

ABSTRACT

of the thesis work of a PhD candidate of the specialty 6D071600 – “Instrument Engineering” M.Zh. Aitimov on the subject of “Research of implementation options and development of complex of multi-parameter intelligent frequency sensors for integrated ON-LINE environmental control systems”

The relevance of the work is due to the need for reliable information on the state of the environment and an assess of the possibility of a disaster: mudflow hazards, fires, pollution of water sources, accidents on the strategic and highly dangerous objects, and so on.

The environment means the financial situation, which is in contact with humanity, and allows each human body to function on the planet. The environment includes: water, air and land. And if these components of the environment will not meet certain requirements of the population, living in the area with affected environmental conditions will be difficult, or impossible.

Environmental disturbances may be caused by the influence of both human and can have a man-made character. Human impact is most often seen in the pollution of water and air, deforestation in mountain and foothill areas, river basins, steppe areas.

Man-made disasters are associated primarily with the seismic activity in the mountains and foothills, as well as floods of rivers, snow melt, overflow and breakthroughs of moraine lakes and so on, which finally cause a considerable economic damage in territories.

With regard to Kazakhstan, a special damage from emergency situations of natural character falls on the mudflows. Mudflows are usually sudden and short-lived, often characterized by catastrophic after-effects - cause huge material damage and often accompanied with victims.

The current environment monitoring and control system does not stand up to scrutiny in terms of problem solving, openness, reliability and efficiency. Thus, the leading organization of Kazakhstan state institute "KazSeleZashshita" of the RK MES currently practices the aerial monitoring of the sources of mudflow danger, which does not provide the required speed and accuracy of the determination of the water level of high mountain lakes and, in addition, is extremely expensive, and carried out only adjacent to Almaty city and Almaty region in the mountainous area of the Trans-Ili Alatau.

Thus, the creation of multi-level environment monitoring and control system is an extremely urgent task not only for Kazakhstan, but also for many countries with mountain and foothill areas.

The basis of the environment monitoring and control system is the multi-parameter sensors of physical quantities that define the information content and reliability of the entire system. Thus, the development of integrated ON-LINE environmental control systems based on the complex multi-parameter intellectual

frequency sensors is a challenge yet to be fully resolved in Kazakhstan and neighboring countries.

The aim of the work is to research and design integrated ON-LINE systems using intelligent RF sensors and an individual accounting system for environmental pollution produced by technogenic objects.

Main objectives: To achieve this goal in the thesis posed and solved the following main objectives:

1. Analysis of the status and trends of development of the environment monitoring and control system
2. Research of the principles of transformation of physical and chemical quantities in the multi-parameter sensors of the environment monitoring and control system and the choice of basic ones.
3. Development and research of a complex of multiparameter sensor component models.
4. Research and analysis of structural and informational features of multi-parameter sensors with secondary electronic frequency converters
5. Development of programs and algorithms of frequency multi-parameter sensors functioning for integrated ON-LINE systems.

The rationale for conducting this scientific research work. The base and baseline data for the development of the topic. The relation with other scientific research works.

The rationale for the work is the Law of the Republic of Kazakhstan "On emergency situations of natural and man-made character", which provides research, observation, control of the situation, forecasting and warning about the threat of accidents, disasters and catastrophes. There's also pointed out that the main objective of the research work in the field of emergency situations of natural and man-made character is to develop methods for monitoring and the establishment of the bank of emergency data, forecasting methods, prevention, control and protection measures, the targeted, scientific and technical programs for forecasting, assessing the impact, preventing and elimination of emergencies.

The creation of a whole complete environment monitoring and control system is extremely difficult and time-consuming task, which is to be solved with the traditional methods only by specialized development teams with specialists in hardware, programmers, designers, systems analysts, engineers, and so on. But, as a result of the development of the theory and practice of modern MIS, SCADA and other control and monitoring systems, was adopted the open systems approach, which uses standard technology platforms, standard interfaces, and so on, that allows to decentralize the development of the environment monitoring and control system. At the same time the main level of the environment monitoring and control system is lower: the level of converters of physical quantities - sensors, on the reliability, accuracy and in formativeness of which depends the throughout work of the monitoring system. Therefore, in order to increase the information content and reduce

the number of types of sensors of physical quantities, they must be multi-functional which means measuring several values simultaneously with a single sensor.

The main idea of the research is to improve the quality of monitoring and controlling the environment state by using multiparameter intelligent frequency PQS (physical quantities sensors) and software based on cloud and mobile technology.

Research methods. The problems posed in the work have been solved with the use of mathematical apparatus of qualimetry, the physics solid-state theory, the theory of mathematical modeling methods planning. The software packages: MathLab, Mathcad, Compass 3D were used as modern modeling tools.

The scientific novelty of the work is as follows:

1. The research and analysis of the state and prospects of the development of a complex of hardware and software for the QMS of the environment have been carried out, and basic concepts have been defined.
2. Technical requirements for sensors of physical quantities used for QMS of the environment have been developed.
3. A complex of physico-mathematical models of multiparameter sensors of physical quantities has been developed.
4. The structural and software methods for improving the quality of multiparameter sensors have been studied and analyzed.
5. The test procedure and metrological certification of multi-parameter sensors has been developed.
6. A mobile application for use in the QMS of the environment has been developed

Rationale and reliability of the results and conclusions. The rationale for the development of this subject is its relevance, ensuring awareness of people with signs of disaster occurrence or dangerous situations, that is the most important scientific, technical and socio-economic problem. The reliability of the developed scientific statements and conclusions was confirmed by the results of tests of experimental samples of multifunctional sensors.

The current state of the problem and the novelty of the subject.

Organizations such as Kazselzaschita of Kazakhstan, the Institute of Automation and Information Technology of the National Academy of Sciences of RK, the Moscow State University of the Russian Federation n.a. Lomonosov and a number of other CIS design organizations and institutes work actively in the area of mudflow monitoring and control system. However, there are now no developments of the systems to monitor and control the environment that can be scaled for various types of monitoring and objects themselves. Furthermore, in existing works and created systems there are used sensors of physical quantities designed for measuring some value which reduces the functionality of the system.

The technical problem of research to create an experimental model of ON-LINE monitoring system equipped with a multi-parameter sensors.

The objectives of the research are:

- review and analysis of the status and trends of the environment monitoring and control system.
- selection and research of principles of transformation of physical and chemical quantities in the multi-parameter sensors of the environment monitoring and control system.
- modeling the elements, structures and schemes of multi-parameter sensors
- investigation and analysis of the structural and information features of multi-parameter sensors with secondary electronic frequency converters
- Development of programs and multiparameter intelligent frequency sensors algorithms functioning for integrated ON-LINE systems.
- experimental testing of the development results.

The object of the research is a complex of multi-parameter frequency sensors for integrated ON-LINE environmental control systems.

The subject of the research is multi-parameter sensors combined in ON-LINE monitoring system

The methodological basis of the work is subject to the following sequence: concept development, analytical modeling; computer modeling; the results testing from tests of experimental samples of multi-parameter sensors

In the course of the thesis work for the first time obtained the following results to be protected:

1. The results of the researches of the current state and trends in the development of systems and a set of technical means of monitoring the state of the environment.
2. The principles of construction and operation of integrated ON-LINE systems and elements of environmental monitoring.
3. The development of requirements for the nomenclature and the main technical characteristics of the physical quantity sensors used in the ON-LINE environmental pollution control system.
4. The results of implementation of multiparameter frequency sensors and integrated ON-LINE pollution control systems based on them.

Scientific results in the framework of the requirements for dissertations.

The thesis work is a holistic scientific research, containing deep analysis of the issues in the research area, the study of current trends and justification of achieved scientific results. The thesis consists of the introduction, 4 chapters, the conclusion, the list of references and appendices.

In the introduction disclosed the urgency, specified the problems related to the investigated problem. It presents the idea of work, objectives and tasks of the research, scientific novelty and practical value of the work.

In the first section of the thesis discussed the state and prospects of development of the environment monitoring and control system, particularly, software and hardware equipment, the structure of systems, the issues to be solved with them, review, classification and analysis of designs of frequency sensors of

physical quantities, the DPharp-sensors design. A brief justification for the task of designing a complex of multi-parameter sensors of ON-LINE environmental control systems was made.

The second section sets out the principles of construction and operation of the integrated ON-LINE systems and nomenclature of sensors of physical quantities. In particular, it presented the concept of construction of mudflow risk monitoring and control system, which marked the entire set of technical tools, including sensors of physical quantities, which are installed on the monitor object, as well as transmitters and receivers of information transmitted from the remote and geographically distributed sensors of physical quantities. Conducted a research of the principles of the conversion of the physical quantities in the multi-parameter sensors. Developed the physical and mathematical models of semiconductor sensing elements with the use of electric counterparts of distributed sensory structures, sensor structures, pressure measurement methods, thermoresistive method. The analysis of design solutions of modeling the elements and sensor structures, technological features of multi-parameter sensors.

The third section describes how to research and analyse the sheet-oriented design implementation of multi-parameter sensors. Developed the algorithms, schemes and programs for multi-parameter frequency sensors for integrated ON-LINE systems, described a scheme developed under the grant of the water pollution monitoring and control system with reference of sensors installed. The design, modeling and research of multi-parameter sensors were conducted. Considered the deploying integrating frequency converters with secondary electronic frequency converters with modulation and without modulation of the measuring circuit output signal. The main advantage of smart sensor is a dynamic programming based on changes in requirements from any external conditions and customer requirements.

The fourth section presents the results of researches regarding the implementation of multi-parameter frequency sensors and the results of tests of experimental layouts. Presented the design of sensing elements and capacitive sensors measuring modules with integrated electronic converters, as well as the developed sheet-oriented solutions during the thesis and the experimental layout of the measuring channel of the pollution monitoring and control system.

In conclusion of the thesis work the basic results were formulated. The annexes present the results of sensors test protocols.

The practical significance of the work.

- A mobile application based on Arduino, which allowed to check the main developed design and software solutions has been developed.
- The innovative patent No. 29649 KZ "The system of individual registration of environmental pollution produced by technogenic objects" has been obtained.
- The results of the dissertation research were used in the educational process of the Department of "Robotics and technical means of automation" of the KazNRTU named after K.I.Satpayev, the Department of "Applied and Business Informatics" of

the Penza branch of the MGUTM named after K.G. Razumovsky, OOO NPC "KIT", Penza.

Approbation of the results. The main results of the thesis were reported and discussed: at the seminars of the Department "Robotics and automation hardware" of KazNITU n.a. K.I.Satpaev; the 5th PBMCs "Scientific aspects of innovative research", Samara, 2013; 12th International Conference on Mobile Systems and Pervasive Computing. Belfort, France; IRTC "Problems of automation and control in technical systems" Penza PSU in 2015; XII ISPs Internet conference "Youth. The science. Innovations (Youth.Science.Innovation)» MSUTM n.a. K.G. Razumovsky (PKU) Penza 2016.

Publications. On the subject of the dissertation published 12 publications, including 6 articles in journals recommended by the Monitoring Committee of the Ministry of Education and Science, 6 reports at the international conferences, 3 articles on the database of Scopus, obtained 1 innovative patent. A training manual entitled "Technical Measurements in Technology and Production of Radioelectronic Apparatus and Measuring Systems" was published.