ABSTRACT AND REFERENCES

INFORMATION AND CONTROLLING SYSTEM

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SUPPORT OF METROLOGICAL TRACEABILITY OF CAPACITANCE MEASUREMENTS IN UKRAINE (p. 4-10)

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The comparative analysis of the results of the RMO international key and supplementary comparisons of national standards of units of electrical capacitance is conducted with the aim of evaluation of convergence. For the comparisons, the reference values with the expanded uncertainties are calculated and the degrees of equivalence of standards of participants and expanded uncertainties for the nominal values of measures of 10 pF and 100 pF on frequencies of 1 kHz and 1.592 kHz are determined. Metrological traceability of the national standard of every participant of comparisons to the units of the International system of units SI is determined.

For verification of consistency of the results of comparisons, the values of the $\chi 2$ criterion for the results of comparisons of standards of participants taking into account the measurement uncertainty are calculated. The obtained values of the criterion of consistency for the participants can be considered consistent, which is the objective confirmation of the measurement uncertainties declared by the participants.

The evaluation of calibration and measurement capabilities of Ukraine for the unit of electrical capacitance is realized. The methodology of evaluation of measurement uncertainty in the wide range of capacitance values (from 10 pF to 10 nF) is proposed. The results the calculations of the values of measurement uncertainties according to the proposed methodology revealed that the results correspond to the data published in the international key comparison database for Ukraine in the range of capacitance values from 10 pF to 10 nF on frequencies of 1 kHz and 1.592 kHz.

Keywords: comparison of standards, metrological traceability, electrical capacitance, national metrology institute, calibration and measurement capabilities.

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ANALYSIS OF MASS-ENERGY BALANCE OF UNMANNED AIRCRAFT FUELED BY SOLAR ENERGY (p. 10-18)

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To understand the characteristics and principles of creation of an aircraft, fueled by solar energy, the fundamentals of providing mass-energy balance and its specificity were considered.

To create a mathematical model that describes interrelations between the basic parameters of an aircraft, fueled by solar energy, it was proposed to describe the main components in stages, namely:

– power, required for the implementation of a horizontal flight;

– total power consumption for performing of a flight, including take-off and maneuvers;

– magnitude of energy, generated during a flight;

– total take-off mass of an aircraft.

The principles of power supply of the aircraft systems under all flight modes were defined. Under the mode of a horizontal flight, there should be enough power, generated by solar panels, to fuel all systems. The power surplus is accumulated in the battery. Under the takeoff and landing modes, as well as during a maneuver, the current deficit of the generated power may be compensated for by power of the battery.

We described the factors that affect performance of solar panels of an aircraft, in particular shading, V-shape of a wing, geometry of aerodynamic profile, cloudiness, and orientation relative to the Sun. The model is proposed for determining the mass of an aircraft in general, which takes into account weight characteristics of the industrial components of an aircraft.

Results of the study might be used in the process of creation of aircraft, fueled by solar energy, at the stage of outline design.

We obtained a generalized analytical model of mass-energy balance of an aircraft, taking into account common operation modes and the laws of solar energy generation, which allows us to conduct analytical prediction of characteristics of prototypes. The model combines technological, operational, and design parameters, and is the basis for the formation of algorithm for choosing the parameters of an aircraft fueled by solar energy.

Keywords: mass-energy balance, aircraft fueled by solar energy, conditions of flight realization.

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DEVELOPMENT OF A GEOMECHATRONIC COMPLEX FOR THE GEOTECHNICAL MONITORING OF THE CONTOUR OF A MINE WORKING (p. 19-25)

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While receiving information under dangerous conditions, at which human presence is difficult or impossible, widely spread are the mobile robotic complexes. Particularly important information to determine the stressed-strained state of the underground workings is data on their geometry. Establishing the values of convergence of underground workings will make it possible to locate dangerous areas and decrease the number of emergency cases. In order to design an experimental sample, we developed basic approaches to create geomechatronic complexes, which define the main tasks, the scope of application, and quality criteria. The motion of the complex along an underground working is accompanied by a spatial change in the position of a distance sensor, which must be considered when establishing the actual values of the profile of a working. As parameters that take into account a change in the position, we proposed six components, three displacements and three Euler angles, which are registered by a microelectronic gyroscope that registers the distance traveled. The proposed algorithm is a cyclical structure, which successively performs data registration from different sensors that define its position, data conversion, and data recording to a memory card. Implementation of the devised algorithm allows us to determine the geometry of a profile of the working with an accuracy of 0.5 cm.

Keywords: geomechatronic complex, coordinate system, profile of working, distance sensor, microcontroller.

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PREDICTING A TECHNICAL CONDITION OF RAILWAY AUTOMATION HARDWARE UNDER CONDITIONS OF LIMITED STATISTICAL DATA (p. 26-35)

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Here we report a method developed for the prediction of technical equipment of railway automation. It is based on the Student spread, the methods of maximum likelihood and unevenly accurate observations.

Development of the method for prediction was necessitated by a limited experience of operating the microelectronic systems of railway automation by domestic transportation enterprises. This led to a shortage of statistical data on their operation. Thus, the issue of the application of microstatistics for technical diagnosis of respective devices has become relevant.

As a result of the study we established that the basis for prediction may be formed by the principle of violation of the equivalence class of failure-free devices. The existence of a faulty device violates the integrity of the class. This makes it possible as a desired probability of failure of the device to determine the probability of its exiting the corresponding equivalence class. Under conditions of minimal statistical data, this approach has proved its suitability for micro-electronic equipment.

Thus, we obtain the possibility to predict technical condition of microelectronic equipment of railway automation under conditions of shortage of statistical data. The method has several disadvantages associated with deliberate understatement of values of confidence probability of failure-free work of devices. However, it lays the foundation for further improvement in the methodology of technical diagnosis of information-control systems on railway transport. This is executed with regard to the introduction of the newest modifications, not sufficiently tested as yet.

Keywords: microprocessor systems, railway automation, Student spread, method of maximum likelihood, microstatistics.

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RESEARCH INTO THE USE OF SCRAMBLERS IN NARROWBAND COMMUNICATION SYSTEMS (p. 35-42)

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One of the most important requirements for speech channel is to provide information security. Speech scrambling is one of the preferred methods for secure speech communications over the narrowband channels. That confirms the relevance of works focused on improvement and investigation of operation features of speech scrambling devices.

The article shows the advantages of using scramblers in narrowband voice communication systems and presents a detailed analysis of strength to hacking of communication channels secured by frequency-domain scrambling technique.

The investigation of strength to hacking is based on the developed digital signal processing algorithm which realizes the band scrambler. The developed algorithm does not require synchronization between the scrambler and the descrambler which is achieved by using of sliding window FFT technique.

Presented experimental results show that the lowest level of the scrambled signal residual intelligibility can be achieved when low frequency bands of speech spectrum are permuted with high frequency ones. Also the article shows that if amount of bands is less than 32 the scrambled signal can be hacked by a simple frequency spectrum inversion in the entire frequency band of the signal.

During scrambling with amount of bands greater than 32, there are variants of band permutation that ensure the level of residual intelligibility near 1020 % and that is secured against hacking by the spectrum inversion.

For a real-time speech communication system, the maximum number of scrambler bands is limited by two factors: the delay time for the scrambling-descrambling process and inserted distortions. It was shown that the maximum amount of bands should be less or equal to 256 for scrambling time delay of 128 ms, communication channel bandwidth of 4 kHz and the level of distortions that causes reduction of intelligibility not lower than 90 %.

The presented information can be used in development of frequency-domain scramblers and for selection scrambler keys, which are optimal by the criteria of strength to hacking, minimum of residual intelligibility and level of inserted distortions.

Keywords: scrambling, band scrambler, fast Fourier transform, sliding window, residual intelligibility.

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DEVELOPMENT OF A SYSTEM FOR THE DETECTION OF CYBER ATTACKS BASED ON THE CLUSTERING AND FORMATION OF REFERENCE DEVIATIONS OF ATTRIBUTES (p. 43-52)

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Adaptive system of cyber attack detection, which is based on the improved algorithms for splitting the feature space into clusters, was developed. The procedure of recognition was improved by using the simultaneous clustering and formation of verifying admissible deviations for the attributes of anomalies and cyber attacks.

The proposed modifications of the algorithm for splitting the feature space into clusters in the process of implementation of the procedure of recognition of anomalies and cyber attacks, in contrast to the existing ones, allow us to form simultaneously the reference tolerances when processing complex attributes of recognition objects (RO). This provides the possibility, at every step of training an adaptive recognition system, to change the verifying admissible deviations for all attributes of anomalies and cyber attacks simultaneously. The proposed algorithms make it possible to prevent possible cases of absorption of one RO class of basic attributes of anomalies and cyber attacks by another class. Predicate expressions for ASR that is capable of self-learning were obtained.

Verification of the proposed algorithms was carried out on the simulation models in MatLab and Simulink. It was proved that the proposed algorithms for the clustering of RO attributes make it possible to receive effective learning matrices for ASR as a part of intelligent systems for cyber attack detection.

Keywords: system of cyber attack detection, cyber security, clustering of attributes, verifying admissible deviations.

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EXAMINING THE LEARNING FIRE DETECTORS UNDER REAL CONDITIONS OF APPLICATION (p. 53-59)

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Theoretical analysis revealed that in order to create learning fire detectors, capable of adjusting to unknown conditions of application, it is expedient to consider the criterion of equality of probabilities of false detection and skipping a fire as a criterion of guaranteed fire detection. By using such detection criterion, it is possible to provide guaranteed fire detection under conditions of the absence of a priori information about statistics of the recorded data. The algorithms and structural circuits of the learning fire detectors were developed for the case of discrete and continuous data recording by sensors. Their distinguishing feature is the possibility of application under indeterminate conditions when there is no a priori information about the type of distribution laws of the recorded data, as well as their capability to adapt to previously unknown and changing application conditions and to provide guaranteed fire detection in this case. It was shown that the main limitation in the implementation of such algorithms is the need to use additional instructions from a trainer about the existence or the absence of a fire on the object. To overcome this limitation, it is proposed to apply the hypothesis about sufficient rarity of events related to a fire on the protected sites. This made it possible to use the registered information about the absence of fire as the instructions from a trainer. In this case, the resulting modified algorithm and the structural circuit of the proposed fire detector that matches it do not require instructions from a trainer and, in this sense, a detector becomes a self-learning fire detector.

Results of examining the fire detectors, performed based on the example of real dynamics of the mean temperature of medium when alcohol is ignited and burned, demonstrated their high efficiency. In comparison with fire detectors that comply with the requirements of standard EN 54-5:2003, the examined self-learning fire detectors possess an essential gain in time (exceeding 170 times) of the guaranteed fire detection on the site under uncertain conditions. The ability of self-learning fire detectors to adapt to previously unknown conditions allows their application under non-stationary conditions in order to detect complex fires.

Keywords: learning fire detector, guaranteed fire detection, a priori uncertainty of detection condition.

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OPTIMIZATION OF THERMAL MODES AND COOLING SYSTEMS OF THE INDUCTION TRACTION ENGINES OF TRAMS (p. 59-67)

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We developed a procedure for the optimization of thermal modes and parameters of the cooling system of induction traction engines of tram carriages. The procedure includes the following basic steps. The optimization of operating modes of an induction traction drive by the criterion of effectiveness of its work under different modes. The optimization of motion modes of a tram carriage along a track section with the assigned motion schedule and profile based on the curves of the motion of a tram carriage, optimal by the criterion of energy consumption, using the method of Hamilton-Jacobi-Bellman. The optimization of parameters of the cooling fan of traction engines by the criterion of efficiency of a cooling system using the Weyl method by the generalized golden section. It is proposed to conduct determining of operating modes of a traction drive in advance based on the solution to the problem of conditional optimization of its modes. In order to determine the optimal operating modes of a traction drive, we selected a combined method: global search is executed by genetic algorithm with a one-point crossover and by selection on the principle of roulette. At the final stage of an optimization procedure, optimum refining is carried out using the Nelder–Mead method. When a tram carriage moved along a track section, we defined the following. We determined the optimal modes of motion of the tram carriage T-3 VPA with induction traction engines for a track section with the assigned motion schedule. It was found that, compared with the basic design, efficiency of the cooling system increased by 27.6 %, which corresponds to a reduction in the proposed criterion of efficiency. Based on the results of modeling a traction engine with an optimal fan, it was established that the largest overheating is observed in the frontal part of the stator winding. The temperature is 139.6 °C at second 3363 from starting the motion and it does not exceed a permissible value of 140 °C.

Keywords: tram carriage, induction engine, optimal operating modes, cooling fan.

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A METHOD FOR LOCALIZING A REFERENCE OBJECT IN A CURRENT IMAGE WITH SEVERAL BRIGHT OBJECTS (p. 68-74)

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To ensure the effective functioning of the correlation-extreme navigation systems (CENSs), a method is developed to localize a reference object (RO) in a current image (CI) with several bright objects. The peculiarity of the method consists in converting the CI to a binary unit by determining the average value of the background and setting it for the threshold of the image quantization, which in turn determines the amount of probabilities of errors of the first and second kinds as well as entails assigning the objects of the viewing surface (VS) and the backgrounds to two classes: the RO and the background. The CI model is represented by the brightness values of the corresponding objects and backgrounds of the VS in the differentiation elements. In the model of the current image, the RO has the highest brightness. Other objects that are similar in brightness and commensurate with the RO are categorized as false. The reference image (RI) is set by the contrast mark and the geometrical shape of the object, and it is binary. An algorism has been developed for localizing the RO in an image by searching for a fragment of a binary CI with a maximum value of units that coincides with the RI. The peculiarity of the algorithm consists in adapting the application procedure for the threshold conversion of a CI with an unknown value of the signal-noise ratio. A method has been developed to clarify the maximum value of the DF and to determine the coordinates of the RO in the field of the CI matrix. The method consists in the summation of the number of units of different sections and finding the highest value of the DF. The highest value of the DF coincides with the full match between the CI and the RI. An analytical expression has been obtained for the estimation of the probability of localizing the RO. The expression establishes dependence of the probability of localizing the RO on the parameters that are specified in the stages of solving the problem of localizing the RO, which are the identification, the multi-threshold selection, and the specification of the maximum DF. By modeling the process of forming the DF, numerical estimates have been obtained for the probability of localizing the RO. The research results indicate the feasibility of using the proposed method in a CENS in relation to a VS with several bright objects.

Keywords: current image, identification and selection of a multi-threshold reference object, unimodal decision function.

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