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МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ
НАЦІОНАЛЬНИЙ ТЕХНІЧНИЙ УНІВЕРСИТЕТ УКРАЇНИ
«КИЇВСЬКИЙ ПОЛІТЕХНІЧНИЙ ІНСТИТУТ ІМЕНІ ІГОРЯ СІКОРСЬКОГО»

ФАКУЛЬТЕТ АВІАЦІЙНИХ І КОСМІЧНИХ СИСТЕМ

ІНТЕЛЕКТ. ІНТЕГРАЦІЯ. НАДІЙНІСТЬ

Тези доповідей учасників
XI міжнародної конференції
студентів та молодих вчених

12 квітня 2018 року

м. Київ

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В авторській редакції

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Kopyt A.

PERFORMANCE AND ENGAGEMENT MEASURING METHODS OF HUMAN OPERATOR

Despite the increasing automation the human operator is still one of the most important element of the human-machine systems. Thus, it is important to know the operator's performance and psychophysiological state, capabilities and limits. In aviation, there is a set of methods to assess the pilot's performance level, and at the same time there is a medical approach to measure and interpret the physiological human state.

The training device and flight simulators rapidly changes and increase its quality. The computational capabilities are much more efficient and allows to perform more than ever. However, the training techniques, and systems to assess the pilot's performance and the engagement level do not follow the hardware so fast.

The research done on Warsaw University of Technology tries to develop a tool that could measure and process a set of information that are available by the training platform to increase the training assessment. The idea of the research is to use the psychological and physiological techniques along with the objective and automated task efficiency analysis to create a wider spectrum of feedback for instructor.

Thus, the research on the systems that could at the same time provide an information about the pilot's psychological state and the task performance could be a useful tool not only for aviation but could be applicable in various domains like robotics, UAVs and automobile industry.

Buczyński H., Gac Ł., Kurek J., Łukasiewicz M., Łukasiuk K., Mandziuk T., Nizio A., Moskal T., Noga B., Wolski Ł.

DEVELOPMENT OF MULTI-AIRCRAFT AREA SEARCHING SYSTEM FOR APPLICATION IN SEARCH-AND-RESCUE MISSIONS

MelAvio Avionics Club is a student organisation focused on development of unmanned aerial systems. We are a group of students who design, build and write software for UAVs. In the previous academic year, the Club's main goal was a successful start in the *Droniada* academic competition. The goal of the competition's mission was to precisely identify the location of 10 radio beacons located in an area measuring approximately 1200 by 600 metres. The time limit for every team's entry was 30 minutes including flight preparation, the flight itself and repacking of the equipment. Since the radio beacons utilised Bluetooth technology, the systems developed could be easily repurposed to seek people trapped in their location due to e.g. an avalanche or a flood while relying solely on their cell phone's signal. MelAvio team early decided to complete the

mission using a UAV fleet consisting of a plane and two quadcopters. This approach aimed to utilise advantages of both types of aircraft. First, the plane took off and quickly combed the whole area looking for beacon signals. The data would then be sent to central server that processed it and prepared routes for quadcopters. After take-off and reaching the region of interest, the quadcopters hovered in three spots around the approximated location of a beacon in order to triangulate its position with greater precision. During the competition itself the system was run in an altered configuration, but overall proved to be a success. The project is now being refactored and repurposed for upcoming international *UAV Challenge Medical Express* competition.

Obrępalski P.
DEVELOPMENT OF AN EDUCATIONAL PLATFORM FOR SIMULATION DEVELOPERS

With simulators being used in numerous fields more often than ever, the demand for skilled engineers and software developers is high. To address this issue, an educational platform is needed to attract and train future simulation specialists.

The platform is based on a replica of SW-4, a Polish light helicopter, used for training purposes. The simulator is used by students and researchers at the Warsaw University of Technology since 2009. Throughout the years of operation, two problems limited its educational use. Firstly, the software was unique to the platform and required expertise to modify. This proved to be a difficulty for students not acquainted with this framework. Secondly, the rendering engine lagged behind its contemporary counterparts. As helicopter flights take place near ground with low speed, an accurate representation of the surroundings is important. To resolve these problems, a choice was made to use o_-the-shelf software, which not only allowed easy modifications, such as implementing flight models, textures and training scenarios created by students, but also contained a state-of-the-art rendering engine. However, this required custom middleware which would provide means of communication between the hardware and the software, while also being backward compatible. It was fully developed by the students, as part of the modernization project. The pilots confirmed a vast improvement in fidelity of the simulator. An linux of students undertaking projects on the platform has been observed. Since commonly available software is used, the experience and knowledge gained by the students during their projects can be easily transferred to their future work environment.

Pikula K.
PROBLEMS WITH SIMULATION OF FLIGHT, BASED ON THE TWO-SEAT GENERAL AVIATION SIMULATOR

The following abstract treats about studies conducted on problems with simulating flight of the small non-commercially used single engine aircrafts (planes dedicated for Private Pilot License training). Recently pilot training for commercial flights are performed mainly on the simulators, due to reducing training costs. In the General Aviation, this is still problem to provide realistic simulation training.

Studies were performed on the real flight plane simulator of two-seat single engine aircraft, built by Students' Aviation Association at the Warsaw University of Technology. The simulator was created based on Cessna 150 fuselage. Cockpit panel, which allows to simulate wide variety of cockpit configuration, was designed and developed by the members of Association. Researches were mostly focusing on divisibility of attention during the flight on the simulator, also on the problems with visual and instrument flying. In the researches were participating licensed pilots without any major experience on the flight simulator.

In conclusion, results showed that simulating flight in current conditions has still many issues and requires upgrades for the simulator to make it more realistic. Despite that, it is still good and useful way to train pilots, to make their habits and to get them used to indicators.

Strawa N., Sadowski W., Radziszewski P.

ANALYSIS OF ELECTRODYNAMIC SUSPENSION SYSTEM IN HYPERLOOP PROTOTYPE VEHICLE APPLICATION

In times of rapidly progressing globalization the possibility of fast long-distance travel between high traffic cities has become an extremely important issue. Currently available transportation systems have numerous limitations, therefore, the idea of creating completely new solution - Hyperloop transportation system, which would respond to the needs of modern society, has emerged recently. As a newly conceived concept, Hyperloop requires invention of previously unknown technologies or adaptation of those already existing.

Main challenge in high speed transport design is overcoming friction and aerodynamic drag which significantly rise with velocity. For the Hyperloop infrastructure consists of the system of evacuated tubes, where the pods are traveling, therefore aerodynamic drag is minuscule and can be neglected. On the other hand, friction can be diminished by implementing passive magnetic levitation system.

In this work electrodynamic suspension (EDS) system model applied to the Hyperloop prototype vehicle is derived. The authors present comparison of two approaches to simulate suspension dynamics: series of decoupled 2D models and one comprehensive 3D simulation. The purpose of such comparison

is to verify whether methods used in aerospace engineering for aircraft dynamics description may be applicable to Hyperloop.

First, the theoretical background is introduced in order to provide the reader with the Hyperloop transportation system principles. Further, analytical ex- pressions describing passive magnetic levitation are obtained from the standard circuit theory and implemented in the dynamic model. Series of simulations were conducted in Matlab/Simulink and MSC Adams environments using previously built model. Results are toughly analysed and discussed. Finally, the relevant conclusions were drawn.

Bobkov Y., Bereznychenko V.

CONSTRUCTION OF SENSORS THERMAL MODELS

When developing heat flux density sensors, it is necessary to create their thermal model. This allows to significantly reduce the time and material costs in the development of the sensor. At present, the following methods for constructing thermal models have become most widespread.

1. A method based on usage of the procedures of mathematical physics. The essence of the method consists in drawing up differential equations of heat conduction, connecting temporal and spatial changes in temperature at any point of the sensor. To solve differential equations it is necessary to specify boundary conditions. This method is quite accurate. The main drawback is complexity.
2. The finite differences method. The method in which the investigated object is divided into layers of the same thickness and continuous changes of temperature and its temperature field are represented as a broken curve. Graphical methods are used for the solution. The drawback of this method is its low accuracy.
3. The numerical method. The basis of this method is the construction of a differential equation of heat conduction in the form of finite differences. The disadvantage of the method lies in the large number of calculations in solving the differential equation.
4. Method of electrothermal analogy. In this method, thermal processes in some object are represented in the form of an electrical circuit. In the simplest case, the circuit consists of resistive and capacitive elements, as well as sources of electromotive force (EMF). Resistive elements characterize the thermal conductivity of the material in the static regime, and the capacitive elements in the dynamic mode. Using EMF, the temperature difference of the object is simulated. The solution of the thermal problem is accomplished by calculating the electrical circuit. The method is simple and allows to obtain enough accuracy for solving engineering problems.

This method was chosen to construct the thermal model of the developed heat flow and temperature sensor.

The heat flow sensor proposed in the work performed is based on measuring the temperature difference by two thermocouples located at a known, fixed distance in a cylindrical monolithic body.

For the described sensor design, a thermal model was constructed using the thermal analogy method. This model used the source of EMF, which appropriate the temperature difference on the surfaces of the sensor housing, and resistors, that characterize the heat capacity of individual components. Capacities in the model were not used, since the characteristics were investigated in a quasi-stationary mode.

To test the constructed thermal model and to study the effect of the thermal conductivity of the material of the hull, three sensors with ABS-plastic, ebonite and fluoroplastic cases were manufactured.

Conducted laboratory experiments have confirmed the correctness of the constructed model.

Bogynia E., Kryvokhatko I.

AERODYNAMIC CHARACTERISTICS OF TELESCOPIC WING

In the last decade folding tube launch UAV became common, for which telescopic wings are reasonable. By the time telescopic wing aerodynamic characteristics are researched much less than ones of constant geometry wing. In known sources the calculation of complex form wing, calculation of the aerodynamic characteristics of the telescopic wing by the panel-vortex method are given, but the mathematical model does not take into vortices between the sections of the wing. There are no analytical dependencies of aerodynamic characteristics and effective aspect ratio on the ratio of section chords, section thicknesses and wing widths.

The panel-vortex method requires a model of significant schematization of the aircraft surfaces, which affects the accuracy of the results negatively. On the other hand, the finite element method uses the solution of the complete Navier-Stokes equations for a three-dimensional flow and allows obtaining a more accurate result by taking into account vortices between sections, makes it possible to express the dependencies of aerodynamics characteristics on geometric parameters.

In present work telescopic wings` aerodynamic characteristics were determined with help of finite elements method (Ansys software) and panel-vortex method, as well as results obtained during wind tunnel experiment.

Changes of aerodynamic characteristics of the telescopic and rectangular wings have common patterns, but the increase of maximal lift-drag ratio from wingspan grow is higher than that of a rectangular wing. This is due to the decrease of the induced drag of the telescopic wing not just because of aspect

ratio, but also due to approaching of the circulation distribution to the optimal (elliptical) as a result of the appearance of the wing narrowing.

Finite element method with unstructured mesh allows to consider vortices on joints between telescopic wing`s sections and as a result to get more accurate values for lift coefficient. Both panel-vortex method and finite element method allow estimating the drag decreasing due to the telescopic wing span growth. However, the panel-vortex method is more accurate in prediction the dependence of drag changing versus lift coefficient (if lift increases then drag changing increases as well).

Bondarenko O., Pryshchepa A.

ENHANCEMENT OF ACCURACY OF SOLID VITAL GYROSCOPE WITH METALLIC RESONATOR

Timeliness. Gyroscope - an instrument for measuring or maintaining orientation. The principle of the work of vibration gyroscopes is based on the measurement of the coriolis acceleration. Initially, gyroscopes were used as low-precision motion sensors in mobile communication devices and portable computers, new applications began to appear with new requirements to improve metering characteristics. Currently, gyroscopes are used in inertial navigation (INS), stabilization of terrestrial vehicles, aircraft, ships, optical guidance axes, location determination, etc.

The solid-state vibrating gyroscope is one of the most promising developments in modern gyroscopy. Its main advantages, which consist of a long service life and an affordable price, serve as a weighty argument when choosing a high-quality angular speed sensor. Vibration gyroscopes are better for use in inertial systems due to their simple manufacturing and reliability compared to other type gyroscopes, such as circular laser gyroscopes and fiber optic gyroscopes.

They are widely used due to its low cost and compactness, but for a number of reasons, their accuracy is not sufficient for some tactical and navigational purposes.

New scientific and technical results. The purpose of the project is to develop an algorithm for compensation of errors and optimal design of a sensing element (resonator) of a solid-state vibration gyroscope to increase its accuracy.

There is a need to create methods for selecting the design parameters of sensitive elements, developing methods and algorithms for compensating errors. The method of compensating for the errors of a solid-state vibration gyroscope with a metal resonator from the influence of non-measurable and technological factors is developed. And also experimental work with the programmed

microcontroller has been carried out, the signal of control of solid-state vibration gyroscope with the help of a microcontroller has been formed.

Practical applicability. Increasing the accuracy of a solid-state vibration gyroscope with a metal resonator will expand the area of its application.

Borysov O.

SYSTEM FOR CONTROLLING PERSONS UNDER CONDITIONS OF INCOMPLETE DATA

In this paper will be consider a software system that is capable of recognizing and identifying people by their faces. This system uses modules for dynamically connecting /disabling the recognition and detection algorithms of the face.

This approach can significantly improve the efficiency of the system through the use of one or more algorithms that are effective in a current situation.

The system uses xml file to configure the modules. The system divided into four parts: storyboard, face filtration, selection of the most probable candidate and operation trigger.

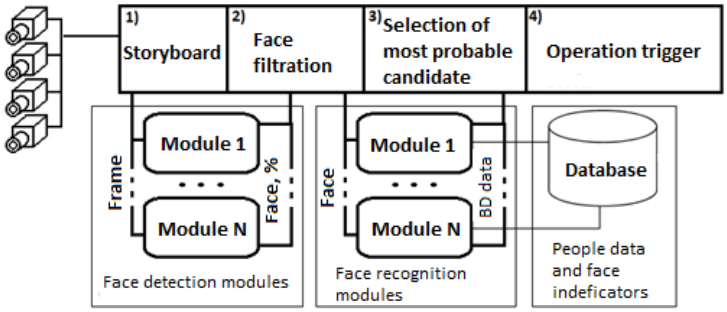

Fig. 1. Scheme of the system

• Storyboard - the system requires a data buffer that can divide the video stream between the modules. The principle of the buffer is following: the system take control over the video stream, and then the stream divides into frames, frame duplicates and transmutes to the correspondent module by using the JGroups.

• Facial filtration - intended to reduce the load on the face recognition modules. The logic of the work is following: delete all the same faces and faces with low probability.

• The selection of the most probable candidate - after the recognition, the face that has the most recognition among the modules, selects to process further.

• The fourth part is responsible for the trigger of systems that execute when the system the identified person.

Each of the modules is an independent program. Startup and termination of the module manages by the system through the interface provided by the module.

• The face detection modules are detecting faces from a frame and assign each face a value from 0 to 100 on how much the algorithm is sure that the selected pixels is face.

• Face Detection Module - these modules have access to databases that store identifiers and information about people.

This system has many applications, and its modularity gives possible to recognize not only people but also other objects. The fourth section of the system can be modify to be modular – that modification will give the system more flexible decision-making capabilities.

Kobets D., Shantyr S.

SHAFT ROTATION SPEED MEASURING MODULE

At present, the DTA-10 type rotation speed sensors are used to measure the rotational speed of the propulsion system shafts with the auxiliary mechanisms of the MI-24 helicopter. The principle of operation of the sensors is based on the use of magnetoelectric induction. At the output of the sensor arise electrical voltage pulses with a frequency proportional to the rotational speed of the inductor. Such a design of the tachometer requires the mounting of the inductor on the shaft of the propulsion system, which has negative consequences during exploitation.

The purpose of the work is to develop and research a multichannel module for measuring the speed of rotation of shaft propulsion system and auxiliary mechanisms of helicopter MI-24.

The analysis of the design and technical characteristics of the power plant with the auxiliary mechanisms and methods used to measure the speed of the shaft rotation was performed in this work. On the basis of the conducted analysis was suggested to use contactless eddy-current method, the use of which will simplify the construction of the meter, will increase the accuracy of the measurement and reliability of the device. The structural scheme of the module for measuring the speed of the shaft rotation is proposed. The scheme consists of four measuring channels. Channels 1 and 2 (Figure 1) have a measurement range up to 15000 rpm and are serviced by one microcontroller, channels 3 and 4 have measurement ranges up to 37,000 rpm and 16,000 rpm, respectively, and are serviced by separate microcontrollers. The channel structure includes the eddy current sensor S, the generator G, the normalizing converter NC and the comparator C. The procedure for measuring the speed of rotation is implemented on the microcontroller. In addition, the microcontroller

provides KEY keyboard control, LED display of operating modes, alarms for rotational speed deviations from the operating mode, and the exchange of data and commands with the onboard computer.

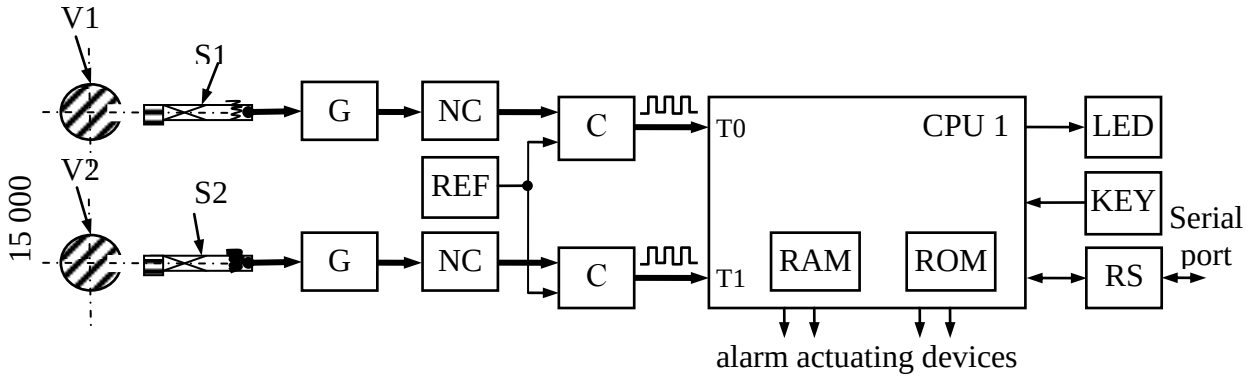

Fig. 1. The block diagram of the measuring channel of the shaft rotational speed

An algorithm for measuring the module's channel is developed. The research of the algorithm's working was performed in the environment of MathCAD Prime 3.1.

The proposed design of the sensor does not require installation of any structural elements on the shaft of the power plant. The design simplifies the location of the module on board. The module is built on the modern industrial RISC controller Microchip series AVR.

Kravchenko K., Prohorchuk O.

CONTROL SYSTEM OF AGRICULTURAL UNMANNED AERIAL VEHICLE

Experts note that the most promising market for commercial use of unmanned vehicles is agriculture. One of the directions of development is the use of unmanned aerial vehicles for precise treatment.

The purpose of the work was to select the flight trajectory of a UAV with minimal energy expenditure. In the process, an optimality criterion was chosen based on the minimization of the trajectory in a certain area of flight and the minimum UAV turn. The chosen optimality criterion is that the smaller the UAV trajectory, the less energy resources are consumed. But this takes into account the efficiency of UAV flight. The efficiency of the trajectory depends on the area of the surface being treated. The question arises of creating an algorithm for calculating the shortest path of processing certain agricultural fields. To minimize the path, we analyze the minimum possible UAV turn, as well as the length and width of the field.

The result of the work will be software., Which when entering the parameters of the field, the weather and the aircraft will output the most effective trajectories.

Matsiletska O., Prokhorchuk O.

DETERMINATION OF GEOGRAPHICAL COORDINATES OF OBJECTS BY MEANS OF UNMANNED AERIAL VEHICLES

The use of various new technologies replaces traditional methods. Along with traditional aerial photography, shooting is becoming more and more demanding with the use of unmanned aerial vehicles (UAVs). UAVs nowadays develop at an amazing speed, in virtually all spheres of activity it is expedient to use unmanned aerial vehicles. The scope of unmanned aerial vehicles is unlimited. At present, the use of UAVs for agricultural land, inaccessible land, forest and water resources will be particularly relevant.

The use of small-scale unmanned aerial vehicles has many advantages and exceeds the traditional method of shooting from the aircraft due to the speed of rapid deployment of equipment and operational preparation for launching the UAV (no need for special landing platforms). Moreover, the ability to fly at a minimum altitude of 150-200 m allows you to stay under the clouds at almost any time. In addition, high permission on the terrain allows you to see the smallest details of the relief and objects even centimetric precision.

The paper describes a new algorithm for increasing the accuracy of determining the geographic coordinates of objects by means of UAV in the conditions of perturbed atmosphere. Pictures obtained by UAVs at low altitudes can provide users of geographic information systems with sound and up-to-date information and will allow them to reduce the cost of services by an order of magnitude compared to space or aeronautical systems.

At the same time, the wide use of UAV in the civilian sector of the economy is impossible without solving a number of scientific and technical problems, regulatory, legislative and organizational problems.

Nechyporenko O., Bryzhan S.

INCREASE OF THE RELIABILITY OF AIRCRAFT MAGNETOMETER SYSTEM

Relevance. As a result of the development of electronics and microelectronic mechanical systems technology, MEMS magnetometers have appeared that function as a compass in the form of microcircuit and are part of the complex navigational systems of small unmanned aerial vehicles (UAV), in particular quadcopters. The relevance of this research is to develop methods to improve the reliability of both SUAV in general and their components, systems and elements.

New scientific and technical results. Development of method of increase of reliability and exactness of the magnetometer system at planning and providing of reliable work in the conditions of exploitation on UAV by

introduction in the system additionally two magnetometer sensors (functional redundancy) and algorithm of diagnostics of their signal outputs by comparison of their indications. The research hasbeen carried out on a magnetometric system developed on the basis of a digital three-axis magnetometer (compass) Bosch type HMC5883. To compensate the temperature error, equations are obtained for determining the basic angles of the orientation of the object – the azimuth, the zenith and the sighting angles, when the main electrical parameters of the magnetometric converter are determined a priori. To increase reliability a method of structural redundancy was used, which is a parallel loaded redundancy method when a device or system is backed up by identical backup elements connected permanently into operation. The use of this method allowed choosing the necessary amount of reserve magnetometers, namely three sensors (one basic and two reserve ones). Algorithms for diagnosing failures of the magnetometric system have been developed, on the basis of which the programs have been developed: for failure on one axis, by comparing the indications.

Practical applicability. For practical application the software program has been developed aboard the quadcopter, the installation of which on the Arduino microcontroller made it possible to diagnose the failure of one of the magnetometers of the magnetometric system, to resume its up state (eliminate failure), and thereby improve the magnetometer system reliability significantly.

Nechyporenko O., Hoinetc O.

ENSURING THE RELIABILITY OF A MINIATURE BAROMETRIC ALTIMETER BASED ON A PIEZORESISTIVE PRESSURE SENSOR

The urgency of the research is caused by the solution of the problem of increasing the reliability of the barometric altimeter at ultra-low altitudes, which have a short duration and take place at flight of quadcopters. The aim of the research is to develop a method for increasing the functional reliability of the miniature barometric altimeter of a quadcopter by complexing the altimeter with a platformless inertial system (PINS) and a satellite navigation system (SNS). The research used a barometric altimeter, developed on the basis of a digital piezoresistive atmospheric pressure sensor (module with barometer as BMP-280 from BOSCH). The module BMP-280 also has a built-in sensor of temperature.

The new scientific and technical results include the choice of the most effective method of increasing reliability - the method of functional redundancy. Therefore, to increase the reliability of the barometric altimeter, a functional complexating method was chosen, when redundancy in the system is created by redundancy of the main function of the object according to the purpose. Such main function of the barometric altimeter is a measurement of altitude of the quadcopter flight. Thus, as a functional reserve, all on-board measuring systems

can be considered, which give an opportunity to obtain information about the flight altitude.

There is a knew integrated navigation system for unmanned aerial vehicles, which consists of the BINS navigation complex based on micromechanical sensors (iMEMS) and SNS, which has high reliability indicators. The system is implemented as a loosely coupled scheme based on the optimal Kalman filter, which allows both the development of independent solutions in the BINS & SNS, as the complex solution obtaining on the basis of the Kalman filter according to the SNS and BINS data. This research suggests a complexing of the miniature barometric altimeter based on a piezoresistive pressure sensor with this system.

Reliability measure $P_c(t)$ of the complexating system of measuring of flight altitude with three functional redundants is $P_c(t) == 1-[1-0,95]^3 = 0,999875 >> P(t) = 0,95$. Therefore, the functional redundancy proposed in the research will greatly enhance the barometric altimeter reliability.

A miniature barometric altimeter is designed for its practical application onboard of quadcopter. In addition, using the developed complex flight altitude measurement system will improve the reliability of both the altimeter and the quadcopter in general.

Nechyporenko O., Melashenko V.

QUADROCOPTER OF INCREASED RELIABILITY WHICH CONTINUES FLIGHT IN CASE OF A FAILURE OF ENGINE PROPELLER COMBINATIONS

Timeliness. The role of the problem of ensuring the main property of dependability - reliability - grows through the need to transformation the quadcopters from one-time objects to reusable use. The problem of ensuring reliability at the moment is one of the urgent tasks of design, production and operation of technical objects, in particular unmanned aerial vehicles, such as multicopters (quadcopters, copters).

New scientific and technical results. The aim of the work is to analyze and increase the reliability of the quadcopter using existing methods. A quadcopter flight duration is restricted by the accumulator power and it is from 20 to 40 minutes. That is, in such short time, the probability of parametric failures occurrence from wear, fatigue or gradual physical degradation is negligible. Therefore, for the first time, the quadcopter functional reliability was investigated. As a criterion for functional failure the loss of its flight was considered which leads to an accident, that is, to the quadcopter fall. The statistical data of quadcopter functional failures were collected. On the basis of

analysis and calculation of statistical estimates of the failure probabilities of component elements, it was found that the most unreliable elements are elements of an engine-propeller combinations (EPC) of quadcopter. As "the weakest link", the EPC needs the backuping or redundancy. In contrast to the classical structural redundancy, which causes an increase in mass-dimensional parameters, in this work the redundancy software methods were considered, when an additional (backup) quadcopter motion control program is used after the failure of one or two EPCs.

When adding a special program to the quadcopter software in case of one EPC's failure, the quadcopter can fly on two engine-propeller combinations which fixed on one beam. The flight controller software with the algorithm for diagnosing EPC's failures, which lead to the quadcopter fall, has also been developed. On the basis of the quadcopter reliability analysis, the main causes and events that lead to its failure (loss of flight and fall) are found, namely: the EPC's failures due to overheating of the speed controller of the brushless engine and damage to a part of propeller. For each of the above-mentioned reasons for the EPC's failures which leads to the quadcopter fall, the additional software has been developed.

Practical applicability. The additional programs that eliminate failures and fault diagnosis algorithms are designed for their practical application onboard a quadcopter . This can significantly improve the reliability and cost-effectiveness of its reusable use.

Prokhorchuk O., Parkhomenko N.

CONTACTLESS OPTICAL SYSTEM FOR CALCULATING THE PATH OF A SMALL-SCALE UNMANNED AERIAL VEHICLE

Relevance of the topic. Contactless optical computing systems have long been used in robotics for the automatic control of motion in conditions where the volume of a priori information is not sufficient and to solve the problems of management requires an analysis of the environment in real time. But today, such a system is not so commonly used in the UAV because of the lack of universal algorithms for solving visual observations and objects recognition of visual observation.

New scientific and technical results. The problem of autonomous system positioning of UAVs in the area where it is impossible to use GLONASS / GPS sensors (for example, loss of signals from satellites, reloading of the module, etc.) was considered in the work. There are several options for implementing this positioning method for small UAVs. Among them: based on the real-time

image of the terrain that can be made by one or two cameras, with the simulation of an electronic map and without it. In the work, the method was proposed, which is to automatically find several tens of characteristic points in each frame. An analysis of their movement from frame to frame gives information about the motion of an object. A large number of such points guarantees the accuracy of the definition of displacement, course and orientation angles. In this case, the automatic control system on the basis of such information produces control commands for solving the problem of stabilization or guidance.

The main limitation of the method is the possibility of only relative determination of coordinates and orientation, which can lead to an increase in the navigation error over time. Also among the reasons that make it impossible to find the corresponding pairs of points in the pictures: insufficient illumination, impossibility to use in the case of cloudiness, impossibility of using over a smooth surface without distinctive singular points (flat, uniformly lit water surface "without flickering" and waves, homogeneous and even sandy desert without vegetation). It is worth noticing that such a system does not consume a lot of UAV's energy resources and does not require usege of additional equipment.

Practical applicability. Despite all the disadvantages of such a system, this method can and should be implemented in small UAVs and further used in the absence of a signal from the GLONASS / GPS sensors.

Sariboga H., Levchenko T., Matyushchenko A.

RESEARCH OF POLARIZATIONAL COMPOSITION STRATOSPHERIC OZONE LAYER OF EARTH USING ULTRAPHIOLETIC PICCOLARIMETER

Relevance. The general objective of the project is to conduct research on the polarization components of the diffusion reflected by the stratosphere of solar radiation. Such data can be obtained using the space ultraviolet polarimeter (UVP), which operates in the wavelength range of 230-290 nm. This device is currently being developed at the National Technical University of Ukraine «Igor Sikorsky Kyiv Polytechnic Institute» and the Main Astronomical Observatory of the National Academy of Sciences of Ukraine.

New scientific and technical results. The data obtained by such a space experiment will allow us to come closer to solving the problem of aerosol component impact on changes in the ozone layer of the Earth. Such a ultra-violet

picopolarimeter (UVP) is scheduled to be installed on board the satellite's peak satellite "South".

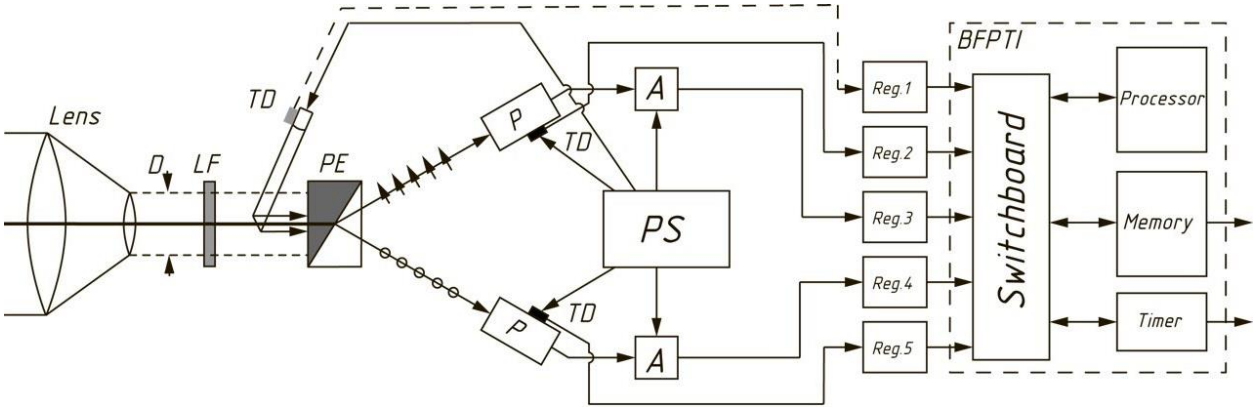

Fig. 1 The block diagram of the UFP

D - diaphragm, LF - light filters, TD - thermal sensors, PE - polarization element, P - photodiode, A - amplifier, PS - power supply, Reg. - register, BFPTI - block of formation, processing and transmission of information

The general view of the structural scheme is presented in Fig. 1. The UVP has a two-channel structure, it does not have moving elements and consists of:

- Optical parts (diaphragm, lens, Volaston prism, light filters);
- Registration block of the useful signal and the processing of the information received (photovoltaic receivers (photodiodes), temperature and pressure sensors, frequency meter (signal correction block), ADC, control unit (on-board calculator));
- Unit for transmitting information to Earth (encoder, radio transmitter, radio channel, etc.).

The input value for the entire instrument and its optical part as the primary converter is UV radiation. According to the terms of reference, we need to design an on-board UPS with overall dimensions of not more than 100x100x100 mm. Regarding the registration system, the conversion function should have a linear appearance. The radiation intensity measurement range is preferably 10^4. The measured value is the intensity of the light flux of radiation I [W / m²], which is the initial value of the optical part of the device.

Practical applicability. As a result of this work, a model of the electrical part of the UVP was developed on the basis of an ultraviolet photodiode. Structural and functional diagrams of the device were developed. By calculation the efficiency of the design is substantiated.

Sautin A.

CORRUPTION OF THE CARD OF SHUHART

The basis for controlling the stability of the results are control cards, which represent a graphical way of displaying and controlling the accuracy of the test results, widely used and tested by the practice of statistical control of the quality of technological processes. Control cards give an opportunity to visualize and quickly evaluate the state of the test process, facilitate analysis and interpretation of the results.

The control of the stability of the results is based on a series of control procedures. It is advisable to establish the number of observations and intervals between them accordingly, based on the ratio of the speed of possible changes in the statistical characteristics of the measurement results under the influence of various random variables and the possible disruption of the test process in such a way that deviations in the conduct of the trial process could reasonably be neglected.

The basic idea of the control cards is to divide the observations into subgroups, within which variations are allowed, due only to random causes, while the difference between these subgroups may be due to special reasons, not only random, which should be detected control cards. For this purpose, reference value is used in relation to which the results of observations are detected, the values of which are greater than could be expected under the influence of only random variables.

During the study of the sensitivity of the control cards, it was discovered that the probability of detecting the change in the process directly proportional to the size of the subgroups to which the investigated observations are divided, that is, the greater the number of elements in the subgroups, the greater the likelihood of detecting the technological process disruption, and, directly, the sensitivity of the control cards.

The urgency of this work is confirmed by the constant growth in the last two decades of publications on various aspects of multidimensional methods of statistical control in foreign and domestic editions: it is work to improve multidimensional control by using maps on the main components, on regression residues, control in conditions of volatility of the volume of samples, change of regimes technological process, in case of violation of normal distribution of controlled parameters and others. If at the end of the last century the work of American specialists was mostly presented, then in recent years, articles and books from researchers from many other countries are actively published.

Sheinych S., Shantyr S.

MICROPROCESSOR-BASED FREQUENCY METER FOR INTERNET CALIBRATION SYSTEMS

Internet metrology encompasses the Internet/Ethernet technologies for effective solution of metrology tasks. Particular attention is given to remotely

controlled calibration systems which used networks and telecommunications. It makes enable to operational control to metrological characteristics of measuring equipment and has advantages over traditional calibration methods. It is a reduction in the cost and calibration time; solves the problem associated with decommissioning/commissioning and with transportation. But despite of all the benefits of Internet-calibration, there are still unresolved issues in technology of hardware, safety and law.

The purpose of the work is to create and research a microprocessor frequency meter (MFM) for Internet-calibration systems.

Analyzing the Internet-calibration systems in measuring devices of time and frequency, the general requirements for MFM are formulated. In the aspect of technical parameters and characteristics, the MFM must have: two measurement channels that provide measurement in the frequency range from 0.01 Hz to 1 MHz with averaging time of 10-3 s, 10-2 s, 10-2 s, 1 s, 10 s, 100 s; Input sensitivity 10 mV (RMS); input voltage range up to 12 V (RMS); reference signal 1 MHz; internal memory size up to 16 kB; USB interface v 2.0.

In accordance with specified requirements, the block diagram of the Microprocessor frequency meter for Internet-calibration system was proposed and developed (fig. 1).

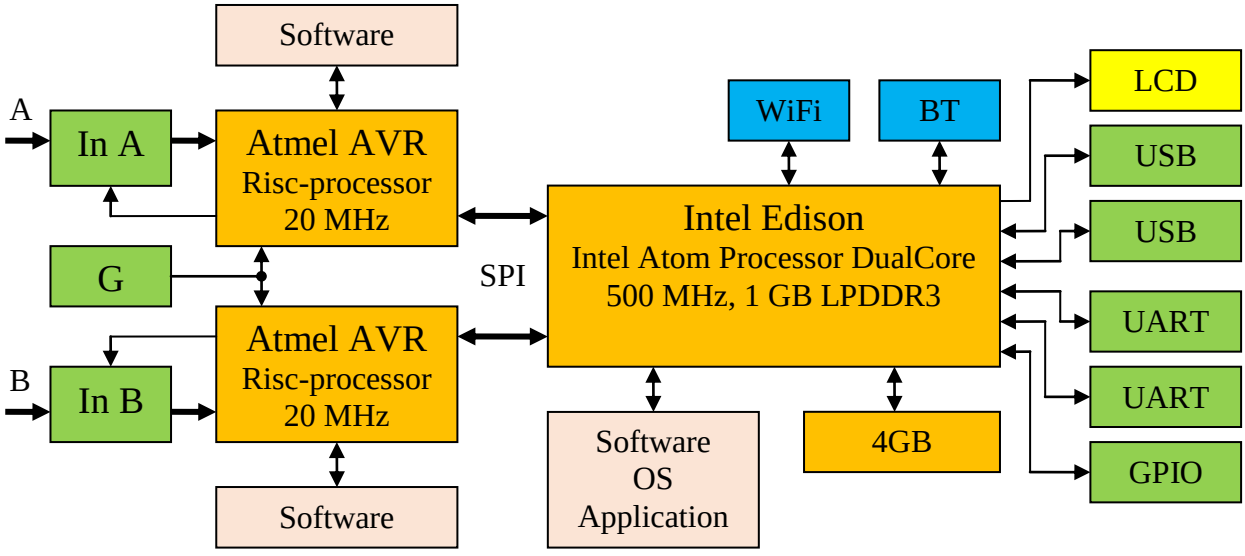

Fig. 1. The block diagram of a microprocessor frequency meter

The core of the MFM developed on the basis of Intel Atom Processor DualCore 500 MHz processor which based on Intel Edison technology, It provides communication requirements, processing functions, logging, analysis and archiving of measurement results, a graphical WIMP user interface. Measuring procedures are implemented on Atmel AVR 20 MHz RISC

processors. Communications between the MFM core and the measuring channels are implemented through the SPI interface.

Shevkun M., Dobroliubova M.

AUTOMATED VERIFICATION COMPLEX FOR TELEPHONE CONVERSATION DURABILITY AND INFORMATION QUANTITY MEASUREMENT SYSTEMS

Automated verification complex for telephone conversation durability (TCDMS) and information quantity measurement systems (IQMS) is important for the society as mobile services and access to Internet resources are among the most essential services of the present, since they provide the opportunity for constant communication, access to securities, fast purchase of goods, instant payments on accounts of various types, objects navigation and search on the ground, etc.

The timeliness of the automated verification complex development is driven by the fact that that a) the communication providers need to record the volume of services provided for further charging and determination of subscriber payment system; b) in accordance with the Resolution of the Cabinet of Ministers of Ukraine No. 374 dated June 4, 2015 and No. 94 dated January 13, 2016, TCDMS and IQMS are included in the regulated measurement equipment and are subject to conformity assessment and periodic verification; c) verification systems usually work in manual or semi-automatic modes while automated complexes are developed only abroad for today.

Automated verification complex for TCDMS and IQMS is based on the Arduino Mega 2560 card; the SIMCom Wireless Solutions company's GSM/GPRS module, serie SIM800L (unlike analogues the SIM800L module supports a larger range of AT commands and offers better processing speed, which provides optimal file download functionality), and the Ai-Thinker company's GPRS/GSM module, model A6 (supports state-of-the-art mobile communication and data transmission standards, AT commands, and a number of AI-THINKER commands), that are analogues of mobile phones/modems; a personal computer (PC) and an SD card module. The complex allows you to measure the date, time, duration of the telephone conversations in seconds, which are recorded by the TCDMS mobile operator, and the amount of information transmitted by the communication channel, which in turn in the same channel is measured by the mobile operator's IQMS. Indicated values are compared with each other, which makes it possible to evaluate metrological characteristics, which in turn are converted to normalized values. The combination of a verification system with a computer allows you to obtain, process and store quickly large volumes of information for future use.

Implementation of this complex is especially relevant for organizations and enterprises that carry out metrological activities in the field of telecommunications, namely the conformity assessment and periodic verification of TCDMS and IQMS. Using the developed complex will increase the verification efficiency and reduce the cost of metrology works. In the future, it is planned to decorate the complex with the possibility of automatically creating a verification protocol.

Shkilniyk Y.

CALIBRATION OF ANGULAR SPEED TRANSDUCERS WITH A WIDE RANGE OF MEASUREMENTS

Measuring angular velocity (gyroscopes) with high precision is important for providing complex technological processes of medicine, machine tools, aircraft engineering and rocket technology. Measurement of angular velocity in a wide range is important in the study of the behavior of detachable parts of aircraft, aerospace technology in order to determine the trajectory of their movement. Ensuring the accuracy of the measurement performed by the calibration operation.

In view of the above, there is a need to create a calibration method for measuring the angular velocity converter with a wide range using a reference gyroscope with a narrower range of measurements. It is suggested to measure the angular velocity by a reference gyroscope with a narrow measuring range, positioning it at an angle to the axis of rotation of the wide-range gyroscope and thus carrying out the calibration procedure. The value of the angular velocity for the gyroscope axis *Z*, passing the calibration procedure, ω will be determined by the formula:

$$\omega = \omega' * cos\,\alpha$$

The error of measuring the angular velocity by an exemplary gyroscope is determined by taking into account its own error of measurement of the angular velocity by the ω' model gyroscope and the error of the angle α.

$$\delta_{exem} = \delta_{\omega'} + \delta_{\alpha}$$

Another source of error is the instability of the rotational speed of the stand, coupled with the time characteristics of the data collection system. The total time of determining one angular velocity for a single gyroscope $t_{measure}$ consists of the time the mechanical value is converted into an electrical signal t_{mv}, the time of the normalizing transformation t_{nt} and the time of the analog-digital conversion t_{ADC}.

$$t_{measure} = t_{mv} + t_{nt} + t_{ADC}$$

For two gyros, the value of time will be $2 \cdot t_{measure}$. This value should be less than the value of the oscillation of the rotational speed of the stand in time.

For the implementation of this calibration method, a system consisting of a sample MEMS (Microelectromechanical systems) gyroscope with a digital output ICM-20600 with a basic measurement error of ±1% and a measurement range of ±2000 °/s from InvenSense and a calibrated gyroscope with a digital output of the ITG -3701 with the main measurement error ±3% and measurement range ±4000 °/s, STM32F100RB microcontroller for measuring data, permanent memory card M95640 and personal computer.

Skrypkovska M.

THE DEVICE FOR MEASURE THE INCLINATION ANGLES OF A MOTIONLESS OBJECT RELATIVE TO THE LOCAL HORIZON PLANE

The need to measure the angles of inclination is actual to many branches of technology and industry. At the today Ukraine devices market there are no domestic accelerometer devices for measuring roll and pitch angles (DMRPA), which would meet the following requirements: the mean square error less than one angular minute in the range of angles ± 10 °, the operating temperature range -40 ... + 70 ° C, output information in a digital code with a discreteness of 1 angular second. Such DMRPAs are needed to control the position of radars and antennas, horizontals of platforms and vehicles.

The developed DMRPA provides measurements of the roll and pitch angles in accordance with the above requirements. Issuance of output digital data for consumer is carried out on the interface RS-422.

The DMRPA's metal rectangular case consists of a bottom base plate having three legs for attachment to the object base surface and a casing. On the base plate two accelerometer sensors (AS) - primary accelerators transducer, with mutually perpendicular measuring axes, are installed. Digital temperature transducers are installed near them. The analogue parts of the device electronic circuit board contain the electronics for the transformation of the pendulum sensitive elements displacement into the voltage, and electronics of the feedback regulators, the current from which goes to the coil of the reverse compensating converter. This current is proportional to the projection of gravity accelerating on the sensitivity axis of the AS, and is converted into a voltage across the precision resistor. The microcontroller located on the board includes two high-precision analogue-digital converters, converting signals from these resistors into digital codes, proportional to measured acceleration. The microcontroller

software performs algorithmic compensation for the measurement errors of the acceleration and the calculation of the roll and pitch angles.

During the experimental tests, it has been confirmed that for various combinations of temperatures and angles of inclination in the range of angles of inclination ± 10 ° and temperatures minus 40 ... + 70 ° C, the mean square error is not more than one angular minute, which is unique for the devices presented on the modern domestic market.

Consequently, this development will allow the establishment in Ukraine of the production of high-precision DMRPAs to meet the needs of domestic new technic manufacturers. Further research can be directed to the study of long-term instability of the DMRPA's parameters, the reduction of the mean-square error due to the installation of additional temperature sensors and the improvement of temperature errors compensation.

Smirnov V., Bogomazov S.

MICROPROCESSOR POWERED MONITORING OF HUMAN BODY PHYSICAL STATE

In modern world there is often a necessity of measuring and, more important, storing and analyzing various bodily parameters, e.g. surface temperature, inner temperature, blood pressure, heart rate, oxygen content in blood etc. As such there exists a vast number of specialized equipment that provides capabilities of measuring parameters which were mentioned previously. There is one drawback in such devices, though, and that is the price, which can reach up to tens and hundreds of US dollars.

The main goal of conducted research was to develop a proof-of-concept device that provides a capability of reliably measuring a heart rate while also fitting into a moderately accessible price range of $5-10.

The main sensor of choice is an MAX30100 integrated circuit, manufactured by Maxim Integrated. The MAX30100 is an integrated pulse oximetry and heart-rate monitor sensor solution. It combines two LEDs (Light Emitting Diodes), a photodetector, optimized optics and a low-noise analog signal processor to detect pulse oximetry and heart-rate signals. MAX30100 is a tiny sensor, not exceeding 1cm in any dimension, providing a lot of room for other components. Minimal external hardware components are needed for integration into a wearable device.

The data processing and relaying is accomplished using an ATMEGA328 8-bit general purpose microcontroller, manufactured by Atmel Corporation. The ATMEGA328 has UART (Universal Asynchronous Receiver-Transmitter) interface that is used to transmit heart rate readings to the PC (Personal Computer), which in turn displays and analyzes the received data.

The processed data is displayed on the computer's monitor via graphical user interface, provided by a standard web-browser of user's choice. A web-interface, as opposed to a system-dependent graphical user interface, has been chosen for the reasons of cross-platform support, so that the user can access graphical interface from any device inside a local network that has a basic web-browser (alternatively, access can be broaden to include whole Internet if needed, so that readings from the device could be monitored from any point on Earth).

The most costly parts of the device are the MAX30100 sensor (est. ~$2.30) ATMEGA328 microcontroller (est. ~$1.50) and printed circuit board (est. ~$0.50). The upper bound for the cost of additional components (i.e. operational amplifiers, resistors, capacitors and connectors) has been initially estimated as $1.00. Thereby the cost of manufacturing one such device is approximately $5.30, give or take, depending on the volume of production. Thus the initial requirement for the cost of manufacturing is satisfied with a good margin.

Tuyakhova A.

MEASURING TASK SOLUTION OF ROOM POSITIONING USING MICROMECHANICAL INERTIAL MEASURING MODULE

Movement control system is the most important part of any rocket and space complex. To manage complex aircraft, it is necessary to find solutions of navigation problems. Various navigation systems are used for this purpose. Among the various navigation systems, inertial systems have highly developed, they are characterized by great autonomy, versatility, and high accuracy of mobile object positioning.

The goal of the project is to determine the current location coordinates and use them to manage the center of mass of the object.

Inertial navigation systems became a basis for navigation systems of modern mobile objects. Due to the ability to find the angular position of the object with high accuracy in any range of angles and with a high information output rate, modern inertial navigation systems have no alternatives.

The following methods are used: the method of subtraction of the path, the method of all orientation angles, the method of auto-calibration. The method of calculating the path is that proportional accelerations are measured in the given coordinate system, integrated twice and the velocity and current coordinates are obtained. The method of autocalibration of accelerometers and angular velocity sensors of platformless inertial navigation system is based on re-orientation effect of sensor sensitive axis to support vectors of acceleration of gravity and angular velocity of the Earth's rotation due to corresponding turns of the sensor unit relative to the geographical basis. Calibration of accelerometers and gyroscopes is carried out in the inertial measuring module. It is performed

on special stands by assigning test input influences and measuring the output signals of accelerometers and gyroscopes.

The algorithm of determining the growth of coordinates and angular position is developed. One of several algorithms of calculation is used to determine the turn matrix. The algorithm of the platformless inertial navigation system in the inertial coordinate system with Poisson equations is used in the work. A real-time measurement solution is developed.

Small dimensions and take-off mass necessitate miniature information measuring systems to determine the orientation of objects in space, built on various physical principles. Such systems are widely used to determine the orientation parameters of remote-piloted vehicle in the micro and mini class, as well as in the control systems of moving objects. The obtained results allows to find solutions of navigation problems for complex aircraft operation.

Voitiuk O., Kryvokhatko I.

THE WINGLETS` EFFECT ON AERODYNAMIC CHARACTERISTICS OF THE TANDEM-SCHEME AIRCRAFT

Tandem scheme as aircraft aerodynamic layout means comparable areas of forward and rear wings and is well-known in aviation.

Tandem-scheme aircraft allows increasing in lifting capacity with limited winspans and may have benefits for low wing load. So it has found a new application for modern unmanned aerial vehicles.

Winglets are almost not used for tandem-scheme aircrafts. Theoretically, winglets installing on the forward wing allows not only reducing of forward wing induced drag, but rear wing drag as well. As experimental confirmation has not been found in the open sources, the task of the winglets effect research on the tandem-scheme aircraft aerodynamics remains unsolved.

The purpose of this work is to research the aerodynamic characteristics of tandem-scheme UAV with and without winglets on forward and rear wings with help of computational fluid dynamics.

In this work 3d-models of forward and rear wigs of the tandem-scheme aircraft were built for aerodynamic computations. The first version of the model consists of the forward and rear wings without winglets, the second one is the same except the winglets on the forward wings and the third one has the winglets on both forward and rear wings.

The direct computations was performed with Ansys software including pressure-based solver and Menter`s turbulence model (k-ω SST) with default settings in standard atmospheric conditions. This approach does not allow determining the absolute values of drag, but allows comparisons to be made for several similar cases. Reference value for force coefficients is the area of both wings, for the pitch moment coefficient is the total chord of the two wings as

well, and for the roll and yaw moment coefficients is the average wingspan as well.

Presented research revealed that winglets on the forward wings of tandem-scheme aircraft increase lift-drag ratio and lateral stability, decrease wing induced drag, directional stability and longitudinal stability. The winglets on rear wings increase insignificantly lift-drag ratio, but improve stability in all directions greatly. Winglets installation on both wings increases the maximum lift-drag ratio by 0.3...0.4, the maximal lift coefficient by 0.04, the roll and the yaw stabilities 2.7...2.8 times. Further increasing of winglets` area on the rear wings allows complete replacing of the vertical stabilizer with winglets on the forward and rear wings and so obtaining an additional gain of maximal lift coefficient and lift-drag ratio.

Yaremko R., Yeremenko V.

DIGITAL MEASUREMENT MEASUREMENT CONCENTRATION OF MIXTURES OF GAS IN MAGNETS

Gas analyzers, devices that measure the content (concentration) of one or more components in gas mixtures. Each gas analyzer is designed to measure the concentration of only certain components against the background of a particular gas mixture in normalizing conditions. Along with the use of separate gas analyzers, gas control systems are created, which combine dozens of such devices. In most cases, the work of the gas analyzer is impossible without a number of auxiliary devices that provide the necessary temperature and pressure, the purification of the gas mixture from dust and resins, and in some cases and from some interfere with the dimensions of the components and aggressive in-v.

The gas analyzer is intended for continuous automatic control of the volume fraction of methane (CH_4) in the atmosphere of mine workings (including coal mines), hazardous by mine gas or dust, and the issuance of signaling when the measured component of the established threshold values is reached.

At present, the most common electrochemical and optical devices. Such devices are capable of monitoring the concentration of gases in real time.

The structural and functional scheme of this digital methane concentration meter is based on the use of a microprocessor system - a microcontroller. The use of microcontrollers in measuring technology has significant advantages over analog methods of measurement and data processing:

- reduction of mass and dimensions of devices;
- reduction of energy consumption and, as a result, longer work without recharging batteries;
- Modularity of measuring devices;

the ability to create measurement systems using standard interfaces;
- the possibility of changing the processing algorithm without changing the hardware part, only by software methods;
- the possibility of implementing complex algorithms;
- program correction of errors.

The choice of a microcontroller is based on the satisfaction of the requirements of the specification, basically it is given the error and functional support.

Yaremko Y., Yeremenko V.

INFORMATION-MEASURING SYSTEM OF DIAGNOSTICS OF A CONDITION OF UNITS FOR RAILWAY TRANSPORT

At present, the task of determining the technical condition of the bucket units of freight cars equipped with cassette tapered bearings and forecasting their residual life in operation using the built-in control means is actual.

The prospect of creating a modern, competitive freight cars require not only increasing construction speeds and increased axle loads, but also provide mileage in axle-box assemblies of up to 1 million km without repair (called the new generation cars equipped with axle-box nodes with double-row conic bearings of cassette type). In addition, these cars have a variety of designs running parts that use bearings from different manufacturers with different oils. Therefore, existing control systems do not provide adequately the necessary level of technical condition assessment books for these cars. This problem is particularly acute because the proportion of such freight cars is gradually increasing.

Of particular importance for the safety of traffic on the railway transport is the high reliability of the rolling stock rolling stock.

The task of improving the methods and means of estimating and predicting the resource of the boot knots of freight wagons of the new generation is set.

The aim is to improve methods and means of assessment and resource forecasting in axle-box assemblies of freight cars of new generation. To determine the main diagnostic signs of cracks in axle-box assemblies of freight cars which lead to traffic accidents; to perform a comparative analysis of existing systems of control of technical state of axle-box assemblies in operation and to determine the most efficient; propose a structure for the diagnostic assurance in axle-box assemblies of freight cars of new generation.

To solve the problems, theoretical studies were performed on the basis of the system approach using probability theory and mathematical statistics, pattern recognition theory, methods of technical diagnostics, forecasting on the basis of time (dynamic) series.

In this paper we have discussed various methods of diagnostics. First the model of assessment of technical state of axle unit built-in control, which introduced an additional sign of recognition - of the temperature of the axle boxes of the rotational frequency of the wheel pair, which allows a more reliable estimate of the technical condition of the axle unit. The mathematical model of forecasting of a residual resource of axle unit that is in front of the abandoned state, information on the temperature provided by the built-in controls when the train moves.

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03056, Київ-56, вул. Політехнічна, 14, корп. 15
тел./факс (044) 241-68-78, 241-66-64, e-mail: izdatelstvo@ntu-kpi.kiev.ua