Informatics, computer engineering and control

CONTROL SYSTEM SYNTHESIS FOR THE ETHYLBENZENE DEHYDROGENATION PROCESS BASED ON THE PREDICTIVE FUNCTIONAL CONTROL METHOD

S.L. Podvalny, A.P. Popov, S.G. Tikhomirov, O.G. Neizvestny

Abstract: the article describes the application of the predictive control method in the synthesis of an automated system for software control of styrene production. Based on the results of the object system analysis, the method of process control is justified, the review and evaluation of the possibility of using various types of control devices is carried out. Within the framework of the model-oriented design concept, an automated system is synthesized that implements predictive functional control (PFC) of the concentration of styrene at the outlet of the reactor unit first stage. A structural synthesis was performed, and the control system operation algorithm was developed. A set of dynamic models describing heat exchange processes and physical and chemical transformations occurring in the system under study is used as a structural element that performs the construction of a predictive trajectory of changes in the controlling and controlled parameters. The calculation of the optimal value of the control action was carried out taking into account the inertia of the process equipment, the parameters of the state of the catalytic layer of the reactor, energy flows and components of the reaction medium in accordance with the formed complex integral criterion of the energy efficiency of the process while ensuring maximum productivity. A comparative analysis of the results of calculating transient processes for the main channel of the control system, obtained using a PID structure controller and a control device that implements the PFC control method

Key words: predictive functional control, functional structure, control algorithm, prediction horizon, ethylbenzene dehydrogenation

COMPARATIVE ANALYSIS OF POPULAR PLATFORMS FOR LEARNING MANAGEMENT SYSTEMS

S.A. Kovalenko, A.V. Barabanov, N.I. Grebennikova, V.A. Malinovkin

Abstract: at the moment, the online education system is taking on new dimensions. The need for a platform that will harmoniously combine modern functionality and ease of use is increasing. Creating electronic platforms using the latest technical developments allows you to organize high-quality online education. This article provides an overview of the platforms, namely: "Moodle", "iSpring Learn" and "Google Calssroom". These services have a large target audience and high demand in the field of online education. They can be used for both full-time and part-time training, storing course information, tests, and lectures, as well as monitoring training progress and maintaining reports. We considered the advantages and disadvantages of each service. We compare the platforms by a number of characteristics, namely: usability, mobility of the system (deployment system without the involvement of specialists), the presence of the built-in editor of the course, the availability of video conferencing, the availability of core functionality, additional functionality, support of various kinds of file extensions, the flexibility of the system, the availability of mobile applications, costs when using the platform. These aspects are the main ones when choosing a platform, as they are key when using online learning services

Key words: information storage, learning process management, platform for organizing quality education online

DYNAMIC PROBLEM ON ASSIGNING A SINGLE TASK WITH TIME LIMITS

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Abstract: the purpose of this work is the development of mathematics and software for solving the problem of assigning a single task, taking into account the time constraints during which it has to be completed. Another important feature is the ability to correct already assigned but not yet completed tasks that have entered the system earlier. The need for such correction appears if the appointment of a specialist and time for a given task within the existing schedule is impossible. The choice of correspondence between specialists and tasks is carried out in order to achieve maximum efficiency obtained from the task. As a result, a model that contains a set of constraints that take into account all the features of the task, and an objective function that maximizes the efficiency of this job, as well as all planned but not yet started work was obtained. In addition, an approach to solving the problem is proposed, based on the interaction of intelligent agents, each of which is responsible for his task and assigns a specialist and time to him. The novelty of the approach is based on the possibility of canceling the previously planned schedule, which may be caused by strict time constraints, and, as a consequence, the impossibility of solving the problem with the available data

Key words: assignment problem, time constraints, mathematical model

DETECTION OF TRAFFIC SIGNALS USING COLOR SEGMENTATION AND A RADIAL SYMMETRY DETECTOR

R.M. Shakirzyanov

Abstract: currently, unmanned systems for controlling various vehicles, including cars, are becoming widespread. Driving an unmanned vehicle involves solving problems related to the recognition of traffic objects: pedestrians, cars, obstacles (in the form of holes, bumps, poles, trees, buildings, etc.), road signs, markings, traffic lights. An algorithm for solving the problem of detecting and recognizing circular traffic signals is proposed. To solve this problem, the following are involved: rapid transformation of radial symmetry, color segmentation, morphological operations. A feature of the algorithm is that the areas of the location of the light signals are preliminarily determined by color, followed by the refinement of the shape and position of objects in the image. Based on the proposed method, software was developed for detecting traffic signals in photographs. The software was tested on a publicly available database of images containing traffic lights. The proposed algorithm has shown its efficiency, it can be expanded in terms of the types of signals recognized and used as part of control systems for unmanned vehicles, as well as part of driver assistance systems for solving problems to prevent dangerous and emergency situations

Key words: computer vision, image processing, radial symmetry transform, color segmentation, traffic light detection

ALGORITHM FOR CONSTRUCTING A REACHABILITY TREE FOR STOCHASTIC PETRI NETS

D.S. Zvyagin

Abstract: the article describes the basic definitions of the reachability tree of Petri nets. It also considers various examples of stochastic Petri nets, in which, after setting the initial markings in the first positions, the values in all other positions are determined. The work shows examples of determining markings by calculating the vector of the diagonal convolution. Each example of a stochastic Petri net is analyzed. This analysis is necessary for various distribution systems and processes, especially in the final stage. The main analysis methods are reachability tree and matrix equations. I consider one of such methods for analyzing Petri nets. Using the reachability tree, you can analyze, identify, and correct process failures that can occur when there are deadlocks and when transitions are fired incorrectly. Based on the examples considered, I propose a generalized algorithm for constructing a reachability tree for stochastic Petri nets. The proposed algorithm for constructing the reachability tree of stochastic Petri nets can be applied to all nets with both finite and infinite reachability sets. This algorithm will be a useful tool for analyzing stochastic Petri nets

Key words: modeling, stochastic Petri nets, reachability tree

SYNTHESIS OF A CONTROL SYSTEM FOR THE DESTRUCTION PROCESS OF CROSS-LINKED POLYMERS UNDER COMBINED EXTERNAL ACTIONS

S.L. Podvalny, A.P. Popov, A.V. Karmanov, G.S. Tikhomirov, N.K. Obraztsov

Abstract: previous scientific research in the field of radiation destruction of spent polymer materials, waste and industrial rubber goods, as well as their thermomechanical processing, is not sufficient for designing and automation of production lines of low molecular weight polymers using radiation processing on an industrial scale. This paper presents the results of the development of a decision support system for the process of controlled destruction of resin butyl rubber vulcanizates under the combined actions of radiation and thermal mechanical treatment. The developed system is the main functional element of the synthesized control system. Control parameters for the butyl rubber vulcanizates destruction process were determined. A system analysis of the reclaimed butyl rubber production process as a control object was carried out. A method for controlling the stages of a technological process is proposed, in which a combination of control actions is used. The synthesis of the structure of the mathematical support for the decision support system was completed. Particular search criteria for optimal parameters were formed, the structure of connections between them was established, and a method for aggregating a generalized criterion was selected. Using a fuzzy Choquet integral and a fuzzy Sugeno measure, an algorithm for estimating the optimal process parameters was developed. The search problem for the optimal parameters was carried out using a genetic algorithm. The results of computational experiments of multicriteria optimization of technological parameters were obtained. An algorithm for controlling the destruction process with combined control actions was developed

Key words: destruction, ionization radiation, mechanical treatment, mathematical model, process control, decision support system

Radio engineering and communication

ANTENNA SYSTEM BASED ON A FLAT LUNEBERG LENS WITH THROUGH ROUND HOLES AND AN AXISYMMETRIC TEM-HORN

A.V. Ashikhmin, Yu.G. Pasternak, V.A. Pendurin, F.S. Safonov

Abstract: a characteristic feature of the last fifty years has been the desire for ever-increasing transmission speeds in ubiquitous wireless communications. With the advent of the Internet, namely technology (IoT), significant research efforts are being invested in wireless networks that require high transmission speeds and increased bandwidth. In this paper, we consider a Luneberg lens designed on a grounding system using the technology of manufacturing round holes, with a dielectric plate with a system of round holes on top, forming the necessary law of change in the effective refractive index from the radius (material-Rogers 5880, thickness-0.508 mm). A special feature of this design is the through round holes in the flat Luneberg lens. The minimum hole diameter is 0.4 mm; the maximum one is 2.6 mm. The minimum width of the partition between the holes is about 0.3 mm. There are totally 1295 holes (diameters - 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8, 2.0, 2.2, 2.4, 2.6 mm). Several options for implementing this lens are shown. Several variants of what the holes in the lens body should be for the preferred mode of operation are also considered, and conclusions are drawn about each. Using mathematical and numerical analysis, the difference in the cases of the presence or absence of "lids" in the "cups" that form a TEM - horn in the form of a rotation figure is investigated

Key words: mathematical model, Luneberg lens, TEM-horn, directivity pattern

DEPENDENCE OF VIVALDI ANTENNA CHARACTERISTICS ON THE SUBSTRATE METALLIZATION

S.M. Fyedorov, A.S. Badaev, E.A. Ishchenko, E.V. Papina, K.A. Berdnikov, S.I. Derevyankin

Abstract: the article considers a Vivaldi antenna, the operating range of which corresponds to the frequencies allocated by the State Commission on Radio Frequencies for fifth generation networks. The use of various conductive materials in the manufacture of the emitter allows one to achieve both economic advantages and the required characteristics of radiation patterns. In the process of modeling, we determined the return losses of the antenna, as well as the influence on them of the material of the conductive part of the antenna, the radiation pattern, and the efficiency. We determined all characteristics by electrodynamic modeling. The study was carried out for conductive materials such as copper, aluminum, gold, silver, iron, platinum, tantalum, molybdenum. Based on the results obtained, we determined that the best conductor is silver, while copper and aluminum are not much inferior to it in terms of radiation and efficiency. The worst materials for the manufacture of the conductive part of the antenna are tantalum, iron and platinum, so when they are used, the efficiency of the antenna, the real gain of the antenna, decreases. The article presents graphs of S_{11}-parameters for the cases under study, compares them, and also presents the main characteristics of the directional patterns and determines the effect of conductive material on them

Key words: Vivaldi antenna, scattering matrix, return loss, radiation pattern, conductor materials

DEVELOPMENT OF A PROCEDURE FOR DESIGNING DIGITAL AUTOMATES WITH MEMORY ON FPGA

A.A. Pirogov, Yu.A. Pirogova, S.A. Gvozdenko, D.V. Shardakov, E.V. Syemka

Abstract: programmable logic integrated circuits (FPGAs) are custom integrated circuits whose logic is defined by programming. FPGAs are manufactured completely off-the-shelf, i.e. belong to standard products, which is accompanied by well-known advantages - mass production and cost reduction. Due to the regular structure, FPGAs are implemented with a level of integration close to the most efficient one. The use of FPGAs makes it possible to obtain devices that can change configuration, adjusting to a specific task, thanks to their flexible, programmable structure. When developing complex devices, ready-made blocks - IP-cores or complex-functional blocks (SF blocks) - can be used as components for design. The use of software SF blocks allows you to use them as efficiently as possible in the final project, largely reducing design costs. The purpose of the work is to study the technique of describing triggers in the VHDL language, using the built-in Active HDL schematic editor to form the structures of various digital automata and verifying models at the logical level. In this study, we considered schemes of pseudo-random sequence generators, which are used in cryptography problems, where the properties of the programmable FPGA structure are quite relevant

Key words: digital automata with memory, programmable logic, timing diagram

MATHEMATICAL MODEL OF THE RADIATING APERTURE OF HEADLIGHTS CONSISTING OF SEGMENT-PARABOLIC ANTENNAS

Yu.G. Pasternak, V.A. Pendyurin, K.S. Safonov

Abstract: the solution of the communication problem in the Arctic, as well as in the tundra, in the taiga, in the forest, in the sea, in the fields is possible only with the use of mobile satellite communication systems. FSUE "Space Communications" (Moscow) has a constantly expanding group of satellites. For reliable communication in the Arctic and Northern latitudes, in addition to geostationary satellites, satellites moving along high-orbit trajectories were launched. To switch from one satellite to the other included in the subscriber's visibility area, it is necessary to use antenna arrays. The problem is that currently there are no mobile terminals for high-speed satellite communication, and the cost of foreign analogues prevents their widespread use (up to 50 thousand dollars). Typically, a phased array radar is used to track thousands of corner points to track hundreds of targets. Such requirements can only be met by scanning the beam in space for a microsecond. It is clear, that electronic beam control is necessary since it is not possible to mechanically rotate the antenna. Only some of the above problems will be touched upon in this article. An electronic model of the antenna array and its mathematical model is presented

Key words: mathematical model of the antenna array, segment-parabolic antenna

STOCHASTIC DECODING OF LINEAR BLOCK CODES USING CHECK MATRIX

A.V. Bashkirov, I.V. Sviridova, M.V. Khoroshaylova, O.V. Sviridova

Abstract: stochastic decoding capability has recently been proposed for decoding LDPC codes. This paper expands on the application of the stochastic approach to decoding linear block codes using parity check matrices (PCMs) such as Bose-Chowdhury-Hawkingham (BCH) codes, Reed-Solomon (RS) codes, and BCH component-based block turbo codes. We show how the stochastic approach is able to generate soft-output information for iterative decoding with soft-input and soft-output Soft-Input Soft-Output (SISO). We describe the structure of high degree stochastic node variables used in codes using PCM parity check matrices. Simulation results for BCH code (128, 120), RS code (31, 25) and RS (63, 55), and BCH block turbo code (256, 121) and (1024, 676) demonstrate the decoding efficiency on close to SISO iterative decoder with floating point implementation. These results show decoding performance close to the adaptive trust propagation algorithm and / or turbo-oriented adapted trust propagation algorithm

Key words: stochastic decoding, low-density decoder, check matrix

STUDY OF THE INFLUENCE OF RFID TAG BENDING ON BASIC CHARACTERISTICS

S.M. Fyedorov, E.A. Ishchenko, E.V. Papina, K.A. Berdnikov, Yu.D. Savkina

Abstract: the article discusses a passive RFID tag that sits on a flexible substrate, which leads to a problem with changing characteristics when the tag is bent. In the course of the study, we carried out modeling for three situations: a flat tag, curved inward and outward. Thanks to modern methods of electrodynamic modeling, it is possible to determine all the main characteristics of an RFID tag - in the active mode: return loss, radiation pattern; in passive mode: diagram of backscatter, currents and voltages in the load. During the simulation, we plotted graphs of the dependence of the amplitudes of currents and voltages in the load on frequency, peak values of the effective scattering area. Thanks to the data obtained, it is possible to determine the most optimal frequencies for irradiation of an RFID tag in order to ensure its operation in an active mode (high currents and voltages in the load), as well as in the detection mode - large ESR values. The article provides graphs and tables for comparing the cases under study, which show changes in characteristics when the tag is bent, which makes it impossible to use the system in wide frequency ranges, since its possible bends should be taken into account

Key words: RFID tag, backscatter plot, radar cross section

DEVELOPMENT OF RECONFIGURABLE DEVICES BASED ON PROGRAMMABLE LOGIC INTEGRATED CIRCUITS

A.A. Pirogov, Yu.A. Pirogova, S.A. Gvozdenko, D.V. Shardakov, B.I. Zhilin

Abstract: digital filtering of recognized signals is an indispensable procedure for the detection and recognition of messages. Filtering is understood as any transformation of signals in which certain relationships between different signal parameters are purposefully changed in the input sequence of the processed data. Systems that selectively change the shape of signals, eliminate or reduce interference, extract certain information from the signals, and so on, are called filters. Accordingly, filters with any purpose are a special case of signal conversion systems. Programmable logic integrated circuits (FPGAs) are configurable integrated circuits whose logic is defined through programming. The use of FPGAs for digital signal processing tasks makes it possible to obtain devices capable of changing the configuration, adapting to a specific task due to their flexibly changeable, programmable structure. When developing complex devices, ready-made blocks - IP-cores or complex-functional blocks (SF blocks) - can be used as components for design. The use of software SF-blocks allows them to be used most effectively in the final structure, to a significant extent to reduce design costs. The purpose of the work is to build an RTL model of the SF-block for digital signal processing, its verification both at the logical and physical levels

Key words: digital signal processing, programmable logic, timing diagram

METHODS FOR COLLECTING AND EVALUATION OF DIAGNOSTIC SIGNALS IN ANALYSIS OF EMF IMPACT ON ELECTRONIC DEVICES

M.A. Romashchenko, D.V. Vasilchenko, A.L. Neklyudov, S.N. Rozhnenko, K.Ch. Kolbaia

Abstract: currently, the developers of radio electronic devices face many problems that must be taken into account in the process of designing radio electronic devices (RED). One of these problems is to ensure the uninterrupted operation of the device in an unfavorable radio-electronic environment and the passage of the mandatory certification of the product according to noise immunity standards. A striking example of an unfavorable radio-electronic environment are modern cities, where there is a lot of industrial interference caused by the active use and high concentration of high-frequency communications, radio stations, network technologies, computer equipment and household appliances. Such a large concentration of radio electronic equipment during operation causes many external electromagnetic fields, which negatively affect the performance of other electronic devices, causing them to malfunction and malfunction in general. This article examines the basic principles of data analysis methodology when testing electronic devices for exposure to electromagnetic radiation. The problem to be solved by this technique is to identify the degree of resistance of electronic devices to the effects of electromagnetic radiation at the stage of their design. The methodology describes the collection of data from the hardware of the complex for testing electronic devices for the effect of electromagnetic interference, as well as their further processing based on the base of heuristic solutions

Key words: electromagnetic compatibility, polarization of electromagnetic waves, electromagnetic interference, electronic design, certification, tests, testing, quality improvement

MATHEMATICAL MODEL OF A MODIFIED ROTMAN LENS BASED ON AN ASYMMETRIC STRIPE LINE

Yu.G. Pasternak, V.A. Pendyurin, F.S. Safonov

Abstract: Rotman printed lenses are one of the main promising directions for ray formation in multipath antenna arrays (MAA) due to their sufficient simplicity of construction and their wide-band properties, namely, due to the frequency overlap coefficient (it can reach 2-3 or even more). The principle of operation of such lenses is based on different paths of wave propagation within its structure, thanks to which the lens can work with an extremely wide frequency band. However, because of this, a new problem arises - an increase in the overall dimensions of the antenna system. As a result, this design is very difficult to integrate into a compact transceiver system. This problem is proposed to be solved by developing a more compact Rotman lens folded in half. We explain this cardinal method of changing (reducing) the overall dimensions of the Rotman lens by the fact that the main type of wave that transfers the overwhelming share of energy is the TEM wave, for which there is practically no dispersion in microwave laminates with small losses. And for radar, radio direction finding and communication, these are the ways to solve technical difficulties. Before creating an experimental model or layout of the antenna array, it is necessary to conduct a number of experiments, calculations and confirm the specified technical characteristics of the PAA. In this paper, a mathematical model of the Rotman lens was created and calculated based on the fact that it was folded in half

Key words: mathematical model, modified Rotman lens, TEM wave

INTERCONNECTION OF VIVALDI ANTENNAS IN THE MIMO ANTENNA ARRAY

S.M. Fyedorov, E.A. Ishchenko, I.A. Zelenin, E.V. Papina, E.D. Men'shikova, S.I. Derevyankin

Abstract: the article discusses a MIMO antenna array formed of two Vivaldi antennas, which should provide operation in the frequency range allocated for fifth generation networks - 24.25-24.65 GHz. To determine the main parameters of the antenna, we applied modeling, on the basis of which we determined the main characteristics of the MIMO antenna array: the envelope correlation coefficient, the diversity gain, the multiplexing efficiency. According to the results, we determined that with a distance between antennas of 6.13 mm, the maximum possible characteristics of a MIMO antenna array are achieved, and a distance of 2.45 mm is sufficient for stable operation. The article gives the dimensions of the antenna under study, graphs of return loss (S11 - parameters), radiation patterns, envelope correlation coefficient, diversity gain, multiplexing efficiency at different distances between the antenna elements. Ensuring the stability of the MIMO antenna array is an important task since all modern communication systems use this technology to implement multichannel transmission, and, consequently, to increase the information transfer rate. We used specialized software to determine geometric characteristics and perform modeling

Key words: MIMO antenna array, envelope correlation coefficient, diversity gain, multiplexing efficiency, fifth generation communications, Vivaldi antenna

Mechanical engineering and science of machines

APPLICATION OF A STATISTICAL APPROACH TO THE ANALYSIS OF RISKS OF LIFT EQUIPMENT OPERATION

Yu.N. Skorskaay, P.V. Vitchuk, V.Yu. Antsev, N.N. Trushin

Abstract: the article presents studies related to the thematic area of risk assessment of the operation of elevator equipment using a statistical approach. The subjectivity of the methods of qualimetric assessment of reducing the risks of operating elevators made it possible to propose a statistical approach to assessment in all cases where it is possible. The most difficult and crucial stages of the analysis and risk assessment of the operation of elevator equipment is the collection of information necessary to establish the laws of distribution of service life and determine the gamma-percentage resources of its structural elements, as well as a detailed study of all the circumstances of these failures. The analysis of statistical data that we carried out made it possible to investigate the durability of individual elements of the elevator equipment and use these data to assess the service life and substantiate the risks of operating both the elevator as a whole and its individual elements. And the analysis of the reasons for the failure of equipment elements made it possible to assess the need for measures to increase their service life, reliability, and quality of service. Modern methods of computer processing of information in combination with the introduction of a self-diagnostic system for elevator equipment can significantly increase the efficiency of the elevator maintenance system, and timely diagnostics can minimize accidents and ensure the safety of operation

Key words: lift, risk, failure, safety, statistical approach

INFLUENCE OF THE PHYSICO-CHEMICAL STATE OF CONTACT SURFACES ON THE DEVELOPMENT OF THE PROCESS OF DIFFUSION WELDING OF TITANIUM

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Abstract: the aim of this work is to establish the influence of the physico-chemical state of the contact surfaces of titanium, characterized by the thickness of oxide films, embrittled and gas-saturated layers, on their interaction during diffusion welding. Investigations were carried out on cylindrical specimens of titanium alloy OT4, the contact surface of one specimen was a circular cone with an apex angle of 120°, the second specimen had a flat surface. The formation of the surface layers was carried out by annealing the samples in a vacuum of 2.6 Pa at a temperature of 750° C for 10 min, which was accompanied by the formation on the contact surfaces of oxide films 51.5 nm thick, embrittled layers ~ 3.5 μm deep and gas-saturated layers up to 16 μm. Partial removal of the gas-saturated layer from the contact surfaces before diffusion welding was carried out by regulated chemical etching in a mixture of nitric and hydrofluoric acids. Diffusion welding was carried out at a temperature of 900° C and a pressure of 5 MPa for 3 min in a vacuum of $3 \cdot 10^{-2}$ Pa with additional protection against oxidation by a titanium foil screen. The quality of the welded joint was assessed by static tensile tests, visual assessment of the topography of the fracture surfaces and determination of the oxygen content in the surface layers by X-ray spectral microanalysis. We established that in diffusion welding of titanium, the parameter characterizing the physico-chemical state of contact surfaces and responsible for the development of the process of their interaction is the thickness of the surface embrittled layer. The removal of the embrittled layer from the pre-oxidized contact surfaces before welding ensures the development of the process of the formation of chemical bonds between the surfaces to be welded and the formation of a diffusion joint with strength at the level of the base metal, and when removing a slightly larger thickness of the embrittled layer, an increase in strength during static rupture tests

Key words: titanium, annealing, gas-saturated layers, strength, topography