

ABSTRACT AND REFERENCES

INFORMATION AND CONTROLLING SYSTEM

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INTERLABORATORY COMPARISONS OF THE CALIBRATION RESULTS OF TIME METERS (p. 4-11)

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The analysis and selection of the methodology for processing the results of interlaboratory comparisons (IC) were carried out. The universal algorithm for processing the primary IC data was proposed, which allows the reference laboratory to take into account all the features of reporting on ICs.

The transmission sample for IC on the calibration of time meters was investigated. The reference values and corresponding expanded uncertainties for this IC are determined. The results of interlaboratory comparisons of calibration results of the time meter at points from 30 s to 3600 s are presented. Comparison of the results obtained during the calibration of the time meter by ten laboratories was carried out according to the radial scheme within 2016. The deviations of the results obtained by each laboratory were determined and the correctness of the results was evaluated taking into account the measurement uncertainty using the criterion for the performance statistics for the selected time intervals.

The competence of the staff of laboratories participating in IC on the calibration of time meters was estimated. An analysis of the evaluation results showed that the staff of eight out of ten laboratories, including the reference one, has a high level of competence. It has been established that, unlike other factors, the competence of the staff of laboratories participating in IC has little effect on the IC results.

Keywords: interlaboratory comparisons, calibration laboratory, measurement uncertainty, time meter, comparison sample.

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DEVELOPMENT OF A SELF-DIAGNOSTICS SUBSYSTEM OF THE INFORMATION MEASURING SYSTEM USING ANFIS CONTROLLERS (p. 11-19)

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A hybrid self-diagnostic system was designed to evaluate correctness of functioning of sensors of the information-measuring system of testing hydraulic transmissions of diesel locomotives of UHP 750 type. The system features the possibility of checking certain four parameters in steady-state operation conditions using known mathematical dependencies. For the other 14 parameters (for which mathematical dependencies were not studied and which have a high complexity of calculations), 14 neural-fuzzy ANFIS networks were developed. Self-diagnostic algorithms using ANFIS controllers were elaborated. The algorithms provide prediction of individual system parameters with the help of ANFIS controllers and a further comparison of the predicted parameters with the measured parameters. The ANFIS controller

structure with the proposed Sugeno rule set was constructed and its efficiency was shown.

Network training and test of the diagnostic subsystem were performed using the data sets obtained in a series of tests of hydraulic transmissions conducted at Promteplovoy diesel locomotive repair plant. The test results have shown that application of the proposed procedure ensures obtaining of correct result of the self-diagnostic subsystem operation.

Keywords: hydraulic transmission of diesel locomotive, information-measuring system, parameter measurement sensors, neural-fuzzy controller.

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DEVELOPMENT OF THE ALGORITHM OF RELIABILITY-CENTERED MAINTENANCE OF PHASED ARRAY ANTENNAS (p. 20-31)

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The strategy and algorithm of reliability-centered maintenance of active phased array antennas are developed. The use of this strategy and algorithm makes it possible to determine the time and volumes of corrective replacements of the antenna subarray modules based on the results of predicting the reliability indexes of the array antenna as a whole. This procedure is performed as a result of consistent refinement of statistical estimates of reliability indexes of the modules during the normal operation of the phased array antenna.

For processing statistical information on the failures of the array antenna modules and determining the estimates of the sample mean, upper and lower confidence limits, the method of quantiles is used. As the law of distribution of the operating time of the array antenna modules, the combination of exponential and diffusion nonmonotonic distributions is used. The example of implementation of the reliability-centered maintenance strategy and algorithm for the receive phased array antenna including 100 antenna subarrays is presented.

The results of the research can allow organizing the APAR condition-based maintenance and minimizing the operating costs. Implementation of the obtained results can ensure failure-free operation of active phased array radars during operation with the timely provision of antenna subarrays with spare modules.

Keywords: active phased array antenna, forecasting of reliability indexes, diffusion nonmonotonic distribution.

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DEVELOPMENT OF THE ALGORITHM FOR AIRCRAFT CONTROL AT INACCURATE MEASUREMENT OF THE STATE VECTOR AND VARIABLE ACCURACY PARAMETER (p. 32-38)

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A parametric method of the synthesis of control in the closed circuit, taking into account explicitly generalized error of the inertial module, is presented. The law of control in the form of analytical formulas is typically assigned to the control program and does not change during flight of an unmanned aerial vehicle. This decreases the capabilities of the autonomous flight control system to overcome control errors, which occur for various reasons.

To verify assumptions about a possibility of improving the accuracy of an aerial vehicle control by the data of the strapdown inertial navigation system on a certain time interval of autonomous operation, the calculation experiment was conducted with the use of the developed software complex, simulating operation of the automatic flight control system.

Parametrization of the law of control is considered as the main contribution (the outcome). Introduction of the parameter made it possible to decrease a negative impact of measurement errors and other disturbing factors on accuracy of reaching by the point of flight destination. Through computer modeling, it was shown that it is possible to decrease the impact of a generalized measurement error on generation of values of control functions by changing the value of the parameter.

Analytical expressions for the estimation of accuracy of automatic control at the known generalized error of the inertial module and limited disturbing influences were obtained. After analyzing the influence of these factors on accuracy of the object control, a set of recommendations on selection of a variable parameter of synthesis of control depending on precision level of the sensors, used in the inertial module of measuring sensors, was generated.

Keywords: accuracy of terminal control, error of inertial measurements, strapdown inertial navigation system.

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DEVELOPMENT OF HARDWARE AND SOFTWARE FOR CALCULATION AND MONITORING OF THE UNBALANCE FACTOR IN THREEPHASE VOLTAGE SYSTEM (p. 39-45)

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Hardware and software for measuring and monitoring the unbalance factor of the three-phase voltage system is developed. The shortcomings of the existing technical and software solutions for calculating the unbalance factor, as well as problems of applying the methods used for analog control systems to digital systems are described. The block diagram of the microprocessor system for measuring the voltage unbalance factor in the ship three-phase network with the effective values of phase voltages is used. The analysis of the analytical expressions to calculate the unbalance factor allowed minimizing the utilization of system hardware necessary for the formation of all necessary signals. The optimized structure of the digital filter to calculate the effective value of the deterministic periodic signal at the optimum speed of a discrete system is proposed. An increase in the sampling rate in the optimized filter structure does not lead to an increase in the number of arithmetic operations of addition and multiplication, which is an advantage of the proposed system in comparison with similar ones. This allows monitoring of instantaneous changes in the unbalance factor of three-phase voltage and

enables the system to operate in real time. The developed hardware and software can be integrated into the automated control system of the power plant and used in voltage control systems, as well as for the timely detection of voltage unbalance to protect equipment and prevent violation of normal operation.

Keywords: power quality, unbalance factor, ship power plant, voltage monitoring, digital automation.

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DEVELOPMENT OF THE METHOD OF DISTRIBUTION OF MEMORY IN NONSTATIONARY LOADED INFORMATION PROCESSING SYSTEMS (p. 46-53)

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The trend of growing capacity of modern infrastructures and popularity of network services raises the requirements for multi-server information processing systems they work with. The occurrence of events on a regional and global scale affects the activity of processed data streams, which can lead to losses of processed information and decrease in the quality of services for end users. The dependence of the variation coefficient of time intervals between adjacent requests and the probability of loss of the request processed by the software module is found. The two-level control scheme of the shared memory resource of all modules and the functioning algorithm of managers are proposed. The experiment proves the efficiency of the developed method and algorithm for abnormal situations. This method is applicable and effective for various information processing systems and will allow the rational use of computing resources. The application of the method will allow preserving the efficiency of information processing systems for cases of local overload of nodes. Practical implementation of the method will reduce losses of processed information to 10 %. This is especially important for systems that process user-defined data streams based on the concept of software-defined networks.

Keywords: multi-server modular information processing system, memory resource management, software-defined networks.

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IMPROVEMENT OF THE ULTRASONIC TESTING METHOD FOR MATERIALS WITH SIGNIFICANT ATTENUATION (p. 54-61)

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We present a phase method for ultrasonic thickness measurement of materials with significant attenuation and variants for its improvement in order to increase the efficiency of detection of informative signals and the accuracy of determining their time position. At present, composite materials have become widespread in various technical fields. Various methods, including acoustic, are used for their non-destructive testing. It should be noted that a large part of such materials has significant coefficients of attenuation of acoustic oscillations. Therefore, extending the capabilities of methods for ultrasonic thickness measurement of articles made from such materials is an important task.

There are two ways that are proposed to improve the method: by using a combination of procedures for preliminary filtering of the investigated signals based on empirical mode decomposition and subsequent adaptive median filtering of r -statistics, as well as applying weight processing of r -statistics.

We carried out computerized measurement experiments, which allowed the justification of choosing the aperture of a sliding window in the devised methods; we obtained dependences of signal/noise values of the initial informative characteristics on signal/noise values of the investigated signals. It is shown that the error in determining a time position of the detected echo impulses, when using the improved methods, is 1.5–2 times less than the error when the basic method is applied.

The results obtained could be used for the development of new ultrasonic echo impulse thickness measurement devices with improved metrological characteristics.

Keywords: ultrasonic thickness measurement, signal phase characteristic, Hilbert transform, Hilbert-Huang transform, median filtering of signals.

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ITERATIVE HARD-DECISION DECODING OF COMBINED CYCLIC CODES (p. 61-72)

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We propose error correction iteratively decodable cyclic codes (IDCC) that consist of two cyclic Hamming codes with different generator polynomials. As a mathematical apparatus, we apply the theory of linear finite-state machines (LFSM) in binary Galois fields. A generalized decoding algorithm was constructed based on power permutation of bits in the code word and the new technique for combining the codes.

By using hard decisions only, it is possible to achieve high speed and simple hardware-software implementation of encoder and decoder on linear feedback shift registers. The IDCC (n, k) -code makes it possible to correct the errors of multiplicity to $(n-k)$. A code word may have arbitrary length: both small and large. Code rate (k/n) is close to one.

It was established in the course of research that approaching the theoretical limit (border) by Shannon maximally close significantly increases length of codes, complicates encoders and decoders, increases a delay in decoding, and other problems appear. That is why the main criterion for the optimality of error correction coding is proposed to be those code characteristics that are important for practical application (time and hardware costs, focus on contemporary circuitry and parallel processing). From this point of view, the developed IDCC codes can be considered as an alternative to well-known iterative codes (LDPC codes and turbo codes) whose main advantage is the maximum proximity to the Shannon limit.

This is important because at the present stage of development of science and technology one of the relevant scientific and technological problems is the task on ensuring high reliability of data transmission in different systems of digital communication. The proposed codes make it possible to solve the specified task at minimal resource costs and high efficiency.

Keywords: iterative decoding, cyclic codes, Hamming codes, linear finite-state machine, interleaving.

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DEVELOPMENT OF METHOD AND ALGORITHM OF DYNAMIC GYROCOMPASSING FOR HIGH-SPEED SYSTEMS OF NAVIGATION AND CONTROL OF MOVEMENT (p. 72-79)

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The main direction of solving the problem of creating and improving motion control systems for modern aerospace objects is the use of redundant information coming from inertial sensors and a receiver of satellite navigation signals. This explains why the issues of rational combination of information in such systems and the optimization of algorithms for its processing on the on-board computer are given considerable attention today. But not all tasks of increasing the accuracy of navigational definitions can be solved with the help of satellite information. The initial exhibition of the navigation system for azimuth also belongs to such tasks. The design of the dynamic gyrocompass on laser gyroscopes with mechanical dither device is proposed and described in detail. In this design, measurements are made in conditions of controlled rotation of the sensor unit. Thanks to this, without loss of functionality, it is possible to abandon the mechanical dither device, which significantly reduces the level of the high-frequency component of the measurements. Such reduction is important from the point of view of increasing the convergence rate of the azimuth estimate to the true value and increasing the gyrocompass performance as a whole.

An algorithm for applying this method of gyrocompassing has also been developed. It processes the current measurement variables of two gyroscopes with high frequency. This technology makes it possible to improve the autocompensation of the quasi-stationary component of the error; to reduce the sensitivity of the azimuth estimate to the effect of an external magnetic field, which led to an increase in the accuracy of determining the azimuth using a dynamic gyrocompass. With the help of modeling it is proved that the accuracy of this gyrocompass is higher than in the case of using gyroscopes with mechanical dither device.

Keywords: gyrocompass, laser gyroscope, accelerometer, drift, course angle, navigation system, traffic control.

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