses and its modes of operation at different voltage values at the output of the control generators and various temperature ranges are described, on the basis of which simulation in CAD Multisim and analysis of the work of a two-channel generator of the manipulator of rectangular pulses are carried out. The simulation results are presented in the form of graphs showing the dependence of the voltage at the output of a two-channel generator-manipulator of rectangular pulses when the voltage level of the control generators changes. This generator can be used in pulsed radio transmitting devices, in measuring equipment as a source of rectangular pulses, manipulated in frequency and amplitude. The generator, by changing its design, generates and simultaneously manipulates in amplitude and frequency the generated sequence of rectangular pulses. This extends the functionality of the well-known generator of amplitude-manipulated rectangular pulses

Key words: double-channel generator, amplitude-shift keying, frequency-shift keying, asynchronous RS-trigger, MOS transistors, logic elements

PRINCIPLES OF PROTECTION OF PRINTED ELECTRONIC MODULES FROM ELECTROSTATIC DISCHARGE AT THE STAGES OF PRODUCTION AND TESTING

M.A. Romashchenko, D.S. Seimova, S.N. Rozhenko

Abstract: protection from static electricity is currently one of the most important tasks of any activity in the field of design and production of electronic devices. Awareness of the risks associated with the influence of surge voltages, including electrostatic discharge, and the application of methods of protection from their effects are becoming increasingly important for many enterprises working in the field of electronic industry. Structures of electronic components become more sensitive to the occurrence of electrostatic discharges with the modernization of technology. 5 volts of electrostatic discharge is enough to change the internal structures of small electronic components. Growing trends towards miniaturization lead to the fact that the cases of some elements of the printed module are so small that even a minimal exposure to an electrostatic pulse can cause permanent damage to the device as a whole. Electrostatic discharge is a known factor contributing to a decrease in the reliability and performance of electronic devices. This article presents a methodology for implementing mechanisms for protecting printed modules of electronic devices from electrostatic discharge in CMOS technologies

Key words: electrostatic discharge (ESD), printed circuit board (PCB), electronic devices (ED), printed module

ACTUAL APPROACHES TO THE ASSESSMENT OF THE RADIO COMMUNICATION CHANNEL IN THE SYSTEM OF MOBILE SUBSCRIBERS WITH A HIGH SPEED OF MOVEMENT

O.N. Chirkov

Abstract: this article discusses the problem of channel estimation in “car-to-car” communication systems with 5G support under conditions of high speed of movement and changing characteristics of the transmission medium. In order to provide reliable and high-speed 5G wireless communications in a highway environment, it is important to provide an accurate estimate of the radio channel. To improve the evaluation characteristics and increase the noise immunity of orthogonal frequency division multiplexing (OFDM) systems, an advanced Kalman filter is used in combination with an iterative detector and a decoder in the receiver. An advanced Kalman filter is proposed for joint estimation of the channel frequency response and time correlation coefficients. To construct a more accurate matrix of the filter weights, the iterative structure of the receiver is used based on the posterior logarithmic likelihood ratio (LLR). Using an iterative approach in the receive path will reduce the estimation errors in the extended Kalman filter. Modeling of non-stationary radio channels in a system of moving objects with a high speed of movement was carried out in the MatLab package. The simulation results show that the proposed iterative channel estimation approach with an extended Kalman filter of OFDM systems in environments with high subscriber mobility increases the channel estimation efficiency by 3 or more dB compared to traditional methods

Key words: channel estimation, Kalman filter, detector, decoder, iterative estimation, mobile subscriber

ANALYSIS OF PERSPECTIVE APPROACHES TO THE CREATION OF ELECTRICALLY SMALL ANTENNAS WITH EFFICIENCY APPROACHING THE DEFINED IN ACCORDANCE WITH THE CHU-HARRINGTON-LEE-CRITERIUM

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Abstract: based on an analysis of open scientific and technical literature, an analysis of modern approaches to the creation of electrically small antennas was carried out. The most important characteristics that determine the operating frequency band of the antenna and its efficiency are described. The results of studying the quality factor of electrically small antennas depending on the type of excited modes are presented, as well as the mathematical expressions for electrically small antennas for evaluating the quality factor. The methods of accounting for losses in the electrical characteristics of antennas are considered. An example of the using electrically small antennas from half a loop (and similar structures) for installation on various military equipment is presented, as well as graphical dependencies characterizing the influence of the size of the antennas on the number of half rings. The paper considers the use of metamaterials: use as a shell to compensate for high reactivity, implementation of strip antennas of various designs, the use of broken ring resonators, the creation of an electrically small dipole antenna. Various methods for reducing the size of dipole antennas are also described: the implementation of a vibrator with a different shape of the shoulders (for example, tree-like). Various designs of spiral antennas are presented: flat and three-dimensional, as well as some ways to improve them

Key words: electrically small antennas, quality factor, efficiency, bandwidth

METHOD OF INTERDISCIPLINARY ENGINEERING ANALYSIS OF ELECTRONICS STRUCTURES BASED ON PROGRAMMABLE MATERIALS

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Abstract: a methodology for interdisciplinary engineering analysis of electronic structures made of programmable materials was developed. Thanks to this technique, it is possible to improve and simplify the process of developing “smart” materials and to develop the technology of programmable materials itself. The developed technique includes analytical calculation, numerical simulation in CAD, as well as testing at an experimental bench. A layered composite programmable material was used as an object for modeling, which includes the main active element, an electrorheological fluid, which changes its own properties under the influence of an external electric field. However, this technique with small modifications is also applicable to magnetorheological materials. According to the results of the study, the properties of the new material were established, the influence of its geometrical parameters, composition, external electric field on its stiffness, damping coefficient and the ability to withstand resonance phenomena were determined. This design area is extremely promising due to its low cost, high speed and ease of implementation, as well as wide and easy availability. The developed methodology will make it possible to hone and improve the process even better, as well as better study the properties of the materials being developed

Key words: interdisciplinary engineering analysis, electrorheological and magnetorheological materials, interdisciplinary analysis algorithm

INFLUENCE OF VACUUM ANNEALING ON TOPOGRAPHY OF DESTRUCTION SURFACES AND REPEATED-STATIC ENDURANCE OF ALLOYS OT4

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Abstract: heating of titanium to high temperatures leads to the formation of oxide and gas-saturated layers on its surface, while the mechanical characteristics of the material and, in the first place, plasticity, sharply deteriorate. In this article, as a criterion for the embrittlement of surface layers on titanium, it is proposed to use the form of their fracture formed upon failure, for example, by bending. We studied the structure of fractures on polished samples of size 30×10×3 mm from OT4 sheet alloy, which were annealed in a vacuum of 2.6 Pa at temperatures of 600-900 °C and then destroyed by bending force. The thickness of the oxide films was estimated by their interference coloration, and the depth of the gas-saturated layer - by measuring the surface microhardness after the regulated removal of part of the surface layer by chemical etching. The effect of oxide and gas-saturated layers on the mechanical properties of the OT4 alloy was judged by the results of tests of 0.8 mm thick sheet metal samples on repeated static tension at a cycle asymmetry coefficient of $R=+0.1$, a frequency of 0.6–0.8 Hz, and stresses $\sigma_{\max} \approx (0.6...0.8) \sigma_v$ at the UMM-10 installation. The structure of fractures makes it possible to reveal a brittle fracture zone corresponding to the propagation of a crack in an oxide and a brittle part of a gas-saturated layer and a quasi-viscous fracture zone in which the separation crests transform into a dimple formed during crack propagation in a part of a gas-saturated layer with an oxygen concentration insufficient for embrittlement. Mechanical tests of the samples showed that when brittle layers with a depth of more than 20 microns are formed on the surface, its durability during repeated-static tests does not exceed (15...18)% of the durability of the base material. The restoration of the fatigue characteristics of titanium alloys, it is proposed to perform the removal of the surface layer with a thickness not less than the thickness of embrittle, for example, by chemical etching

Key words: titanium alloys, embrittlement, cyclic endurance, annealing, chemical etching

RESEARCH OF THE INFLUENCE OF CUTTING SPEED ON THE FORMATION OF HIDDEN KINEMATIC CONNECTION WHEN STRENGTHENING INTERNAL HELICAL GROOVES WITH LARGE ANGLES OF SPIRAL LIFTING

V.V. Kuts, D.S. Gridin

Abstract: the article shows the results of the study based on computer simulation of the pulling process in order to establish the influence of the cutting speed of the tool, providing processing of the internal helical grooves with large angles of the spiral. Cases of processing helical grooves in thin-walled parts with a broach with a different range of cutting speeds are considered. A new processing concept was proposed for the implementation of hidden kinematic connection in the processing of internal helical grooves. Investigations of the pulling process were carried out in order to establish the influence of cutting speeds on the formation of a hidden kinematic connection, at which no burrs are formed during the processing of helical grooves. Graphs of the dependence of the cutting speed on the obtained after processing the angle of inclination of the helical grooves are presented, as well as the regression equations describing the obtained dependence are determined. According to the statistical analysis of the data obtained from the graph, the coefficients of determination for linear regression are calculated, confirming the statistical significance of the obtained coefficients. The analysis of the obtained research results was carried out, according to which the recommended ranges of cutting speeds were established for the considered angles of inclination of the spiral when machining internal helical grooves with large angles of elevation of the spiral

Key words: broach, helical groove, geometric model, rake angle, trailing angle, shaping

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