ABSTRACT AND REFERENCES

INFORMATION AND CONTROLLING SYSTEM

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DEVELOPMENT OF METHODS TO IMPROVE NOISE IMMUNITY IN THE FIFTHGENERATION MOBILE NETWORKS BASED ON MULTIPOSITION SIGNALS (p. 6-16)

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We have examined technologies for building 5 G mobile networks, which should provide for the creation of ultradense networks in order to render high-quality services. A formalized statement of the problem on synthesis of the optimal signal based on conditions for relative invariance to an additive interference has been prepared. A method for the optimization of signal parameters based on a mean square criterion has been developed. We have proposed to solve the optimization problem by applying the nonlinear programming methods. It has been shown that solving this problem makes it possible to find a signal with the predefined parameters, invariant to deterministic interferences.

We have developed a method for the optimization of signal parameters based on a uniform criterion. The method is based on determining a totality of signal decomposition coefficients, at which a maximum of the module of an output signal form a demodulator, taken for all values of a random parameter, is minimal. It has been proposed to solve the problem by employing the linear programming methods. Application of this method makes it possible to improve noise immunity in a data transfer system and increase the rate of information transmission along a communication channel.

Synthesis of the optimal signal with respect to the additive interference has been performed. A given signal renders the maximum possible noise immunity to the system. We have considered a discrete difference transform that possesses a universal property of invariance relative to a wide class of interference.

It has been shown that the achievement of an absolute or a relative invariance and the expediency of applying one of the specified methods depend on the characteristics of an interference, the degree of their a priori certainty, as well as the feasibility to form a reverse communication channel. Simulation results have shown that the methods for the formation of an invariant signal, proposed in this paper, could improve a system noise immunity in the communication channel by 5–7 dB. Introduction of the devised methods would make it possible to increase the rate of transmitted information by 30 %, provided the assigned reliability of data transfer is ensured. Enabling the invariance of an information transfer system would make it possible to build the ultradense fifth-generation networks.

Keywords: network noise immunity, additive interference, optimal signal, quasi-deterministic interference.

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CONSTRUCTION OF MATHEMATICAL MODELS FOR THE ESTIMATION OF SIGNAL STRENGTH AT THE INPUT TO THE 802.11 STANDARD RECEIVER IN A 5 GHz Band (p. 16-21)

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The paper proposes mathematical models for the spatial estimation of signal strength at the input of the receiver for the 802.11x family of standards in a 5 GHz range. The models were constructed based on the experimental research into signal distribution for the angular and central location of an access point.

A special feature of these models is taking the main energy parameter into consideration under a real-time mode, and accounting for the maximally possible number of impact factors. In addition, the permissible limits have been determined for these models, which exert a minimal influence on the effective data transfer rate.

It was established that for the 802.11 standard, in a 5 GHz frequency range, the rather significant signal fluctuations exist. Depending on the extent to which premises are filled with various objects, the level of fluctuations can amount to $\delta=\pm 4..8$ dBm, subject to the MIMO system availability. The greatest concentration of radiation energy is observed directly at the transmitting antenna at a distance of up to two meters; it subsequently fades on 10...20 dBm.

It has been established that the presence of MIMO technology introduces a certain heterogeneity to spatial distribution. In this case, there are zones with a lower signal level, as well as zone-bands with a higher level in the presence of multiple antennas. The effectiveness of such a system is maximal in the plane of the arrangement of antennas.

The advantages of the derived models for the spatial signal distribution include: the estimation of a signal level in space for any premises; taking into consideration fluctuations in the primary energy parameter, as well as parameters for the transmission medium; accounting for the parameters of premises, as well as the extent to which space is filled with objects. Such models are most effective for application in methods to diagnose and control wireless networks and channels in the 802.11x family of standards.

Keywords: wireless channel, 802.11 standard, signal distribution, signal strength, 5 GHz frequency range.

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CHARACTERISTICS OF RADIOLOCATION SCATTERING OF THE Su25T Attack Aircraft Model At Different Wavelength Ranges (p. 22-29)

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This paper demonstrates that mathematical modeling makes it possible to build and explore radiolocation profiles of modern and advanced aircraft. Construction and studying mathematical models based on modern information and computer technology can implement methods for calculating the characteristics of secondary radiation of aircraft at required accuracy, in order to ensure their practical feasibility. We have substantiated a method for the calculation of characteristics of aircraft secondary radiation to analyze the radiolocation scattering of the Su-25T attack aircraft model. The advantage of this method is taking into consideration the integrated representations of classical electrodynamics and shortwave asymptotics. A model of the surface of Su-25T aircraft has been built and a method of mathematical modeling has been constructed. The basic characteristics of radiolocation scattering of aircraft have been substantiated – the effective surface of scattering, the "non-coherent" effective surface of scattering, average and median values for the effective surface of scattering, the distribution laws of the amplitude multiplier of reflected signal. The paper reports results of calculation of these characteristics for the radiolocation scattering of Su-25T aircraft for different radiation frequencies of the probing signal. The obtained results are proposed for application during modernization and design of promising means of radiolocation. The results presented here are useful to assess the feasibility of different structural variants of such tools aimed to detect, track, and recognize aircraft of the same type. Application of the results obtained would make it possible to optimize the design of modernized and promising aircraft in order to reduce their radiolocation visibility. The proposed method is the basis for mathematical modelling of radiolocation characteristics of different types of aircraft under the assigned spatial and time-frequency parameters of probing signals, in order to solve the applied tasks on radiolocation.

Keywords: aircraft wind tunnel model, secondary radiation, effective surface.

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DEVELOPMENT OF THE PROCEDURE FOR FORMING NONSTATIONARY SIGNAL STRUCTURES BASED ON MULTICOMPONENT LFM SIGNALS (p. 29-37)

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Noise protection of existing radio lines with noise-shaped signals and digital types of modulation was studied. Analysis

has shown that the use of such signals in conditions of the radio-electronic conflict does not permit to provide necessary level of noise immunity and transmission security of radio communication lines. It was explained by presence of cyclo-conditionality of the carrier oscillation in signals with digital modulation types. Such properties simplify detection and search of signals by means of spectral correlation methods of modern hostile means of electronic surveillance.

To solve this problem, the use of nonstationary signal structures with variable central frequency and spectral density of power was proposed. A procedure of forming such signal structures by application of the Gram-Schmidt orthogonalization procedure to the ensemble of multicomponent LFM signals with controlled spectral characteristics was developed.

It was proposed to estimate various signal structures of multicomponent signal by means of phase portraits of summed signals depending on the scaling factor value. This factor's boundary values at which complexity of the multicomponent signal structure is ensured and degeneration of the process into classical LFM is prevented were established.

Change of probability of a symbol error in a channel with the use of multicomponent orthogonal signal structures was studied depending on the signal/noise ratio. This makes it possible to estimate potential noise immunity of the radio line provided that the signal/noise ratio is determined by energy indicators of the radio channel and the spectral density of the noise of natural origin.

Structural security of the developed signal structures was estimated by means of an energy detector and a cyclo-stationarity detector. It was established that in the case of energy detection, nonstationary signals, and signals of any other type of modulation are equivalent. However, probability of detecting nonstationary signal structures decreased 2–2.5 times compared to other types of signal modulation when using the cyclo-stationarity detector.

Keywords: non-stationary multicomponent signal structures, Gram-Schmidt orthogonalization, cyclo-stationarity of carrier oscillation, structural security.

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ANALYSIS OF THE EFFICIENCY OF SPACETIME ACCESS IN THE MOBILE COMMUNICATION SYSTEMS BASED ON AN ANTENNA ARRAY (p. 38-47)

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We performed analysis of effectiveness of various methods and criteria of space-time processing of the signals by an adaptive antenna array with a view to identifying the algorithm suitable for using in arrangement of space-time access to mobile communication systems.

It was shown that all methods are based on the assessment of an integrated vector of weight coefficients, included in the reception tract of every antenna element and controlled by certain algorithms.

It was shown that recursive procedures that make it possible to correct the vector of weight coefficients in the dynamic situation, including non-stationary signal-interference situation, are more constructive for using in problems of space-time access. This is especially important for communications with mobile subscriber stations and allows reducing the time for processing calling signals due to the rapid convergence of recursive procedures.

A comparative analysis of Widrow-Hoff and Kalman-Bucy algorithms was conducted. It was shown that the Kalman-Bucy procedure, in addition to optimality, in complicated signal-interference situation is characterized by maximally short time of convergence to the sustainable state. The convergence of the procedure is ensured on the time interval, allocated for the action of calling signals of subscriber stations in a mobile network.

We proposed the model for studying the influence of initial conditions on the effectiveness of space-time access by the parameter of the convergence rate of the algorithm for adaptive space-time signal processing in an antenna array. It is possible to approximate the vector value to the optimal due to configuration of the integrated vector of weight coefficient based on the use of the information about directions of arrival of calling signals of subscriber stations in a mobile network.

The results of the calculations of the indicator of the signal/(interference+noise) ratio on the convergence pitch for different algorithms of an adaptive antenna array were obtained. It was shown that it was possible to improve essentially the transitive characteristics of the algorithms for a linear four-element adaptive antenna array due to the successful initial choice of the value of the integrated vector of weight coefficients. This made it possible to increase the value of the signal/(interference+noise) ratio at the outlet of an antenna up to 4 dB.

Keywords: space-time access, adaptive space-time processing, antenna array, integrated weight coefficient.

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PROCEDURE FOR THE SYNTHESIS OF MODELS OF ELECTROTECHNICAL COMPLEXES (p. 48-54)

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A procedure for developing visual mathematical models of multichannel electrotechnical complexes which reduces time of synthesis of mathematical models and error likelihood was developed. The procedure includes two stages: representation of an electrotechnical complex in a form of a structure of the energy path and its transformation into a visual-block model.

Representation of the system in a form of a structure of energy paths is based on the principle of system decomposition proposed

by the authors which involves definition of six types of structural elements in the power conversion structure: source and receiver, distributor and consolidator, converter and energy storage.

The principle of decomposition allows one to create a library of models of subblock, components of the visual-block model and introduce unification of the subblock designation.

To illustrate the proposed procedure, an example of building a visual model of a DC drive for a rolling mill roll and its implementation on a personal computer were considered.

A fragment of the library of components of the visual-block model with a mathematical description of the components included in the considered example was given.

The introduced unification creates conditions for effective work of developers in elaboration of this procedure of model synthesis in terms of formation of a library of subblocs. In addition, unification of the form of representation of the library of components creates conditions for effective communication of researchers and developers within the frames of complex integrated projects.

The model at the stage of developing structure of energy paths is a convenient tool for visualizing system operation and contributes to understanding of its functioning.

The form of the obtained mathematical model is convenient for its further transformation into a model in variables of state which, in turn, is the starting point for synthesis of control systems.

Keywords: electrotechnical complex, principle of decomposition, energy path, system component, visual-block model.

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DEVELOPMENT OF A DATA ACQUISITION METHOD TO TRAIN NEURAL NETWORKS TO DIAGNOSE GAS TURBINE ENGINES AND GAS PUMPING UNITS (p. 55-63)

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The application of neural networks is one of promising ways to improve efficiency when diagnosing aviation gas turbine engines and gas pumping units. In order to start functioning of such network, it should be trained first using the pre-defined training sets. These data should fully characterize work of the object in a wide range of operating modes and at various technical states of the diagnosticated assemblies. In addition, it is necessary to have a similar data set to monitor quality of the neural network learning.

To train the network to recognize faults of one type, a set of 20–200 or more training examples is required. Obtaining such information in operation or in full-scale tests is a rather long or costly process.

A method for acquisition of training and control data sets was proposed. The sets are intended to train static neural networks recognizing single and multiple faults of the elements of air-gas channels

of gas turbine engines and gas pumping units. The method enables obtaining sets of working process parameters describing operation of objects at various technical states of an air-gas channel, effect of measurement errors and object functioning in a wide range of modes and external conditions. Composition of the pumped gas is additionally taken into account for gas pumping units.

To obtain the required parameters, a mathematical model of the working process of the object of the second level of complexity was used.

The sets characterize work of operable objects and objects with significant malfunctions in spools of compressors and turbines and in a combustion chamber and for the case of a gas pumping unit, in its supercharger.

Two variants of formation of sets were considered: using the measured parameters of the working process; deviations of the measured parameters from their reference values and the parameters used as regime parameters in the mathematical model of the working process. For the second variant, check of expediency of including the regime parameters in the sets was made. It has been shown that regime parameters can be excluded from data sets in some cases.

Keywords: diagnosis, neural network, training set, control set, gas turbine, gas pumping.

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