International Scientific – Practical Conference
« INFORMATION INNOVATIVE TECHNOLOGIES»

Prague – 2020
April 20-24

UDC 681.3 + 681.5
I 64

I 64 Information Innovative Technologies: Materials of the International scientific – practical conference. /Ed. Uvaysov S. U., Ivanov I.A. – M.: Association of graduates and employees of AFEA named after prof. Zhukovsky, 2020, 332 p.

ISSN 2542-1824

The materials of The International Scientific – Practical Conference is presented below. The Conference reflects the modern state of innovation in education, science, industry and social-economic sphere, from the standpoint of introducing new information technologies.

It is interesting for a wide range of researchers, teachers, graduate students and professionals in the field of innovation and information technologies.

ISSN 2542-1824

Proceedings of the conference contains

- information about the organizers;
- materials of the conference.

EVENTS

Plenary meeting

Fundamental issues of innovations
Results of fundamental researches in different scientific and practical activities are considered
Form of the report: plenary
Time-limit of the speech – up to 30 minutes

Section meetings

Section 1. *Information technologies in education*
Questions under consideration: educational process management at the high, secondary and basic education; distance education; ICT for improvement of teaching quality and others.
Form of the report – section
Time-limit of the speech – up to 10 minutes

Section 2. *Information technologies in science and industry*
Use of modern information technologies in provision of scholar researches and new types of equipment and technologies creation.
Form of the report – section
Time-limit of the speech – up to 10 minutes

Section 3. *Information technologies in social-economic sphere*
This section is dedicated to issues of innovative and information technologies use in different spheres of society life and activities.
Form of the report – section
Time-limit of the speech – up to 10 minutes

Section 4. *Economy of information systems and digitalization*
The section is devoted to the economic analysis of information systems and the current process of transition to a digital economy (digitalization).
Form of the report – section
Time-limit of the speech – up to 10 minutes

ATTENTION! *Please follow the updates on the site* ***WWW.DIAG.RU***

ORGANIZERS

General organizer	
MIREA - Russian Technological University	
Russian Centre for Science and Culture in Prague	

Sponsors	
Experimental laboratory NaukaSoft	

Support	
Russian Academy of Sciences	
Ministry of Education and Science of the Russian Federation	

Organisational partners	
Association of graduates and employees of AFEA named after prof. Zhukovsky	
Immanuel Kant Baltic Federal University	
Institute of Electronics and Information Technology of Lublin University of Technology	
FSBEI HE DSMU MOH Russia	
Permanent Mission of the Republic of Dagestan to the President of the Russian Federation	
Tomsk State University of Control Systems and Radioelectronics.	

THE SCIENTIFIC SUPERVISOR

Sigov A.S., Professor, Doctor of Physico-Mathematical Sciences, Academician of Russian Academy of Science, President of RTU MIREA

CHAIR OF THE PROGRAM COMMITTEE

Kudzh S.A., Professor, Doctor of Technical Sciences, Rector of RTU MIREA

PROGRAM COMMITTEE

Cheremisina E.N., Prof.	Dubna, Director of the Institute of System Analysis and Management of International University "Dubna"
Chernodarov A.V., Prof.	Moscow, Experimental laboratory NaukaSoft
Golovanova N.B., Prof.	Moscow, Deputy First Vice-Rector of RTU MIREA
Gorbunov A.P., Prof.	Pyatigorsk, Rector of PSU
Gusein-zade N.G. , Prof.	Moscow, Head of Department, GPI RAS
Ismagilov F.R. , Prof.	Ufa, Head of Department, USATU
Kacejko Piotr, prof.dr hab.inż.	Lublin, Rektor of Lublin University of Technology
Karpenko A.P., Prof.	Moscow, Head of Department, BMSTU
Khalutin S.P., Prof.	Moscow, General Director Experimental laboratory NaukaSoft
Klaban Vladimír, Prof. Ing., CSc	Brno, RAŠÍNOVA VYSOKÁ ŠKOLA s.r.o.
Kokes Josef, Assoc. prof., CSc.	Prague, prorector of VSMIEP Prague
Kulikov G.V., Prof.	Moscow, RTU MIREA
Kuzaev G.A., Prof.	Nordheim, Prof. radio group of Norwegian Institute of Science and Technology
Meshcheryakov R.V., Prof.	Moscow, Institute of Control Sciences Academician V.A. Trapeznikov
Nazarenko M.A., Docent	Moscow, Head of Department, RTU MIREA
Omarov N.S.-M., Prof.	Makhachkala, First Vice-rector of Dagestan state medical university
Pankov V.L., Prof.	Moscow, Advisor of Rector, RTU MIREA
Pozhidaev E.D., Prof.	Moscow, scientific director of faculty MIEM HSE
Prachař Jan, Ing., PhD.	Prague, Evropský polytechnický institut
Ragutkin A.V.	Moscow, Vice-Rector for Innovative Development of RTU MIREA
Shashurin G.V., Docent	Moscow, Head of the Faculty, BMSTU
Shelupanov A.A., Prof.	Tomsk, President of TUSUR
Shmid A.V., Prof.	Moscow, General Director of "EC-Leasing"
Sokolov V.V., Prof.	Moscow, Advisor of Rector, RTU MIREA
Timofeev G.A., Prof.	Moscow, Head of "NUK RK" BMSTU
Timoshenko A.V., Prof.	Moscow, Vice-Rector for Academic Affairs of RTU MIREA
Vasilev A.G. , Prof.	Moscow, Director of the Institute, RTU MIREA
Vityazev V.V., Prof.	Ryazan, Head of Department, RSREU
Wójcik Waldemar, Prof. dr hab. Inż.	Lublin, director of the Institute of Electronics and Information Technology of Lublin University of Technology

CHAIR OF THE ORGANIZATION COMMITTEE

Uvaysov S.U. - Professor, Doctor of of Technical Sciences, Head of Department, RTU MIREA.

DEPUTY CHAIR OF THE ORGANIZATION COMMITTEE

Konchakov A.V. – Director of Russian Centre for Science and Culture in Prague.

ACADEMIC SECRETARY

Ivanov I.A. - Candidate of Technical Sciences, Docent, RTU MIREA

ORGANIZATIONAL COMMITTEE

Abramov O.V., Prof.	Vladivostok, Head of Department, IACP FEB RAS
Aliev S.A., Prof.	Makhachkala, Head of Department, Dagestan State Medical University
Avdeuk O.A., Docent	Volgograd, Head of Department, VSTU
Bitukov V.K., Prof.	Moscow, RTU MIREA
Bushmeleva K.I., Prof.	Surgut, Head of Department, SurSU
Chernova N.I., Prof.	Moscow, Head of Department, RTU MIREA
Gorshkov P.S., Docent	Moscow, Adviser Experimental laboratory NaukaSoft
Grodzenskiy S.Ya., Prof.	Moscow, RTU MIREA
Isaeva Z.U.	Makhachkala, Director of the Medical Center
Kasimov A.O., Docent	Almaty, AIPET
Kechiev L.N., Prof.	Moscow, HSE
Kharkov V.P., Prof.	Moscow, Adviser to General Director Experimental laboratory NaukaSoft
Klimov K.N., Prof.	Moscow, JSC LEMZ
Kostin M.S., Docent	Moscow, Head of Department, RTU MIREA
Kofanov Yu.N., Prof.	Moscow, HSE
Kravets A.G., Prof.	Volgograd, VSTU
Kulagin V.P., Prof.	Moscow, Head of Department, RTU MIREA
Levin V.A.	Prague, Czech Republic
Lvov B.G., Prof.	Moscow, Head of Department, HSE
Nefedov V.I., Prof.	Moscow, Head of Department, RTU MIREA
Lukyanova L.V.	Prague, Specialist of the Russian Center for Science and Culture in Prague
Paramonov A.A., Prof.	Moscow, RTU MIREA
Saenko V.S., Prof.	Moscow, HSE
Saushev A.V., Prof.	St. Petersburg, Head of Department, Admiral Makarov SUMIS
Starikh V.A., Prof.	Moscow, Head of Department, HSE
Stukach O.V., Prof.	Moscow, HSE
Teplov S.V.	Moscow, General Director of Technopark “STROGINO”
Vorobev G.A., Docent	Pyatigorsk, Head of Department, PSU
Vorunichev D.S.	Moscow, Deputy deputy director of the institute, RTU MIREA
Vyshnepolsky V.I., Doc.	Moscow, Head of Department, RTU MIREA
Yurkov N.K., Prof.	Penza, Head of Department, PSU
Zamuruev S.N., Prof.	Moscow, Head of Department, RTU MIREA

COORDINATION COMMITTEE

Panasik D.S., RSC Energia
Milovanova N.V., RTU MIREA

INFORMATION PARTNERS

"Information Technologies"
"Measurement Techniques"
"Quality. Innovation. Education»
"Sensors and Systems"
"EMC Technologies"
"Legal Informatics"
"Methods of Management Quality"
"Management Challenges"
"Caspian Journal Management and High Technologies"
"Reliability & Quality of Complex Systems"
"Russian technological journal"

Section 1
INFORMATION TECHNOLOGIES IN EDUCATION

EDUCATION SYSTEM IN THE CONDITIONS OF DIGITAL ECONOMY DEVELOPMENT

Sotnikov A.D., Katasonova G.R.
The Bonch-Bruevich Saint-Petersburg State University of Telecommunications
+7(911)993-06-66, adsotnikov@mail.ru +7(9030955810) 1366galia@mail.ru

Abstract – The analysis of the structural characteristics of competence is carried out, which allows the construction of «digital» competencies demanded by the market using the infocommunication domain model and the object model used in the field of information systems. The first descriptive model describes three domains in which physical, energetic processes take place, there are information objects.

The second model, the object model, involves using the concept of an «object» to describe entities, one of the key properties of which is the encapsulation of attributes and methods — the static and dynamic properties of an object, reflecting both «quantitative» characteristics and behavioral «algorithmic» properties of an object. The educational system is considered as a «production system», the purpose of which is to create a product with specified properties (a set of competencies), the structural and, as a result, quantitative characteristics of which can be set formally and quantified.

Keywords: digital economy, information society, competence, educational systems, domain model, object model

Global changes in technology and production dictate new requirements for personnel and their training. Suddenly, new types of activities arise, familiar ones quickly transform and traditional professions disappear. At the same time, opposite trends are operating in the labor market - a shortage of workers in some professions and lack of demand for others. The swiftness of such changes, obviously, does not correspond to the inertia of the traditional educational system, oriented, to a large extent, to the classical model of the formation of knowledge and skills. The competency-based education model does not have time to design educational processes focused on the formation of promising competencies that are in demand in the near future.

In connection with the development of digital (production, social, etc.) information technologies, the so-called “digital skills” [1], which allow solving professional problems and feel comfortable in the information society, are of particular importance.

The Digital Economy program adopted by the Government provides for the preparation of a sufficient number of knowledgeable information technology users with the necessary competencies. What needs to be changed in the educational system in order to prepare specialists in various subject areas for a breakthrough into the digital future? Firstly, it is correct to define goals that are characterized by “external” circumstances in relation to the educational system.

Secondly, to consider the internal characteristics and properties of the educational system, namely, the elemental composition, the structure of the educational system, the processes taking place in the system, which, in turn, provide the interaction of elements to achieve educational goals.

In the pedagogical community, considerable attention is currently being paid to technologies and methods of educational processes. Nevertheless, rightly noting their influence on the effectiveness and results of activity, such an “inside” view does not allow one to notice and subject to research the essential characteristics of the educational system as a whole.

The educational system is not an autonomous system. It is part of a society that is changing (developing and improving, and possibly degrading), thereby changing goals and priorities, and that is why it is not a fixed, unchanging system. No matter how perfect the educational system is, it must dynamically change with society. Despite the high technological effectiveness, education is still, to a large extent justified, regarded as a creative process more reminiscent of art than science. This does not allow the use of modern formal methods of activity analysis and accurate assessment of its results.

Using the systemic methodology, we will try to determine the structural characteristics of the educational system as a priority task, and then consider the processes associated with the purposeful functioning of the system. For this, we consider the educational system as a production system [1], the purpose of which is to create a product (result of activity) with specified properties. In this case, it is legitimate to talk about the requirements for raw materials (raw materials), production processes and tools.

The quality requirements of the resulting product are also becoming apparent. It is important that all of the listed entities can and should be formally described and quantified. The system as a whole is also formally described, regardless of the application area and the specifics of its application.

With this approach, in the context of the development of the digital economy in Russian society, it becomes natural and legitimate to use well-known methods of organizing and managing activities, from business plans to reengineering business processes and using information systems.

In connection with the development of digital (production, social, etc.) information technologies, the so-called “digital skills” [1], which allow solving professional problems and feel comfortable in the information society, are of particular importance. The key features of the digital economy is the effective (fast and relatively low cost) implementation of many business ideas that is impossible in a traditional economy.

However, questions about the composition and internal structure of the necessary competencies, as well as the question of transforming the educational system, creating appropriate technologies and mechanisms for forming, managing development, evaluating and controlling competencies, remain open.

In the competence model that is being actively introduced today, the task is to form a set of competencies - personal properties that allow you to adapt effectively in a changing environment. To solve arising, often new and non-standard tasks through the use of a set of skills available to the subject. Thus, the concepts of “skills” and “competencies” are closely and organically related.

In work [2] three groups of skills are justified that are especially important and characteristic of the digital economy. The first group consists of general skills in the field of information and communication technologies (ICT), which are needed by the widest circle of employees in order to gain access to information (in databases or a network) in everyday work, use professionally oriented software, and successfully interact with colleagues.

The second group is professional skills for the development and production of information products and services. These skills are related to software development, creating Internet resources (Web pages, Web applications, databases, e-commerce tools, financial and banking applications, solutions based on advanced IT technologies - distributed ledgers, big data, Internet things. The third group of skills is associated with complex activities, information interaction of participants, the use of complex IT platforms and social networks. This group has a multidisciplinary nature, from enchivostyu and tre-vidual high adaptability, the highest overall "education" and the level of professional qualifications.

Considering the educational system as a special case of the production system, and using well-known formalized models and methods for the tasks of analysis and improvement of similar systems, we note that the fundamental difficulty with this approach is that educational activity is not related to material objects, but with informational and cognitive entities, which are quite unusual to operate with today. Such categories as knowledge, abilities, skills do not fit in the best way with modern notations of business processes.

Even the competency-based approach does not remove most of the issues until the internal structure and composition of the essence of the concept of «competence», which is considered as a fundamental characteristic of the resulting product of the educational system's production activity, is determined.

The solution to the problem is to use the domain model of infocommunications [3], which is successfully used in the analysis of complex infocommunication systems, considering the world around us as a combination of three relatively independent, interacting areas (domains), each of which is characterized by its own entities and the rules for their interaction - physical (PD), information (ID) and cognitive (CD) domains.

The key process in the model is the process of information interaction of participants, consisting in a sequential and connected change in the state of objects representing the participant in each of the domains.

Each entity has its own, as a rule, multivariate representation in the corresponding domain, and interaction is considered as the transfer of information representations (image messages) between domains. Formally, the above is described as follows [3]:

$$\left\lfloor \left\langle \left\lfloor \left\langle A_n \right\rangle^{\xi A_n} \right\rfloor_{n=1,..N} \right\rangle^{\xi C^m} \underset{Q_{22}^{\xi C^k \xi C^m}}{\longleftarrow} \overset{Q_{22}^{\xi C^m \xi C^k}}{\longrightarrow} \left\langle \left\lfloor \left\langle A_n \right\rangle^{\xi A_n} \right\rfloor_{n=1,..N} \right\rangle^{\xi C^k} \right\rfloor_{m=1,..M}^{k=1,..K}$$

where:

A_n - physical domain object;

C_n^m - *n*- information object (element of the thesaurus of the system);

ξC_n^m - thesaurus of the m information system;

$\left\langle A_n \right\rangle^{\xi A_n}$ - one (n) of the many possible representations of an object A_n.;

$\xrightarrow{Q_{22}^{\xi C^m \xi C^k}}$ - direct (and analogous inverse) transformation of thesauri of systems represented in neighboring houses during translation of the information representation (image) of an object between domains;

N - number of objects;

M - number of information systems.

This model allows us to consider physical, informational and cognitive entities that are found both in educational activities and in other areas from a general perspective [2].

The educational system provides the transfer and assimilation of the essence of the cognitive domain from one subject to another. This transfer occurs through the objects of the information and physical domains. At the border of each of the domains, the thesauri of these entities are transformed with certain losses and distortions.

The domain model allows you to focus on the main issues - the perception, assimilation and understanding of knowledge by students. Here the key processes are at the border of the information and cognitive domain where the interface between the information environment and the student is implemented. This is where the process of perceiving information begins. The issues of generation, delivery and presentation of knowledge are also successfully considered by this model from strict positions that allow quantitative assessment and reasonable conclusions about the advantages and disadvantages of the specific implementation of the educational (production) system, in particular about its competitive advantages over other educational systems [2].

Evaluation of the result of the activities of the educational system, based on the competency-based model, suggests that competencies are not only present, but their characteristics that have value should be accurately determined. This, in turn, requires that structural components and related competency properties be identified. This problem is solved using a well-known object model that encapsulates static and dynamic properties (attributes and methods) of an object.

At the same time, competences are allocated attributes correlated with factual data, traditionally interpreted as «knowledge», and algorithmic or process-oriented «skills». Inheritance as a property of the object model is also extremely useful, especially from the standpoint of the practical construction of competencies in real educational systems. Inheritance also allows you to formalize and automate a number of technological procedures.

Thus, in a dynamic, rapidly changing world, educational systems with high inertia can be considered as production systems and can be effectively investigated using two models - a descriptive domain model of infocommunications and a constructive object model. The analysis of the educational system in such a study is carried out using formal methods and appropriate quantitative assessments, which make it possible to draw a reasonable conclusion about the advantages and disadvantages of specific educational systems and their compliance with established goals in the context of the development of the digital economy.

Using the models mentioned above together, it is possible to analyze the competencies of a particular educational program in two directions. First, to identify those professional areas in which the program is localized and for these areas to determine which entities belong to which of the three domains. Simply put, the entities of the cognitive domain will correlate to a greater degree with the categories «know», the entities of the information domain with the categories «be able», and the entities of the physical domain with instrumental skills like «use».

We can make a reasonable assumption that the previously mentioned groups of various «digital» skills form the basis of three types of digital competencies, which, having the same internal structure, determined by a combination of attributive (factual) knowledge and algorithmic skills, differ in the relative proportion and «volume» of each of these component.

The considered approach to the analysis of the structural characteristics of competence allows us to construct «digital» competencies demanded by the market as the essence of a popular object model, while considering the educational system using the domain model of infocommunications as a «production system» whose goal is to create a product with specified properties (a set of competencies), structural and, as a result, the quantitative characteristics of which can be set formally and quantified.

REFERENCES

1. Arzumanyan Yu.V., Zakharov A.A., Sotnikov A.D. The concept of information interaction in socially oriented communities // In the collection: Actual problems of information and telecommunications in science and education IV International scientific-technical and scientific-methodical conference: a collection of scientific articles in 2 volumes. 2015.S. 688-691.

2. Sotnikov A.D., Katasonova G.R. Models of applied and socially-oriented info-communication systems // Fundamental Research. 2015. No. 2-27. S. 6070-6077.

3. Sotnikov A.D., Katasonova G.R., Strigina E.V. Analysis of the modern education system based on the domain model of infocommunications // Fundamental Research. 2015. No. 2-26. S. 5930-5934.

EXPERIENCE IN DEVELOPING E-LEARNING RESOURCES

Larina T.B., Gavrikova E.O.
Russian University of Transport (RUT-MIIT)
7 (916) 427-2334 tblarina@gmail.com

Abstract – The article describes the results of the development of an electronic training course using iSpring Suite tools.

Keywords: electronic training, electronic educational resources, development tools of electronic courses, iSpring Suite.

INTRODUCTION

The most important factor in improving the educational process is the introduction of modern information technologies. One option for digital learning is the development of e-learning courses [1]. E-textbooks are the most common form of e-learning resources. The content of the e-textbook must conform to educational standards, educational programs and work programs of disciplines. Depending on the implementation level, the electronic textbook uses text and graphics, hypertext links, multimedia elements that ensure complete presentation and learning of the educational material [2].

PROBLEM DEFINITION

In this article, we want to share our experience in developing an e-learning course with using iSpring Suite tools. The basis of the substantive content of the course is the methodological materials of the leading lecturer of the discipline "Operating systems administration". These include a working program, a fund of evaluation funds, presentations of lectures, contents of laboratory works, test questions.

The iSpring Suite enables you to create e-learning courses, presentations, interactive tests, and surveys in a familiar environment PowerPoint [4]. iSpring Suite consists of iSpring QuizMaker - Test Editor, Questionnaires and Surveys, iSpring Pro - Professional Training Course Editor with audio and video support, built-in YouTube and Flash videos, iSpring Kinetics - for interactive presentation in the classroom.

You can publish content in Flash and HTML5 formats, support publishing on mobile platforms iPhone, iPad and Android, and share learning materials through the iSpring Cloud service. This Russian-language product has full technical support for the user, including documentation, reference materials, online consultations. The selection of this tool is made based on the previous comparative analysis of available and popular tools for development of electronic educational resources [3].

STRUCTURE OF AN ELECTRONIC COURSE

The electronic training course is divided into thirteen topics, containing nine laboratory tasks and control tests for each topic. Figure 1 shows the graph with the structure of the developed course.

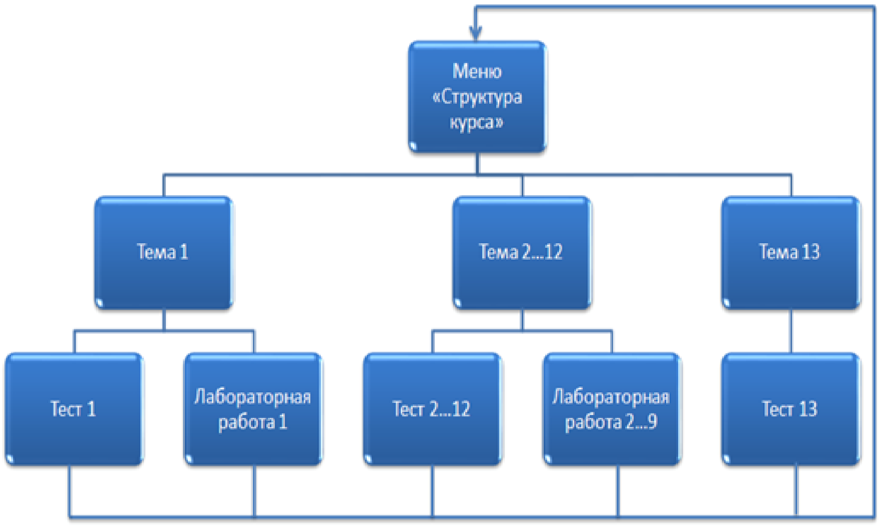


Fig. 1 Structure of the e-learning course

All branches of the column, except for entering the Course Structure menu, can be navigated two-way. It is possible to complete the study of the topic without passing the test and, on the contrary, to go to the test without scrolling through all pages of the topic.

MENU OF COURSE STRUCTURE

This page opens after the course is started (Fig.2) and contains a list of topics to be studied. The title of each theme is accompanied by a number and a link. Clicking on the link redirects the student to the title menus of each topic. You can return to the menu by clicking back in the browser navigation or by closing the tab, depending on your browser settings.

Fig. 2 View of Course Structure menu

MENU OF THE TOPIC

When the topic is opened, the student enters its menu (Fig.3). It is designed in the player frame iSpring with navigation buttons. For more information, see "Additional navigation buttons".

The home page contains the topic number and name. Under the theme name there are buttons - links to go to the study of the material, testing and laboratory work. You can return to the topic menu by clicking Home. Clicking the Go to Study Material button opens the Contents of the topic.

Fig. 3 View of Topic menu

CONTENTS OF THE TOPIC

After moving on to the topic, the student will see a slide listing the main questions covered in the topic (Fig.4). Each item in the list is a hyperlink leading to the slide from which the presentation begins.

From any slide of the current theme, you can return to its contents by clicking Home.

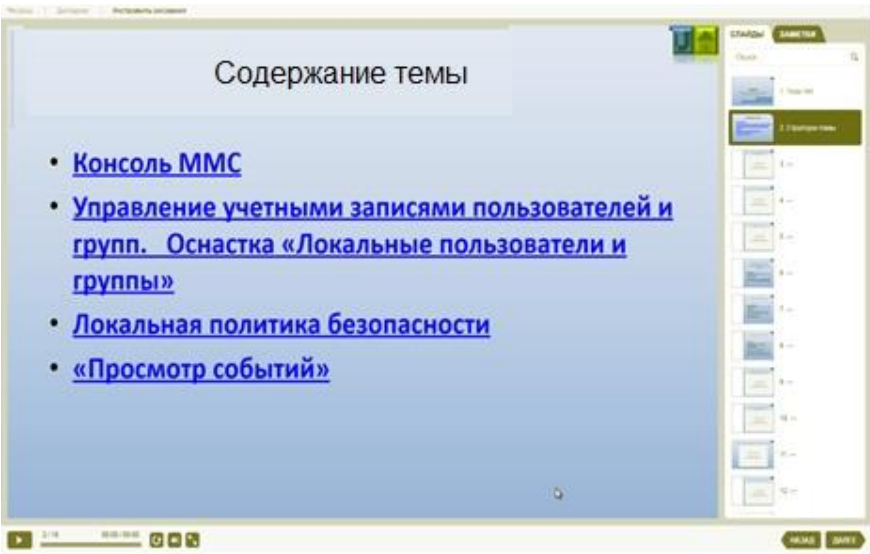


Fig. 4 Topic Content

SLIDE OF A TRAINING MATERIAL

The central part of the screen is occupied by a slide containing basic concepts, definitions, images, or examples illustrating the material. The slide can contain video or other interactive elements, such as buttons to open tooltips (Fig.5).

On the left side is a scroll bar with text. On the right side of the window there is a navigation bar for the theme with thumbnail slides. Its contents are similar to the standard left slide bar used when editing a presentation in Power Point.

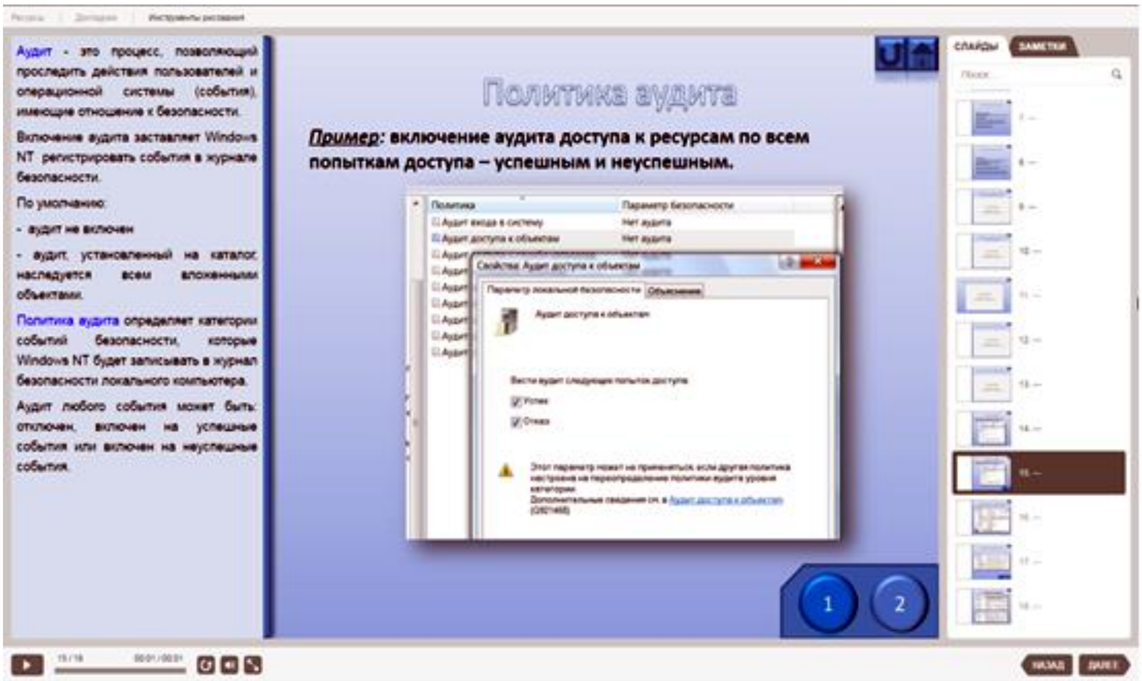


Fig. 5 Standard Slide View

Under the theme navigation bar in the lower-right corner are the buttons for switching between the slides, "forward" and "backward." They are convenient to use in sequential study of the course material.

In the lower left corner there are buttons for controlling video viewing. Their purpose is traditional: to reproduce, suspend, rewind videos. The video display area is located at the center of the slide. Typically, video playback starts automatically when you move to a slide. You can pause or continue, if necessary. The video playback on the slide is looped and is restarted when the movie is finished.

The Course Viewer provides the Drawing Tools panel for additional convenience in supplying material. You can use Marker and Eraser tools to make markups directly on the slide.

ADDITIONAL BUTTONS OF NAVIGATION

They are located in the upper right corner of the slide. Clicking the Return button takes you to the previous slide. The right Home button returns the user to different menus, up the nesting structure. The menu to return to is easily determined by the color of the button.

Some information slides have pop-up buttons in the lower right corner. They are present if there is not enough one image, video, or example to illustrate the material. The number of pop-up buttons varies depending on the number of additional slides.

When you go to a specific additional slide, the corresponding button is highlighted. The user always knows which of the additional slides he is currently viewing.

TESTING

After studying the theme, the student can start testing by clicking Go to Test in the subject menu. The title screen of the test shows the name of the topic to be tested (Fig.6). The "Skip Test" button will return the user to the topic main menu.

There is no possibility to return to the training material during the test.

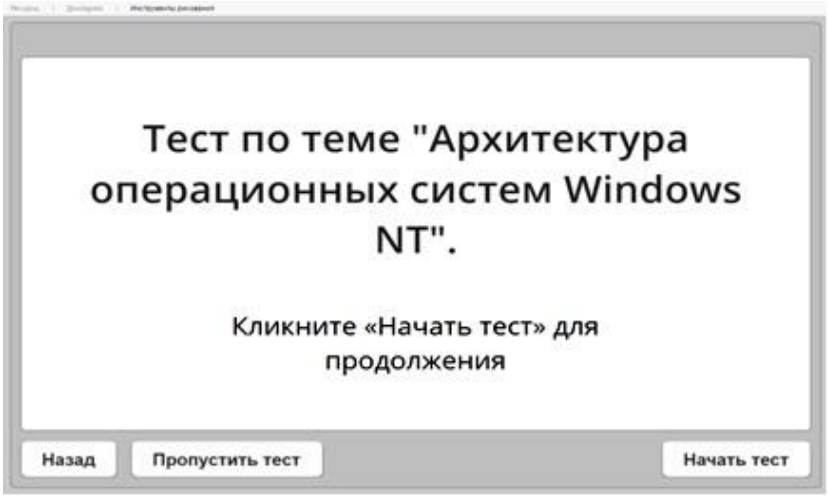


Fig. 6 Theme Test Cover Screen View

The test question screen contains a drop-down menu that navigates test questions. The student can move on questions in an arbitrary order. In a collapsed view, the menu displays the question number and the total number of questions in the test.

After answering all questions, click Submit All. If the student did not answer all the questions of the test, a warning will be issued. Once the submission has been confirmed, the test result will be displayed. By default, the test has a pass-through ball of 80% of the total number of questions. If the percentage is set, the student is considered tested and will be offered the option of entering the main menu (Fig.7).

The score count is organized so that partial responses can be taken in some cases. This applies to multiple choice or nested answer questions. In these cases, the outcome is composed of the percentage of responses correctly selected.

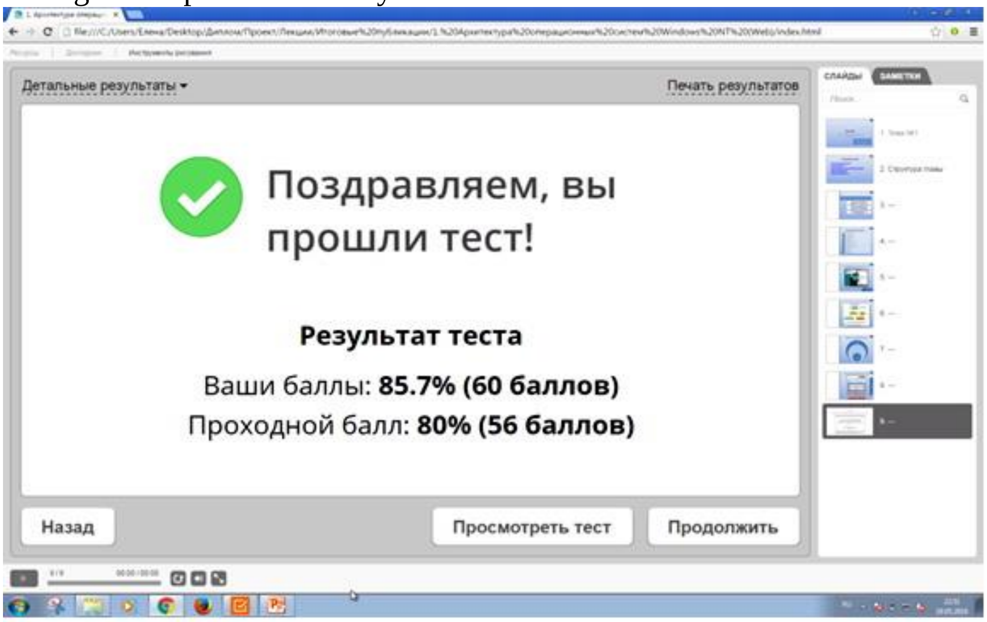


Fig. 7 Test Completion Screen

After the end of the testing, the student has the opportunity to view the results of the test for each question, see their wrong answers and the correct answer option (Fig.8).

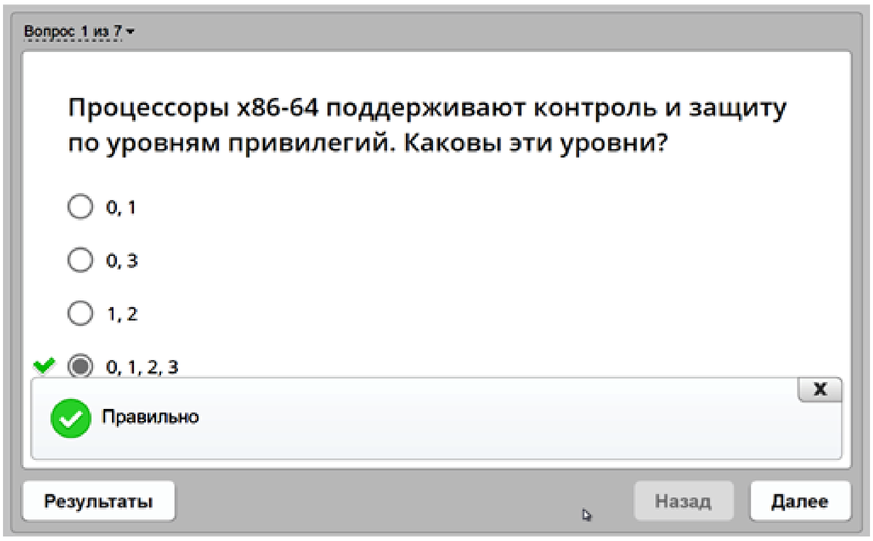


Fig. 8 Test Question Answer Results

SYSTEM REQUIREMENTS

The only software requirement to work with the created course is the presence of a browser. The functionality of the course was tested on Internet Explorer 11, Mozilla Firefox 36.0.1, and Google Chrome v.50.02661.102. The choice of browser is left to the user, however, the display settings of the browser Mozilla Firefox we consider more preferable. You can use the iSpring Suite, which has a built-in player to view the course. But, to do that, you need to have a license to use it.

CONCLUSIONS

Based on iSpring Suite version 8, an electronic training course in Operating System Administration has been developed. The experience of the completed development shows the completeness, convenience and efficiency of using the iSpring in the development of e-learning courses. The developed electronic educational resource is used in the educational process of the Department "Computing Systems, Networks and Information Security".

REFERENCES

1. GOST P 53620-2009. "Information and communication technologies in education. Electronic educational resources. General provisions". Approved by Order of Rostekhregulation of 15.12.2009 № 956-Article
2. Larina T.B., Gavrikova E.O. E-learning: review and analysis of concepts.//Educational resources and technologies. – 2018. – No. 3 (24). – Page 49-55.
3. Larina T.B., Gavrikova E.O. Analysis of development tools of electronic educational resources. //Information Innovative Technologies: Materials of the International scientific – practical conference. –M.: Association of graduates and employees of AFEA named after prof. Zhukovsky, 2019, Page 234-240.
4. Website of the iSpring company. URL: http://www.ispring.ru/ispring-suite

APPLYING ANYLOGIC TO DISCIPLINES WHERE BUSINESS PROCESSES NEED TO BE STUDIED, MODELED AND OPTIMIZED

Norkin O.R., Parfenova S.S.
Southern Federal University, Taganrog
olernor@gmail.com, svetlanapar66@mail.ru

Abstract – Computerization is now firmly embedded in all areas of human activity: production, finance, trade, governance, education, etc. This can be explained by the increasing volume of information being processed and the complexity of the systems being studied. At the same time it is necessary to pass the following, rather general, stages: problem – model – optimization of model – solution of problem. The analyst cannot work without modern software tools that help to successfully pass all these stages. One such means is AnyLogic. Therefore, it is important to make extensive use of this software tool in the educational process of universities. As a result, there will be an increase in the analytical competences of students.

Keywords: simulation modeling, system analysis, business analysis, business process, AnyLogic.

INTRODUCTION

Simulation modeling solves real-world problems safely and wisely. It is a convenient tool for analysis: it is clear, easy to understand and verify. In different areas of business and science, simulation modeling helps to find optimal solutions and gives a clear picture of complex systems [1]. Simulation is used when it is impossible or impractical to perform experiments on a real system, most often because of their cost or duration.

Simulation modeling allows you to analyze the model in action. This is different from other methods, such as Excel or linear programming. The user studies processes and makes changes to the simulation model in the course of work, which allows to better analyze the system operation and quickly solve the current problem.

Using one modeling method, it is difficult to imagine a system in a model at the required level of abstraction. For example, you can use system dynamics to simulate the behavior of offline objects. Tasks of this kind are perfectly handled by agency modeling. Conversely, it is pointless to use discrete-event modeling for continuous patterns when there is systemic dynamics.

PROBLEM STATEMENT

The tasks that have to be solved in real business are most often complex, so when modeling it is more reasonable to break them into constituent parts and describe them using different methods. It is impossible to reliably imagine a complex business system and its internal and external relationships using one approach – some elements have to be excluded or seek workarounds in modeling. Modern modeling tools allow you to cope with this task.

AnyLogic [2] is a multi-function animation tool for dynamic modeling that integrates with existing IT management systems.

Since AnyLogic you are not limited to one modeling method. Using a suitable method or combination of methods, you can create an optimal simulation model for solving a specific problem. If your model involves many individual objects, you can use agency modeling. If you only have information about global dependencies, use system dynamics. If the system can be described as a process, it is better to use discrete-event modeling. If the system has all these features, combine different methods.

The methods presented are interesting as part of a business analysis that is built on the study of commercial objectives. Business analysis also involves developing approaches to address the challenges that arise in achieving them.

Business analysis is scientific research of phenomena, development of methodologies and complex measures, a kind of discipline, and business analytics – practical application of developed business analysis of knowledge and methodologies. A separate type of business analysis is a system analysis aimed at maximizing the company's information technology performance [3, 4]. On the practical side, system analysis is a theory and practice of improving intervention in a problem situation. Therefore, the system approach and methodology are very relevant in the field of systems design, development and application [5, 6]. AnyLogic is a modern tool that helps system and business analysts work with various complex systems, especially those that model production and technological processes.

SOLUTION OF THE PROBLEM

A specialist who performs business analysis must know all the methodological tools of business analysis and take a comprehensive approach to converting information into solutions. This allows you to analyze and evaluate the effectiveness of the company's business processes, improve them, and develop completely new business processes based on simulation experiments.

Currently, the need for qualified specialists to solve the tasks described above is increasing every year. Therefore, the task of modern training of specialists in the field of simulation in general and business analysis in particular is relevant.

The disciplines "Business analysis", "Modeling of systems and supply chains", "Optimization and reengineering of business processes", "Design of information systems" are quite important and determining in the professional training of students in the field of computer technology. Modern high-quality training in these disciplines requires software support for laboratory and practical training. We believe that AnyLogic is suitable for this purpose, as a modern software tool for achieving the goals of the educational program [7].

Typical tasks that are solved in the framework of the above disciplines:

* analyze and evaluate the effectiveness of business processes;
* identifying and eliminating bottlenecks;
* optimization and improvement of business processes;
* increase productivity while reducing costs.

Let's consider an example of using the AnyLogic modeling system in the educational process. To study the operation of a real object, it was decided to create a model of a hospital where patients are received and treated. Based on the results of the simulation, it was supposed to identify "bottlenecks" in the work of the hospital. The model will consider the management of multiple processes in the form of various procedures for interaction between patients and doctors. The model will also use resources: doctors, nurses, and patients. Resource management will be different in different model situations. A special resource and process for processing "urgent patients"will be introduced into the model. These patients need immediate help, that is, they need to provide all the necessary resources immediately upon admission to the hospital. This saves the States of processes that are being robbed of resources.

We start working in AnyLogic, create a model and call it Hospital (Fig.1).

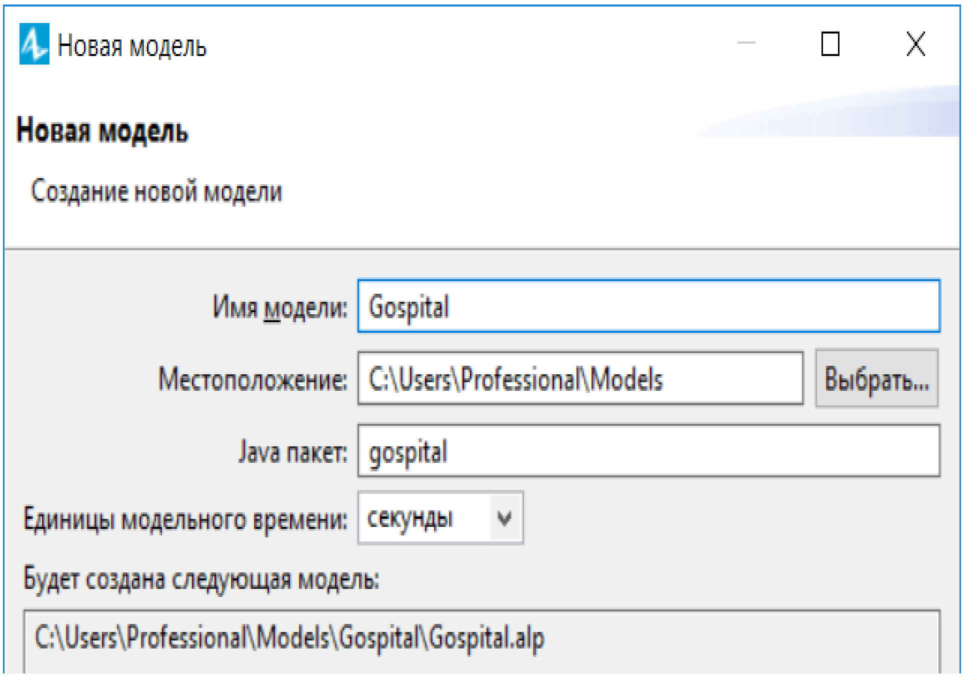


Fig. 1 Initial stage of working with the hospital model

Then use AnyLogic to describe the simulation scenes: models of the hospital space with room elements. Similarly, we will create different ways to move patients to doctors ' offices and treatment rooms. We will also add rectangular nodes in the waiting areas for doctors near the sofas. Create the path of the patient queue to the registry and the location of the registry.

AnyLogic provides an «Attractor tool» or a space markup element. This is an important animation modeling tool that allows you to specify the exact locations of model agents in a rectangular or polygonal node.

We will add "Attractor" objects to nodes where it is necessary to specify more precisely the location and angle of the object, such as queues before the entrance and places of patients and doctors at the reception.

Model preparation is complete, and you can begin to formulate model logic. To do this, go to the «Process Modeling Library» tab in the palette.

Add a «Source» block from the «Process Simulation Library» palette and name it «Patients», this block creates agents. Typically used as the starting point of the agent flow. He will create patients. We will indicate the intensity for him – 50 patients per hour, as well as the location of arrival of patients – the node of the network GIS "Spavn," speed 5 km/h (Fig.2).

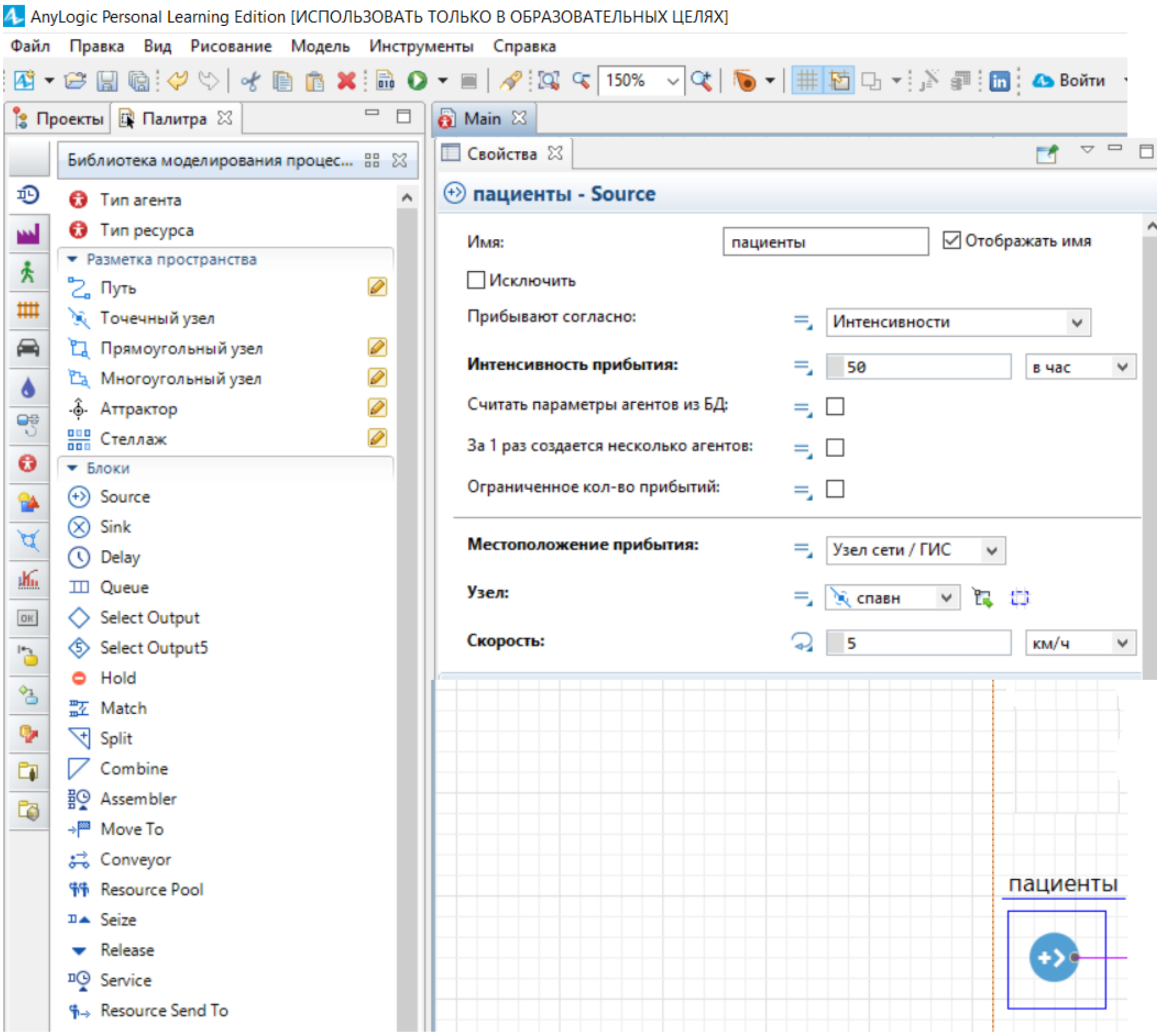


Fig. 2 Adding and detailing a «Source» block

The system allows to describe in stages the logic of patient 's movement to doctors of different specialization. We start with a LOR doctor (Fig.3). Then we will add a branch of patient movement to the new doctor – surgeon (Fig.4). And in the same way we will add the logic of moving patients to other specialists, resuscitation and procedural rooms.

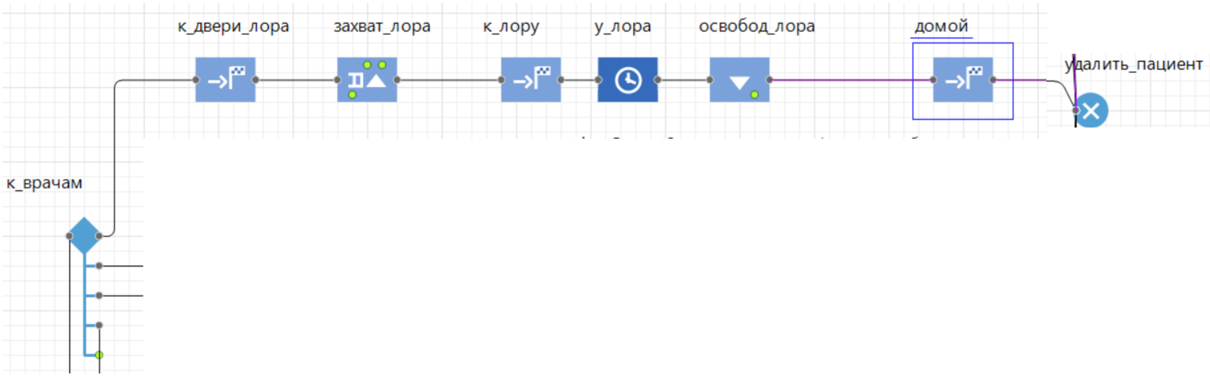


Fig. 3 Branch of logic of patient's movement to LOR-doctor

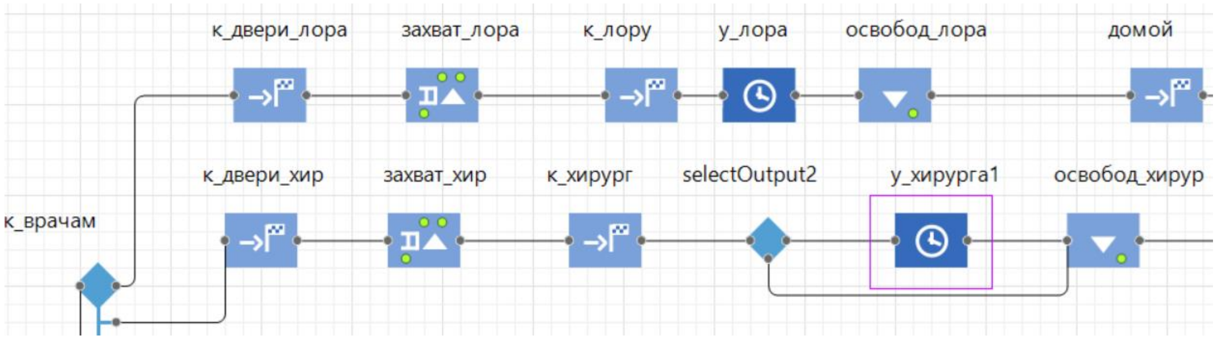


Fig. 4 Adding a branch of patient motion logic to a surgeon

The result is a formalized description of the set of technological business processes that define the functioning of the hospital as a system. The AnyLogic tools then enable you to present the described model in 2d and 3d shapes (Fig.5, 6).

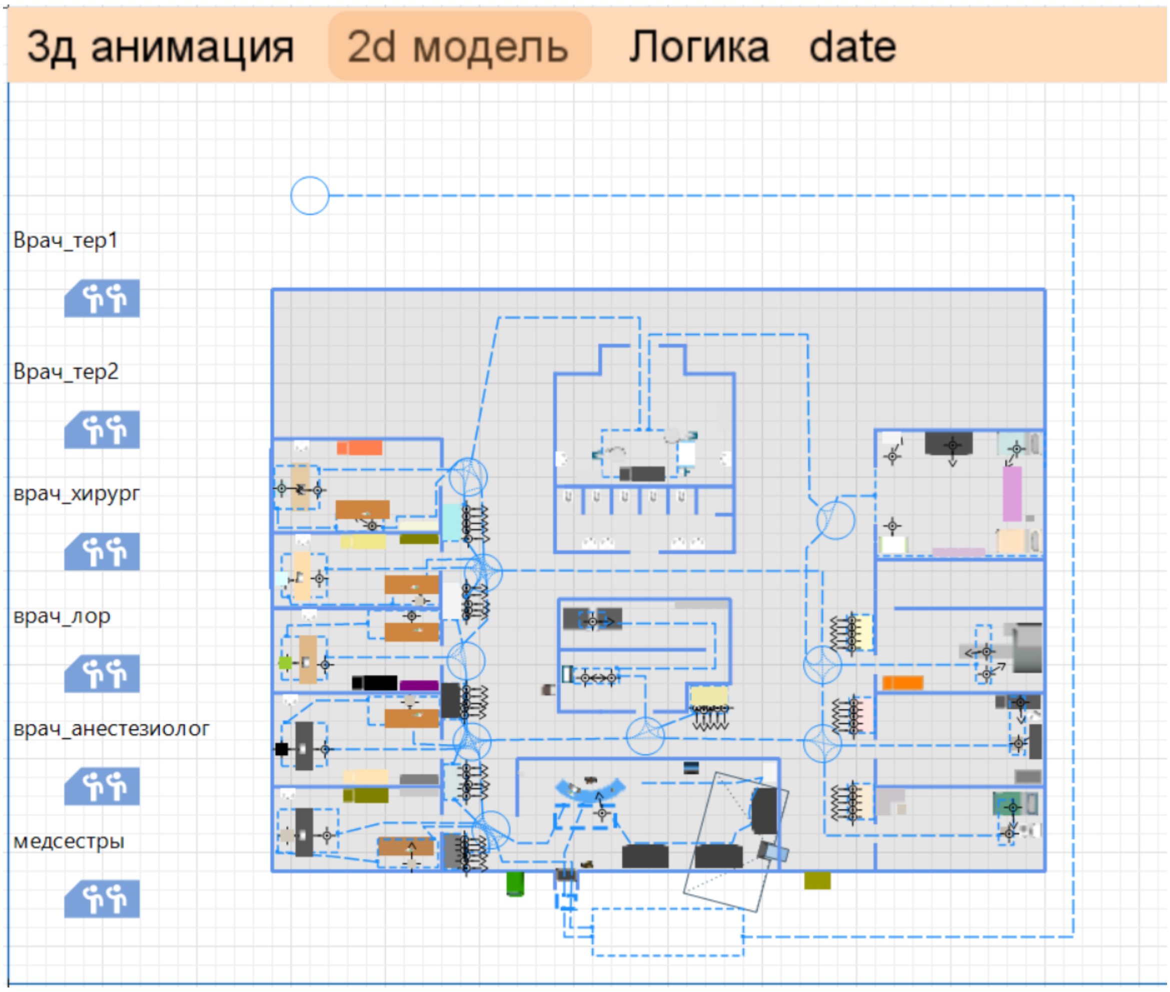


Fig. 5 Final 2d hospital model

At present, the study of Business Analysis is based on a workshop using AnyLogic. In the future, it is planned to expand such practice into thematic close disciplines (presented at the beginning of the article), which provide for practical modeling of dynamic systems or supply chains, as these systems are commonly called in the notation of the AnyLogic.

The success of using AnyLogic in the practice of business analysis of complex systems depends on studying the problem system, carefully considering the system interaction of business processes for accurate and detailed representation in the AnyLogic simulation system.

Fig. 6 Final 3d hospital model

CONCLUSION

In today 's world, one of the growing promising areas of education in universities is the use of computer technologies, which promote the process of training to a qualitatively new level of development. The implementation of didactic goals of disciplines related to modeling and analysis of complex systems requires the application of various software systems. This article discusses the AnyLogic system, which harmoniously combines the excellent visibility of the animation simulation and the accuracy of the analytical description of the models.

The organization of the educational process on the basis of the AnyLogic opportunities allowed to increase the level of cognitive activity of students during the workshops, to implement an individual approach when planning the educational trajectory of each student depending on his capabilities, to differentiate the level of complexity of tasks without loss of quality of learning of the material by the student.

REFERENCES

1. N.N.Chernyshova, “Simulation modeling of business processes”: Educational and methodological manual. -Nizhniy Novgorod: Izdvo of Nizhny Novgorod State University, 2010. –28 p. (rus).
2. https://www.anylogic.ru/supply-chains/
3. S.S.Parfenova, O.R.Norkin, S.A.Hovanskov, “Practice of applying a system approach in evaluating complex systems” // LAP Lambert Academic Publishing GmbH & Co, Saarbrücken, Germany, ISBN 978-3-659-39812-4, 2015. –84 p. (rus).

4. O.R.Norkin, S.S.Parfenova, "The role of uncertainty factor in system analysis and its impact on conflicts in system design" // Informatica, vychislitelnaya technika i ingenernoe obrazovanie. 2013. Iss. No. 2 (13). – pp.1-4. (rus).

5. S.Parfenova, O.Norkin. Systems analysis as a basis for innovative engineering training // INNOVATIVE TECHNOLOGIES AND DIDACTICS IN TEACHING: materials of conference. –Berlin: MVB Marketing- und Verlagservice des Buchhandels GmbH, 2013. – pp. 129-133.

6. O.R.Norkin, S.S.Parfenova, "The role of system analysis in the training of a modern engineer" // VII International scientific and methodological conference "Modern problems of the technosphere and training of engineering personnel." LES PROBLEMES CONTEMPORAINS DE LA TECHNOSPHERE ET DE LA FORMATION DES CADRES D'INGENIEURS. – Donetsk, UKRAINE, 2013. – pp.175-178. (rus).

7. O.R.Norkin, S.S.Parfenova, "Training manual in the discipline "Business-analytics" // –Taganrog: Izdvo ITA YUFU, 2019. –72 p. http://elibrary.ru/author_items.asp?authorid=397672 (rus).

USE OF ADDITIVE TECHNOLOGIES IN DENTISTRY

Shkrum A.S., Katasonova G.R.
Saint Petersburg State University, The Bonch-Bruevich Saint-Petersburg State University of Telecommunications
+7(9817827410) pozitivka3333@mail.ru, +7(9030955810) 1366galia@mail.ru

Abstract. Additive technology allows using a 3D printer to create physical objects of a three-dimensional image based on layer-by-layer formation of a solid object. The field of application of additive technologies is constantly expanding and rapidly developing, there are huge opportunities for using technology in various subject areas and types of industries. Methods and special application software for 3D modeling are considered. The analysis of the use of special machinery and electronic equipment, a variety of multilayer materials for use in various subject areas, including in the field of medical technology.

A review of the areas of modern dentistry (orthopedics, surgery, orthodontics) in which, with the advent of additive technologies and new types of materials, has made it possible to print orthopedic prostheses, sterile instruments, and liners. The stages of modern orthodontic treatment in dentistry using 3D printing are considered. The main aspects of the development of additive technologies in medicine are determined.

The object of research is additive technology. The purpose of this study is to review the fixed assets, methods and tools for applying 3D technology in dentistry.

Keywords: additive technologies, modeling, 3D-printing, dentistry.

Today, Russia and the world are actively engaged in the process of popularizing additive technologies or 3D printing, the use of which can reduce costs, save time and find universal solutions for modeling and manufacturing products and parts in a wide variety of subject areas.

By additive technology (Additive Manufacturing - added) is understood layer-by-layer building and synthesis of an object using 3D computer systems. Over the past three years, the number of Russian companies using additive technologies in modeling and product development has significantly increased, which indicates the demand for 3D technologies in the manufacture of end products in aircraft manufacturing, construction, the agricultural industry, shipbuilding, astronautics, the automotive industry, medicine and pharmacology.

Modeling is the process of studying the structure and properties of an original using a model. 3D-modeling is the process of developing virtual three-dimensional models of any objects, which allows you to accurately represent the shape, size, texture of the object, evaluate the appearance and ergonomics of the product [2].

The development of new information technologies in the context of active digitalization of society has allowed us to create a wide range of 3D modeling software that represents the future product directly on the computer screen in all angles, allowing you to quickly eliminate the identified shortcomings at any stage of its development. Graphic systems of three-dimensional graphics allow you to view the product from different planar sides even with its future environment, simulate virtual reality objects, creating images based on these models.

The leaders among numerous computer aided design systems (CAD), 3D-modeling, 3D-animation and visualization of objects are 3dsMax, AutoCAD, Maya from Autodesk, open source software Blender, Compass3D from Ascon, SketchUp from Google [1]. The main advantages of this type of program is a significant reduction in design costs, integration with other software products (applications for engineering calculations, an interactive image management system, programs for obtaining and processing panoramic and cephalometric images, etc.).

In some cases, the introduction of 3D modeling software (CAD) in production can significantly save resources, simplifies staff work, and improves product quality, thereby expanding the capabilities of the company.

Designed in the form of drawings, 3D models are printed automatically in 3D printers capable of producing products with freely moving parts that do not need to be assembled, enabling companies to economically create non-standard products in small quantities. The principle of operation of a 3D printer consists in layer-by-layer image formation using a certain type of powder (material).

For three-dimensional printing, plastic, gypsum powder, polymers, wax, liquid photopolymers, ceramics, titanium, resin, stainless steel, polystyrene can be used as the main material.

The most popular technologies for 3D printing are:

1) simulation using a layer deposition method (FDM);
2) stereolithography (SLA);
3) selective laser sintering (SLS).

Using the FDM (Fused Deposition Modeling) deposition method, the product is obtained by soldering the extrusion of a thermoplastic filament into layers repeating the contours of a digital model. The FDM method uses inexpensive materials and is preferred for rapid prototyping of simple parts.

This printing method has low accuracy and resolution, which is why this is not the best way to obtain products of non-standard geometric shapes with high requirements for manufacturing accuracy and surface quality. In 3D printers (FDM technology), mechanical and chemical polishing, expensive structural thermoplastics are used to improve the quality of the resulting surface.

Products obtained using SLA (Laser Stereolithography) technology, which uses photopolymerization — the process of curing a liquid photopolymer resin into a hardened plastic using a laser — have clear outlines, a smooth surface with high accuracy and resolution. In SLA, depending on the technical requirements, for the manufacture of parts, different resin compositions are used that correspond to the properties of technical and industrial thermoplastics. This type of printing is universal and popular in the manufacture of products in the dental and jewelry fields, in mechanical engineering and education.

For mass production, the printing method using selective laser sintering is used - SLS (Selective Laser Sintering), which uses a powerful laser beam to melt small particles of polymer powder. Using this method, durable products with complex internal parts having non-standard geometry are printed.

In addition, the world's only 3D full-color printing with the principle of gluing a powder consisting of gypsum is CJP (ColorJet printing) technology. Another MJM (MultiJet Modeling) technology is based on the principle of multi-jet 3D modeling using photopolymers and wax.

The trend in the modern development of additive technologies is the development of consumables, namely waterproof, flame-retardant polymers, extruded granulate printing, bioprinting, the use of new types of composite materials, photopolymers. In particular, composite materials filled with carbon fibers, glass, nanotubes allow you to print durable and complex products with the necessary temperature requirements on simpler and more affordable equipment.

A significant reduction in shrinkage of materials allows to achieve high-quality repeatability of product dimensions, which is one of the most important parameters for 3D printing.

Thus, the appearance of improved new modern materials, that is, printing objects by combining various materials using a laser, makes it possible to more effectively use FDM, SLA, SLS technologies to create new types of consumer products, where the main trend for 3D printing is the development of materials, focused on specific subject areas and production tasks.

One of the areas of medicine where additive technologies are being introduced into medical practice at the fastest pace is dentistry. As a result of the appearance in additive 3D printing of new types of materials in the field of dentistry (orthopedics, surgery, orthodontics), it became possible to print for the subsequent procedure of endoprostheses, bone and cartilage tissues, orthopedic prostheses, and liners.

For example, one of the areas of constant clinical application of additive manufacturing is design technology taking into account the anatomical features of personalized implants, a number of companies working in the field of medical technology are successfully engaged in 3D-printing of surgical auxiliary instruments for operations [4].

This trend has led to the fact that at present in a number of sections of dentistry, primarily in orthodontics and orthopedics, a new stage of the technological revolution is actually unfolding, which, in addition to the undoubted advantages (improving the quality and effectiveness of treatment, reducing the risk of complications and unwanted side effects) , poses new challenges for the professional community in the context of the need to increase the level of knowledge and skills in implementing technologies, as well as the need to review existing educational ny programs and standards.

So, in modern dentistry, to increase the accuracy and quality of diagnosis and treatment, digital technologies of virtual examination and treatment modeling are widely used, including computed tomography, intraoral scanning, 3D modeling and printing in orthodontics, as well as CAD / CAM technology (Computer Assisted Design / Computer Assisted Manufacturing) in orthopedics, which, as the name implies, involves the integrated use of virtual data collection methods, planning and modeling of future treatment, as well as 3D production tools and materials used in its framework.

The use of CAD / CAM technologies in orthopedic dentistry has a relatively long history and was hampered by the lack of available methods for their implementation in medical practice. The development of computer technology and computerized means of production in the last decade has allowed orthopedic dentists to significantly increase the effectiveness of treatment using CAD / CAM technologies, including providing better predictability of the desired results, high accuracy of fastening of the orthopedic structure, lower porosity compared to the traditionally processed design and etc [5].

An important point in the use of CAD / CAM technologies in orthopedic dentistry is the possibility of full personal control by the attending physician at all stages of treatment, including diagnosis, planning, production and use in the treatment process. With the appropriate equipment, a 3D printer and qualifications, the participation of a technician and other specialists in it is no longer necessary.

In the field of orthodontics, the situation looks a little different. The formation of the digital infrastructure of dental treatment has led to the emergence and rapid growth of the popularity of technology with individual removable equipment (eliners). Moreover, the description of such a treatment method was first encountered in specialized literature in the United States as far back as the 1940s, however, its practical implementation was practically impossible until the advent of 3D diagnostics and 3D printing. Currently, the use of this method is becoming increasingly popular among orthodontists, as it has a number of undoubted advantages: aesthetics, the absence of significant difficulties for the implementation of oral hygiene, less trauma compared to traditional bracket systems.

It should also be noted that, in contrast to traditional orthodontic appliances, in which the correction of occlusion occurs gradually along the planes, during treatment with eliners, simultaneous and multidirectional movement of teeth is organized.

Currently, the Russian market has a number of systems of the so-called "transparent orthodontics", including systems developed by international companies that have somehow entered the Russian market (through the development of a Russian-language software interface and, in some cases, production localization), for example, Invisalign (American company Align Technology), and Russian companies Flexi Ligner, True Smile, Star Smile, 3D Smile and many others.

Despite the differences caused by the features of the interface, the organization of clinical support and production, these systems use the same principles of organization and stages of orthodontic treatment:

1) taking impressions / 3D scanning;
2) data collection / 3D visualization and construction of a digital anatomical model;
3) 3D printing of liners;
4) joint work of the doctor and patient on the use of mouthguards.

A separate area of technological development in connection with the introduction of additive technologies in dental practice is the field of creating improved and new materials for the manufacture of dental instruments (eliners, etc.) and products (crowns, tabs, etc.). Active work is underway to improve the quality of photopolymers for 3D printing. One of the important problems when creating products that are used in medicine and dentistry is the issue of complete tracking of each stage with accurate diagnostics, elimination of errors and defects in the manufacturing process of the product, that is, competent quality management of the additive manufacturing of the part.

In this regard, large manufacturers of creating 3D models plan to assign an electronic passport to each product, which will contain all information about the part, including, for example, a video of its layer-by-layer construction in the printer’s camera, with which you can track what is happening in each layer.

Today, new software is being developed that allows meticulous collection of product data at the time of its creation with further analysis, linking the production method and technology with the subsequent product life cycle. In turn, 3D scanners are responsible for the high quality of digitization, which are able to scan objects of any complexity with high performance and resolution. They provide high-quality and operational data collection and analysis of a real object (shape, color, dimensions) for its subsequent conversion into a digital three-dimensional model.

The main aspects of the development of additive technologies are:

1) design for additive manufacturing;
2) education and training;
3) the use of an increasingly wide range of different materials for 3D printing;

4) production of individual orders and small-scale production;
5) partnership and cooperation;
6) startup companies;
7) stimulating the effective operation of the supply chain;
8) data, security and cross-industry interaction;
9) investments in the use of additive technologies in production;
10) corporate centers for training and implementation of excellence [3].

Thus, the Russian market in the field of 3D is developing at a steady pace and is gaining competence to enter the international level, covering the whole range of solutions from 3D printers and supplies to improving 3D scanners and software, the rapid development of 3D services. The main advantage of additive manufacturing is the ability to quickly customize the manufacturing process of manufacturing products at the request of consumers and the production of a certain amount of the final product.

For the field of dentistry, it becomes obvious that additive technologies (3D printing) are a way to significantly save resources and improve product quality, an effective tool in training, these are new opportunities for modernizing and expanding a business.

REFERENCES

1. Bugaev I.V. The role of computer modeling in additive technologies // International Research Journal. 2016. No. 5-3 (47). S. 64-66.

2. Modeling systems and processes: a textbook for academic undergraduate / V. N. Volkova, G. V. Gorelova, V. N. Kozlov [and others]; under the editorship of V.N. Volkova, V.N. Kozlova. - M.: Publishing house Yurayt, 2015 .-- 449 p. - Series: Bachelor. Academic course.

3. Shustikov V. Additive technologies - what it is and where it is used // [electronic resource]. - Access mode: https://sk.ru/news/b/press/archive/2019/09/18/additivnye-tehnologii-_1320_-chto-eto-takoe-i-gde-primenyayutsya.aspx / (access date 17.02 .2020).

4. Kotelnikov G.P. The use of 3D modeling and additive technologies in personalized medicine // G.P. Kotelnikov, A.V. Kolsanov, A.N. Nikolaenko, N.V. Popov, V.V. Ivanov, A.E. Shcherbovsky, S.A. Prikhodko, P.V. Platonov // Sarcomas of bones, soft tissues and skin tumors. 2017. No 1. S. 20-26.

5. Astvatsatryan L.V., Gazhva S.I. Modern aspects of the use of 3D-technology in the manufacture of removable dentures // Modern problems of science and education. 2017. No1.

6. Kalyagina V.N. Orthodontic treatment with the use of transparent mouth guards (eliners). Young scientist. July 2019. No. 30 (268). S. 27-29.

APPROACH TO ADAPTIVE LEARNING

Soloveva T.N., Kulikova E.A.
Perm State National Research University
kulikova-lena1998@yandex.ru

In recent years, the need for adaptive learning has become increasingly relevant. In this article, we propose an approach to the organization of adaptive learning, and also describe the structure of an adaptive learning system. The adaptive approach assumes that each student will learn on an individual trajectory, which is built based on his psychological characteristics, specificities, and needs of the individual. Among them may: the assimilation of material, the pace of training, available knowledge, skills, and much more. An integral part of the training is the presentation of educational material and regular monitoring, which will be carried out through an adaptive educational system.

Keywords: adaptive learning, approach to the organization of adaptive learning, individual trajectory of learning, designing the system of adaptive learning.

INTRODUCTION

Not so long ago, educational institutions used a traditional approach to learning. The traditional approach includes one content of learning, one way of presenting it and one pace of teaching work applies, as a rule, to all students. The main disadvantage of this approach is its static nature: the teacher before the start of the academic year forms the program, the study materials does not transform depending on the level of knowledge drawback of students [1]. In addition, teachers can use the same syllabus over consecutive years.

Due to the rapid development of information technology, over the past decade, the use of electronic educational resources (ESM) in traditional learning has become an integral part of the educational process. Some ESMs also use the traditional approach: they make one program for a subject for all students [1]. However, there are more and more ESM with a new approach to learning. These resources are built on a differentiated approach: in the learning education, the individual psychological characteristics of students are taken into account, and then groups of students are formed with varying depths of learning material and teaching methods. The differentiated approach was first applied in Western countries from the mid-19th century, and in Europe and Russia only from the beginning of the 20th century. The use of differentiated learning helps to improve learning outcomes, help students gain in-depth knowledge, including making the learning process interesting.

The amount of information is growing rapidly in the modern world. Therefore, it is no longer enough to use a differentiated approach to the learning process, now it is necessary to personalize the training of each individual student [2]. Current trends in the development of e-learning technologies enable the development and implementation of adaptive learning resources and environments.

PROBLEM STATEMENT

Adaptive educational environment refers to platforms or resources that provide special methods for a personal educational space filled with educational content that «adapts» to the student's abilities and knowledge for effective learning [2]. This system takes into account various "parameters" of the student (starting from the level and structure of initial preparedness and ending with mood), quickly monitors the results of ongoing training, which allows rational selection of tasks and exercises, as well as methods for presenting material for further advancement.

However, at present in education, there is no single definition of the concept of adaptability of software. This situation arose because adaptability can be determined in different ways for different types of software systems. For information systems, adaptability is understood as the presence of a system reaction to changes in the subject area, and for virtual simulators, the program's ability to change its structure and behavior depending on the actions and characteristics of the user. In addition, the views on the implementation of the adaptation process within the framework of the consideration of one class of systems may differ and greatly depend on the chosen to design methodology.

SOLUTION

In this article, we propose an approach to the organization of adaptive learning, and also describe the possible structure and components of an adaptive learning system that will help shape the individual educational trajectory of the student.

The term "individual educational trajectory" is understood as a personal way for a student to achieve a specific educational goal or study task that matches his abilities, interests, and needs.

The material that needs to be studied is provided to the student, taking into account his accumulated knowledge, performance, and experience. This implements adaptation during training: the provision of educational materials and materials for control appropriate to the student's level [2]. Thus, a student who has shown good results in studying the previous material needs to be provided with materials and practical tasks with a complexity higher than he studied, because simpler materials and tasks will not develop his potential. And vice versa, a student with low training, who is not able to learn educational material of increased complexity and solve complex tasks, must be offered a «lite version» of educational texts and assignments. Since more complex educational content can lead to a decrease in the motivation of such a student up to the rejection of educational activities [3]. Since the educational process has a tight period, the educational material is divided into blocks per average student. The developed information system is available to the student at any time, and thanks to this, he will be able to access the training materials at any time during homework and independent work. There is also no prohibition on completing assignments, which will enable the student to "go through the topic/block" at the maximum possible difficulty level for him. Experience shows that the possibility of repeated passage of educational material increases the motivation of the student. This creates an «individual educational trajectory».

Our proposed approach to the organization of adaptive learning consists of the interaction of a student, teacher and teaching system (see Fig. 1). Then the adaptive training system may contain the following components: a domain model, a block for monitoring and analyzing the assimilation of material, and an adaptation model.

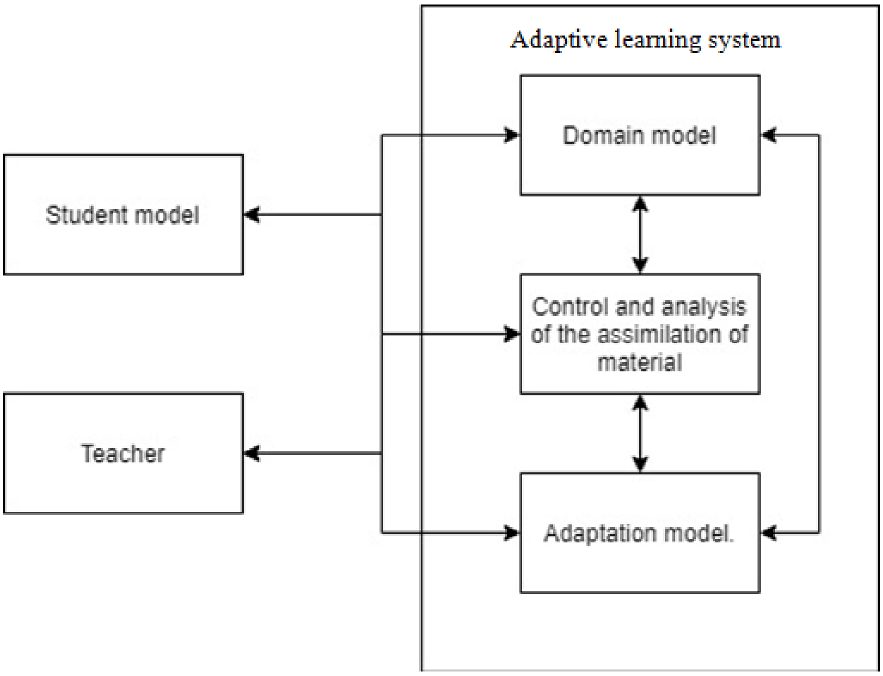


Fig. 1 The structure of adaptive learning

In fact, in this approach, the role of the teacher shifts from the lecturer to the technologist of the educational process: the main role is not played by the teacher's teaching activities, but by teaching the students independently under the guidance of a teacher indirectly within the framework of an adaptive teaching system, taking into account their needs and abilities. Therefore, an important issue is the organization of theoretical material, the formation of tasks and rules for evaluating the results at each step of student learning.

We describe in detail each component of our proposed approach to organizing adaptive learning.

The first component is a teacher. He creates educational content for various learning paths (at least three editions: easy, medium, advanced) and uploads all materials to the system. In the learning process, the teacher can watch the individual trajectories of all his students, as well as observe their results when solving tests, tasks and analyze the level of mastering the material.

The domain model contains the structure and materials that the teacher loads into the system. The domain model acts as a data warehouse that contains all educational content: the name of topics, sections, their contents and navigation links associated with the structure of the presented data [5]. The domain model is designed to develop the structure of the relationship between the individual elements of the subject and transitions between them, taking into account the abilities and needs of students. The structure of these interconnections will provide an opportunity for students to switch to an element of educational material and the level of complexity to be done within the framework of adaptive learning [4].

The student’s model includes all the information: necessary to build his individual trajectory (the level of mastery of each topic, description of errors, grades, test results, etc.). The student model provides that information about the student will change over time, new elements will be added and, accordingly, the path of studying the subject will change as the student goes learns the subject matter. That is, it contains not only general information about the student but tracks all his actions in the process of adaptive learning [6].

The block of control and analysis of the assimilation of material in the adaptive educational system is designed to determine the level of knowledge of the student about the subject area through assessment. To evaluate the learning outcomes, the teacher develops various control and measurement materials: an input test, sets of questions and tasks, tests for topics to test understanding of the current material, tasks for independent solution, training simulators for developing skills, final tests, etc. Also at this stage, recommendations are formed for the student (the system and the teacher) for a more successful assimilation of the materials on the subject, which he can view in the system.

The adaptation model of the training system includes an automated navigation system and the adaptation of educational content, taking into account the individual characteristics of the student. To adapt the educational content, there are three editions of the presentation of the material, which differ in the degree of detail and presentation: text, graphics, tables, audio and video materials, interactive resources. Navigation on educational materials is carried out based on the achieved level of assimilation of the material. At this stage, the educational content is being adapted (increasing or decreasing the level of complexity), based on a built-in individual schedule. If during the training the student poorly mastered the new material and could not fill the knowledge gaps, he will be transferred to a lower level of complexity. At the next test (after using the recommendations), the student can go to a different level of difficulty, depending on the assimilation of the previous material.

To summarize all of the above, we will draw up a functional diagram. It presents the relationship of all components and traces the sequence of the proposed approach to adaptive learning. (see Fig. 2-3).

Figure 2 is a functional diagram of the proposed approach to adaptive learning, and in figure 3 the block «adaptive learning cycle» is specified.

We mean that the teacher plans the training material on the topic of the subject for study in a certain period, thus obtaining a schedule for studying the topic, which is the input to the diagram.

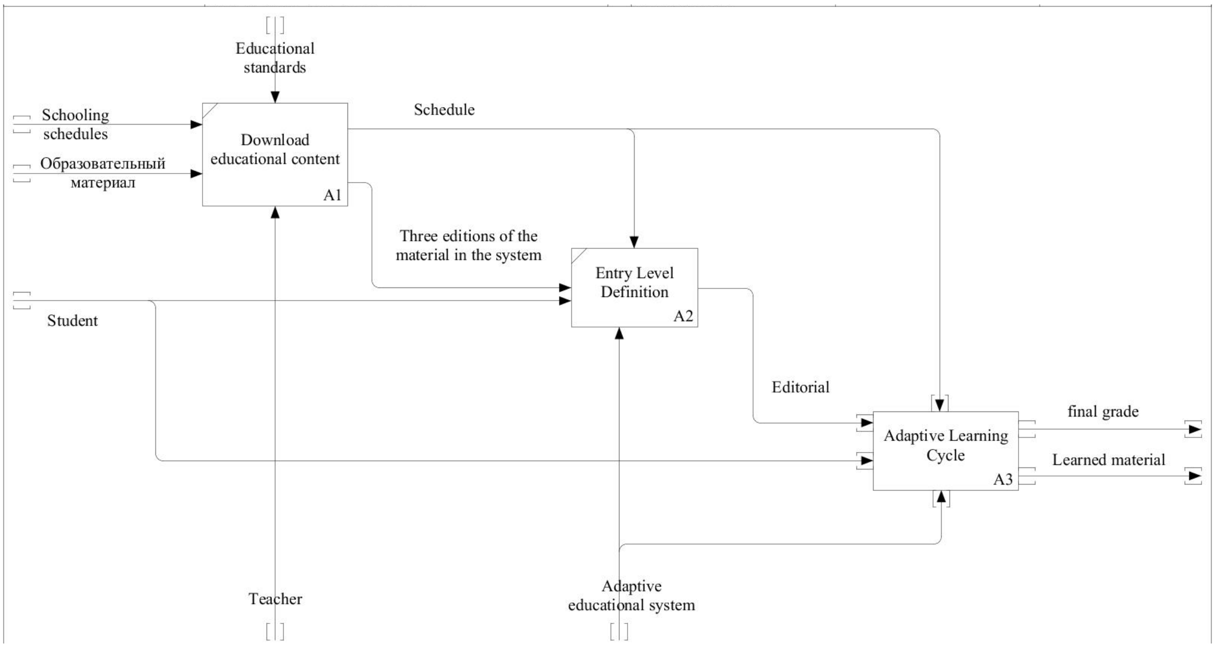


Fig. 2 Functional diagram of the approach to adaptive learning (part 1)

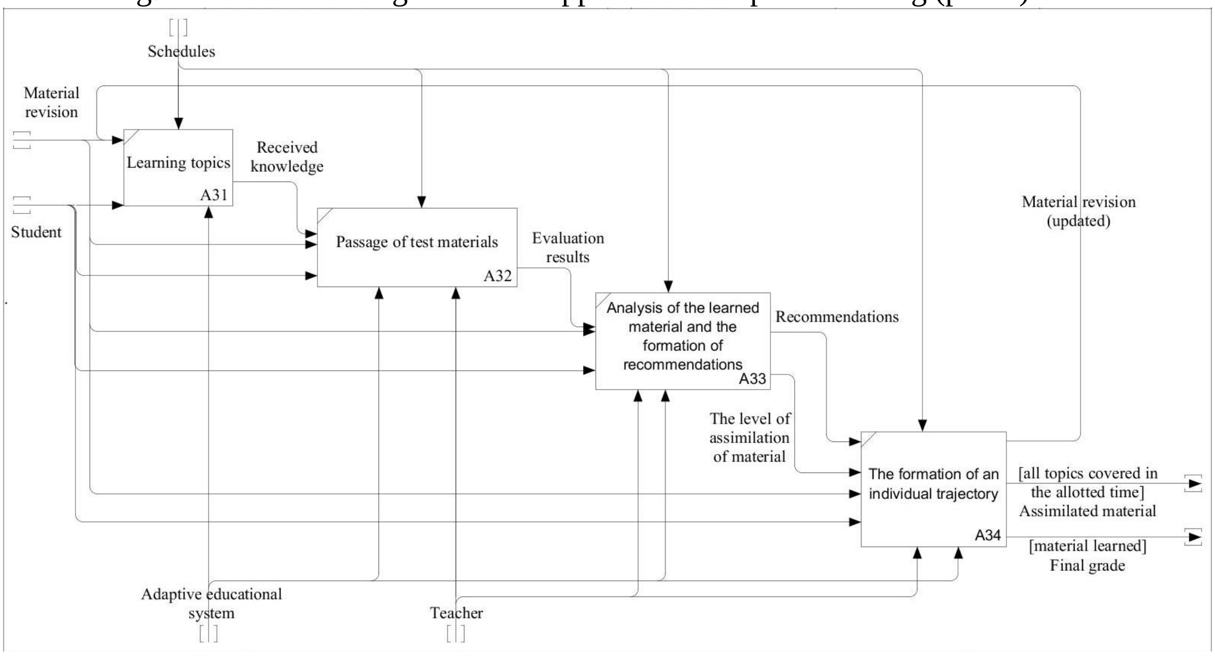


Fig. 3 Functional diagram of the approach to adaptive learning (part 1)

For a better understanding, we will comment on these diagrams:

1. The teacher selects and downloads teaching materials in three editions (easy, medium, advanced), which differ in the degree of detail and form of presentation (A1);

2. The student passes the entrance test, according to the results of which it is determined by which of the three editions he will study the material (A2). Assume that the initial edition is defined as «average»;

3. A student in the adaptive learning system studies the provided educational material and also performs assignments (A31). In our case, the student will be provided with materials edited by "average";

4. After studying the necessary material, the student needs to undergo a control event for which control and measuring materials are developed that also correspond to his level (A32);

5. Then there is an automated or manual verification of the student's work (errors are determined, evaluation is determined, etc.). Based on these results, the level of assimilation passed by the student is determined. Also, based on the results of the control, the level of assimilation of the material, behavior and other characteristics of the student, recommendations are formed (by the system or teacher) that will help him better understand the topics in the future. For example, recommendations may contain topics that the student needs to repeat, either a description of another approach to solving problems or a parsing of errors (A33);

6. Navigation is carried out on the training material based on the achieved level of assimilation of the material and taking into account the individual characteristics of the student (stored in the student's model). At this stage, the educational content is being adapted (increasing or decreasing the level of difficulty (A34). Suppose that a student (from whom it was previously determined that he is studying materials edited by "average") poorly understood the material and did not cope with all the tasks, then his level decreases. Further, he will study materials edited by «easy» instead of «medium».

Then the student returns to the study of educational material (the next or the same topic). In the following stages, it is also possible to lower or increase the level of complexity of the proposed training materials. That is, each student "in his way" goes between the proposed levels, building his individual learning path. Such a cycle will be repeated until the student has studied the material corresponding to the schedule. As a result, it turns out that each student has mastered the material in the maximum volume and understanding for himself.

CONCLUSIONS

Using this approach, students receive the organization of the individual process of studying a subject at a pace: comparable to their needs and abilities. We also assume that the use of the approach will allow the educational aspect of education to be realized through the independent formation by the student of his study schedule within the allotted period, this develops in them independence and responsibility for learning. It is important to note that the teacher can constantly monitor each student (through the means of the adaptive educational system). He can view all the changes in individual trajectories and help the student choose the right direction of his development through the educational trajectories of the subject.

REFERENCES

1. Uvarov A.Yu. Informatization as a digital transformation of education: Proceedings of the II International Scientific Conference "Education Informatization and e-Learning Techniques". - Krasnoyarsk, September 25-18, 2018. - P. 67-72.
2. Adaptation of mathematical educational content in electronic learning resources / Yu. V. Vainshtein, V. A. Shershneva, R. V. Esin, T. V. Zykova // Open Education. 2017. Vol. 21, No. 4.
3. Tomashev M.V., Dolzhenko S.V. Intelligent testing systems in distance and module learning // Polzunovsky Almanac. - 2010. - No. 2. - P. 179-181.
4. Brusilovsky P. Developing adaptive education hypermedia systems: from design models to authoring tools // Authoring tools for advanced learning technologies by Murray T., Blessing S., Ainsworth S. (eds.). Kluwer Academic Publishers, NL. 2003. - 557 p.
5. Esichaikul V., Lamnoi S., Bechter C. Student modelling in adaptive e-learning systems // Knowledge Management and E-Learning. - 2011. - Vol. 3. - № 3. - P. 342-355.
6. Voishvillo E.K. Concept as a form of thinking: logical and epistemological analysis. M.: Publishing house of Moscow State University, 1989. P. 240.

INFORMATION SYSTEM FOR CONTROLLING THE SALE OF EXCISABLE GOODS

Soloveva T.N., Kunakaev I.L.
Perm State National Research University
ambressiore@gmail.com

Abstract – This article describes one of the approaches to the development of an information system that is designed for legal ways to prevent the illegal sale of tobacco products and alcoholic beverages. Its advantages and disadvantages are analyzed. The described method can be used in any country that is interested in controlling the sale of these categories of goods.

Keywords: information system; control; tobacco products; alcohol products.

INTRODUCTION

Many countries have laws governing the sale of alcohol and tobacco products. In some countries, it is forbidden to trade at night or during certain hours. In other countries, it is forbidden to sell these products to minors. Somewhere there is a complete ban on sales.

Worldwide, the illicit alcohol and tobacco trade poses a serious threat to public health and economic development. In the case of tobacco, about one in ten cigarettes in the world is not sold legally [1].

Tobacco and alcohol control measures are widely implemented, but their effectiveness is reduced due to tax optimization and tax evasion. According to representatives of the tobacco industry, high taxes on tobacco products lead to tax evasion. At the same time, the evidence suggests that the following factors are equally important, which are not always related to taxes: widespread corruption, lack of decisive action by governments to prevent illegal trade, and the presence of unofficial channels for the sale of tobacco and alcohol products [1, 2].

The introduction of strict measures to prevent illegal trade will improve the effectiveness of high taxes and prices on tobacco and alcohol. Moreover, in the future, this may lead to a reduction in the use of this product and its negative consequences for health and the economy.

PROBLEM STATEMENT

The world Health Organization estimates that around 7% or just over 24 million children between the ages of 13 and 15 smoked cigarettes in 2007-2017 [3]. And so-called smokeless cigarettes were smoked by almost 13.5 million children (also aged 13 to 15 years) during this period. Some data on users of both categories of tobacco are presented in the tables below. Tables 1 and 2 provide information on smoking cigarettes and smokeless tobacco among boys and girls aged 13 to 15, respectively.

TABLE 1. PREVALENCE OF CIGARETTE SMOKING AND ESTIMATED NUMBERS OF CIGARETTE SMOKERS AMONG CHILDREN AGED 13–15 YEARS IN THE WORLD (2007-2017)

Average prevalence rate (%)			Estimated number of cigarette smokers (millions)		
Boys	Girls	Both sexes	Boys	Girls	Both sexes
9.3	4.2	6.8	17.0	7.1	24.1

TABLE 2. PREVALENCE OF SMOKELESS TOBACCO USE AND NUMBER OF USERS AMONG BOYS AND GIRLS AGED 13–15 YEARS IN THE WORLD (2007-2017)

Average prevalence rate (%)			Estimated number of cigarette smokers (millions)		
Boys	Girls	Both sexes	Boys	Girls	Both sexes
4.6	2.6	3.6	8.8	4.6	13.4

As for alcohol, 26.5% or about 155 million teenagers aged 15-19 are currently using it [5]. If you evaluate the indicators for other years, you can see a trend that reflects the decline in the number of teenagers who use alcohol. However, there are an impressive number of countries where there are only more drinkers and smokers. The situation with smoking is similar - in many countries, the number of children aged 13 to 15 who smoke continues to increase [4].

Below are two charts containing data on adolescent alcohol consumption in different regions and in the world, respectively. Based on the tables, which presented above, and charts it can be concluded that the problem of alcohol consumption and tobacco smoking by adolescents is relevant and requires measures to help eliminate it. This problem is caused by the fact that teenagers do not have problems buying goods, which they can not sell. First of all, it is worth fighting this fact.

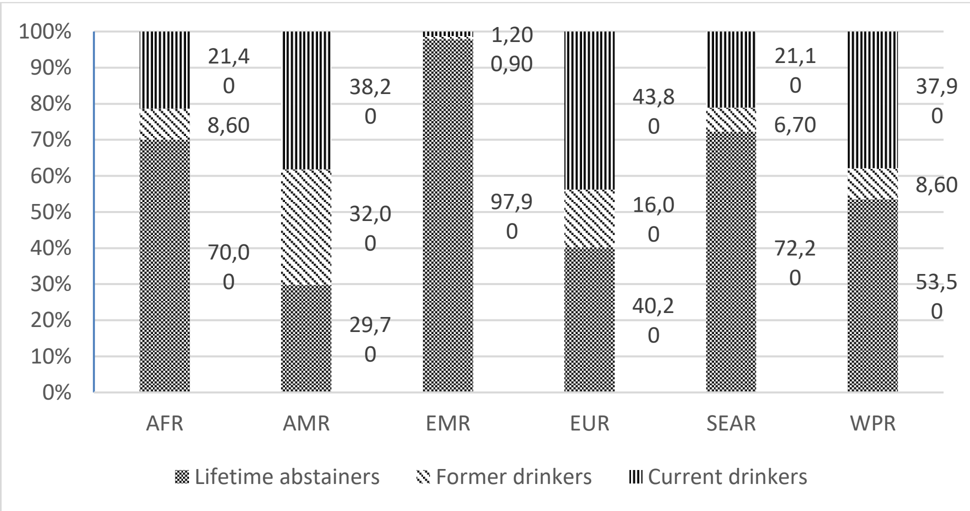


Fig. 1 Percentage (in %) of current drinkers, former drinkers and lifetime abstainers among the total population (15–19 years) by WHO region, 2018

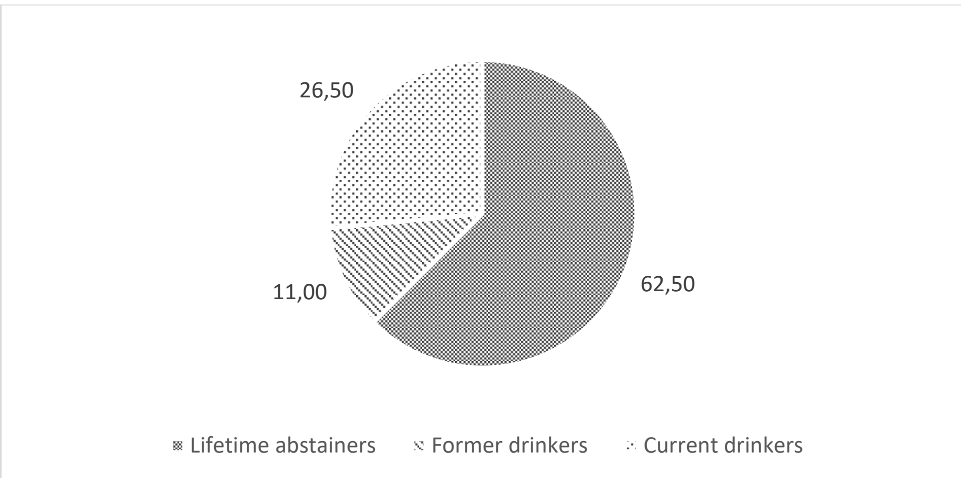


Fig. 2 Percentage (in %) of current drinkers, former drinkers and lifetime abstainers among the total population (15–19 years) by the World, 2018

SOLUTION

The creation of an information system that makes it possible to mark places where alcohol and tobacco are trafficked can help solve the problem described above. This system will allow you to speed up work with documents and report violations from anywhere. Working with documents means contacting the appropriate authorities about violations of legal acts related to the sale of alcohol and tobacco products.

Despite the fact that government control is almost always present, it has the disadvantage that there are not enough people who would track offenses in the field of illegal trade. Using an information system in the form of a smartphone app would increase the level of civic initiative and attract many more people to address the issues mentioned in this text.

The principle of operation of the information system is simple. In total, there are two main roles: administrator and applicant. When a user logs in to the mobile app, they can log in as one of the roles or register as an applicant. If an applicant detects illegal trade in alcohol or tobacco, they can log in to the app, specify the location of the violation and describe what happened using prepared templates that are stored in the app. The administrator simply checks the applications and decides whether to approve or reject the applicant. If approved in the audit, the administrator informs the appropriate authorities about the offense and its details.

In more detail, the logic of the information system is presented in the form of two use case diagrams (in UML notation). A comment in the form of a grey rectangle on the diagram for the applicant (Fig. 2) implies that the applicant will not be able to delete or edit the application if it has already been checked by the administrator and received a decision. That is, deleting and editing is only possible until the application is verified by the administrator. Moreover, in case of deletion, the application is deleted everywhere, and not only in the applicant's interface. User ratings have been added to ensure that there is competition in the "game" form. In part, this is an element of gamification in this app that should increase interest in using it.

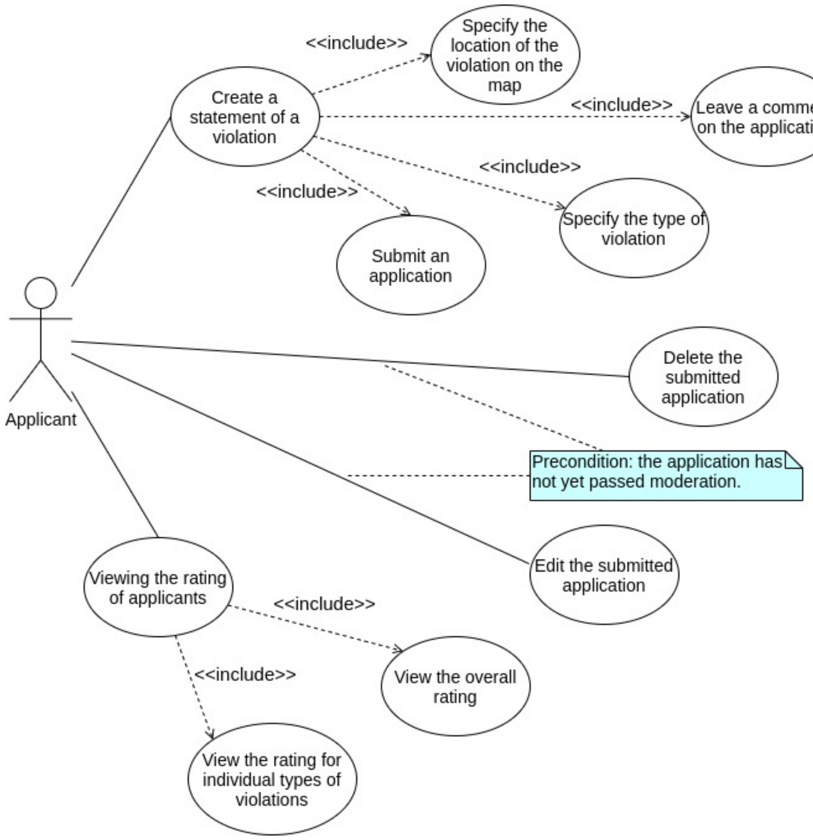


Fig. 3 Use case diagram for applicant

For the administrator role (Fig. 3) the main difference is that it can 't create statements, but it can make decisions about them, that is, approve or deny verification.

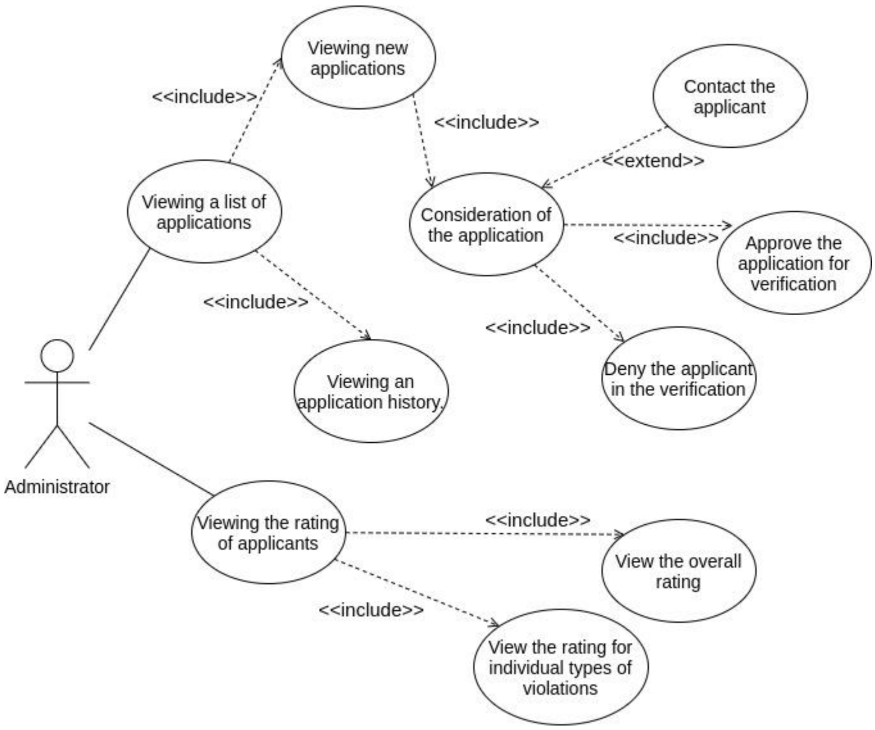


Fig. 4 Use case diagram for administrator

Briefly about the advantages of this information system:

1) The app uses a map that allows you to select any place where illegal trade in alcohol and tobacco is noticed;
2) Increasing the level of civic initiative;
3) Improving the health of citizens;
4) Increasing the country's income.

Of course, there are a couple of drawbacks:
1) The need to maintain and regularly update the app and the types and types of offenses it contains in accordance with the laws of the country in which this app is used;
2) Different countries may have their own sources of maps used in the application (this means connecting third-party maps using the API - Application Programming Interface), so it is not possible to run the same application in all countries.

There are countries that have already developed similar information systems. However, it is often possible to mark only certain stores that sell alcohol or tobacco illegally. For example, you can only mark a store that has a license to sell alcohol on the map. Thus, ordinary kiosks can sell alcohol without a license , commit offenses, and citizens will not be able to indicate this place on the map.

It is important that any resident can specify any place.

CONCLUSION

Increasing the income of any country is undoubtedly a very important task. However, the health of citizens should be even more important. Therefore, first of all, this information system is aimed at increasing the cohesion of people who are interested in a common goal for them: to ensure a healthier life for themselves and those around them. Using the app will reduce the level of consumption of tobacco products and alcoholic beverages. This will affect many indicators of quality of life. Someone will stop smoking, someone will inhale less second-hand smoke, somewhere from the closure of illegal points of sale of alcohol will be less crime. All this can be easily achieved if the citizens themselves, who are interested in such results, help their country with this information system.

REFERENCES

1. “Tobacco. Fact sheets of World Health Organization”, available at: https://www.who.int/ru/news-room/fact-sheets/detail/tobacco
2. Tobacco taxation policy in the Republic of Moldova. World Health Organization Europe; 2017.
3. WHO global report on trends in prevalence of tobacco smoking 2000-2025, second edition. Geneva: World Health Organization; 2018. Licence: CC BY-NC-SA 3.0 IGO.
4. Wang TW, Gentzke AS, Creamer MR, et al. Tobacco Product Use and Associated Factors Among Middle and High School Students – United States, 2019. MMWR Surveill Summ 2019;68(No. SS-12):1–22. DOI: http://dx.doi.org/10.15585/mmwr.ss6812a1
5. Global status report on alcohol and health 2018. Geneva: World Health Organization; 2018. Licence: CC BY-NC-SA 3.0 IGO.
6. World health statistics 2018: monitoring health for the SDGs, sustainable development goals. Geneva: World Health Organization; 2018. Licence: CC BY-NC-SA 3.0 IGO.

VIRTUAL MODELING AS A METHODOLOGICAL APPROACH TO TEACHING STUDENTS IN DIGITAL

Trubina I.I.
Federal State Budget Scientific Institution, Institute for Strategy of Education Development, Russian Academy of Education, Moscow, Russia
+7(903)7927126, uvshp@mail.ru

Abstract – In this society, information itself becomes a commodity, and the price of any commodity is the sum of the price of the material and information components. The goal of this game is to create a model of a "company" for creating a certain product or providing popular services. In the process of implementing virtual business activities, it is possible to use a computer and computer modeling. The article presents the methodological implementation of the above approach in the form of a project activity scheme focused on the creation and development of a certain "company" that turns out selected products.

Keywords: virtual models, digital society, entrepreneurial literacy/

The problem of changing the technological paradigm was on the agenda of the World Economic Forum in Davos in 2016 [10]. Numerous discussions and very delicate analytics have shown that human society is dealing with a new technological and social phenomenon, which will have a critical effect on the entire human civilization in the near future. At the same time, analysts refrained from assessing what this impact will be: positive, negative, short-term or stretching for many years. There are still no definite answers to these questions today. Nevertheless, human society has entered a new phase of its development viz the fourth industrial revolution [4].

It is impossible to think of modern economic activity without information and communication technologies. In the framework of the fourth industrial revolution, digital technologies have been and are being created that are qualitatively different from the technologies of the previous stages of the industrial revolution [6]. Many of these technologies have unique capabilities and, at the same time, carry significant risks that are not peculiar to the technologies of the previous stage.

Mastering the fundamentals of entrepreneurial activity is impossible without the development of modern information technologies (and now, digital ones). On the other hand, mastering the fundamentals of entrepreneurship is an objective of the modern modular general educational course in technology, wherein the most important component is digital technology. In this regard, there is a need for a methodological tool enabling one to simultaneously master entrepreneurial activity fundamentals by means of digital technologies [2]. The proposed methodological approach fits into the context of students' project activities viz the creation and development of virtual "companies", which allows students to independently, at a model level, go through the entire business cycle [7].

The advantage of such learning activity forms is as follows. Experience shows that the main disadvantage of specialized training is that professionally oriented problems of the economic sphere within each subject are considered from the point of view inherent in this science, without regard for the methods and tools used in related areas of knowledge. As a result of uncoordinated study of essentially unified phenomena of economic life, the formation of a systematic view of the problems being studied is insufficient in students [5] . The knowledge and skills gained in one subject are not transferred to the questions discussed in another subject. To provide the future specialist with general education and professional knowledge in business, readiness to work in the information society, it is necessary to change the preparation of students. The “virtual company” project serves this purpose [3], [11].

This project was developed given that project-based and problem-based methods of instruction are the most effective methods specified, in particular, in the Federal State Educational Standard of the Russian Federation. It should be borne in mind that a "virtual company" is not a "free business game", but solves very specific training tasks.

The focus in the selection of theoretical items and the development of hands-on activities within this project was focused on the problems wherein the content is understandable and engaging for senior students and requires the latter to use their knowledge gained in different school subjects and apply their integrated skills.

From the perspective of the content of training we can conditionally distinguish 4 topics in the Virtual Company project: "Clerical work", "Advertising as a marketing activity", "Company business planning", "Company financial activities". The structure of the project, of course, is somewhat different.

In addition to the economic component itself, the acquisition of information technologies is crucial, as they are essential for the activities of a modern economist. Moreover, the problems that economists solve should methodologically be split into two components:

- problems that require calculations;
- problems that do not require calculations.

In all cases, the problems are solved according to a certain universal scheme [1],[9]:

- state the problem;
- make and analyze models of objects and processes considered in the problem;
- select a method for solving the problem;
- formalize;
- implement the selected method, including by means of software;
- analyze the results, adjust the models and the method of solution;
- apply the results.

The implementation of the Virtual Company project assumes that students will become familiar with fundamental economic concepts and master the formulas used in the operation of an enterprise or company and in bank settlements; will gain certain skills in working with software for economic activities.

The general structure of the Virtual Company project is shown in Table 1.

TABLE 1. THE GENERAL STRUCTURE OF THE VIRTUAL COMPANY PROJECT

Project stage	Questions under study	Digital resources	Knowledge and skills to be formed	Concepts in use
1	2	3	4	5
The choice of an operations area, product and competitive strategy. The company's public image.	*Economic knowledge*: Entrepreneurial idea. Creation of the company logo. Sales market analysis. Financial plan. Possible problems of the production process. Determining the price of goods.	Graphic and text editors. Scanning software for graphic images. Project Expert is a program for developing business plans and evaluating investment projects.	Acquaintance with the psychological characteristics of the perception of color, shape, location of graphic objects. The ability to develop the company style reflecting a particular activity and	Perception of information, forms of presentation of information. Goods differentiation. Company trade mark. Logo. Brand block, company tag line.

Project stage	Questions under study	Digital resources	Knowledge and skills to be formed	Concepts in use
1	2	3	4	5
	Drawing up a financial plan. Identification of funding sources. Choice of a business ownership structure. Creation of departments and distribution of responsibilities. Sources of supply and pricing. Manufacturing control. *Accounting.* Cash book and book of banking operations. Periodic reports. Initial and final balance. *Knowledge and skills in the field of information technology* Methods of presenting graphic information. Creation of drawings. Image editing. Combination of graphics and text. Multimedia applications.		promoting its positive image. The ability to find the desired information.	Company style. The essence of an entrepreneurial secret.
Organization of company workflow.	Rules for paperwork. Working with templates. Creation of standard documents. Inserting a picture into a document.	Text and image editors. Translation software. E-mail. Scanning and text recognition software.	Knowledge of the peculiarities in the wording of official documents and documents of a personal nature, generally accepted abbreviations of	Document flow. Forms of the presentation of business information. Organizational and administrative documents.

Project stage	Questions under study	Digital resources	Knowledge and skills to be formed	Concepts in use
1	2	3	4	5
	Installation of software. Sending documents over a network. Digitalization of documents. Automatic translation of documents into other languages using CAT software. Printing and reproduction of documents.		words. The ability to make samples of standard documents. Knowledge of the rules of business communication when using telecommunications. Information security.	Letterhead. Essential details of a document. Workflow methods. Means of communication and information exchange. Business correspondence. Internal and external environment of entrepreneurship.
Advertising the company, its goods, services.	Creation of static and dynamic images. Viewing a video. Saving an image. Creation of multimedia computer presentations. Interactive presentations Giving presentations. Creating multimedia documents. Web site development.	Cloud services (cloud presentation on Prezi, etc.). Text editors. Browsers.	Familiarity with the ergonomic requirements for placing information on screen and paper documents. The ability to make comments on a video. The ability to justify the effectiveness of the created video in terms of goals. Skills in creating hypertext documents.	Human perception of information. Advertising. Types of advertising (image advertising, promotional advertising, sustainability advertising). Information support of product promotion on the market. Advertising campaign. Search for information according to specified criteria. Request for retrieval from

Project stage	Questions under study	Digital resources	Knowledge and skills to be formed	Concepts in use
1	2	3	4	5
				information systems. Search engines.
Planning the company activities.	Information models. Formalization of problem conditions. Project planning with Gantt charts. The study of information models by means of spreadsheets.	Spreadsheets. Text editors. Project Expert Software: https://www.expert-systems.com/financial/pe/ GanttProject App	The ability to present information in tabular form, to make calculations and analyze the results.	Optimization. Criteria for optimality. Acceptable and optimal solutions. Target function. Extrema of the objective function. Gantt chart.
Market analysis.	The construction of structures reflecting the movement of goods and information: graphs, charts, smart charts, "Chernoff faces."	Smart chart plotting apps	Knowledge of the types of business graphics and the peculiarities of their use. The ability to use market analysis methodologies based on "Chernoff faces". The ability to analyze information presented as a smart chart.	Demand. The function of demand. Offer. The function of offer. Market equilibrium. Supply and demand model. Business graphics. Smart charts. Chernoff faces
Assessment of the company performance.	Built-in functions of spreadsheets (financial, statistical, mathematical). Solving equations, inequalities, systems of equations and inequalities in Excel spreadsheets.	Spreadsheets	The ability to assess the calculation results and draw conclusions about the company profitability, the best option for investing capital, financial risk – from the analysis of information presented in	Relational tables. Essential details. Indicators. Data processing methods. Performance criteria. Cost price. Performance. Profitability. Tax rates.

Project stage	Questions under study	Digital resources	Knowledge and skills to be formed	Concepts in use
1	2	3	4	5
			different forms (numerical, graphic, tabular). The ability to justify one's choice.	Average values. Deviations of average values. Interest rates of banks. Simple and compound interest formulas. Loans. Correlation.
Financial reporting.	Creating databases using spreadsheets and databases. Different ways to organize data. Database information retrieval. Data archiving.	Spreadsheets. Archivers.	The ability to create tables, queries, generate reports based thereon. Familiarity with the types of business reports and the rules for their design.	Database. Types of databases. Relational databases. Forms of business reports.

It was ***found*** that the problem of mastering the entrepreneurial activity fundamentals together with the development of information and communication technologies (as well as digital technologies of the 4th industrial revolution) is relevant in the light of the implementation of the new Concept of technological education in the Russian Federation and the creation of a modular comprehensive educational course in technology including the fundamentals of entrepreneurial activity.

The ways of forming the fundamentals of entrepreneurial activity in digital society on the basis of a virtual model of entrepreneurial activity implemented in the process of implementing the Virtual Company project have been identified.

REFERENCES

1. Beshenkov, S.A. (2002). Modelirovaniye i formalizatsiya [Modeling and formalization]. Moscow, BINOM, Laboratoriya znaniy, (rus.)

2. Beshenkov, S.A. et al (2017). Information and Cognitive Technologies. Modern Educational Trend. International Conference "Education Environment for the Information Age" (EEIA-2017). Moscow, Russia. Retrieved from: https://www.futureacademy.org.uk/files/images/upload/EEIA2017FAF021.pdf

3. Learning Analytics For Tracking Student Progress. (2016). Hanover Research, November. Retrieved from: https://www.imperial.edu/research-planning/7932-learning-analytics-for-tracking-student-progress/file , pp.93-98.

4. Schwab, K. (2016). Chetvertaya promyshlennaya revoliutsiya [The Fourth Industrial Revolution]. Moscow, Eksmo, 208, (rus).

5. Schmarzo, B. (2014). What Universities Can Learn from Big Data – Higher Education Analytics. InFocus Blog|Dell EMC Services, July 2. Retrieved from: https://infocus.dellemc.com/william_schmarzo/what-universities-can-learn-from-big-data-higher-education-analytics//Schwab, K. (2016). Chetvertaya promyshlennaya revoliutsiya [The Fourth Industrial Revolution]. 208.

6. Serdyukova, N.A., Serdyukov, V.I., Neustroev, S.S. (2019). Testing as a Feedback in a Smart University and as a Component of the Identification of Smart Systems. Smart Innovation, Systems and Technologies. Springer, V. 144, pp. 527–538.

7. Shihnabieva, T.S., Beshenkov, S.A. (2016). Intelligent system of training and control of knowledge. Smart Innovation, Systems and Technologies Series. V. 59, Springer Verlag, pp. 595–603.

8. Shutikova M.I., Beshenkov S.A., Mindzaeva E.V. (2019). Information and cognitive technologies in the context of the 4th technological revolution: education aspects. Journal of Siberian Federal University – Humanities and Social Sciences, No. 9, pp. 1694–1713. DOI: https://www.scopus.com/authid/detail.uri?authorId=57201195846

9. Shutikova, M.I., Mozolin, V.V. (2005). Informatsionnoye modelirovaniye – osnova postroieniya kursa informatiki ekonomicheskogo profilya [Information modeling is the basis for the development of a computer science course focused on economics]. Informatika i obrazovanie, No. 7, pp.127–130. [in Rus.].

10. Trubina, I.I., Beshenkov S.A., Braines A.A. (2018). Informatics discipline in the context of digital civilization. Education Environment for the Information Age No**.** 90 pp**.** 768–774 DOI**:** https://www.futureacademy.org.uk/files/images/upload/EEIA2018F090.pdf

11. .Yalamov, G. (2019). Possible Negative Impacts of Intelligent Learning Systems on the Development of the User's Identity. International Conference on the Development of Education in Eurasia (ICDEE 2019): Advances in Social Science, Education and Humanities Research, 05, V. 316. pp. 17–19. DOI: https://doi.org/10.2991/icdee-

ORGANIZING EXPERIMENTS WITH HARD DISK DRIVE AND ITS CONTROLLER IN PC PERIPHERALS' STUDYING

Bogodistova E.S.
Russian University of Transport

Abstract – A computer training program for interactive experiments with hard disk drive and its controller is proposed, which can be placed in a real and virtual environment. In the first case the research takes place not on a model, but in a real computer system with the direct hard disk drive control for heads positioning operations, reading and writing by physical address, the sector contents mapping and the drive status observation. A comparison is made for similar experiments with hard disk drive carried out in a virtual machine.

Keywords: computer training program, hard disk drive, controller, interactive experiment, user interface, real and virtual environment.

INTRODUCTION

The computer training program "PERUN\HARDDISK" is a part of the complex "PERUN" described in [1]. The complex is used for interactive experiments with PC peripherals [2-4]. The name of the complex is an abbreviation from words "PERipheral UNits".

The complex "PERUN" solves the following tasks: maximum possible study level approximation to the equipment of a computer classroom; eliminating the need to develop and debug complex programs; providing a convenient user interface and service for experimenting with equipment.

PROBLEM STATEMENT

Operation features of the peripheral device controllers, including the disk subsystem, are defined in [5]. There are two controllers for hard disk drive (HDD) within a computer system.

The system disks controller is the chipset controller of the corresponding standard interface: USB for portable disks and PATA or SATA (Parallel or Serial AT Attachment) for system disks. The drive controller is integrated into the drive and performs the following functions as described in [5]:

– Data encoding/decoding and placement on a magnetic medium;

– Controlling a servo system that positions magnetic read/write heads;

– Performing operations on information blocks (writing, reading, checking);

– Parallel-serial and inverse data conversion when writing to the medium and reading information from the medium;

– Error protection (error-correcting coding, detection and correction of data errors);

– Organizing exchange with the computer core and the drive;

– Self-test of the drive and own equipment.

For better understanding by students the disk subsystem functioning processes it is important to organize the laboratory practicum on HDD experiments at the physical level. The computer training program “PERUN\HARDDISK” is designed to solve this task. Some approaches to solving the problem were described in [6].

SOLUTION OF THE PROBLEM

The computer training program “PERUN\HARDDISK” provides the direct HDD control. Various experiments are carried out not on a model, but in a real computer system. There are possibilities to select the drive, to initiate basic operations (drive recalibration, magnetic heads positioning, reading and writing sector by the physical address), to observe on the screen and analyze one or more physical sectors contents including checking field, and to get the drive and controller status information after command execution.

Tools are provided for viewing the file allocation table and identifying free clusters for recording. There are software buffers for viewing the data read from the disk, entering and editing data before writing.

Work with the program, including the launch of commands, is carried out using the keyboard and mouse.

The program menu includes items INFO (options “about program”, “drive characteristics”, and “laboratory task”), DISK, RESET, TEST, and REVIEW.

The menu item DISK contains four sub items: SUBSYSTEM CONFIGURATION, DRIVE SELECT, LOGICAL DRIVE PARAMETERS, and SEARCH FOR FREE AREAS. The sub item SEARCH FOR FREE AREAS contains two options for using a disk with data that should not be lost when performing experiments. The CYLINDERS procedure forms a list of partially free cylinders, i.e. the cylinders with the free sectors. The LIST OF FREE AREAS procedure performs a search and compiles a list of free sectors in a given partially free cylinder.

The menu item TEST contains 8 options for calling routines that work with HDD controller at the physical level (programming registers level) and initiate execution of the main operations: RECALIBRATE, SEEK, READ SECTOR, READ LONG, READ VERIFY SECTOR, WRITE SECTOR, WRITE LONG, FORMAT TRACK, EXECUTE DEVICE, and INITIALIZE DEVICE.

The option FORMAT TRACK includes the sub items FORMATTING TABLE and FORMATTING OPERATION. The disk formatting is excluded. However, it is possible to prepare the formatting table and the control information block for the formatting command with correctness control.

The menu item RESET is necessary to perform several actions. The first action is the soft controller reset, including the Error Register and the Status Register reset. There are two inner controller registers named the Current Cylinder Number and the New Cylinder Number that are involved in positioning the magnetic heads. These registers are zeroing too. The next action is to execute the RECALIBRATION command to bring the position of the magnetic heads in accordance with the software reset by moving their on the cylinder 0.

Two software buffers are available for the user to view the data read from the disk, enter and edit data before writing. The item REVIEW contains 3 options to observe on the screen read buffer, write buffer and both buffers simultaneously in hexadecimal and symbolic form.

An interactive mode is provided when setting command parameters and monitoring the status of the controller and the drive after the command execution. Contextual help is available at all stages of work.

The training program ensures the interaction of the computer system with the drive controller at the physical level in accordance with its programming model (Table 1). The model reflects the operation modes with a physical and logical address: Cylinder-Head-Sector, CHS (Cylinder Number C = 0, 1, … ; Head Number H = 0, 1, … ; Sector Number S = 1, 2, …) and Logical Block Addressing, LBA = 0, 1, … .

TABLE 1. HDD CONTROLLER REGISTERS

Register	**Bit**							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Device Control	-	-	-	-	-	Reset (Software)	Interrupt Enable	-
Device/ Head Number	-	CHS mode: 0; LBA mode: 1	-	Device Selection	CHS mode: Head Number; LBA mode: LBA (27/24)			
Cylinder Number (CN)	CH Register. CHS mode: CN high byte; LBA mode: LBA (23/16)							
	CL Register. CHS mode: CN low byte; LBA mode: LBA (15/8)							
Sector Number	CHS mode: Sector Number; LBA mode: LBA (7/0)							
Sector Count	Sector Count							
Command	Operation Code							
Error *1)	-	Bad ECC *2)	-	ID Not Found	-	Aborted Command	Track Zero Error *5)	Data Address Mark Not Found *3)
Status	Busy	Drive Ready	Write Fault	Seek Complete	Data Request	Corrected Data	Index*4)	Error *5)
Data	Data byte in PIO mode							

Abbreviations in Table 1: ID – sector identifier, ECC – Error Correction Code, PIO – Programmed Input/Output.

Notes to Table 1: *1) Error Register format after command execution. *2) Bit 6 of the Error Register ("Bad ECC") means unrecoverable data error. *3) Bit 0 of the Error Register ("Data Address Mark Not Found") refers to sector identifier address mark. *4) Bit 1 of the Status Register ("Index") is set to 1 with an active index signal coming from the drive. *5) When track 0 is not recognized, the command RECALIBRATE ends by setting the "Error" bit in the Status Register and the "Track Zero Error" bit in the Error Register.

The Device Control Register is used for software reset and control the interruption request of the selected device. The purpose of the remaining registers is clear from their names.

The Sector Number, Cylinder Number, and Head Number fields in LBA mode contain the logical address bits specified in the table. In LBA-48 mode, these registers for devices double and contain 16-bit numbers. Note that the drive controller with a serial SATA interface includes these registers too, but the program works with the devices' Shadow Registers located in the host controller. Each connected device has its own set of registers. Accessing the shadow registers causes the process of interaction between the host controller and connected device and commands execution. Data exchange between real device registers and shadow registers, as well as data transfer are carried out via a serial interface.

After transferring to the controller a block of control information corresponding to the READ, WRITE, READ LONG, WRITE LONG and FORMAT TRACK commands, there is data exchange between the system and the drive. The direction of information flows when executing commands are shown in Figure 1.

Experiments with the READ LONG and WRITE LONG commands allow to investigate the error correction code (ECC) used. When executing these commands the drive controller transfers data and ECC field between the host controller and the drive without changes.

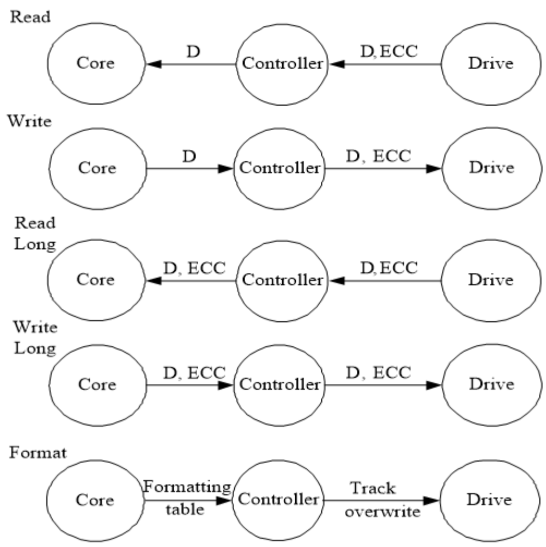


Fig. 1 The direction of information flows when executing basic commands

The first group of experiments involves the study and practical mastering of the HDD operation principles when executing basic commands.

It is proposed to identify the permissible values of the parameters C, H, and S, select a drive, perform a controller reset, the RECALIBRATE command, and the SEEK command to position magnetic heads on a given cylinder.

The following steps include executing the commands: READ SECTOR by the CHS address with viewing the contents in the read buffer, and EXECUTE DEVICE to check the operability of the drive and controller.

At the next stage, before writing to the disk, you need to search for free areas and find free sectors. Then it is necessary to read the selected sector contents, to enter some data to this sector, read it and compare the contents of the read and write buffers.

The experiments results are recorded in the protocol, information about the disk subsystem state is decrypted, and an analysis of the errors that occur is performed.

The second group of experiments is devoted to the study of the disk subsystem features. Tasks include the following items:

– Reading of several sectors without preliminary magnetic heads positioning;

– Determining the effect of the retry modification bit for READ command (the repeat can be used when unrecoverable reading error is detected);

– Preparation of formatting tables and control information blocks for various sector interleave ratio and different values of the sector attribute byte, and validation using the FORMAT TRACK command option (without formatting);

– Mapping of the disk free space for one of the cylinders (in tabular form).

It is proposed to study the data protection of a certain free sector by the ECC control code. It is required to determine the length of the ECC field, to make and verify assumptions about the coding algorithm. For these purposes, it is necessary to develop test information blocks and propose a sequence of commands READ, WRITE, LONG READ and LONG WRITE with analysis of the read information and the controller state.

The computer training program is performed in a virtual machine too. Virtual drives connect to a virtual guest OS by emulating a connection through an IDE controller. When working in a virtual environment, the errors “ID Not Found”, Track Zero Error”, and “Data Address Mark Not Found” are never encountered. LONG READ and LONG WRITE commands are not supported and cause an “Aborted Command” error.

To analyze system information about the modern drives parameters and features, it is recommended to use one of the applications for the home computer. Table 2 shows examples of typical data for several hard magnetic disk drives and solid-state drive (the terminology of the application reports has been saved).

All ATA drives use zoned-bit recording (ZBR) with a variable number of sectors per track. Low-level formatting is done at the factory and the system hides the true formatting scheme from the user.

For all drives, the number of cylinders C, the same number of heads and sectors ($H = 16$, $S = 63$) and a sector size of 512 bytes are reported. The number of LBA sectors corresponds to the product $C\times16\times63$; the capacity corresponds to the $LBA\times512$ product. “The size of the physical / logical sector” parameter allows to distinguish between Advanced Format (4K Sector) if “4 KB / 512 bytes” is specified. The drives use 512-Byte Sector Format and Advanced Format.

The calculations show that the reported values of the unformatted and formatted capacity are the same value, expressed approximately in different measurement units. Binary (mebibyte, MiB; gibibyte, GiB; Tebibyte, TiB) and decimal (megabyte, MB; gigabyte, GB; terabyte, TB) units are used, respectively. The rotation speed is indicated in revolutions per minute (rpm) for HDD; “SSD” is indicated for solid-state drive instead of the rotation speed.

In addition, it is proposed to find out the mode numbers supported by the home drive: Programmed I/O (PIO); Multiword Direct Memory Access (MWDMA); Ultra DMA mode with data transmission on both the rising and falling edges of the clock signal.

TABLE 2. HDD PARAMETERS

Parameter	Example Number		
	1	2	3
The size of the physical / logical sector	512 bytes / 512 bytes	4 KB / 512 bytes	512 bytes / 512 bytes
Device type (Interface)	SATA-II	SATA-III	SATA-III
Parameters C/H/S	1453521 / 16 / 63	3876021 / 16 63	969021 / 16 / 63
LBA sectors	1465149168	3907029168	976773168
Bytes in sector	512	512	512
Unformatted capacity *1)	71405 MB	1863 GB	476940 MB
Formatted capacity	750 GB	2 TB	500 GB
Rotation speed	7200 RPM	7200 RPM	SSD

Note to Table 2: *1) the correct units for unformatted capacity are MiB and GiB.

DISCUSSION

Performing experiments with equipment allows teacher to discuss a wide range of issues with the students: the interaction of the periphery with the computer system core, the functioning of the drive, the problems of servo control, methods of channel and noise-resistant coding; ways to increase the density of recording on a magnetic medium, advantages of zoned-bit recording, Advanced Format, and sector format without identifier (No-ID), and etc. It is useful to compare automatic control systems used in the optical, magnetic disk and tape drives.

The computer training program “PERUN\HARDDISK” has the following features and limitations:

– It is hardware dependent program, it works with a 16-bit FAT table and recognizes small capacity drives with Parallel ATA interface;

– It uses the so-called standard HDD commands supported by the ATA-2, ATA-3 specifications; data exchange for these commands is performed in PIO mode.

It must be taken into account that the modern HDD controller hides the true formatting scheme from the user.

Despite these limitations, the proposed computer training program and methodology allow engaging students in interesting discussions on computer peripherals and may be useful in the educational process.

CONCLUSION

The proposed methodology and developed tools allow to improve the level of training and to accelerate the practical mastering of the HDDs operation principles and their interaction with the computer system core. This approach contributes to the students’ competence in IT technology.

REFERENCES

1. Bogodistova E. S. Telnov G. G. Jeksperimenty s periferijnymi ustrojstvami s pomoshh'ju komp'juternyh obuchajushhih programm-trenazherov [Experiments with peripheral devices using computer training programs], Innovacii na osnove informacionnyh i kommunikacionnyh tehnologij: Materialy XI mezhdunarodnoj nauchno-prakticheskoj konferencii. Moscow: NIU VShJe, 2014, pp. 50-55. (in Russian)

2. Bogodistova E.S., Telnov G.G. Experiments with Video Subsystem and Video Timing Parameters Estimation, Information Innovative Technologies: Materials of the International Scientific-Practical Conference (April 24-28, 2017, Prague), Ed. Uvaysov S.U., Ivanov I.A. Moscow: Association of graduates and employees of AFEA named after prof. Zhukovsky, 2017, pp. 127-130.

3. Bogodistova E.S., Telnov G.G. Interactive experiments with optical disc drive and estimating recording density, Information Innovative Technologies: Materials of the International Scientific-Practical Conference (April 23-27, 2018, Prague) , Ed. Uvaysov S.U., Ivanov I.A. Moscow: Association of graduates and employees of AFEA named after prof. Zhukovsky, 2018, pp. 56-64.

4. Bogodistova E.S., Telnov G.G. Interactive experiments with printers and plotters in real and virtual environment, Information Innovative Technologies: Materials of the International Scientific-Practical Conference (April 22-26, 2019, Prague), Ed. Uvaysov S. U., Ivanov I.A. Moscow: Association of graduates and employees of AFEA named after prof. Zhukovsky, 2019, pp. 209-214.

5. Bogodistova E. S., Mamchenko A. E., Shamrov M. I. Programmiruemye kontrollery v komp'juternyh i upravljajushhih sistemah [Programmable controllers in computer and control systems], *Informacionnye tehnologii – Information Technology,* 2014, no. 11. pp. 53-59. (in Russian)

6. E. S. Bogodistova, G. G. Telnov. Eksperimenty s kontrollerom i nakopitelem na zhestkom magnitnom diske v interaktivnom rezhime [Interactive experiments with hard disk drive and its controller], Innovatsionnyye, informatsionnyye i kommunikatsionnyye tekhnologii: Sbornik trudov XV Mezhdunar. nauch.-prakt. konferentsii "INFO-2018" (October 1-10, 2018, Russia, Sochi), Gl. red. S. U. Uvaysov; Otv. red. I. A. Ivanov. Moscow: Assotsiatsiya vypusknikov i sotrudnikov VVIA im. prof. Zhukovskogo, 2018, pp. 24-29. (in Russian)

ANALYSIS OF READINESS OF AGRICULTURAL SCIENTIFIC AND EDUCATIONAL RESOURCES FOR DIGITAL TRANSFORMATION

Medennikov V.I., Muratova L.G.*, Luppov V.V.*, Salnikov S.G.*
Federal Research Center "Informatics and Control" of the Russian Academy of Sciences,
*VIAPI n.a. A.A.Nikonov the branch of FSBSI FSC AESDRA - VNIIESH
+7 (916) 680-73-29, dommed@mail.ru

Abstract— The article discusses the problems of digital transformation of scientific and educational resources in connection with the adoption of the Digital Economy Program, in which almost all information resources will be stored on the Internet in some clouds. To assess the effectiveness, including economic, digital transformation, an extremely important indicator is the initial (current) state of both information resources and tools and technologies for their storage and processing. These problems are considered on the example of agriculture.

Keywords: digital transformation; scientific and educational resources; software.

INTRODUCTION

Currently, ways to improve the efficiency of use of human capital are on the first place on the agenda of most states. Human capital in almost all developed countries of the world exceeds half of the accumulated national wealth. Economically developed countries of the world are fighting for the formation of a new economy - the economy of knowledge, innovation, the latest technology, global information systems. Although our country in terms of national wealth per capita exceeds the world average by 4.4 times, its share in the total amount of world human capital is 8%. Moreover, this indicator is gradually decreasing [1]. Great expectations in the world in terms of improving the efficiency of use of human capital are assigned to the digital transformation of society. However, those countries and organizations that have not only access to data, but also effective technologies for their processing, receive economic advantages. The level of differences in the use of these factors in the digital economy is even called the “digital divide”.

Therefore, given the importance of education in the modern world, studies of the digital divide of one of its main components, the gap in the field of information technology in the education sphere, are becoming relevant. An analysis of the results of the study will allow us to formulate a scientifically-based effective transformation of current information technologies into a promising single digital platform for the scientific and educational resources of Russia, the formation trends of which in the form of a single world educational space are observed today.

The article discusses the results of a study of the current state of information resources of tools and technologies for their storage and processing of agricultural scientific and educational resources.

PROBLEM STATEMENT

Although Rosobrnadzor by order No. 785 dated 05/29/2014 “Requirements for the structure of the official website of an educational organization in the information and telecommunication network“ Internet ”and the format for presenting information on it” obliged universities to partially bring their sites to a standard type, however, these requirements do not include scientific and educational resources, since one of the main activities for assessing universities in Russia in the first place is educational activity. In foreign educational institutions, research is one of the main activities. Prior to the enactment of this order, information was published on the websites of universities, in any form, which of course made it difficult to use the sites, both from the controlling organizations and ordinary users.

The sites of the research institute are generally not required. Moreover, the state did not realize that improving Internet technologies allows them to be integrated into a single information Internet space of scientific and educational resources (EIIPNOR) from a single scientific and methodological position with a simple navigation system understandable to any user with the placement of IR in the cloud under control powerful DBMS on the basis of common classifiers, such as the State rubricator of scientific and technical information (SRSTI) and the All-Russian product classifier (OKP) [2, 3]. Thus, the state does not use such a powerful lever for transferring scientific knowledge to the economy. Moreover, the analysis showed that the ongoing restructuring of research institutes in some cases has a negative impact on the state of their sites. Created by the FIC and the Federal Research Center, at best, maintain their previous sites, which only have brief information about the affiliated research institutes (management, structure, contacts). The sites of affiliated research institutes are most often not supported or even liquidated, and the information on publications on them, scientific developments, etc., is not transferred to the sites of parent organizations. As a result, valuable information on the results of the research institute does not reach the consumer. Thus, many uninformative websites appeared that provide scant information about the scientific resources of the research institute. FANO planned that the FIC and the Federal Science Center should be leaders in the scientific community and, in particular, in informatization, and have sites on which other research institutes should be placed.

One of the promising areas of digitalization of universities, research institutes is the formation of EIIPNOR, which will play a threefold role: support for scientific research, raising the level of education (sometimes retraining) for all segments of the population, an effective system for transferring scientific and educational knowledge to the economy through unlimited access to this knowledge not only traditional users in the person of scientists, students and teachers, but also future applicants and employers, government agencies, producers, business, management, other categories of the population. Such a space should remove the contradictions between the volumes of accumulated information, knowledge and their effective use, as well as a tool to improve the quality of human capital, its assessment, and the impact on social welfare in the country.

From this point of view, there is the problem of choosing the appropriate research methodology for university sites.

SOLUTION OF THE PROBLEM

A large-scale survey of the needs of producers in 22 regions by traveling to them with a questionnaire of management bodies and businesses showed that the following types of knowledge representations are most in demand in the Russian economy: development, publications, consulting activities, regulatory information, distance learning, application software packages, databases data. It turns out that these types of knowledge are also present on the websites of research institutes, universities, information and consulting services (IKS) [4].

For the most complete assessment of the state of information resources, their processing tools, the availability of applied tasks on sites, the effectiveness of the use of information, in particular, the scientific and educational resources reflected on them, relevant studies were presented based on the developed questionnaire, which reflects 214 indicators of it activities (122 indicators evaluate the representation of the university itself, 40 indicators for the faculty, 46 indicators for the evaluation of departments and 6 indicators for the overall assessment of the site) [3].

To map heterogeneous site structures into homogeneous structures, given that, in accordance with current trends in Internet technologies, when providers begin to provide services for storing site content in powerful database management systems, we assume that information, scientific and educational resources should be stored , on the one hand, in the form of catalogs, or in the form of a full-format electronic representation, on the other hand, in the form of an unordered list, or in the form of an ordered electronic representation.

Brief results of the state of IR on sites.

Of all the universities (59 in 2013 and 54 in 2017), only 85% presented information on websites only in the form of a list with a complete lack of an online regime on developments, with an increase in their number over three years at 93.6% from 2013 to 2017. However, this increase was provided only by 10 universities, the rest either reduced or even stopped publishing information about the developments. It is worth noting that the electronic development catalogs have already appeared on the sites of three universities, however, without posting information about them in the DBMS.

Over the course of three years, their number has decreased in universities, which present information on publications on websites from 93% to 89%. At the same time, an increase in publications occurred in departments by 3.3%, with a significant decrease of 2.6 times in faculties and in general in universities by 6.5 times. Moreover, only in the Kuban State Agrarian University did an electronic catalog and a full-format presentation of publications appear. On the whole, the picture is mottled; no coordinating hand is felt by anyone. The lack of a DBMS leads to a mismatch of publications on presentation forms and quantity in departments, at faculties, and in universities as a whole, which makes them display cases and unsuitable for many users.

Only 12% of universities presented information on databases in 2016 with a decrease to 11% by 2017. Two universities: RGAU – ICCA placed 145 databases on the website (only at the university level) in the form of an electronic catalog and Kuban GAU (538, of which 4 in departments, 7 departments, 527 at the university level) in an unordered list. Check their performance is impossible.

The submission by universities of information on application software packages (SPT) has increased from 17% in 2013 to 24% by 2017. It is also impossible to verify their operability, since, like the developments, the RFP and databases are not presented online. This is due to the fact that currently the vast majority of providers do not provide services for the use of optimization and statistical RFPs, not even Excel. Some providers provide services only for the use of DBMS, which no university has used.

Of the 59 universities in 2013, only five universities presented distance learning information on the websites, mainly in the form of an unordered list, and six universities by 2017. also in the form of an unordered list. This also indicates that the presentation on the sites of scientific and educational resources is left to the discretion of the developers.

Of the 59 universities in 2013, only on the website of the Ryazan State Academic University was a consulting type of activity (51 consultants) related to the fact that in Ryazan, at one time, an information and consulting service was actively working. By 2017 there was a sharp jump, both in the number of consultants - by 3.5 times, and in the number of universities - over 14. In Ryazan GATU there was only one consultant.

In 2013, the regulatory information was presented on the websites of 39 universities: in the form of an unordered list of 299 copies, in the form of an unordered full-format electronic submission - 936 and the form of an ordered full-format electronic submission 1385. By 2017, there was a sharp reduction, respectively, from 299 to 65, from 936 to 328 and from 1385 to 19. This is apparently due to the great complexity of maintaining this type of information resource, especially without a DBMS.

Let us analyze the software used by the websites of agricultural universities for the requirements of the CE both for the integration of information resources (IR), information systems (IS), and software compatibility (software) to evaluate them as tools for processing information resources and developing applied tasks.

A total of 395 types of software found in 54 sites of agricultural universities were combined in 16 different groups (Table 1).

TABLE 1. NAME AND BRIEF PURPOSE OF SOFTWARE GROUPS

Cod	Name of software	Brief description of the purpose of the	Quanti
1	CMS	Automated site content management	54
2	JS framework	Website page layout	94
3	JS graphics	Graphics on the pages of the site	12
4	Analytics	Information about the site	56
5	Web server	The server on which the site runs	57
6	Web framework	Similar to item 3	24
7	Video player	Services for displaying video on the site	5
8	Widget	Showing small software inserts	4
9	Map	Showing geographic maps on a site	1
10	Mobile framework	Creating a mobile version of the site	1
11	OS	The operating system on which the site is	27
12	Other	Software not found in other groups	3
13	Web Server	Additions to clause 5 for specific needs	4
14	Ad network	Organization of advertising on the site	1
15	Fonts	Additional fonts	17
16	Programming	The language used in the site	50

As you can see, the most numerous group was the “JS framework” group, which contained 94 entries (23.8% of the total number of software found on all sites). Further by a large margin are the groups of software "Analytics", "Web Server" and "Programming Language". The average number of software is represented by the software groups "CMS", "Web Framework" and "Operating System". The remaining groups are represented by a small amount. Let us consider in more detail the composition of the most important groups. A full description of all groups is given in [3]. The distribution of software in this group is given below (tab. 2).

TABLE 2. SOFTWARE DISTRIBUTION IN THE CMS GROUPS

Numb	**Name**	**Quantity**	**Percentage of total**
1	1C-Bitrix	17	31,5
2	DataLife Engine	1	1,9
3	DNN	2	3,7
4	Drupal	1	1,9
5	InstantCMS	1	1,9
6	Joomla	16	29,6
7	OpenCms	1	1,9
8	No data	15	27,8
	TOTAL	**54**	**100,0**

Thus, by a small margin, in the first place (31.5% of the total number of sites) was CMS "1C-Bitrix". The second place was taken by CMS "Joomla" (29.6% of the total number of sites). In the remaining groups in the composition of the software, the same diversity is observed as for the given group.

CONCLUSION

Studies have confirmed the assumption that in the requirements for the websites of universities by the Ministry of Education and Science, Rosobrnadzor, Ministry of Agriculture, there is an underestimation of the scientific activities of universities.

Universities so far consider their sites as showcase, without investing special funds in their rational use. Their audience is, first of all, applicants, then students, but not commodity producers, managers, scientists and the public. The presentation of scientific and educational resources on the sites is insignificant, unsystematic and rests only on the enthusiasm of the performers.

The analysis showed that the providers in the arsenal have only a DBMS, but there are no statistical or optimization packages. Moreover, there are no funds for the development of expert systems, artificial intelligence. Providers explain the reasons for this situation by the fact that there is no demand, that is, there is no social order for tools for more complex modes of processing information resources, in addition to the information and reference one.

ACKNOWLEDGMEN

This work was supported by RFBR (grant № 20-07-00836)

REFERENCES

1. T. Regent, "Problems and opportunities of human capital for the digital economy of Russia", a collection of reports by participants in the International Scientific Conference dedicated to the 90th anniversary of S.P. Kapitsa "Human Capital in the Digital Economy Format" - Moscow, February 16, 2018. - pp. 183 - 1894, (rus)

2. V. Medennikov, L. Muratova, S. Salnikov, V. Luppov, A. Lichman, "Models and methods for the formation of a single information Internet space of agricultural knowledge", GUZ Publishing House, Moscow, 2014, (rus)

3. V. Medennikov, L. Muratova, S. Salnikov, V. Luppov, A. Lichman, "Methodology for assessing the effectiveness of the use of informational scientific and educational resources", Analyst, Moscow, 2017, (rus)

4. V. Medennikov, L. Muratova, S. Salnikov, "Analysis of the effectiveness of the information and consulting service (ICS) ", VIAPI, Moscow, 2002, (rus)

CONCEPTUAL APPROACHES TO FORMING A UNIFIED DIGITAL PLATFORM OF AGRARIAN SCIENTIFIC AND EDUCATIONAL RESOURCES

Kulba V.V., Medennikov V.I.*, Flerov Y.A.*, Salnikov S.G.**
Institute of Control Sciences of the Russian Academy of Sciences, *Federal Research Center ”Informatics and Control” of the Russian Academy of Sciences, **VIAPI n.a. A.A.Nikonov the branch of FSBSI FSC AESDRA - VNIIESH
+7 (916) 680-73-29, dommed@mail.ru

Abstract— The article discusses conceptual approaches to the formation of the information Internet space of scientific and educational resources on the basis of a single digital platform, the need for which is associated with an exponential increase in the volume of information in education and science, which has appeared to create new information technologies that ensure the efficiency of extracting the necessary knowledge, as well as the need in these resources, not only traditional users represented by scientists, students and teachers, but also Other applicants and employers, government agencies, producers, business, management, and other categories of the population.

Keywords: digital platform; scientific and educational resources; internet space.

INTRODUCTION

Currently, the world is undergoing a transition to a digital economy, requiring the integration of both information resources and information systems. This is achieved through the formation of standards for the presentation of information resources, management functions, as well as through an integrated approach to the design, development and implementation of information systems, the training of relevant specialists.

Today, the country is dominated by a “task-based” method of developing and implementing software, when various manufacturers purchase separate software systems that are neither functionally nor informationally related to each other. But the main thing is that these "ready-made" software systems due to the lack of standards for the presentation of information resources, management functions, processing tools and their implementation; poorly take into account or do not take into account the requirements and specifics of tasks solved within the framework of user organizational systems. This approach currently exacerbates the problems of digital transformation and the integration of information resources and IP in the transition to a digital economy and, in essence, means the use of outdated technologies more familiar to many heads of IT departments. This view can be expressed in the words of W. Churchill "Generals always start a war by old methods." As a result, most industries found themselves at different levels of integration of information systems, while a huge number of isolated and functionally incompatible local information systems appeared, which would hinder their integration into a single system in order to implement the Digital Economy Program.

The article discusses methodological approaches to solving these problems by forming a single information Internet space of scientific and educational resources in the transition to a digital economy using the example of agriculture.

PROBLEM STATEMENT

In connection with the exponential growth of information volumes in specific areas of activity, problems arose in creating new information technologies that provide the opportunity to extract the necessary knowledge. These problems have gained particular importance in the field of information accumulation in education and science, the subsequent transfer of knowledge to the economy, since at present such a paper system has been destroyed.

In this regard, the objective objective is the formation of a single information Internet space of scientific and educational resources (EIIPNOR), which will be in demand both in the process of supporting scientific research and in increasing the effectiveness of education at all levels. Such a space, in our opinion, should become an instrument for resolving the contradiction between the volumes of accumulated knowledge and the possibility of their effective use.

Such a task, of course, is the most important component of the digital economy program, since research and development are an important area of influence on economic growth, one of the sources of the most valuable strategic resources - human capital and knowledge, which determines the level of socio-economic development of society associated with the advent and use of the Internet with all its attendant technologies, which made it possible for an unlimited number of users to access various information systems to the topics, and also significantly expanded the range of automated tasks. At the same time, it became possible to integrate various information systems and information resources not only in individual organizations, but also across industries, countries and the entire world community.

The lack of integration technologies in the development of databases (DB) of various informational scientific and educational resources (INOR) leads to a significant overrun of resources and confuses an ever-increasing number of potential users when searching for the necessary information. For example, the state spends significant resources on the development and maintenance of the INOR database: “The unified state information system for recording the results of research, development and technological work for civil purposes (EGISU R&D)”, the database of the Federal Institute of Industrial Property (patent documents, trademarks, industrial designs, computer programs, databases and integrated circuit topology) and Elibrary.ru, which have a heterogeneous representation and a rather narrow purpose, respectively, specific audience. The purpose of the first database is obvious from the name. R&D is presented here in the form of scientific reports made for budgetary funds. The second goal is to register the above developments without the possibility of familiarization with them. The third goal is to create a national scientific citation index (RSCI) with the prospect of using it to evaluate the results of scientific work of scientists or research teams. However, the narrow focus of these databases, mainly on the accounting function, generates the heterogeneity of their structures, making them unclaimed for a wide range of users who want to have a convenient system for acquiring knowledge. Unfortunately, valuable and relevant information from Russian scientific foundations and federal target programs is also practically inaccessible for use in the innovation sphere.

The roots of this process lie in the absence of an integration approach in the design and development technologies of information systems in our country, as a result of which a hodgepodge of tens, and then hundreds and thousands of isolated and functionally incompatible local control systems at plants, factories, and agricultural enterprises appeared. The failure of the national network project, based on the typification and integration of information systems, proposed by academician Glushkov V.M. also played a negative role. [1, 2] to create a nationwide automated system (OGAS) in the 60s of the twentieth century. Although significantly increased capabilities and the level of development of Internet hardware and software currently allow to realize the ideas of V. Glushkov. fully.

The transition to integrated information systems in the Russian Federation is complicated by a number of circumstances - the lack of intellectualization of the Internet, i.e. the lack of tools for the development of mathematical models by providers, statistical information processing, expert systems, etc. online.

SOLUTION OF THE PROBLEM

At present, Russian research institutions (research institutes) and higher education institutions are normatively forced to develop their sites, for example, as mentioned above, in the

Russian Federation, the Ministry of Education and Science and Rosobrnadzor have put forward requirements for the content of the sites of universities. True, this does not apply to INOR yet, and there are no requirements for the websites of the research institute. Those in our country who are not obligated to this, as a rule, calmly ignore these resources.

An analysis of the sites of research institutes, universities, information and consulting services made it possible to identify seven types of research and development that are present in one form or another on these sites: development, publication, consulting activity, regulatory information, distance learning, application software packages (DBP), and databases. It is these types of representations of scientific knowledge that are most in demand in the economy [3].

Moreover, the improvement of Internet technologies allows them to be integrated, again on the basis of ontological modeling, into a single information Internet space of scientific and educational resources from a single scientific and methodological position with a simple navigation system understandable to any user with the placement of information resources in the cloud under control powerful database management system based on common classifiers, such as the State rubricator of scientific and technical information and the All-Russian product classifier [4, 5 , 6].

For example, the implementation of EIIPNOR will make it possible to fulfill the wish of one farmer who, when examining agricultural organizations for the effectiveness of the information and advisory services, said: “I would like a system in which I could quickly find, for example, a development in the form of a means to combat any disease plants, animals, then immediately get all publications, all consultants, regulatory information on this topic, distance learning on the use of the drug with analysis of all consequences of the decision. Then in the appropriate database to find the right supplier of the drug with minimizing the cost of acquisition and delivery".

The possibility of creating a single information Internet space of scientific and educational resources was tested on the basis of economic and mathematical modeling, as well as practical implementation in the development of the portal of the Russian Academy of Agricultural Sciences in 2007-2008. It was established: 12321 publications, 2541 development, 444 consultants for consulting activities on the topic. At that time, there were significantly fewer publications in the Elibrary database, there were no other types of scientific and educational resources, and at the moment there are no [7]. Lack of funds and science reform forced to stop these works.

The model presented three possible options for such integration. In the first version, it is supposed to transfer to a single database from a single provider of catalogs of information arrays. Upon successful search for the necessary information in the catalog, the user is sent to a site that stores full-text or more detailed information. The second option reflects the situation when all the information is transferred to a single provider. In the third version, part of the information is transferred in the form of catalogs, and part is completely. In tab. 1 shows possible options for such integration.

TABLE 1. OPTIONS FOR INTEGRATING INFORMATION INTO EIIPNOR

EIIPNOR Integration Levels	University sites	Advantages	Disadvantages
Migrating directories only	The site displays only directories in a common format	Unambiguous understanding of information by all users, simplicity and ease of search	Ontological compatibility issues with other information
Full transfer of all types of INOR in the	The site is a subsection of	Significant savings on site maintenance,	Problems associated with dependence on

form of a catalog and full-size representation	EIIPNOR, INOR is displayed in a common format, the design of the remaining sections of the site may be original	a clear understanding of INOR by all users, simplicity and ease of search	one provider, information security risks
Partial transfer of some types of INOR	A number of different INORs may not be transferred entirely due to corporate interests	Storage of only intolerable INOR, the ability to preserve certain interests	Support for two sites with a sharp increase in costs

Computational experiments on the formation of a single information Internet space of scientific and educational resources [7] showed that the technical and software capabilities of providers that provide services for developing sites on the most common 1C-Bitrix tool currently allow at least all information to be transferred , all agricultural knowledge accumulated over the past 5 years, to one of them as part of the provider's allocated bandwidth. Savings only on the development and maintenance of sites will exceed 1 billion rubles a year due to the integration and typification of a site development system.

The requirements for university sites by the Ministry of Education and Science, Russian Federal Supervisory Authority, branch ministries for assessing the activities of educational institutions, make these sites become more and more alike. The day is not far off when universities should go to standard sites. And this is the first step to creating a single information Internet space of scientific and educational resources. When standard sites were introduced in universities and research institutes and their integration with this space, INOR would automatically fall into EIIPNOR, and from there into the Elibrary database, which would turn into one of the EIIPNOR service subprojects, similar to the RePec (Research Papers in Economics) project [8, 9].

The RePec project is characterized by a systematic approach that allows free access in the world network to the information resources of scientific papers on economics published in the world.

RePec is a project based on the joint work of hundreds of volunteers from 93 countries to expand the dissemination of research in the field of economics and related sciences. The center of the project is a decentralized bibliographic database of scientific papers, reports, documents, journal articles, books, book chapters and software products published around the world. RePec can be called a single information space for economic research on a global scale.

RePec is currently the world's largest online collection of working papers, journal articles, and economic software products. It also contains databases on organizations and authors in the field of economics. The demand for such a project is evidenced by the fact that in September 2017, users uploaded 441,497 document files and viewed 1,657,039 annotations, and in total, from January 1998, downloaded 97,933,110 files and viewed annotations 393,736,069.

This project allows for a scientometric approach, a quantitative assessment of the role of scientific organizations, publications and their authors in the world in a particular field of economic research, to calculate various ratings of scientific research in the field of economics and related fields, to evaluate the effectiveness of scientific activity in a certain field of or another organization, author, serial publication by ranking among the largest possible number of such organizations, publications, authors in the global context, determine the dynamics of the impact factor s of various publications, authors' h-indices, the number of citations and their ranking with open access to these data in the global network, which makes it possible to adequately assess the subject's place in world science. This feature is implemented using various RePec service subprojects located in various databases. RePec website provides links to these databases [8, 9].

Thus, we can conclude that in large Western universities, authors do not submit complete lists of their publications on the pages of their faculty website, but prefer to provide links where their works can be viewed in full. In fig. 1 shows the functional structure of EIIPNOR with a list of various subprojects-services, the number of which will constantly increase with the accumulation of information.

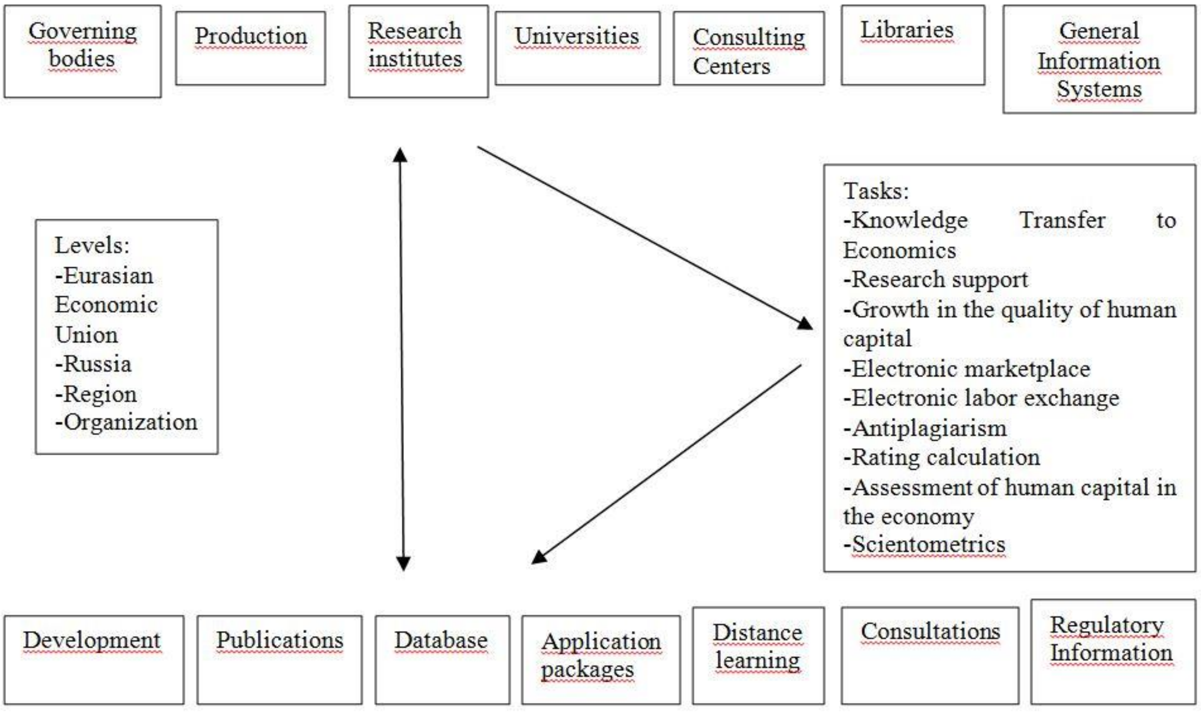


Fig.1 Functional structure of EIIPNOR

CONCLUSION

The transition to the platform of a single information Internet space of the country's scientific and educational resources is one of the urgent tasks in the framework of the transition to the digital economy and will significantly (tenfold) reduce the cost of developing, implementing and maintaining information systems in science and education. The proposed platform will be a powerful tool for bringing the most effective innovative solutions to the economy.

As it develops on the basis of EIIPNOR, it will be possible to assess the impact of human capital on the social well-being and development of Russian society, introduce elements of artificial intelligence, analytical work, and allow the development of an independent, low-cost, automated methodology for evaluating the activities of universities and research institutes, in particular, the effectiveness of INOR, a unified, both for universities and research institutes, due to the presence of measurable and comparable indicators located in a single cloud database.

ACKNOWLEDGMEN

This work was supported by RFBR (grant № 20-07-00836)

REFERENCES

1. Benjamin Peters: How Not to Network a Nation: The Uneasy History of the Soviet Internet. MIT Press, США, 2016.

2. V. Glushkov, “Macroeconomic models and principles of building the OGAS”, Statistics, Moscow, 1975, (rus)

3. V. Medennikov, L. Muratova, S. Salnikov, “Analysis of the effectiveness of the information and consulting service (ICS) ”, VIAPI, Moscow, 2002, (rus)

4. V. Medennikov, L. Muratova, S. Salnikov, V. Luppov, A. Lichman, “Models and methods for the formation of a single information Internet space of agricultural knowledge”, GUZ Publishing House, Moscow, 2014, (rus)

5. F. Ereshko, V. Kulba, V. Medennikov, “Integration of the digital agribusiness platform with digital platforms of related industries”, Agribusiness: Economics, Management, 2018, No. 10, pp. 34-46, (rus)

6. A. Zatsarinny, “Digital platform for scientific research”, Materials of the International Scientific Conference “Mathematical Modeling and Information Technologies in Engineering and Business Applications”, Voronezh State University Publishing House, 2018, pp. 104-113, (rus)

7. V. Medennikov, L. Muratova, S. Salnikov, V. Luppov, A. Lichman, “Methodology for assessing the effectiveness of the use of informational scientific and educational resources”, Analyst, Moscow, 2017, (rus)

8. LNCS Homepage, http://repec.inecon.org/, last accessed 2019/10/10.

9. LNCS Homepagehttp://logec.RePec.org/scripts, last accessed 2019/10/09.

Section 2
INFORMATION TECHNOLOGIES IN SCIENCE AND INDUSTRY

INTERMEDIATE PRE-PRE-AMPLIFIER FILTER IN THE RECEIVING LINE OF THE EARTH RADIO FREQUENCY MONITORING SYSTEM

Andreev I.S., Gladkiy D.A., Ivanov V.S.
RTU MIREA
+7(916)798-11-41, ilyxa.andreev@mail.ru

Abstract— The article is devoted to the development of a filter of a preliminary amplifier of an intermediate frequency in the receiving path of the radio frequency monitoring system of the earth's surface, constructed on the principle of a superheterodyne type receiver. The solution to the problem is to find a compromise solution to create a receiver with greater sensitivity, selectivity, as well as a wide range of instant viewing.

Keywords: intermediate preamplifier, intermediate preamplifier, radio frequency monitoring, superheterodyne receiver.

INTRODUCTION

Currently, electronic equipment is being intensively developed and improved. It is effectively used in almost all spheres of scientific and industrial activity, the national economy, military industry, it is used in medicine and in everyday life. Due to a significant increase in the quality, reliability and cost-effectiveness of many types of manufactured electronic equipment, reduction of material consumption and energy consumption, electronics has become widespread not only in ground systems, but also on the decks of ships, onboard aircraft and, in particular, in spacecraft. Today without radio-electronic systems it is impossible to realize communication, to control objects located in near-Earth space. With the increase in the number of various electronic equipment, it became necessary to carry out radio frequency monitoring.

To characterize the monitoring and control of processes in various industries and other spheres of human activity, the term "monitoring" is the most popular.

Radio frequency monitoring is the most effective tool for obtaining objective information about the state of the electromagnetic environment as a whole, as well as the real state of the use of radio frequency intelligence by the state. To ensure increased regulatory efficiency in the use of radio frequency reconnaissance, the introduction of new radio technologies, complexes, standards and communication services in a market economy, this information is irreplaceable.

PROBLEM STATEMENT

Radio frequency monitoring systems of the Earth’s surface are most often located on artificial Earth satellites in relatively low orbits (about 1000 km). When designing and developing receiving devices for such systems, high demands are placed on the sensitivity of the receiving devices [1]. In addition, humanity is actively using a wide range of radio frequencies for various purposes, which makes signal reception difficult.

SOLUTION OF THE PROBLEM

Therefore, the most commonly used scheme is a superheterodyne receiver, which has established itself due to its high sensitivity and selectivity. The following scheme is proposed for using superheterodyne receivers in RF monitoring equipment (Fig. 1).

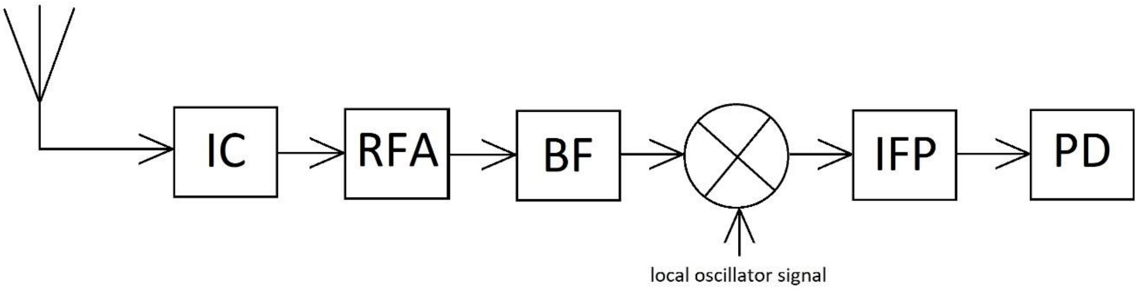


Fig. 1 Block diagram of the receiving path

Where IC is the input circuit, RFA is the radio frequency amplifier, BF is the bandpass filter, the IFP is the intermediate frequency preamplifier, and the PD is the processing device.

Since the entire receiving path is designed for conducting radio frequency monitoring in a wide frequency range from 120 MHz to 540 MHz, and the signals are received at a sufficiently large distance from radio sources, it is necessary to divide the entire range into narrower intervals to maintain a given sensitivity. Therefore, one of the key tasks in the development of superheterodyne-type receivers is the development of a narrow-band filter located in a preliminary amplifier of an intermediate frequency [2]. This intermediate frequency amplifier is called preliminary, because after it is placed another intermediate frequency amplifier. This design is done due to the fact that in satellite systems for radio frequency monitoring for different frequency ranges different antenna devices are used, each of which has its own receiving path, and hence its own intermediate frequency preamplifier. But the monitoring of signals is carried out sequentially, that is, these channels are connected in turn. This allows you to achieve the smallest weight and size parameters, as well as to provide higher reliability using an intermediate frequency amplifier for one receiver, and not in each channel.

Due to the fact that the filter and amplifier are a single device (more on this below), such an amplifier is often called an active filter. With it, an intermediate frequency amplification of 40 dB is achieved, as well as the required selection to select a narrow frequency band (20 MHz) to view a sufficiently large range of frequencies in real time. The optimal value of 20 MHz is a compromise value so that the instantaneous viewing band is wide enough, but at the same time, the receiver sensitivity remains high (about 125 dB / W).

Since the IFP forms the passband of the IF path and provides the required gain, its structural diagram can be represented as follows (Fig. 2).

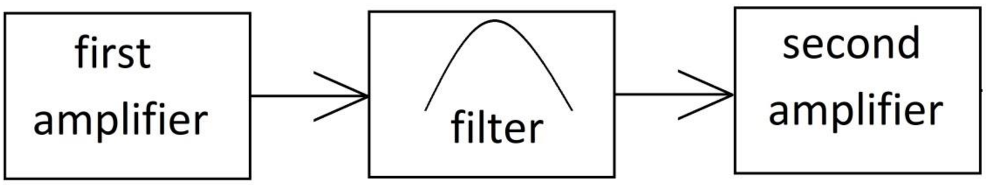


Fig. 2 Block diagram of an intermediate frequency preamplifier

The electoral system or filter should be U-shaped and have a frequency band of 60 to 80 MHz. Creating such a selection system with a narrow passband, we will scan the entire frequency range from 120 to 540 MHz.

The selectivity of the receiving system at the intermediate frequency is easiest to provide with two resonant connected circuits. Moreover, as you know, any filter has certain characteristics only for a certain resistance (input and output) for which it was calculated. If the resistance at the input of the filter or at its output does not correspond to certain calculated values, then the filter characteristics will deviate from the calculated ones, and in the worst case, the filter will cease to function at all.

Therefore, it is important to provide so-called filter buffering [3]. This is done so that the output impedance of the first amplifier (or buffer element) is consistent with the input impedance of the filter, and the output impedance of the filter is sufficiently consistent with the input impedance of the second amplifier (buffer).

In practice, these buffers are amplifiers (or transistors). The main idea is that the complex resistances of the transistors are significantly higher than these resistances, which guarantees the stability of the frequency response and phase response.

For high selectivity and ensuring a good coefficient of rectangularity, a system of coupled circuits is used. Two circuits are called connected if the processes that occur in one of them affect the processes in the other. There are many types of circuit connections, but the external capacitive one, which is shown in the figure, is more stable (Fig. 3).

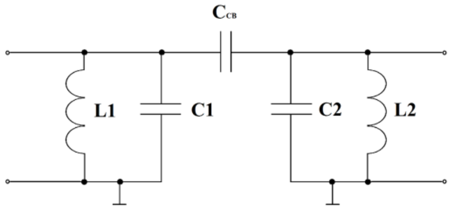


Fig. 3 Dual circuit system with external capacitive coupling

The degree of influence of the contours on each other is determined by the coupling coefficient (K_{coup}). It is found by the formula (1):

$$K_{coup} = \sqrt{K_1 K_2}\,, \tag{1}$$

where K_1 and K_2 are the coupling coefficients of the first and second circuits. They are determined by the following formulas (2 and 3).

Calculations and simulations were carried out in the Microwave Office (MWO) program, which is included in the popular software product used for the design of electronic devices, AWR DESIGN ENVIRONMENT (AWRDE). In this program, it is possible to synthesize a filter according to specified parameters. Those. the type of filter is set, the connection between the circuits, the required intermediate frequency (in this filter is 70 MHz), the passband. Manipulating the values of the elements, we select the most suitable. We add optimization parameters and achieve the best performance. The filter circuit of the intermediate-frequency pre-amplifier designed in the MWO program is shown in Figure 4.

$$K_1 = \frac{C_1}{C_1 + C_{CB}} \tag{2}$$

$$K_2 = \frac{C_2}{C_2 + C_{CB}} \tag{3}$$

where C_1, C_2 and C_{CB} - capacities of the corresponding capacitors.

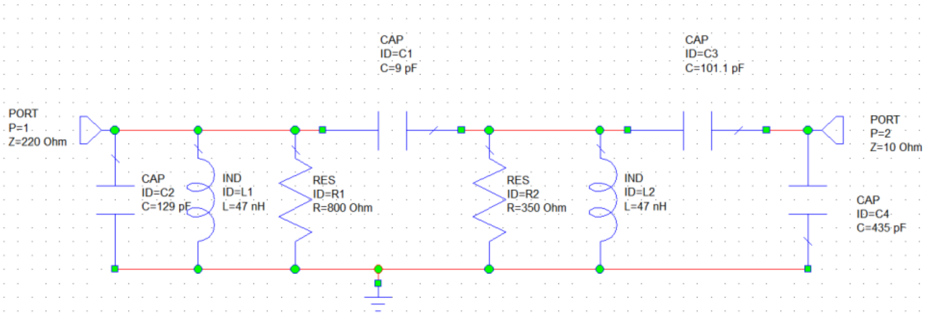


Fig. 4 Intermediate frequency pre-amplifier filter circuit

Depending on the coupling coefficient of the two circuits, the required characteristics can be achieved. First, the first circuit is set up taking into account the influence of the second one through capacitive coupling. Then the same thing is done with the second circuit. As a result, by manipulating the coupling coefficient between two connected loops, optimum values are achieved. The resulting amplitude-frequency response of the filter is shown in Figure 5.

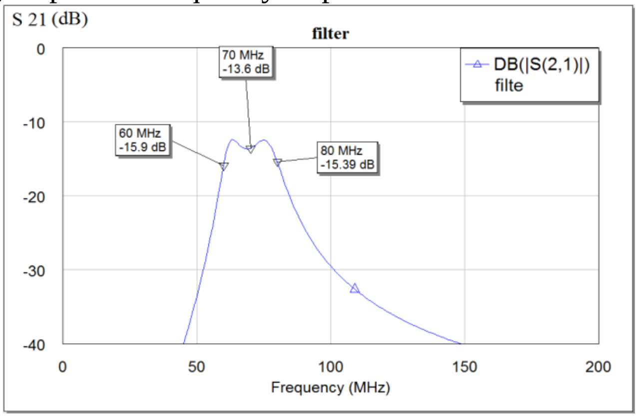


Fig. 5 Frequency response of an intermediate frequency preamplifier filter

CONCLUSION

This paper demonstrates the development of an intermediate-frequency pre-amplifier filter in the receiving path of the Earth surface radio frequency monitoring system using the Microwave Office software for designing electronic devices. The resulting bandwidth of 20 MHz is quite large, but still not limiting. By increasing this characteristic, the time for sequential viewing of the entire range is reduced. Improving the elemental base of the first stages of amplifiers in the receiving path and reducing their noise figure can further increase the bandwidth, while maintaining the sensitivity of the entire system at the proper level.

REFERENCES

1. Rembovsky A.M., Ashikhmin A.V., Kozmin V.A. Radio monitoring. Tasks, methods, tools. M.: Publishing. Hotline - Telecom, 2012.
2. Znamensky A.E., Lotkova E.D. Highly selective filters with transistors. M.: Publishing. Communication, 1967.
3. Mattei D.L., Young L., Jones E.M.T. Microwave filters, matching circuits and communication circuits. M.: Publ. Communication, 1972, translation from English. edited by Alekseev L.V., Kushnira F.V.

PHYSICAL AND TECHNICAL FEATURES OF SIGNAL CONVERSION IN THE MICRO-OPTICAL-MECHANICAL SYSTEM OF FIBER-OPTIC PRESSURE SENSORS

Badeeva E. A., Badeev A. V., Khasanshina N. A., Motin A. V., Chukareva M. M.
Penza State University

Abstract – In Russia, work is underway to create and improve various fiber-optic information and measurement systems. This involves the development of a specific component base-fiber-optic pressure sensors. Sensors are being developed based on new principles of signal conversion in a micro-optical-mechanical Converter system. Physical and technical features of signal conversion in the micro-optical-mechanical system of fiber-optic pressure sensors are investigated. Methods for modulating the intensity of optical signals in fiber-optic converters have been developed. Signal modulation consists in changing the ratio between the area of the illuminated surface of the receiving ends of optical fibers and the cross-sectional area with uniform illumination of the light flux. Differential conversion of optical signals directly in the zone of perception of measuring information is proposed.

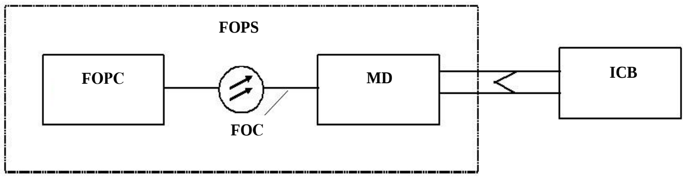
Keywords: fiber-optic pressure sensor; micro-optical-mechanical system, signal conversion, measuring converter, micro-displacement, optical-modulating element, light flux, differential conversion

Innovative development of modern science and technology in Russia is aimed at creating new safe devices for use in construction, medicine, the aerospace industry, shipbuilding, nuclear power plants and other areas of the national economy. Work is underway to create and improve various fiber-optic devices, systems, their components, and technologies for manufacturing optical fibers themselves. Fiber-optic information and measurement systems (FOIMS) are being developed. FOIMS are distinguished by the use of fiber-optic cables (FOC) as a physical medium.

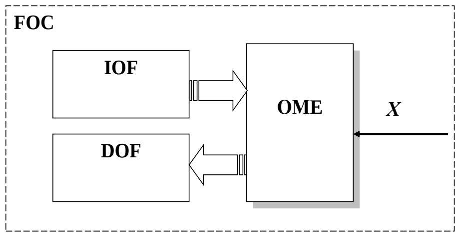
This ensures more efficient use of measuring information about the state of the object in comparison with electrical data in conditions of electromagnetic interference, increased spark and explosion hazard, radiation and other harmful environmental influences. The creation and implementation of VOIIS at domestic facilities involves the development of a specific component base and, first of all, fiber-optic sensors (FOS) of various physical quantities. Pressure measurements occupy one of the leading positions among other physical quantities. A fiber-optic pressure sensor is a set of fiber-optic converters (FOPC).

Fiber-optic sensors are developed based on the proposed principles of converting optical signals in a micro-optical-mechanical system of FOPC. They are based on the block-modular construction principle. This principle allows you to determine the technical characteristics of individual converter units at the design stages. This will improve the metrological and operational characteristics of the FOS in general. In the developed pressure sensors, the designs of the FOC, FOPC and ICB are unified (figure 1, a)).

Linear and angular micro-displacement converters are developed as basic elements. Their principle of operation is based on changing the intensity of optical signals under the influence of the measured pressure. The converter is a structural and technological set of incoming and diverting optical fibers (IOF and DOF) and an optical modulating element (OME) located in a certain way relative to each other (figure 1, b)).



FOPC-fiber-optic pressure converter, FOPS-fiber-optic pressure sensor, FOC-fiber-optic cable,
MD-matching device, ICB- information conversion block



VOC-fiber-optical converter, IOF - incoming optical fibers,
DOF - diverting optical fibers, OME-optical modulating element

a) block-modular principle of building a fiber -optic sensor b) unification of the converter

Fig. 1 Diagrams of the fiber-optic converter and pressure sensor

The light flux in the optical system of the pressure sensor cconverter is distributed as a hollow truncated cone. There are sections with uniform light distribution (figure 2). This allowed us to develop methods for modulating the intensity of optical signals in a fiber-optic cconverter. Signal modulation consists in changing the ratio between the area of the illuminated surface of the receiving ends of the fibers DOF and the annular or ellipsoid zone of the cross section with uniform illumination of the light flux. The illuminated zone is formed by the light stream coming from the radiating end of the fiber, in the far-range diffraction zone, and changes depending on the position of the OME. The element OME is a mirror-reflecting surface of various attenuators, spherical and cylindrical lenses.

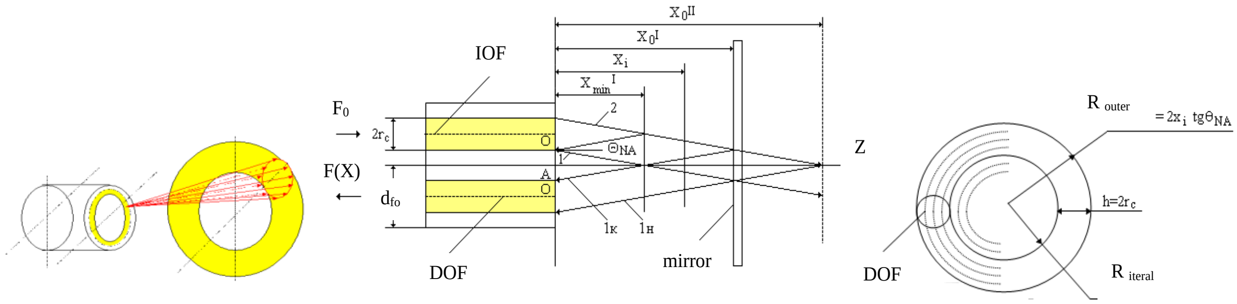


Fig. 2 Formation of a ring zone at the exit of the optical fiber

For a cconverter with a mirror surface, the optical signal intensity is modulated by moving the illuminated reflecting surface (figure 4). The light rays from the IOF-fibers pass the distance Xi to the mirror and back to the DOF-fibers at an aperture angle to the optical axis of the optical fiber. In this case, an illuminated annular zone with a width equal to the diameter of the optical fiber core is observed in the plane of the DOF-fibers.

If the mirror moves in the X direction relative to the ends of the optical fibers, the position of the ring zone relative to the DOF-fiber changes in the Z direction, which leads to a change in the area of the receiving end of the OV illuminated by the reflected light stream. The mirror moves in the X direction relative to the ends of the optical fibers. This changes the position of the ring zone relative to the DOF-fiber in the z direction. This leads to a change in the area of the receiving end of the DOF-fiber illuminated by the reflected light stream.

Modulation of the intensity of the light flux in a fiber-optic converter, when the illuminated mirror reflecting surface moves at an angle α relative to the ends of the optical fibers, occurs in a similar way. Only in this case, the annular zone is transformed into an ellipsoid zone, which is shifted relative to the fibers in the z direction. For a converter with reflective attenuators, the optical signal is modulated by moving the mirror and absorbing surfaces of the attenuator in the Z direction relative to the ends of the fibers.

Differential conversion of optical signals directly in the measurement zone by dividing the light flux into two light streams using a differential element of the OME is proposed. Measurement conversions are performed independently in the first and second measurement channels (MC), which eliminates errors inherent in fiber-optic sensors on the modulation of the optical signal intensity. Figure 3 shows the relative changes in the intensity of light flows from moving the OME in the transverse direction Z:

- F1/F0=f(Z) (section I) of the first measurement channel,
- F2/F0=f (Z) (section II) of the second measurement channel in the measurement range for the micro- displacement converter.

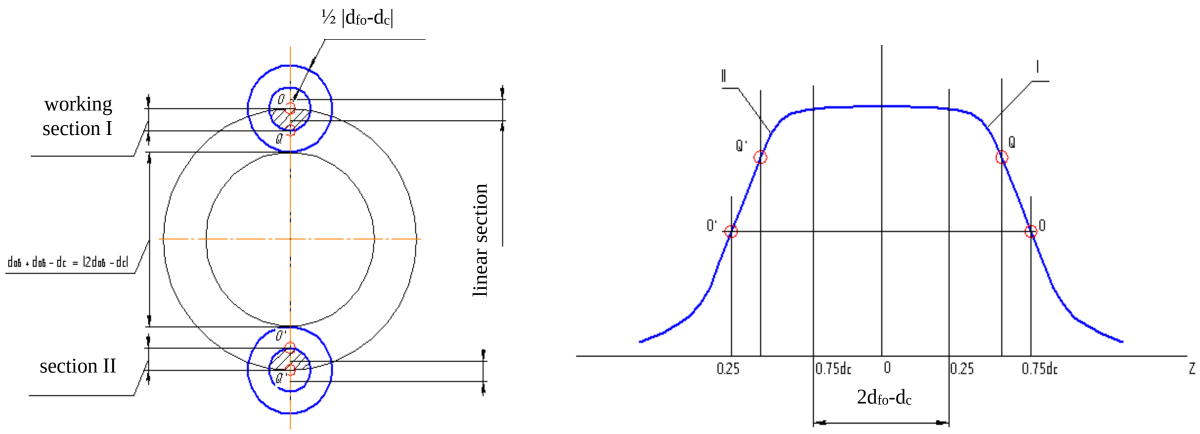


Fig. 3 Relative change in the intensities F1/F0=f (Z) (section I) and F2/F0=f(Z) (section II) of the light flux in the fiber-optic converters in the region of the receiving ends of the diverting optical fibers

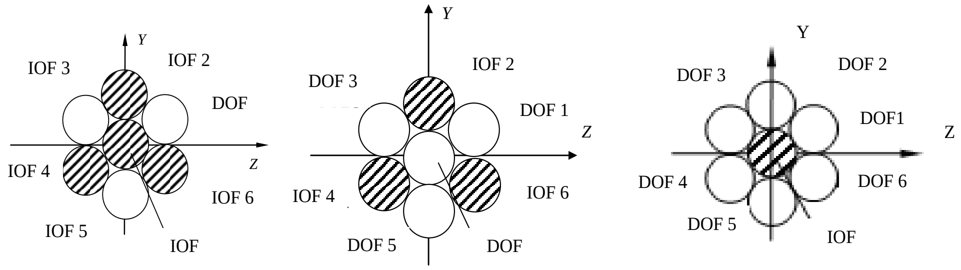
Function graphs have non-linear sections at the start and end of the measurement ranges of the first and second measurement channel. This is due to a significant change in the area of the illuminated surfaces in the plane of the location of the diverting optical fiber.

By cutting off nonlinear sections of the conversion functions, you can increase the linearity of the dependencies F1/F0=f (Z) and F2/F0=f(Z) and the depth of modulation of optical signals. This is possible by changing the design parameters of the micro-displacement converter:

- changing the distance between optical fibers and OME;
- changing the design parameters of the OME (for example, the radius of the attenuator hole, the diameter of the lens, etc.).

An important element of the implementation of the differential scheme is the requirement of independence of the two measurement channels. This is possible if there is a horizontal line connecting the dependencies F1/F0=f(Z) and F2/F0=f(Z) on the graph. In this case, the light flux of the first measuring channel does not enter the diverting optical fiber of the second measuring channel. And the light stream of the second measuring channel does not enter the diverting optical fiber of the first measuring channel. The distance between the optical axes of the diverting optical fibers of the two channels must be equal $[(2d_{fo} - d_C) + 0{,}5d_C]$.

Several variants of the fiber layout at the end of the cable have been developed (figure 4). The analysis of the influence of the relative position and quantitative ratio of the input and output optical fibers in the space of the converter on the process of distribution of the light flux is carried out. The results of modeling in the MathCad system with OME in the form of a mirror surface are shown in figure 5.



a) *b*) *c*)

Fig. 4 Geometric constructions to substantiate the relative position of the input and output optical fibers in the bundle

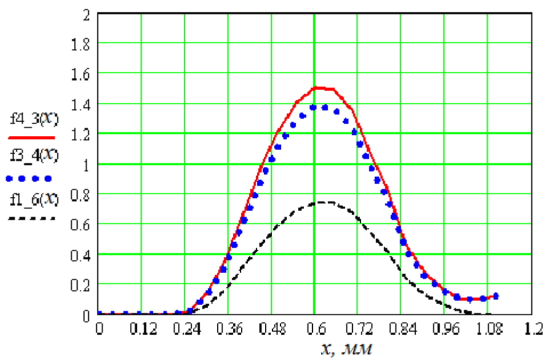


Fig. 5 Results of modeling a fiber-optic linear micro-displacement converter of a reflective type

Based on the results of the simulation, the following conclusions are made:

1) the maximum intensity of the light flux corresponds to the movement of the center of the membrane in the range W=3d_c…3,5d_c,

2) the maximum intensity value for the model exceeds the intensity value for the model by only 7%. Therefore, it is advisable to use both models when designing sensors.

Conclusions are made for a fiber-optic pressure converter with a limit attenuator:

1) the most effective insertion of optical radiation into the diverting optical fiber is achieved at l_1=1,53 mm and l_2=1,37 mm;

2) when the number of diverting optical fibers is equal to 6, the radiation receiver receives a greater amount of optical power than when a smaller number is used, for example, two;

3) for physical implementation, an attenuator with a round hole is recommended, as it is more technologically advanced in manufacturing.

CONCLUSION

The theory of light flux conversion in the optical system of fiber-optic converters is refined, based on the actual physical features of its distribution in the far diffraction zone after leaving the end of the incoming optical fiber in the form of a hollow truncated cone and determining the location of sections with a uniform illumination distribution. Physical and technical features of signal conversion in the micro-optical-mechanical system of fiber-optic pressure sensors are investigated.

The theory of differential conversion of optical signals is developed.it is based on the formation of two or more independent light streams from one radiation source in the measurement zone by using differential ohms that move under the influence of the measured pressure relative to the ends of the optical fibers of the two measuring channels.

The differential scheme of the optical system allows you to reduce by 2...3 times the majority of additional errors of the FOIMS system (the total error in severe operating conditions is not more than 3 %), and reduce the influence of radiation (when the transparency of optical fibers changes by no more than 20 %) on the measurement result.

ACKNOWLEDGMEN

The research was carried out with the financial support of the Russian Foundation for Basic Research (RFBR) in the framework of the scientific project No. 18-38-20045

REFERENCES

1. Murashkina T.I., Badeeva E.A. Fiber-optic devices and systems: scientific developments of the STC «Nanotechnologies of fiber-optic systems» of the Penza State University. Part I: monograph.: Saint Petersburg. -2018. - p. 187.

2. Rubtsov I.S., Murashkina T.I., Badeeva E.A. Main trends in improving sensor equipment // Actual problems of protection and safety: Tr. 17th all-Russian scientific and practical conference. – SPb.: RARAN publishing house, 2015. - Vol. 8. - pp. 119-120.

THE ROLE OF CLUSTER TECHNOLOGIES IN THE MODERN WORLD

Bocharov Dmitry Alekseevich
Federal State Institution of Higher Education «Russian University of Transport»
+7 (915) 279-83-18, i2t@diag.ru

Abstract – The article presents the history of the emergence, development, implementation of cluster technologies and systems, often called "supercomputers". The main capabilities and advantages of operating the system are revealed. Models of formation and types of cluster systems are considered.

Keywords: cluster technologies; fault tolerance; virtualization technology; load balancing; high performance computing.

All the leading countries of the world are engaged in the development, implementation and implementation of cluster systems. Since the development of computer technology and with each stage of its operation, there is a need to increase the amount of computing power, performance and fault tolerance of a system that provides its resources to solve various problems. The development of communication technologies has made cluster systems publicly available.

In the conditions of the rapid development of the information society, information is one of the most important goods, since success in any field of activity, commercial or entrepreneurial, is associated with information systems whose work is based on local area networks. The availability of an operating system is in many cases an important and necessary factor. Over the past fifty years, networks and cluster technologies have developed at a rapid pace. This development allows all enterprise managers to use information resources to increase labor productivity and profits. By combining several interconnected independent devices into a single system to solve various problems, we got a cluster in the form of an independent unit.

The use of fault tolerance requires and involves the introduction of redundant hardware and software. Thanks to fault tolerance, it is possible to continue the functioning of the system after malfunctions occur.

The latest developments and technologies overwhelm the market. More productive components for personal computers and servers are produced, however, the relevance in using cluster technologies does not decrease, but is a priority decision.

Doing business in various fields contributes to the continuous growth and change of information technology. Various hardware and software tools are developed and implemented that allow more efficient management of the complex information infrastructure of the enterprise. Such tools include virtualization technology, which has rapidly become popular in various fields of application. It allows you to implement and run on physical servers or computers, many isolated from each other virtual operating systems. The use of cluster solutions based on virtualization technology opens up many different promising opportunities that tremendously increase flexibility, fault tolerance, work efficiency and the use of hardware resources. Cluster systems and virtualization technologies are used in various areas of IT infrastructure. This includes basic infrastructure, corporate mail, a single directory service, databases, file services, print management, functional systems of primary and secondary activities. Therefore, constantly increasing the computing power, flexibility and management efficiency, in order to ensure higher efficiency and productivity of an organization or enterprise of any level.

Often cluster systems are called supercomputers. At their core, they differ only in appearance and work in the same way, using the principle of parallel network computing. The main principle of cluster organization is to build a scalable cluster architecture, which is implemented from computing nodes, using many different components, such as memory modules, hard drives, motherboards and processors.

«A cluster is a type of parallel or distributed system that consists of several interconnected computers and is used as a single, unified computer resource», Gregory Pfister, one of the first architects of cluster technology, gave this definition to the cluster [7].

The development of the idea of combining computers into a cluster began in the early 80s thanks to Digital Equipment, which introduced the VAXCluster cluster operating on the basis of the OpenVMS operating system (OS) [7, 8]. In the 90s, the rapid development of cluster technologies began, associated with great interest shown by various developers and equipment manufacturers, such as: IBM, Hewlett-Packard, Sun, SGI, Fujitsu, Compaq, NEC, Dell, Hitachi, Intel and many others.

The first most successful project, revealing the success and efficiency of using cluster solutions in these years, is the Beowulf project, developed by Thomas Sterling and Don Maker. He appeared in the summer of 1994 at one of NASA's space centers - CESDIS (Center of Excellence in Space Data and Information Sciences). The assembly was a cluster of 16 486DX4 processors with a frequency of 100MHz and 16 MB of memory. On each node, 3 network adapters were installed connecting the nodes with each other using three "parallel" Ethernet cables with a data transfer speed of 10 Mbit. For functioning, specialized software was also developed, which includes high-performance network drivers. [1, 2]

In 1998, Michael Warren led the Avalon project. The cluster system was developed at the Los Alamos National Laboratory for work in the field of astrophysics. Initially, the Linux cluster worked on 68 DEC Alpha processors with a frequency of 533 MHz, then the number of processors was expanded to 140. Each node had 256 MB of RAM, one network adapter from Kingston and a 3.2 GB hard drive. The nodes were interconnected using four 36-port Fast Ethernet switches and a 12-port Gigabit Ethernet switch, developed by 3Com. The Avalon cluster performance was 47.7 GFlops. [3, 4]

The unit of measure for cluster power is Flops (floating - point operations per second) - the number of floating point operations per second.

GFlops (gigaflops) - a billion floating point operations per second.

GFlops (gigaflops) - a billion floating point operations per second.

The real cluster performance is the performance obtained when solving an academic or industrial problem. The systems in the Tor500 ranking are ranked according to the results of the LINPACK test - a real academic problem for solving a system of linear equations.

In the 21st century, cluster development work is not interrupted. Many countries compete among themselves, developing more powerful cluster solutions every year. In the 54th issue of TOP500 (November 2019), China and the United States lead in this area. [11]

The presented cluster systems have various fields of application, such as: cryptography, nuclear testing, determination and prediction of weather forecasts, DNA decoding, drug development, artificial neural networks, artificial intelligence, etc.

Thanks to modern developments, high-tech projects have been created and applied to organize work in various fields of activity.

CLUSTER SYSTEM FEATURES

From the history of the development of cluster systems, it follows that this product was developed and implemented mainly to provide the possibility of increasing the productivity and speed of computing processes. The developers sought to increase the speed of the system at all costs. With the development of society, modern organizations need much more opportunities from the implemented cluster system for organizing business and research. From the point of view of the majority of managers, investing a substantial share of finances for acquiring a system that provides small functionality is unjustified.

The development of cluster technologies has expanded and provided consumers with the following main opportunities [5, 6]:

1) The use of one software module to manage multiple hardware of an arbitrary number of nodes - as a rule, the organization of a cluster system is implemented using one software that provides all the necessary functionality for combining nodes into one system and its convenient management;

2) Carry out activities to add and improve both software and hardware resources, without stopping the operation of the entire cluster - after long-term operation of the equipment, there is always a need to add new nodes, replace RAM, hard disks with more productive or larger ones. In such situations, the usual system has to be stopped indefinitely, which entails a simple workflow, resulting in a decrease in profit and productivity of the enterprise. The cluster system is devoid of this drawback;

3) In the event of failure of one or more nodes, the continuity of the cluster is ensured, providing the ability to quickly replace or repair a failed system resource;

4) Ensuring data synchronization between all cluster units - all data that the cluster system works with is accessible to all nodes, thereby minimizing the problem of losing some important information in the event of a system failure or shutdown caused by unforeseen circumstances;

5) Efficient and flexible distribution of hardware resources between all decisions implemented on the basis of a cluster.

Various failures, the intervention of the operating or maintenance personnel in the operation of the resource should not affect users who are consumers of the resource.

Thanks to these capabilities, the operation of a cluster system becomes efficient, highly accessible and productive.

BASIC TYPES OF CLUSTERS AND FORMING MODELS

Depending on the purpose, there are three main types of clusters:

1) Failover - High-Availability cluster (HA). This type of system is often called a "high availability cluster", which is created to ensure continuous operation in the event of a failure or

failure of one or more nodes. Resuming operation, as a rule, does not affect the user's workflow, as it occurs within a few seconds or minutes, causing perhaps only slight delays when accessing the resource that was running at the time of the failure.

High availability is achieved through the use of hardware redundancy and virtualization technology. The construction of such a system involves the use of at least two independent nodes using a system for storing information data and providing guaranteed access to them.

Where the continuity of important databases, trading floors, banks, ensuring round-the-clock production and operation of business processes is required, this type of cluster system is used, gaining advantages in reliability, high availability of services and applications, reducing information loss and downtime.

2) Load balancing cluster - Also, these cluster solutions are called Network Load Balancing, which means “network load balancing”. The principle of operation is carried out using the TCP / IP protocol stack by uniformly sharing network traffic between all nodes of the system, thereby performing many different copies of the application on many nodes. The system administrator is given the opportunity to flexibly configure the load for each specific node. Using this type of cluster eliminates the situation when one server does all the work, spending a lot of resources and time on it, while all other servers are idle and unnecessarily consume electricity.

The distribution of requests between machines is carried out by one or more computing nodes located at the "input". This type of cluster system is used in data centers (DPC), ERP / CRM and telecommunication systems.

In the event of a failure of one or more nodes, a process called “convergence” occurs, which is an exchange of messages between all members of the cluster to determine the current state and membership of each node in the system. After the convergence process is completed, the load is redistributed between the remaining nodes.

3) Computing clusters are designated by the acronym HPC Cluster (High Performance computing cluster) - a high-performance computing cluster. By organizing a computing cluster, emphasis is placed on achieving maximum computing power, without providing for the use of systems that increase reliability and fault tolerance. This solution is used in educational, research organizations, analytics, artificial intelligence systems, neural networks. [9, 10]

The cluster is built using several nodes, since the performance of computing processes increases in proportion to the number of nodes added to the system.

High performance of the processor and a large amount of RAM are essential indicators for computing clusters. In the event of a failure or failure of one of the nodes, the main node distributing all the computing tasks will redistribute the load between the remaining network nodes and will autonomously try to resume the operation of the failed computing node.

In addition to the three main types of clusters, it is worth noting the distribution of computing systems, since their principle of operation is largely similar to cluster technology. Very often they are called Grid systems - a form of distributed computing in which a “virtual supercomputer” is presented in the form of many clusters connected using a high-speed network, working together to perform a huge number of tasks (operations, work, applications).

A grid system is an environment that is consistent, open, and standardized, providing flexible, secure, coordinated sharing of computing resources within a single virtual organization. This system, like other cluster systems, can be organized from ordinary personal computers or servers interconnected by a high-speed data network.

When forming cluster systems, two models are distinguished.

The first model is based on the use of a common data storage array, which provides the advantage of quickly switching and restoring the service in the event of a failure of one or more hardware resources ensuring the system is working. When using this model, it is worth considering that in the case of working with a very large database and using a large number of hardware units, a decrease in performance may occur. This is due to the increase in the time spent on the migration of resource-intensive services to another system node.

The second model - all involved nodes are independent of each other as well as their peripheral devices. In the event of an unexpected failure of one of the nodes, the redistribution is performed between the servers by manually or automatically starting the disconnected service on another server. In this model, the process of using a common database is complicated.

The choice of a specific type and model of a cluster is limited by the requirements for the functionality and architecture of the system being developed and implemented.

Modern enterprises can no longer be imagined without the organization of corporate information systems and networks in them. With each step to a new stage of development, a higher system reliability is provided and developed. The ability to create clusters by their characteristics can leave far behind even the most powerful stand-alone computers. The success of the functioning of the organization depends on the use of corporate services. Efficiency increases if employees and customers of the company can use the resources without interrupting the workflow. Today, competition between firms is very high and the quality of the services provided greatly affects the image and profits of the company.

REFERENCES

1. V. Voevodin, Supercomputers: yesterday, today, tomorrow // Journal: "Science and Life" – URL: https://www.nkj.ru/archive/articles/7365/.
2. S.V. Ablameyko, S.M. Abramov, V.V. Anishchenko, N.N. Paramonov, O.P. Siskin. Principles of building supercomputers of the Skif family / Joint Institute for Informatics Problems of the National Academy of Sciences of Belarus, Minsk; Institute of Software Systems of the Russian Academy of Sciences, Pereslavl-Zalessky. – URL: http://skif.pereslavl.ru/psi-info/rcms/rcms-publications/2004-rus/23-04.pdf.
3. A. Borzenko, Supercomputers / Virtual Computer Museum – URL: http://www.computer-museum.ru/histussr/super_comp.htm.
4. V. Kuznetsov, For the first time launched the most powerful supercomputer that simulates the work of the human brain / Hi-News.ru. – URL: https://hi-news.ru/technology/vpervye-zapushhen-samyj-moshhnyj-superkompyuter-imitiruyushhij-rabotu-chelovecheskogo-mozga.html.
5. Server cluster // STEC – 2018 – URL: https://www.stekspb.ru/autsorsing-it-infrastruktury/it-glossary/server-cluster/.
6. Clusters and clustering // ComputerPress – 2018. URL: https://compress.ru/article.aspx?id=11943.
7. Anoprienko A.Ya., Saint V.A. High-performance information-modeling environments for research, development and maintenance of complex dynamic systems // DonNTU – 2001, c. 346-367.
8. Nancy P. Cronenberg, Henry M. Levy, William D. Strecker, “VAXcluster: A Close-Coupled Distributed System” // ACM – 1986, 85 c.
9. V.A. Varfolomeev, O.L. Gutsu, Computing Clusters // Moscow – 2014, 35c.
10. G. I. Shpakovsky, A. E. Verkhoturov, N. V. Serikova, Guide to work on a computing cluster // Minsk BSU – 2004, 172 c.
11. TOP500List – URL: https://www.top500.org/lists/2019/11/.

AN AUTOMOTIVE INERTIAL-ODOMETRIC NAVIGATION SYSTEM WITH PERIODIC SATELLITE POSITIONING

Chernodarov A.V., Patrikeev A.P., Ivanov S.A.*
"NaukaSoft" Experimental Laboratory, Ltd., Moscow, Russia, *"Ramensky Instrument Engineering Plant", JSC, Ramenskoe, Moscow Region, Russia

Abstract — Special features of the functioning of navigation systems (NS) under urban conditions are considered. The object of studies was an NS built on the basis of inertial, odometer and satellite systems. The technology of integration of such systems is proposed. As a kernel, the inertial navigation system SINS-500NS based on fiber-optic gyros is included in this NS. The results of natural development of inertial-and-odometer NS with periodic satellite positioning presented in this paper are given and analyzed.

Keywords: inertial navigation system, fiber-optic gyros, odometer, satellite navigation system, Kalman filter.

INTRODUCTION

At present, the problem of increasing the accuracy characteristics of strapdown inertial navigation systems (SINS) under urban conditions of usage still remains topical. This results from the following difficulties of satellite SINS support under such conditions [1]: instability of information coming from satellite navigation systems (SNS) due to natural noise; signal re-reflection from buildings and urban structures; miss of signals due to shadowings and also in tunnels; coming of outlying signals when the satellite constellation is changed and when the geometry factor is bad. At the same time, the fact that in present-day motor vehicles, we have odometers, onboard computers, and also equipment for transmission, recording, and displaying of data about motion parameters allows us to construct an integrated inertial-odometer system of autonomous navigation. With the availability of additional information coming from an SNS, it is apparently possible to perform, in real time, dynamic calibration of an odometer and SINS sensors, namely: of gyros and accelerometers.

The purpose of this paper is to study the possibilities for the integration of an inertial system and an odometer one during their use under urban conditions, with due regard for the dynamic calibration of sensors, provided that information from the SNS is available.

In this paper, to achieve the purpose mentioned earlier, error equations for the integrated inertial-odometer navigation system have been developed, along with algorithms for inertial satellite, inertial-odometer, and odometer-satellite observations for their processing by the use of the extended Kalman filter (EKF) [2].

HARDWARE SUPPORT OF THE INERTIAL-ODOMETER-SATELLITE NAVIGATION SYSTEM

As an object intended for experimental development, use has been made of an inertial-odometer complex that includes a modernized version of the SINS-500NS inertial satellite navigation system [3] (see Fig.1), which was developed by the "NaukaSoft" Experimental Laboratory, Ltd. (Moscow); a motor-vehicle computer; the ELM-327 adapter [4] (see. Fig.2); tablet computer. The inertial measurement unit (IMU) of the above SINS-500NS system is built on the basis of fiber-optic gyros (FOG). The frequency of data updating and data recording on a flash memory built in the system is 1 kHz for the IMU, for odometer such a frequency is 10 Hz, and for a SNS and other external observations, such a frequency is 1Hz. Technological decisions that are considered in the present paper have been executed on a basis of the Linux real-time operating system which provides the support of a modular architecture of the SINS construction. The presence of a built-in flash memory

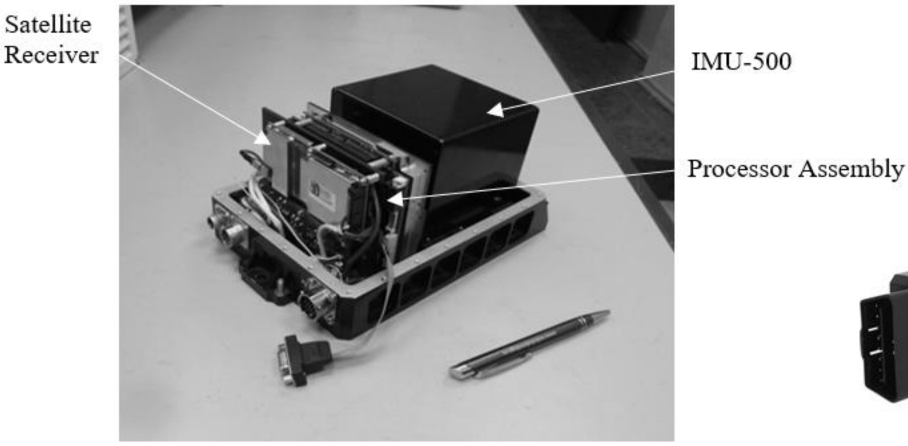


Fig. 1 SINS-500NS navigation system

Fig. 2 ELM-327 adapter

has made it possible to obtain and to analyze the recorded data with due regard for actual operating conditions. Furthermore, this has enabled the math-based software to be modernized and studied on a set of paths and the algorithms synthesized. The ELM-327 adapter is intended to interface a motor-vehicle computer with equipment for external data recording. The block diagram of the integrated inertial-odometer navigation system with satellite calibration and positioning is shown in Fig. 3, where MVC is a motor-vehicle computer.

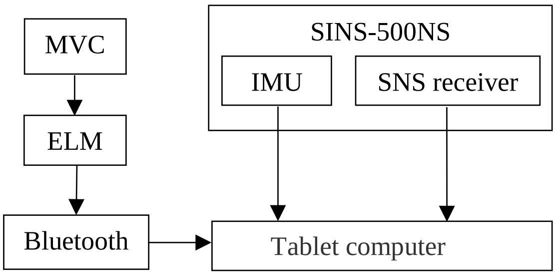


Fig. 3 Block diagram of the integrated inertial-odometer-satellite navigation system

The hardware and mathematical-software support of the integrated inertial-odometer-satellite navigation system is designed according to the object-oriented modular technology.

MATHEMATICAL SOFTWARE SUPPORT OF THE INERTIAL-ODOMETER-SATELLITE NAVIGATION SYSTEM

The kernel of the automotive navigation complex is the SINS-500NS system. The mathematical-software support of this system is based on the separate solution of equations for navigation and attitude quaternions [3]. The following regular operating modes are implemented in the SINS-500NS system.

The initial alignment mode includes the following stages. The initial alignment mode includes the following stages. The stage of coarse initial alignment is realized on a basis of the method of analytical gyro compassing from the output signals of SINS sensors.

The stage of fine initial alignment is realized on a basis of the method of vector matching of geophysical invariants that are both computed from SINS information and “a priori” known. The geophysical invariants are parameters the values of which are “a priori” known and which are unchanged with time and space. Such invariants are as follows: angular rate of Earth rotation; gravity acceleration at the point of SINS location; navigation parameters that are determined with due regard both for a motionless SINS base and for the above base moving at a known velocity.

A special feature of the mode mentioned is associated with the implementation of “pseudo reckoning” of attitude parameters and navigation ones from sensor signals when the system base is immovable. At this stage, errors in the IMU angular position, and also sensor residual drifts and the parameters of their dynamic models are estimated.

In the SINS-500NS system, the navigation problem is realized in the inertial and inertial satellite modes.

The vector of SINS errors is comprised of 18 parameters, namely: errors in the reckoning of components of the relative-velocity vector; errors in the reckoning of elements both of navigation and of attitude parameters; angular drifts of FOGs; biases of accelerometers and also an error in the reckoning of elevation with respect to the Earth ellipsoid. In regular modes, the vector of SINS-500NS errors is estimated with the EKF by processing the following observations [3].

In the fine initial-alignment mode: $$Z_{\Theta(i)} = C_{0(i)}^{\mathrm{T}} \int_{t_{i-1}}^{t_i} \dot{\bar{\Theta}}(\tau)d\tau - [0 \vdots 0 \vdots \Omega\Delta t_i]^{\mathrm{T}}; \quad (1)$$

$$Z_{k(i)} = [\varphi_i \lambda_i]_{\mathrm{SINS}}^{\mathrm{T}} - [\varphi_i \lambda_i]_{\mathrm{PIA}}^{\mathrm{T}}; \quad (2)$$

$$Z_{V(i)} = [V_\xi V_\eta V_\zeta]_{(i)\mathrm{SINS}}^{\mathrm{T}}. \quad (3)$$

In the inertial satellite mode: $$Z_{k(i)} = [\varphi_i \lambda_i]_{\mathrm{SINS}}^{\mathrm{T}} - [\varphi_i \lambda_i]_{\mathrm{SNS}}^{\mathrm{T}}; \quad (4)$$

$$Z_{V(i)} = C_{4(i)}^{\mathrm{T}} [V_\xi V_\eta V_\zeta]_{(i)\mathrm{SINS}}^{\mathrm{T}} - [V_E V_N V_H]_{(i)\mathrm{SNS}}^{\mathrm{T}}, \quad (5)$$

where PIA stands for the position of the initial alignment; φ_i, λ_i are the geodetic latitude and longitude of the SINS position; $\Delta t_i = t_i - t_{i-1}$ is an observation step; C_0 is the direction cosine matrix (DCM) that characterizes the angular position of the IMU - fixed frame with respect to the inertial frame; $\bar{V} = [V_\xi \quad V_\eta \quad V_\zeta]^{\mathrm{T}}$ is the vector of the relative velocity of IMU motion, given by its components along the axes of the semi-wander azimuth reference frame $o\xi\eta\zeta$ [2]; C_4 is the direction cosine matrix that characterizes the angular position of the wander azimuth reference frame $o\xi\eta\zeta$ with respect to the geodetic frame *oENH*; $\Delta t_i = t_i - t_{i-1}$ is the observation step.

In the SINS-500NS system, the inertial-odometer mode is additionally implemented. In the realization of the autonomous inertial-odometer navigation mode, as external information for the SINS, use has been made both of the ground speed and of the distance traveled in a certain time interval, which were measured by the odometer. When using the ground speed, the estimation of the error vector of the SINS and its sensitive elements in the navigation mode can be performed by processing that have the following form

$$Z_{V_{\mathrm{ODM}}(i)} = [V_\xi V_\eta V_\zeta]_{(i)\mathrm{SINS}}^{\mathrm{T}} - C_3^{\mathrm{T}} [V_{x_{\mathrm{ODM}}} \ 0 \ 0]_{(i)}^{\mathrm{T}}, \quad (6)$$

where $V_{x_{\mathrm{ODM}}}$ is the speed measured by the odometer; $C_3 = C_0 C_1^T C_2^T$; C_1 is the DCM that characterizes the movement of the car relative to the Earth; C_2 is the DCM that characterizes the rotation of the Earth during the operation of the SINS.

Observations $Z_{V_{\mathrm{ODM}}(i)}$ allow us to estimate both velocity errors and errors of the SINS orientation parameters.

When using information about the distance traveled, the estimation of the error vector of the SINS and its sensitive elements in the navigation mode can be performed by processing the following observations

$$Z_{\Delta S(i)} = \Delta S_{\mathrm{SINS}(i)} - \Delta S_{\mathrm{ODM}(i)}, \quad (7)$$

where $\Delta S_{\mathrm{SINS}(i)} = \sum_{k=i-N+1}^{i} \Delta S_{\mathrm{SINS}(k)}$; (8)

$\Delta S_{\mathrm{SINS}(k)} = \sqrt{\Delta S^2_{x(k)} + \Delta S^2_{y(k)} + \Delta S^2_{z(k)}}$;

$[\Delta S_{x(k)} \; \Delta S_{y(k)} \; \Delta S_{z(k)}]^{\mathrm{T}} = C_4 C_3 [\Delta S_{\varphi(k)} \; \Delta S_{\lambda(k)} \; \Delta S_{R(k)}]^{\mathrm{T}}$;

$\Delta S_{\varphi(k)} = [\varphi_{\mathrm{SINS}}(t_k) - \varphi_{\mathrm{SINS}}(t_{k-1})]R$; $\Delta S_{\lambda(k)} = [\lambda_{\mathrm{SINS}}(t_k) - \lambda_{\mathrm{SINS}}(t_{k-1})]R\cos\varphi_{\mathrm{SINS}}$;

$\Delta S_{R(k)} = R_{\mathrm{SINS}}(t_k) - R_{\mathrm{SINS}}(t_{k-1})$; $\Delta S_{\mathrm{ODM}(i)}$ - is a travelled distance, measured by odometer; R is the value of SINS position vector.

The motor-vehicle computer fixes time $\Delta t_i = t_i - t_{i-N}$ to which there corresponds 1 km of the distance traveled. This time corresponds to the N terms in relation (8). In the EKF, the interrelation of observations (7) and SINS errors is taken into account via the following mathematical model:

$Z_i = \tilde{H}_i x_i + \tilde{\vartheta}_i$,

where $x_i = x(t_i)$ is the vector of SINS errors; $\tilde{\vartheta}_i$ is the vector of perturbations in a measuring channel, which has the covariance matrix $\tilde{R}_i$; $\tilde{H}_i = \sum_{k=i-N+1}^{i} H_k \Phi_k^{-1}$;

$\tilde{\Phi}_k^{-1} = \prod_{j=i-N_k+1}^{i} \Phi_j^{-1}$ is the observation matrix;

Φ_k^{-1} is the inverse transition matrix for the vector of SINS errors; N_k is the number of cycles when reckoning the distance traveled with the help of SINS on the interval $[t_{i-N_k}, t_i]$.

Inertial satellite odometer calibration can be implemented by forming and processing the following observations

$$Z_{V_{\mathrm{ODM}}}(i) = V_{x_{\mathrm{ODM}}}(i) - V_{x_{\mathrm{SNS}}}(i), \tag{9}$$

where $[V_x V_y V_z]^{\mathrm{T}}_{(i)\mathrm{SNS}} = C_3 C_4 [V_E V_N V_H]^{\mathrm{T}}_{(i)\mathrm{SNS}}$.

ANALYSIS OF THE RESULTS OF STUDIES

Experiments have been carried out on the ground when the necessary equipment was housed in a mobile laboratory on the basis of an automobile. The timing diagram of operation of the SINS-500NS system included the following stages: coarse initial alignment (t = 0÷300sec), fine initial alignment (t = 300÷760sec), and a navigational mode (t >760sec). The results of a comparison analysis of SINS operation when using different schemes for the damping of sensor errors were obtained on a basis of the reckoning of motion parameters from the recorded signals of sensors of the IMU, SNS, and the odometer. Figure 4 shows the horizontal path when the testing laboratory is moving under urban conditions, where

$\Delta\varphi_{\mathrm{R}} = [\varphi(t) - \varphi(t_0)]R$; $\Delta\lambda_R = [\lambda(t) - \lambda(t_0)]R\cos\varphi$.

In Fig. 5, the true heading angle of the IMU is shown. Certain of the results of the experiments are presented in the following figures: in Figs. 6,7, odometer-measured travel speed and traveled path are shown; in Fig. 8 is shown the estimate of FOG drift; in Fig. 9 is shown the estimate of accelerometer (ACC) bias; in Fig. 10 is shown the estimate of odometer bias. These estimates were obtained in the processing of observations (1) - (9) with a frequency of 1 Hz. In Figs. 11-15, the following circular position errors of the SINS-500NS system are shown:

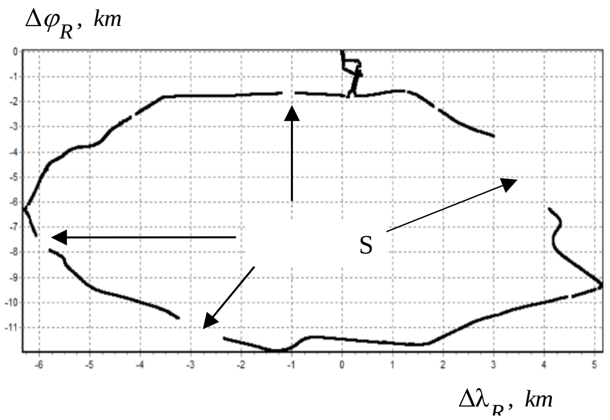


Fig. 4 Horizontal path of the testing-laboratory motion under urban conditions

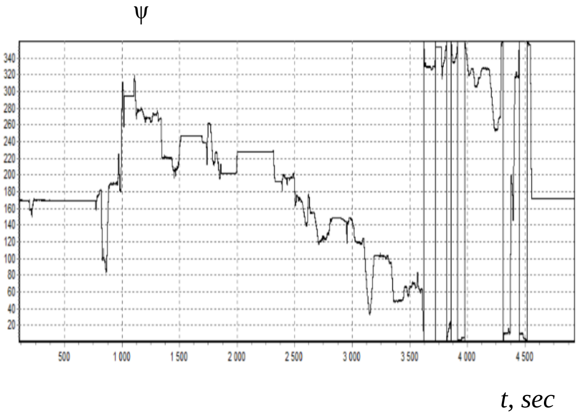


Fig. 5 True heading

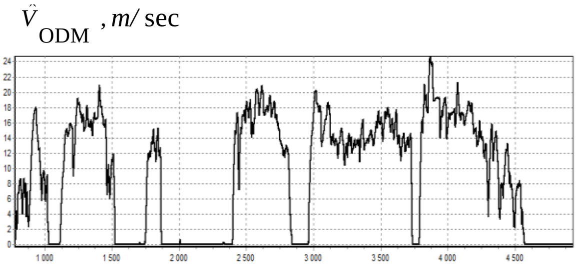
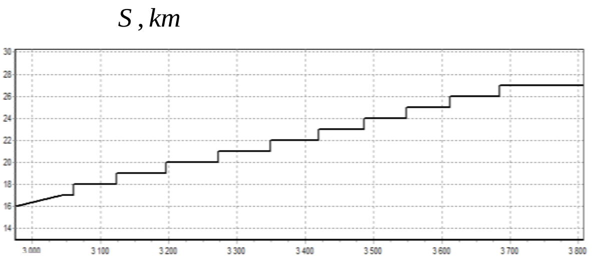


Fig. 6 Odometer-measured travel speed



ig. 7 Odometer-measured traveled path

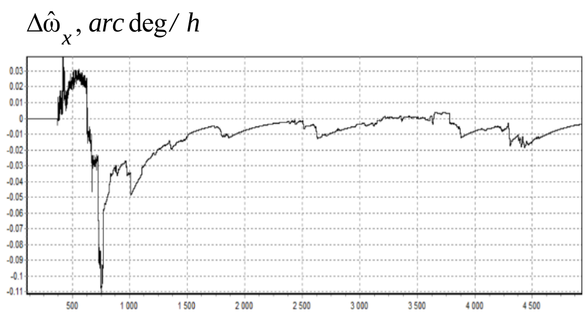
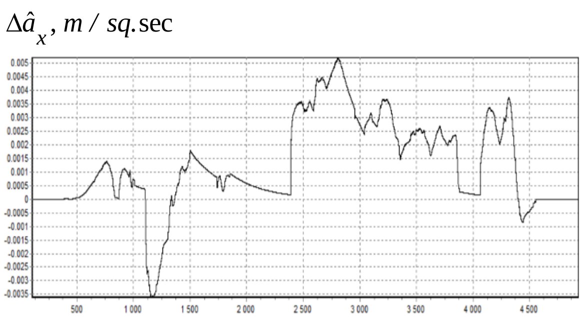


Fig. 8 Estimate of the drift for the *ox*



9 Estimate of the bias for the *ox* ACC

in Fig. 11, in the inertial mode; in Fig. 12, in the inertial mode with velocity correction using an odometer, in Fig. 13, in the inertial mode with velocity and distance correction using an odometer; in Fig. 14, in the inertial-and-odometer mode with satellite correction and without integrity monitoring; in Fig. 15, in the inertial-and-odometer mode with satellite correction and with integrity monitoring, where

$$\Delta S = \sqrt{\delta_\varphi^2 + \delta_\lambda^2}\ ;\ \delta_\varphi = (\varphi_{SINS} - \varphi_{SNS})R\ ;\ \delta_\lambda = (\lambda_{SINS} - \lambda_{SNS})R\cos\varphi_{SNS}\,.$$

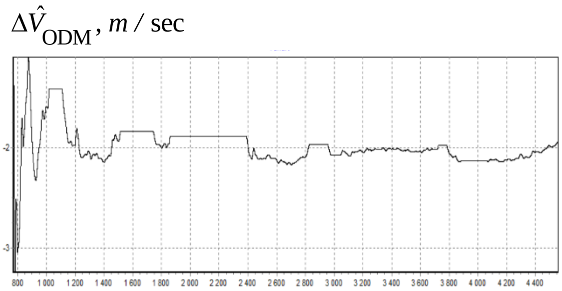
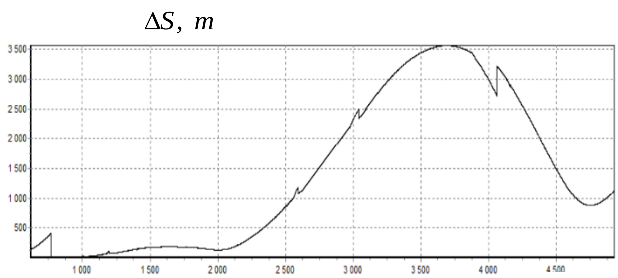


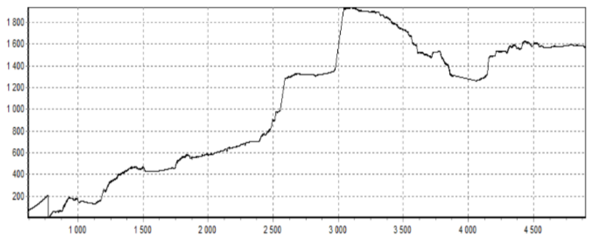
Fig. 10 Estimate of the bias for the odometer



11 Circular position error in the inertial mode

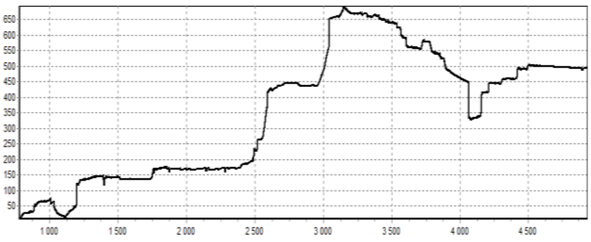
ΔS, m

ΔS, m



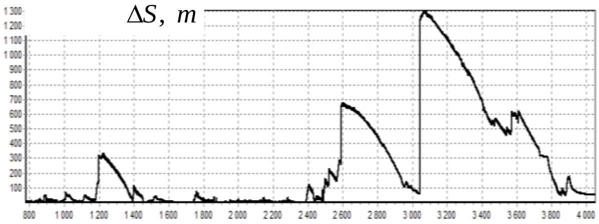
t, sec

Fig. 12 Circular position error in the inertial mode with velocity correction using an



t, sec

Fig. 13 Circular position error in the inertial mode with velocity and distance correction using an



t, sec

Fig.14. Circular position error in the inertial-odo mode with satellite correction and without integrity monitoring

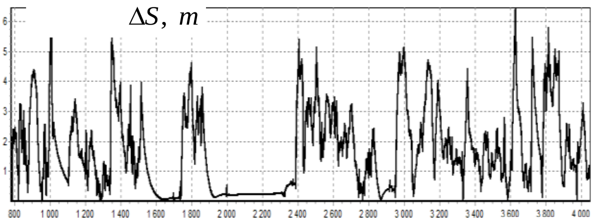


Fig.15. Circular position error in the inertial-odometric mode with satellite correction and with integrity monitoring

Violation of the information integrity of the SINS-500NS system, see Fig. 14, is associated with the use of abnormal satellite signals in the formation of observations. A technology intended to counteract violations reduces to adaptive-robust processing of observations [5]. It can be seen in Fig. 15 that adaptive-robust processing of inertial-satellite observations ensures the integrity of navigation definitions and increases the reliability of positioning of moving objects in a complex jamming environment, typical for urban applications. Adaptive-robust processing of observations is implemented based on the use of the combined criterion of agreement χ^2 / ϑ^2 [5,6] and the corresponding decision rules.

CONCLUSIONS

Improving the accuracy of the autonomous reckoning of the parameters of motion of ground objects can be based on the integration of the SINS and odometer system. For this, a motor-vehicle computer and an adapter can be used to coupling the SINS and odometer. The odometer can be calibrated according to the SNS and SINS.

In turn, the estimation of the drifts of the SINS sensors can be performed both at the fine initial alignment and in the inertial-odometric mode, as well as in the presence of information from the SNS. The odometer can be calibrated according to the SNS and SINS. The solution of these problems is based on the mathematical apparatus of Kalman filtering, which allows one to take into account and use correlation relationships between errors of sensors and the observed parameters.

REFERENCES

1. Schmidt G.T. GPS Based Navigation Systems in Difficult Environments, Gyroscopy and Navigation, 2019, vol. 10, no 2, pp. 41 - 53.

2. Babich O.A. Obrabotka informatsii v navigatsionnykh kompleksakh [Data Processing for Navigation Complexes]. Moscow, Mashinostroenie [Moscow: Publishing house "Engineering making"]. 1991.

3. Chernodarov A.V., Patrikeev A.P., Korkishko Yu.N., Fedorov V.A., and Perelyaev S.E. Software Seminatural Development for FOG Inertial Satellite Navigation System SINS-500, Gyroscopy and Navigation, 2010, vol. 1, no 4, pp. 330 - 340.

4. Eisenberg A. Presenting the professional OBD2 Bluetooth ELM327 Diagnostic Reader / Scanner // Total Car Diagnostics [web]. Cop/ 2019. URL: (accessed: 25.10.2019).

5. Chernodarov A.V., Patrikeev A.P., and Korobkov Yu.N. Kontrol i adaptivno-robastnaya zaschita informatsionnoy tselostnosti inertsialno-sputnikovyih navigatsionnyih sistem. [Monitoring and Adaptive Robust Protection of the Information Integrity of Inertial Satellite Navigation Systems] // Aerokosmicheskoe priborostroenie [Aerospace instrument making]. 2019. № 10. P. 3 – 9.

6. Chernodarov A.V. Kontrol, diagnostika i identifikatsiya aviatsionnykh priborov i izmeritelno-vychislitelnykh kompleksov [Monitoring, Diagnostics, and Identification of Aviation Instruments and Measuring-and-Computing Complexes]. Moscow, Nauchtekhlitizdat [Moscow: Publishing house “Scientific and technical literature ”]. 2017.

COMPARATIVE ANALYSIS OF METHODS FOR ESTIMATING MODEL PARAMETERS BASED ON RANDOM SAMPLES

Domracheva A.B, Sapegina E.A.
Bauman Moscow State Technical University
+7 (499) 263-65-77, domracheva@bmstu.ru

Abstract — The paper compares well-known methods for estimating model parameters based on random samples, such as RANSAC, R-RANSAC, NAPSAC, and MLESAC. The comparison is carried out on test data sets obtained by a given transformation scheme of the original image.

Keywords: model parameters estimation, random sample, RANSAC, MLESAC, R-RANSAC, NAPSAC, outlier, trend defining point.

INTRODUCTION

The number of models, generally based on statistical data of the full-scale or semi-natural experiment results, has increased in the last decade. Frequently such data contain outliers, which do not let us to confirm the robustness of model in practice. The type of model built on the basis of the traditional method of least squares significantly depends on the presence of outliers. The type of model, constructed with the traditional method of least-squares, vastly depends on the presence of outliers [1].

The RANSAC (random sample consensus) method [2] and its modifications: MLESAC [3], R-RANSAC [4], NAPSAC [5] is an alternative to the method of least squares, and allows one to distinguish both outliers and trend defining points.

The RANSAC method and its modifications are quite universal and are applicable for determine the outliers in images particularly for clustering line segments [6].

Comparison of methods was carrying out on the basis of algorithms’ performance indicators and robustness of algorithms with source data distortion (increase of the outliers’ number).

A clouds of known points was used as test sets (each point was determined by a set of its coordinates), which were defining reference points of an image or three-dimensional object (corners of buildings and facilities, road marking, etc.). Outliers (borders of shadows, foliage, etc.) included in the set of reference points are known in advance.

DESCRIPTION OF METHODS

The RANSAC algorithm (random sample consensus, Fischler and Bolles, 1981) was proposed to determine the image orientation by the reference points of this image [2], therefore RANSAC is usually considered as a computer vision algorithm.

The method involves constructing a model on a limited set of points T from the presented set S, $T \subset S$. Next, the contribution of each point $t \in T$ of the reduced set to the total error of the obtained $\boldsymbol{M}_R$ model is estimated. Obviously, outliers make the greatest contribution. If there are too many of them, the bounded set of points T can be changed to an alternative one. After a certain number of attempts m (1) to choose the set T, the algorithm will either result in the $\boldsymbol{M}_R$ model with the maximum number of outliers, or if the number of outliers does not exceed the minimum threshold value, it is believed that the $\boldsymbol{M}_R$ model cannot be determined.

$$m = \frac{log(1-z)}{log(1-w^k)}, \quad (1)$$

where w is the probability that each point in the $T \subset S$ subset satisfies the $\boldsymbol{M}_R$ model, and z is the probability of detecting at least one such subset T, k is the method parameter.

In the case the RANSAC algorithm, the final result is the first solution found in which the number of points determining the trend is greater than the minimum value, which is not always objective.

The MLESAC [3] algorithm (maximum likelihood estimation sample consensus, Torrand and Sisserman, 1998) solves this problem.

The modification is to apply the maximum similarity function to the estimation of the correspondence of points from the subset $T \subset S$ of the $\boldsymbol{M}_R$ model

$$D = \sum_i \gamma\left(\frac{d_i}{\sigma}\right), \quad \gamma(e) = \begin{cases} e^2, & e < 2 \\ 4.0, & e \geq 2 \end{cases} \quad (2)$$

where d_i is the correspondence error of the i element of the model, σ is the standard deviation, the parameter of the method. Thus, the smaller the value of the maximum similarity function (2) the more preferable the solution.

The NAPSAC algorithm [4] (*n* adjacent points sample consensus, Mint, Torr, Bishop et al., 2002) was proposed with the aim of eliminating another RANSAC problem, namely, the loss of method efficiency with increasing input data. The modification is based on the idea of localization, that is: outliers in the image are closer to each other than to the trend defining points. So not all of the subset $T \subset S$ is random, but only its first element t_1, the rest are the elements of the subset T closest to t_1. The preferred solution is the one in which the maximum number of the trend defining points is found.

The R-RANSAC algorithm [5] (randomized RANSAC, Chum, Matas, 2002) allows to reduce the operating time of the basic RANSAC algorithm by refusing to search for knowingly false solutions. The overall performance of the algorithm is affected by the number of outliers in the data and the number of elements in the control subset $T \subset S$. If the test is performed not on the entire subset T, but only on a part of its elements, the performance of the method will increase. In practice, the number of control points (T elements) is established equal to 1-2. As in the case of the NAPSAC algorithm, a solution is considered preferable if the maximum number of the trend defining points is found.

ANALYSIS OF ALGORITHM COMPARISON RESULTS

Table 1 shows the results of comparing the performance speed of presented algorithms (*ms*). The heading column shows the names of the methods, the heading line shows the number of outliers in the input data set.

TABLE 1. COMPARISON OF ALGORITHMS' PERFORMANCE, TIME *(ms)*

Number of points/ Algorithm	30	100	500	1000
RANSAC	0.06881	0.56648	15.20634	65.64055
MLESAC	0.07081	0.68217	20.09840	78.30042
NAPSAC	0.06482	0.57246	16.28246	66.86326
R-RANSAC	0.03291	0.11369	7.13392	39.24207

Table 2 illustrates the effect of the amount of outliers (indicated in the heading line) on the method stability (names are indicated in the heading column), which is characterized by the probability of constructing a model from given input data with the number of attempts m=10.

TABLE 2. THE PROBABILITY OF MODEL CONSTRUCTING
ON THE SOURCE DATA WITH A DIFFERENT NUMBER OF OUTLIERS

Outliers, %/ Algorithm	10	20	30	40	50	60	70	80	90
RANSAC	1	1	1	1	1	0,07	0	0	0
MLESAC	1	1	1	1	0,99	0,05	0	0	0
NAPSAC	1	1	1	1	0,99	0,68	0,50	0,43	0,16
R-RANSAC	1	1	1	0,99	0,97	0,54	0,14	0,12	0, 01

Table 3 and fig 1 illustrates the effect of the number of attempts (indicated in the heading line) on the method stability (names are indicated in the heading column), which is characterized by the probability of constructing a model from given input sets with 30% of outliers.

Similar data for input sets with 50% of outliers is shown in table 4 and at fig.2.

TABLE 3. THE PROBABILITY OF MODEL CONSTRUCTING
ON THE SOURCE DATA WITH 30% OF OUTLIERS

Number of points/ Algorithm	1	2	3	4	5	6	7	8	9	10
RANSAC	0,77	0,93	0,96	1	1	1	1	1	1	1
MLESAC	0,66	0,90	0,98	1	1	1	1	1	1	1
NAPSAC	0,60	0,87	0,98	0,98	0,99	1	1	1	1	1
R-RANSAC	0,54	0,73	0,91	0,94	1	0,99	0,98	1	1	1

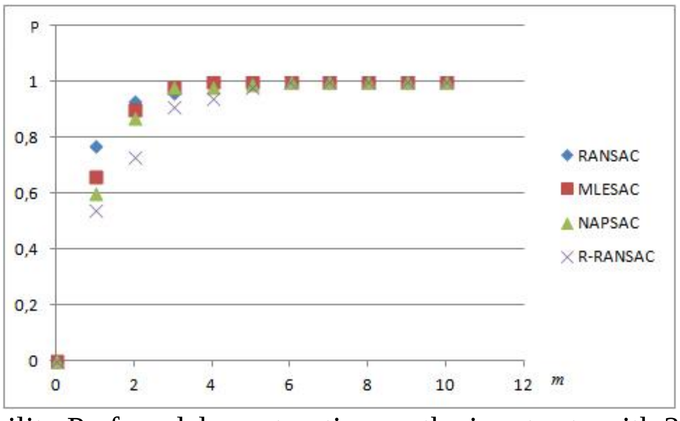


Fig. 1 The probability P of model constructing on the input sets with 30% of outliers, *m* - number of attempts

TABLE 4. THE PROBABILITY OF MODEL CONSTRUCTING
ON THE SOURCE DATA WITH 50% OF OUTLIERS

Number of points/ Algorithm	1	2	3	4	5	6	7	8	9	10
RANSAC	0,53	0,80	0,89	0,93	0,98	0,98	1	1	1	1
MLESAC	0,57	0,75	0,92	0,91	0,98	0,98	0,99	1	1	1
NAPSAC	0,47	0,69	0,88	0,92	0,95	0,96	0,99	1	1	1
R-RANSAC	0,33	0,44	0,61	0,69	0,74	0,85	0,89	0,96	0,98	1

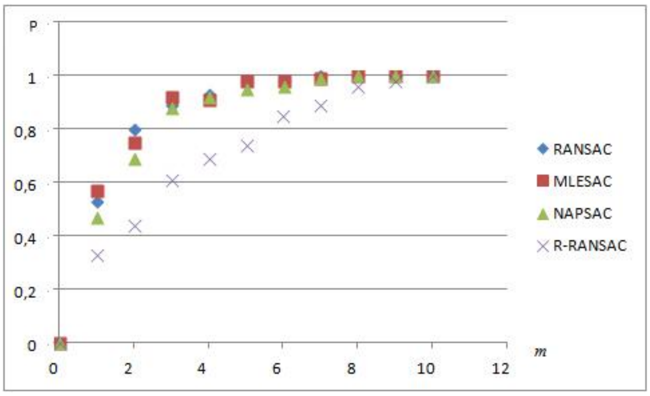


Fig. 2 The probability P of model constructing on the input sets with 50% of outliers, *m* - number of attempts

With a small amount of outliers in the input data the R-RANSAC is the fastest algorithm, it can be seen from table 1, but is not provides an effective solution (Fig.1, Fig.2). At more significant values, RANSAC and MLESAC are preferable, in addition MLESAC provides an effective solution compared to RANSAC. The NAPSAC algorithm turns out to be able to give sufficiently effective solutions even with the input data volume increase.

CONCLUSION

Based on the work done, the application of the RANSAC algorithm and its modifications can be recommended for estimating model parameters based on random samples. In the case of an insignificant amount of data (up to 30 points), the RANSAC method is comparable as in terms of performance so in robustness with its modifications. Herewith the MLESAC algorithm provides effective solutions.

With the increase of input data volume the R-RANSAC algorithm appears the fastest, but using the NAPSAC algorithm grants more efficient solutions.

It is planned to investigate the dependences of the performance decrease on the input data volume increase in the presented methods in the future, and also to estimate the repeated generation probability of the solution in different methods

REFERENCES

1. Martin A. Fischler, «Random Sample Consensus: A Paradigm for Model Fitting with Apphcatlons to Image Analysis and Automated Cartography» / Martin A. Fischler, Robert C. Bolles // Communications of the ACM, 1981, V. 24, № 6, 1981. – pp. 381-395.

2. H. Cantzler, R.B. Fisher, M. Devy, Quality enhancement of reconstructed 3Dmodels using coplanarity and constraints, in: Proc. annual Symp. for Pattern Recognition, DAGM '02, Zürich, Switzerland, September 2002, pp. 34-41.

3. M. Zuliani, «RANSAC for Dummies», Vision Research Lab, University of California, Santa Barbara, 2011.

4. P.H. S.Torr, A.Zisserman.Robust computation and parametrization of multiple view relations, Oxford University, 1998.

5. D. Myatt, P.H.S.Torr, J.M.Bishop, R. Craddockand, S. Nasuto, «NAPSAC: High Noise, High Dimensional Model Parameterisation - It's in the bag», 13th British Machine Vision Conference, September, 2002.

6. O. Chum, J. Matas, «Randomized RANSAC with $T_{d,d}$ test», 13th British Machine Vision Conference, September, 2002.

ANALYSIS OF LOSSES IN PRODUCTION SYSTEMS - ORGANIZATIONAL ASPECT

Grodzensky S.Ya., * Emanakov I.V., Ovchinnikov S.A.
MIREA - Russian Technological University, *FGUP "VNII "Center"
emanakov2@yandex.ru

Abstract - The organizational aspects of the analysis of losses in production systems are considered. The classification of losses by various objects of analysis and the structure of the source data for the analysis of each type of loss are developed. Consistent organizational procedures have been developed that are applied in practice to analyze and eliminate losses and improve production processes. An algorithm of procedural analysis by types of losses "Expectation", "Excess stocks / overproduction"and "Excessive processing / defects" is presented.

Keywords: production system, losses, lean production.

INTRODUCTION

To ensure competitiveness and sustainable development, modern manufacturing enterprises need to make systemic decisions aimed at improving the quality, reducing the cost of production and delivery time. To achieve these goals in world practice, many approaches have been developed, among which the Lean Production concept, which combines various management methods, is recognized as one of the most effective.

Lean Production is aimed at eliminating losses in all areas of the organization's activities, including building relationships with consumers, designing products, building supply chains, production management, transportation and logistics. At the same time, loss is understood as any action in the course of which resources are spent, but value is not created for the consumer of the product.

In [1, 2], methodological approaches used to identify and eliminate existing losses in managerial and production processes and assess possible reserves for increasing the efficiency of the enterprise's production system are reviewed. However, from the point of view of practical application in existing production, it is necessary to consider in more detail the organizational aspect of the implementation of the proposed methodological solutions.

ANALYSIS ORGANIZATIONAL PROCEDURES

Table 1 presents the classification of the main types of losses, indicating the objects of analysis in the production system and the source data.

TABLE 1. CLASSIFICATION OF LOSS BY OBJECTS OF ANALYSIS

Type of loss	Object of analysis	Initial data for analysis
Expectation is the time that products or staff spend inaction without creating value	Process	VSFC Process Instance Statistics
Excessive movements - unnecessary movements of workers, losses in the selection of materials, the search for tools, information, documents, etc.	Work center (workplace)	Spaghetti diagram The length, quantity and time of movement during working hours
Excessive transportation - moving materials, parts and finished products over long distances and more often than necessary	Plot Shop Company	Spaghetti diagram The length, quantity and time of movement during working hours
Excess stocks - the storage of any stocks in quantities significantly exceeding the established production need, taking into account regulatory insurance stocks	Work center (workplace) Plot Shop Company	The number of normative and actual stocks by nomenclature
Overproduction - production of products (services) in a larger volume than required by the customer	Work center (workplace) Plot Shop Company	The number of finished products according to the nomenclature (planned and actual)
Excessive processing - modification of the product, giving it properties and qualities that the customer does not need and which do not represent value to it	Product	Manufacturing Technology
Defects - production of defective products (failure to meet expected consumer requirements) / improper service	Product	The number of defects by redistribution, indicating the causes of defects by type: technological, structural, etc.

Organizational procedures used in practice to analyze and eliminate losses and improve production processes should include:

- development of a value stream flow chart (VSFC) “as is”;
- collection and processing of statistical data on process instances: the time of the standard process path (TSPP), the time of creating added value (TCAV) in the process, the time of organization (TO) of the process;
- determination of the list of procedures / operations with maximum impact on the TSPP;
- development of proposals for improving the process;
- development of the VSFC “as it should be”;
- forming a plan for the transition to the “as it should be” process.

Let us consider in more detail the organizational aspects of the analysis of losses in processes using the example of the analysis by types of losses “Expectation”, “Excess stocks / overproduction” and “Excessive processing / defects”.

Analysis by type of loss - “Expectation”

Development of VSFC "as is".

The development of the VSFC “as is” is carried out in a single instrumental environment (for example, Business Studio), based on the existing operating model of the enterprise’s activities by management level.

Responsible:

- an employee of the unit responsible for the development of the production system (DPS), in terms of process modeling;
- employees of the units participating in the process, in terms of providing information on the implementation of the process and agreeing on the “as is” VSFC.

Result - The VSFC Model “as is”.

Collection and processing of statistical data on process instances.

The following data is generated: TSPP, TCAV, TO.

Responsible:

- an employee of the unit responsible for the DPS, in terms of data processing;
- employees of structural units participating in the process, in terms of data reporting.

The result is statistics on process instances.

Defining a list of processes / procedures / operations with maximum impact on TSPP.

Responsible:

- employee of the unit responsible for the DPS.

Result - A list of processes (basic, management, providing) with the maximum impact on the TSPP of the analyzed process.

Development of proposals to improve the process.

Responsible:

- employee of the unit responsible for the DPS, in terms of aggregating proposals for improving the process;
- employees of structural units participating in the process, in terms of the formation of proposals for improving the process.

Result - Proposals (projects, activities) aimed at improving (changing, improving) the analyzed process.

Development of VSFC "as it should be."

VSFC development “as it should be” is carried out in a united instrumental environment (for example, Business Studio), based on the existing operating model of the enterprise’s activity by management level.

Responsible:

- an employee of the unit responsible for the DPS, in terms of the development of the VSFC “as it should be”;
- employees of structural units participating in the process, in terms of coordination of the VSFC “as it should be”.

Result - The VSFC Model “as it should be”.

Formation of a transition plan to the “as it should be” process.

The formation of the plan for the transition to the “as it should be” process is carried out in accordance with the project management procedures [3,4].

Responsible:

- employee of the unit responsible for the DPS, regarding the aggregation of the plan;
- employees of structural units participating in the process, in terms of the formation of proposals in the plan.

The result is a plan for the transition from the “as is” process to the “as it should be” process.

Analysis by type of loss - “Excess stocks / overproduction”

Development of the production chart of the product "as is".

Responsible:

- employee of the unit responsible for the DPS, in terms of charting;
- The head of the analyzed structural unit, in terms of providing source data.

The result is an “as is” production diagram.

Collection and processing of statistics on stocks / overproduction.

Responsible:

- employee of the unit responsible for the DPS, in terms of processing statistical data;
- Head of the analyzed structural unit, in terms of providing statistical data.

Result - statistical data (information) on stocks of overproduction.

Determining the list of stocks / overproduction with the maximum impact on economic indicators.

Responsible:

- an employee of the unit responsible for the DPS, regarding the formation of the list;
- economist, in terms of calculations.

The result is a list of stocks / overproduction with the maximum impact on the economic indicators of the analyzed work center (site, workshop, enterprise).

Development of proposals to improve the process.

Responsible:

- an employee of the unit responsible for the DPS, in terms of aggregating proposals to improve the process;
- Head of the analyzed structural unit, in terms of the formation of proposals for improving the process.

The result - proposals (projects, activities) aimed at improving (changing, improving) the organization of the workplace (site, workshop, enterprise).

Development of the production diagram of the product "as it should be."

Responsible:

- employee of the unit responsible for the DPS, regarding the development of the “as it should be” chart;
- Head of the analyzed structural unit, in terms of the development of the “as it should be” chart.

The result is an “as it should be” production chart.

Formation of a transition plan to the “as it should be” process.

The transition plan is formed in accordance with the project management procedures [3,4].

Responsible:

- employee of the unit responsible for the DPS, regarding the aggregation of the plan;
- Head of the analyzed structural unit, in terms of the formation of proposals in the plan.

The result is a plan for the transition from the “as is” process to the “as it should be” process.

Analysis by type of loss - “Excessive processing / defects”

Analysis of the manufacturability of the product.

Responsible:

- employee of the unit responsible for the DPS, in terms of processing the results of the analysis;
- employee of the technological department, in terms of analysis of production technology;
- Employee in the design department, in terms of analysis of product design.

The result is bottlenecks in the “as is” production technology and / or product design.

Development of proposals for improvement.

Responsible:

- employee of the unit responsible for the DPS, in terms of coordination of work;
- employee of the technological department, in terms of improving production technology;
- employee of the design department, in terms of improving the design of the product;
- economist, in terms of calculations on economic efficiency.

Result - proposals (projects, activities) aimed at improving (changing, improving) the production technology and / or design of the product.

Formation of a plan for the transition to production technology / product design "as it should be".

The transition plan is formed in accordance with the project management procedures [3,4].

Responsible:

- employee of the unit responsible for the DPS, in terms of coordination of work;
- employee of the technology department, in terms of the transition to production technology "as it should be";
- an employee of the design department, in terms of the transition to the design of the product "as it should be";
- economist, in terms of calculations on economic efficiency.

The result is a plan for the transition from production technology / product design "as is" to production technology / product design "as it should be".

ANALYSIS RESULTS

Based on the results of the analysis of all types of losses, based on the collected statistics, the enterprise management ("process owners") should develop and make informed decisions aimed at improving the efficiency of both individual production processes and the entire production system of the enterprise.

REFERENCES

1. Grodzensky S.Ya., Emanakov I.V., Ovchinnikov S.A. Metodica viyavlenia poter v proizvodstvennoi sisteme // Naykoemkie tehnologii. - 2018, t.19, No. 1, P. 10-13.
2. Grudzinsky P.V., Emanakov I.V., Ovchinnikov S.A. Viyavlenie i analiz poter pri vnedrenii berezhlivogo proizvodstva na promishlennih predpriyatiyah // Kachestvo i zhizn. - 2017, No. 3, P. 56-60.
3. GOST ISO 21500–2014 Rukovodstvo po proektnomy menedzhmenty.
4. GOST R 58184–2018 Sistema menedzhmenta proektnoi deyatelnosty. Osnovnie polozhenia.

REPEATER OF BASE STATION OF TRUNKED COMMUNICATION SYSTEM

Ivanov V.S., Andreev I.S., Gladky D.A., Vetrova V.V.
RTU MIREA
+7(906)780-55-51; jeksonsv@yandex.ru

Abstract - the work is devoted to the development of a repeater of the base ground station of a trunking communication system. As a result of the analysis of the source data, it was decided to design the functional and structural diagrams of the base ground station of the trunking communication system based on an analog transceiver operating in duplex mode on the principle of transferring information from one operating frequency to another in real time (Figure 1).

Key words: Repeater, trunking communication systems, base ground station, power amplifier.

INTRODUCTION

Currently, the development and operation of any enterprise is determined by the degree of application of modern communication systems. Transport, energy, and many other industries, in principle, cannot function without the use of mobile radio communication systems. And for services such as the police, fire brigade, ambulance - mobile radio communications can determine the line between life and death. The latter use a trunked communication system, the principle of which is largely similar to a cellular communication system. The main difference is that TCSs are simpler in terms of construction principles and provide subscribers with a smaller set of services, but due to this they are cheaper than cellular ones. If we use the analogy with cellular communications, then in the simplest case TCS is one cell of the cellular system, but with a somewhat specific set of services. Almost the radius of the TCS cell can reach 40-50 km or more. This results in greater transmitter power compared to cellular communications, greater power consumption of the power source, large dimensions and weight of the AT. The main application of TCS is corporate (service, departmental) communication, for example, operational communication of the fire service with the number of exits (channels) “to the city”, significantly less than the number of system subscribers [1].

PROBLEM STATEMENT

5 tasks are defined in the developed project: calculation of the coverage area, selection of the functional scheme of the communication system , selection of the block diagram of the repeater, calculation of the circuit diagram of the high-frequency power amplifier, development of the General design type.

Main requirements: operating frequency range: 470-480 MHz; radiation type: 8K50F3E; transmitter output carrier power: tunable (10/25/50) W; receiver sensitivity: 0.3 mV; operating conditions: UHL1.

SOLUTION OF THE PROBLEM

The range of radio stations can be estimated using the formula:

$$R(\text{км}) = 3.65\sqrt{h_1(\text{м})} + \sqrt{h_2(\text{м})}; \tag{1}$$

where h and h2 is the height of the radio station and base station antennas.

We chose the height of the base station's antenna suspension of 300 meters. Given that the height of the radio station's antenna is limited by human growth, we assume it is equal to 1.5 m. We calculate the maximum possible coverage area.

$$R(\text{км}) = 3.65\sqrt{300} + \sqrt{1.5} = 67\text{км}; \tag{2}$$

Next, the functional scheme of the trunking communication system was selected.

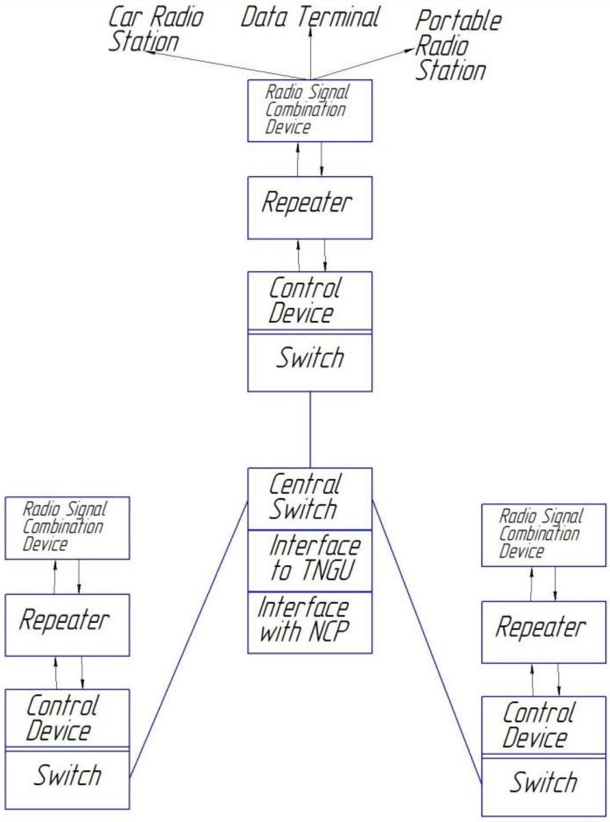


Fig. 1 Block diagram of a multi- zone TCS with a Central Switch

The use of distributed interzonal switching is only appropriate for systems with a small number of zones and with low requirements for the efficiency of interzonal calls (especially in the case of connections via switched TNGU channels). Systems with high quality of service use an architecture with a Central control system. The structure of a multi-zone TCS with a CC is shown in figure 1.

The main element of this scheme is the interzonal switch. It handles all types of interzonal calls, i.e. all interzonal traffic passes through a single switch connected to the BS via dedicated lines. This provides fast call processing and the ability to connect centralized PD. Information about the location of subscribers of the system with the Central Bank is stored in a single place, so it is easier to protect it[2].

The block diagram of the repeater is shown in figure 2. The signal from the receiving antenna coming to the repeater's input is received, processed and detected by its superheterodyne receiver with double frequency conversion. the Received and detected signal is amplified by a low-frequency amplifier. Next, the amplified signal is sent to three circuits:

1. Circuit for determining the presence of a signal in the channel.

This circuit is designed to determine whether there is a useful signal in the received signal and is used as a noise canceller.

2. The circuit for determining the presence of a tone component in the received signal.

It is intended for determining the presence of a tone component in the received signal and decoding it. Used to prevent unauthorized use of the repeater.

3. Processing and control circuit of the detected signal.

It consists of a low-pass filter, a controlled switch, and a low-pass mixer.

In the mixer, a new tone is added to the received and detected LF signal and, if necessary, a status code message or a signal from an external microphone.

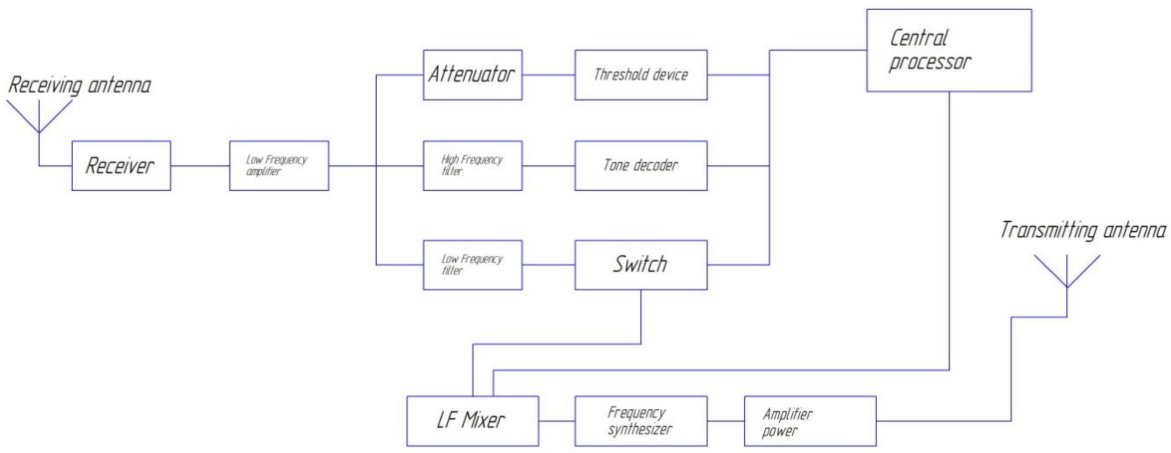


Fig. 2 Block diagram of the repeater

The signal after the mixer is sent to the input of the repeater transmitter, which consists of a controlled frequency synthesizer and modulator. The operating frequency of the transmitter is set by the processor. The signal from the transmitter is sent to a high-frequency power amplifier (UM unit). After the power amplifier, the signal is sent to the repeater's antenna output via a circulator. The circulator is necessary for diverting the reflected wave from the antenna to the reflected wave meter.

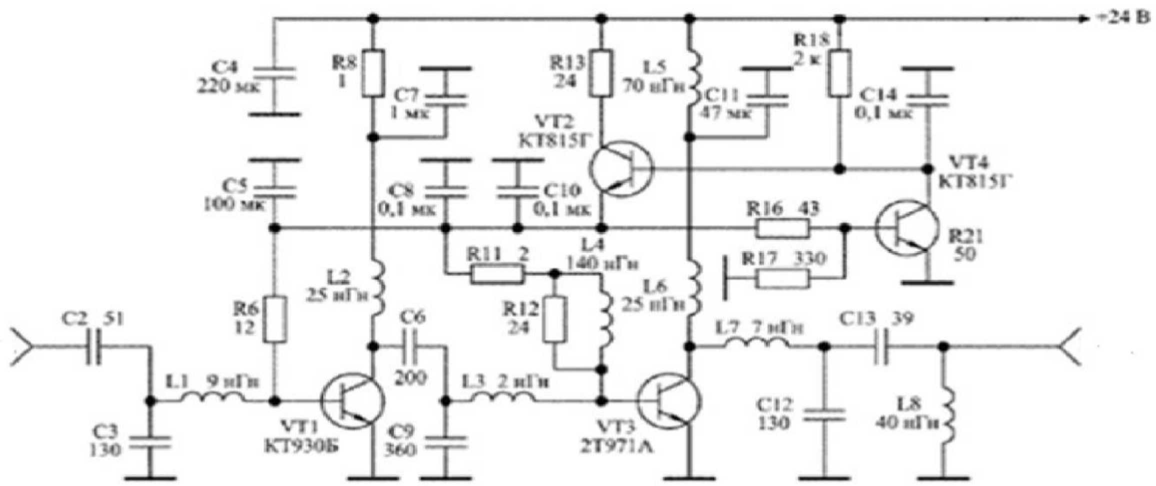


Fig. 3 Schematic diagram of pumas

Elements C1, C2, L1 form the contour chain-1, elements C 5, C 6, L 3 form the contour chain-2, elements L7, C8, C9, L8 form the output resistance transformer, the base offset voltage stabilizer is made on transistors VT 2 and VT 4. These elements were calculated using reference formulas [3].

The designed view of the repeater is shown in figure 4.

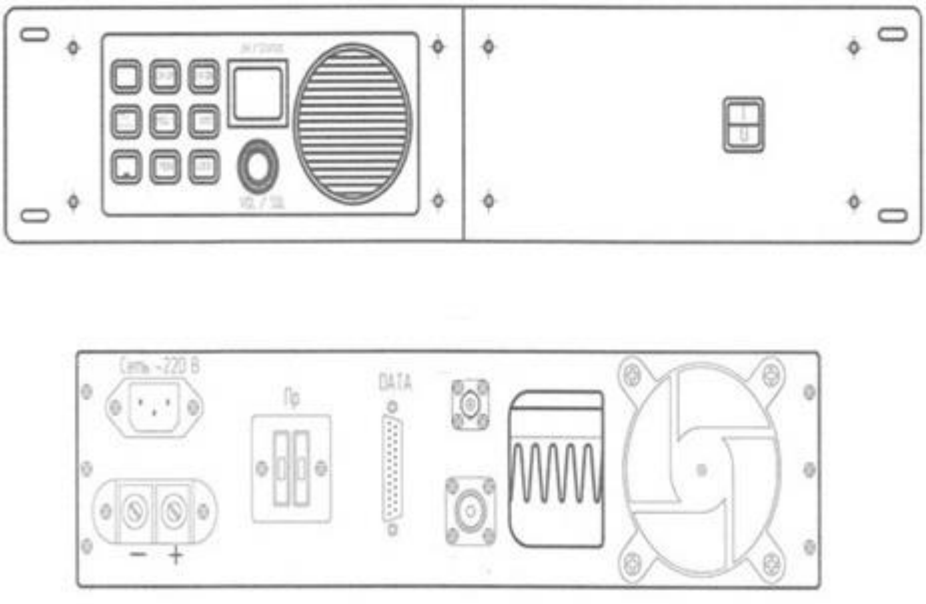


Fig.4 Appearance of the repeater

Controls and controls are placed on the front panel of the unit and have appropriate labels that facilitate management and control of its operation.

Based on the work done, a test bench was assembled for testing. The scheme of the test facility includes a designed high-frequency power amplifier and a specialized measuring complex NR8920A and is shown in figure 5.

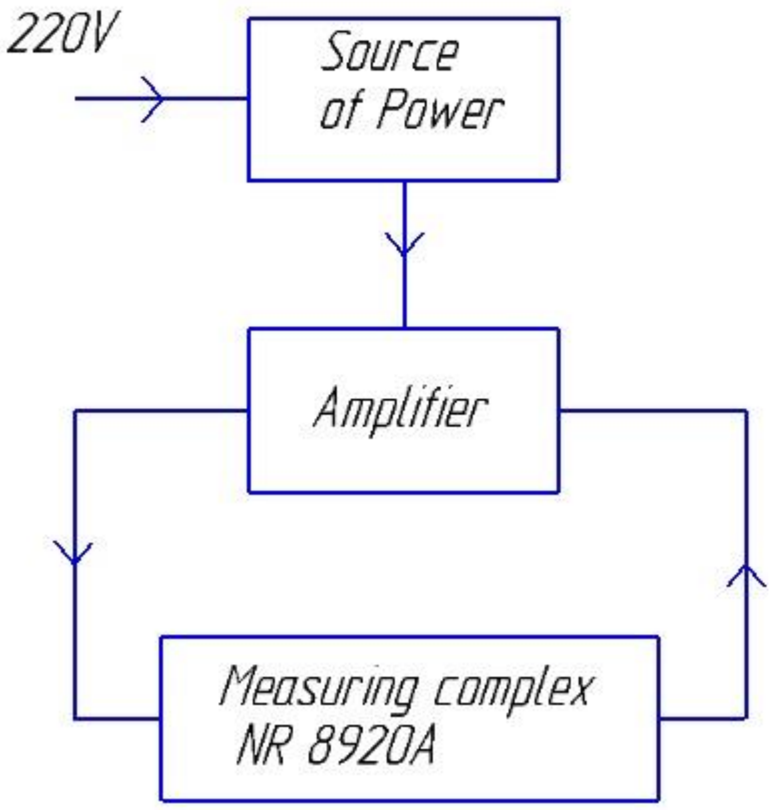


Fig. 5 Test bench diagram

The measurement results shows that the level of out- of-band radiation exceeds the permissible level, and the flatness is not more than 1%, indicating a well- structured scheme and loyalty of its calculations.

TABLE 1. RESULTS OF OUT-OF-BAND RADIATION MEASUREMENTS

Level emitting, dB.	**Measured Emission Bandwidth, kHz.**	**Measurement infelicity, kHz.**	**Permissible value, kHz.**
-40	12,690	0,180	No more 15,481
-50	15,620	0,180	No more 20,180
-60	19,260	0,180	No more 25,479

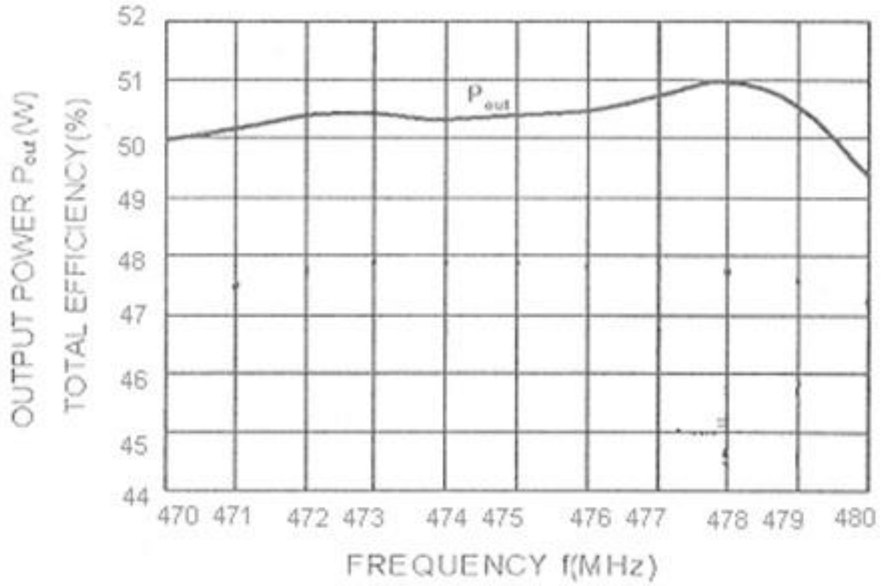


Fig. 6 Frequency response Graph

CONCLUSION

As a result of this work, the basic ground station of the trunking radio communication system was designed on the basis of a promising repeater with digital control, built on the principle of a digital block structure. Development and production of this repeater in Russia is expedient, since there is interest in them , and there are no analogues with the required characteristics on the Russian market of communication system manufacturers.

REFERENCES

1. K. Wesolowski, A.I. Ligovskoi. Mobile radio communication systems -Moscow: Hotline-Telecom, 2006 (Moscow: spp printing house "Nauka"). - 536 p

2. Sakalema D. Zh. - Mobile radio communications , Moscow: Hotline-Telecom, 2012. - 512 p.

3. Titov A. A. Tunable bandpass power amplifier of the 400 range ... 460 MHz / / Circuitry.-2004. - N. 4. - P. 8-10.

RATE OF TIME OF PACKING OF POWER AND CONTROL EQUIPMENT FOR NPPS. SECOND APPROXIMATION

Loskutov I.A.
RTU MIREA
+7 (926) 152-32-42, faxvex@ya.ru

Abstract – The article continues the work on rationing the time of the packaging manufacturing process for power and control equipment for nuclear power plants. In connection with parallel studies conducted at different stages of the technological process of working with these products, the designations of some variables were changed. A modification of the basic equation is performed and the introduction of the drawing replacement parameter during operations in the packaging shop is shown.

Keywords – NPPs, rationing, modeling, mathematical description, technological process, packaging.

INTRODUCTION

Creating a rational technological process is a complex undertaking. In most cases, line managers do not have proper management education in technical areas, because they are simply specialists who replaced retired colleagues / proven employees during the creation of a new department or production / as often happens, invited acquaintances of the top manager. Of course, most of them will eventually gain experience and be able to perform their duties efficiently, but it will take a considerable amount of time, perhaps many years. There is a natural question-how to improve the efficiency of work in production. The answer is obvious – to normalize work. Previously, during the Soviet era, there were norms and rationing specialists who teach from books in the likeness [1]. The average execution time of an operation was calculated, a Gantt chart or similar system was created, and a task was given to the worker with the expectation that he would perform it exactly. Of course, in those days, the system proved itself, it is not surprising that in modern Russia and in many CIS countries, these methods are still actively used. However, in today's market economy, it is not rational to count on average indicators.

It should be noted that the normalizer as a specialty has not disappeared completely, but most companies have assigned this work to managers.

It is often possible to notice how one employee does not cope with their duties at work, and another employee is forced to wait for new orders, because he has fulfilled his norm. At this point, a good Manager will try to keep him busy, but he will also be charged with awarding this employee for processing. As a result of inexperience, there may be an imbalance and a gradual growth of discontent in the working group, which may lead to the sliding of the management system into liberalism, which we discussed in [2]. To prevent this from happening, it is proposed to create a mathematical model that can be used to implement a technical process based on an assessment of the worker's performance and functionality. In this paper, the model will be considered in relation to packaging sites that work with nuclear products, however, if desired, it can be modified for any branch of mechanical engineering.

CHANGES IN EQUATIONS

It is obvious from the title that this work is a continuation of another work [3]. Previously, the basic equation for packing power and control equipment for nuclear power plants was derived. Since several mathematical models are being developed in parallel (for different stages of the process), it is more rational to come to a common view. Therefore, the following symbols for all disturbing parameters (events) will be replaced):

1. Performing another, more important work at the moment "S" (was "K»)
2. Human needs (physiological, psychological) "T "(was "L»)

3. Errors "U "(was "M»)
   3.1. Incorrectly sawn boards "U1" (was " M1»)
   3.2. Incorrectly installed spacers " U2 "(was " M2»)
   3.3. The wrong package size "U3" was used (it was " M3»)
   3.4. Corrupted connection " U4 "(was "M4»)
   3.5. Other "U5" (was "M5»)
4. Modification of the drawing at the packing stage " V "(was "N»)
5. Worker fatigue "W "(was "O»)
6. Other "Z" (was " S»).

Accordingly the basic equation will take the following form

$$\begin{cases} i_j = \sum_{\omega=1}^{22} x_j + 2U_{1j} \\ \bar{X} = \sum_{j=1}^{22} \sum_{\vartheta=i_{j-1}}^{i_j} t_j \prod_{\mu=1}^{j} W_j^{i_j-\vartheta} + \sum_{j=23}^{29} \sum_{\delta=\varsigma_{j-1}}^{\varsigma_j} t_j \prod_{\xi=23}^{j} W_j^{\varsigma_j-\delta} \prod_{\psi=1}^{22} W_\psi^{x_\psi-\vartheta} \end{cases} \quad (1)$$

Where:

- x_j – number of operations to work with an element from the array "Y";
- U_{1j} – number of errors that occur when working with an array element "Y";
- $\prod_{\mu=1}^{j} W_j^{i_j-\vartheta}$ – accounting for fatigue accumulation during operation with an element from the array "Y";
- ς_j – number of operations to work with an element from the array "R";
- $\prod_{\xi=23}^{j} W_j^{\varsigma_j-\delta}$ – accounting for fatigue accumulation during operation with an element from the array "R";
- $\prod_{\psi=1}^{22} W_\psi^{x_\psi-\vartheta}$ – accounting for accumulated fatigue after the completion of the array "Y".

MODIFICATION OF THE EQUATION

Consider the possibility of modifying the drawing.

With one modification, i.e. the modification appeared after the completion of the package assembly operation, the equation for "$\bar{V}$" will look similar to equation (1) with the addition of an additional part in the form of operations for attaching parts to the new drawing:

$$\begin{cases} i_j = \sum_{\omega=1}^{22} x_j + 2U_{1j} \\ l_k = \sum_{\eta=1}^{22} q_k + 2U_{1k} \\ \bar{V} = \sum_{j=1}^{22} \sum_{\vartheta=i_{j-1}}^{i_j} t_j \prod_{\mu=1}^{j} W_j^{i_j-\vartheta} + \sum_{j=23}^{29} \sum_{\delta=\varsigma_{j-1}}^{\varsigma_j} t_j \prod_{\xi=23}^{j} W_j^{\varsigma_j-\delta} \prod_{\psi=1}^{22} W_\psi^{x_\psi-\vartheta} + \\ \sum_{k=1}^{22} \sum_{\rho=l_{k-1}}^{l_k} t_k \prod_{\sigma=1}^{k} W_k^{l_k-\rho} + \sum_{k=23}^{29} \sum_{\alpha=\nu_{k-1}}^{\nu_k} t_k \prod_{\beta=23}^{k} W_k^{\nu_k-\alpha} \prod_{\theta=1}^{22} W_\theta^{q_\theta-\rho} \end{cases} \quad (2)$$

In this case, the resulting equation for $\bar{X}$ will look like:

$$\begin{cases} i_j = \sum_{\omega=1}^{22} x_j + 2U_{1j} \\ l_k = \sum_{\eta=1}^{22} q_k + 2U_{1k} \\ \bar{X} = 2\sum_{j=1}^{22} \sum_{\vartheta=i_{j-1}}^{i_j} t_j \prod_{\mu=1}^{j} W_j^{i_j-\vartheta} + \sum_{j=23}^{29} \sum_{\delta=\varsigma_{j-1}}^{\varsigma_j} t_j \prod_{\xi=23}^{j} W_j^{\varsigma_j-\delta} \prod_{\psi=1}^{22} W_\psi^{x_\psi-\vartheta} + \\ \sum_{k=1}^{22} \sum_{\rho=l_{k-1}}^{l_k} t_k \prod_{\sigma=1}^{k} W_k^{l_k-\rho} + \sum_{k=23}^{29} \sum_{\alpha=\nu_{k-1}}^{\nu_k} t_k \prod_{\beta=23}^{k} W_k^{\nu_k-\alpha} \prod_{\theta=1}^{22} W_\theta^{q_\theta-\rho} \end{cases} \quad (3)$$

Where:

- q_k – number of work operations performed on a new drawing with an element from the "Y " array";
- U_{1k} – number of errors that occur when performing work on a new drawing with an array element " Y";
- $\prod_{\sigma=1}^{k} W_k^{l_k-\rho}$ – accounting for the accumulation of fatigue that occurs while working on a new drawing when performing an operation with an element from the "Y " array";

- ν_k – number of operations for working on a new drawing with an element from the "R " array";
- $\prod_{\beta=1}^{k} W_k^{\nu_k-\alpha}$ – accounting for the accumulation of fatigue that occurs when working on a new drawing during an operation with an element from the array " R";
- $\prod_{\theta=1}^{22} W_\theta^{q_\theta-\vartheta}$ – accounting for accumulated fatigue that occurs when working on a new drawing after completion of the array "Y";
- t_j, t_k – the running time of the process j, k, respectively.

Often, modifications do not require complete disassembly of the finished container, and sometimes only the addition of elements occurs (for example, fixing additional bars for better fixation). We also take into account the fact that the drawing can be changed an indefinite number of times.

$$\begin{cases} i_j = \sum_{\omega=1}^{22} x_j + 2U_{1j} \\ l_k = \sum_{\eta=1}^{22} q_k + 2U_{1k} \\ \bar{V} = \sum_{j=1}^{22} \sum_{\vartheta=i_{j-1}}^{i_j} t_j \prod_{\mu=1}^{j} W_j^{i_j-\vartheta} + \sum_{j=23}^{29} \sum_{\delta=\varsigma_{j-1}}^{\varsigma_j} t_j \prod_{\xi=23}^{j} W_j^{\varsigma_j-\delta} \prod_{\psi=1}^{22} W_\psi^{x_\psi-\vartheta} + \\ \sum_{\varphi=1}^{2\tau} (\sum_{k=1}^{22} \sum_{\rho=l_{k-1}}^{l_k} t_k \prod_{\sigma=1}^{k} W_k^{l_k-\rho} + \sum_{k=23}^{29} \sum_{\alpha=\nu_{k-1}}^{\nu_k} t_k \prod_{\beta=23}^{k} W_k^{\nu_k-\alpha} \prod_{\theta=1}^{22} W_\theta^{q_\theta-\rho}) \end{cases} \quad (4)$$

Where:

- τ – the number of changes to the drawing.

Since one change leads to both disassembly and subsequent assembly, the process in the equation is multiplied by 2. If disassembly or assembly does not occur, the values of the corresponding parameters will be zero and will not affect the form of the equation in any way.

We will introduce an additional parameter " Q(t)", which will take into account the time to study the changes in the drawing. This parameter will refer to the disturbing array " R" and, like other parameters, will have a different value depending on the modification:

$$\begin{cases} i_j = \sum_{\omega=1}^{22} x_j + 2U_{1j} \\ l_k = \sum_{\eta=1}^{22} q_k + 2U_{1k} \\ \bar{X} = \sum_{j=1}^{22} \sum_{\vartheta=i_{j-1}}^{i_j} t_j \prod_{\mu=1}^{j} W_j^{i_j-\vartheta} + \sum_{j=23}^{29} \sum_{\delta=\varsigma_{j-1}}^{\varsigma_j} t_j \prod_{\xi=23}^{j} W_j^{\varsigma_j-\delta} \prod_{\psi=1}^{22} W_\psi^{x_\psi-\vartheta} + \\ \sum_{\varphi=1}^{2\tau} (\sum_{k=1}^{22} \sum_{\rho=l_{k-1}}^{l_k} t_k \prod_{\sigma=1}^{k} W_k^{l_k-\rho} + \sum_{k=23}^{29} \sum_{\alpha=\nu_{k-1}}^{\nu_k} t_k \prod_{\beta=23}^{k} W_k^{\nu_k-\alpha} \prod_{\theta=1}^{22} W_\theta^{q_\theta-\rho} + Q_\varphi) \end{cases} \quad (5)$$

Despite the fact that the "$\sum_{\varphi=1}^{2\tau}$" element takes into account both assembly and disassembly, the process of studying changes is repeated at each iteration. This parameter is not the same for both related processes. During disassembly, an employee of the packaging department studies which elements need to be removed, and during assembly-how and where to attach them.

U_{1k} each assembly/disassembly operation has different values.

The accumulation of fatigue " W " for each process also has different values, often due to psychological dissatisfaction with the person due to changes that led to the alteration of packaging containers, a similar relationship is observed with the working time.

The resulting equation (5) does not take into account the possibility of an early stop of the packaging process. There are two ways to introduce this parameter to the model:

1. Equating the output variable value to the stop value " WA";
2. Creating a cyclical description with verification at each iteration the process has ended or is in progress.

In the first case, the equation will look like:

$$\left\{\begin{array}{l} i_j = \sum_{\omega=1}^{22} x_j + 2U_{1j} \\ l_k = \sum_{\eta=1}^{22} q_k + 2U_{1k} \\ \bar{X} = \overline{ZA} + \sum_{\varphi=1}^{2\tau}(\overline{QA} + Q_\varphi) \\ \left\{\begin{array}{l} \text{If } \overline{WA} \geq \overline{ZA} \\ \overline{ZA} = \sum_{j=1}^{22}\sum_{\vartheta=i_{j-1}}^{i_j} t_j \prod_{\mu=1}^{j} W_j^{i_j-\vartheta} + \sum_{j=23}^{29}\sum_{\delta=\varsigma_{j-1}}^{\varsigma_j} t_j \prod_{\xi=23}^{j} W_j^{\varsigma_j-\delta} \prod_{\psi=1}^{22} W_\psi^{x_\psi-\vartheta} \\ \text{If } \overline{WA} < \overline{ZA} \\ \overline{ZA} = \overline{WA} \\ \text{If } \overline{WA} \geq \overline{QA} \\ \overline{QA} = \sum_{k=1}^{22}\sum_{\rho=l_{k-1}}^{l_k} t_k \prod_{\sigma=1}^{k} W_k^{l_k-\rho} + \sum_{k=23}^{29}\sum_{\alpha=\nu_{k-1}}^{\nu_k} t_k \prod_{\beta=23}^{k} W_k^{\nu_k-\alpha} \prod_{\theta=1}^{22} W_\theta^{q_\theta-\rho} \\ \text{If } \overline{WA} < \overline{QA} \\ \overline{QA} = \overline{WA} \end{array}\right. \end{array}\right. \quad (6)$$

In second case:

$$\left\{\begin{array}{l} i_j = \sum_{\omega=1}^{23} x_j + 2U_{1j} \\ l_k = \sum_{\eta=1}^{23} q_k + 2U_{1k} \\ \bar{X} = \overline{ZA} + \sum_{\varphi=1}^{2\tau}(\overline{QA} + Q_\varphi) \\ \left\{\begin{array}{l} \text{If } \overline{WA} \geq \overline{ZA} \\ \overline{ZA} = \sum_{j=1}^{23}\sum_{\vartheta=i_{j-1}}^{i_j} t_j \prod_{\mu=1}^{j} W_j^{i_j-\vartheta} + \sum_{j=23}^{29}\sum_{\delta=\varsigma_{j-1}}^{\varsigma_j} t_j \prod_{\xi=23}^{j} W_j^{\varsigma_j-\delta} \prod_{\psi=1}^{22} W_\psi^{x_\psi-\vartheta} \\ \text{If } \overline{WA} < \overline{ZA} \\ \overline{ZA_J} = \sum_{j=1}^{23}\sum_{\vartheta=i_{j-1}}^{i_j} t_j \prod_{\mu=1}^{j} W_j^{i_j-\vartheta} + \sum_{j=23}^{29}\sum_{\delta=\varsigma_{j-1}}^{\varsigma_j} t_j \prod_{\xi=23}^{j} W_j^{\varsigma_j-\delta} \prod_{\psi=1}^{22} W_\psi^{x_\psi-\vartheta} \\ \overline{ZA} = F_{min}\left(\overline{ZA_J} - \overline{WA} > 0\right) \to 0 \\ \text{If } \overline{WA} \geq \overline{QA} \\ \overline{QA} = \sum_{k=1}^{23}\sum_{\rho=l_{k-1}}^{l_k} t_k \prod_{\sigma=1}^{k} W_k^{l_k-\rho} + \sum_{k=23}^{29}\sum_{\alpha=\nu_{k-1}}^{\nu_k} t_k \prod_{\beta=23}^{k} W_k^{\nu_k-\alpha} \prod_{\theta=1}^{22} W_\theta^{q_\theta-\rho} \\ \text{If } \overline{WA} < \overline{QA} \\ \overline{QA_k} = \sum_{k=1}^{23}\sum_{\rho=l_{k-1}}^{l_k} t_k \prod_{\sigma=1}^{k} W_k^{l_k-\rho} + \sum_{k=23}^{29}\sum_{\alpha=\nu_{k-1}}^{\nu_k} t_k \prod_{\beta=23}^{k} W_k^{\nu_k-\alpha} \prod_{\theta=1}^{22} W_\theta^{q_\theta-\rho} \\ \overline{QA} = F_{min}(\overline{QA_k} - \overline{WA} > 0) \to 0 \end{array}\right. \end{array}\right. \quad (7)$$

In equation (7), there are two lines that contain a search for the minimum changing value of the parameter $\overline{QA_k}$:

$$\overline{ZA} = F_{min}\left(\overline{ZA_J} - \overline{WA} > 0\right) \to 0;$$
$$\overline{QA} = F_{min}(\overline{QA_k} - \overline{WA} > 0) \to 0;$$

Their meaning is as follows-since, in practice, the process is usually not immediately interrupted due to the appearance of a new drawing, it is more reasonable to assume that it must first be completed. The true time of work should be considered not the moment when the modification appeared, but the moment when the worker stopped completing the last action.

Note that equations (2-7) consider a situation in which fatigue accumulates only during the assembly and disassembly of packaging containers and each time they are reset when a new one is started. In real life, this happens, due to the fact that the study of the drawing, even with minimal changes, is a very long process, during which the worker has time to physically relax. If the changes are insignificant, they should not be introduced as a separate stage of assembly / disassembly of the package, but should be included as components in the current technological process.

CONCLUSION

The resulting equation significantly improved the mathematical description of the process and eliminated some inaccuracies. However, in order to accurately describe all the work being done and their impact on the process as a whole, it is necessary to further decide how it is possible to combine equations (6) and (7). Work in this direction will continue.

REFERENCES

1. Silantieva N.A., Malinovsky V.R. / Technical regulation of labor in mechanical engineering - 2nd ed. pererab. and additional - M.: Mashinostroenie, 1990, 256 p.

2. Loskutov I.A. Selection of management type on production developed by the development of equipment for a peaceful atom // Vestnik KemRIPK. Federal state Autonomous educational institution additional professional education "Kemerovo Regional Institute of Advanced Training». Kemerovo. 2018. no.3. pp. 18-26

3. Loskutov I.A. Rate of time of packing of power and control equipment for NPP // Journal of Natural Sciences Research. 2019. no.4. pp.14-18. URL:https://naukaru.ru/en/nauka/article/34750/view (Date of access 20.02.2020).

DEVELOPMENT OF A SOFTWARE MODEL OF REDUNDANCY WITH ROTATION FOR A MULTI-CHANNEL VOLTAGE CONVERTER

Lukina A.S., Tselischev I.S.
MIEM HSE
+7 (495) 916-88-80, aslukina_4@edu.hse.ru

Abstract — The paper considers the influence of changes in the load factor when power channels fail in multi-channel voltage converters on the value of their operating time to failure and taking into account the probability of failures (probability of successful switch over) when switching power channels in converters.

Keywords: reliability; dependability; redundancy; diverse redundancy; redundancy with rotation; electrical load factor; probability of successful switch over; multi-channel voltage converters.

INTRODUCTION

In the context of global automation, the task of improving the reliability of computer equipment is becoming more and more urgent. For example, the failure of the power supply system of the information system of a military defense object entails serious material damage, and sometimes can cause a disaster. In practice, the most common method for improving reliability is redundancy [1, 2].

This software model describes a diverse redundancy with rotation of power channels in multi-channel voltage converter (MCVC). Diverse redundancy “N+1+K” refers to a redundancy without restoration, where “N from (N+1)” is an active redundancy with N major elements and 1 hot reserve, the elements of which are reserved with K cold reserves [3, 4].

PROBLEM STATEMENT

In this paper, we consider ways to account for changes in the load factor in the event of failure of power channels (when power channels fail) and the probability of successful switch over in the simulation modeling of MMVC. We also provide an algorithm for recalculating the total operating time of MCVC in connection with the failure of channels during switching [5].

SOLUTION OF THE PROBLEM

When assessing the reliability of a redundant system, the main parameter is the failure rate of its components. The component failure rate is calculated based on the component failure rate of its type of radio electronic element [6]. Mathematical models of the failure rate for most types of radio electronic elements have the following form [7]:

$$\lambda_{component} = \lambda_{basic} \times \prod_{i=1}^{n} \mathrm{K}_i \, , \tag{1}$$

where λ_{basic} is basic failure rate of element's type (or group), calculated based on the results of tests for reliability and durability for this type; K_i is coefficients that take into account changes in the operational failure rate depending on various factors; n is the number of factors taken into account.

One of the factors affecting the operational failure rate of the radio electrical element is the value (amount) of electrical load, which is characterized by a load factor ($\mathrm{K_p}$) [8]. It is obvious that when power channel fails, the electrical load on the remaining channels increases, which in turn leads to an increase in their operating failure rate [9].

Thus, for the correct calculation of channel operating time [10], it is necessary to recalculate the component failure rate after each failure using the provided formula:

$$\lambda'_{component} = \lambda_{component} \cdot \frac{\mathrm{K'_p}}{\mathrm{K_p}} \, , \tag{2}$$

where $\mathrm{K'_p}$ is a current value of coefficient of electrical load of the channel; $\lambda_{\mathrm{component}}$, $\mathrm{K_p}$ refer to values of failure rate and the coefficient of electrical load before failure, respectively.

Further, we will discuss in more detail how to calculate the electric load coefficient for various types of redundancy, which are most often used when reserving voltage converters.

1. Active redundancy

By definition, in the active redundancy group (see Fig. 1) all channels are constantly in operation mode [11].

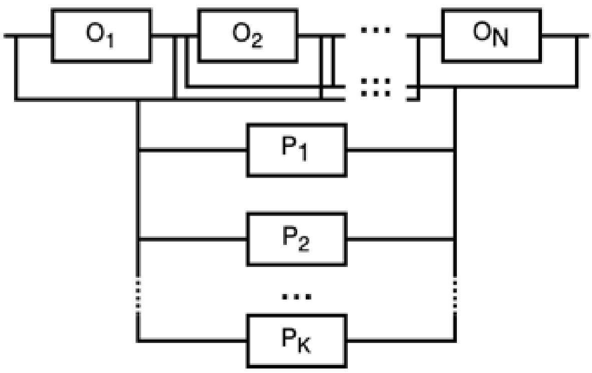


Fig. 1 Reliability block diagram of active redundancy

For an active redundancy, the K_p coefficient is calculated using the following formula:

$$K_p = \frac{N}{N+R} \, , \tag{3}$$

where N refers to number of major elements, R – number of reserves.

Therefore, for each failure, the K_p coefficient of the operable channels will increase until it reaches 1. It follows from (3) that the channel failure rate also increases. The algorithm for taking into account the load factor when calculating the operating time of the active redundancy group is proposed in fig. 2 [12].

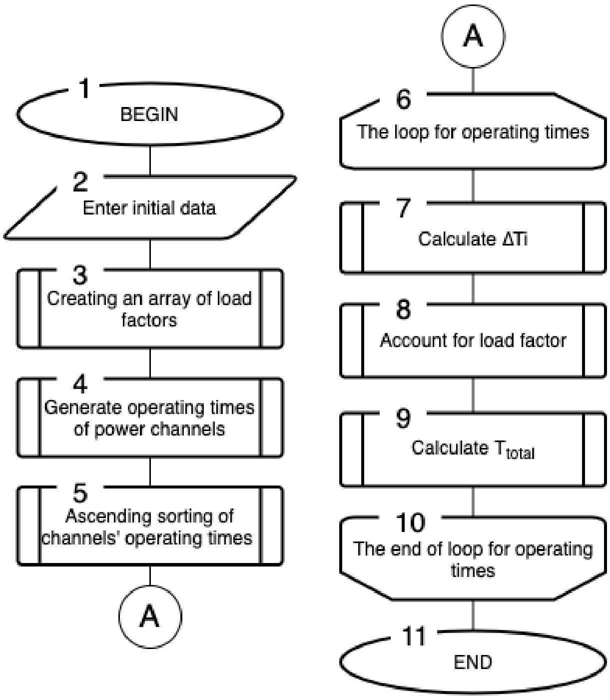


Fig. 2 Algorithm for calculating the operating time of the active redundancy

First, you need to determine the number of major and backup (hot reserves) channels. Let's put them equal to N (main) and R (reserve), respectively (Block 2 in Fig. 2). Then, using the formula (3), an array of load factors (Block 3) is calculated, the values of which are equal to the possible number of failures (the failure criterion of the reserved group) – ($R+1$) [13]. Next, the power channels are generated (Block 4), after which they are sorted in ascending order (Block 5).

The total time taken into account the load changes is calculated in Block 9 using the formula:

$$T_{total} = \frac{T_1}{K_{p(N+R)}} + \frac{\Delta T_2}{K_{p(N+R-1)}} + ... + \Delta T_{R+1}, \tag{4}$$

where ΔT_i is the value of the time interval between $(i-1)$ -th and i-th failures, $K_{p(N+R-i+1)}$ – load factor for ($(N+R-i+1)$ operating channels (it is obvious, that $K_{pN} = 1$).

2. Diverse redundancy

For diverse redundancy (see Fig. 3) the cold reserves (R_1 ... R_K) are in standby mode, so they do not affect the K_p coefficient of the working channels, which will remain unchanged until all K channels fail [13] (the K_p coefficient is calculated using the formula (3) for $R=1$).

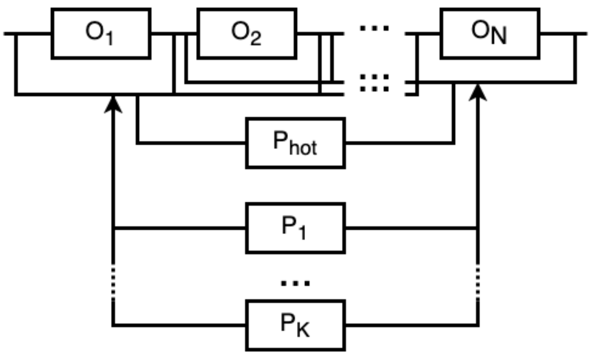


Fig. 3 Reliability block diagram of the diverse redundancy

After the failure of K channels, the scheme is converted to an active redundancy and the coefficient is also calculated using the formula.

In the framework of the developed program, diverse redundancy with rotation of power channels is considered, so it is necessary to determine the dependence of the $К_р$ coefficient on rotation. During rotation, there is no difference between the main(major) and cold reserve channels, since all channels are in both operation and standby mode for the same time [14]. Therefore, when rotating power channels, the electric load coefficient is calculated using the formula:

$$К_р = \frac{N+1}{N+1+K}. \quad (5)$$

Therefore, $К_р$ increases with each failure until it becomes equal to 1 (similar to an active redundancy).

MCVC in accordance with [15] is the object of multiple cyclic application. In the framework of the developed software model, power channels are considered non-recoverable, that is, they are not subject to restoration during the service life in the event of a failure. Therefore, one of the reliability indicators for power channels according to the classification [15] is $P_{0(on)}$ - the probability of failure-free operation (inclusion).

The probability of a failure- free channel operation is a random variable that obeys the law of uniform distribution. For failure-free calculations, $P_{0(on)}$ take close to 1. Since failure is the opposite of a fail-safe event, the probability of failure is in the range $\left(P_{0(on)};1\right]$. In other words, a failure to switch is an unlikely event [16].

Usually, the number of item switches during redundancy is quite small [17]. For example, for the standby redundancy with N main(major) and K backup elements (see Fig. 1) the number of item switches will be exactly equal to the number of backup items (K). In this case, the probability of switching, as an unlikely event, can be ignored without losing the accuracy of the estimation of the total operating time of the reserved group.

However, when rotating, the number of switches increases greatly. It depends on the number of power channels and the number of full rotation cycles during which the MCVC is expected to operate. The full rotation cycle refers to the length of time during which each of the power channels will be in both standby and operating mode. Note that in this voltage converter model, full rotation cycles can be of any length. The rotation period refers to the length of time between adjacent switches, which is defined as:

$$T_{period} = \frac{T_{full.rotation.cycle}}{N+1+K}, \quad (6)$$

where $T_{full.rotation.cycle}$ refers to value of current full rotation cycle; $N+1+K$ refers to number of working power modules.

Accordingly, for each full rotation cycle, the number of switches for one channel is $m = 2$, as defined by the full rotation cycle.

Thus, in general, the number of switches can be quite large. This, in turn, can significantly affect the reliability of the voltage converter [13].

The description of the patent [18] suggests switching channels after 24 hours. For example, consider a converter whose centralized part contains $N = 3$ main(major) power channels reserved by one hot reserve and $K = 2$ backup channels located in cold reserve. With an estimated service life of 1 year, the number of switches for a single power channel is defined as:

$$Q_i = m_i \times t\,, \tag{7}$$

where Q_i is the number of switches for the i-th channel m_i l, refers to the number of switches for the i-th channel in one full rotation cycle and t is the number of full rotation cycles.

According to the formula (7), Q will be equal to 730. Since in this example the values of the full rotation cycles are constant, the formula (7) is converted:

$$Q_i = m_i \times \frac{T_{work}}{T_{full.rotation.cycle}}\,, \tag{8}$$

where T_{work} is the service life, $T_{full.rotation.cycle}$ refers to the value of the full rotation cycle.

In this case, the total number of switches will be 4380. For comparison, in the standby redundancy with the same number of major and backup switching channels, there will be only 2.

Since the probability of a successful switch over is independent, the probability of a successful switch decreases as the number of switches increases:

$$P_{total} = P_{on1} \times \ldots \times P_{onq}\,, \tag{9}$$

where q is the number of switches; P_{oni} is the probability of a successful switch over during i-th switch.

Within the limits of the considered values for ensuring the probability of failure-free operation of the MCVC for one year, $P = 0{,}95$ for "absolutely" reliable modules (the probability of failure of the module $P_0 = 0$) the probability of a single switch must be:

$$P_1 = \sqrt[k]{P} = 0{,}99998\,, \tag{10}$$

where k is the number of switches, P is the probability of failure-free operation of the MCVC for one whole year.

From the calculations given above, it is obvious that taking into account the possibility of failure during switching is necessary for a correct assessment of the voltage converter's reliability.

A special separate module was created for calculating the operating time for channel failures when switching channels [19]. Let's consider in more detail the algorithm for accounting for the probability of successful switch over and the associated recalculation of the converter's operating time.

Due to the fact that to consider the probabilities it is necessary to calculate the number of switches it is done after the initial assessment of operating time.

To correctly identify the power channels that are in operation and standby mode at any time, a matrix of channel transitions is created, in which the rows correspond to the channel numbers, and the columns correspond to the rotation periods.

If two adjacent cells in the i-th row of the matrix are not equal to each other, then at this point in time, the i-th power channel switched (either to the standby mode or to the operating mode state). For each such point in time, an implementation of a random variable is generated that is equal to the probability of a successful switch. If this number is greater than the one specified in technical specifications $P_{0(on)}$), then there is a channel failure in this experiment. Since the failure occurred earlier than the calculated operating time, it is necessary to recalculate the operating time implementations for the remaining channels, as well as the final implementation of the MCVC operating time for the current number of channels.

Recalculation of channel’s operating time is performed according to the formula (11), and the final performance — according to the formula (12).

$$t_i^{'} = t_i - \sum_{j=1}^{n}\left\{T_{period.j} \times \left[\left(N+1\right) + \left(K \times \frac{\lambda_{s\tan dby}}{\lambda_{work}}\right)\right]\right\} - T_{period.n+1} \times \left[r_i + \left(w_i \times \frac{\lambda_{s\tan dby}}{\lambda_{work}}\right)\right], \quad (11)$$

where $t_i^{'}$ is the new operating time of i-th power channel, t_i is the initial operating time of i-th power channel, n refers to the number of – количество completed full rotation cycles before failure, n + 1, therefore, is a full rotation cycle in which a failure occurred, $T_{period.j}$ is a rotation period in the j-th cycle of full rotation, r_i and w_i are numbers of rotation periods in the n+1 full rotation cycle during which the i-th power channel was in operation and standby modes, respectively, λ_{work} is failure rate in operating mode, $\lambda_{s\tan dby}$ – failure rate in standby mode.

$$T = \sum_{j=1}^{n} T_{full.rotation.cycle.j} + T_{period.n+1} \times (r + w)\,, \quad (12)$$

where $T_{full.rotation.cycle.j}$ refers to the value of the j-th full rotation cycle, $(r + w)$ is the number of periods of rotation in n+1 cycle is a full rotation.

If the probability does not exceed the threshold value for any of the switches, then the channel's operating time remains the same.

After determining the MCVC’s operating time, its reliability block diagram is reconfigured in accordance with the following rules:

— before failure, the locations of power channels are determined by the transition matrix;

— if a failure occurs, the first backup channel in the queue is connected to the failed channel, which becomes the first of the working channels.

Further, the reconfigured reliability block diagram is considered a new converter with fewer channels and the algorithm for calculating the operating time is repeated until the number of power modules becomes equal to $N+1$.

It is worth noting that the software model provides an event when there was no failure during the entire rotation time. In this case, the probability of switching is also calculated. If there is no failure during switch over, the rotation stops and the reservation method is replaced with regular diverse redundancy.

The block diagram of the software module algorithm described above is shown in Fig. 4.

CONCLUSION

The amount of electrical load is one of the most important factors that affect the failure rate of channels, regardless of the type of redundancy. Thus, in order to create a correct software model for assessing the reliability of the MCVC, it is necessary to take into account the change in the electric load coefficient caused by failures of power channels during operation.

The probability of successful switch over in case of a large number of switches has a significant impact on the operating time. In this regard, to create a correct software model of redundancy with rotation, it is necessary to take into account the probability of successful switch over.

The model used in our program provides for the possibility of failure during the switching and the increase in value of the electric load on the power channels when a failure occurs. This will allow our simulation model of MCVCs to be as close to the actual conditions of their operation as possible. In the future, this will provide an opportunity to determine the optimal full rotation cycle for the specified reliability bock diagram and channel reliability characteristics [20].

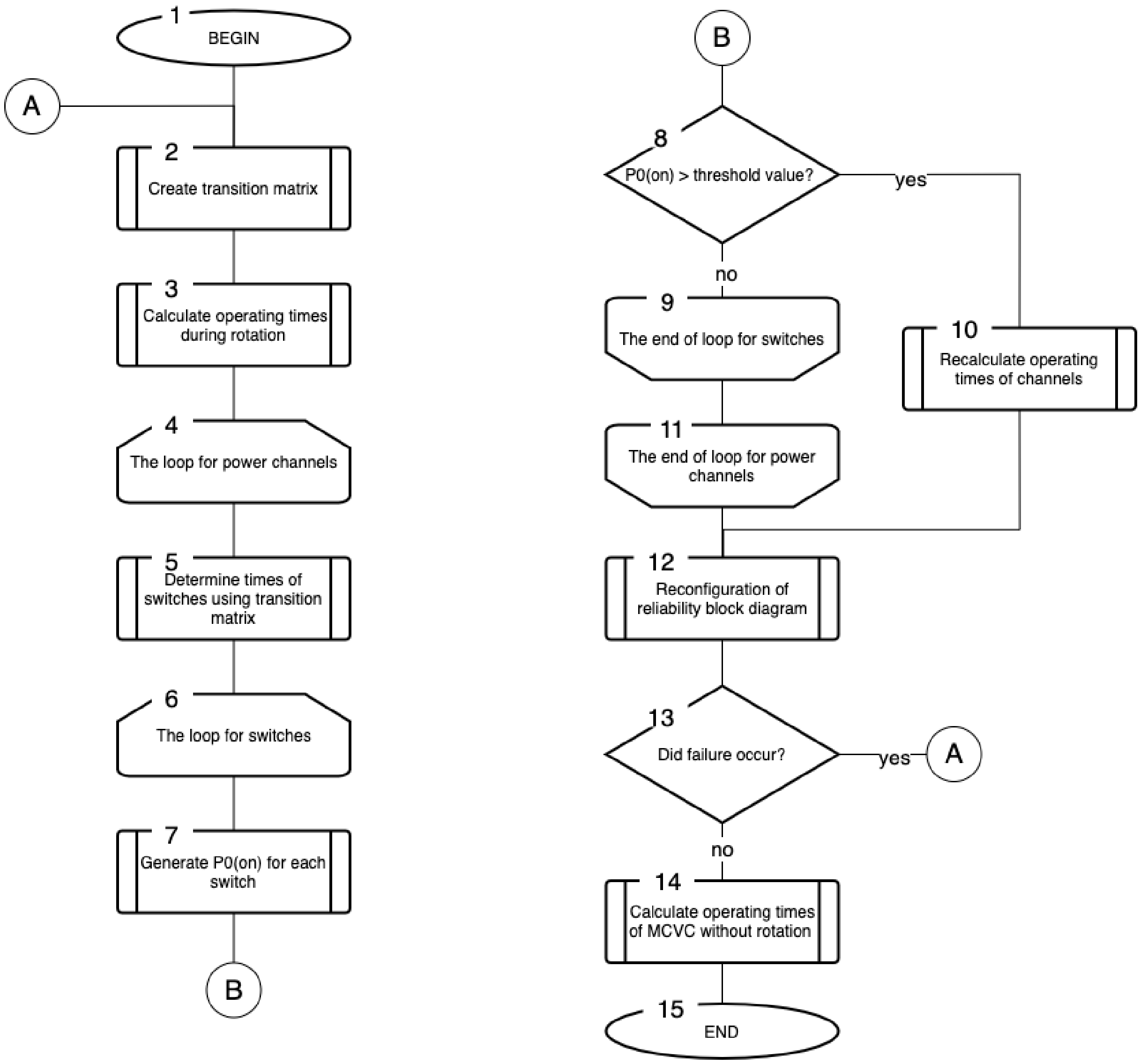


Fig. 4 Block diagram of the algorithm for the operation of the module for calculating the probability of channel failures during switching

REFERENCES

1. B. A. Kozlov and I. A. Ushakov, “Handbook for Reliability Prediction of Electronic Equipment and Automation” (in Russian), Moscow, Russia: Sovetskoe radio, 1975.

2. B. V. Gnedenko et al., “Mathematical Methods in the Reliability Theory” (in Russian), Moscow, Russia: Nauka, 1965.

3. Y. N. Libenko and A. N. Chetin, “Ways to Improve the Reliability of Secondary Power Supply Systems for Radio-Electronic Equipment” (in Russian), Power Supply, no. 4, pp. 10-2, Dec. 2010.

4. A. N. Chetin, “Application of Power Channels Rotation Method for Multi-Channel Voltage Converter Reliability Improvement” (in Russian), Practical Power electronics, no. 1, pp. 33-36, Jan. 2013.

5. V. V. Zhadnov et al., “Modern Problems of Automation of Dependability Prediction” (in Russian), Dependability, no. 2, pp. 3-12, Jun. 2007.

6. V. V. Zhadnov, “Calculation of the reliability of electronic modules: scientific publication” (in Russian), Moscow, Russia: Solon-Press, 2016.

7. Handbook “Dependability of ERP” (in Russian), Moscow, Russia: MO RF, 2006.

8. V. V. Zhadnov and A. N. Tikhmenev, "Simulation Modeling in Estimating Reliability of Fail-Safe Electronic Equipment", Dependability, no. 1, pp. 44-54, Apr. 2013. DOI: 10.21683/1729-2646-2013-0-1-32-54.

9. L. A. Baranov and Y.A. Yermolin, "Dependability of Objects with Non-Stationary Failure Rate. Dependability" (in Russian), Dependability, no. 4, pp. 3-9, Dec. 2017. DOI: 10.21683/1729-2646-2017-17-4-3-9

10. V. V. Zhadnov, "Model of Electronic Components Failures for Use in Simulation" (in Russian), in Proc. Innovative Technologies: Materials of the International Scientific-Practical Conference, Moskow, Russia, 2019, pp. 125-130.

11. Dependability in Technics. Dependability Prediction. Basic Principles, Interstate Standard 27.301, 1995.

12. A. S. Lukina and I. S. Tselischev, "Research of Change of Load Coefficient when Reserving Power Channels of Voltage Converter" (in Russian), in Proc. XXIV Annual Inter-University Scientific-Technical Conference of Students, Graduate Students and Young Specialists named after E. V. Armensky, Moskow, Russia, 2020, (in print).

13. V. V. Zhadnov, "Model of Voltage Converter with Rotation of Power Channels for Calculation of Its Operating Time in Statistical Modeling" (in Russian), in Proc. International Symposium "Reliability and Quality-2019", Penza, Russia, 2019, vol. 1, pp. 18-23.

14. A. N. Chetin, "Reliability Prediction of Power-Supply System with Dataway-Modular Architecture" (in Russian), Proceedings of Tomsk State University of Control Systems and Radioelectronics, no. 2(24), part 1, pp. 253-257, Jun. 2011.

15. Industrial Product Dependability. Contents and General Rules for Specifying Dependability Requirements, Interstate Standard 27.003, 2016.

16. G. S. Sadyhov et al., "The Lower Confidence Limit for the Probability of Failure-Free Operation of an Object Operating in a Pulsed Mode" (in Russian), in Proc. International Symposium "Reliability and Quality-2018", Penza, Russia, 2018, vol. 1, pp. 209- 210.

17. M. Artyukhova et al., "Current Approaches to Analysis of the Project Reliability of Electronic Devices of Cyclic Use", Reliability: Theory & Applications, no. 3, vol. 10, pp. 20-31, Mar. 2015.

18. Method of Controlling a Group of Secondary Power Sources (SPS) Connected in Parallel to Common Load Bus, by Y. N. Libenko and V. N. Rotarenko. (1993, March 23). Patent USSR: MPK H02J 9/06 1804678.

19. A. S. Lukina and I. S. Tselischev, "Study of Redundancy Efficiency in Multi-Channel Voltage Converter" (in Russian), in Proc. Conference "Information Society Technologies" 2020", Moscow, Russia, 2020, (in print).

20. V. V. Zhadnov and S. N. Polesskiy, "Development of Methods and Tools for Design Studies of the Dependability of Electronic Equipment" (in Russian), in Proc. International Symposium "Reliability and Quality-2010", Penza, Russia, 2010, vol. 1, pp. 14.

DISTANCE LEARNING METHODS AND TECHNOLOGIES AT AN OIL AND GAS ENTERPRISE

Bushmeleva K.I., Maiorov V.V.
SurGU
bkia@yandex.ru, Maiorov64@list.ru

Annotation—In the context of the increasing role of the innovative factor in the economic growth of Russian companies, the requirements for the qualitative characteristics of personnel and, above all, for their professional qualification level are increasing.

In the article, the authors determine the relevance of corporate personnel training system building. The modern market of training systems is considered, positive and negative sides are revealed. Five stages of distance learning are defined and considered.

Keywords: distance learning, oil and gas company, educational institutions, computer technologies.

The oil and gas industry is one of the most important for the Russian economy. Many industrial enterprises function, and the social sphere improves due to it. It is also one of the most dynamically developing and high-tech industries, as the demand for clean, safe, affordable energy increases every year, which leads to the growing demand for oil production. And, according to experts, the current state of the oil and gas industry in Russia opens up the possibility of further development of this complex. The undoubted advantage of the oil industry is that it firmly holds the second place after banking in terms of salaries.

Distance learning is a form of training in which the educational process uses the best traditional and innovative methods, means and forms of training based on computer and telecommunication technologies.

The goals of distance learning are:

• introduction of the latest modern information technologies in the educational process;

• introducing students to a creative approach in the educational process, independent activity;

• receiving regular consultations from the teachers;

• ability to use specialized literature without buying it;

• giving teachers the opportunity to decide how to build a teaching system, with the possibility to automate the entire process, making their work more creative and independent.

There are three main components in the distance learning system:

1) a student with his educational needs;

2) a teacher, coordinating and directing the educational activities of the student;

3) a specific educational environment in which the learning process is carried out.

Successful operation of the system is possible provided that both a student and a teacher are ready to interact in the new conditions. Distance learning in an educational institution is characterized by the following forms:

Chat: All students have simultaneous access to the chat. Thus, the student and the teacher can communicate in different places, as in reality: the teacher can conduct classes for an unlimited number of students, ask and answer questions, discuss, conduct control and practical classes [1].

Testing: It is assumed that each student has access to the electronic environment of the educational institution, where he can take tests, answer forum questions, and ask teachers questions.

Forum: The teacher gives questions for discussion, and the students answer these questions.

Oil production is a complex process that requires unique equipment, the most advanced technologies and knowledge. Oil has not been extracted manually for a long time, which means that each employee of the oil and gas company must be a highly qualified specialist. This is extremely important, since oil and gas companies are classified as the most dangerous production facilities. Accidents in this sphere happen according to a complex scenario, including various types of emergency events. Most often these are fires, explosions, and releases of hazardous substances. The consequences of accidents can harm not only the Oil Company, but also turn the region into an environmental disaster zone. The analysis of accident investigation materials conducted by Rostekhnadzor showed that almost half of the cases were caused by personnel low qualification or the presence of people without professional training at critical workplaces.

The oil and gas industry is currently facing a serious problem that needs to be solved immediately. It includes a new, more effective, not formal, but absolutely working approach to the training and retraining of specialists in the field of industrial safety of hazardous production facilities in the oil and gas industry [6].

Thousands of engineering students graduate annually from Russian universities. Only a third of them can work in the oil and gas industry, but they need to be retrained, because the level of training is behind of the industry development and is insufficient.

The way out of this situation is in the constant working specialists retraining and high-quality training of engineering students. This work is not only expensive, but it is rather long, since the learning process cannot be fast. However, thanks to the development of computer technology, it has become possible to improve the learning process: to make it more effective, but at the same time less costly. Also, computer technology allows you to conduct training without leaving your working place, which completely eliminates accidents during training [7].

Computer technologies make it possible to simulate complex technological complexes for training and advanced training of specialists in the field of oil, gas production, refining and petrochemistry. In many countries, the use of computer simulators for staff training is becoming a legal norm.

A modern market of training systems offers oil and gas companies various types of training simulators: simple training simulators, training complexes, automated training systems. They have reliable dynamic modeling, soundtrack, can include gaming technology, provide control over the progress and training quality and always give a high-quality result in the learning process. It is through the use of simulators that it is possible to increase the level of operational and engineering personnel training in the industry through the formation of basic skills of working with a control system and skills in emergency situations without affecting the real technological process and without carrying out the experiments on real objects [4].

Computer simulators for training personnel of oil and gas companies today are not a luxury, but an absolute necessity. It should also be noted that with the advent of the global Internet, distance learning has entered a new stage of development.

All these conclusions were fully confirmed by Gazprom Neft recent survey by. According to the results of assessing the benefits of each type of training, the majority of votes were collected by distance learning. Among the disadvantages of this scheme were named:

• inability to receive feedback,
• lack of communication or difficulty in communication with other program participants;
• limited development of practical skills.

The psychological factor of changing the situation and moving to another social environment during full-time study was also important for the respondents. Among the advantages, the respondents noted the opportunity to revise the previous material, saving time on travelling to the place of study, the opportunity to study at the workplace, and possibility to choose the schedule and terms of study [4].

An important advantage of distance systems is a high level of personalization. A student can independently determine the rate of studying, the period of time when he wants to study, which sections of the educational material to study and in what sequence. In this case, the content of the training can be combined for a particular student. All of these factors are extremely important in a limited time environment. Another important advantage of distance learning is effectiveness. This indicator largely depends on the subject of the distance course, but in most cases it is higher than in the traditional form of training. Some researches show that the duration of distance training can be reduced by 30-40% compared with the traditional form, and the rate of material memorizing increases by 10-30% [2].

The distance learning system at Gazprom Neft has been operating since 2010. At the moment, it includes 23 courses, and one more is in development.

There are three main areas of training: adaptation, personal effectiveness skills, and working with Microsoft Office. As part of adaptive distance programs, employees can take an introductory course or combined course on self-service systems, business trips and requests for the role assignment in the system. They can know about the self-assessment system, take courses on staff recruitment and study the main features of the target management system.

The set of courses aimed at acquiring personal effectiveness skills includes the programs “Oil Industry for Non-Oil Workers”, “Modern Management Skills”, “Effective Time Management”, “Development and Management Decision Making”, “Business Correspondence” and several courses on labor protection and safety measures. Self-service Microsoft Office package development is a standard and common option, which is also available to employees.

All employees of the Gazprom Neft corporate center take an introductory course and a course on self-service systems as soon as they start working in the company. The rest of the courses are assigned in accordance with the planned annual request or can be chosen by the employee in case of necessity during the year.

Recently, all the managers of the corporate center, whose responsibilities include working with staff, have been able to join the new course “HR for non-HR”. This is a special program for line managers, including test tasks, regulatory documents, in other words, the entire knowledge base on personnel management available in the company.

Currently, a new course is being developed - “Fundamentals of Oil Refining”, this is an analogue of the course “Oil Industry for Non-Oil Workers”, focused on logistics, refining and marketing products and intended for specialists who don’t have any special education, but have to deal with such problems. The implementation of the program is scheduled for the end of this year.

LMS (learningManagementSystem) is a software unit for the system management of educational processes. In this block, a common base is created where educational materials, trainings and courses are accumulated. Materials can be managed with the help of this structure, as well as the trainees. Using this platform allows you to increase and save information and control data of the learning process during the required period. Employees are entered into a common electronic database, they are given individual tasks in their personal accounts, introductory and subsequent thematic courses are run. To connect the theory with the practice the managers can work with virtual customers. It is convenient to run such training even with employees in other regions, while there is an opportunity to control training from a distance.

Training materials (various content and electronic courses) are developed depending on the profile and needs of the company. Universal products, such as: tests for personnel management, tests for time management, tests about work with Outlook are also used.

Electronic distance learning is implemented at the enterprise in 5 successive stages:

1. Analysis of EE tools (e-learning).
2. The choice of LMS according to the goals, needs, prospects and objectives of the company.
3. Planning the learning process in electronic form.
4. Implementation, support and promotion of a new training format.
5. Assessment of system productivity.

At the first stage, a three-module scheme of work (autonomous control, content, copyrighted materials) is built. A knowledge base and employee access to work tools (courses, video conferences, seminars, social networks, and authoring training programs) are being formed.

At the second stage, LMS is selected taking into account the desired prospects, tasks, and needs of the enterprise. Managers assess the capabilities of providers, ease of configuration and adaptation, technical potential and the cost of specific LMS supporting . Competentum, S-T-I, and e-Spring are popular in Russia, many of them work with the Multimedia Laboratory and the Mirapolis platform.

At the third stage, the educational process is planned, the expediency of third-party specialists participation, the creation of individual integrated programs is considered. Training and self-learning activities are planned, as well as providing effective assistance for business development and methods of final analytics.

At the fourth stage, an HR manager is appointed, company personnel are informed about the introduction of new training methods, training groups are created. By the time the system enters the stage of practical implementation, the goals of e-learning and development prospects should be clearly identified, a PR team created, a management system set up, partners selected and funds should be allocated.

The fifth stage is monitoring the learning outcomes. Performance indicators are the justification of the budget, increasing number of students in the groups, a change in the employees' approach to work, an increase in professionalism, and an improvement in the results of work processes. If the monitoring results are found to be unsatisfactory, some of the constituent elements of the process are adjusted. The correspondence of the level of the training program to the level of the audience, the aggregate relationship between different educational programs is checked.

Training tools and types of training material are selected depending on the specific goals of an individual company. Three basic teaching aids are used nowadays. For the company, one, two or all three methods can be selected, depending on the needs:

• webinars;

• distance learning systems;

• editors of electronic courses.

Webinars are reading and listening to online lectures. Students can be employees of remote branches, and the lecturer conducts classes from anywhere (central office, home, cafe). The webinar uses live communication through a microphone, chatting, demonstrations on the desktop, and presentations. If necessary, webinars are recorded on video and sent to listeners for subsequent use of materials and consolidation of knowledge. The webinar form is effective in order to save expenses on face-to-face trainings, payment of travel expenses and hotel accommodation for lecturers. An important point when choosing a webinar is to ensure uninterrupted communication between users. For a webinar, you should choose a stable platform to support interactive.

Remote learning systems allow you to organize virtual schools around the world, run training courses, monitor student performance and analyze learning outcomes. Typical distance learning features:

• a base for storing electronic courses, educational content on video, virtual tests. Employees of companies at a convenient time come in and re-examine the material for fixing;

• work with individual employees who take individual courses. This also applies for sub divisions and branches;

• detailed statistics for monitoring the quality of training, analysis of the learning rate, test results, assessment of employee progress;

• a system of chat or forum communication, idea and suggestion interchange.

When choosing this system, it is important to choose the right implementation method - work in the cloud or from the server.

The editor of electronic courses is needed as a tool for creating a variety of interactive trainings, testing, electronic courses, providing animation, video recordings, narration, slide shows, graphic and text files. To create an electronic training course, the qualification of a programmer is not required, but knowledge of PowerPoint is required, on the basis of which simple presentations are created. Employees will be able to take courses not only from computers, but also from mobile gadgets (smartphones and tablets).

A training management system is necessary for the convenience of using it by employees, quality control of effectiveness, analysis and testing. LMS provides adaptation of new employees, personnel reserve training, partners and clients training, certification and the internal knowledge base formation.

Today, ready-made control systems are developed, and, as a rule, each product has a free trial version that can be run as a test start, to evaluate the convenience and functionality, and then make a choice in favor of a specific product. The most popular platforms are Looop, iSpring Learn, Agilia and others.

Looop platform [4] is used by many well-known progressive corporations, representatives of small and medium-sized businesses in various fields of activity. Employees learn through computers and mobile applications, use the cloud service. The only negative point is the lack of Russian version.

iSpring Learn [4] - Russian development, designed for training and learning management in the cloud. The head of the company creates an account and registers in the system, downloads training content, and in the future the team works with these materials in the same way as in standard file storage like GoogleDrive or Yandex.Disk. iSpring Learn recognizes specialized training courses, documents, sound clips, videos and presentations. Materials can be combined into a comprehensive training program, you can set up a sequence of classes, assessment criteria and certification process. The system provides various user roles - author, administrator, user. Adding participants is maximally simplified. You can invite new users by e-mail, via the link, etc. It is possible to divide users into groups, for example, “beginners” and “professionals” or you can divide material into thematic areas of training: “security”, “sales”, “production”. The level of knowledge can be monitored in real time, in-depth statistics of results and analysis are provided. The iSpring Learn platform is chosen by many well-known companies, for example, Kazakhstani mobile operators, the Russian group ForaFarm, LaModa, Alfa Capital.

The head of the company faces a number of obstacles even at the planning stage of the implementation of the training system. It is necessary to develop an individual effective training scheme, to think over the aspects of compulsory programs. Branches of the company are often located in different areas of the city or regions. A significant problem is the constant shortage of working time and budget, as well as the high number of employees in need of such training.

In order to correctly introduce distance e-learning technology into the company’s work, an optimal step-by-step scheme is used:

1. The available learning resources, formats and tools are analyzed. At this stage, the most effective knowledge base and ways of perceiving the material are selected: webinars, distance theoretical courses, forums.
2. A management system is selected in accordance with the individual goals and objectives of the company. Today, the leader is presented with a choice of the LMS Multimedia Laboratory, Mirapolis, iSpring, etc. All options are considered through the prism of practical application, after which the best option is selected.
3. A training plan is being made up, the main points of which are connecting different specialists to the process, planning training events, making up individual programs for groups of employees and other necessary actions.
4. The goals and prospects of implementation are determined, an affiliate network is formed, and a control system is set up.
5. The effectiveness of the project is evaluated from a financial point of view and from the side of the working time cost. The limits of the budget and the number of employees being responsible for it are determined.

6. A test training course is run for a small group of employees (for example, for people working in one department). Results are discussed and analyzed.
7. The final analytics is carried out, after which the final decision is made about the implementation of the educational electronic system.

The process of distance e-learning introduction at an enterprise requires a continuous control at each stage. If a stage deviates from the set efficiency parameters, the whole process can begin to go through in a distorted form, and the final results will not bring the desired effect. In this case, the time and money spent on a new training format will be spent to no purpose.

Monitoring allows you to assess the level of readiness of the enterprise to implement a distance learning system, as well as to monitor the change dynamics over time periods. To do this, a single assessment system is created with criteria for comparing indicators for different structural units of the enterprise, different training systems and levels. Area of maximum achievements is defined, the quality of management and strategy, information-technical and educational-methodological support are investigated. Learning environment, the means of educational content transferring, the correspondence of offline and online support, and the indicators of the scale of implemented teaching method use are examined.

Information about going through each stage is collected automatically by means of web interfaces. A rating is created that is continuously monitored during the new training model implementation stages. Monitoring includes such techniques as:

• collecting feedback from system participants in a common account;

• achievement analysis at different stages, comparing the learning outcomes in different departments, as well as full-time and distance learning participants achievements;

• periodic assessment of the acquired knowledge;

• different rate analysis, working and commercial successes of employees, business improvement, completed projects;

• analysis of reduced training costs. If the analysis clearly shows the effectiveness of distance learning, you can stay the course of system implementation.

If the results seem ineffective, a correction should be made in the problematic. To do this, an expert group is created, and an analysis of the problematic stage or direction effectiveness is carried out. As a result of this group work, tactics are developed to improve the organization of training.

Methods for balancing the effectiveness of the process can be: the replacement of training tools or the introduction of additional methods for getting information, improving the technical base, additional investments. For example, if you do not get enough knowledge about the product you are selling, you can add a few additional explanatory webinars on a topic during a certain period of training, introduce online consultations on a "question-answer" basis, and attract specialists from the head office.

One of the effective correction methods is introspection, in which the results are evaluated using a special point system, and the efficiency rate is calculated. Each participant has his own personal account, introducing additional sections such as "Help", "New Tasks", "Assignment", "Report Table".

The distance learning system is a powerful tool for the company development, staff training and enterprise professional status improving. The maximum effect of the system implementation can be traced to achieve certain goals, for example, increasing sales, optimizing the workflow, improving interaction with partners, ensuring security, etc. The process of distance learning implementation needs continuous monitoring. In the absence of proper control, the effect will be reduced, and the costs will be significant. In each company, the introduction of distance and e-learning is carried out according to an individual scheme, which is associated with the goals and objectives, structure and profile of the enterprise.

REFERENCES

1. Computer simulators for oil and gas company's personnel training: luxury or necessety.URL: http://e-learn.sike.ru/news/trenazhery-dlya-podgotovki-personala-neftegazovyh-kompanij(17.01.2020).

2. Distance learning at OJSC «Gazprom Neft» (Optimal distance) – Production managemet. URL: http://www.up-pro.ru/library/personnel_management/training/distancionnoe-obuchenie.html (17.01.2020).

3. Modern types and methods of personnel training: advantages and disadvantages. URL: https://www.ispring.ru/elearning-insights/metody-obucheniya-personala(17.01.2020).

4. Implementation of personnel distance learning in the company. URL: https://www.crmm.ru/knowledge_base/Mesto_e_learning_v_korporativnom_obuchenii/vnedrenije_distancionnogo_obuchenija_personala(17.01.2020).

5. Distance learning characteristics: advantages, organization, methodology. URL: https://inostudent.ru/obrazovanie/texnologiya-distancionnogo-obrazovaniya.html(Дата обращения: 17.01.2020).

6. Oil and gas technologies: main features, where and how to work. URL: https://qwizz.ru/%D0%BD%D0%B5%D1%84%D1%82%D0%B5%D0%B3%D0%B0%D0%B7%D0%BE%D0%B2%D1%8B%D0%B5-%D1%82%D0%B5%D1%85%D0%BD%D0%BE%D0%BB%D0%BE%D0%B3%D0%B8%D0%B8/ (17.01.2020).

7. OJSC «Lukoil» distance learning system. URL: https://www.docme.su/doc/543742/sistema-distancionnogo-obucheniya-oao-%C2%ABlukojl (17.01.2020).

8. Modern types of learning: distance learning – «what is inside?» и «how does it work?»URL: http://www.hr-journal.ru/articles/op/op_697.html (17.01.2020).

CURRENT STATE AND SCIENTIFIC AND TECHNOLOGICAL FORECAST OF A REVOLUTIONARY BREAKTHROUGH IN WAVE SOLID-STATE GYROSCOPE TECHNOLOGY

Zhuravlev V.Ph., Perelyaev S.E.
Ishlinsky Institute for Problems in Mechanics of the Russian Academy of Sciences

Abstract – The wave solid-state gyroscope (VTG) or the hemispherical resonator gyroscope (HRG) is a very unique device in the field of practical application of high-precision inertial sensors. One of its earliest applications was the successful mission of the Cassini spacecraft to Saturn. After that, the choice of a new HRG instrument is an objectively selected gyroscope technology to support all space missions. The hemispherical resonator gyroscope HRG by Safran Electronics (France) based on a miniature hemispherical quartz resonator (Crystal) has proved that this particular gyroscope is able to meet all modern requirements. Parameters and characteristics that were previously achieved by well-known modern industrial optical technologies implemented in ring laser gyroscopes (RLG) and fiber-optic gyroscopes (FOG) are now very successfully implemented by inertial sensors VTG/PRG, with much higher reliability of gyroscope data, according to the latest research by the Agency DARPA (USA). Thanks to its HRG sensors, Safran Electronics & Defense's PRIMUS Inertial Measurement Unit family achieves high performance in a small size and is perfectly ready for integration into applications even with the most demanding requirements. Based on the advanced HRG technology, the new PRIMUS IMU family demonstrates Safran Electronics & Defense's leading gyro expertise by providing high navigation grade performance at a much lower cost and smaller

size than RLG (ring laser gyros) or FOG (fiber optic gyros)-based IMUs. PRIMUS is ideal for any application that requires very low random walk, excellent bias over temperature, low power consumption, low weight, high durability with unmatched reliability.

Keywords: Hemispherical Resonator Gyros (HRG); RLG (ring laser gyros); FOG (fiber optic gyros); Inertial sensors; Inertial Systems.

INTRODUCTION

Analysis of existing developments (analogues) in our country and abroad showed that the greatest success in creating a new wave solid-state gyroscope (VTG/|HRG) was achieved in the United States (Delco, which is now part of the Corporation "Northrop Grumman"). In 1965, this company was the first in the world to start searching in this area, and in 1982 it presented the first pre-industrial precision samples of a new type of inertial sensor (gyroscope). Until this time, all work in the United States on the new device was closed and there were no publications in open sources. In 1992, long-term certification tests of the new device were carried out in the Draper Laboratory (USA) and the parameters of uncompensated random drift (SKO) were confirmed to be no worse than 0.015 deg/h. At the same time, bins samples were developed based on HRG-158 with a diameter of a hemispherical quartz resonator of 58 mm, which were flown at a flying laboratory in Germany and these flights confirmed the accuracy of Autonomous operation at a level not worse than 0.78 nautical miles per hour. Industrial production of such HRG-158 and bins gyroscopes (Carousel-400) based on them was planned to replace the classic platform (gimbals) ins. However, in the 80-90s of the last century, the main eyes of the world's leading manufacturers of bins were turned towards promising laser gyroscopes and the development of ins based on them. Therefore, the pilot production of large wave gyroscopes HRG-158 with a hemispherical resonator Ø=58mm was discontinued and the developers were recommended to reduce the size and maintain the accuracy of the device for its wide application in rocket and space technology. As a result, the specialists developed a new small-sized HRG-130R with a quartz resonator diameter of 30 mm and saved the main accuracy parameters of the new device. In 1994-1995, the Laboratory the Draper team tested the HRG-130R and issued a certificate (passport) for the new HRG-130 small-sized gyroscope with a 30mm hemisphere diameter and a drift accuracy of at least 0.005 deg / h. testing of the new device for its use in the Trident ICBM control system was carried out during the period from 1999 to 2004.

The test results objectively showed that the HRG-130P meets the requirements for use in the Trident missile guidance system better than all other gyroscopes. Later, in the United States, industrial production of new devices of the HRG-130 type was established, and by 2004, about 100 HRG-130-based orientation systems were flying in outer space, which worked more than 10 million hours without failure. The new HRG-130 gyroscope was used to provide an ultra-long one-way flight of the Cassini (SPACECRAFT) NASA (more than 7.5 years) as part of the unique Saturn exploration space project. The Huygens probe, which the Cassini carried on Board, landed on Titan for the first time on January 14, 2005. On September 15, 2017, at 14:55:06 Moscow time, Cassini completed its 20-year mission in the Saturn system and burned up in the atmosphere of the gas giant. NASA broadcast the last minutes of the probe's life live. In France, from 1995 to 2005, SAGEM successfully developed a low-cost medium-range HRG and organized mass production of such gyroscopes for use on Board space objects and in the homing heads of aircraft weapons (guided bombs). Later, the specialists of this company developed HRG for space applications of the class 0.1 deg/h. According to open data from 2010, at least 1000 units were produced at the SAGEM plant near Paris with a 20mm resonator. Later, in 2013, bins was presented to foreign specialists and passed flight testing on the basis of HRG navigation accuracy class with a drift of at least 0.01 deg/h. The line of inertial aircraft systems based on HRG was actively advertised at the French air show Le Bourget in 2015.

As for other foreign developers and manufacturers of new gyroscopes, it is known that DOOSAN (Republic of South Korea) is very successful in developing an accurate HRG for its own air defense systems.

There is also a very active development of an exact HRG of its own design in Israel. Israel Aerospace Industries LTD (IAI), a well-known aerospace Corporation that plans to install HRG on its own unmanned aircraft, has shown interest in the new device. In China, new technologies for the production of HRG have been successfully developed and actively used in space programs.

PROBLEM STATEMENT

Mechanics of gyroscopic and navigation systems, as the science of mechanics goes back to the opening of Leon Foucault (1862), which established a property fast-rotating rigid body to maintain the orientation of the axis of rotation on the direction to a fixed star. The urgent need for a course-indicating device other than a magnetic compass for metal-hulled warships, which emerged at the end of the nineteenth century, determined the initial stage of intensive development of the corresponding section of mechanics and engineering. The next rapid stage of development of the mechanics of gyroscopic navigation systems is associated with the creation of rocket technology. The control system of German missiles was based on systems based on the use of gyroscopes and accelerometers as sensitive elements. In Soviet missiles, these systems were significantly improved. Improvement has affected both circuit solutions and the sensitive elements themselves. As a result, inertial navigation systems have appeared that can ensure the operation of the missile control system in a completely autonomous mode, without the use of external radio information. A similar path was taken by American developers of rocket technology, as it turned out later with very similar technical solutions. The task of navigation support for long autonomous trips of nuclear submarines gave a serious impetus to the development of gyroscope. Maintaining the accuracy of Autonomous navigation for a long time required the creation of a perfect gyroscope with extremely little care in maintaining orientation. In recent decades, intensive work has been carried out to find an alternative to the Foucault top-a mechanical gyroscope with a fast-rotating rotor. As a result, ring laser gyroscopes (RLG) were created and widely used, using the property of a standing light wave formed by two counter-coherent beams in a closed optical circuit. Interferometric fiber-optic gyroscopes (iFOG) have been created and are being intensively improved they use the same physical effect as laser gyroscopes, but they measure the phase shift of counter coherent beams without their direct addition. A distinctive feature of the laser gyroscope is an almost unlimited range of measured angular velocities. This property made it possible to abandon the spatial stabilization of the block of sensitive elements placed on the platform in a three-axis gimbals, and switch to cordless systems with mathematical recalculation of information measured in the axes of the object on the axis of the trihedral, convenient for navigation. Strapdown (Beskardanovaya) inertial navigation systems (SINS) based on laser gyroscopes are now very widely used in aviation. The properties of a standing wave, but already mechanical, formed by elastic vibrations of a thin hemispherical quartz shell, are used in a fundamentally new type of gyroscope. In Russian literature, it is called a wave solid-state gyroscope (VTG), in foreign literature – a hemispherical resonator gyro (HRG). The American version of HRG successfully provided navigation for the Cassini space project. The development of Autonomous navigation tools is one of the leading areas of technical progress. Combined with the computerization of society, navigation tools have become one of the leading components of the information environment. Gyroscopic devices are still an integral part of Autonomous navigation systems for maneuverable aircraft and guided missiles for various purposes. Modern aviation, rocket and space technology has become a special area of application for Autonomous inertial navigation systems (INS). In these traditional areas of applied gyroscope, autonomous inertial navigation systems are subject to increased accuracy and much more stringent operational requirements. They must function precisely in severe environmental conditions, have high reliability, long service life, high accuracy, have a small weight, size and energy consumption. All these requirements stimulate the development of fundamentally new types of gyroscopes, since the classic mechanical gyroscopes developed several decades ago do not meet the requirements of today in a number of parameters, mainly due to the presence of rotating and wearing components (electric motor, bearings). The use of a mass fixed in the bearings as a sensing element makes the classic rotary gyroscope sensitive to vibrations and mechanical loads. Although the characteristics of a traditional rotary mechanical gyroscope have been continuously improved by developers and industrial manufacturers for decades. The fundamental improvement of the main technical parameters of modern inertial sensors by technologists, design engineers and developers is associated with the new generation of solid-state wave gyroscopes. The principle of operation of HRG is based on the inert properties of standing elastic waves excited in axisymmetric shells.

The unique principle of operation gives the new gyroscope a number of unique advantages: the complete absence of rotating parts and a very large working life of the device; high accuracy and small random error; resistance to severe environmental conditions (temperature, vibration, gamma radiation); relatively small dimensions, weight, and power consumption; preservation of inertial information during a short power outage.

All the advantages noted above make the HRG one of the most promising gyroscopic sensors for use in modern strapdown inertial navigation systems (SINS). HRG has a number of obvious advantages over other types of gyroscopes – dynamically adjustable, laser, and fiber-optic-in terms of the mastered manufacturing technology, configuration and control system, as well as the achievement of potential accuracy characteristics. The design of the HRG completely lacks rotating parts, so the working life of the device is quite large (from 150,000 hours or more); the ability of the inertial sensor to tolerate very large overloads and shocks; compactness, small weight and dimensions; preservation of inertial information during a short power outage; low energy consumption; short readiness time; weak dependence on the ambient temperature when certain design and technological conditions are met; resistance to high-energy ionizing radiation. Thus, integrating and / or functioning in the mode of the angular velocity sensor HRG is one of the promising areas of development of precision gyroscopic sensors. HRG navigation class accuracy with a hemispherical quartz resonator due to the availability of manufacturing technology and achieved accuracy characteristics, attract the attention of all developers of modern gyroscopic technology.

MAIN CONCLUSION

As the main conclusions, we point out the following important operational advantages of the new generation wave solid-state gyroscope (VTG):

1. High accuracy, low power consumption, structural simplicity of mechanical components, resistance to power interruption, short availability time, wide operating temperature range, resistance to ionizing radiation, low sensitivity to linear overloads, high dynamic range of angular speeds, long service life, high reliability of the device, the possibility of using fully automated production in the manufacture of main parts of VTG.

2. The absence of complete loss of inertial information, in contrast to ring laser gyroscopes (RLG) and fiber-optic gyroscopes (FOG), with short-term failures in the operation of functional (service) electronics.

3. The number of parts of commercially produced medium-sized, precise and precision VTG is approximately 8-10 times less than RLG and FOG.

4. The simplicity and reliability of precision VTG determine its low cost in industrial production and relatively low resource costs for the implementation and support of production.

CONCLUSION

If the scientific community always regarded the HRG as a premier gyro with outstanding accuracy and reliability characteristics, few anticipated that HRG would be capable to successfully address the mass market. Safran, thanks to innovative design [5] and massive industrial investments, was capable to achieve it. With its 20 mm diameter resonator (fig. 1), Safran is able to address an unmatched range of applications.

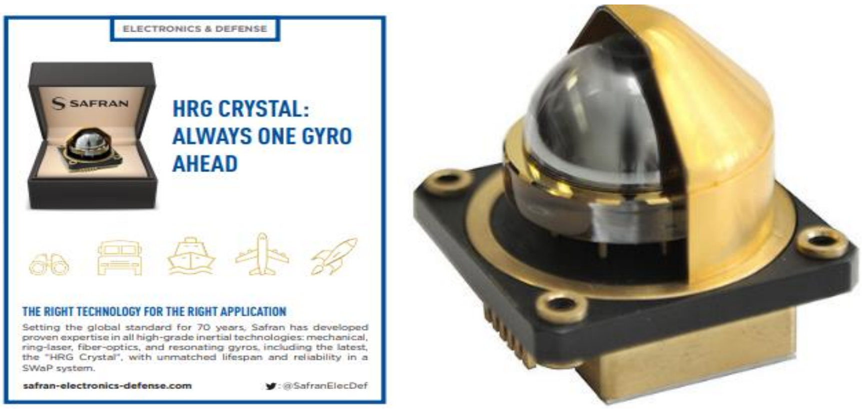
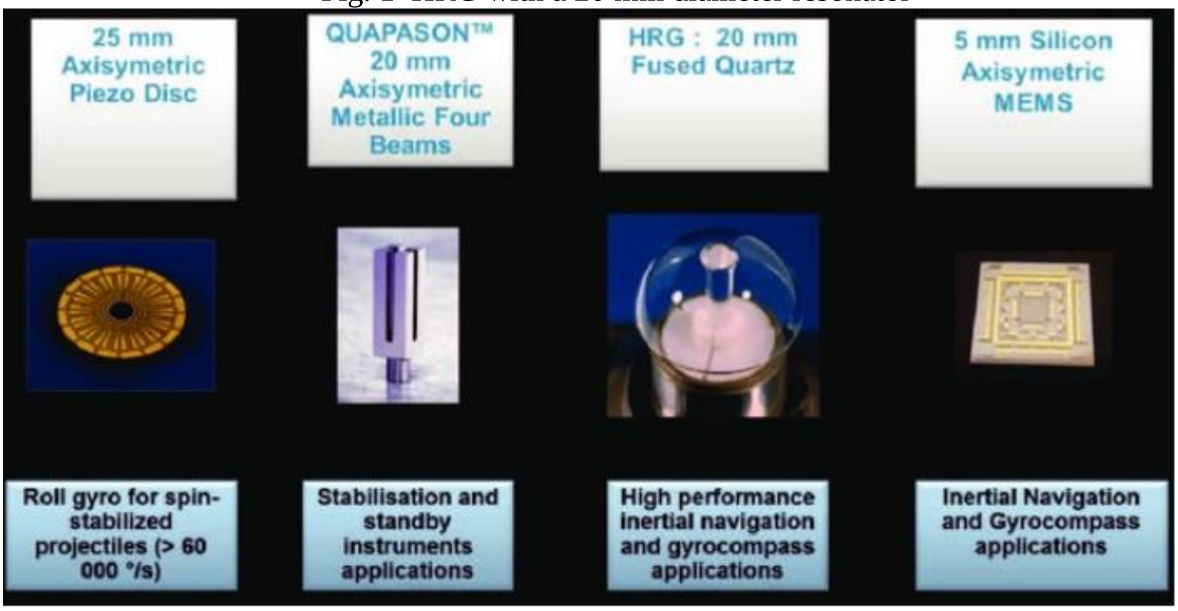


Fig. 1 HRG with a 20 mm diameter resonator



The Hemispherical Resonator Gyroscope (HRG), also called wine-glass gyroscope or mushroom gyro, is a compact, low noise, high performance angular rate or rotation sensor. An HRG is made using a thin solid-state hemispherical shell, anchored by a thick stem. This shell is driven to a flexural resonance by electrostatic forces generated by electrodes which are deposited directly onto separate fused-quartz structures that surround the shell. The gyroscopic effect is obtained from the inertial property of the flexural standing waves. Although the HRG is a mechanical system, it has no moving parts, and can be very compact.

From very cost effective marine compass to ESG grade strategic submarine navigation, from tripod mounted north finder to space launcher navigation, Safran HRG is able to fulfill needs for accuracy even in harsh environmental conditions and always in a very cost effective way. Safran has proven that HRG is much more than an innovative gyro technology; it is a disruptive technological breakthrough. HRG is a technology not only able to replace RLG and FOG but also to replace ESG as well as the promising Cold Atom technology for ultimate performances level. HRG is therefore able to recompose the inertial gyro technology landscape which could be soon pictured as per the fig 2.

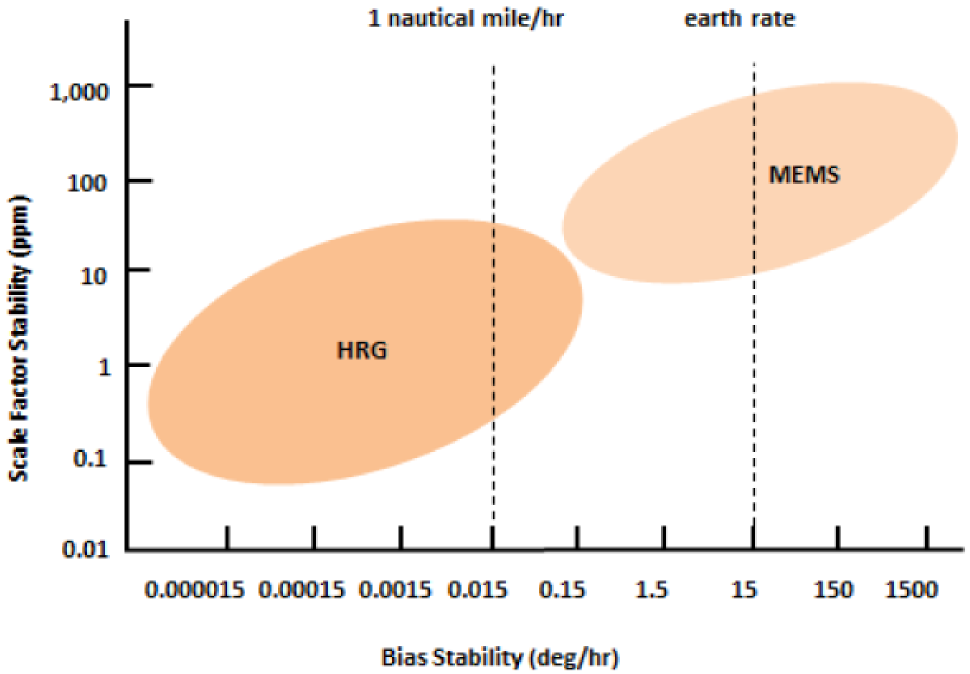


Fig. 2 Future gyro technology applications

It is known that the ultimate performance technology is the Electrostatically Suspended Gyroscope (ESG). Today, R&T studies are conducted on Cold Atoms especially with the aim to replace ESG in the future. From the 80s, Safran developed ESG and therefore has a deep knowledge how to use it in systems. Inspired by the way ESG short-medium-long term errors are compensated, Safran designed a prototype of navigation system based on its HRG and assessed performances, in operational conditions, at sea.

Technical data as well as actual performances are unfortunately classified but it was proven that HRG was able to reach performances ESG actually achieves and Cold Atom gyros are still contemplating.

ACKNOWLEDGMEN

This work was supported by RFBR (AAAA-A20-120011690138-6) Dynamics and motion control of complex mechanical systems, aircraft apparatuses and other moving objects, robotics, biomechanics, micromechanics, mechanics of navigation and gyroscopic systems.

REFERENCES

1. A.Matthews, «The Operation and Mechanization of the Hemispherical Resonator Gyroscope», 978-1-5386-1647-5/18/©2018 IEEE. – pp. 7 – 14.

2. D.M. Klimov, V.Ph. Zhuravlev, Y.K. Zhbanov, «Quartz hemispherical resonator (wave solid-state gyroscope)», ISBN: 978-5-9909668-5-7, Moscow. 2017. – pp. 40 – 45.

3. Perelyaev S.E. «Principles Governing Development of a Solid-State Wave Gyroskope Operating in a Combined Mode (Integrating Gyroscope and Angular Velocity Sensor (AVS)» // International Scientific – Practical Conference «Information Innovative Technologies», Prague, 2017.

4. Perelyaev S.E., «Wave solid-state gyroscope - the inertial sensor of new generation»: International Scientific – Practical Conference «INFORMATION INNOVATIVE TECHNOLOGIES», ISSN 2542-1824, Prague,, 2018
5. G. Remillieux, F. Delhaye, «Sagem Coriolis Vibrating Gyros: a vision realized», in Proceedings of Karlsruhe Conference on Inertial Sensors and Systems, 2014.
6. A. Jeanroy, P. Leger, «HRG flat electrodes», Patent US 6474161.
7. A. Jeanroy, A. Bouvet, G. Remillieux, «HRG and Marine applications», in Proceedings of 20th Saint Petersburg International Conference on Integrated Navigation Systems, 2013.
8. Alain Jeanroy, Gilles Grosset, Jean-Claude Goudon, Fabrice Delhaye, «HRG by SAFRAN - From Laboratory to Mass Production», in Proceedings of Inertial Sensors, 2016.
9. A. Lenoble, T. Rouilleault., PRIMUS: «SWAP-oriented IMUs for multiple applications», in Proceedings of Karlsruhe Conference on Inertial Sensors and Systems, 2016.

INTEGRATE FUZZY ANALYTIC HIERARCHY PROCESS INTO FAILURE MODE AND EFFECTS ANALYSIS TO IDENTIFY PRIORITY FUNCTIONS IN PRODUCT IMPROVEMENT PROCESS

Grodzenskiy S.Ya., Chesalin A.N., Pham Van Tu
RTU – MIREA (Moscow)
grodzenskiy_s@mail.ru, chesalin_an@mail.ru, anhtutula.king@gmail.com

Abstracts – Although FMEA identifies important hazards in a system, its results may not be comprehensive and the approach has limitations. Various solutions to this problem have been proposed, for example, using fuzzy logic instead of the classic RPN model. This article provides an overview of the combination of Failure mode and effects analysis (FMEA) and fuzzy analytic hierarchy process (FAHP) to identify the function of priority improvement in the quality improvement phase of Product Lifecycle. The article presents the steps for experts to evaluate and compare the importance of functions that need improvement by comparing two fuzzy numbers in fuzzy AHP. There by helping the group to make decisions that can make correct decisions during the quality improvement phase.

Keywords: Quality improvement, FMEA, AHP, fuzzy AHP, hybrid method of FMEA and FAHP.

1. INTRODUCTION

Failure mode and effects analysis (FMEA) is the process of examining as many components, assemblies, and subsystems as possible to identify potential failure modes in the system and their causes and their consequences [1]. Successful FMEA operations help identify potential failure modes based on experience with similar products and procedures or on the common physical basis of fault logic. It is widely used in development and manufacturing industries during different stages of the product life cycle. Although FMEA identifies important hazards in a system, its results may not be complete, and there are limitations to this approach, some studies have shown that traditional FMEA tools have limitations in determining the weights of the assessed product functions and their consistency. Therefore, to increase the accuracy of the assessment, it is necessary to combine FMEA with another method such as FAHP method to determine the priority of functions in the stage of potential risk identification and improvement product. FAHP is considered as a tool to determine the weight of the functions being evaluated.

Therefore, if combining the FAHP and FMEA models, it will overcome the disadvantages of each model and increase the accuracy of the assessment. In the past, there have been many studies integrating these two models into project risk management [2] to identify the factors affecting the cause of failure [3] and apply them to the Manufacturing Process [4]. However, the number of studies using the integrated FMEA-AHP fuzzy model in identifying potential risk priority indicators is still limited, especially the study using both of the above two tools to identify priority function in the improvement of the product lifecycle.

2. BASICS OF THE CONCEPT OF RESEARCH METHODS

Suppose a decision-making committee is composed of Y decision makers (D_t, t = 1, .., Y) responsible for evaluating X product function (F_i, i = 1, ... X) based on the Z standard (C_j, j = 1, ..., Z) where the rating for the functions is based on each criterion and the weight of these functions is expressed as a linguistic variable (Zadeh, 1975a,b) and presented as triangular fuzzy numbers (l, m, u). The process of the model is presented as follows:

Step 1: Define a set of standards for evaluating and grouping product functions that need improvement.

In manufacturing enterprises, the criteria used to evaluate and categorize product functions that need to be improved can be divided into two main groups: economic, environmental and second criteria is about safety, competition.

Step 2: Determine the weight for each criterion.

In this section, the FAHP method is applied to determine the priority (weight) of the criteria for evaluating product functions. Normally, the application of extension FAHP method is considered to be simple, popular and presented by Chang (1996) [5].

FAHP model works to determine the weight of the standards. The model uses linguistic variables to represent comparative assessments given by decision boards.

Let: F = {F_1, F_2, ..., F_X} be a set of X objects;

D = {D_1, D_2, ..., D_Y} is a set of Y comparative comments.

According to Chang's method, each Fi object corresponds to a comparable object, denoted by F_i. Accordingly, each Fi object will be compared with X the remaining target object, we notation as follows:

$$\tilde{a}_{i1}, \tilde{a}_{i2}, \ldots, \tilde{a}_{iX};\ \tilde{a}_{i1}, \tilde{a}_{i2}, \ldots, \tilde{a}_{iY};$$

Where, all values of $\tilde{a}$ are a triangle fuzzy number.

Using the arithmetic mean method, we can determine that each Fi object will be compared with X the remaining target object, we notation as follows:

$$\tilde{a}_{ij} = (l_{ij}, m_{ij}, u_{ij}) \text{ и } \tilde{a}_{ij}^{-1} = (1/u_{ij}, 1/m_{ij}, 1/l_{ij}),$$

with

$$l_{ij} = \frac{1}{Y}\sum_{k=1}^{Y} l_{ik},\ m_{ij} = \frac{1}{Y}\sum_{k=1}^{Y} m_{ik},\ u_{ij} = \frac{1}{Y}\sum_{k=1}^{Y} u_{ik}.$$

$i, j = 1,2, \ldots, X., i \neq j, \tilde{a}_{ij} = (1,1,1)$.

Step 2.1. Calculate the value of the sum of fuzzy numbers for the i-th object by the formula:

$$\tilde{S}_i = \sum_{j=1}^{X} \tilde{a}_{ij} \otimes \left[\sum_{i=1}^{X}\sum_{j=1}^{X} \tilde{a}_{ij}\right]^{-1} \tag{1}$$

with ⊗ stands for extended multiplication of two fuzzy numbers.

We have:

$$\sum_{j=1}^{X} \tilde{a}_{ij} = \left(\sum_{j=1}^{X} l_{ij}, \sum_{j=1}^{X} m_{ij}, \sum_{j=1}^{X} u_{ij}\right)$$

$$\sum_{i=1}^{X}\sum_{j=1}^{X}\tilde{a}_{ij} = \left(\sum_{i=1}^{X}\sum_{j=1}^{X} l_{ij}, \sum_{i=1}^{X}\sum_{j=1}^{X} m_{ij}, \sum_{i=1}^{X}\sum_{j=1}^{X} u_{ij}\right)$$

then we get:

$$\tilde{S}_i = \left(\frac{\Sigma_{j=1}^{X} l_{ij}}{\Sigma_{i=1}^{X}\Sigma_{j=1}^{X} u_{ij}}, \frac{\Sigma_{j=1}^{X} m_{ij}}{\Sigma_{i=1}^{X}\Sigma_{j=1}^{X} m_{ij}}, \frac{\Sigma_{j=1}^{X} u_{ij}}{\Sigma_{i=1}^{X}\Sigma_{j=1}^{X} l_{ij}}\right)$$

Step 2.2. Calculate the degree of possible relationship between two fuzzy numbers.

$$V(\tilde{S}_i \geq \tilde{S}_j) = sup_{y \geq x}\left[min(\tilde{S}_j(x), \tilde{S}_i(y)\right]. \quad (2)$$

The above formula can be expressed as follows:

$$V(\tilde{S}_i \geq \tilde{S}_j) = \begin{cases} 1, & m_i \geq m_j \\ \frac{u_j - l_j}{(u_j - m_i) - (m_j - l_j)} & l_j \leq u_i.\ i, j = 1,2,\ldots,X., i \neq j \\ 0 & Other\ cases \end{cases} \quad (3)$$

где $\tilde{S}_i = (l_i, m_i, u_i)$ и $\tilde{S}_j = (l_j, m_j, u_j)$.

To compare $\tilde{S}_i$ and $\tilde{S}_j$, we need to calculate the value of: $V(\tilde{S}_i \geq \tilde{S}_j)\ and\ V(\tilde{S}_j \geq \tilde{S}_i)$.

Step 2.3. Calculate the likelihood of the probability that the relationship will occur, some fuzzy numbers are larger than the others.

$$V(\tilde{S}_i \geq \tilde{S}_j |\, j = 1,2,\ldots,X., i \neq j) = V\left(\tilde{S}_i \geq \tilde{S}_1) \cap (\tilde{S}_i \geq \tilde{S}_2) \cap \ldots \cap\ (\tilde{S}_i \geq \tilde{S}_X)\right)$$
$$= minV(\tilde{S}_i \geq \tilde{S}_j), j = 1,2,\ldots,X.$$

At the last step, we estimate the preferred vector $W_i = (W_1, W_2, \ldots, W_X)$ of the correspondence matrix $\tilde{a}_{ij}$ as follows:

$$W_i = \frac{V(\tilde{S}_i \geq \tilde{S}_j |\, j = 1,2,\ldots,X., i \neq j)}{\Sigma_{i=1}^{X} V(\tilde{S}_i \geq \tilde{S}_j |\, j = 1,2,\ldots,X., j \neq i)}, i = 1,2,\ldots,X.$$

We have:

$$V(\tilde{S}_i \geq \tilde{S}_j |\, j = 1,2,\ldots,X., i \neq j) = V\left(\tilde{S}_i \geq \tilde{S}_1) \cap (\tilde{S}_i \geq \tilde{S}_2) \cap \ldots \cap\ (\tilde{S}_i \geq \tilde{S}_X)\right)$$
$$= minV(\tilde{S}_i \geq \tilde{S}_j), j = 1,2,\ldots,X.$$

then we get:

$$W_i = \frac{minV(\tilde{S}_i \geq \tilde{S}_j), j = 1,2,\ldots,X;\ i \neq j}{\Sigma_{i=1}^{X} minV(\tilde{S}_i \geq \tilde{S}_j), j = 1,2,\ldots,X; j \neq i}, i = 1,2,\ldots,X. \quad (4)$$

Step 3. Calculate the Risk Level (Examining Risk Priority Numbers in FMEA).

Examining Risk Priority Numbers (RPN) is a technique for analyzing risks associated with potential problems identified in Failure Mode and Effect Analysis (FMEA).

The risk priority of the traditional FMEA (RPN) and the risk priority number of integrated FMEA-AHP fuzzy (FRPN) are calculated as follows.

$$RPN_i = Severity \times Occurrence \times Detection \qquad FRPN_i = W_i \times RPN_i$$

Step 4. Compare the FRPN indexes with each other, whichever is greater is the first priority to improve.

3. RESEARCH RESULTS

The proposed method is applied to the automotive manufacturing business, the company needs to modernize the production technology of automotive equipment and components to improve product quality and reduce risks. damage to the user. During the operation of the vehicle, stability and safety are some of the most important requirements for customers. This method focuses on possible failure modes during operation. Here we give 4 main criteria that affect the quality of cars (stability and safety) including (engine (D), transmission (T), brakes (B) and electrical equipment (E)). Here are four key factors that affect car customer satisfaction (efficient and safe use).

Functional objects have different weight in relation to the importance of the quality of automobile production in terms of possible failures. The first main step of the proposed methodology is implemented by pairwise comparison by 3-5 experts to determine the importance of functional objects in improving the quality of the process, taking into account possible failures. Estimates of experts on linguistic variables for functional objects in terms of their importance are obtained in accordance with table 1.

TABLE 1. MATRIX Ã, PAIRWISE COMPARISON OF PERFORMANCE CRITERIA BY NUMBERS

№	D	T	B	E	W
D	1, 1, 1	5/6, 1, 5/3	5/6, 4/3, 7/3	4/3, 2, 3	0.32
T	3/5, 1, 6/5	1, 1, 1	13/12,16/9, 5/2	17/12,19/9, 17/6	0.34
B	3/7, 3/4, 6/5	2/5, 9/16, 12/13	1, 1, 1	7/9, 3/2, 7/3	0.21
E	1/3, 1/2, 3/4	6/17, 9/19, 12/17	3/7, 2/3, 9/7	1, 1, 1	0.13

W- relative weight.

Using the formula (1), we obtain:

$\tilde{S}_1$ = (4, 5.33, 8)⊗(1/23.728, 1/17.673,1/12.825) = (0.168, 0.302, 0.624)

$\tilde{S}_2$ = (4.1, 5.89, 7.53)⊗(0.042, 0.0566, 0.078) = (0.172, 0.33, 0.587)

$\tilde{S}_3$ = (2.61, 3.813, 4.456)⊗(0.042, 0.0566, 0.078) = (0.11, 0.216, 0.348)

$\tilde{S}_4$ = (2.115, 2.64, 3.742)⊗(0.042, 0.0566, 0.078) = (0.089, 0.15, 0.292)

Using formulas (3) we get:

$V(\tilde{S}_1 \geq \tilde{S}_2) = \frac{0.172-0.624}{(0.302-0.624)-(0.33-0.172)} = 0.942$, $V(\tilde{S}_1 \geq \tilde{S}_3)$ =1, $V(\tilde{S}_1 \geq \tilde{S}_4)$=1,

$V(\tilde{S}_2 \geq \tilde{S}_1)$=1, $V(\tilde{S}_2 \geq \tilde{S}_3)$ =1, $V(\tilde{S}_2 \geq \tilde{S}_4)$=1,

$V(\tilde{S}_3 \geq \tilde{S}_1) = \frac{0.168\text{-}0.348}{(0.216\text{-}0.348)\text{-}(0.302\text{-}0.168)}$=0.687,

$V(\tilde{S}_3 \geq \tilde{S}_2)$= $\frac{0.172-0.348}{(0.216-0.348)-(0.33-0.172)} = 0.607$, $V(\tilde{S}_3 \geq \tilde{S}_4)$ =1,

$V(\tilde{S}_4 \geq \tilde{S}_1)$= $\frac{0.168-0.292}{(0.15-0.292)-(0.302-0.168)} = 0.456$,

$V(\tilde{S}_4 \geq \tilde{S}_2)$=$\frac{0.172-0.292}{(0.15-0.292)-(0.33-0.172)} = 0.4$,

$V(\tilde{S}_4 \geq \tilde{S}_3)$ =$\frac{0.11-0.292}{(0.15-0.292)-(0.216-0.11)} = 0.734$.

Finally, using formula (4), we obtain

d’(D) = $V(\tilde{S}_1 \geq \tilde{S}_i |\, i \neq 1) = V(\tilde{S}_1 \geq \tilde{S}_2, \tilde{S}_1 \geq \tilde{S}_3, \tilde{S}_1 \geq \tilde{S}_4)$ = min(1,0.942,1) = 0.942

d’(T) = $V(\tilde{S}_2 \geq \tilde{S}_i |\, i \neq 2) = V(\tilde{S}_2 \geq \tilde{S}_1, \tilde{S}_2 \geq \tilde{S}_3, \tilde{S}_1 \geq \tilde{S}_4)$ = min(1,1,1) = 1

d’(B) = $V(\tilde{S}_3 \geq \tilde{S}_i |\, i \neq 3)$= $V(\tilde{S}_3 \geq \tilde{S}_1, \tilde{S}_3 \geq \tilde{S}_2, \tilde{S}_3 \geq \tilde{S}_4)$= min(0.687,0.607,1) = 0.607

d’(E) = $V(\tilde{S}_4 \geq \tilde{S}_i |\, i \neq 4)$= $V(\tilde{S}_4 \geq \tilde{S}_1, \tilde{S}_4 \geq \tilde{S}_2, \tilde{S}_4 \geq \tilde{S}_3)$= min(0.456, 0.4, 0.734) = 0.4

the result is $W' = (0.942, 1, 0.607, 0.4)$

Through normalization, and we got weight vectors relative to the decision criteria D, T, B and E.

$$W = (0.32, 0.34, 0.21, 0.13)$$

TABLE 2. THE RESULT OF THE CALCULATION OF FRPN FOR FMEA – FUZZY AHP

№	S	O	D	RPN	Rank RPN	**W**	FRPN	Rank FRPN
D	6	6	4	144	2	0.32	46.08	1
T	4	4	8	128	4	0.34	43.52	2
B	7	6	4	168	1	0.21	35.28	3

E	6	6	4	144	2	0.13	18.72	4

From the above results, we can see that, if used according to traditional FMEA, the priority order for functional improvement are: B, D, E, T respectively. However, with the combination of traditional FMEA and fuzzy AHP, we get another result, according to which the order of priority for improvement is: D, T, B, E.

4. CONCLUSION

With the help of fuzzy analytic hierarchy process, experts can determine the priority weight of the product's functions, thus helping the decision-making team have more bases to evaluate and make accurate decisions for each function are prioritized for improvement in the process of improving the quality of the product lifecycle.

REFERENCES

1. Grodzenskiy S.Ya., Grodzenskiy Ya.S., Chesalin A.N. Tools and methods of quality management: Textbook. - Moscow: Prospekt, 2019. -128 p.
2. Emad R., Fatemeh M. Using fuzzy FMEA and fuzzy logic in project risk management: Iranian Journal of Management Studies (IJMS). Vol. 8, No. 3, July 2015. pp: 373-395.
3. Reza K.A., Hamid R.F., Hassan J. A hybrid of fuzzy FMEA-AHP to determine factors affecting alternator failure causes: international Journal of Industrial Engineering Computations. September 2014.
4. Mehmet E., Ahmet C.K. A Fuzzy Hybrid Approach for Fuzzy Process FMEA: An Application to a Spindle Manufacturing Process: International Journal of Computational Intelligence Systems, Vol. 5, No. 4 (August, 2012), 611-626
5. Chang D. Y., Applications of the extent analysis method on fuzzy AHP, European Journal of Operational Research 95(3) (1996) 649–655.

HEADSETS WITH ACTIVE NOISE CANCELLATION FOR STAFF OF AIRCRAFTS. PROJECTING FEATURES.

Kobozev A.A., Raevskiy G.P.
MIREA – Russian Technological University
+7 (905) 622-92-25, alexsedlex@rambler.ru; +7 (910) 422-84-50, geraevskiy@yandex.ru

Abstract — Issue of discuss is problem of projecting and features of designing headsets with active noise cancellation, found wide using by staff of aircrafts. This article described the problem condition and base challenges which designer has when he creates such devices. Recommendations have been developed to overcome them.

Keywords: Active noise reduction; Active noise cancellation; headphones; active noise canceling headset; headphone design.

INTRODUCTION

The results of numerous studies, including [1, 2], indicate the effect of acoustic noise on human fatigue. Proven [3] is also the fact of a decrease in concentration of attention under the influence of this factor (Fig. 1). Obviously, in those areas of activity where the life and health of people depend on the mental and general physical condition of the employee, all possible measures must be taken to maintain him in the best possible way.

To reduce the negative impact of noise on the condition of the crew, headsets are used, the structure of which includes headphones, designed to protect hearing organs. In most cases, systems of this type with passive noise reduction are not effective enough to absorb the low-frequency component, which dominates the noise spectrum of the aircraft (Fig. 2) and has the most harmful effect on the human body. The solution to this problem was made possible through the use of headsets with an active noise reduction system, which are especially effective in the indicated frequency range.

When designing such devices, the developer faces a number of specific problems, the presence of which is especially important to consider when designing.

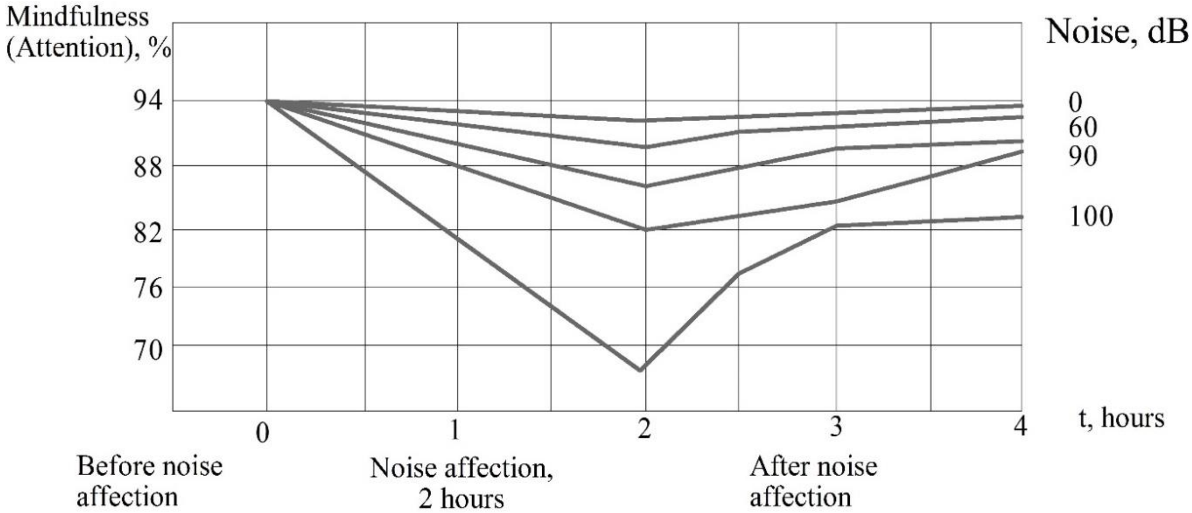


Fig. 1 Dependence of attention concentration on the level and duration of exposure to noise

PROBLEM STATUS

The principle of active noise reduction in head phones is as follows: an additional (tracking) microphone is built in to the earphone from the inside or outside (sometimes on both sides), the signal from which goes to the electronic module, where it is processed, and the amplification, and then the signal returns into the headphone via the phone or an additional speaker in antiphase to the noise signal. Using special signal processing algorithms, if a headphone has a speech microphone (i.e., if it is a headset), you can distinguish the user's voice against ambient noise, muffling the latter due to the spatial separation of the two microphones and the selection of their directivity characteristics.

In this case, the main (speech) microphone in the process of transmitting speech perceives the operator’s voice more than the auxiliary microphone.

Thanks to a set of measures to ensure active noise cancellation, it is possible to achieve a reduction in harmful noise influences penetrating from the external environment under the ear cushion of the headset by more than 20 dB (at individual frequencies up to 30 dB) with a maximum noise level of up to 115 dB. This reduces the impact of the especially low-frequency component of noise, the most dangerous in that it contributes to the rapid accumulation of physical and psychological fatigue in the crew.

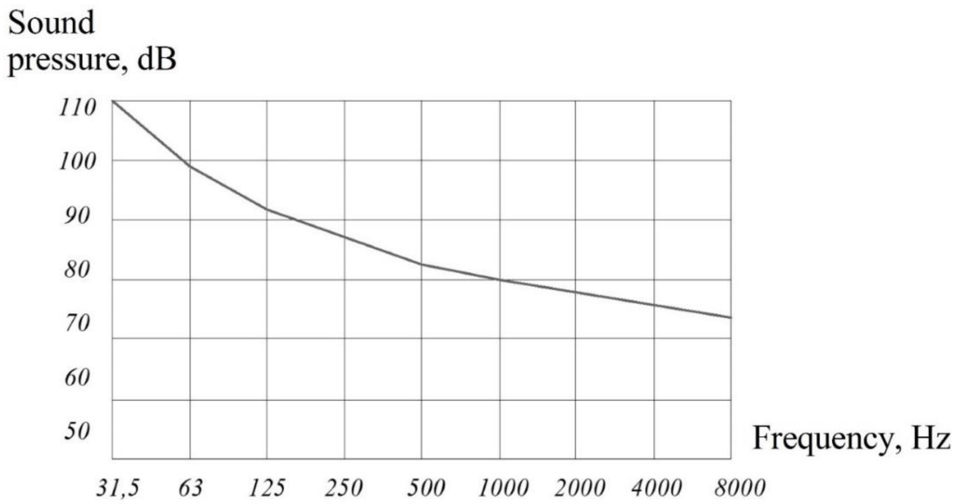


Fig. 2 Dependence of the spectral density of noise on frequency in the cockpit of MI-8 helicopter

A typical block diagram of an active noise reduction system is shown in Figure 3.

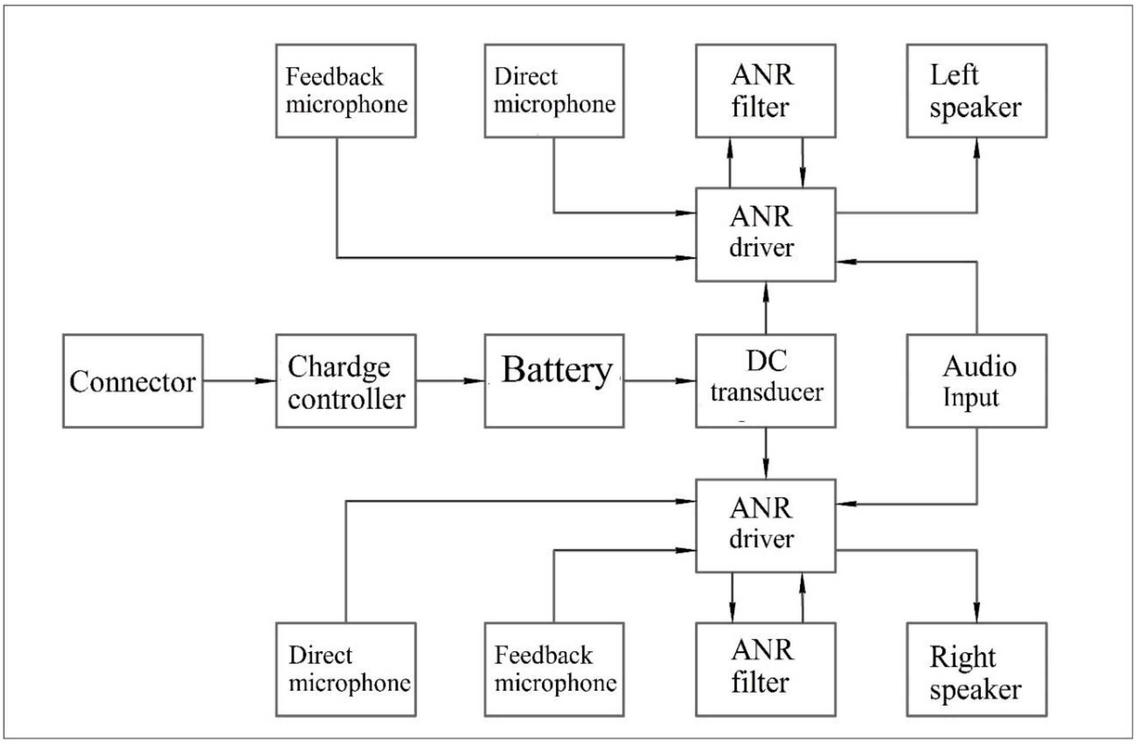


Fig. 3 Block diagram of the active noise cancellation system in the headset phones

With all the obvious advantages for the user, the development of such devices requires a comprehensive solution from the developer, taking into account the solution of a number of problems discussed below.

1. The frequency response characteristic of the tracking microphone’s sensitivity, measured in its working area, should be as even as possible in the working sound range, and the resonance frequency should be as high as possible, since the presence of microphone resonance in the working range of phones can lead to acoustic feedback, t. n "Ties" in systems that do not use built-in spectrum analyzers. The appearance of the latter will not allow you to effectively configure the system if developers refuse to use built-in spectrum analyzers, the use of which can

significantly increase the cost of production due to the high cost of their microcircuits, and the large labor costs when setting up and adjusting.

2. The natural frequency of the resonance of the volume of the headphone camera should be as high as possible so that the signal inverted from the telephone or the auxiliary speaker does not turn out to be in phase with the harmful noise signal falling at the natural frequency of the camera, which creates the effect directly opposite to the desired one. At the same time, the quality factor of the resonance of the camera should be minimal in order to avoid the occurrence of acoustic feedback ("ties").

3. The frequency response of the sensitivity of the telephone or auxiliary speaker and the transfer function of the electronic module must take into account the decrease in sound pressure developed by the sound source in the low frequency region due to reflection of sound waves from the walls of the internal volume of the earphone.

4. The dynamic range of the electronic module and the sensitivity of the telephone or auxiliary speaker should be selected in such a way as to equally absorb noise from 65 to 115 dB, penetrating under the ear pads, i.e. the total dynamic range of the system should reach 50 dB.

5. The auxiliary microphone must be effectively protected from vibrations that occur in the system at frequencies close to resonant, since they can also cause acoustic feedback (“ties”) and, as a result, self-excitation of the entire system.

6. The design of the filter of the electronic module must take into account the phase characteristics of the telephone or auxiliary speaker, auxiliary microphone, internal volume of the headphone camera and phase correction due to the influence of reflected sound waves.

7. The system must withstand the effects of harmful factors in accordance with the requirements of the international standard [4], ie provide comfortable, from the point of view of noise conditions, crew work in almost any climatic conditions, including in conditions of emergency depressurization of the aircraft. At the same time, the system can be exposed to significant vibrations, shock and overload due to shaking of the aircraft, the headset falling from the head of the operator during operation or during transportation.

8. The designer must take all possible measures to prevent the system from self-excitation due to accidental physical or electrical influences, since a phase rotation of the inverted signal by more than 90 ° can lead to an increase in the noise level in the headphones and, as a result, damage to the pilot’s hearing or even shell shock, especially if the frequency of self-excitation will fall on the minimum region of curves of equal loudness [5].

9. The economic component of the project should take into account the possibility of ensuring its technical characteristics and a long reliability resource in the conditions of the relative narrowness of the market for product sales.

PROPOSALS FOR SOLVING THE PROBLEM

According to our estimates, to date, the theoretical model for constructing active noise reduction systems has not been sufficiently developed, and the design is based mainly on empirical data and measurement results with a consistent selection of suitable technical solutions. Despite the large number of patents in this field, this topic is rather poorly consecrated in the scientific literature and is extremely superficial in nature.

The solution to the problem, in our opinion, lies at the junction of classical acoustics, electroacoustics and theory of automatic control. In this case, it is recommended that the experimental base be built on the basis of [6] in order to ensure repeatability of the results.Что касается перечисленных выше проблем, то накопленный опыт конструирования систем активного шумоподавления подсказывает следующие пути их решения:

1. The use of condenser electrets as tracking microphones as the most broadband and sensitive transducers with minimum dimensions.

2. The separation of the volume of the earphone chamber into several sections with various structural elements when filling air cavities with sound-absorbing materials of various nature.

3. Providing the ability to adjust the transfer function of the electronic module in amplitude and frequency in the headset.

4. The use of tracking microphones with the greatest possible sensitivity and elements with the lowest level of intrinsic noise in the working frequency range.

5. Cushioning and damping of the housing of the tracking microphone using sound-absorbing pads and limiting the area of contact between the housing of the microphone and the housing of the telephone or auxiliary speaker and earphone.

8. A mandatory study of the phase characteristics of the structural elements of the system in conditions most close to the operating conditions.

7. Selection of the highest quality materials and mandatory testing for climatic and mechanical stresses.

8. See item 7.

9. Development of understandable technical and economic requirements for development and their mandatory accounting in the design.

CONCLUSIONS

The task of designing active noise canceling devices is especially relevant for use in aviation as an additional means of ensuring flight safety. Its effective implementation requires the development of a detailed theoretical model and an integrated approach to design using the best modern measurement techniques and analysis of their results.

REFERENCES

1. Minaeva V.V., Gaponenko A.V. Vliyanie shuma na organism cheloveka // Mezhdunarodnyi studentcheskiy vestnick. – 2015. – № 3-1.

2. Okto Hebrani, Sandra Madonna, Prismita Nursetyowati. The Effect of Noise on Work Fatigue in an Oil and Gas Industries // Indonesian Journal of Urban and Environmental Technology. – April 2018. Department Environmental Engineering, Faculty of Engineering and Computer Science, Bakrie University, Jakarta, 12960, Indonesia.

3. I.A. Pogonysheva, D.A. Pogonyshev, A.A. Krylova. Vliyanie shuma na psychophisiologicheskie parametry i rabotosposobnost organisma cheloveka // Vestnick NVGU. - №1/2015.

4. Environmental conditions and test procedures for airborne equipment. RTCA/DO-160G. SC-135, RTCA Inc. 1997.

5. Y.S. Vahitov. Teoreticheskiye osnovy electroakustiki i elektroakusticheskaya apparatura. – M.: Iskusstvo, 1982.

6. IEC 61842-2014. Microphones and earphones for speech communications.

BUILDING A STRENGTH MODEL OF TELEMETRY TRANSMITTER OF THE ON-BOARD COMPLEX

Sokolan P.I., Raevskiy G.P.
MIREA - Russian Technological University, Moscow
+7 (906) 790 38 41, polina.sokolan@gmail.com; +7 (910) 422 84 50, geraevskiy@yandex.ru

Abstract – Currently, the on-board equipment being developed is subject to various mechanical impacts. Therefore, calculations for assessing the mechanical strength and rigidity of the construction are an important part of the development.

During the development of the telemetry system was developed the design of the telemetry transmitter of the on-board complex, designed to transmit telemetry information to ground-based receiving and registration equipment.

The product is a monoblock, with are functional nodes inside. In working mode, this construction can be subjected to various mechanical loads, such as quasi-static and low-frequency dynamic overload, sinusoidal vibration, occasional broadband vibration, shock-pulse loading.

At the design stage, a calculation was made to determine the strength of the system. All calculations were made in the CAD SolidWorks Simulation environment. Two cases were considered: linear acceleration and impact effect.

At the design stage, calculations were made to determine the system's sustainability to mechanical impacts. As a result of calculations on the impact of linear acceleration and impact effect, it was found that the main volume of the structure is spread to stresses not exceeding the limit of fluidity.

Then the overall weight model of the system was created and is subject to mechanical testing. Two types of tests were conducted: a test of resistance to the effects of linear acceleration and a test of resistance to impact effect.

As a result of tests of violations in the construction of the overall weight model was not revealed except for small scratches and scuffs, which allows to conclude the reliability and durability of the system.

The calculations and tests allow to draw conclusions:

- the transmitter is resistant to the linear acceleration with an amplitude of 12 g;
- the transmitter is strong enough to be exposed to 250g with a pulse duration of 0,5-1 ms.

The tests are being carried out confirming the applicability of computer aided design systems such as SolidWorks to determine the parameters of mechanical loads during the construction development phase.

Keywords: system, impact effect, linear acceleration, tests, model, monoblock, telemetry.

During the development of the telemetry system was developed the design of the telemetry transmitter of the on-board complex, designed to transmit telemetry information to ground-based receiving and registration equipment. The information obtained from the sensor-transforming equipment is necessary for the analysis and assessment of the condition of on-board systems and elements of the design of mobile objects.

One of the objectives of the development was to create a construction that ensures the stable operation of the system in pre-service conditions.

The product is a monoblock, with are functional nodes inside. In working mode, this construction can be subjected to various mechanical loads, such as quasi-static and low-frequency dynamic overload, sinusoidal vibration, occasional broadband vibration, shock-pulse loading.

At the design stage, a calculation was made to determine the strength of the system. All calculations were made in the CAD SolidWorks Simulation environment. Two cases were considered: linear acceleration and impact effect.

Let's take a look at the first case. First, it is necessary to set the material and boundary conditions of the calculation model. The entire construction consists of aluminum parts. To speed up the calculation, it was decided to simplify the model by eliminating elements that did not affect strength, such as lightweight internal components. Simplified appearance of the transmitter presents on Figure 1.

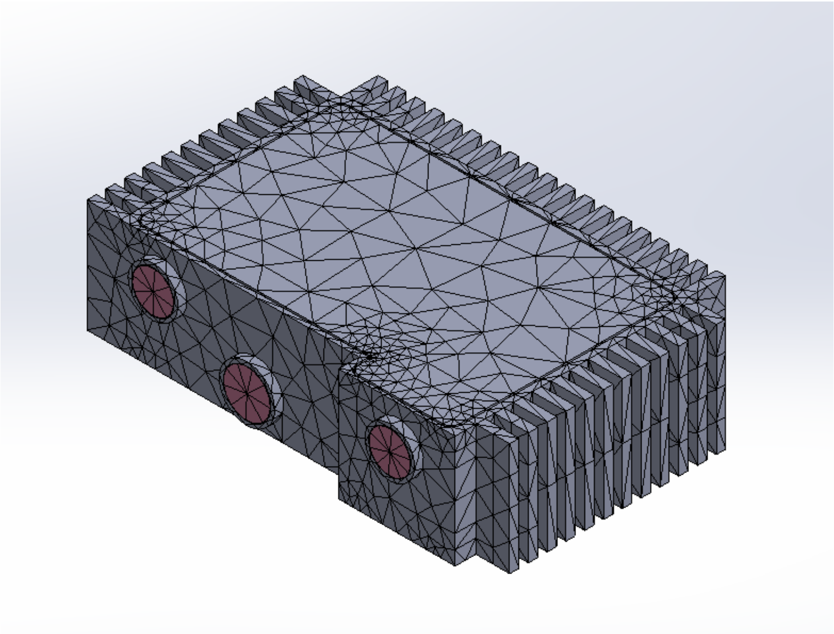


Fig. 1 Simplified appearance of the transmitter

At the bottom of the model, a fixed geometry is set that determines the installation surface. Since the design is used in the calculation, it is necessary to determine the connections between the parts. All items are also connected by global contact by default. Border terms and conditions of model presents on Figure 2.

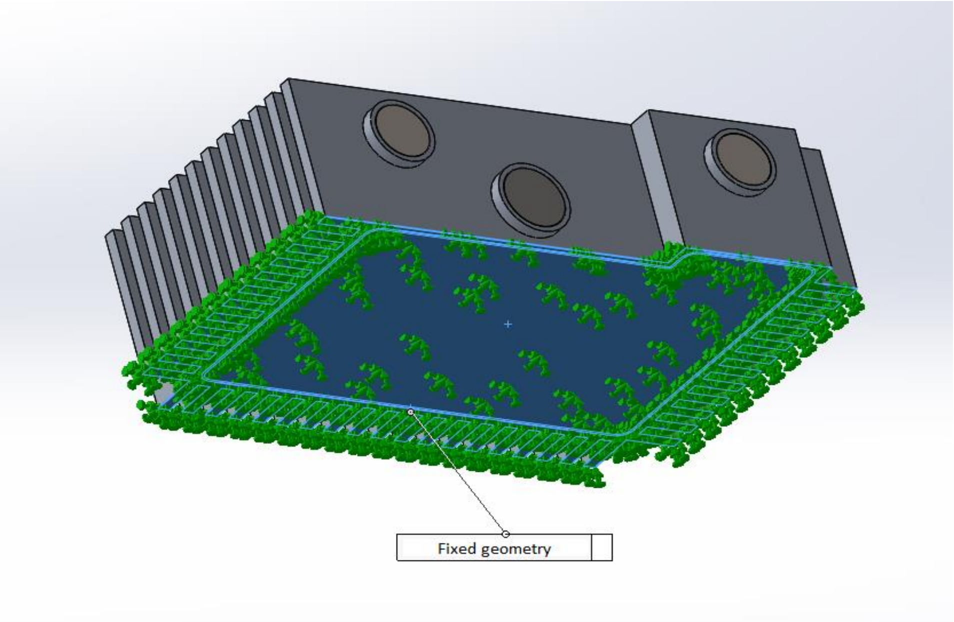


Fig. 2 Border terms and conditions

The calculation sets the boundary terms and conditions and the value of external forces. In this case, the linear acceleration value is set *to 12 g* (210 $m \cdot s^{-2}$), operating simultaneously on *the ax's X, Y, and 10 minutes. The results of the calculation assess the tense-deformed state of the structure, in particular the stress averaged on Mises and equivalent deformation.* Result of the calculation present on Figure 3 and Figure 4.

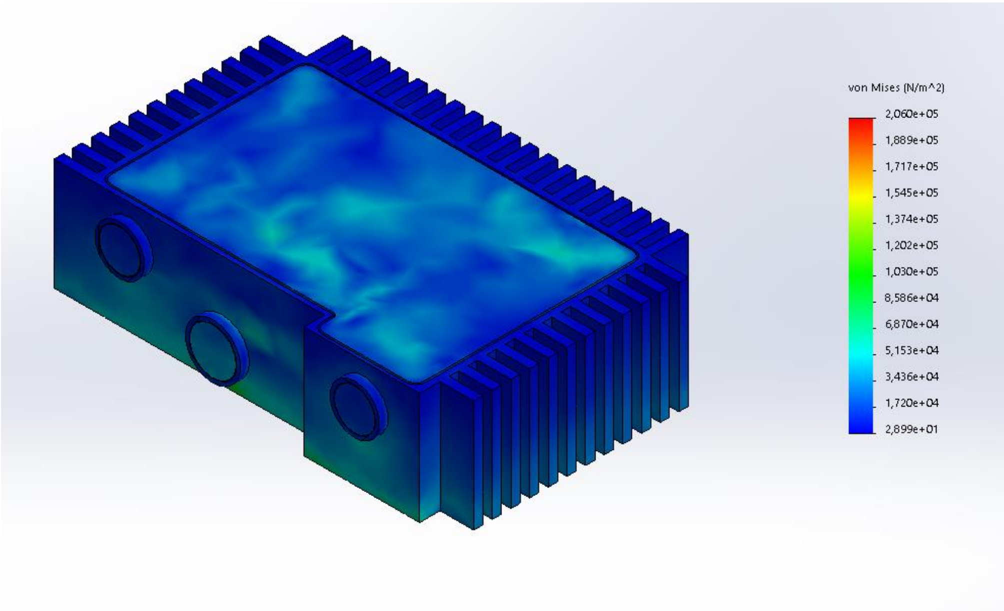


Fig. 3 Diagram of stresses for linear acceleration

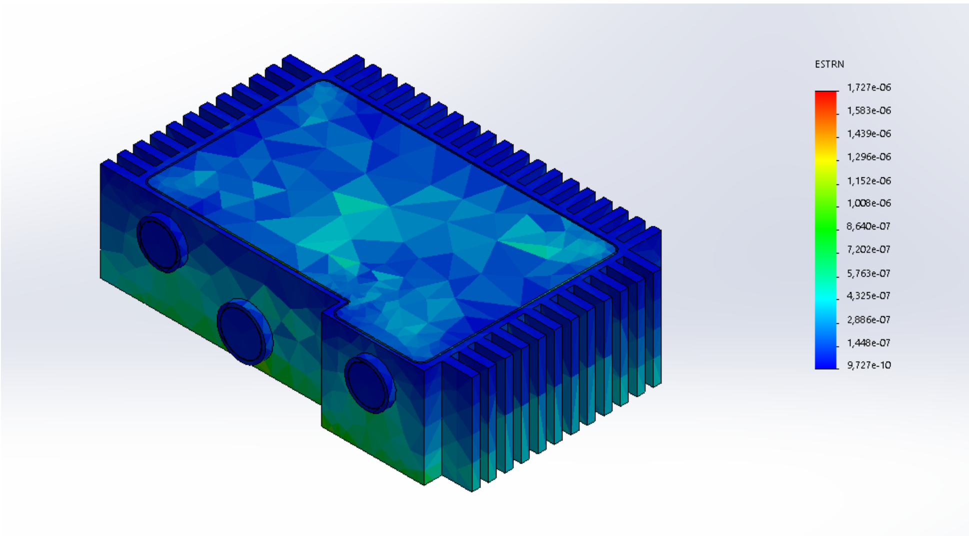


Fig. 4 Diagram of deformation for linear acceleration

The mechanical stress diagram can be concluded that the most loads are exposed to individual parts of the construction, but in general, the main volume of the construction is spread by mechanical stress that do not exceed the limit of material fluidity. Presented parameters of deformations also make it clear that this construction has a margin of safety. Therefore, the durability of the construction to the impact factor is ensured.

In the second case, it is necessary to calculate the impact effect. It also uses a linear dynamics section, but this time a subsection of the modal time story. This method allows to calculate a single impact depending on the time. All parameters are set in the same way as the first case, except for the load. In this case, the construction is affected by an acceleration of 250g for the time of 1 ms. A graph of acceleration dependence on impact time present on Figure 5.

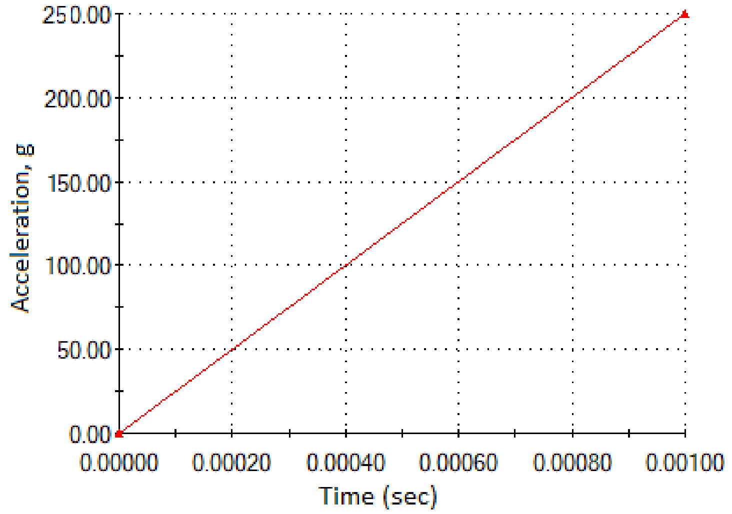


Fig. 5 A graph of acceleration dependence on impact time

The results of the calculation present on Figure 6 and Figure 7.

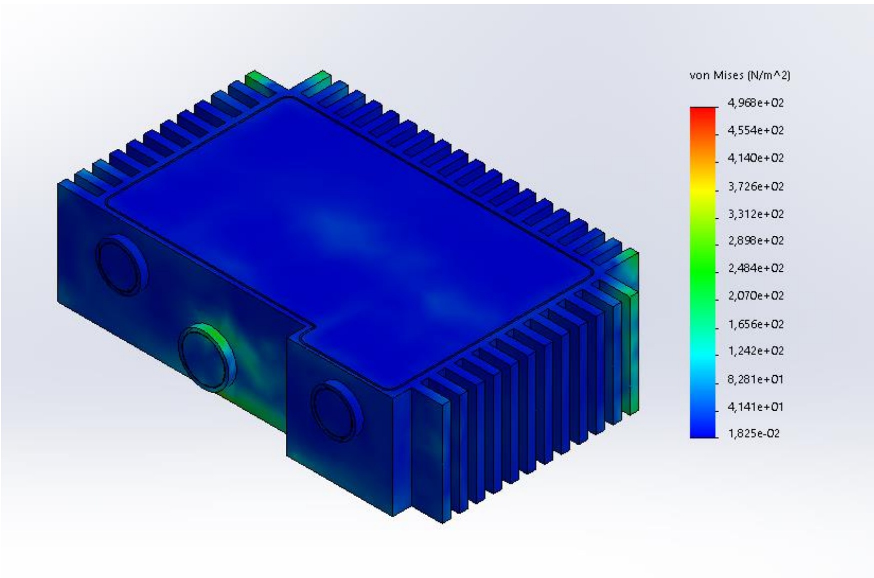


Fig. 6 Diagram of stresses for impact effect

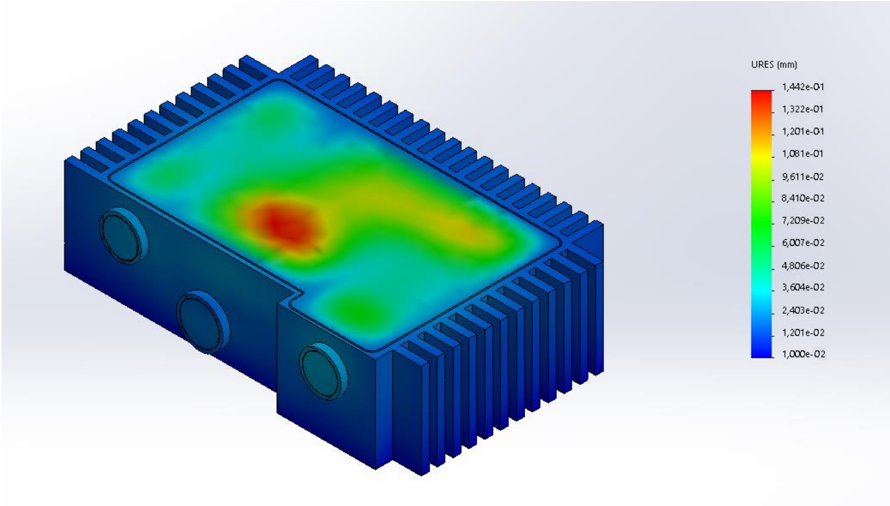


Fig. 7 Diagram of displacement for impact effect

As in the first case, maximum stresses occur in the places of fastenings, but judging by the schedule of displacement the greatest displacement of the construction are in the upper cover area and is about 140 microns.

Then the overall weight model of the system was created and is subject to mechanical testing. Two types of tests were conducted: a test of resistance to the effects of linear acceleration and a test of resistance to impact effect.

As a result of tests of violations in the construction of the overall weight model was not revealed except for small scratches and scuffs, which allows to conclude the reliability and durability of the system.

The calculations and tests allow to draw conclusions:

- the transmitter is resistant to the linear acceleration with an amplitude of 12 g;
- the transmitter is strong enough to be exposed to 250g with a pulse duration of 0,5-1 ms.

The tests are being carried out confirming the applicability of computer aided design systems such as SolidWorks to determine the parameters of mechanical loads during the construction development phase.

REFERENCES

1. Alyamovskii A.A. SolidWorks Simulation. Kak reshat' prakticheskie zadachi. – g. Sankt-Peterburg: BKhV-Peterburg, 2012g. – 443s.

2. Shalomeenko M., Alyamovskii A., Zingarevich A., Inzhenernyi analiz v srede Solid Works Simulation. – g. Moskva: SAPR i grafika, 2014g. S. 68–74.

3. Nikonov K.P. Raschet v srede SolidWorks mekhanicheskikh vozdeistvii na datchik davleniya dlya ispytatel'nogo oborudovaniya aviatsionnoi tekhniki. – g. Moskva: Elektronnyi zhurnal «Trudy MAI». Vypusk 70. – 20s.

4. Alyamovskii A.A. Inzhenernye raschety v SolidWorks Simulation – g. Moskva: DMK Press, 2010g. – 464s.

5. Edvabnik V.G. Ob ekvivalentnosti ispytanii bortovoi elektronnoi apparatury na vozdeistvie garmonicheskoi i shirokopolosnoi sluchainoi vibratsii. – g. Novosibirsk: Inerekspo Geo–Sibir', 2014g. S. 194–197.

6. Proskurin A.V., Shlishevskii A.V. Opredelenie uskorenii ob"ekta ispytanii, zakreplennogo na bruse, pri vozdeistvii udarnykh nagruzok. g. Moskva: Vestnik Moskovskogo gosudarstvennogo tekhnicheskogo universiteta im. Baumana. Seriya «Mashinostroenie». S. 83–93.

PROBLEMS OF CURRENT SATELLITE LASER RANGING EQUIPMENT ENGINEERING ALGORITHM

Zotov A.N.
MIEM HSE
azotov@hse.ru

Abstract — This paper considers the possibility of using supporting programs in the design of satellite laser ranging electronic equipment. The problems that can be solved by extending traditional engineering algorithm and its further integration into the design process are indicated. The shortcomings and advantages of this approach are considered, the problems of creating such a system are outlined.
Keywords: reliability, expert system, Altium Designer, ASONIKA-K

INTRODUCTION

Being competitive in the market is the goal of every enterprise. To become or stay competitive requires delivering a quality product for a minimal price. A lot of thought is put in the process of creating an efficient roadmap for a product's lifecycle from technical documentation to post-production stages. Creating an engineering algorithm which results in fast and cheap production of quality product is the objective of every enterprise. But doing that has been proved to be hard, especially with existing problems in reliability prediction field [1,2].

PROBLEM STATEMENT

Currently, novice engineers who design the equipment lack the knowledge in the reliability prediction field. This and poor cooperation between them, and engineers who calculate the reliability of the equipment, especially in inadequate estimate of the input data in the calculation of reliability are one of the most notable reasons of prolonged and costly design process. This also affects the reliability of the final product. Usually novice engineers do not aim to create equipment which operates for a long time with low failure rates, they aim to create one which just operates.

Gathering and analyzing data on equipment failure reasons from one particular enterprise in Russian Federation showed that about a third of all failures are due to errors in the design of the produced equipment. Lessening the amount of mistakes on the design stage will moderately heighten equipment's reliability and prolong its life.

Satellite Laser Ranging (SLR) equipment is expected to have 60000 hours life and 11 years lifetime. Equipment must operate in temperatures between 5°C and 40°C with 85% humidity. Since the point of an SLR is to perform extremely accurate distance measurements, the equipment has to work with very high frequencies to accommodate.

To meet these requirements a reliability prediction is performed on different stages of design and production. But this process is time consuming and labor intensive. Searching for electrical characteristics of electrical components in datasheets, choosing a suitable mathematical model to calculate the failure rate and selecting right coefficients for the model – these processes slow down the development and negatively affect resulting quality of equipment because of a high possibility of making an error when manipulating big arrays of data. More so, an engineer must have experience and knowledge of modern electronic components to make right design decisions.

Some software suites were developed to simplify and speed up the reliability analysis, like Windchill Risk and Reliability, or ASONIKA system. These suites' aim is not only to allow to calculate reliability automatically, but to allow users with no reliability expertise perform the calculations.

However, modern reliability prediction software lacks automation in data input. A lot of data has to be found and input manually. And there's a lot of it needed to perform an accurate calculation, plus, it's different for every group of electrical component. This process requires a lot of attention for a considerable amount time from a person performing the calculation.

So, as it turns out, while the calculation itself is simple and fast and takes a few minutes, preparing for such calculation takes days to arrange.

At the same time, a lot of CAD software (Altium Designer, etc) already has a great deal of data needed for reliability prediction calculation. Transferring this data to reliability prediction software would greatly lessen the burden on the person setting up the reliability calculation. This would also shorten the amount of time the reliability prediction takes, reduce amount of mistakes in the input data and make the process more automated overall.

There's also a problem of correctly interpreting results of reliability calculation and performing correct changes to the design. Lack of experience of an engineer may lead to design errors being made.

SOLUTION OF THE PROBLEM

To combat these problems some changes to existing engineering algorithm are proposed.

Firstly, since CAD systems contain some necessary data for reliability prediction, it is possible to introduce a converter of data from a CAD system format to a reliability prediction software format[3].

For example, Altium Designer allows use of custom component libraries which contain custom data for electronic components (fig. 1). This information may be extracted to a Bill of Materials (BOM) in a form of an Excel spreadsheet. Resulting spreadsheet contains a list of used components and their respective characteristics. It would be more suitable to store and pass this data in an EXPRESS format, but Altium Designer does not support exporting to this format. This leaves using Excel tables as a data transfer format.

МС - ПЛИС | МС - Конвертеры интерфейсов | Кварцевые Генераторы SMT

Part Number	ID	Value	Supply Operation	Supply Current	Output Voltage	Temperature Coefficient
STCL1160YBFCWY5	1	STCL1160YBFCWY5	+4.5...5.5V		5V	
TA-72.000MBD-T	2	TA-72.000MBD-T	+3.3V	30mA	3.3V	25ppm
TA-100.000MBD-T	3	TA-100.000MBD-T	+3.3V	30mA	3.3V	25ppm
7X-25.000MBE-T	4	7X-25.000MBE-T	+3.3V	20mA	+0.33...2.97V	25ppm
7X-50.000MBE-T	5	7X-50.000MBE-T	+3.3V	20mA	+0.33...2.97V	25ppm
BF-125.000MBE-T	6	BF-125.000MBE-T	+2.5\3.3V	80mA	+0.9...1.6V	50ppm
ASGTX-D-500.000MHZ-1	7	ASGTX-D-500.000MHZ-1	+3.135...3.465V	40mA	+0.9...1.6V	1ppm
7X-25.000MCB-T	8	7X-25.000MCB-T	+2.5V	20mA	+0.25...2.25V	50ppm

Fig. 1 Example of data contained in Altium Designer libraries

To accommodate for wide variation in required data for different components' groups a template system has to be implemented. Since Altium Designer already has a possibility to store templates for BOM files, it is only needed to implement the template system in reliability prediction software. Template explicitly states what column of data in a table refers to. For example, rated resistance could be stored in the column "Value" and rated power could be stored in column "Power/Voltage" (figure 2). The templates are meant to be set up one time and then used for every transfer of data. Templates also allow for transfer of data from different CAD systems.

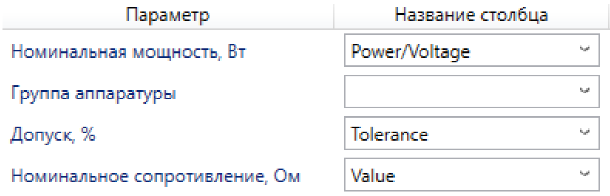


Fig. 2 Defining column names in the template

To illustrate how this addition to engineering process would benefit it, an example converter was developed. It allows importing to ASONIKA-K-SCH system from any CAD software which allows export of data as BOM table.

The developed converter is integrated into ASONIKA-K-SCH system (fig. 3) and provides a friendly user interface for viewing and manipulating data before the import process (fig 4).

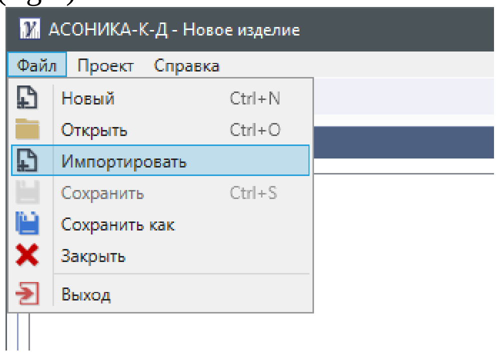


Fig. 3 Integrated import module

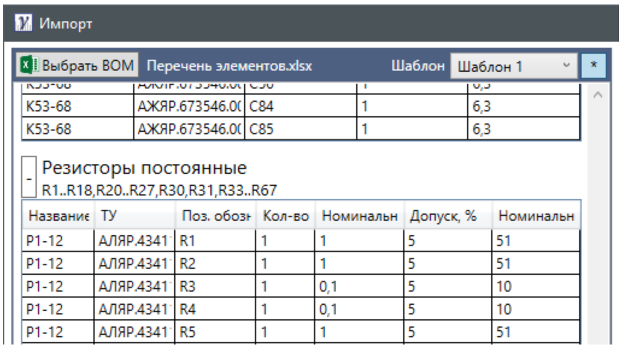


Fig. 4 Imported data overview

Testing the converter showed that using it allows for much shorter process of setting up the reliability prediction calculation.

For the second change to the engineering algorithm, an expert system for analyzing reliability prediction and for general engineering problems is proposed.

An expert system is a program which contains knowledge in a certain region of appliance. The knowledge data is composed in way which allows forming logical decisions based on the data. This data comes from human experts and other sources. For example, expert systems found a lot of use in medical appliances, such as diagnosis and treatment of various diseases.

Expert systems have been developed as research instrumental tool in the 1960s and were seen as artificial intelligence of special type designed to successfully solve complex problems in a narrow subject area, such as medical diagnosis of diseases. Classic problem of creating a general-purpose artificial intelligence program that would able to solve any problem without specific knowledge in the subject area (for example, medical diagnosis of diseases) was too complicated.

Commercial the introduction of expert systems took place in the early 1980s, and since then expert systems became very widespread. Currently expert systems are used in business, science, technology, manufacturing, as well as many other areas where there is a well-defined subject area.

Expert system allows an unqualified person to make a decision which is beyond their level of training or experience [4].

Expert systems possess these advantages:

– high data availability and fast response;
– reduced production cost (cost of knowledge per user is constantly decreasing);
– permanence (collected data does not perish).

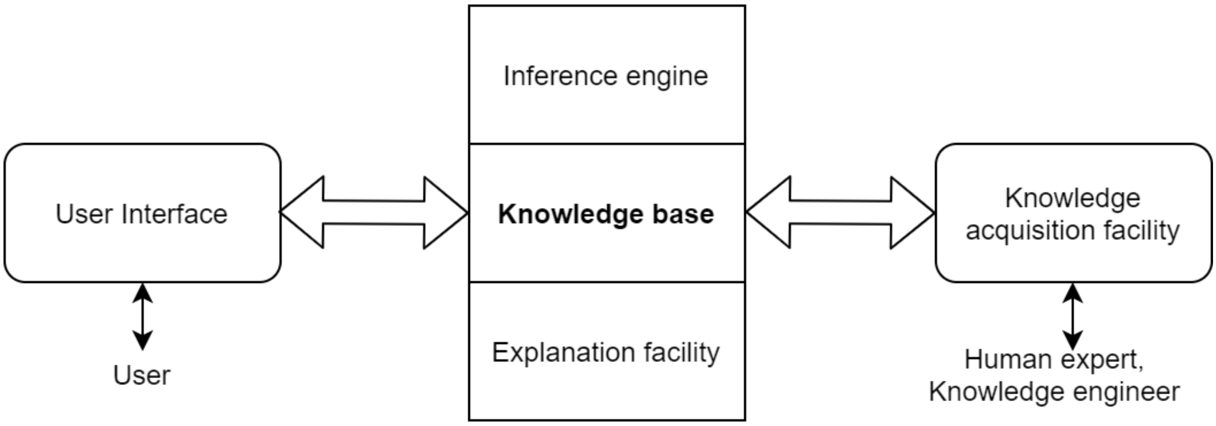


Fig. 5 Expert system structure

Generalized expert system structure is shown on figure 5. It should be noted that these elements are representing a core of an expert system, and some expert systems may be more complex than shown.

The roles of the parts of an expert system are as follows [5].

User Interface – the main point of interaction with an expert system for a user. Includes inputting initial data as well as displaying the generated solution.

Knowledge base – the core of an expert system. It contains rules and facts of some region of appliance.

Inference engine – part of an expert system which is responsible for deducting decisions and imitating a human expert. Operates using information form knowledge base.

Explanation facility allows user to see how a particular decision was deducted. It is crucial to make user trust the decision an expert system made.

Knowledge acquisition facility allows human expert and knowledge engineer filling knowledge base with facts and rules.

An expert system could be developed using these ways [6]:

- programming it using traditional programming languages such as C++, Java, Python, etc.;
- programming it using languages aimed at developing artificial intelligence suites (LISP, PROLOG, etc.);
- using specialty tools for developing an expert system, such as CLIPS, DROOLS, etc.;
- using readily-made expert systems, which only needs its knowledge base filled with facts and rules of some particular appliance (EXSYS, G2).

Since an expert system is proposed to help the engineering process, there is no need to make one from scratch. But also it has to be included in the engineering process and be able to interact and gather data from both CAD systems as well as reliability prediction software, a standalone version would not be fir to do that. For this application, specialty tools for developing an expert system such as CLIPS would be suited best.

Most of the work on an expert system is devoted to the issues of extracting knowledge from an expert, choosing the appropriate knowledge model and its software implementation and the process of deriving knowledge. When choosing a model for presenting knowledge, such forms of representation as production systems, semantic networks, frames, conceptual graphs are widely used. Less commonly used is a logical representation model, which is based on predicate calculus and which is the theoretical basis for substantiating other representation models [7].

Since a production model would be sufficient for an expert system aimed to help an engineer to perform his duties and it is the easiest to fill and maintain, it is recommended as a starting point.

CONCLUSION

Using an expert system and a CAD data converter would solve problems reliability prediction being too complex and time consuming. Also, it would reduce a number of errors made in the process of reliability prediction, which would lead to more quality equipment.

REFERENCES

1. Reliability prediction of electronic equipment: problems and experience / Slavko Pokorni / OTEH 2016, pp 695-700.
2. Modern problems of reliability calculation automatisation./ Zhadnov V.V., Zhadnov I.V., Polessky S.N. / Dependability. / 2007, № 2, pp. 3-12.
3. Integration of circuit board CAD and reliability prediction software / Zotov A.N. / New information technologies in automated systems: materials of the twenty-second scientific and technical seminar / Institute of Applied Mathematics of M. V. Keldysh RAN/ 2019. pp. 78-81.
4. Expert systems in medicine: academic illusion or real power? / K. S. Metaxiotis, J. E. Samouilidis / The Journal of Information Technology Theory and Application (JITTA), 2:1, 2000, pp 19-25.
5. Methods of increasing quality of electronic equipment on the stage of design / Zotov A.N. / Works of International symposium Reliabilty and Quality / Penza: PGU, 2018, pp. 109-112.
6. Principles of Expert Systems / Peter J.F. Lucas, Linda C. van der Gaag / Centre for Mathematics and Computer Science, Amsterdam / 2004.
7. Expert Systems: Principles and Programming, Fourth Edition / Joseph C. Giarratano, Gary D. Riley / «I.D. Williams» / 2007, 1152 pages.

INVESTIGATION OF A LINEAR MODEL OF CONTACT INTERFERENCE

Grachev N.N., Andryukhin A.G.
RTU MIREA
+7 (903) 214-51-56, nngrachev@mail.ru

Abstract—the paper considers the results of studies related to the modeling of contact noise generation processes in the design of electronic equipment taking into account electromagnetic compatibility. The paper analyzes the causes of the formation of contact radio interference. The main place is devoted to the analysis of the linear model of contact noise formation. A representation of the irradiated alternating contact in the form of a linear parametric inertial four-terminal device is considered..

Keywords: electromagnetic compatibility, electronic equipment, contact interference, modeling.

INTRODUCTION

Under certain conditions, the irradiated alternating contact can be considered as a linear inertial device with parameters controlled by some random modulating process (switching, vibration, shaking, etc.) changing the amplitude and frequency-phase relationships of the high-frequency conductivity induced by an external electromagnetic field [8] . The full equivalent circuit of the irradiated alternating contact as a source of contact noise can be represented in the form shown in Fig.1. These models are currently accepted as sources of contact interference [1].

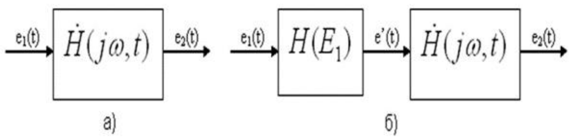


Fig. 1 Representation of the irradiated alternating contact in the form of a linear parametric inertial four-terminal (a) and the representation of the irradiated alternating contact operating in a nonlinear mode, in the form of a series connection of two four-terminal (b).

When considering an alternating contact in a linear mode, the occurrence of contact noise can be approximately represented as a transformation of the electromagnetic field strength by some hypothetical four-terminal with a complex transfer function $\dot{H}(j\omega,t)$ (Fig. 1a).

The electromagnetic field intensity of the secondary radiation of an alternating contact can be determined by the formula:

$$e_2(t) = \frac{1}{2\pi}\int_{-\infty}^{\infty} \dot{S}_{e_1}(\omega)\dot{H}(j\omega,t)e^{j\omega,t}dt \qquad (1)$$

Where $\dot{S}_{e_1}(\omega)$ is the energy spectrum of the irradiating electromagnetic field.

The change in contact resistance according to the periodic law also leads to the periodic law of the change in time of the transfer function $\dot{H}(j\omega,t)$.

Let the main frequency of change of the transfer function $\dot{H}(j\omega,t)$ be equal to Ω. We expand the function $\dot{H}(j\omega,t)$ in a Fourier series:

$$\dot{H}(j\omega,t) = \dot{H}_0(j\omega) + \sum_{n>1}\dot{H}_n(j\omega)\cos(n\Omega t + \varphi_n) \qquad (2)$$

We set the intensity of the irradiating electromagnetic field in the form

$$e_1(t) = E_{1m}\cos\omega_0 t = E_{1m}\,\mathrm{Re}[e^{j\omega_0 t}] \qquad (3)$$

The electromagnetic field intensity of the secondary radiation will be determined by the formula

$$\begin{aligned} &e_2(t) = E_{1m}\,\mathrm{Re}[\dot{H}(j\omega,t)] = E_{1m}\{H_0(\omega)\cos(\omega_0 t + \varphi_0) + \\ &\frac{1}{2}\sum_{n>1}H_n(\omega)[\cos<(\omega_0 + n\Omega)t + \phi_n + \varphi_n> + \\ &+\cos<(\omega_0 - n\Omega)t - \phi_n + \varphi_n>]\} \end{aligned} \qquad (4)$$

An analysis of the last formula shows that the field strength of the secondary radiation of the irradiated alternating contact can be written as the sum of two components

$$e_2(t) = e_2'(t) + e_2''(t) \qquad (5)$$

Component

$$e_2'(t) = E_{1m}H_0(\omega)\cos(\omega_0 t + \phi_0) \qquad (6)$$

represents the intensity of the irradiating electromagnetic field with amplitude reduced by $H_0(\omega)$ times and undergoing a shift by φ_0.

Second component

$$\begin{aligned} &e_2''(t) = E_{1m}\{\ \sum_{n>1}H_n(\omega)[\cos<(\omega_0 + n\Omega)t + \phi_n + \\ &\varphi_n> + \cos<(\omega_0 - n\Omega)t - \phi_n + \varphi_n>]\} \end{aligned} \qquad (7)$$

represents a distortion of the electromagnetic field during irradiation of a periodically changing contact and characterizes the resulting contact noise. The spectrum of the electromagnetic field of the secondary radiation contains in its composition a component at the frequency of the irradiating field and additional components at frequencies $\omega_0 \pm n\Omega$. The contact noise spectrum is always wider than the spectrum of the irradiating electromagnetic field, and the frequency band occupied by contact noise expands with an increase in the switching frequency of the alternating contact. Contact noise arising from irradiation of an alternating contact can be classified by the type of electromagnetic field distortion. Depending on the transfer function $\dot{H}(j\omega,t)$, the following types of spurious modulation of the electromagnetic field can be distinguished: amplitude, phase, amplitude phase. Moreover, with amplitude-phase modulation, there may be a functional relationship between changes in amplitude and phase. An approximate radiation spectrum of an interference source of the type linear alternating contact when irradiated with its monochromatic field is shown in Fig. 2.

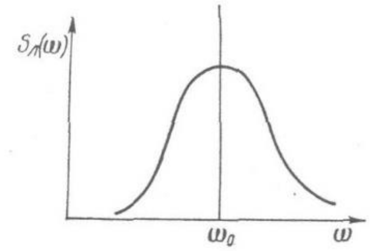


Fig. 2 The spectrum of contact interference when irradiating a linear contact

OBJECT OF STUDY

A variable contact, as it were, plays the role of a modulator. The width of the resulting spectrum depends on the frequency of contact change and the prevailing type of modulation, which is ultimately determined by the parameters of the equivalent four-terminal network and the frequency of the field irradiating the contact.

All the variable contact pairs formed during the movement of moving objects, by the nature of the change in time of contact resistance can be divided into two large groups:

- contacts with rolling and sliding friction;
- randomly switching breaking contacts.

The first group of variable contacts includes contacts between the structural elements of moving objects that have loose mechanical joints or allow small mutual displacements under operating conditions. Typically, such joints are formed between structural members that are loosely connected by bolts, screws, and because of partial divergence of the welds. The same group includes alternating contacts between the axis and rotating parts (screws, wheels, and blades), contacts between the wheels and rails of railway cars, freight carts and the like. Instead of the seemingly constant contact between such structural elements, in fact, when moving objects there is an unstable contact, consisting of many short-term interrupted elementary contacts through α-spots. The reasons for the change in the number of α-spots forming the effective contact area at different points in time are the inevitable deviations of the shape, size, profile and surface finish of the contacting elements. The unstable nature of the contact between such elements is especially evident with an increase in the speed of movement due to vibration and shaking.

The function of changing contact resistance in time for the variable contacts of the first group is continuous. The discreteness of the change in the number of α-spots forming the effective contact area at successive times is so small and their number is so great that the change in contact resistance in time can be considered a continuous random variable. The second group of variable contacts is formed by the structural elements of moving objects, the contact resistance between which during movement varies in a wide dynamic range from a very small value when closed to an infinitely large value when opened. This group of contacts consists mainly of structural elements between which there are no rigid mechanical connections, but which have the ability to touch during the movement of a moving object. The same contact can exist between loosely connected structural elements under conditions of strong vibration, when sudden shocks cause abrupt changes in contact resistance. A description of the change in the contact resistance of the alternating contacts of the second group can be carried out using a random pulse sequence. When analyzing the spectrum of the electromagnetic field of contact interference, we assume that random changes in the modulus H (ω, t) and the argument φ (ω, t) of the transfer function of the four-terminal network form a process that is stationary in the broad sense. In addition, we believe that the correlation interval of the function significantly exceeds the period of change in the frequency of the irradiating electromagnetic field. This condition is usually satisfied.

The occurrence of contact noise can be approximately represented as a conversion of the electromagnetic field strength by some hypothetical four-terminal network with a complex transfer function

Let us consider the case of irradiation of variable contacts with rolling and sliding friction by a mono harmonic field with a frequency ω_0 and with a random phase φ uniformly distributed in the range from –π to + π.

The randomness of the distribution of the phase of the intensity of the irradiating electromagnetic field does not affect the form of its correlation function, which is [1]

$$B_{e_1}(\tau) = \frac{E_{1m}^2}{2}\cos\omega_0\tau \tag{8}$$

Where E_{1m} is the amplitude of the tension.

Let us call the moment function of the four-terminal network the autocorrelation function of a random process characterizing the time-varying parameters of the four-terminal network [2]:

$$\dot{B}_H(t,\tau) = m_1\left\{\dot{H}(j\omega,t), H^*(j\omega,t+\tau)\right\}$$

(9)

Where m_1 is the sign of mathematical expectation; $H^*(j\omega, t+\tau)$ is the complex conjugate transfer function.

Given formula (7), we can write

$$\dot{B}_H(t,\tau) = m_1\{H(\omega,\tau), H(\omega,t+\tau)e^{j[\varphi(t)-\varphi(t+\tau)]}\} \tag{10}$$

and for the case of a functional relationship between changes in amplitude and phase $\dot{B}_H(\tau)$, the expression for determination will take the form

$$\dot{B}_H(t,\tau) = m_1\{H[\varphi(\omega,\tau)], H[\varphi(\omega,t+\tau)]e^{j[\varphi(t)-\varphi(t+\tau)]}\} \tag{11}$$

The continuous nature of the change in contact resistance at contacts with rolling and sliding friction determines the validity of the representation in the form of a stationary random process. In this case, the transfer function can be written as the sum of two components

$$\dot{H}(j\omega,t) = \dot{H}_0(j\omega) + \Delta\dot{H}(j\omega) \tag{12}$$

Where $\dot{H}_0(j\omega)$ is a constant complex value;

$\Delta\dot{H}(j\omega)$ - the fluctuating part of the transfer function.

Then the moment function of the four-terminal can be represented as

$$\dot{B}_H(t,\tau) = \dot{B}_{H_0}(\tau) + \dot{B}_{\Delta H}(t,\tau) \tag{13}$$

Suppose that the changes form a fluctuation process with a normal distribution law and with a variance of modulus change equal to. The correlation function of such a process can be written as [3]

$$B_{\Delta H}(\tau) = \lim_{T\to\infty}\frac{1}{T}\int_{-T/2}^{T/2}\mathrm{Re}[\dot{B}_{\Delta H}(t,\tau)]d\tau = \sigma_{\Delta H}^2 e^{-k|\tau|} \tag{14}$$

Where k is a coefficient characterizing the rate of decrease of the correlation between the values at the moments t and t + τ with increasing τ .

Considering that the correlation function $B_{H_0}(\tau) = H_0^2(\omega)$ corresponds to the constant component $\dot{H}(j\omega)$, the moment function of the four-terminal network can be determined by the formula

$$B_H(\tau) = H_0^2(\omega) + \sigma_{\Delta H}^2 e^{-k|\tau|} \tag{15}$$

From the stationary conditions in the broad sense and the statistical independence of the law of change of the transfer function from the irradiating field, it follows that the correlation function of the electromagnetic field of the secondary radiation will be equal to the product of the correlation function of the irradiating field and the moment function of the four-terminal network

$$B_{e_2}(\tau) = B_{e_1}(\tau) B_H(\tau) \tag{16}$$

Then

$$B_{e_2}(\tau) = \frac{E_{1m}^2}{2}[H_0^2(\omega) + \sigma_{\Delta H}^2 e^{-k|\tau|}]\cos\omega_0\tau \tag{17}$$

The energy spectrum of the contact noise field can be found by the formula

$$S_{e_2}(\omega) = \int_{-\infty}^{\infty} B_{e_2}(\tau) e^{-j\omega\tau} d\tau = \frac{\pi}{2} E_{1m}^2 H_0^2(\omega)[\delta(\omega-\omega_0) + \delta(\omega+\omega_0)] + E_{1m}^2 \sigma_{\Delta H}^2 k[\frac{1}{k^2+(\omega-\omega_0)^2} + \frac{1}{k^2+(\omega+\omega_0)^2}] \tag{18}$$

A graphical representation of the energy spectrum in the region of positive frequencies is presented in Fig. 3.

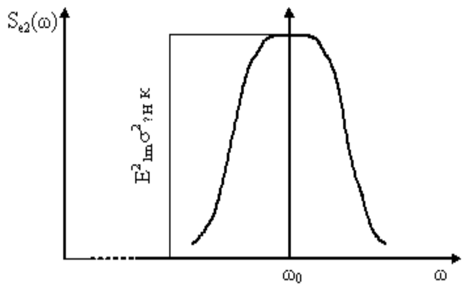


Fig. 3 Dependence of the energy spectrum of S_{e2} (ω) upon irradiation of alternating contacts with rolling or sliding friction

RESULTS AND CONCLUSIONS

Thus, the spectrum of the secondary radiation field with a nonharmonic irradiating field and a change in contact resistance with time according to a continuous random law with a nonzero average value contains a discrete component at the irradiation frequency and a continuous spectrum symmetrically located relative to the frequency of the irradiating field.

Spectral analysis of the electromagnetic field of secondary radiation under more stringent assumptions regarding the change is associated with significant mathematical difficulties [4]. More rigorous calculations than those presented here show that the power ratios of the discrete and continuous components of the spectrum of the secondary radiation field will depend on the depth of phase distortion upon irradiation of the alternating contact, and the solid part of the energy spectrum may be asymmetric.

A pulse process describes the change in contact resistance of the alternating contacts of the second group. The parameters of this impulse sequence characterizing the geometric shape or position of the pulses (amplitude, duration, moment of occurrence of the leading edge, duty cycle, etc.) are generally random functions of time.

REFERENCES

1. E. M. Vinogradov, V. I. Vinokurov, I. P. Kharchenko. Electromagnetic compatibility of electronic equipment. - L .: Shipbuilding, 1986. p. - 264.

2. K. K. Venskauskas, A. A. Zirnis Development Trends and Basic Characteristics of Deca and Hectometer Radio Means // Foreign Electronics No. 6, 1979. - pp. 31-68.

3. P. A. Obrezumov. Ship communications and radio-navigation. - M.: Transport, 1977. p. 240.

4. G. P. Bogomolov. The main characteristics of the electromagnetic environment on ships of the navy // Marine radio communication: Sat. scientific labor. - L.: Transport, 1985. - pp. 131-138.

5. A. D. Knyazev, V. F. Pchelkin. Problems of ensuring the joint operation of electronic equipment. - M.: Soviet Radio, 1971. - 200 p.

6. Venskauskas K.K. Electromagnetic interference and methods for their suppression on ships. - M .: V / O Mortehinformreklama, 1991. p.768.

7. V. I. Kravchenko. Elimination of contact noise. "Technology and armament", No. 1, 1973.

8. A. Y. Klementenko, B. A. Panov., V.F. Sveshnikov. Contact interference to the radio. - M .: Military Publishing, 1979. - 116 p.

9. A. A. Vorshevsky, P.A.Vorshevsky, A.M.Agafonov. Tests for electromagnetic compatibility of electronic equipment located on the ship’s navigation bridge // "Technologies of electromagnetic compatibility": Scientific and technical journal No. 2 (21), 2007. - pp.10-21.

10. S. Wankowicz. EMC on sea-going ships. Proc. of the Third International Wroclaw Symposium on EMC. 1976. - pp. 168-175.

11. Nikolay Grachev, Saygid Uvaysov, Ivanov I., Wojcik W., Komada P., Shedreyeva I., Karnakova G. Analysis of the physical foundations of the build quality of the diagnosis structures based on electronic means of recording and analyzing the parameters of electromagnetic radiation mechanical contact connections // Przeglad Elektrotechniczny. No. 5, 2017. pp. 138-143.

12. D. V. Lazarev, N. N. Grachev. Scientific, methodological and safetyassessment software for electromagnetic radiation of radio frequencies at marine infrastructure facilities // Technologies of electromagnetic compatibility. No. 3, 2013. - pp. 29-38.

MODEL OF VOLTAGE CONVERTER WITH REDUNDANCY OF POWER CHANNELS FOR CALCULATION OF ITS OPERATING TIME IN STATISTICAL MODELING

V.V. Zhadnov
National Research University “Higher School of Economics”
+7 (495) 916-88-80, vzhadnovt@hse.ru

Abstract – The problems of forming the operating time to failure of multi-channel voltage converter for statistical modeling are considered. A formal model of the converter with “N out of M active redundancy” is proposed, which allows for the calculation of the converter's operating time taking into account changes in the electrical load of the channels in case of failures. The developed model is created within the limits of assumptions and the restrictions accepted in operating standard documents. The possibility of reducing the computational costs when applying this model in statistical modeling is shown.

Keywords: voltage converter, power channel, dependability, redundancy, operating time, statistical modeling.

INTRODUCTION

When designing power electronic equipment, one of the tasks is to ensure the required level of dependability. Along with various methods, designing power electronics equipment, one of the most frequently used methods in practice to ensure of reliability level is redundancy. Thus, in [1] it is shown that in order to achieve high values of reliability indicators, multi-channel voltage converters must be made on the basis of a backbone-modular architecture. This architecture allows for the implementation of sliding "N out of M active redundancy" for power channels.

At the early stages of designing multi-channel voltage converters, calculation methods and software are used to evaluate their reliability indicators [2. 3]. It is obvious that the more accurate the estimate of these indicators is, the more likely it is that the created converter will meet the requirements. However, in practice, the calculation is limited to obtaining "lower" estimates of reliability indicators, which is due to limitations inherent in analytical methods [4].

At the same time, the method of statistical modeling is a universal method for calculating the reliability of electronic equipment [5]. This method is used mainly for calculating indicators of the "operating time" type (numerical integration method). For the practical implementation of this method, software tools for simulation have been created that have universal languages for describing the formal model. This makes it much easier to create a software model, since it is generated automatically [6-8]. However, these languages have a number of limitations, for example, in terms of the ability to describe changes in the parameters of the reliability block diagram (RBD) when component parts fail, and this applies not only to universal, but also specialized languages [9].

Therefore, when simulating operating time, even with "typical" redundancy methods (in this case, with "N out of M"), but having specific features, the software model must be created "manually" based on the formal model.

PROBLEM STATEMENT

Backbone-modular architecture of the power part (PP) of a multi-channel voltage converter with "N out of M" redundancy present in [1] and is shown in fig. 1.

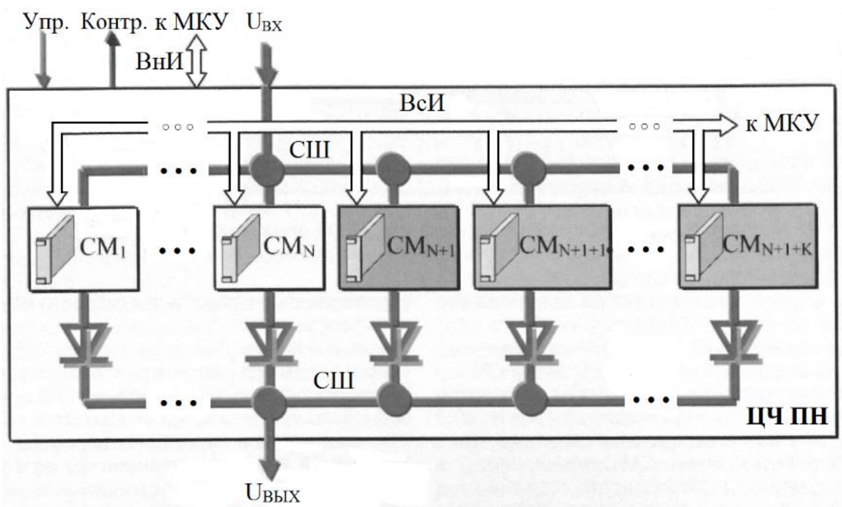


Fig. 1 Power part of the voltage converter with "N out of M active redundancy"

As seen in fig. 1 the power part of the voltage converter (PP VC) contains of N main power modules (PM_1-PM_N) and redundancy modules (PM_{N+1}, PM_{N+1+1},..., PM_{N+1+K}) that are in the operation mode. The reliability block diagram (RBD) for this redundancy method of power modules (channels) is shown in fig. 2.

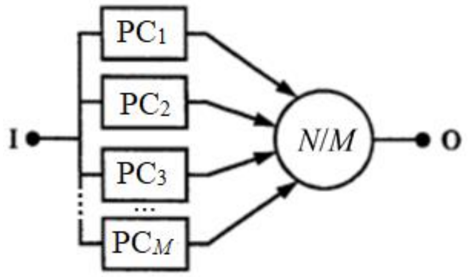


Fig. 2 Reliability block diagram of power part of a multi-channel voltage converter

Reliability function of such a group is determined by the formula from standard [10]:

$$P(t)=\sum_{i=0}^{M-N}\left[C_M^i\cdot\left(e^{-\Lambda\cdot t_{\text{бр}}}\right)^{M-i}\cdot\left(1-e^{-\Lambda\cdot t_{\text{бр}}}\right)^i\right], \tag{1}$$

where C_M^i is number of combinations; Λ is the failure rate of the element; t is time; N is number of elements; M is the total number of elements.

As can be seen from (1) in the method for calculating the RBD of the group "N out of M active redundancy", given in the standard [10], the dependability characteristics (Λ) for each element of the RBD are assumed to be constant (do not depend on the number of failed elements). However, this condition is not met for the voltage converter in question.

SOLUTION OF THE PROBLEM

This is due to the fact that the power channel (P_{PC}) depends on the number of operable channels (m) that work on the load [1]:

$$P_{\text{PC}}(m)=\frac{P_{\text{VC}}}{m}, \tag{2}$$

where P_{VC} is the rated power of the converter.

It follows from (2) that the electrical stress factor of the channel (K_L) also depends on m:

$$\text{K}_\text{L}(m)=\frac{P_{\text{PC}}(m)}{P_{\text{PC}_{\text{nom}}}}, \tag{3}$$

where P_{PCnom} is the nominal capacity of the channel.

Note that for m = N, the value of $P_{\text{PC}}(m)$ will be equal to P_{PCnom}.

Since the channels are electronic modules of the first level (EM1), the values of their failure rate (Λ_{PC}) are calculated using the method given in the standard [10]:

$$\Lambda_{\text{PC}}=\sum_{i=1}^{I}\lambda_{\text{O}_i}, \tag{4}$$

where $\lambda_{\text{O}i}$ is the operational failure rate of the i-th element of the channel; I is the total number of elements in the channel.

In turn, the value of $\lambda_{\text{O}i}$ is calculated using the models given in the handbook [11]:

$$\lambda_\text{O}=\lambda_\text{b}\cdot\prod_{j=1}^{J}\text{K}_j, \tag{5}$$

where λ_b is base failure rate of the element; K_j are factors; J is the total number of factors.

One of the factors that are included in the model (5) is the operating mode factor (K_{OM}). K_{OM} учитывает влияние электрической нагрузки и температуры на величину λ_O [11]. Factor K_{OM} takes into account the influence of electrical and temperature stresses on the value of λ_O [11]. For example, for silicon semiconductor devices (except mixing and microwave detector diodes), the mathematical model of the K_{OM} has the form:

$$\mathrm{K_{OM}} = A \cdot e^{\left[\frac{N_T}{273+t+175-t_{\mathrm{Jmax}}+\Delta t \cdot \mathrm{K_{ES}} \cdot \left(\frac{t_{\mathrm{Jmax}}-t_{\mathrm{dec}}}{150}\right)}\right]+\left[\frac{273+t+175-t_{\mathrm{Jmax}}+\Delta t \cdot \mathrm{K_{ES}} \cdot \left(\frac{t_{\mathrm{Jmax}}-t_{\mathrm{dec}}}{150}\right)}{T_M}\right]^L}, \quad (6)$$

where a A, N_T, T_M, L, Δt are model's constant; t is ambient temperature (package); K_{ES} is the ratio of the working electrical stress to the maximum allowed temperature t_{dec}; t_{dec} is the maximum ambient temperature for which at 100% electrical stress junction temperature does not exceed maximum allowable t_{Jmax}.

For transistors and transistor assemblies, the K_{ES} value is defined as:

$$\mathrm{K_{ES}} = \frac{P_{\mathrm{OM}}}{P_{\mathrm{max}}}, \quad (7)$$

where P_{OM} is scattering power in operating mode; P_{max} is the maximum allowable power of scattering at a temperature equal to t_{dec}.

The graph of the K_{OM} dependence on the K_{ES} is shown in fig. 3.

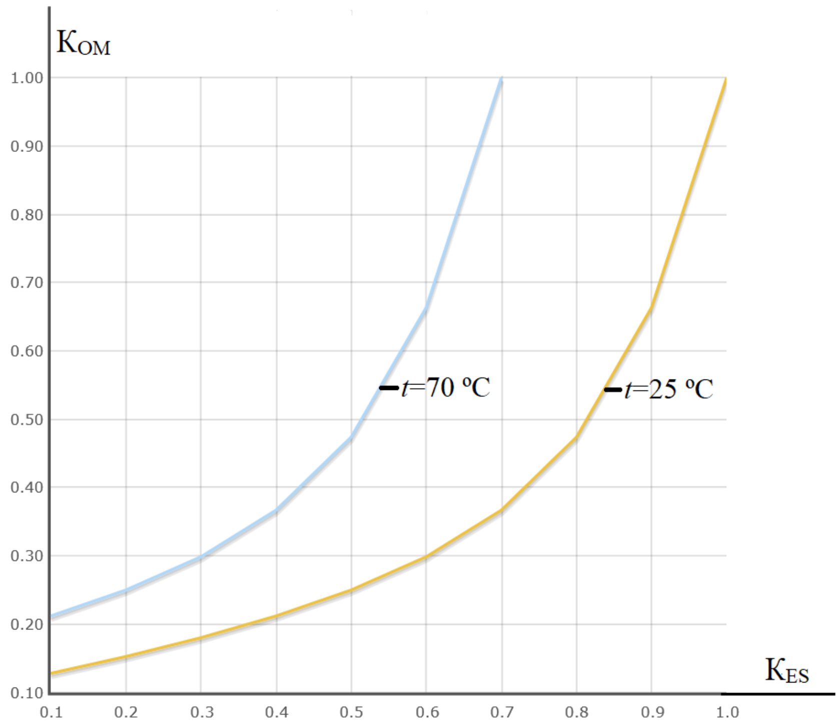


Fig. 3 Dependence operating mode factor on electrical stress factor

As seen in Fig. 3 the decrease in K_{ES} leads to a significant decrease in the K_{OM}, and, consequently, to a decrease in the λ_O.

Since the Λ_{PC} is calculated for the nominal stress of the channel ($K_L = 1$), when using this value (Λ_{CKnom}) in the reliability prediction of the PP VC according to the method of the standard [10], only their lower estimate ("worst case") can be obtained, and the calculation error will grow with the increase in the number of redundancy channels.

This is due to the fact that if the K_{ES} values of the control circuit elements are weakly dependent on the channel K_L value, the K_{ES} of the power circuit elements is already largely determined by the K_L value, and these elements significantly affect the final value of Λ_{PC}.

In contrast to analytical methods, the statistical modeling method allows you to take into account changes in the dependability characteristics of the converter channels in case of failures.

For an exponential failure model, the value of the operating time realization ($\hat{t}$) is calculated using the formula:

$$\hat{t} = -\frac{\ln(x)}{\Lambda_{\text{PC}}}, \tag{8}$$

where x is realization of the basic random variable (BRV).

As shown above, the P_{PC} value depends on m and can be calculated for m = (N+1), ..., (M+N):

$$P_{\text{PC}_m} = \frac{N}{m} \cdot P_{\text{PC}_{\text{nom}}}. \tag{9}$$

Then, for these $P_{\text{PC}m}$ values, it is necessary to determine the electrical (and, if necessary, thermal) modes of operation of the channel elements, i.e. find the values of K_{ES} and t_m for all elements. Then, using the formulas (4) and (5), can be calculated the channel failure rates when fails 0, 1, 2, ..., (M-N) channels in the converter and then can be forms an array $\Lambda_{\text{PC}0}$, $\Lambda_{\text{PC}1}$, $\Lambda_{\text{PC}2}$, …, $\Lambda_{\text{PC}(M\text{-}N)}$.

This array is used for calculating the realization of channel’s operating time, namely:

- according to the formula (8), the realizations of channel’s operating time ($\hat{t}_{\text{PC}_m}$) are calculated for failures and an array is formed (values of $\hat{t}_{\text{PC}_{M-N+1}} = \hat{t}_{\text{PC}_{M-N+2}} = ... = \hat{t}_{\text{PC}_M}$, because they are calculated for $\Lambda_{\text{PC}} = \Lambda_{\text{PCnom}}$);

- according to the formula (8) for the same values, the realizations of channel’s operating time ($\hat{t}_{\text{NOM}_l}$) are calculated and an array ($\hat{t}_{\text{NOM}_1}, \hat{t}_{\text{NOM}_2}, ..., \hat{t}_{\text{NOM}_M}$) is formed;

- array elements $\hat{t}_{\text{NOM}_1}, \hat{t}_{\text{NOM}_2}, ..., \hat{t}_{\text{NOM}_M}$ are ordered in ascending order;

- calculated the realizations of converter's operating time ($\hat{t}_{\text{PC}_{l,(M-m)}}$) to failure of the 1-st, 2-nd, ..., M-th channels:

$$\hat{t}_{\text{PC}_{l,(M-m)}} = \sum_{s=0}^{M-m} \frac{\left(\hat{t}_{\text{NOM}_{l,(s+1)}} - \hat{t}_{\text{NOM}_{l,s}}\right) \cdot \hat{t}_{\text{PC}_s}}{\hat{t}_{\text{NOM}_{l,(s+1)}}}, \text{ при } \hat{t}_{\text{NOM}_{l,0}} = 0, \tag{10}$$

where the first index (l) is the number of channels in the converter, and the second (s) is the number of their operating times in ascending order.

After the calculation $\hat{t}_{\text{PC}_{l,(M-m)}}$ is determined by realization of operating time of PP VC ($\hat{t}_{\text{VC}}$) to failure, which is the realization of operating time (M-N+1)-th channel:

$$\hat{t}_{\text{VC}} = \hat{t}_{\text{PC}_{l,(M-N+1)}}. \tag{11}$$

Since the statistical modeling method requires multiple calculations $\hat{t}_{\text{VC}}$, in this case, the amount of computational costs can be reduced.

Indeed, it follows from (8) that:

$$\frac{\hat{t}_m}{\hat{t}_{\text{NOM}}} = \frac{\Lambda_{\text{PC}_{\text{NOM}}}}{\Lambda_{\text{PC}_m}} \Rightarrow \hat{t}_m = \frac{\Lambda_{\text{PC}_{\text{NOM}}}}{\Lambda_{\text{PC}_m}} \cdot \hat{t}_{\text{nom}} \Rightarrow \text{K}_m = \frac{\Lambda_{\text{PC}_{\text{NOM}}}}{\Lambda_{\text{PC}_m}}, \tag{12}$$

where $\hat{t}_{\text{NOM}}$ is realization of the channel's operating time at $\Lambda_{\text{PC}} = \Lambda_{\text{PC}_{\text{NOM}}}$; $\hat{t}_m$ is realization of the channel's operating time at $\Lambda_{\text{PC}} = \Lambda_{\text{PC}_m}$.

Then, using (12), you can pre-generate an array K_0, K_1, K_2, …, $\text{K}_{(M\text{-}N)}$, which will be used for calculating realizations of the converter's operating time, namely:

- using the formula (8), the realizations of the converter's operating time ($\hat{t}_{\mathrm{nom}_l}$) are calculated and an array $\hat{t}_{\mathrm{NOM}_1}, \hat{t}_{\mathrm{NOM}_2}, ..., \hat{t}_{\mathrm{NOM}_M}$ is formed;

- array elements $\hat{t}_{\mathrm{NOM}_1}, \hat{t}_{\mathrm{NOM}_2}, ..., \hat{t}_{\mathrm{NOM}_M}$ are ordered in ascending order;

- calculated the realizations of channel's operating time:

- realization of channel's operating time that failed first:

$$\hat{t}_{\mathrm{PC}_{m=M}} = \hat{t}_{\mathrm{NOM}_{l,1}} \cdot \mathrm{K}_0\,, \tag{13}$$

- realization of channel's operating time that failed second:

$$\hat{t}_{\mathrm{PC}_{m=(M-1)}} = \hat{t}_{\mathrm{PC}_{m=M}} + \left(\hat{t}_{\mathrm{NOM}_{l,2}} - \hat{t}_{\mathrm{NOM}_{l,1}}\right) \cdot \mathrm{K}_1\,, \tag{14}$$

- realization of channel's operating time that failed (M-N) (the last of the redundancy channels):

$$\hat{t}_{\mathrm{PC}_{m=(M-N)}} = \hat{t}_{\mathrm{PC}_{m=M}} + \sum_{s=1}^{M-N} \left[\left(\hat{t}_{\mathrm{NOM}_{l,(s+1)}} - \hat{t}_{\mathrm{NOM}_{l,s}}\right) \cdot \mathrm{K}_s \right], \tag{15}$$

- realization of channel's operating time that failed (M-N+1) (the first of the main ones):

$$\hat{t}_{\mathrm{PC}_{m=(M-N+1)}} = \hat{t}_{\mathrm{PC}_{m=(M-N)}} + \left(\hat{t}_{\mathrm{NOM}_{l,(M-N+1)}} - \hat{t}_{\mathrm{NOM}_{l,(M-N)}}\right), \tag{16}$$

- realization of channel's operating time that failed M (last):

$$\hat{t}_{\mathrm{PC}_{m=M}} = \hat{t}_{\mathrm{PCK}_{m=(M-N)}} + \sum_{s=M-N}^{M-1} \left(\hat{t}_{\mathrm{NOM}_{l,(s+1)}} - \hat{t}_{\mathrm{NOM}_{l,s}}\right), \tag{17}$$

Since the criterion for failure of the group “N out of M active redundancy” is the failure of its (M-N+1) elements, the realization of the converter's operating time before failure (M-N+2), (M-N+3), ..., M channels can be not calculated. The value of $\hat{t}_{\mathrm{VC}}$ will be equal to the realization of the operating time of the channel that failed (M-N+1).

Then, taking into account (13)-(16), the formal model of the PP VC with “N out of M active redundancy” of power channels can be presented in the following form:

$$\hat{t}_{\mathrm{VC}} = \hat{t}_{\mathrm{NOM}_{l,1}} \cdot \mathrm{K}_0 + \sum_{s=1}^{M-N} \left[\left(\hat{t}_{\mathrm{NOM}_{l,(s+1)}} - \hat{t}_{\mathrm{NOM}_{l,s}}\right) \cdot \mathrm{K}_s \right] + \left(\hat{t}_{\mathrm{NOM}_{l,(M-N+1)}} - \hat{t}_{\mathrm{NOM}_{l,(M-N)}}\right), \tag{18}$$

where the values of the model parameters are determined by formulas (12), (8), (4) and (5).

To create a software model (program module), you can use the algorithm calculation $\hat{t}_{\text{ПН}}$ shown in fig. 4.

Block 1 (see fig. 4) runs the module on a command from the simulation program. In Block 2, enter the parameters of the formal model - N, M, Λ_{PCnom} and the array Λ_{PCK0}, Λ_{PC1}, Λ_{CK2}, …, $\Lambda_{\mathrm{PC}(M\text{-}N)}$. In Blocks 3-5, elements of the array K_0, K_1, K_2, …, $\mathrm{K}_{(M\text{-}N)}$ are calculated using the formula (12). In Blocks 6-9, elements of the array $\hat{t}_{\mathrm{NOM}_1}, \hat{t}_{\mathrm{NOM}_2}, ..., \hat{t}_{\mathrm{NOM}_M}$ are calculated using the formula (8). In Block 10, elements of the array $\hat{t}_{\mathrm{NOM}_1}, \hat{t}_{\mathrm{NOM}_2}, ..., \hat{t}_{\mathrm{NOM}_M}$ are ordered in ascending order. In Block 11, calculates on the formula (13) the realization of operating time of channel that failed first. In Blocks 12-14, the realization of operating time of channel that failed last from the number of redundancy channels is calculated using the formula (15). In Block 15, the formula (18) is used to calculate the realization of operating time of the PP VC. Block 16 outputs this value, and Block 17 terminates the module and passes control to the simulation program.

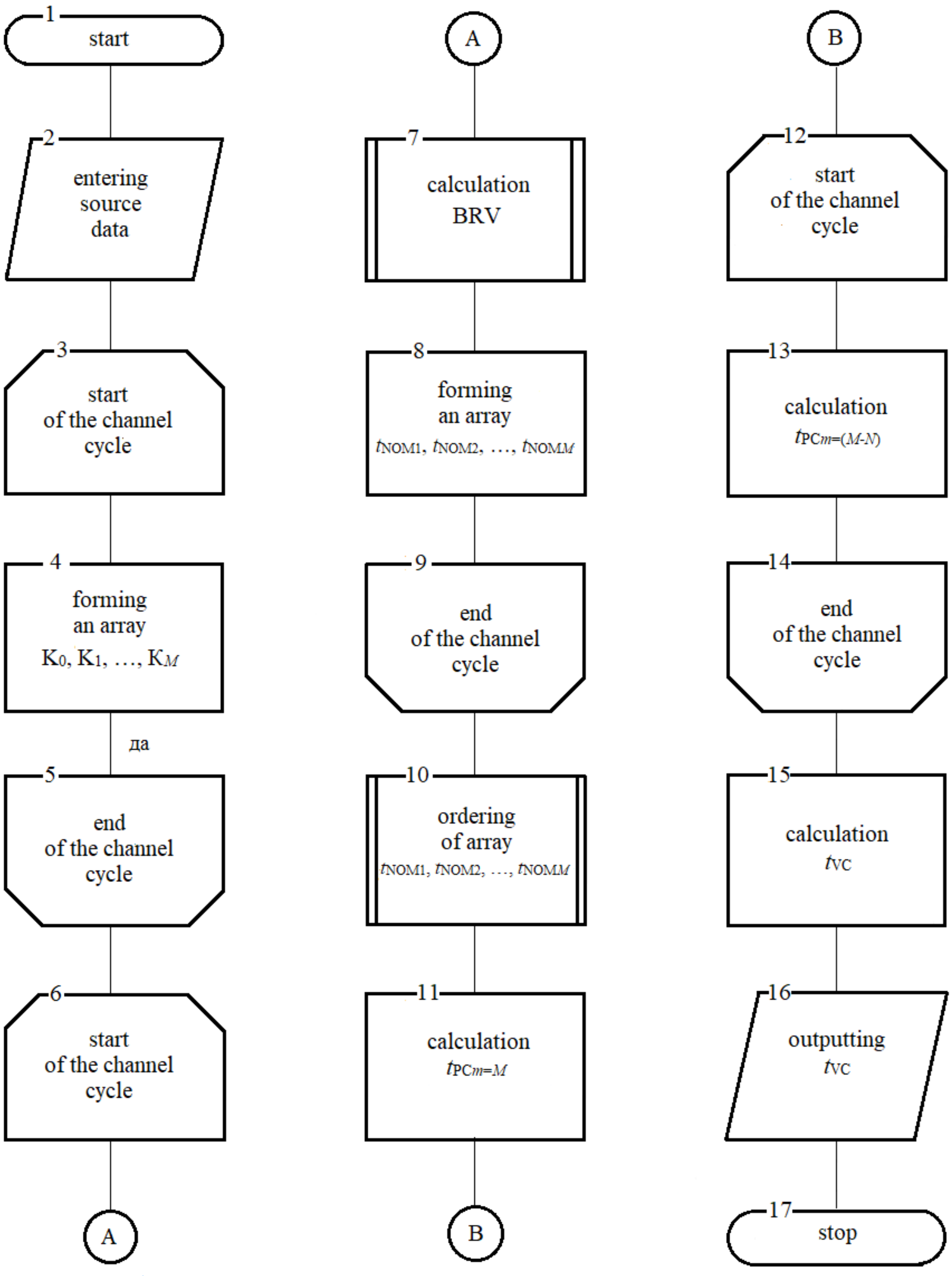


Fig. 4 Algorithm for calculating the operating time of the voltage converter

CONCLUSION

Thus, the model (18) makes it possible to the reliability prediction of multi-channel voltage converter ("N out of M active redundancy" method), taking into account changes in the reliability characteristics of their power channels in case of failures.

However, it should be noted that the effect of using this model can only be obtained if can be calculated Λ_{PC} for the power channels (i.e., there are initial data). In practice, such data is often not available, because often ready-made modules are used as PC, for which the reliability characteristics are given in the Data Sheet only for typical (nominal) modes.

In addition, the above model, like any other model, is valid within the limits of the above restrictions (exponential model of channel failures, accuracy of calculating their failure rates, etc.).

Therefore, the results of reliability prediction of multi-channel voltage converter obtained with this model help should be adjusted according to the results of tests and controlled operation.

REFERENCES

1. Y. N. Libenko and A. N. Chetin, “Ways to Improve the Reliability of Secondary Power Supply Systems for Radio-Electronic Equipment” (in Russian), Power Supply, no. 4, pp. 10-2, Dec. 2010.

2. G. L. Kovalenko et al., “Application of an Automated System for Ensuring the Dependability and Quality of Equipment for Design Studies of the reliability of SPS” (in Russian), Electronic equipment, Series “Radio Parts and Components”, no. 2(79), pp. 42-44, Feb. 1990.

3. V. V. Zhadnov, “Automation of Studies of Reliability of Secondary Power Supply Sources” (in Russian), in Proc. International Symposium “Reliability and Quality-2012”, Penza, Russia, 2012, vol. 2, pp. 173-176.

4. V. V. Zhadnov, “Modern Problems of Automation of Dependability Prediction” (in Russian), Dependability, no. 2, pp. 3-12, Jun. 2007.

5. Dependability in Technics. Dependability Prediction. Basic Principles, Interstate Standard 27.301, 1995.

6. T. Schreiber, “Modeling on GPSS” (in Russian), Moscow, Russia: Mashinostroenie, 1980.

7. V. D. Boev, “Modeling in the AnyLogic Environment: Textbook for Universities” (in Russian), Moscow, Russia: Yurayt, 2018.

8. O. K. Alsova “Simulation of Systems in the ExtendSim Environment: Textbook for Academic Baccalaureate” (in Russian), 2-nd ed., Moscow, Russia: Yurayt, 2018.

9. V. V. Zhadnov and A. N. Tikhmenev, “Simulation Modeling in Estimating Reliability of Fail-Safe Electronic Equipment”, Dependability, no. 1, pp. 44-54, Apr. 2013. DOI: 10.21683/1729-2646-2013-0-1-32-54.

10. Radio-Electronic Equipment. Method of Dependability Prediction, Industry Standard 4G 0.012.242, 1984.

11. Handbook “Dependability of ERP” (in Russian), Moscow, Russia: MO RF, 2006.

INFLUENCE OF NON-FLUCTUATION INTERFERENCE ON THE NOISE IMMUNITY OF INCOHERENT RECEIVING OF SIGNALS WITH DIFFERENTIAL PHASE-SHIFT KEYING

Kulikov G.V., Kulagin V.P., Nguyen Van Dung, Do Trung Tien
MIREA – Russian Technological University
+7 (910) 456-21-68, kulikov@mirea.ru

Abstract— The paper studies the noise immunity of an autocorrelation demodulator of signals with differential phase-shift keying in the presence of Gaussian noise, Rayleigh fading, harmonic and retransmitted interference in the radio channel. Analytical formulas are obtained for the error probability at M=2 and 4 in two cases: with harmonic interference and Rayleigh fading and with harmonic interference without fading. The results of simulation are given, including in the presence of retransmitted interference, confirming the theoretical results.

Keywords: differential phase-shift keying, autocorrelation demodulator, harmonic interference, retransmitted interference, Rayleigh fading, noise immunity.

INTRODUCTION

Phase-shift keying (PSK), including multiple M-PSK, is used in many digital information transfer systems. The noise immunity characteristics of the optimal coherent receivers of such signals are well studied for many interference situations [1-7]. Due to the simplicity of technical implementation in practice, incoherent reception methods are often used. Thus, the autocorrelation algorithm allows the use of a delayed signal as a reference oscillation. In this case, differential encoding of information and, accordingly, differential (relative) multiple phase-shift keying (DMPSK) are used. The number of possible values of the phases of the packages *M* is usually small and is generally equal to 2, 4 or 8.

The autocorrelation demodulator (ACD) of the DMPSK signals is constructed according to a quadrature scheme and contains two channels – in-phase (upper) and quadrature (lower) (Fig. 1) [2]. In some schemes, integrators are used as LPF1 and LPF2.

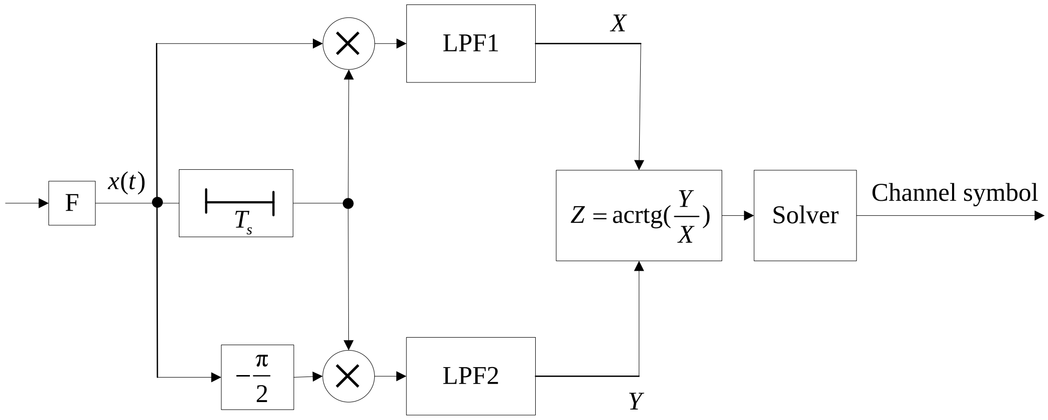


Fig. 1 Block diagram of an ACD of DMPSK signals

Due to the complexity of determining the statistical characteristics of the processes at the input of the solver, the noise immunity analysis of such a demodulator was performed for special cases [1,2], most of which concern the reception of 2-PSK and 4-PSK signals against the background of noise interference. However, in the literature there are few studies of the noise immunity of the autocorrelation reception of such signals for cases when noise and non-fluctuation interference are present in the radio channel.

The aim of this study is to obtain the noise immunity characteristics of an ACD of a DMPSK signal in the presence of various interference at its input – harmonic, retransmitted, multiplicative (Rayleigh fading) and noise.

SIGNAL AND INTERFERENCE MODELS

The authors will write two adjacent sendings of the DMPSK signal at the *i*-th and (*i*-1)-th clock intervals equal to the duration of the channel symbol T_s, as follows

$$\begin{aligned} s_i(t) &= A\cos(\omega_0 t + \varphi_1),\ t \in ((i-1)T_s, T_s], \\ s_{i-1}(t) &= A\cos(\omega_0 t + \varphi_2),\ t \in ((i-2)T_s, (i-1)T_s], \end{aligned} \tag{1}$$

where $A = \sqrt{2E_s/T_s}$ – the signal amplitude; $E_s = E_b \log_2 M$ – the energy of the channel symbol; E_b – the energy per one bit of information; ω_0 – carrier frequency; φ_1 and φ_2 – phases of the packages, the difference of which carries information about the channel symbol and can take one of *M* possible values that differ by a value $2\pi/M$.

Let us consider a situation when, in addition to the useful signal (1), the radio communication channel contains additive fluctuation noise $\xi(t)$ with power σ^2_{ξ}, targeted harmonic interference $s_{п}(t) = \mu A \cos(\omega_0 t + \eta)$ with a relative intensity μ and a random uniformly distributed phase η, or a retransmitted interference, which is a signal (1), delayed by time $\tau < T_s$. Moreover, it can be assumed that both the signal and the interference experience slow Rayleigh fading, characterized by a coefficient β:

$$\varpi(\beta) = \frac{\beta}{\sigma^2}\exp(-\frac{\beta^2}{2\sigma^2}).$$

DERIVATION OF FORMULAS

To analyze the noise immunity of the ACD, the authors use the technique described in [8, 9] and based on the presentation of the output signals of the in-phase and quadrature channels in a quadratic form. In this case, it is possible to obtain the parameters of the distributions of random processes at these points of the circuit and estimate the probability of the error of the resultant signal vector falling into one or another quadrant of the complex *XY* plane. The calculations made it possible to obtain the following expressions in the presence of Rayleigh fading and harmonic interference:

- the probability of a symbolic (bit) error during fading for $M = 2$:

$$P_{ef\,2} = \frac{1}{2}\frac{1}{cq+1}, \quad (2)$$

- the probability of a symbolic error for $M = 4$:

$$P_{ef\,4} = 1 - P_{ПП4} = \frac{1}{4}\frac{4cq+3}{(cq+1)^2}, \quad (3)$$

where $q = \sigma^2 / \sigma^2_{\xi}$ is the signal-to-noise ratio; $c = 1 + \mu^2 + 2\mu\cos\eta$.

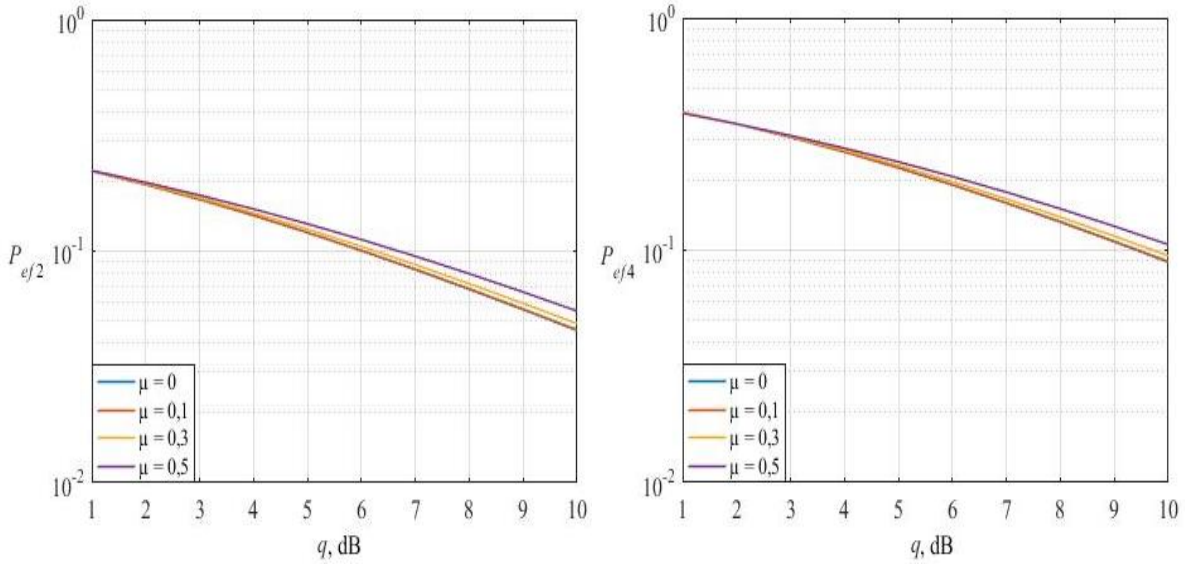
Without harmonic interference at μ = 0, $c = 1$, and expression (2) reduces to the well-known formula given in [1].

THE RESULTS OF THE ASSESSMENT OF ACD NOISE IMMUNITY OF THE DMPSK SIGNALS

a) a radio channel with Rayleigh fading and harmonic interference

The expressions for the probabilities of symbolic error (2), (3) are conditional with respect to the parameter η – the random phase of harmonic interference. After a numerical averaging, one can get the final results.

Fig. 2 shows the dependences of the probability of a symbolic error on the signal-to-noise ratio in a radio channel with Rayleigh fading and harmonic interference. It can be seen that harmonic interference with low intensity practically does not affect the noise immunity of the demodulator, and in this case, Rayleigh fading has a dominant effect. If $\mu = 0.5$, then for $P_{ef} = 10^{-1}$ the additional energy loss due to harmonic interference is about 0.7 dB compared with the case when there is no such interference.



a) b)

Fig. 2 The dependences of the probability of a symbolic error on the signal-to-noise ratio in a radio channel with Rayleigh fading and harmonic interference
a) for $M = 2$, b) for $M = 4$

b) a radio channel with harmonic interference without Rayleigh fading

It is known that the error probabilities for amplitude fading P_{ef} and without fading P_e are related by the ratio [1]:

$$P_{ef} = \int_0^\infty P_e(A)\varpi(A)dA.$$

Therefore, to obtain the probability of a symbolic error in a radio channel without Rayleigh fading, one can use a technique based on the use of the inverse Laplace-Carson transform $P_e = L^{-1}(P_{ef})$ [10, 11]. To do this, one can replace the variable $p = 1/2\sigma^2$ in formulas (2), (3) taking into account the expression for the signal-to-noise ratio q.

For $M = 2$, one can get:

- in the presence of harmonic interference

$$P_{e2} = \frac{1}{2}\exp(-cq_0), \tag{4}$$

where $q_0 = \dfrac{A^2}{2\sigma_\xi^2}$;

- in the presence of fluctuation noise only, one can get the known relation [1]

$$P_{e2} = \frac{1}{2}\exp(-q_0). \tag{5}$$

For $M = 4$:

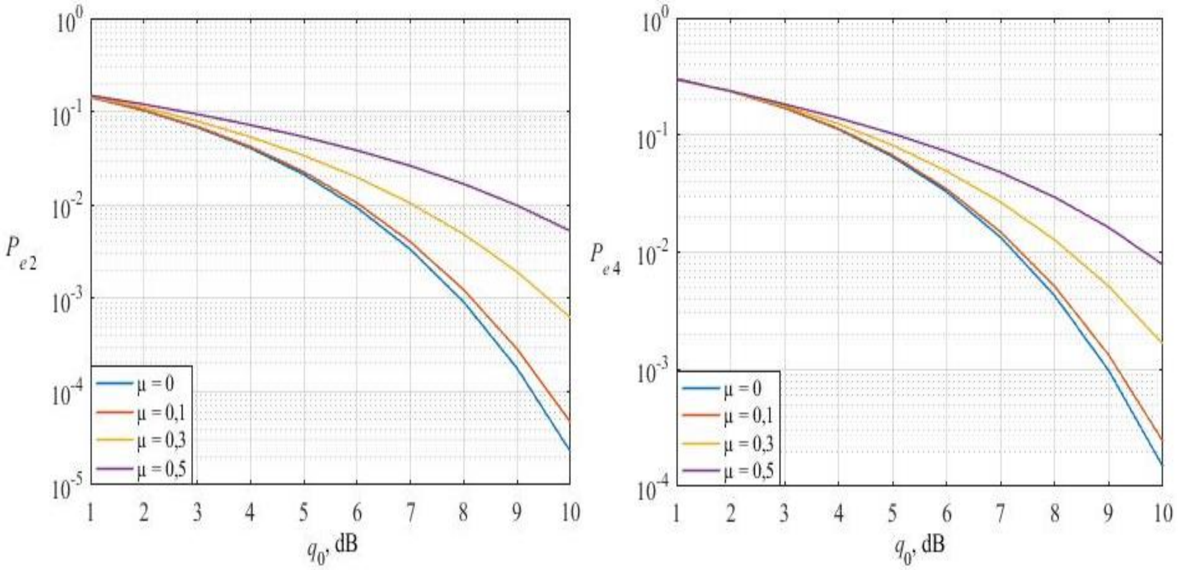
- in the presence of harmonic interference

$$P_{e4} = \frac{3+cq_0}{4}\exp(-cq_0). \tag{6}$$

- in the presence of fluctuation noise only

$$P_{e4} = \frac{3+q_0}{4}\exp(-q_0). \tag{7}$$

Fig. 3 shows the dependences of the probability of a symbolic error on the signal-to-noise ratio q_0 in a radio channel without fading, constructed according to formulas (4)-(7). It can be seen that the targeted harmonic interference can rather severely impair the interference immunity of the ACD of the DMPSK signal, and with increasing the signal position, the interference immunity of the ACD decreases. With an increase in the noise intensity μ from 0 to 0.5 at a signal-to-noise ratio of 10 dB, the probability of a symbolic error for M=2 and M=4 deteriorates by two orders of magnitude.



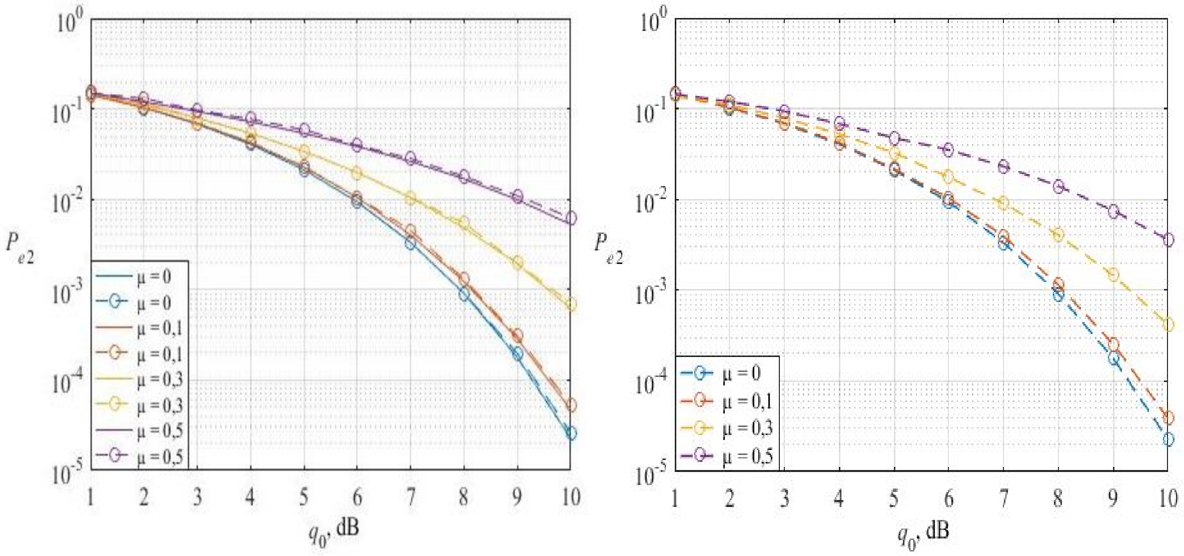
a) б)

Fig. 3 Dependences of the probability of a symbolic error on the signal-to-noise ratio in a radio channel without fading

a) for $M = 2$, b) for $M = 4$

THE RESULTS OF THE SIMULATION OF ACD OF THE DMPSK SIGNALS

Fig. 4 presents comparative theoretical and simulation dependences of the probability of a symbolic (bit) error on the signal-to-noise ratio for M=2 in the presence of harmonic (a) and retransmitted (b) interference in the communication channel. The solid lines correspond to the theoretical one, and the dashed lines correspond to the simulation probability of a bit error.



a) б)

Fig. 4 Theoretical and simulation dependences of the probability of a symbolic error on the signal-to-noise ratio in the presence of harmonic and retransmitted interference for M=2

CONCLUSION

The paper analyzes the noise immunity of the ACD of DMPSK signals in the presence of Rayleigh fading, harmonic and retransmitted interference in the radio channel. The results obtained allow drawing the following conclusions.

1. The noise immunity of the ACD of DMPSK signals is significantly reduced when there are Rayleigh fading in the radio channel. Their influence is stronger than the influence of harmonic interference.
2. In a radio channel without fading, the targeted harmonic interference significantly reduces the noise immunity of the ACD. Thus, with an increase in its intensity from 0 to 0.5 at a signal-to-noise ratio of 10 dB, the probability of a symbolic error for M=2 and 4 deteriorates by two orders of magnitude.
3. The simulation results are in good agreement with theoretical results, which confirms their reliability.

ACKNOWLEDGMEN

The work is conducted with financial support from the Ministry of Science and Higher Education of the Russian Federation (unique identifier RFMEFI57418X0190).

REFERENCES

1. L.M. Fink, “Theory of Discrete Message Transmission”, 2nd ed., revised, supplemented, Moscow, Sovetskoye radio, 1970. – 728 p,(rus)
2. Fuqin Xiong, “Digital Modulation Techniques”, 2nd ed., United States, Artech House, Inc., 2006. – 1039 p.
3. J.G. Proakis, “Digital Communications”. 4th ed., N. York, The McGraw-Hill companies Inc., 2001. – 928 p.
4. G.V. Kulikov, Nguyen Van Dung, A.V. Nesterov, A.A. Lelyukh, “Noise Immunity of Receiving Signals with Multiple Phase Shift Keying in the Presence of Harmonic Interference”, Naukoyemkiye Tekhnologii, 2018. No. 11. – pp. 32–38,(rus)
5. G.V. Kulikov, Nguyen Van Dung, “Analysis of Noise Immunity of Receiving Signals with Multiple Phase Shift Keying when exposed to Scanning Interference”, Rossiyskiy Tekhnologicheskiy Zhurnal, 2018. Vol. 6. No. 6. – pp. 5–12. Available at: https://rtj.mirea.ru/upload/medialibrary/947/RTZH_6_2018_5_12.pdf. DOI: 10.32362/2500-316X-2018-6-6-5-12 (Accessed 26 Febrary 2020),(rus)
6. Nguyen Van Dung, “Noise Immunity of the Coherent Receiver of Signals with Multiple Phase Shift Keying in the presence of Retranslated Interference”, Zhurnal Radioelektroniki, 2019. No. 3. Available at: http://jre.cplire.ru/jre/mar19/4/text.pdf. DOI 10.30898/1684-1719.2019.3.4 (Accessed 26 Febrary 2020),(rus)
7. G.V. Kulikov, Nguyen Van Dung, Do Trung Tien, “The Effect of Phase-Shifted Interference on the Noise Immunity of the Correlation Demodulator of Signals with Multiple Phase Shift Keying”, Rossiyskiy Tekhnologicheskiy Zhurnal, 2019. Vol. 7. No. 2. – pp. 18–28. Available at: https://rtj.mirea.ru/upload/medialibrary/4c2/RTZH_2_2019_18_28.pdf. DOI: 10.32362/2500-316X-2019-7-2-18-28 (Accessed 26 Febrary 2020),(rus)
8. N.P. Khvorostenko, “Statistical Theory of Demodulation of Discrete Signals”, Moscow, Svyaz, 1968. – 366 p,(rus)
9. G.V. Kulikov, “Noise Immunity of the Autocorrelation Demodulator of MFM Signals in a Communication Channel with Harmonic Interference”, Radiotekhnika, 2004. No. 8. – pp. 20–22.
10. I.S. Gradshtein, I.M. Ryzhik, “Tables of Integrals, Sums, Series and Products”, Moscow, Nauka, 1971. – 1108 p,(rus)

11. I.N. Bronstein, K.A. Semendyaev, “Math Reference for Engineers and Students of Technical Colleges”, Moscow, Nauka, 1981. – 720 p,(rus).

INFORMATION THEORY FUNDAMENTALS OF GROUND-SPACE MONITORING AUTOMATED SPECIAL-PURPOSE OPTICAL-ELECTRONIC SYSTEM

Lovtsov D.A., Gavrilov D.A.
Lebedev Institute of Precise Mechanics and Computer Engineering, Russian Academy of Sciences

Abstract – The paper presents the fundamentals of the advanced ground-space monitoring high-efficiency automated special-purpose optical-electronic system theory fundamentals. The results presented have theoretical and practical importance in the performance of the information efficiency supply tasks in various implementational fields required visual information processing.
Keywords: optoelectronic system, visual information processing, efficiency.

Within global informatization and intensification of informational rivalry, the issues of ensuring the efficiency of visual information processing during the integrated information monitoring (ground, air, space, and underwater), carried out in the interest of solving national economic and special problems using remotely piloted vehicles equipped with the automated optoelectronic devices, are of particular relevance. The central problem in the field of technological and logical image processing is the creation of ground-space monitoring (GSM) automated special-purpose optical-electronic systems (AOES) that provide solutions to visual information processing with high accuracy, resistant to various destructive factors with a clearly defined and investigated applicability range [1, 2, 3, 4]. The conceptual modeling of effective GSM AOES was carried out on the basis of a problem-oriented option of the integrated “ICD” (“information-cybernetic-didactic”) approach [1, 2], that is, a systematic approach with emphasis on its informational, cybernetic and didactic aspects, consisting of the integration of *informational* approach methodology (when the object is treated as a focused information system), *cybernetic* approach methodology (when the object is treated as a control system at the level of information processes and informational base functioning algorithms), *didactic* approach methodology (when the object is treated as a self-learning system) as part of a *systematic* approach methodology (when the object is treated as complexly layered and multi-faceted system).

The main functionality of GSM AOES is the task of detecting, *localizing* and *classifying* the objects on photo and video as applied to various phono-target environments [2]. The difficulty in solving these problems increases due to: loss of information when projecting a three-dimensional scene (exposure) onto the image plane, noise on the image, changing the scene exposure, complex shape of objects, changing the object shape, partial or complete object overlap and blocking in the scene, complex motion path of the object, object exceedance and its appearance in the frame, relative camera movement, processing requirements in real time, etc.

The well-known invariant functional structure of control systems [1] is used as a conceptual-logical model of GSM AOES, while the tasks of GSM are distributed according to the functional subsystems as follows: ensuring the stabilization of video images - P_1 subsystem [5]; detection, localization and maintenance - P_2 [6]; classification and selection - P_3 [5]; formation of control effects - P_4; creation of training samples and adjustment of system methods - P_5 [7]; dynamic range compression and signal transmission - P_6 [8]; cryptoconversion of signals - P_7.

The model reorganization levels (layers) are characterized as follows:

Level 1. The choice of an action method $m \in M$ from the set M of possible methods according to algorithm *A*:

$$A: m \in M.$$

The main subsystems operating at this level are the *measurement* subsystem (P_1) and the *central coordination and organizational management* subsystem (P_5).

Level 2. Adaptation and modification of problem solution methods in the informational rivalry conditions. As a result of training in real conditions and narrowing of the set *N* of uncertainty, it is formed an effective algorithm *A* for choosing an action method:

$$H \to 0, A = F\{G, K\}.$$

The main subsystem functioning at this level is the *information exchange* subsystem (P_6).

Level 3. Self-organization, selection of a strategic model are carried out on the basis of justification and assignment of the current output operators *G*, *K* assessment the action method quality, corresponding to the main goal *S(t).* The output operator *G* defines a rule for displaying a set of *X* elements at the input to the set *Y* of output results for a given $m \in M$ action method selected from the set *M* under the uncertainty conditions *H*:

$$G: X \times M \times H \to Y.$$

The action quality method *K* assessment operator determines the rule for displaying the set *Y* of output results for a given $m \in M$ action method selected from the set *M* to the set of quantities *R* associated with the system quality features:

$$K: M \times Y \to R.$$

The main subsystems operating at this level are the *observation* subsystem (P_2) and the *identification* subsystem (P_3).

Level 4. Development and decision making based on the received analytical information. The main subsystem functioning at this level is the *decision-making* subsystem (P_4).

The required degree of protection and security of information arrays is supported by the *information protection* subsystem (P_7) continuously at all levels.

At the same time, it is necessary to develop a rational usage method *W** of an informational structurally-informative resource $Q_s \cup Q_z$ to process only the most valuable visual information $Q_{z\text{o}}^*$, which may lead to the development of optimal management decisions U_g^*, leading to the achievement of goals *g* with a given limit $I_{z\text{o}}^0$ of the information processed.

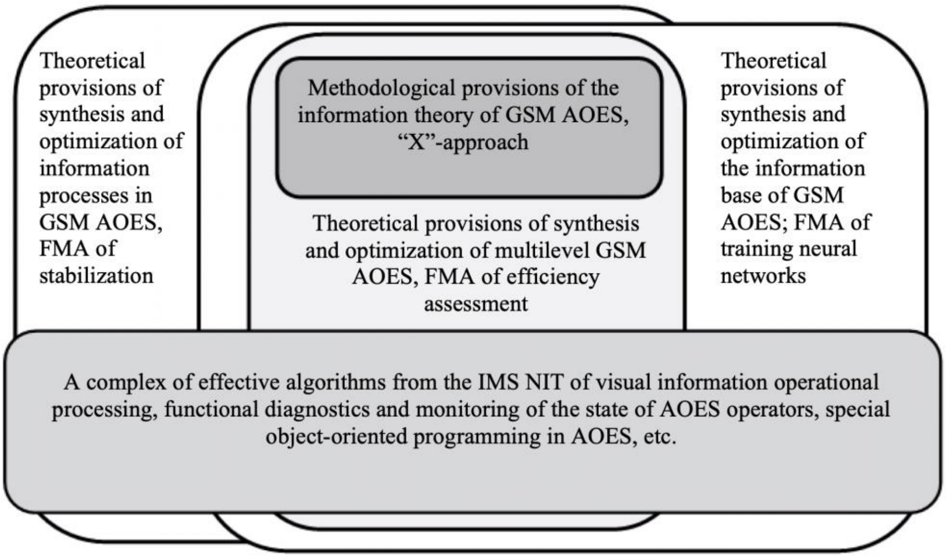
$$Q_s \cup Q_z \overset{W^*}{\Rightarrow} Q_{z\text{o}}^* \to U_g^* \big| I_{z\text{o}}^0.$$

The information theory of complex GSM AOES (see figure) is based on an object-oriented technology of creating the information-mathematical software and hardware-software tools to process the visual information.

Conceptual design of an effective GSM AOES was carried out in a logical sequence at the following main stages [9, 10]:

At the *first stage*, as a result of a system analysis, the main trends and development directions for the image processing methods based on classical and neural network approaches were determined; the main problems arising during the visual information processing were highlighted; a scientific problem was identified; and decomposition of the information processing goals was performed.

At the *second stage*, the main methodological provisions of the information theory of GSM AOES were substantiated, including the search for optimal solutions; a conceptual-logical model was justified; and the information and technical structure that ensures the information efficiency of GSM AOES within the information confrontation conditions was developed.



General structure of the totality of the developed theoretical principles of the information theory of GSM AOES

The developed methodological principles are based on the proved *statement* that the degree of informational entropy of the system remains unchanged, and are formulated as follows: with an increase in the informational entropy H of the system, the uncertainty degree of the system does not change ceteris paribus, but the number of ways to implement a certain state of the system increases.

At the *third stage*, the synthesis and optimization of the information processes of GSM AOES were carried out, including development of a formal mathematical apparatus for stabilization of the visual information flow, evaluation and improvement of the information efficiency of GSM AOES.

It is proved the statement about the squared distance of any element of pseudo-Euclidean space - a real quadratic space, - in which scalar multiplication is given by the non-degenerate symmetric bilinear form sign (k, l). The squared distance of any element of pseudo-Euclidean space $x \in \mathbb{R}^M$ to an affine combination $x_c \in \mathbb{R}^M$ of elements $\{x_1, \dots, x_n\}$ c with the coefficients $\mathrm{c} = (\mathrm{c}_1, \dots, \mathrm{c}_n)$, where $x_c = \sum_{k=1}^{n} \mathrm{c}_k x_k \in \mathbb{R}^M, \sum_{k=1}^{n} \mathrm{c}_k = 1^T c = 1$, is determined by the equality:

$$r^2(x_c, x) = \sum_{k=1}^{n} \mathrm{c}_k r^2(x_k, x) - \frac{1}{2}\sum_{k=1}^{n}\sum_{l=1}^{n} \mathrm{c}_k c_l r^2(x_k, x_l).$$

At the *fourth stage*, during synthesis and optimization of the information base of GSM AOES, a formal mathematical apparatus for training neural networks was developed, a formalized markup method was created, and formalization of solving the problems of object detection, localization and classification was performed [3].

In particular, it is proved the statement about the contour symmetry axis, which states that if there is a symmetric contour $U = \{u_l\}_{l=0}^{N-1}$, whose symmetry axis coincides with the abscissa, and the point u_0 lies on the symmetry axis, then there is equality for the Fourier descriptor $F = \{f_l\}_{l=0}^{N-1}$ of contour U $I_m(f_l) = 0, l = \overline{0, N-1}$, where $f_l = u_0 + \sum_{k=1}^{N-1} u_k \cdot exp\left(-i \cdot \frac{2\mathrm{p}}{N} \cdot l \cdot k\right), l = \overline{0, N-1}$ is a discrete Fourier transformation for the contour U.

At the *fifth stage*, the synthesis and optimization of multilevel GSM AOES was carried out, including development of an integrated structure to solve the problem of assessing the information efficiency of GSM AOES in the information confrontation conditions; a formal mathematical apparatus for the effectiveness evaluation [4] was developed based on the proved *statement* on the equivalence of recognition algorithms, according to which the recognition algorithms G_{F1} and G_{F2} are equivalent, if metric potentials F_1 and F_2 are similar. $F_{\tilde{\alpha}_1}(\bar{x})$ - metric potential of the field created by vertex $\tilde{\alpha}$ in point $\bar{x}$ of the space $\bar{D}^N$. Each such potential defines a metric recognition algorithm G_F with the decision function R_0. Algorithms G_1 and G_2 are considered equivalent, if $\bar{x} \in \bar{D}^N$ $\operatorname{sign}\left(R_0^{(1)}(\bar{x})\right) = \operatorname{sign}\left(R_0^{(2)}(\bar{x})\right)$ algorithms G_1 and G_2 work the same for any $\bar{x} \in \bar{D}^N$.

At the *sixth stage*, the information-mathematical support (IMS) was developed for the effective solution of information problems concerning visual information operational processing, including functional diagnostics and monitoring of the state of people-operators; a mathematical model of the survival of GSM AOES operators was developed for the case of using an automated diagnostic system; and the operational information processing automation IMS was created.

The developed information-mathematical support is based on a proven *statement* about structural features of the objects concerned. Structural features of the objects concerned are localized in the image coordinate system recorded by GSM AOES and have their own fractal dimensions and maximum eigenvalues of autocorrelation matrices.

At the *final stage*, analysis and evaluation of the operational processing of visual information were performed, the IMO of the multilevel GSM AOES was developed, and the experimental studies of the developed algorithms were conducted.

The developed set of theoretical provisions of the information theory of GSM AOES is of scientific importance in solving the problems of developing effective automated special-purpose (interdisciplinary, etc.) optical-electronic systems, providing processing of multidimensional visual information, and can significantly increase the efficiency of using the existing methods and means of detection, localization and image classification and, as a result, improve the quality (accuracy) of visual recognition and formation, ensure the confidentiality of information processing, as well as increase the safety and reliability of the assessment situations under intense information competition and continuously changing environment.

REFERENCES

1. Lovtsov D. A. Informatsionnaia teoriia ergasistem: Tezaurus. – M.: Nauka, 2005. – 248 pp. ISBN
5-02-033779-X.

2. Lovtsov D. A., Gavrilov D. A. Automated special purpose optical electronic system's functional diagnosis // Proceedings of International Seminar on Electron Devices Design and Production, SED-2019 (23 – 24 April 2019). – Prague, Czech Republic: IEEE, 2019. – Pp. 70 – 73. DOI: 10.1109/SED20198798409. – https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=8798409.

3. Gavrilov D. A. The computer system testing of algorithms for detection and localization of objects in video sequences. – Nauchnoe priborostroenie. – 2019. – V. 29. – № 1. – P. 21 – 28. – DOI: 10.18358/np-29-1-i149156

4. Gavrilov D.A. Quality assessment of objects detection and localization in a video stream // Vestnik MGTU im. N.E. Baumana, ser. "Priborostroenie". – 2019. – Vol. 125.– №2. – P. 40–55. – DOI: 10.18698/0236-3933-2019-2-40-55.

5. Gavrilov D.A., Pavlov A.V. Streaming hardware based implementation of SURF algorithm// Proc. Univ. Electronics. – 2018. – Vol. 23. –№5. – P. 502–511. DOI: 10.24151/1561-5405-2018-23-5-502-511

6. Gavrilov D.A., Melerzanov A. V., Shchelkunov N. N., Zakirov E. I. Use of Neural Network Based Deep Learning Techniques for the Diagnostics of Skin Diseases // Biomedical

Engineering. – 2019. – Vol.52. – № 5. – P. 348–352. DOI.org/10.26347/1607-2502201807-08045-054

7. Gavrilov D. A., Mestetskiy L. M., Semenov A. B. A Method for Aircraft Labeling in Remote Sensing Images Based on Continuous Morphological Models// Programming and Computer Software. – 2019. –Vol. 45. –N6. – P. 303–310. – DOI: 10.1134/S0132347419060025.

8. Gavrilov D.A., Pavlov A.V., Shchelkunov D.N. Digital imaging system with hardware implementation on XILINX PLD // "Journal of radio electronics" (Zhurnal radioelektroniki). – 2018. –№ 10. – DOI 10.30898/1684-1719.2018.10.6, http://jre.cplire.ru/jre/oct18/6/text.pdf.

9. Lovtsov D. A., Gavrilov D. A. An efficient automated electronic optical system for aerospace monitoring // Legal informatics. – 2019. – № 2. – C. 29 – 35. DOI 10.21681/1994-1404-2019-2-26-39

10. Lovtsov D. A., Gavrilov D. A. Modelirovanie optiko-elektronnykh sistem distantsionno pilotiruemykh apparatov: monografiia. M. :Tekhnolodzhi-3000, 2019. – 164 Pp. ISBN 978-5-94472-036-8.

Legal informatics

TASK OF IMPROVING TARGET INDICATORS OF UNIVERSITY ACTIVITY BASED ON CORRELATION - REGRESSION METHODS AND FACTOR ANALYSIS

Mikryukov A.A, Kuular A.V.
Institute of Digital Economics and Information Technology, Plekhanov Russian University of Economics
+7(916) 601-98-04, Mikrukov.aa@rea.ru

Abstract — The aim of the study is to develop scientifically based proposals to increase the university's performance indicators in the international institutional ranking QS to the required values, considering the presence of a combination of latent (hidden) factors. During the study, the following tasks were solved: identification of latent factors affecting the basic indicators of the university, assessing their significance and degree of influence on the basic indicators, as well as their grouping. Based on the results of the correlation - regression and factor analysis, measures are formulated to achieve the specified values of the QS University institutional rating indicators. It is shown that measures to achieve the specified indicators must be carried out considering the revealed correlation dependencies between factors and basic indicators, as well as the interpretation results of the developed factor model.

Keywords: correlation - regression analysis, factor analysis, basic indicators, institutional rating.

INTRODUCTION

By the Decree of the President of the Russian Federation of May 7, 2012 "On measures to implement state policy in the field of education and science", the Ministry of Education and Science launched the "Project 5-100", which is a state program to support the largest Russian universities [1]. The aim of the project is to increase the prestige of Russian higher education and the withdrawal of at least five universities from the number of project participants in the top 100 universities of three authoritative world rankings: Quacquarelli Symonds (QS), Times Higher Education (THE) and Academic Ranking of World Universities**.**

Currently, 25 Russian universities are included in the QS institutional rating [2,3]. In first place among Russian universities is Moscow State University. M.V. Lomonosov, who entered the top 100 of the institutional ranking in 84th position, in second place - Novosibirsk National Research State University (231st position), participating in the "Project 5-100", in third place -

St. Petersburg State University (234th position). The Higher School of Economics (HSE) as of 2020 occupies 322nd position, National Research Technological University "MISiS" - 451st position, Plekhanov Russian University of Economics - 776th position.

Over the past 5 years, Russian universities have shown significant dynamics in entering the top 500 institutional QS rating, having increased their representation by one and a half times (from 9 to 16), mainly thanks to the participants in the “Project 5-100”. This indicator is one of the main guidelines of the federal project "Young Professionals".

In view of the above, the management of REU them. G.V. Plekhanov was formulated the task to move in the world ranking of QS universities by 2025. to the position that MISiS takes today. To this end, an analysis of the possibilities and conditions for achieving a given position was carried out and, based on the developed models, the proposals on ensuring the fulfillment of the task were substantiated.

The task was solved in 3 stages. At the first stage, an analysis of the correlation of basic indicators that ensure the promotion of Plekhanov Russian University of Economics in the institutional ranking of QS World University Ranking: academic reputation, reputation with the employer, the ratio of the number of students to the number of scientific and pedagogical workers, citations for teachers, international teachers, international students.

These indicators are included in the university rating system and are presented in the QS - analytics information and analytical system, which annually updates information on all universities [2]. Based on the methods of correlation and regression analysis in the environment of the analytical platform Deductor 5.3, the coefficients of pairwise correlation of the values of the functional and basic indicators for the Plekhanov Russian University of Economics and MISiS. Based on the obtained values, an analysis of the correlation of indicators promoting the promotion of Plekhanov Russian University of Economics in the institutional ranking of QS World University Ranking. The results of the calculations made it possible to identify the tightness of the relationship between the basic indicators and rating functionality.

At the next stage of the study, hidden (latent) factors were identified that affect the basic indicators of university activity using factor analysis methods. Their significance and degree of influence on basic indicators, as well as their grouping, were assessed. The use of the mathematical apparatus of factor analysis made it possible to reduce the dimension of the problem being solved and to provide grouping and structuring of the obtained data. Interpretation of the results of factor analysis allowed us to identify latent factors that provide the main contribution to obtaining the result.

At the third stage of the study, justification of the set of measures to achieve the planned indicators to improve the institutional rating of QS University was completed.

Thus, an approach to solving the problem of providing conditions for achieving the required values of university performance indicators in the international institutional ranking QS using models developed based on statistical analysis methods is proposed.

PROBLEM STATEMENT

Correlation analysis of basic university performance indicators in accordance with the QS World University Ranking Institutional Rating. In the institutional ranking of the best universities in the world, QS World University Ranking, universities are evaluated by the value of the rating functional, calculated based on the following six basic indicators [4]:
- Academic reputation (AR), makes 40% of the contribution to the rating value;
- employer reputation (ER) - 10% contribution to the rating value;
- the ratio of the number of students to the number of scientific and pedagogical workers (RS/T), - 20% of the contribution to the rating value;
- citations to the teacher (CT) - 5% contribution to the rating value;
- international teachers (IT) - 20% of the contribution to the rating value;

- international students (IS) - 5% contribution to the rating value.

Each indicator has a weight equal to the degree of contribution to the value of the rating functional. The value of the rating functional R is calculated by the formula (1):

$$R = \sum_{i=1}^{6} w_i x_i, \quad (1)$$

where w_i is the weight of the corresponding indicator; x_i- its meaning.

The following initial data for the university for the period 2013 - 2019 were taken as a basis for calculations: rating functionality, basic indicators - academic reputation; employer reputation; the ratio of the number of students to the number of teachers; quoting to the teacher; international teachers; international students.

Based on the methods of correlation and regression analysis in the environment of the analytical platform Deductor 5.3 using the module "Correlation analysis", the coefficients of pairwise correlation of the values of the functional and basic indicators for the Plekhanov Russian University of Economics for MISiS (Table 1) using the Pearson criterion (allows us to assess the significance of differences between the actual and theoretical number of characteristics of the sample).

TABLE 1. CORRELATION MATRIX OF RATING FUNCTIONAL WITH BASIC INDICATORS USING THE PEARSON CRITERIA

Number in order	Basic indicators	Rating functionality of Plekhanov Russian University of Economics	Rating functionality of MISIS
1.	AR	0,152	0,854
2.	ER	0,726	0,607
3.	RS/SPW	0,939	0,511
4.	CP	0,141	0,883
5.	IT	0,182	0,494
6.	IS	0,604	0,667

Similarly, the coefficients of pairwise correlation between the basic indicators are calculated. In accordance with the Cheddock scale, the tightness of the correlation coefficients was estimated [5]. The calculations allowed us to draw the following conclusions.

A strong connection was found between the rating functional and the basic indicators: “The ratio of the number of students to the number of academic staff” (r = 0.939), “Reputation among employers” (r = 0.726) and “International students” (r = 0.604). The strength of the connection between the rating functional and other indicators is practically absent.

For the MISiS rating functionalities, the greatest tightness of communication was found for the basic indicators “Academic Reputation” (0.854) and “Citation for a Teacher” (0.883), the smallest - for the “International Teachers” indicator.

At the next stage of the study, the identification and interpretation of latent (latent factors) affecting the basic indicators using factor analysis methods, which is a class of multivariate statistical analysis procedures, aimed at identifying latent variables (factors) responsible for the presence of linear statistical relationships (correlations)) between the observed variables [5].

SOLUTION OF THE PROBLEM

1. Identification of latent factors and assessment of their significance based on factor analysis. Factors are groups of certain variables that correlate with each other more than with variables included in another factor. Thus, the meaningful meaning of factors can be revealed by studying the correlation matrix of the source data.

To assess the influence of latent factors on basic indicators, we used one of the most common methods of factor analysis - the principal component method, which allows you to reduce (reduce) a large number of related (dependent, correlating) variables, since a large number of variables significantly complicates the analysis and interpretation of the obtained results [6].

The mathematical model of factor analysis is a set of linear equations in which each observed variable xi is expressed as a linear combination of common factors $F_1, F_2, \ldots, F_n$ and a unique factor U_i [7]:

$$x_i = \sum_{k=o}^{n} a_{ik} F_k + U_i \tag{2}$$

where x_i is the variable, $i = 1, m$, (m is the number of variables); n is the number of factors; $n<m$, a_{ik} - factor load; F_k is the general factor, $k = 1, n$; U_i is a private factor.

The factor analysis procedure includes the following steps [8].

Stage 1. Construction of a correlation matrix of a system of variables by calculating the Pearson linear correlation coefficients.

Stage 2. Extraction of factors and calculation of factor loads a_{ik}, which are the main subject of interpretation. At this stage, methods of component analysis (the method of principal components), principal factors and maximum likelihood are used. In solving this problem, the most common method was used, which is the principal component method. It allowed us to isolate groups of closely correlating variables in a multidimensional space and replace them without loss of information content with the main components.

The mathematical model of the principal component method is represented by formula (3).

$$y_j = \sum_{i=1}^{k} \alpha_{ij} \, z_i \, , \tag{3}$$

where: y_j is the main component; α_{ij} is a coefficient reflecting the contribution of the variable z_i to the main component y_i; z_i is the standardized initial variable, $z_i = (x_i - \overline{x_i})/s_i$, s_i is the variance, $i = 1, k$.

The calculation of the principal components reduces to the calculation of the eigenvectors and eigen values ($\lambda_1, \lambda_2, \ldots, \lambda_k$) of the correlation matrix of the source data. The values of α_{ij} are factor loads. They are the correlation coefficients between the source variables and the main components. Factors include those variables for which $|\alpha_{ij}| > 0.7$.

To reduce the dimension of the space $Y = (y_1, y_2, \ldots, y_k)$ by cutting off non-informative variables, the Kaiser criterion associated with eigenvalues was used: the main components included variables that correspond to eigen values $\lambda_i > 1$, since their informative value is higher.

Stage 3. The rotation of the factor solution, which is used if the selected factors cannot be clearly interpreted.

To analyze and interpret the results obtained, the varimax method and the quartimax method are used [9]. Varimax is the method most often used in practice, the purpose of which is to minimize the number of variables that have high loads on the factor data (which helps to simplify the description of the factor by grouping around it only those variables that are associated with it more than others) cannot be used, since in the problem being solved the variables (basic indicators) cannot be reduced, since they are all significant. In view of the foregoing, the quartimax method is used to interpret the results of factor analysis - a method that ensures reduction (minimization) of the number of factors necessary to explain the variation of a variable.

The mathematical apparatus of factor analysis allowed us to solve two of the following problems:
1) a decrease in the dimension of the number of variables used due to their explanation by fewer factors;
2) grouping and structuring of the received data.

Based on the method of principal components, the eigenvalues of the factors are calculated, and a matrix of factor loads is constructed, which is the correlation coefficients between the initial variables (basic indicators) and the main components (factors). The eigenvalue of factor λ_i reflects its contribution to the variance of variables, explained by the influence of general factors. According to the Kaiser criterion, it is believed that those factors for which this indicator is less than 1.0 do not significantly contribute to the explanation of the result. The second calculated indicator is the percentage of the explained variance of the variables.

It is generally accepted that with a justified factorial decision, so many factors are chosen so that they together account for at least 70-75% of the variance. In some cases, this figure can reach 85-90%. The factor load matrix illustrates the strength of the relationship between the variable and the factor. The higher the factor load in absolute value, the higher the bond strength.

Thus, the main subject of interpretation of the results of the performed factor analysis was the extraction of significant factors and the calculation of factor loads.

The next step was the identification of latent factors affecting the baseline. The following factors are attributed to them: Availability of well-known scientific schools and dissertation councils; The presence of basic departments in enterprises; Level of qualification of the teachers; Number of teachers with language training, etc. 15 latent factors were revealed in total.

The calculations based on the principal component method were carried out in the environment of the analytical platform Deductor 5.3 using the “Factor Analysis” module. The analysis and interpretation of the results are based on the quartimax method [10].

The following calculation results were obtained: eigenvalues of factors of the mathematical model of factor analysis based on the principal component method; the volume of explained variance in% (contribution of each factor to the result) and the total percentage of variance (total contribution of factors to the final result). To increase the accuracy of the result, the interpretation considers factors 3.4, which have eigenvalues less than 1.

In the problem to be solved, the first 4 factors were found to be significant, providing the largest contribution to obtaining the result (99%). The contribution of the first factor is 61.91%; the second factor - 22.73%; the third factor - 9.75%, the fourth factor - 4.60%.

Based on the results of the identification of factors, a matrix of factor loads is constructed (Table 2). The factor correlation method used is the maximum of the cross-correlation function. The calculations were carried out for a significance level of 0.50, which allows considering a enough factors. The factorization of the matrix (the procedure for extracting factors) for various levels of significance was carried out. The higher the factor load in absolute value, the stronger the connection of the variable with the factor.

TABLE 2. FACTOR LOAD MATRIX

Variables (basic indicators)	Final factors (Quartimax method) Significance level: 0.50.			
	Factor 1	Factor 2	Factor 3	Factor 4
AR			0,8793	
RR	0,6390			0,5336
RS/T		0,9853		
CT	0,9690			
IT	0,9890			
IS	0,8496			

The following is an interpretation of the results of factor analysis. In accordance with the results of the identification of factors presented in table. 4, the most significant factors influencing the basic indicators are:

- Factor 1 (includes a set of private factors: the number of scientific research projects, the level of their qualifications and the presence of close collaboration (the number of joint research projects) with foreign universities and research organizations) affects the basic indicators of the RR, CT, IT, IS;
- Factor 2 (includes a set of private factors: the number of teachers, the level of teachers' payment) affects the basic indicator of the RS/T;
- Factor 3 (includes a combination of particular factors: the presence of well-known scientific schools and dissertation councils, the presence of close collaboration (the number of joint research projects) with foreign universities and research organizations, the number of scientific research projects, and their level of qualification) affects the basic indicator of AR;
- Factor 4 (includes a set of private factors: the level of training (competencies) of students, the demand for graduates from the employer, the presence of basic departments in enterprises) affects the basic indicator of ER.

Thus, the results of interpretation have shown that factors 1,2,3 have the greatest impact on basic indicators. Those. the task of increasing the values of basic indicators is directly related to the increase in particular indicators characterizing: the number of teachers and the level of their qualifications; The presence of close collaboration (the number of joint research projects) with foreign universities and research organizations; The level of training (competencies) of students, the demand for graduates from the employer, the presence of basic departments in enterprises, the presence of well-known scientific schools and dissertation councils.

2. Substantiation of measures to achieve planned indicators to increase the institutional rating of QS University. The results obtained made it possible to justify the totality of measures to increment the values of private indicators (factors) necessary to solve the problem of achieving university performance indicators by 2025, corresponding to the level of MISiS indicators in 2019.

The correlation dependencies between the functional and the basic indicators are obtained. The presence of a strong relationship of the functional with the indicators: "The ratio of the number of students to the number of teachers" ($r = 0.952$), "Reputation with employers" ($r = 0.854$) and "International students" ($r = 0.636$) was revealed. The strength of the connection of the functional with other basic indicators is insignificant.

The largest contribution (98.9%) to obtaining the final result (the value of the rating functional and its corresponding place in the QS rating) is made by the following private indicators: The number of teachers and the level of their qualifications; The presence of close collaboration (the number of joint research projects) with foreign universities and research organizations; The level of training (competencies) of students, the demand for graduates from the employer, the presence of basic departments in enterprises, the presence of well-known scientific schools and dissertation councils.

Measures to increase the values of indicators should be carried out considering the obtained correlation dependencies of the most significant factors affecting the basic indicators.

CONCLUSION

During the study, the following results were obtained:

- estimates of the relationship between indicators and university rankings based on the methods of correlation and regression analysis;
- a comparative analysis of the results obtained at the universities of the reference group;

- the problem of identifying factors that influence the change in the values of basic indicators is solved, the degree of this influence is assessed;
- based on the interpretation of the results of factor analysis, a totality of factors has been identified that have a significant impact on basic indicators;
- well-founded proposals have been worked out to achieve the required values of basic indicators and rating functionality of the university;
- an approach to solving the problem of providing conditions for achieving the required values of university performance indicators in the international institutional ranking QS using models developed based on statistical analysis methods is proposed.

The results obtained during the study made it possible to justify the feasibility of carrying out the measures necessary to solve the problem of achieving the specified performance indicators of the university.

ACKNOWLEDGMEN

This work was supported by RFBR (grants №№ 18-07-00918A, 19-07-01137, 20-07-00926).

REFERENCES

1. Decree of the President of the Russian Federation of May 7, 2012 "On measures to implement state policy in the field of education and science." [Electronic resource] Access mode: https://base.garant.ru/70170946/ (accessed date 20. 01.2020).

2. Information and analytical system QS - analytics [Electronic resource] Access mode: https://analytics.qs.com (accessed date 20. 01.2020).

3. The project to increase the competitiveness of leading Russian universities among the world's leading scientific and educational centers. [Electronic resource] Access mode: https://www.5top100.ru/ (accessed date 20. 01.2020).

4. Ratings of world universities [Electronic resource] Access mode: https://www.5top100.ru/ (accessed date 20. 01.2020).

5. Draper, N Applied regression analysis / N. Draper. - M.: Williams I.D., 2019.- 912p.

6. Fomina E. E. Factor analysis and categorical method of the main components: a comparative analysis and practical application for processing the results of the survey. Humanitarian Bulletin. 2017, no. 10. http://dx.doi.org/10.18698/2306-8477-2017-10-473.

7. Seagal, E. Practical business statistics. - M.: publishing house "Williams", 2002. - 1056 p.

8. Godin, A.M. Statistics: textbook. M. Publishing and Trading Corporation "Dashkov and Co.", 2002. - 368 p.

9. Bureeva N.N. Multivariate statistical analysis using the STATISTICA IFR. Nizhny Novgorod, Novosibirsk State University N.I. Lobachevsky, 2007, 112 p.

10. Jolliffe I.T. Principal Component Analysis, Series: Springer Series in Statistics, 2nd ed., Springer, NY, 2002, XXIX, 487 p. 28 illus. ISBN 978-0-387-95442-4.

HARDWARE IMPLEMENTATION OF SCALING IN RESIDUE NUMBER SYSTEM IN APPLICATION TO CONVOLUTIONAL NEURAL NETWORKS

Telpukhov D.V., Solovyev R.A., Mkrtchan I.A.
IPPM RAS

Abstract — The paper describes scaling method in residue number system (RNS) and its prospects of use in convolutional neural networks. The benefits of RNS for hardware implementation are high-speed parallel calculations, fault-tolerant designs, better fault correction, etc. One of the main disadvantages is complexity of implementing the so-called non-modular operations, in particular, scaling operation. The comparison of two scaling implementations shows the superiority of the new method over the trivial one.

Keywords: scaling; residue number system; convolutional neural network.

INTRODUCTION

Convolutional neural networks (CNN) are good at processing photo, audio and video data, which makes them usable for large variety of tasks. However, the dimension of data and computational complexity are enormously high. It leads to the use of GPU for better performance, which is rather expensive. The demand for hardware to work with neural networks is growing every year. That's why the necessity in development of special blocks for VLSI and FPGA occurs.

One of the ways to improve the CNN efficiency is by using the residue number system, but this approach leads to some difficulties [1].

COMPLEXITIES OF IMPLEMENTATION

Residue number system is a numeral system based on modular arithmetic. It's defined by a set of integers $(m_1, m_2, \dots, m_n)$ and $M = \prod_{i=1}^{n} m_i$. The advantages of using it for hardware implementation, as opposed to positional numeral system, are high-speed parallel calculations, fault-tolerant designs, better fault correction and etc. One of the main problems is complexity of realization of some operations, such as division, square rooting, comparison and scaling. The amount of such operations must be minimized or reduced to zero. But, in case of the CNN considered in this paper, all of them can't be replaced by addition, subtraction and multiplication. That leads to the main problem - finding optimal and efficient methods of implementing such operations.

One of the main problems of CNN is the growth of data dimension. To avoid this, scaling should be performed after each layer. Considering this operations' complexity, the problem of its realization occurs.

SCALING OPERATION

In order to solve this issue, the method of base extension [2] is combined with the method of scaling by random factor K, which is coprime with all moduli [3]. In both cases, lookup table (LUT) implementations are used.

When considering the first method, it can be concluded, that value $|X|_{m_{n+1}} = x_{n+1}$ for any moduli m_{n+1} can be calculated as (1)

$$x_{n+1} = |X_E - eM|_{m_{n+1}} = \left| M^{(p)}T + \sum_{i=1}^{p} b_i - eM \right|_{m_{n+1}} \quad (1)$$

where:

$M^{(p)} = \prod_{j=1}^{p} m_j$, $\quad 1 \le p < n$, $\quad M_i = \frac{M}{m_i}$, $\quad a_{i,p} = \left\lfloor \frac{M_i \left|\frac{x_i}{M_i}\right|_{m_i}}{M^{(p)}} \right\rfloor$, $\quad e = \{0,1\}$, $\quad b_i = \frac{M^{(p)}}{m_i} \left| \frac{M}{M^{(p)}} \left|\frac{x_i}{M_i}\right|_{m_i} \right|_{m_i}$, $T = \left|\sum_{i=1}^{n} a_{i,p}\right|_{\frac{M}{M^{(p)}}}$

In case when condition (2) is met $e = 1$.

$$\begin{cases} T \geq \dfrac{M}{M^{(p)}} - p + 1 \\ |X_E|_M \leq (p-1)M^{(p)} - M^{(p)} \displaystyle\sum_{i=1}^{p} \frac{1}{m_i} \end{cases} \quad (2)$$

At this stage only T and X_E can't be precomputed. Values of $a_{i,p}$, b_i and T multiplied by $M^{(p)}$ are calculated and placed in LUT when the Verilog-description of the scheme is generated.

In the next step, the second method is used. The result of scaling is $Y = \left\lfloor \frac{X}{K} \right\rfloor$, which in modular form looks like formula below (3).

$$y_i = |Y|_{m_i} = \left| \frac{X - |X|_K}{K} \right|_{m_i} = \left| |x_i - |X|_K|_{m_i} \cdot |K^{-1}|_{m_i} \right|_{m_i} \quad (3)$$

If K is coprime with all moduli, then $|K^{-1}|_{m_i}$ always exists and can be precomputed. To fulfill this condition, $K = 2^N$, where N - natural number. Making the factor power of two also makes scaling easier. In this case K also is m_{n+1}, which is the new moduli of the extended base. It means $|X|_K$ is already obtained with the first method. All y_i values can be precomputed and placed in LUT at the generation step.

It is clear, that all complex operations in RNS were reduced to addition and subtraction in a small arithmetic unit.

COMPARISON WITH THE TRIVIAL METHOD

This implementation was compared with the trivial scaling method in order to determine if a new approach has any advantages. For this purpose, the device based on reverse converter (from positional system to RNS) and forward converter (from RNS to positional system) was developed. Scaling was performed by right logical shift.

In the first test (Fig.1), small dimension prime moduli were used. Their number increased each iteration. Factor $K = 2^8$ remained unchanged.

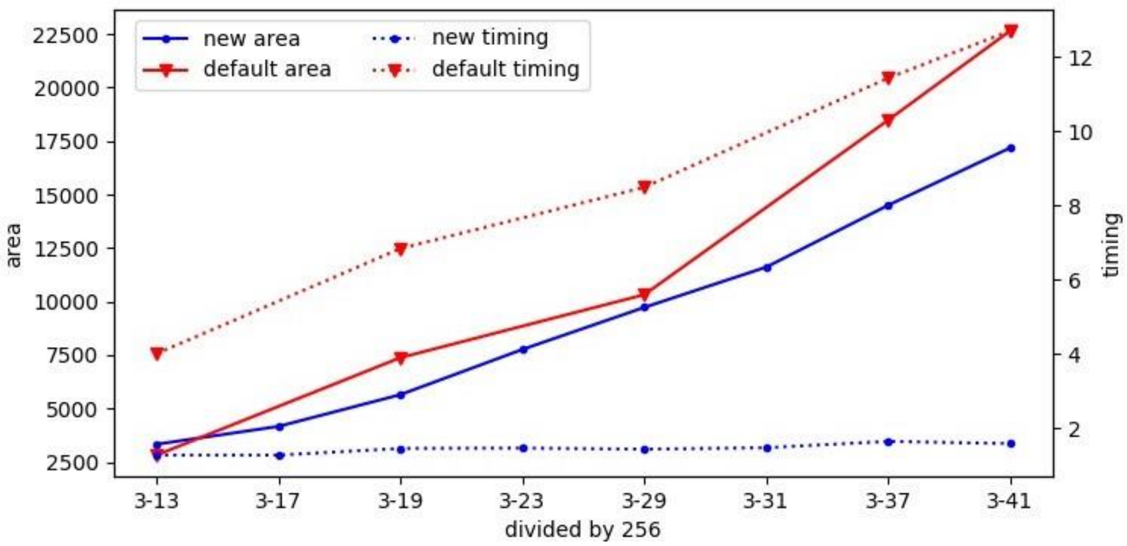


Fig. 1 First test results

In the second test (Fig. 2), a set of moduli (3, 5, 7, 11, 13, 17, 19, 23) was chosen. $K = 2^N, 5 \leq N \leq 12$.

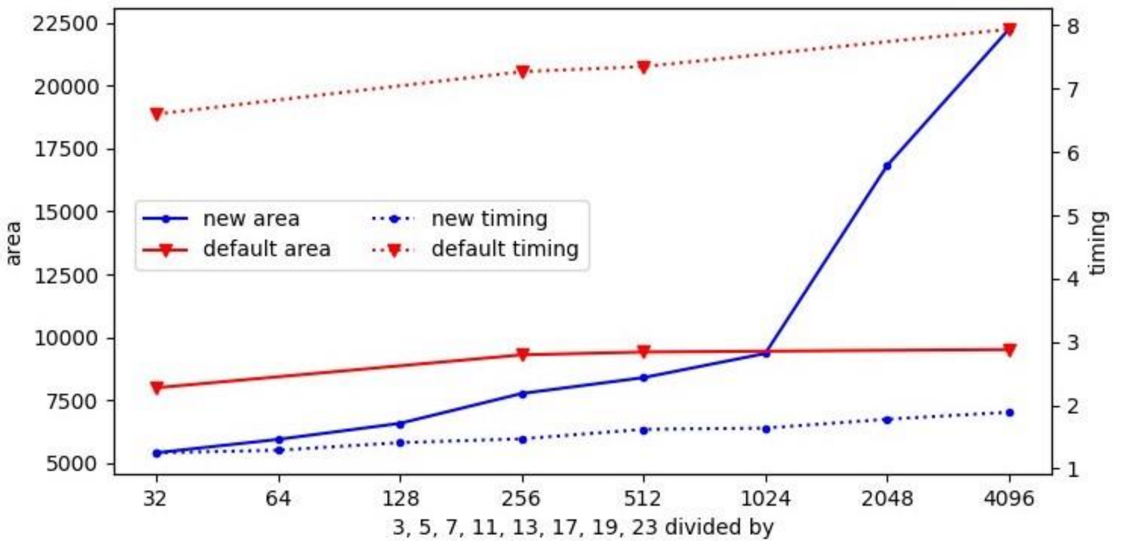


Fig. 2 Second test results

In the third test (Fig. 3), high dimension prime moduli were used. Their number increased each iteration. Factor $K = 2^8$ remained unchanged.

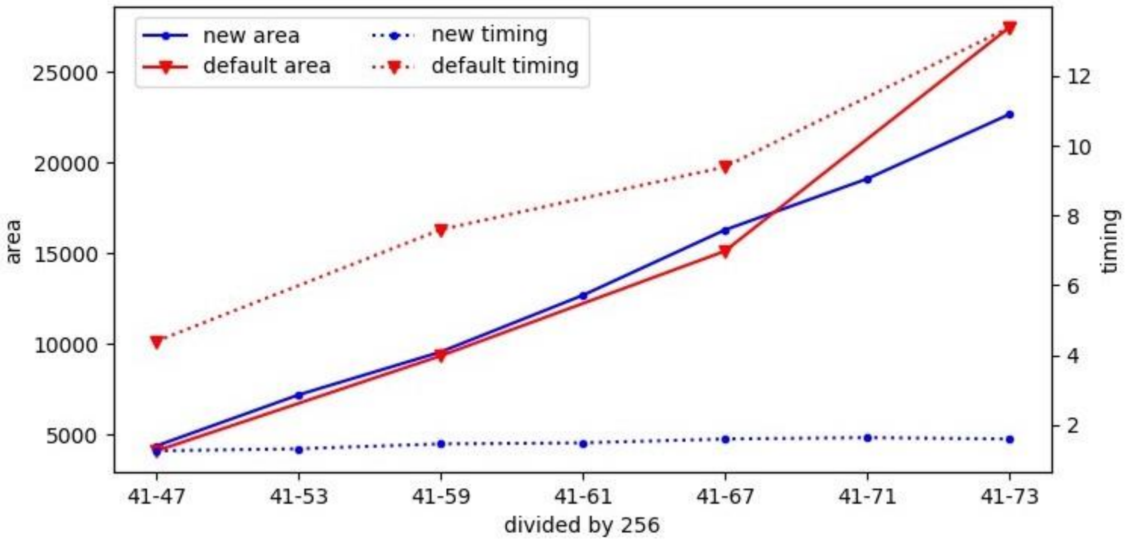


Fig. 3 Third test results

In the fourth test (Fig. 4), a set of moduli (41, 43, 47, 53, 59) was chosen. $K = 2^N$, $5 \leq N \leq 12$.

In the fifth test (Table 1) 3 sets of moduli with roughly the same range M were chosen: (3, 5, 7, 11, 13, 17, 19, 23, 29), (71, 73, 79, 83, 89), (233, 239, 241, 251). $K = 2^N$, $8 \leq N \leq 10$.

TABLE 1. FIFTH TEST RESULTS

Area New	Area Default	Timing New	Timing Default	Modules	K
9731	10326	1.44	8.49	3 - 29	256
11213	10871	1.56	8.56		512
11940	10998	1.61	8.64		1024
12795	10482	1.51	8.4	71 - 89	256
15534	14054	1.65	8.9		512
17468	11443	1.7	9.13		1024

17280	6615	1.42	6.45	233 - 251	256
19705	7353	1.62	6.41		512
22102	9407	1.69	6.94		1024

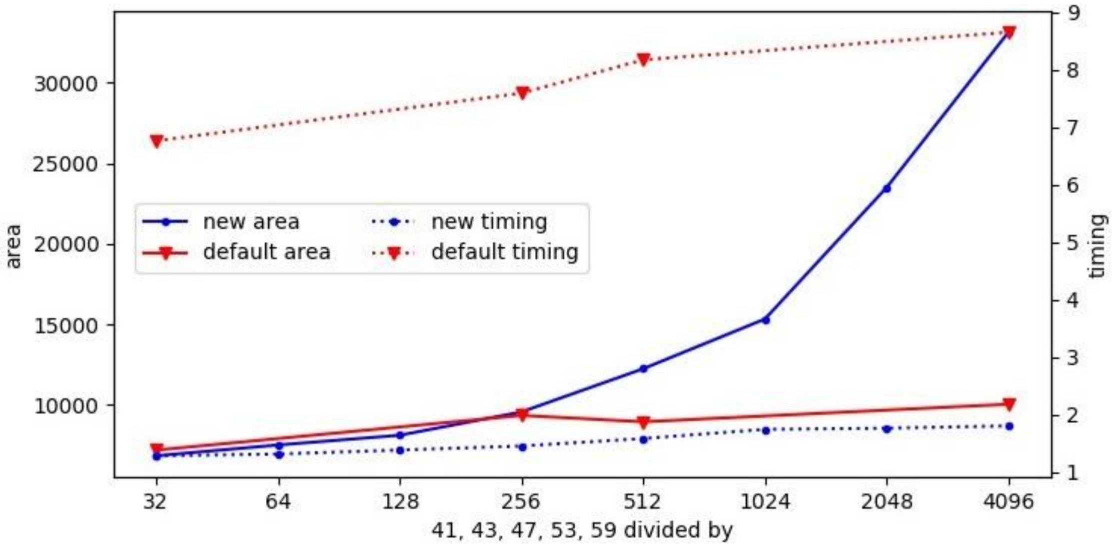


Fig. 4 Fourth test results

CONCLUSION

Based on the test results, we can come to the following conclusions: new method always provides time gain in more than 3 times, it takes less area on the chip in case of using small dimension moduli in addition to small factor K.

Due to fast performance and, under certain conditions, low required area, it is clear, that this realization can be used in designs which need to perform fast calculations with low energy consumption. If no additional problems will be met during the research of the hardware implementation of CNN in RNS, then this method will be used for scaling.

REFERENCES

1. R.A. Solovyev, D.V. Telpukhov, A.G. Kustov, T.U. Isaeva, A.A. Volkov, “Primenenie metodov modulyarnoi arifmetiki pri razrabotke apparatnykh realizatsii neironnykh setei”, Informatsionnye tekhnologii, Vol. 25, № 12, 2019, pp. 747–756.

2. F. Barsi, M.C. Pinotti, “Fast base extension and precise scaling in RNS for look-up table implementations”, IEEE Transactions on Signal Processing, Vol. 43, № 10, October 1995, pp. 2427–2430.

3. Y. Kong, B. Phillips, “Fast Scaling in the Residue Number System”, IEEE Transactions on Very Large Scale Integration (VLSI) Systems, Vol. 17, № 3, March 2009, pp. 443–447.

ESTIMATION OF THE COSTS OF HIDDEN FAILURES IN SYSTEMS WITH BIT-MODULAR ORGANIZATION

Kurbanmagomedov K. D.
Institute of system technologies, Makhachkala, Russia
kurbandin@mail.ru

The article provides an analysis of various approaches to estimating the costs of occurrence and detection of hidden failures that occur in digital systems with a bit-module organization. Based on this analysis, we propose a classification of hidden failures and conclusions about the duration and frequency of checks of these systems.

Keywords: failure, scheme, reliability, cost period, verification, control, diagnostics, model, process.

Relevance.Justification for improving the reliability of analysis of complex technical systems should be carried out in the following areas:

- influence on the accuracy of the analysis status at the expense of improvement of indicators of reliability;
- reduction of cost indicators;
- increase the probability of failure-free operation;
- reduction of risks to the safe operation and ignore the error;
- using adaptive monitoring and diagnostics, selecting blocks and parameters for monitoring and diagnostics during periodic monitoring, and selecting the frequency and duration of monitoring and diagnostics procedures;
- making a decision on the object analysis strategy and selecting the monitoring and diagnostics methodology.

It should be emphasized that these tasks are interrelated and it is important to consistently select significant and less significant tasks and reliability indicators.

In addition, it is necessary to take into account or take into account the features of functioning, the structural organization of the analyzed object, depending on this, to adopt the appropriate model for analyzing the state.

In the end, the study and analysis of factors and indicators will allow us to reduce the risk of operating a truly faulty object and thus avoid accidents and catastrophes.

In connection with the above, it is important to analyze various indicators of the quality of functioning and operation of monitoring and diagnostics objects, assess their interconnectedness, and develop recommendations for their selection according to certain initial requirements for the analyzed object. This is especially true if there is a tolerance for the operation of an object with hidden failures, which introduces some uncertainty in the information about its state, which implies the presence of risks of failures and, consequently, improper functioning. First of all, we should pay attention to the cost indicators[1], which from our point of view are the most priority when solving different classes of tasks and are interrelated and mutually affecting with other indicators of the quality of functioning and operation of objects.

Problem statement. In this paper, the following tasks are proposed in connection with the above:

- determining the dependence of cost indicators on the reliability of the object;
- assessment of the dependence of the damage of hidden failures and the possibility of reducing this damage by selecting the optimal values of reliability indicators;
- assessment of cost indicators and their interdependence both at the production stage and at the operational stage.

The methodology for ensuring the required reliability indicators at the design stage is primarily based on what indicators need to be provided at the stage of production and operation of the object. In particular, it is related to the availability factor, continuous operation time, and downtime by the following dependency

$$C=C_oK_p/K_o=C_o(T_{p.o.}(T+T_p))/T_p(T_o+T_{po}),$$

where K_g - coefficient of readiness, $K_p=1-K_g$ is the coefficient of downtime, T-the mean time between failure, T_p is the average idle time, Tp and K_{po}-, respectively, the average idle time and idle factor, T_p and K_p - similar to values for the object with high reliability[1].

These indicators are most often used in the design process. In this case, the probability of normal functioning of P(t) is determined by the formula $P_{n.f.}(t)=K_g P(t)$, where P(t) is the probability of failure – free operation during t.

Operating costs can be presented

$$C_e=C_o+C_p+C_r,$$

where C_o-the cost of maintenance, C_p-the cost of maintenance, C_r-the cost of repair.

$$C_r=nC_{ri},$$

where C_{ri} is the average cost of repairs, including the cost of replacement part, replacement cost, storage cost spare parts and cost of the damage caused by the failure.

The cost per unit of downtime is equal to

$C_p=C_r/T_p$ and the number of failures is $n=t/(T+T_p)$.

Let's write an expression for the total cost of reliability design, maintenance, and repair of C_Σ object. It is equal to

$$C_\Sigma= C_0(K_{po} / K_p)+C_1+C_2+C_p t K_p$$

The cost of maintaining a serviceable system is determined by the formula

$$C_1=t_{obsl} N C_{1o},$$

where t_{obsl} is the average service time of the object, N is the number of serviced blocks, and C_{1o} is the cost of servicing one block.

Denote by N' - the average number of serviced blocks at time t. With C_{20} - the cost of preventive work with one block we get

$$C_2=t_{prer} N'_t C_{go}$$

Then

$$C_\Sigma= C_0(K_{po} / K_p)+t_{prer}*N_\tau' C_{go}+ t_{obh} N*C_{10}+C_p*t*K_p.$$

If $N=N_t$ and $C_{20}=C_{1o}$are equal, we have

$$C_\Sigma= C_0(K_{po} / K_o)+C_{obs}*N(t_{obs}+t_{prer})+ C_p*t*K_p.$$

If the cost of maintenance and prevention of all blocks are equal, we get it if the equipment is idle when performing these works

$$C_\Sigma= C_0(K_{po} / K_p)+C_{obs}*N*(2T_p)+ C_p*t*K_p.$$

When $n=t/(T+T_p)$ – the number of failures

$$C_\Sigma= C_0\left(\frac{K_{p0}}{K_p}\right)+C_{obh}*\frac{T}{T+T_p} * 2T_p+ C_p*t*K_p.= C_0\frac{T_{po}(T+T_p)}{T_p(T_o+T_{po})} + C_{obh}\frac{T}{T+T_p}\ 2T_p+ C_p t K_p.$$

In the absence of modernization of the object during operation or in the absence of additional measures to improve reliability, we have $K_{p0} / K_p=1$. Then

$$C_\Sigma= C_0+ C_{obs}\frac{2T}{T+T_p}T_п. + C_p t K_p.$$

Let's find an expression for calculating the optimal value of C_Σ depending on the T_p

$$\frac{\partial C}{\partial T_p} = \frac{\partial}{\partial T_p}\left(C_{obs}*\frac{T}{T+T_p} * 2T_p\right)+ \frac{\partial}{\partial T_p}(C_p t K_p). =2C_oT(1+T)/(T+T^2_p)+C_p t(T+ T_p)/(T+ T^2_p).$$

Equate this expression to zero

$$2C_oT(1+T)/(T+T^2_p)+C_p * t(T+ T_p)/(T+ T^2_p)=0.$$

Now we get equality

$$C_p=(2C_oT(1+T)/(T+T^2_p))/t(T+ T_p)/(T+ T^2_p).$$

It is known that the optimal verification period is determined by the formula [1]

$$(T_{k+}\tau_k+T+\frac{C_k}{2C_п}\lambda T_в)e^{-\lambda T k}=T-\frac{C_k}{2C_п}$$

How can you determine the relationship between the monitoring period or duration and the cost of monitoring and equipment down time

$$T_к=[T(2\ \tau_k +\frac{C_k}{C_п})]^{1/2}$$

We are interested in dependence

$$C_p=C_к T/(T_к^2-2\ \tau_k T)$$

The dependence of the operating cost on the detection of hidden failures is also of interest. Let C_1 be the cost of each check, C_2 be the cost of staying in a faulty state[3].Then the cost between checks is equal to[2]

$$\int_{k}^{k+1}\{[(\mathrm{k}+1)\mathrm{C}_1+\mathrm{C}_2(\mathrm{t}_{k+1}-\tau)]\}dF(t),$$

where F(t) is the time distribution before the fault occurs. You can record the expected value for the entire service time

$$\mathrm{M}[C(f)]=\sum_{k=0}^{\infty}\int_{1}^{t+\tau}\{[(k+1)\mathrm{C}_1+\mathrm{C}_2(\mathrm{t}_{k+1}-\tau)]\}dF(\tau).$$

Using this expression, you can minimize losses by finding the extremum of this expression

$$\frac{\partial \mathrm{M[C(t)]}}{d\mathrm{t}}=0.$$

Then

$$\frac{\partial}{\partial \mathrm{tk}}\left\{\left\{\int_{\mathrm{tk}-1}^{t}(\mathrm{~C1k}+\mathrm{C2}(\mathrm{tk}+\tau)\right\}d\mathrm{F}(\tau)+\int_{\mathrm{tk}}^{\mathrm{tk}+1}\{(\mathrm{C}_1(\mathrm{k}+1)+\mathrm{C}_2(\mathrm{t}_{k+1}-\tau)\}\}dF(\tau)=0$$

From there we get:

$$\mathrm{t}_{k+1}-\mathrm{t}_k=\frac{F(\mathrm{tk})-F(\mathrm{tk}+1)}{f(\mathrm{tk})}-\frac{\mathrm{C1}}{C_2}$$

We'll find it from here:

$$\mathrm{C}_2=\mathrm{C}_1/(\mathrm{t}_k-\mathrm{t}_{k+1}+\frac{F(\kappa)-F(\kappa+1)}{f(\mathrm{tk})})$$

For F={1-exp(-λt)}we get

$$\mathrm{C}_2=\mathrm{C}_1/\ (\mathrm{t}_r-\mathrm{t}_{k-1}+\ \frac{1-e^{-\lambda\mathrm{tk}}-(1-e^{-\lambda\mathrm{tk}})}{\lambda\ e^{-\lambda\mathrm{tk}}})=\mathrm{C}_1/\ (\mathrm{t}_k-\mathrm{t}_{k-1}+\frac{e^{-\lambda\mathrm{tk}}+e^{-\lambda\mathrm{tk}-1}}{\lambda\ e^{-\lambda\mathrm{tk}}}).$$

Thus, it is determined based on value indicators, such characteristics as the coefficient of readiness, coefficient of downtime, duration of downtime and normal functioning, period control, the duration control. In addition, the dependencies of the cost of skipping hidden failures on the duration of the control, the failure rate, and the time distribution function between failures are determined.

In the future, it is of interest to study the proposed models and use the results of these studies when choosing the optimal ratio between the initial reliability indicators and the required ones, choosing the optimal values for the period and duration of checks, obtaining specific data on the cost of skipping hidden failures and the necessary measures to eliminate them. The latter factor may affect the fact that the methodology for ensuring reliability will change at all due to the fact that the specified hardware and software modeling and calculation methods cannot provide the specified reliability. As a result, backup, duplication, or other methods may be applied.

This analysis is one of the approaches to justify the need for diagnostic modeling of systems with a bit-modular organization in real time to ensure the required reliability indicators.

It should also be noted that due to the complexity of modern technical systems and the developed material base for creating modeling systems, this approach can be implemented taking into account the reduction in the cost indicators of the created technical systems.

REFERENCES

1. Kulakov N. N., Zagoruiko S. S. Methods for evaluating the reliability of technical products based on technical and economic indicators.-Novosibirsk, Publishing House.- in "science", Siberian branch, 1969.-142p.
2. Shishonok N. A., Repkin V. F., Barvinsky L. L. Fundamentals of the theory of reliability and operation of electronic equipment. -Moscow: Publishing house "Soviet radio", 1964.-250 p.
3. Volkov L. I. Management of aircraft operation. - Moscow: Publishing house "Higher school", 1981. – 368 p.

THE CONCEPT OF ASSESSING THE TECHNICAL CONDITION OF PIPELINE SYSTEMS WITH LAYERED CRACKS

Mutaev M. A.
Institute of system technologies, Makhachkala, Russia
kurbandin@mail.ru

The article proposes an approach to the analysis of pipeline systems using model-based variational problems with movable boundaries. The solution of a problem of operative diagnostics of pipelines with the use of hardware and software systems, allowing removal of maximum information about the object to reduce entropy.

Keywords: pipeline, model, diagram, entropy, algorithm, task, decision, condition, system, crack, defect, bundle.

A feature of the process of changes of reliability oil and gas equipment of dangerous industrial objects, is the gradual nature of the failure [1]:

- influence of physical design changes not only on the physico-chemical parameters, but also on the types of emerging defects;
- strong influence of the modes of the objects on the level of reliability of oil and gas production;
- wide range of external parameters and factors affecting the state of the object, including the temperature regime of the external environment, cyclical loads, change the static and dynamic loads in operation and maintenance;
- a causal link between the defects and the possibility of avalanche occurrence during operation and testing;
- the extension type and the number of defects as a result of poorly performing various production operations and maintenance of equipment;
- the difficulty of monitoring object condition and great material costs required for this related to the unavailability of a facility for direct contact with him relying equipment and personnel to changes or suspension of the operation modes;
- high damage of pipelines and equipment operating at present;
- the need for rapid assessment of prodelav strength operated pipelines[1].

A feature of the development and appearance of new defects in an avalanche is associated with the so-called layered cracks[2], which are characterized by:

the difficulty of identification as in the production and exploitation of oil and gas equipment;

- the gradual nature of development associated with the nature of dynamic loads, may lead to sudden failure and destruction of the material[2];
- the complexity of mathematical modelling in the early design stages and the weak correlation between the nature of development of cracks with the original data;
- a large transition probability of defects of different type in the layered defects, for example, the stratification in different parts of the pipeline can be considered as layered defects, the defects not the quality of the weld can be considered along with defects of the type "internal inclusions of foreign particles" as layered defects.

STATEMENT OF THE PROBLEM

In connection with the above relevant is:

- development and choice of methods and means of control and diagnostics of objects in oil and gas equipment defect-type layered cracks;

- development of models to study objects with layered defects;
- development of algorithms of diagnostics of objects with layered defects;
- choice of NDT method for detecting defects, such as cracks and layered methods of interpretation of the measurement results for later evaluation of the ultimate strength of the object the localization of the defect.

Thus, in this case is a complex task that requires not only adequate mathematical modeling, but also bringing in modern software and hardware, use of operating experience this type of objects and secure object due to the choice of the optimal modes of monitoring objects.

THE METHOD OF SOLUTION

In the implementation assumes sequential execution of the following procedures:

theoretical calculations of the strength of the object in the presence and absence of the selected class of defect;

- processing of calculation results and their presentation and seeing the format convenient for further use;
- calculation of the frequencies of the object, given static and dynamic loads;
- perform strength calculations to reflect changes in operating conditions, loads during the tests, changing temperature regimes and possible emergency situations;
- development of hardware and software modules storing, processing and comparing benchmark results and operational data with the subsequent formation of conclusion about the state of equipment and the development of defects.

THE MODEL OF THE DEFECT

As a model of the defect we consider the problem of calculus of variations with moving ends [3]. It is assumed in the form of functionals to consider the results of solving problems of strength calculation.

Let them have the specified curves y_1=f(x) and y_2= f(x). Recording the functional

$$V(y)=\int_{x_0}^{x_1} F(x, y, y^1)\, dx$$

Assume that the points A(x_0, y_0) andB$(x_1 y_1)$ there are defined on smooth the curves of the line.

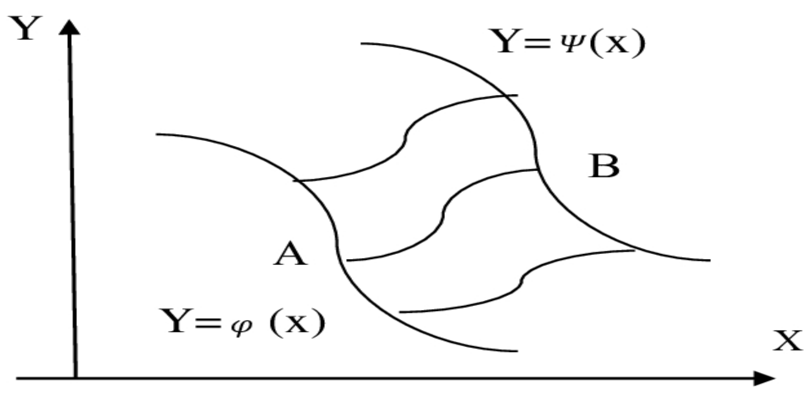


Fig. 1 The representation of smooth curves, corresponding to the cracks

When you search for extremum of the functional

$$V(y)=V(y)=\int_{x_0}^{x_1} F(x, y, y^1)\, dx < \lambda$$

among all curves connecting two arbitrary currents curves φ(x)andΨ(x)and should be done conditions transversality

$$[F+(\varphi^1\text{-}y^1)[Fy^1]_{x=0} = 0$$
$$[F+(\Psi\text{-}y^1)Fy^1]_{x=x_1} = 0$$

In the General case for evaluating the development of cracks it is necessary to make and solve $y = \int f\,(x, y, y^1)$,, to obtain the curves corresponding to the extremals of the field, to verify compliance with the conditions of transversality for the equation

$$f(x_0, c_1, c_2) = \varphi(x_{0)}) \text{ and } \Psi(x_1, c_1, c_2) = \Psi(x_1)$$

of which are determined by permanent c_1 and c_2 and abciss $x_{0,}x_1$,points A and Bb and then calculate the extremum of the functional

$$V(y) = \int_{x_0}^{x_1} f\,(x_{1,}y, y^1)dx|3|.$$

PROCESS MODEL MONITORING DIAGNOSIS

This realizes the following flow chart (Fig. 2.):

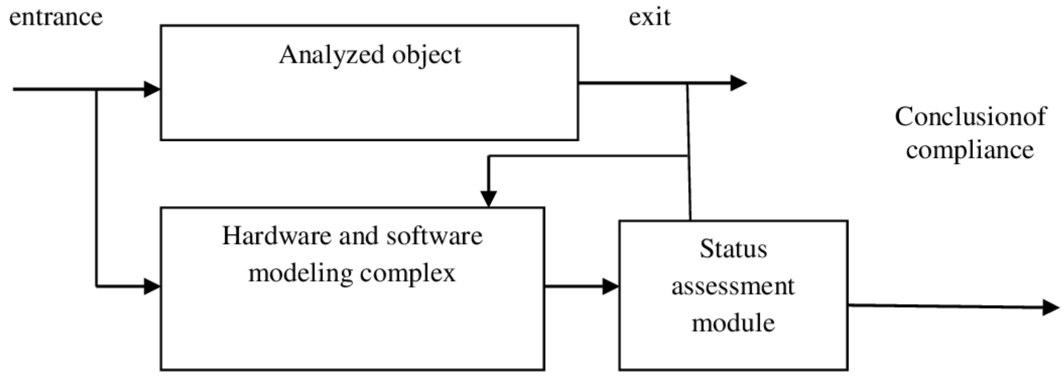


Fig. 2 Diagram of the diagnosis process

Functions of the modeling system are as follows:

- storing the calculated reference values;
- accumulation of information about the source data (changes in the static and dynamic loads, changing environment);
- storage of information about possible defects and in this reactions;
- comparison of the monitoring results of an object with reference values.

INFORMATION MODEL

Modeling system is a tool collection and synthesis of additional information about the state of the analyzed object. Estimating the uncertainty in the analyzed object through entropy Hao(t), and the entropy of the object, based on the received information indicating through H^*ao(t), we can write the inequality H^*ao(t)<<Hao(t). This inequality in each moment of time is determined by the effectiveness of the implementation of the modeling system, which is estimated as a difference of entropies e= Hao(t)- H^*ao(t). As a model in this system can represent a redundant system of receiving reliable information.

When ξ– time operation of the system when calculating the entropy of the analyzed object can be used

$$P\{\xi>t\}=e^{-\alpha t} \text{ and } P\{\xi>t\}=e^{-\mu t},$$

which denote respectively the laws of distribution of time of obtaining reliable information and the distribution of recovery time. The accuracy of the information, corresponding to the true state of the controlled object can be assessed

$$D(t)= Poo(t)/(Poo(t)+Pon(t)),$$

wherePoo(t) is the probability of receiving reliable information from the modeling unit, and Pon(t)–

the probability of obtaining false information about the presence of defects[4].

THE ALGORITHM OF FUNCTIONING OF THE SYSTEM

The process of functioning of the system is oriented in accordance with the algorithm of functioning to maintain the reliability of the object at the desired level. This should take place between

$$P\{\xi>t\}=e^{-\alpha t} \text{ and } P\{\xi>t\}=e^{-\mu t}$$

If $P\{\xi>t\}=e^{-}\alpha t$ is small, the more operations you need to perform complex modeling to synthesize information on the status of the object.

CONCLUSION

The implementation of this approach based on an adapted modeling of the object and a more complete and adequate outbound and synthesized information about the object analysis system modeling.

REFERENCES

1. Yu. V. Lisin, N. .Makhutov N., D. A. Neganov, V. M. Warsocki. A comprehensive analysis of strength of pipelines and basic mechanical properties of pipe systems// Science and technology of pipeline transportation and petroleum products. 2017. No. 1. p. 30-38.

2. Zakharov M. N., Lukyanov V. A. the Strength of vessels and pipelines with the defects of the walls of the oil and gas industries. –M: the unitary enterprise Publishing house "oil and gas" Gubkin Russian state University of oil and gas named I. M. Gubkin, 2000-2016c.

3. Vanko V. I., Ermoshina O. V., Kuvyrkin G. N. Calculus of variations optimal control: Proc. For universities – M: Izd-vo MGTU im. N. Uh.Palmanova 2001. -488c.

4. Sherbakov N. With. The reliability of digital devices. –M: Mashinostroenie, 1989. 224c.

COEFFICIENT OF DIFFERENTIAL THERMOPOWER OF SINGLE LAYER CARBON NANOSTRUCTURES IN THE STRONG ELECTRIC FIELD

Sudorgin, S.A., Lebedev, N.G.*,
Volgograd State Agricultural University , *Volgograd State University
+7(917)725-27-33, sergsud@mail.ru

This work is dedicated to calculation of the dependence of differential thermoelectric power of single-walled carbon nanostructures from the intensity of strong electric field analytically obtained and analyzed numerically.

Keywords: Anderson model, carbon nanostuctures, differential thermopower, single layer nanotubes

INTRODUCTION

The minimization of heat losses and the precise control of the heat transfer and now is one of the most important incentives in the creation and improvement of modern integrated circuits, senor and other micro and nanoelectronic devices. Particularly, a whole class of nanoelectronic components based on carbon nanoparticles is distinguished: monolayer and multilayer graphene and nanotubes. A large number of scientific publications [1] suggests that a change in contact temperature due to the thermoelectric effect in nanoelectronic devices can reach 30%. Paper includes the results of a study of the thermoelectric characteristics of carbon nanoparticles. The character of the dependence of the differential thermoelectric powers of various types of carbon nanostructures in an external strong constant electric field is investigated.

PROBLEM STATEMENT

This article discusses the dependences of the coefficient of differential thermoEMF of single-walled carbon nanotubes in a strong external constant electric field. The methodology for determining and numerically analyzing the transport and conductive coefficients of carbon nanostructures is based on solving the semiclassical Boltzmann equation by the operator method [2] using relaxation time. The obtained model using for the electrical and diffusion properties of single-walled carbon nanotubes, monolayer graphene nanoribbons, with defects, adsorbed atoms, vacancies, and dislocations of adsorbed monovalent atoms [3 - 5].

The differential thermo-emf coefficient is a value that determines the rate of change of the potential difference due to the temperature gradient with temperature. The difference in electron potentials at the ends of the nanostructures leads to an increase in the drift of charge carriers from the warmer end of the nanotube to the colder one. An excess of charge carriers at the cooled end of the tube and a small amount at the hot end causes the appearance of a thermoelectromotive force. Publications of the studying of thermoelectric phenomena in single walled nanotubes [1, 6–8]. The nature of the conductive properties in carbon nanostructures has a similar electronic transport character, for example, in metals near an electronic topological transition. The basis of theoretical studies of electrical conductivity and thermoelectric properties, has long been used the Mott formula [9].

This well-known formula is the fundamental for the analysis of a large number of experimental data. It is necessary to clarify that the application of this formula is not always correct, due to the fact that a number of situations have been discovered in which the dependence of the thermoelectric power is very different from that shown by the Mott formula [9]. One of the main disadvantages of this formula is the dependence of the relaxation time of conduction electrons on their energy.

SOLUTION OF THIS PROBLEM

The energy of conduction electrons does not significantly depend on the absolute temperature in metal structures; therefore, various metals have a much lower thermoelectric power value than semiconductor structures. Great attention to the study of the thermoelectric and diffusion properties of low-dimensional carbon nanostructures is caused by the possibility of using the strong external electric field to control the electric transport properties of nanoparticles to achieve a significant change. A similar situation is observed with other transport characteristics: the coefficient of electrical conductivity and diffusion of electrons. The developed method makes it possible to determine the differential thermoelectric power not only for fields with low intensity, when $eEb\tau / \hbar T \leq 1$, where b is the distance between adjacent carbon atoms in the grapheme, τ is the relaxation time, T is the absolute temperature.

Given the condition that the concentration of conduction electrons is a constant in the linear approximation of the absolute temperature gradient, an analytical formula is obtained for the differential thermoEMF of carbon nanostructures in an external strong electric field:

$$S(E)=\sum_s\int_{-\pi}^{\pi}\frac{\partial f}{\partial T}\sum_m A_{ms}m\sum_{m'}A_{m's}m'\left\{\frac{E^2(m^2+m'^2)+1}{K(E,m,m')}*\right.$$
$$*\left[EmR(E,m,m',p_x)+M(E,m,m',p_x)\right]+$$
$$+\frac{E^3\left(m'^3-2m^2m'\right)+Em'}{K(E,m,m')}T(E,m,m',p_x)\}dp_x+ \tag{1}$$
$$+\frac{1}{\sum_s\int_{-\pi}^{\pi}fdp_x}\sum_{s'}\int_{-\pi}^{\pi}f\sum_{s''}\int_{-\pi}^{\pi}\frac{\partial f}{\partial T}\sum_m A_{ms}m\sum_{m'}A_{m's}m'\frac{1}{P(E,m,m')}F(E,m,m',p_{x'},p_{x''})dp_{x'}dp_{x''}$$

The following notation is used below:

$$K(E,m,m')=\left[E^4(m^4+m'^4-2m^2m'^2)+2E^2(m^2+m'^2)+1\right]\left[E^2m^2+1\right]$$
$$P(E,m,m')=\left[E^2m^2+1\right]^2\left[E^2m'^2+1\right]$$
$$R(m,m',p_x)=\cos(mp_x)\sin(m'p_x)+\cos(mp_x)\cos(m'p_x)-\sin(mp_x)\sin(m'p_x)$$
$$M(m,m',p_x)=\sin(mp_x)\sin(m'p_x)+\sin(mp_x)\cos(m'p_x)+\cos(mp_x)\sin(m'p_x)$$
$$T(E,m,m',p_x)=\left[\cos(mp_x)\cos(m'p_x)-Em\sin(mp_x)\cos(m'p_x)\right]$$
$$F(E,m,m',p_x)=\left[\sin(m'p_x)+Em\cos(m'p_x)\right]*$$
$$*\left[\sin(mp_x)+2Em\cos(mp_x)-E^2m^2\sin(mp_x)\right]$$

$$A_{ms}=\pm\frac{\gamma}{\pi}\int_{-\pi}^{\pi}\sqrt{1+4\cos(ap_x)\cos(\frac{\pi s}{n})+4\cos^2(\frac{\pi s}{n})}\cos(\frac{mp_xb}{\hbar})dp_x \tag{2}$$

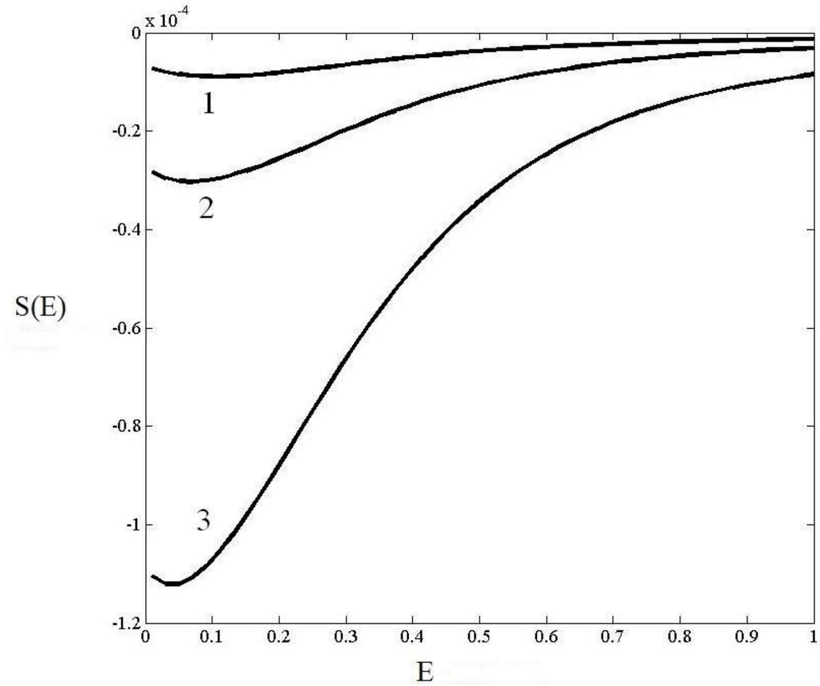


Fig. 1 Dependences of the differential thermoEMF S (E) on the amplitude of the external electric field for various CNTs: 1 - for CNTs of the type (5,0); 2 - for CNT type (10.0); 3 - for CNT type (20,0)

The dependence of the coefficient of differential thermoelectromotive force on the intensity of the external constant electric field for carbon nanotubes of the zigzag type. Dimensionless units are used in this article for the convenience of visualization and numerical analysis. The relative unit of differential thermoEMF along the Y axis is 3.1 V / K. The experimentally obtained values of differential thermoEMF for single-walled nanostructures are usually 200 - 260 μV / K [10] at room temperature T = 300 K. A slight difference between the results of numerical calculations of thermoEMF according to formula (1) recorded experimentally is caused by the fact that the use of the semiclassical method contains a number of approximations: they take into account the electron-phonon interaction, the influence of an external magnetic field, the presence of edge effects, etc. are not considered. A number of publications have shown that the electron-phonon interaction in various types of carbon nanoparticles is insignificant.

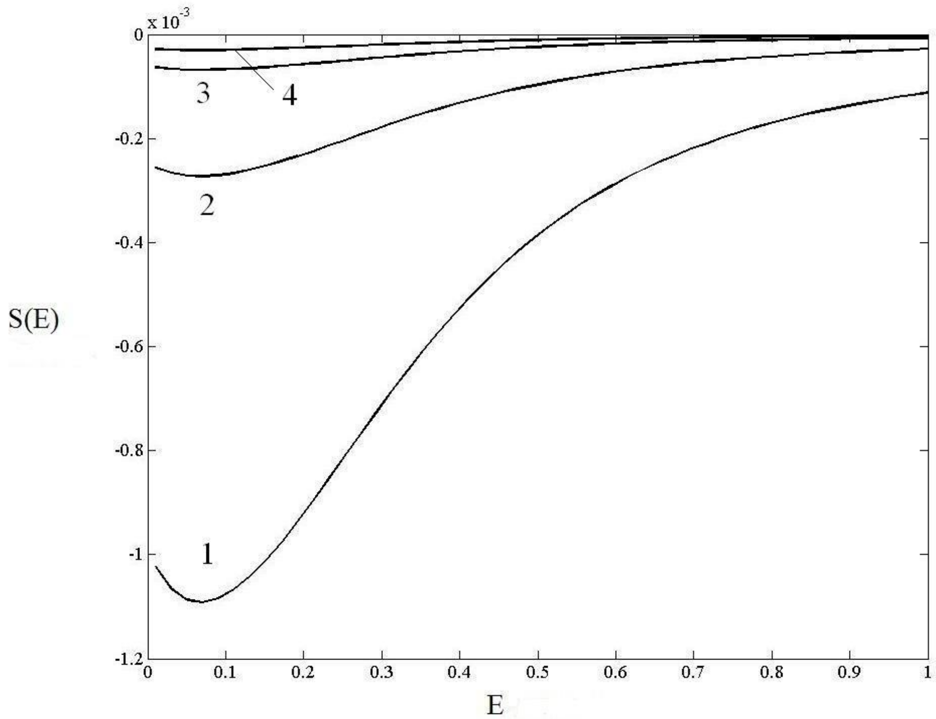


Fig. 1 Dependence of the differential thermoelectric power S (E) on the amplitude of the external electric field E for a CNT of the (10,0) type at different temperatures: 1 - for T = 50 K; 2 - for T = 100 K; 3 - for T = 200 K; 4 for T = 300 K

Based on numerical analysis, it was found that the differential thermo power of nanostructures substantially nonlinearly depends on the strength of the external constant electric field. With increasing amplitude of the electric field, the differential thermo power first increases in value, and then decreases and tends to a constant value. A similar dependence of thermo power on the external field strength is observed for various types of carbon nanotubes: (5.0), (10.0), and (20.0). At T = 310 K for carbon nanotubes (5.0) of the type for the maximum value of the differential thermo power, it is recorded at a field strength E of 5.06 • 105 V / m, and it is 26.4 μV / K for carbon nanotubes (10, 0) type, when E 3.12 • 105 V / m is 97.6 μV / K for type carbon nanotube (20.0) at E 1.94 • 105 V / m - 347.2 μV / K, which is in qualitative agreement with data known from the experiment [10]. The sign of the differential thermoelectromotive force is determined by the type of charge carriers. The charge carriers in carbon nanostructures are conduction electrons, differential thermal electromotive force has negative values. At an external electric field E > 1.1 • 107 V / m, the values of single-walled nanotubes of thermoelectric power tend to constant value.

The results of the studies performed can be used to obtain carbon nanostructures with specified electrical transport characteristics, which is important for the development of microelectronic devices, as well as sensors based on carbon nanostructures.

CONCLUSION

Summarize the results and draw conclusions:

1. The analytical formula is obtained for the differential thermoelectric power coefficient of single-walled carbon nanotubes without defects in the approximation of relaxation time in an external constant electric field.

2. Coefficient of thermoelectric power of various types of single-layer nanostructures without impurities has negative character because that the current carriers in low-dimensional carbon nanoparticles are negative charged electrons.

3. 3. Non-monotonic dependence of electron conductivity and differential thermoelectric power on force the strength of the high external constant electric field was found, and in a strong field the differential thermoelectric power tends to the saturation.

4. As the diameter of nanotubes grows, the coefficient of differential thermoelectric power increases, which is explained by an increase in the number of quantum levels conduction electrons.

ACKNOWLEDGMEN

This scientific work supported by the RFBR (project № 19-42-343001).

REFERENCES

1. A.A. Varlamov, A.V. Kavokin, I.A. Lukyanchuk, S.G. Sharapov, UFN, 182 (2012), 1229-1234.
2. L.D. Landau, E.M. Lifshitz, Physical Kinetics. Fizmatlit, Moscow 2002, ISBN 5-9221-0125-0.
3. M.B. Belonenko, N.G. Lebedev, S.A. Sudorgin, Solid State Physics, 53 (2011), 1841-1844.
4. M.B. Belonenko, N.G. Lebedev, S.A. Sudorgin, Technical Physics, 82 (2012), 129-133.
5. S.A. Sudorgin, M.B. Belonenko, N.G. Lebedev, Physica Scripta, 87 (2013), 015602.
6. J. Small, L. Shi, P. Kim, Sol. State. Comm., 127 (2003), 181-186.
7. J. Small, K. Perez, P. Kim, Phys. Rev. Lett., 91 (2003), 256801.
8. V.E. Egorushkin, N.V. Melnikova, N.G. Bobenko, A.N. Ponomarev, Nanosystems: physics, chemistry, mathematics, 4 (2013), 622-629.
9. N.F. Mott, H. Jones, The theory of the properties of metals and alloys. Clarendon Press, Oxford 1936.
10. J. Small, P. Kim, Microscale thermophysical engineering, 8 (2004), 1-5.

DIRECTIONS FOR USE BIG DATA TECHNOLOGY IN ASSESSING THE EFFECTIVENESS QMS

Grodzensky Ya.S., Fursov S.A.
RTU – MIREA
serfursv@gmail.com

Abstract – The article presents the result of using the approach Map Reduce for processing the processes obtained during operation QMS. To implement the Map Reduce approach an algorithm for processing data obtained during testing was developed. To process the data obtained during functioning of the QMS processes in particular during testing, a program was developed in the Python programming language. The software allows to record test data in a file that is transmitted for subsequent processing and presentation in a user-friendly form.

Keywords: automation, QMS, quality control, quality management, python, big data, map reduce, effectiveness.

INTRODUCTION

Determining the effectiveness of the QMS of manufacturing enterprises is not only a normative requirement of GOST ISO 9001, but also a necessary necessity. The main function of assessing the effectiveness of the QMS is to analyze the organization's achievement of goals and determine the necessary resources for this. Performance assessment results can be used in risk assessment in a risk-based approach.

RESEARCH RESULT

It is also important that performance evaluation allows timely information on processes and quick corrective actions. Evaluation of the effectiveness of the QMS should be built using automated systems and software. [1]

One of the problematic issues is the choice of the QMS effectiveness methodology, since currently there are several methods.

The main indicators in assessing the effectiveness of the QMS can be called:

- the results of achieving the set goals (tasks);
- assessment of the effectiveness of individual QMS processes;
- based on the analysis and evaluation of work in certain areas;
- assessment of QMS compliance with standards;
- assessment of the analysis of the work of individual structural units;
- assessment of the functioning of separately allocated facilities;
- score rating;
- index rationing of an assessment of productivity (MINOR);
- based on the results of the auditor (internal and external). [2]

It should be noted that in most cases, a mathematical apparatus is used in evaluating performance. This raises the question of using software when performing QMS performance calculations. To determine the effectiveness, you can use any of the above methods.

Data collection remains a problematic issue, since in most cases paper-based information carriers are used at enterprises. The solution to this problem is the introduction of CALS - technologies, which significantly reduces the time of receipt, processing and analysis of information, and also makes it possible to use the information received in the information environment of the whole enterprise, rather than a single structural unit.[3]

Data collection can be carried out using software tools that are built into workstations and mobile devices.

The Python programming language allows you to develop small, easy-to-use scripts, as well as build mathematical models for subsequent mathematical analysis [4].

```
main_protocol_auto_en.py ×
main_protocol_auto_en.py > ...
print('Entering test results')
#Determine the length of the sample
print('Enter the number of products to test')
sample_len = int(input())
#Create empty list
samples = list()
for i in range(sample_len):
    sample = input("Enter the result product measurement " + str(i+1) + ": ")
    samples.append("Product " + str(i+1)+ ": " + sample + "\n")
#Opening and writing to a file - sample_file = open('/Volumes/doc/CODE/file.rtf','a', encoding='utf-8')
with open('/Volumes/doc/CODE/file.rtf','a', encoding='utf-8') as file:
    for sample in samples:
        file.write(sample)
file.close()
#Reading from a file
print('Show test results?')
x = str(input())
if (x == 'Yes'):
    sample_read = open('/Volumes/doc/CODE/file.rtf','r', encoding='utf-8')
    print(*sample_read)
else:
    print('Stop')
```

Fig. 1 Writing measurement results to a text file in .rtf format (electronic protocol)

The received information is recorded using software tools developed in the Python programming language into files convenient for handling and processing, we chose the .rtf format. Advantages of the .rtf format - wide support by various software tools and ease of processing. The ability to read information from a regular text file allows the use of information at any level of PDM systems.

It is also possible to record any documented information in format files:

- JSON;
- .csv;
- .docx;
- .xlsx.

In addition to the above formats, it is possible to use SQL databases by converting the resulting files using the Python programming language. This will greatly facilitate the processing of information and the subsequent analysis of the effectiveness of the QMS.

After receiving the information, it is subject to processing, taking into account the form in which it is presented. The processing sequence is shown in Figure 2.

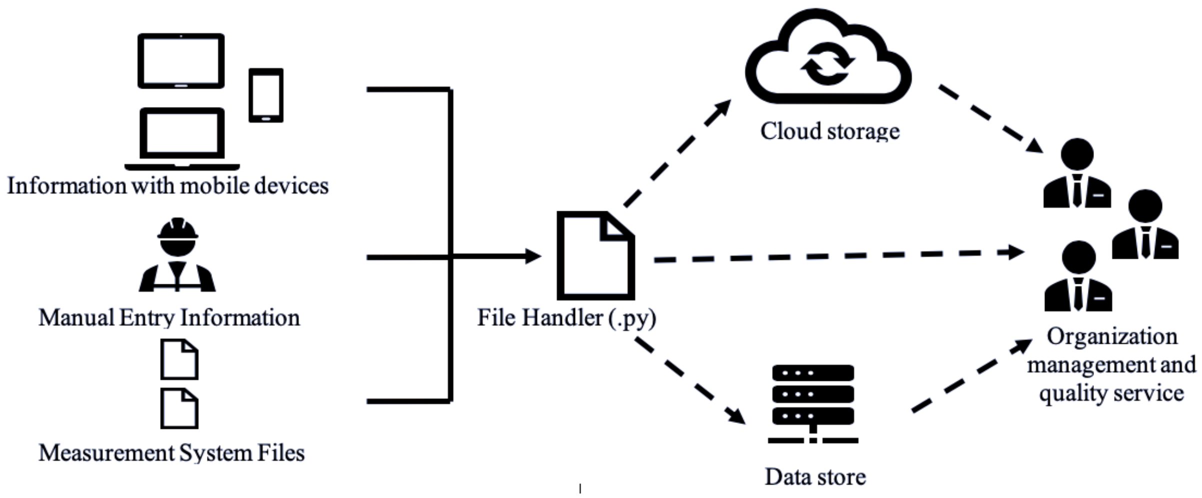


Fig. 2 Distribution of automated data in the digital environment of the enterprise

For data processing, the Map Reduce approach can be used. [5, 6] An algorithm for processing data obtained from documented information is presented in Figure 3.

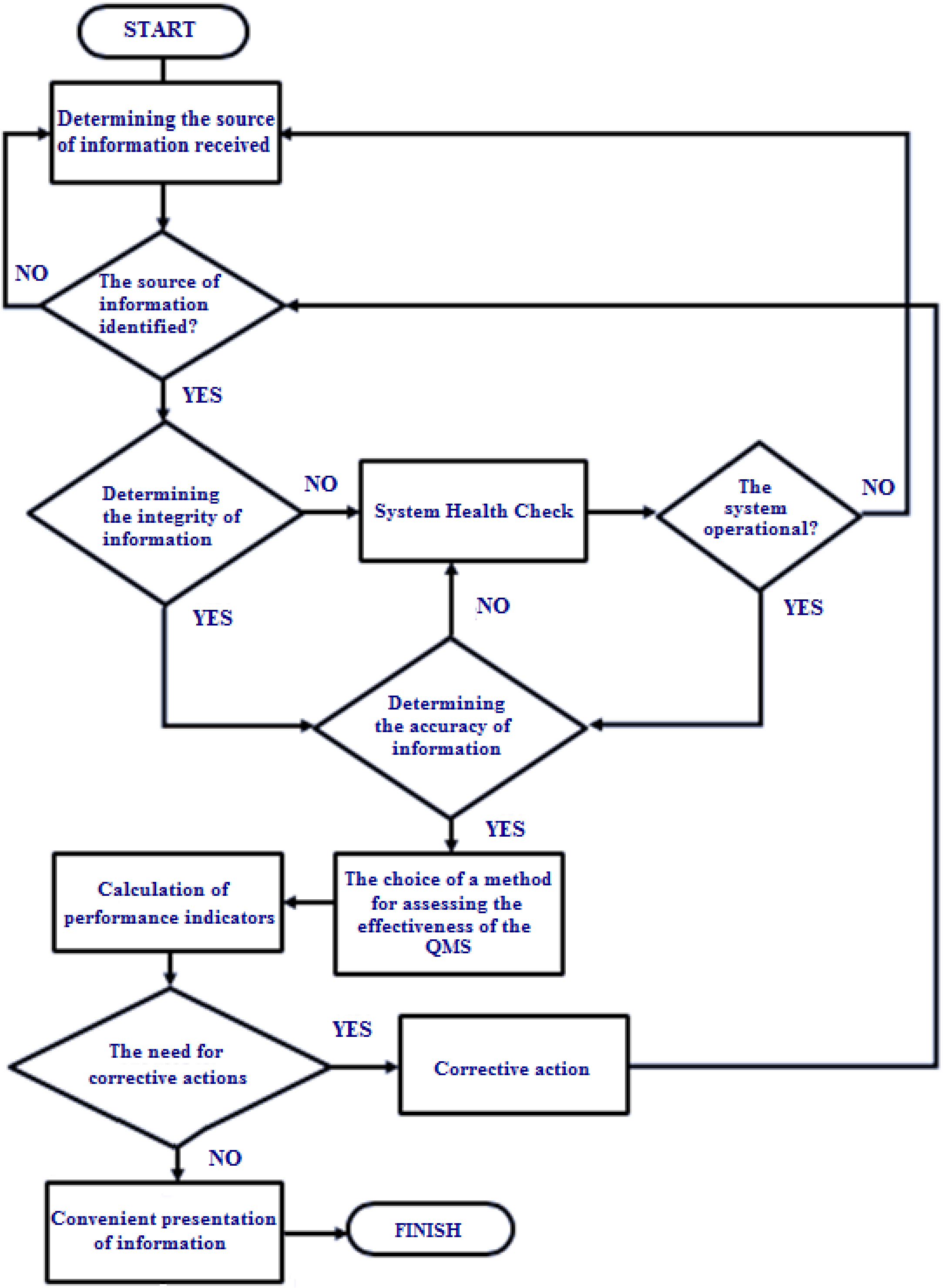


Fig. 3 Algorithm for processing data of documented information QMS by model Map Reduce

To create a software tool for data processing, the Python programming language was used with the connection of the following libraries:

1. NumPy;
2. SciPy;
3. Pandas;
4. Mathplotlib, Seaborn, Bokeh, Ploty – for data visualisation.

Using the above libraries is a simple set of modules and functions that significantly simplify the process of creating software in the Python programming language [7].

The implemented software tool is easily integrated into the digital environment of the enterprise and allows you to process large data and implements the possibility of using Big Data technology. Distributed storage and processing allows you to process unstructured information and turn it into a "digital double" model. In the future, the “digital double” can be implemented in a real model and the organization’s management, together with the quality service, can further predict the functioning of the QMS. A similar approach to assessing the functioning of the QMS can significantly save labor costs of individual units [8].

To determine the effectiveness of the QMS according to the MapReduce model on the Big Data analysis, a calculation was selected by the weighted average assessment of the level indicators (P_j) according to the following formula:

$$\mathrm{P}_j = \frac{\sum_{i=1}^{n} S_i * \beta_i}{\sum_{i=1}^{n} \beta_i} \tag{1}$$

где, S_i- the value of the i-th indicators of the second level;

β_i – coefficient of significance of the i-th indicator.

Based on the results of a weighted average assessment of indicators of the first level, the effectiveness of the QMS can be determined, the higher the value (up to 1), the higher the effectiveness. As a rule, the range of values for evaluating the effectiveness of the QMS of an enterprise is 0,6<$P_{\text{СМК}}$≤0,95 [9].

Using software tools for processing information allows you to quickly obtain data on the performance of individual QMS processes and process it in a convenient form for presentation.

CONCLUSION

Using software tools, in particular BigData, to automate the assessment of the effectiveness of the QMS allows you to get a full-fledged analytical platform, integrated into the enterprise’s information environment. The main advantage of the Python programming language when creating scripts for processing documented information and presenting it in a user-friendly form is the small file size and ease of creating software tools and their subsequent refinement. Further application of BigData in the QMS of the enterprise will automate the management of documented information, as well as carry out an operational and continuous assessment of the functioning of processes built using "paperless technologies." It should be noted that the choice of a performance evaluation method depends on the specifics of the enterprise and should be established in the standardization documents in force at the enterprise.

REFERENCES

1. Afanasyev V. B., Medvedev V. M., Ostapenko S. N., Palikhov G. V., Mamaev V. A. PRODUCT QUALITY MANAGEMENT AT OPK ENTERPRISES USING INNOVATIVE TECHNOLOGIES // Izvestiya TulGU. Technical science. 2019. №12;
2. Grigoryan E.S., Yashin N.S. Methodological approaches to assessing the effectiveness of the quality management system // Bulletin of the Saratov State Socio-Economic University. 2018. No1 (70);
3. Sergeev, A.G. Metrology, standardization and certification: Textbook for undergraduate / A.G. Sergeev, V.V. Terraces. - M .: Yurayt, Publishing House Yurait, 2013 .-- 838 p .;

4. Kirdyaev M.M. An overview of the Python programming language for solving mathematical modeling problems // Nika. 2016. No. URL: https://cyberleninka.ru/article/n/obzor-yazyka-programmirovaniya-python-dlya-resheniya-zadach-matematicheskogo-modelirovaniya (accessed: 02/01/2020);

5. Arkhipova E.S. ROLE OF PROCESSING "BIG DATA" IN MANAGEMENT OF A MODERN ENTERPRISE // Ogaryov-Online. 2019.No.7 (128). URL: https://cyberleninka.ru/article/n/rol-obrabotki-bolshih-dannyh-v-upravlenii-sovremennym-predpriyatiem (accessed 02.02.2020);

6. Laboshin L.Yu., Lukashin A.A., Zaborovsky V.S. The use of MapReduce technology to control access to information resources in corporate networks // Scientific and Technical Journal of St. Petersburg State Polytechnic University. Informatics, telecommunications and management. 2015. No. 2-3 (217-222);

7. Python library packages [Electronic resource]. URL: https://pypi.org/ (accessed: 01/12/2020);

8. Grodzensky S.Ya. Quality management: study guide 2nd edition - M .: Prospect, 2018 - 311 p;

9. Fursov S.A., Kirov A.V. The main approaches to automating the performance assessment of the QMS of an enterprise - a manufacturer of electronic equipment // Materials of the International scientific and technical conference // INTERMATIC - 2017. - Part 5. - P. 1326-1329.

UDK 52.20

GENERALIZED METHOD OF INVERSE PROBLEMS IN SOLVING THE PROBLEM OF CONTROL OF MOBILE SYSTEMS

V. P. Kharkov
"Experimental workshop "Nauchsoft", Moscow

The article describes an approach to the synthesis of control laws for dynamic systems based on the concept of inverse dynamics problems. It is shown that this approach is applicable for control synthesis not only for linear systems, but also for nonlinear systems whose behavior in the state space is described by ordinary differential equations. For example, the synthesis of control of an automatic traction machine WITH a two-shaft engine is given.

Keyword. Optimal control, inverse problems of dynamics, dynamic systems, synthesis of control laws, quality functional.

The widespread use of aircraft and helicopters in solving important national economic tasks such as the delivery of oversized cargo, construction, agricultural work, exploration of mineral deposits, and medical care of the population required aviation to implement new space-time trajectories. These are primarily high-precision flight speed control, in-flight refueling, takeoff and landing on restricted runways, swarming flights of a group of aircraft (LA), and other equally complex flight modes. The complexity of the implementation of these trajectories is due not only to the high requirements for the accuracy of their execution, but also to the need for integrated use of aerodynamic, energy and information resources of the aircraft. The practical implementation of integrated trajectory control tasks is not possible without the use of automatic control.

Among the variety of methods and algorithms for automatic control, a special place is occupied by optimal control systems that correspond to the accepted quality functionality. It is known that the synthesis of optimal control for nonlinear objects and arbitrary quality functional is associated with solving a rather time-consuming problem, namely, solving the boundary value problem of the optimal control theory. It is not possible to get its solutions in real time without additional restrictions. Since mid70-ies of the last century, rapidly began to develop the method of inverse dynamics problems [1], [2] to simplify the solution of problems of control synthesis, and since 80-ies on the basis of the concept of inverse dynamics problems [3], [4] possibility of solving practically all problems of synthesis of control of mobile objects.

Analysis of the above tasks shows that the implementation of any of the above trajectory tasks involves the simultaneous operation of several functional subsystems, for example, stabilization of the angular position, flight speed control, power plant control, etc.in modern conditions, one of the main concepts of improving the aircraft is to ensure fuel efficiency. Along with technological approaches and constructive solutions to improve this indicator, automatic flight control systems also have a wide range of possibilities. Stimulation of the development of aircraft and power plant control systems is caused not only by ensuring minimum fuel consumption, but also by increasing the requirements for the accuracy of maintaining the specified parameters of the flight path, reducing the dynamic resource consumption.

In General, the control of the «LA-power plant» system in the flight speed control mode is a complex process due to the fact that the object model in the state space is determined by a system of nonlinear differential equations, and the quality functional is not fully formalized. It should be noted that this contour is the basic one for almost all control contours.

The article deals with the synthesis of optimal control of the «LA-power plant» system in the mode of flight speed control - automatic thrust control, based on the concept of inverse problems of dynamics.

PROBLEM STATEMENT

For the system (1), you need to find a control that provides a minimum of functionality (2)

$$\dot{V}(t) = g(n_x - \sin\theta),$$

$$\dot{\theta}(t) = \frac{g}{V}(n_y - \cos\theta),$$

$$\dot{H}(t) = V\sin\theta,$$

$$\dot{\bar{n}}_k(t) = a_0 n_1(t),$$

$$\dot{n}_1(t) = a_1 n_1(t) + a_2(\bar{n}_3(t) - \bar{n}_k(t)) + a_3(\bar{n}_3(t) - \bar{n}_k(t))^2,$$

$$\dot{\bar{n}}_b(t) = \varphi_b B_{pr}\bar{n}_k + a_4\bar{n}_b(t) + a_5,$$

$$\dot{G}_T(t) = (a_6 + a_7(\bar{n}_3(t) - \bar{n}_k(t))^k)\cdot G_{TUST}(t) - a_6 G_T(t), \tag{1}$$

$$\varphi_k = b_4 + b_5\frac{P_b^{*j}}{P_{NO}}\sqrt{\frac{T_{NO}}{T_b^{*j}}};$$

$$\bar{n}_{Vz} = (b_{30} + b_{31}\bar{n}_{KPR} + b_{32}\bar{n}_{KPR}^2)\sqrt{\frac{T_b^{*j}}{T_{NO}}};$$

$$\bar{n}_{Kz} = f_1(\delta_{rud}^j) = b_{52} + b_{53}\delta_{rud}^j + b_{54}(\delta_{rud}^j)^2;$$

$$f_2(T_b^{*j}) = B_{10}T_b^{*j} + b_{11},$$

The system (1) has generally known designations with the exception of: GT – fuel, n_k, n_b – compressor and fan speed, respectively, G_{TUST}-steady-state fuel consumption values.

The quality functional is defined as a linear combination of two parameters that characterize the quality of the flight path. This is the accuracy of working out the space-time flight path and the minimum fuel consumption.

$$J = S_k\left(G_k, V, t_k\right) + \int_{t_0}^{t_k} L_1\left(G, t\right) dt + \int_{t_0}^{t_k} L_2\left(V, u, t\right) \cdot dt, \tag{2}$$

where the first integral determines fuel consumption and the second determines accuracy. The terminal term may be absent in the special case.

Control here refers to the amount of deviation of the engine control k_{nob} (RUD), or the set value of the compressor speed n_k. We will perform control synthesis in accordance with the concept of inverse dynamics problems [4].

Basic relations of the generalized method of inverse problems of dynamics. Denote the dynamic system (1) as a matrix differential equation

$$\frac{dx(t)}{dt} = f\left(x, u, t\right), \tag{3}$$

where is the control vector; - is a dimensional vector of the system state; - is a known vector-valued function that is continuous and differentiable the required number of times by its arguments.

You need to find a control that delivers extreme functionality (2)

Some additional condition is introduced in the form of the required ratio between the components of the state vector that must be performed along the trajectory of the system (3), in the form of

$$F\left(x, y_J\right) = 0, \tag{4}$$

where is a continuous-dimensional vector function differentiable once, is an m-dimensional given process.

If condition (4) is not met at the initial time, then due to the inertia of the control object, this condition is replaced with a condition of the form

$$\lim_{t\to\infty} F\left(x, y_J\right) = 0, \tag{5}$$

For certainty of further reasoning, we assume that the function has the form

$$F\left(x, y_J\right) = x_1\left(t\right) - y_{J1}\left(t\right), \tag{6}$$

where are vectors of dimension m.

Taking into account the requirement of analytical connection between the control and the controlled coordinates, we assume that the law of change (5) of the function (6) is defined as a linear homogeneous differential equation of the General order

$$F^{(n)}\left(x_1, y_J\right) + \lambda_{n-1} F^{(n-1)}\left(x_1, y_J\right) + \ldots + \lambda_0 F\left(x_1, y_J\right) = 0, \tag{7}$$

The task of control synthesis is formulated as follows: for the system (3), it is necessary to determine the control that delivers the extremum of the functional (2) when the condition (7) is met.

The required control law is defined as the solution of equation (7) with respect to it, taking into account the expressions (2) and (6).

As a result, when replacing (6) with F(V)=V(t)-Vz(t), we get the following set of actions.

Given the analytical relationship between the thrust of the power plant and the mismatch F (V), we have that equation (7) for the function F(V) has the form

$$\frac{dF(V)}{dt} + \beta_1 F(V) = 0. \tag{8}$$

Subject to (1) and (8) the expression for Rz(t) has the form

$$R_z(t) = (\beta_1 m \Delta V + C_x S q + G sin\theta)(N cos(\alpha + \alpha_{\text{dv}}) K_{\text{priv}})^{(-1)} \tag{9}$$

where $\Delta V=Vz-V$; N is the number of engines. Here, the value Rz(t) is related to the speed of rotation by known ratios.

The second stage of the synthesis involves determining the set value irwd believing in this known Rs. In this case, shall be based on the simplified model of the engine, determining rotational speed with the position PZ δ_{rud}. Similarly, with F(V), a new misalignment function is introduced, but for the compressor speed.

Simulation result. Evaluation of the effectiveness of the proposed algorithms for controlling the traction machine in this work was carried out using simulation methods. The object of the study, the aircraft and the power plant were represented as complete mathematical models, and the control law was determined in accordance with the model (1).

Figure 1 shows graphs of the dependence of fuel consumption when moving δ_{rud}, when there is an additional fuel consumption proportional to the area difference (S_1-S_2).

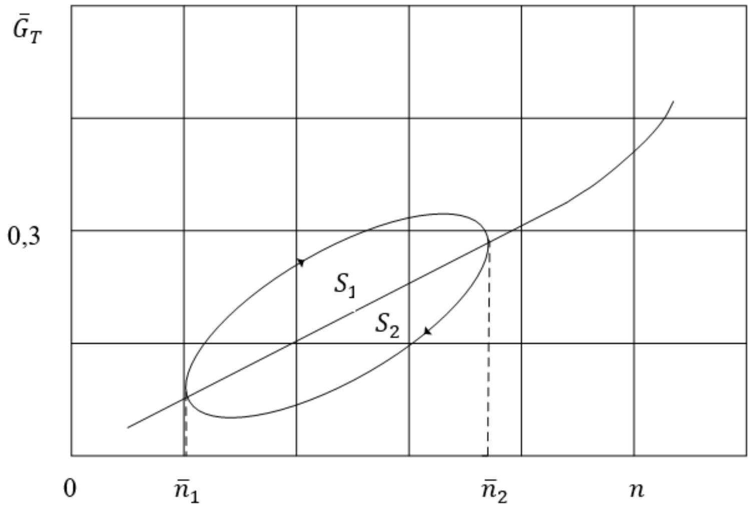


Fig. 1 Typical dependence of fuel consumption on speed

Figure 2 shows graphs of changes in the ORE position when compensating for a velocity disturbance equal to 10 m/s.

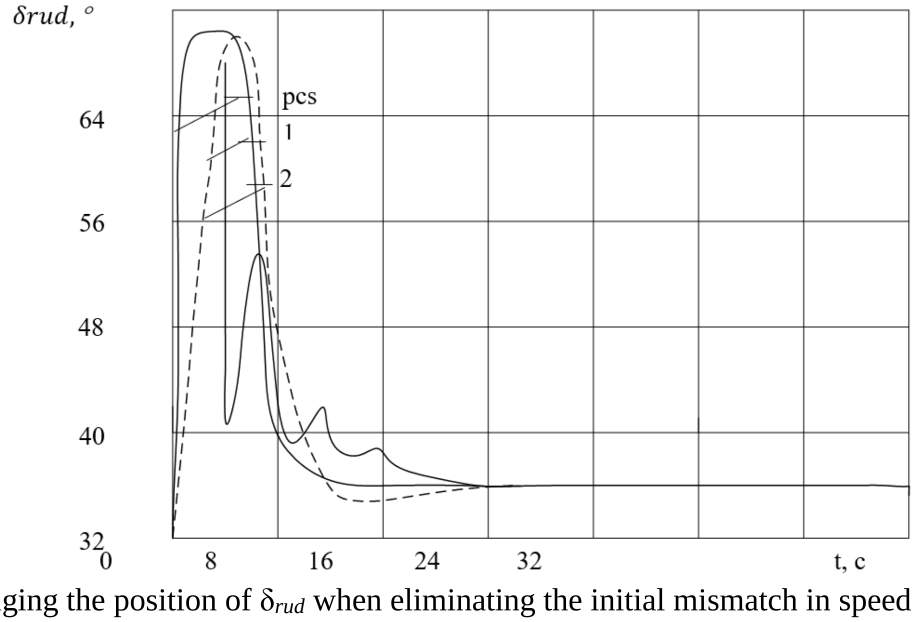


Fig. 2 Changing the position of δ_{rud} when eliminating the initial mismatch in speed ΔV=20m / s

Similar results are shown in figure 3. However here the power plant model was a complete gas dynamic Madeleine

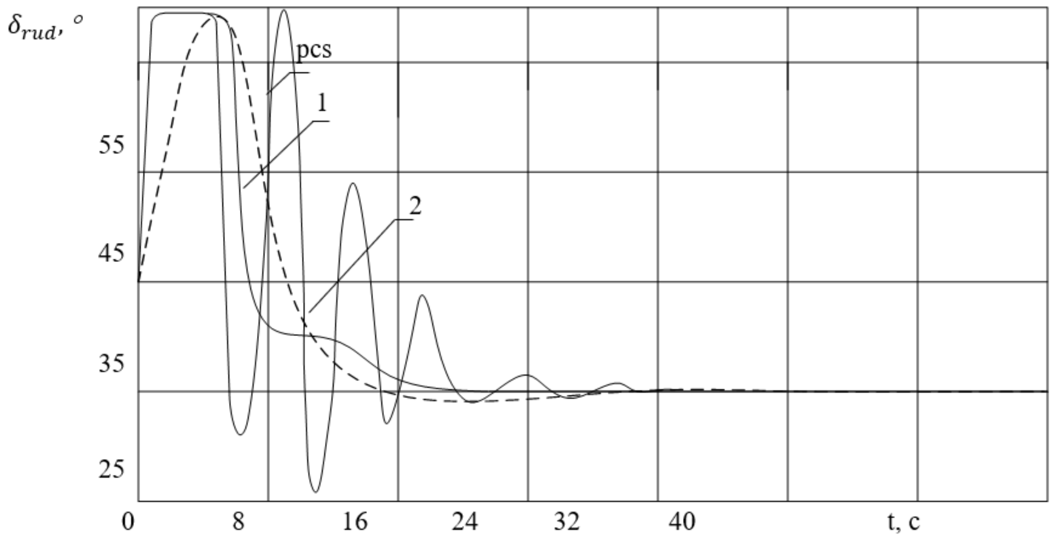


Fig. 3 Position of δ_{rud} when eliminating the initial mismatch taking into account the σ_{bx} model

Based on these figures the frequency and amplitude of vibrations increase.

CONCLUSION

The results show that closed control systems have the required properties, meet the principles of physical reliability, and have adaptive properties.

REFERENCES

1. Krutko P. D. Inverse problems of dynamics of controlled systems. Linear model. - Moscow: Nauka, 1987.

2. Krutko P. D. Inverse problems of dynamics of controlled systems. Nonlinear model. - Moscow: Nauka, 1988.

3. Kharkov V. P. Structural-parametric method of control synthesis for dynamic systems. Izv.USSR ACADEMY OF SCIENCES. Technical cybernetics. - 1991, No. 2. - Pp. 74-83.

4. Kharkov V., P. Adaptive control of dynamic systems based on inverse problems of dynamics/ / - Izv. USSR ACADEMY OF SCIENCES. Technical cybernetics. 1994, no. 4, pp. 115-124.

INFLUENCE OF ENVIRONMENT AND MANUFACTURING CONDITIONS ON DURABILITY ESTIMATION

Karapuzov M.A.
MIEM HSE
+7 (903) 104-53-79, mkarapuzov@hse.ru

Abstract— The paper describes method of RES durability evaluation with the influence of environment and maintenance conditions. Also influence of manufacturing process factors was considered.

Keywords—reliability, durability, resource.

INTRODUCTION

Durability is property to keep high performance until critical low level is reached according to maintenance [1]. Radio engineering systems' (RES) durability estimation is important issue when frequent maintenance procedures are problem. Durability estimation methods must be precise and consider environment condition of RES. Low durability leads to material losses if this issue wasn't solved at the RES design stage. Attention to maintenance and proper durability estimation methods at the design stage are basics of creation reliable RES.

PROBLEM STATEMENT

Durability is a comprehensive characteristic of the quality of materials, objects or structures, which is expressed in their ability to resist the complex effects of external and internal factors that manifest throughout the operation. The durability of the product or material can be judged by the duration of the change to the critical level of their physical properties or controlled parameters. The rate of properties and parameters changes directly depends on operating conditions or environmental factors during operation [2, 3].

Durability confirms during testing as the ability of RES components to withstand the environmental factors effects. However, schedule for maintenance and repair is needed to be planned, i.e. assessment of the degradation processes rate and the critical changes period or the limit state progress of system components.

In addition to environmental factors, the impact of a quality management system should be noticed like manufacturing quality for example. The reason for the decreasing durability may be the imperfection of the methods of input control, poor quality of materials and electronic components, violations of technological discipline and outdated equipment. In other words, the reason for the decreasing durability is low quality manufacturing technologies.

The influence of production quality on the durability of the RES was confirmed by the results of operating period. A distribution chart of the defects causes that lead to unscheduled maintenance and repair is shown on the figure 1.

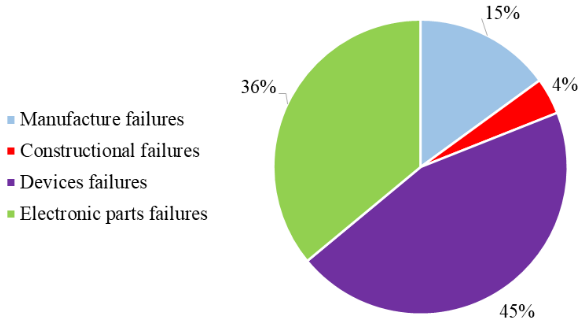


Fig.1. A distribution chart of the defects causes

SOLUTION OF THE PROBLEM

The influence of external factors on the durability evaluation can be estimated by the tests results of prototypes (laboratory models) using a simple formula

$$T_D = \frac{T_{D,EP}}{K_U \cdot K_R} \quad (1)$$

где $T_{D,EP}$ – prior value of the resource for normal operating conditions in accordance with data sheet; K_U – usage coefficient; K_R –rate of observing condition parameter in accordance with maximum value.

The usage coefficient K_U allows to estimate operational time rate over a specific period. The coefficient K_R reflects difference between the current values of the operating parameters and their maximum values. The coefficient K_R can be estimated as described in the references [4, 5] using reliability and durability similarity. At the RES design stage, importance of the climatic factors influence evaluation can be explained by the issues of RES development profitability. It means cost reduction due to the planning maintenance for achieving the required durability level. It was proposed at research [2] to evaluate K_R as a multiplicative coefficient like it was done for failure rate estimation

$$\Pi_{EP} = \frac{\prod_{j=1}^{J} K_j\left(\text{operational}\right)}{\prod_{j=1}^{J} K_j\left(\text{maximum}\right)} = \frac{\Pi_{\text{op}}}{\Pi_{\text{max}}} \qquad (2)$$

где Π_{op} – summary mupltiplier of electronic and condition parameters for each electronic part, operational; Π_{max} - summary mupltiplier of electronic and condition parameters for each electronic part, maximum; K_j - mupltiplier of electronic and condition parameters for each electronic part; J – coefficients number.

The evaluation results with using the multiplicative coefficient [2, 3] showed importance of this coefficient for prior durability estimation. Also these tests showed actual level of the environment factors influence on the RES durability.

One additional coefficient should be used for durability level precise evaluation, which take into account the manufacturing quality. The initial formula is the additive function [4]

$$\Pi_{mfc} = \Pi_P \Pi_{IM} \Pi_E + \Pi_M \Pi_{IM} \Pi_E \Pi_G + \Pi_S \Pi_G + \Pi_N + \Pi_W \qquad (3)$$

где Π_P – parts process factor; Π_{IM} – infant mortality factor; Π_E – environment factor; Π_M – manufacturing process factor; Π_G – reliability growth factor; Π_S – system management process factor; Π_N – no-defect process factor; Π_W – wear out process factor.

This model (3) is derived from a general one [4] and focuses exclusively manufacturing stage factors. It should be noted that these factors are described by the Weibull distribution [4], for which the scale and shape parameters are empirically calculated, as well as the percentage of failures that depend on a specific factor.

$$\Pi_i = \alpha_i \left(-\ln\left[R_i\right]\right)^{\frac{1}{\beta_i}} \qquad (4)$$

где α_i – scale parameter; β_i – shape parameter; R_i – rating of the process for the i^{th} failure cause.

The functions of factors (4) can be approximated by the Weibull distribution. Main idea is the durations of the degradation processes are not equal because of their different sources, failures of each factor are detected in a different time intervals.

The model for evaluation the actual durability level with the factors of operating and manufacturing quality is shown as

$$T_D = \frac{T_{D,EP}}{K_U \cdot \Pi_{EP} \cdot \Pi_{mfc}} \qquad (5)$$

CONCLUSION

The durability level for modern RES issue remains relevant, as well as tests terms which can confirm this level. It is almost impossible to solve this problem using available statistics or evaluation methods for now. Although there are many models for the durability prediction for different types of electronic parts. Also, many papers have been written for durability estimation by using methods like analyzing the physics of failures, modeling the causes of failures, and experimentally determining the durability of electronic components [6, 7].

Statistical methods are more preferable for durability evaluation in the specific operating conditions, but there is a problem to choose to proper one. The range of possible statistical estimation methods is very wide: methods of catastrophe theory, pattern recognition, simulation methods, methods based on the theory of time series, methods of the parametric theory in reliability prediction, physical and statistical approaches, method based on the theory of uncertain sets, etc. However, theory have not been brought to its practical use in engineering practice, and therefore there are no concrete examples. The proposed model (5) is the starting point for research and should be updated in the future.

In a number of articles [2, 3, 6, 7], the issues of the influence of various physical factors, technology factors and operating conditions on the a priori value of durability are considered. It shows effect of durability evaluation with the influence of these factors and importance to take them in account.

REFERENCES

1. V. Avduevsky. Reliability and effectiveness in technics. Handbook. – M.: Machinostroenie, 1986
2. V. Zhadnov. Durability factors estimation for electronic equipment of spacecraft vehicles and systems// NiKSS, 2013. №2
3. M. Karapuzov, S. Polessky, V. Zhadnov. The influence of external environmental factors on the durability of microwave devices.// NiKSS, 2014. №2 (6)
4. Handbook of 217Plus Reliability Prediction Models. - RIAC, 2006.
5. MIL-HDBK-217F: Reliability prediction of electronic equipment. (Notice 1, Notice 2)/Department of defense – 28 February 1995.
6. Physics-of-Failure Lifetime Prediction Models for Wire Bond Interconnects in Power Electronic Modules. Li Yang, Pearl A. Agyakwa, and C. Mark Johnson
7. Failure analysis of power electronic devices and their applications under extreme conditions. Yifei Luo, Fei Xiao, Bo Wang, and Binli Liu

DEVELOPMENT OF AN ALGORITHM FOR OPTIMUM PLACEMENT OF ELEMENTS ON THE SWITCHING FIELD OF A PRINTED UNIT ACCORDING TO TEMPERATURE INDICATORS USING A SELF-ORGANIZING GENETIC ALGORITHM (SOGA)

Giang Van Thanh, Dao Anh Quan, Pham Le Quoc Khanh, V.V.Chernoverskaya
MIREA - Russian Technological University
Moscow, Russia,
8-(909)-632-65-26, giangvanthanh.92tb@gmail.com

Abstract - The task of optimal placement of electronic components on a printed circuit board (PCB) belongs to the class of multicriteria tasks based on accounting and ensuring a number of design requirements, which, in turn, may be contradictory in inherently, since most components have different values of power dissipation, operating temperatures, weight and size characteristics.

Keywords: electronic means, printing unit, temperature, genetic algorithm, optimal placement, multi-criteria optimization.

In recent years, when designing electronic tools, much attention has been paid to the use of neural network technologies and the adaptation of the algorithms embedded in them to solve design problems.

In this paper, we propose a methodology for using the self-organizing genetic algorithm (SOGA) in the framework of solving the multicriteria problem of designing a highly reliable electronic tool, and the result of the study should answer the question: «Is it possible using the SOGA algorithm to obtain the optimal placement of electronic components on the field of the printing unit (PU) from the point of view of ensuring the required temperature conditions of the device if microminiaturization of the structure is necessary (reducing the linear dimensions of the PU)?».

Structurally, the SOGA algorithm can be considered as a cascade of two GAs, based on a two-stage fitness (fitness) assessment process, which should guarantee the optimal selection of chromosomes for each iterative process. The algorithm is based on the weighted sum genetic algorithm (WSGA), in which the internal loop GA is used to optimize the selection of WSGA weights.

As part of the task, a series of experiments was carried out, for which four criteria were formulated, the most significant in terms of design development and ensuring the reliability of the designed unit:

- temperature indicators of the component;
- area of the printed circuit board;
- power dissipation of the component;
- distance to the critical component with high potential.

Based on the selected criteria, four fitness functions f (T), f (A), f (P), f (L) were set, which together form the multi-parameter goal function F (T, A, P, L). The optimization of the objective function F (T, A, P, L), in turn, is the result of the optimization of the initial functions f (T), f (A), f (P), f (L):

$$F (T, A, P, L) = w1\ f1 (T) + w2\ f2 (A) + w3\ f3 (P) + w4\ f4 (L) \qquad (1)$$

The combination of weights w1, w2, w3 and w4 allows you to more accurately take into account the features of each fitness function when finding the optimal goal function F (T, A, P, L), so the task is to determine the best combination of w1, w2, w3 and w4 such so that the objective function is minimized.

The objective of the study is to formulate a multi-purpose search optimization problem of placing electronic components on the surface of PU. One of the tasks of designing the designs of electronic equipment was and remains miniaturization, which within the framework of the presented study consists in reducing the linear dimensions of the printing unit, taking into account the restrictions imposed by the distribution of the temperature fields of the components, the power dissipated by them, and the presence of high-frequency elements in the circuit. A comprehensive consideration of these factors will improve the reliability of RES and extend their service life.

Let us consider in more detail the process of forming 4 functions f (T), f (A), f (P), f (L).

<u>1. The temperature of the component, the function f (T)</u>

To determine the function f (T), which depends on the temperature of the element, a resistive heat network is used to analyze the connection temperature of each component and the thermal connections of the components on the printed circuit board [1].

Using the analytical thermal model of the electronic device, the temperature of each element is calculated. For this, specialized SolidWorks CAD software was used, in particular, its SolidWorks simulation module. The simulation results are presented in Fig. 1.

Further, the temperature of each component is normalized as follows:

$$\mathbf{f_i(T)} = \frac{\mathbf{T_i}}{\mathbf{T_{Allow\_max\_i}}} \qquad (2)$$

where $\mathbf{T_i}$ is the temperature of the ith component in steady state,

$\mathbf{T_{Allow\_max\_i}}$ - maximum temperature permitted by the manufacturer for the i-th component.

The function f (T), taking into account the temperature of all elements, will be determined as the average of the sum of the normalized temperatures of all elements:

$$\mathbf{f(T)} = \frac{\mathbf{1}}{\mathbf{k}}\sum_{\mathbf{i=1}}^{\mathbf{k}} \frac{\mathbf{T_i}}{\mathbf{T_{Allow\_max\_i}}} \qquad (3)$$

where k is the number of circuit elements.

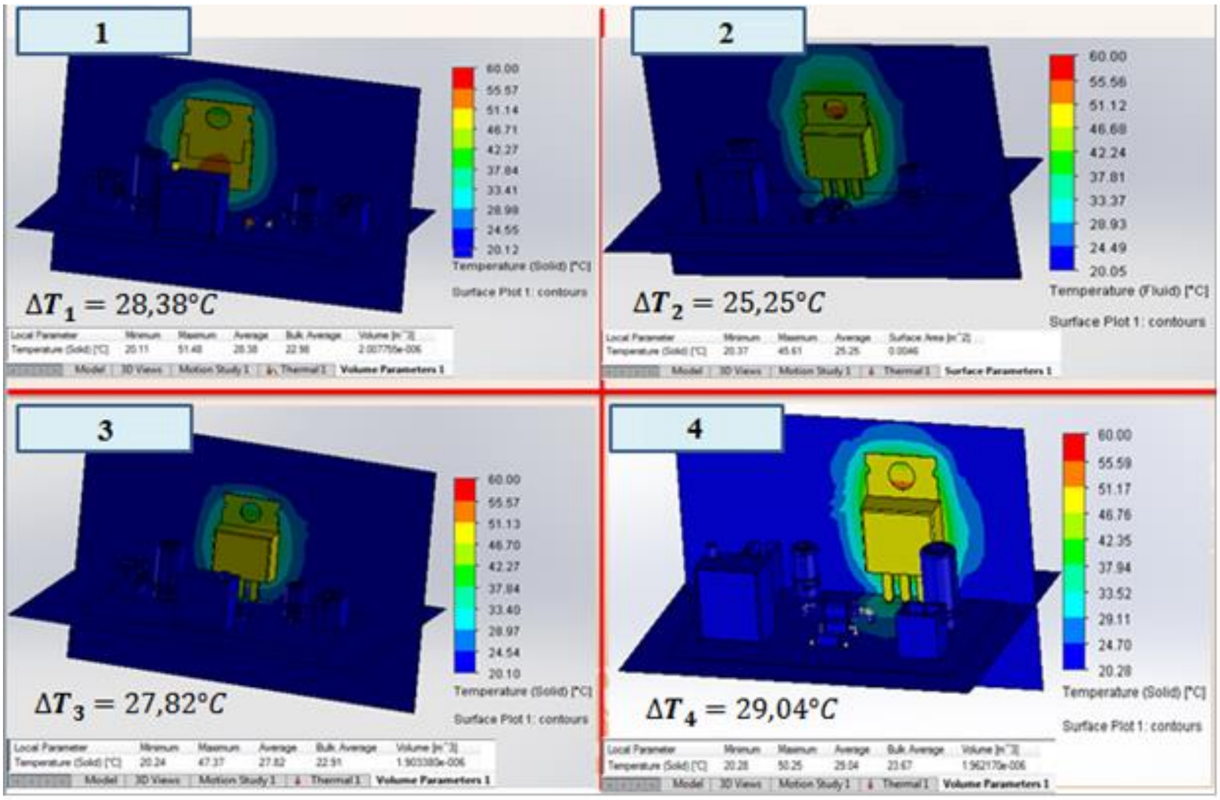


Fig. 1 - Modeling of thermal conditions of the designed unit.

<u>2. Board area, function f (A)</u>

Improving the element base, its microminiaturization allows for more tight installation and reduce the linear dimensions of the printing unit without compromising the functionality of the designed devices. The next optimized parameter in the study was the area of the printed circuit board and its objective function f (A). The objective function for the PCB area can be measured as shown in fig. 2 and obtained analytically using the equation:

$$\mathbf{f}(\mathbf{A}) = \frac{\mathbf{A}}{\mathbf{A_{Allow\_max}}} \tag{4}$$

where **A** = (Xmax - Xmin) x (Ymax - Ymin) - the current value of the area of the PU, mm2;

$\mathbf{A_{Allow\_max}}$ = (Max_allow_x) x (Max_allow_y) - maximum permissible area of PU, mm2.

<u>3. Components with high power dissipation, f (P) function</u>

At the preliminary stage of the placement of elements, it is very important to identify elements with high power dissipation and allocate them in a separate group for analysis. Such electronic radio products (ERP) have, as a rule, a higher operating temperature than other elements of the circuit, so there is a high probability of a temperature increase in the vicinity of these ERP, which can damage the mating elements of the circuit. In order to avoid the influence of heat dissipated by elements of this type on other ERP, it is necessary to place them as close to the edge of the board as possible, which will allow the heat to be dissipated into the environment. In this experiment, the power dissipated by all the elements of the circuit was analyzed, and the ERP with a dissipation power of P = 2.5 W were allocated to a group with a high dissipation power. The position of this component on the circuit board is defined as (place_x, place_y) along the X and Y axes.

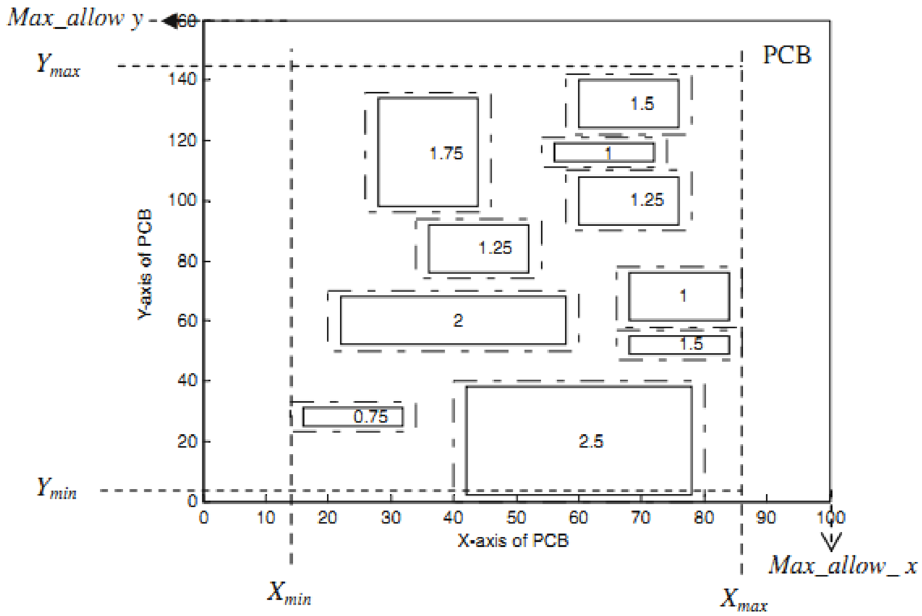


Fig. 2 - Fitness function f (A). Determination of the area of PU.

The objective function for placing such ERP is analytically determined as follows:

$$\mathbf{f(P)} = \frac{\mathbf{placement\_y}}{\mathbf{Y_{Allow\_max}}} \qquad (5)$$

where **placement_y** is the coordinate along the Y axis of the current position of high power ERP;

$\mathbf{Y_{Allow\_max}}$ - possible limit position of the component coordinate along the y axis. If there are more components that have high dissipation power, the objective function can be obtained as the equation:

$$\mathbf{(P)} = \frac{\mathbf{1}}{\mathbf{m}}\sum_{\mathbf{i=1}}^{\mathbf{m}} \frac{\mathbf{placement\_y_i}}{\mathbf{Y_{Allow\_max\_i}}} \qquad (6)$$

Figure 3 shows the placement of high-power dissipation devices near the X axis.

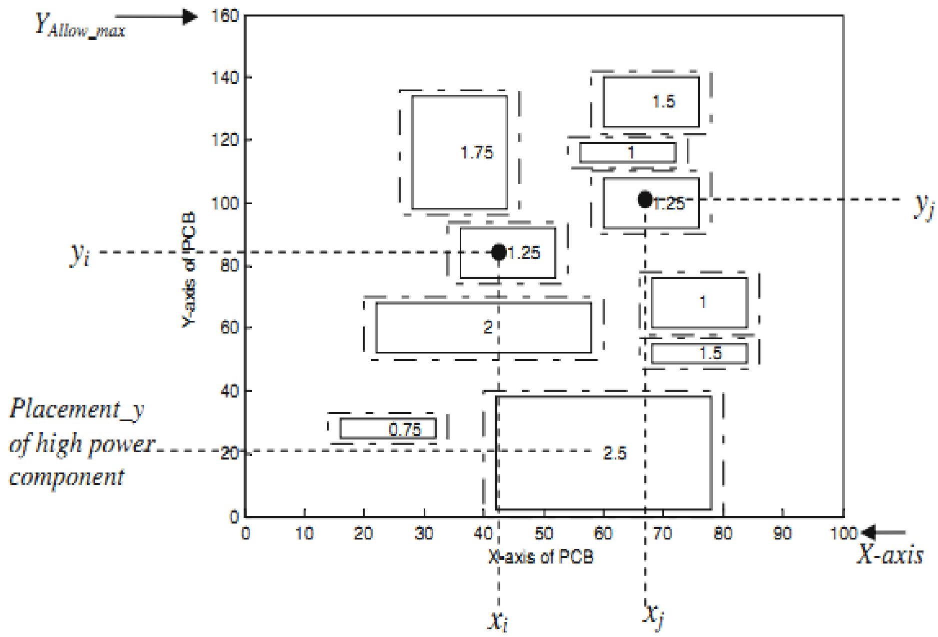


Fig. 3 - Fitness functions f (P) and f (L). Placement of ERP with high power dissipation and high frequency elements.

4. Elements with high potential (high frequency), f (L) function

The high potential component operates on high frequency signals. These components should be located as close as possible to each other in order to be able to design a conductor of minimum length. In the presented experiment, there are two such elements whose dissipation power is P = 1.25 W (Fig. 3). The distance between two high potential ERPs is calculated from the center of each component using the equation:

$$\mathbf{L_{i-j}} = \sqrt{(\mathbf{x_i} - \mathbf{x_j})^2 + (\mathbf{y_i} - \mathbf{y_j})^2} \tag{7}$$

where $(\mathbf{x_i}, \mathbf{y_i})$ và $(\mathbf{x_j}, \mathbf{y_j})$ are the coordinates along the corresponding axes of the centers of the 1st and 2nd ERP, respectively.

The objective function f (L) in this case can be obtained as follows:

$$\mathbf{f(L)} = \frac{\mathbf{1}}{\mathbf{l}}\left[\sum_{\mathbf{i=1}}^{\mathbf{l}}\left(\sum_{\mathbf{j=j+1}}^{\mathbf{l}}\frac{\mathbf{L_{i-j}}}{\mathbf{L_{Allow\_max}}}\right)\right] \tag{8}$$

Self-Organizing Genetic Algorithm Optimization (SOGA)

One of the promising approaches used to solve multipurpose optimization problems is the evolutionary genetic algorithm (GA). Usually, two approaches are used, which are the weighted sum method [4] and the approach based on the Pareto method.

In early implementations of the method based on determining the weighted sum, the solution was found by trial and error to obtain the best combination of weights. They used a fixed combination of weights during the iterative process — it was a fixed weight genetic algorithm (FWGA). In it, the FWGA fitness function was determined by the equation:

$$\mathbf{F(r) = w_1 . f_1(r) + w_2 . f_2(r) + \ldots w_M . f_M(r)} \tag{9}$$

where $\mathbf{r}$ - is a variable parameter,

$\mathbf{f_m}$- m-th objective function,

$\mathbf{w_m}$ - is the weight selected for the m-th objective function within [0,1].

$$\sum_{\mathbf{m=1}}^{\mathbf{M}} \mathbf{w_m = 1;\ w_m = w_1, w_2, \ldots w_V} \quad \textbf{and} \quad \mathbf{r = r_1, r_2, \ldots.} \tag{10}$$

Hajela and Lin (1992) proposed a composite combination of scales to solve the problem, but the task was limited to two objective functions. The application of an objective approach to finding the optimal combinations of weights required a more complex mathematical formulation and significantly greater computing power, which at that time turned out to be unattainable. Murata and Ishibuchi (1995) and Murata et al. (1996) proposed a random weighted sum total (RWGA) genetic algorithm that is based on a weighted sum of several objective functions. During the weight selection phase in each generation, the RWGA generates a random weight vector for each solution. The use of a random weighted sum allows you to find a solution in accordance with formula 9, while different directions of the search are created in each generation process. The advantage of this method is its computational efficiency, i.e. suitability for finding the optimal solution that can be used as a starting point for other methods (Chang et al. 2009; Guan et al. 2009). However, the random selection of weights does not guarantee that the chromosomes undergoing selection are the most accurate chromosomes, and therefore does not guarantee that weight combinations are optimal.

In practice, it is very difficult to choose the optimal weighting coefficients for each objective function (even for experts who are well acquainted with the problem area). The best optimal solution that satisfies all objective functions is often difficult to implement or leads to an unacceptable solution in relation to other objective functions.

Another approach to solving the multicriteria optimization problem is the Pareto method, which belongs to the class of unconditional optimization problems, which does not form a unique solution (the only solution in this case can be considered as a degenerate case), but generates a set of solutions in a given space. It is called the space of the worst solutions or the Pareto-optimal set, where each element of the set satisfies the goals at an acceptable level without the dominance of any other solutions (Coello et al. 2007). However, choosing a solution from the Pareto-optimal set requires a detailed study of the problem and extensive experience in solving such problems, which may be difficult for the developer, in contrast to the WSGA approach.

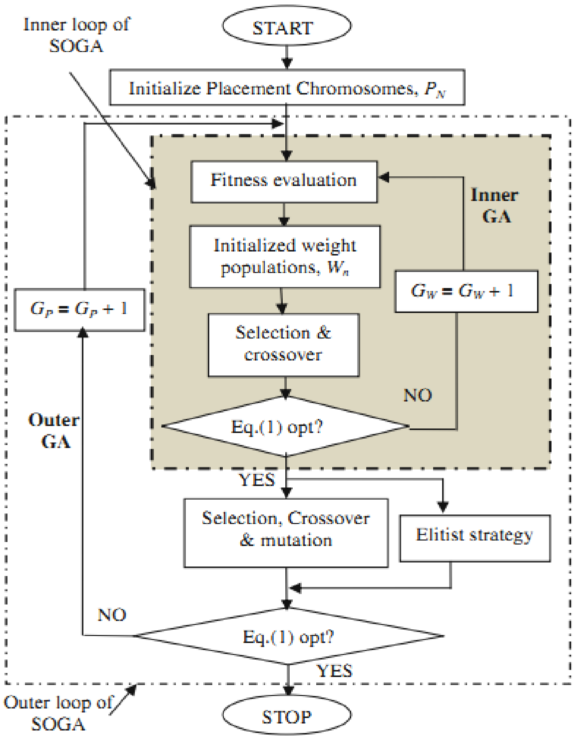


Fig. 4 - SOGA Evaluation Process Flow Chart

In this study, to solve the problem of multicriteria search engine optimization, it is proposed to use the self-organizing SOGA algorithm, in which the internal GA cycle is used to optimize the combination of weights of all objective functions, and the external GA cycle is used to optimize the complex objective function. The SOGA flow process is shown in Fig. 4.

Chromosomes $\mathbf{P_N}$ of the external loop of the genetic algorithm P_1, P_2, ..., P_N represent solutions for placing (x_1, y_1; x_2, y_2; ....; x_k, y_k) all ERPs on a printed circuit board. In the inner loop of the algorithm, **Wn** chromosomes are represented by a combination of weights M of the objective functions M(w_1, w_2, ..., w_M), and the population is represented as, w_1, w_2,..., w_M. For each of the P_N-chromosomes, the internal cycle of the genetic algorithm will optimize the combination of weights of M-functions. Here, G_P is the number of the iterative process of the outer loop of the algorithm, and GW is the number of the iterative process of the inner loop of GA.

REFERENCES

1. (Ammous et al. 2003; Lee 2003; Wassigi and Sachdev 2006; Wellvehi et al. 2007; Dawn Ebski and Gorecki 2007; Suwa and Hadim 2008)

2. Zang Wan Thanh, Dao Anh Quan, Fam Le Quoc Han. Optimization of the placement of the elements of the printing unit by temperature. // Collection of scientific articles based on the materials of the IV International Scientific and Practical Conference “Actual Problems and Prospects for the Development of Radio Engineering and Infocommunication Systems” (RadioInfocom-2019), Moscow, RTU MIREA: collection of scientific articles . - M .: MIREA - Russian Technological University, 2019.p.306-309.

3. Zang Wang Thanh, Dao Anh Quan, Fam Le Quoc Han. Diagnostics of manufacturing defects by temperature characteristics. // Collection of scientific articles based on

the materials of the IV International Scientific and Practical Conference "Actual Problems and Prospects for the Development of Radio Engineering and Infocommunication Systems" ("Radio Infocom-2019"), Moscow, RTU MIREA: collection of scientific articles. - M .: MIREA - Russian Technological University, 2019.p. 314-316.
4. (Tan et al. 2002; Ghosh and Dehuri 2004; Konak et al. 2006)

USING A SELF ORGANIZING MAP TO DIAGNOSE ERRORS ON ELECTRONIC BOARDS BASED ON THERMAL IMAGING

Dao Anh Quan, Popova Tatiana Aleksandrovna, Uvaysova Aida Saygidovna, Ivanov Ilya Aleksandrovich
MIREA - Russian Technological University, Moscow, Russia
+7(917)-560-73-35, tatiana241187@gmail.com

Abstract: There will inevitably be failures and errors during operation and manufacture of electronic devices. Electronic circuit boards are the least reliable link. Therefore, fault analysis is a very important task that requires multilateral systemic elaboration. Non-destructive testing and testing techniques have many advantages and are widely used to detect defects on electronic circuit boards. One of the most effective methods of non-destructive testing is the method of using thermography to diagnose printed circuit boards. Using a self-organizing map to analyze and diagnose thermal images will improve diagnostic capability and accuracy.

Keywords: self-organizing maps, thermal imaging, neural network, SOM, simulation modeling

INTRODUCTION

Analysis of the technical condition of electronic equipment during fault analysis is one of the most complex processes. Today, a common method for diagnosing elements of electronic equipment is the analysis of electrical parameters. Thermal model allows to detect defects or confirm the serviceability of electronic components. In this work it is proposed to use a diagnostic system based on a self-organizing map for thermal field control.

CONCEPT OF THERMAL SURVEY METHOD

Thermal image (thermography) is an image taken using an infrared thermal camera (fig.1).

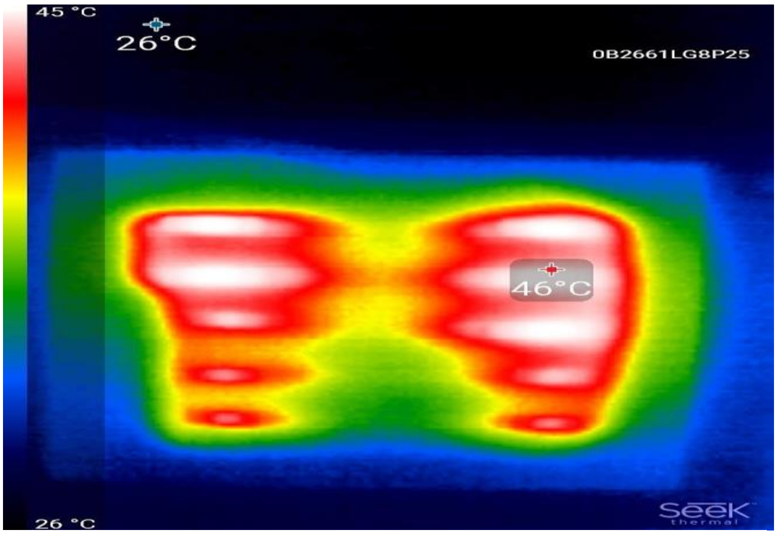


Figure 1: Thermal image of printed circuit boards

Image threshold setting is mainly used for image segmentation. Threshold processing is also a common method of detecting material defects in an infrared thermography image. Threshold processing is the process of separating objects from their background in a digital image. The main tool in this splitting process is the histogram. Assume that the gray level corresponds to the image f (x, y), which consists of light objects on a dark background, such that the object and background pixels have gray levels grouped into two dominant modes. The object is extracted from the background by selecting a threshold T separating these modes.

$$g(x,y)=\begin{cases}1 & \text{if } f(x,y)>T\\ 0 & \text{if } f(x,y)\le T\end{cases}$$

For the most optimal analysis of the obtained images it is proposed to resort to the use of a neural network. Due to limitations caused by the use of a self-learning network, a simulation model of the board under study is constructed. Next, a data set for a board in perfect condition and a board containing probable defects is obtained using mathematical methods. Then, using mathematical methods, a data set is obtained for a board in perfect condition and a board containing probable defects. This study suggests using SOM. SOM is a neural network model that implements a characteristic nonlinear projection from the high-dimensional space of sensory or other input signals to a small dimensional array of neurons. The SOM is an unsupervised learning algorithm which produces a map pattern features on its output layer. Input patterns with similar features are mapped onto neighboring output nodes. The network consists of an input layer with m neurons and an output layer with n neurons as shown in fig 2.

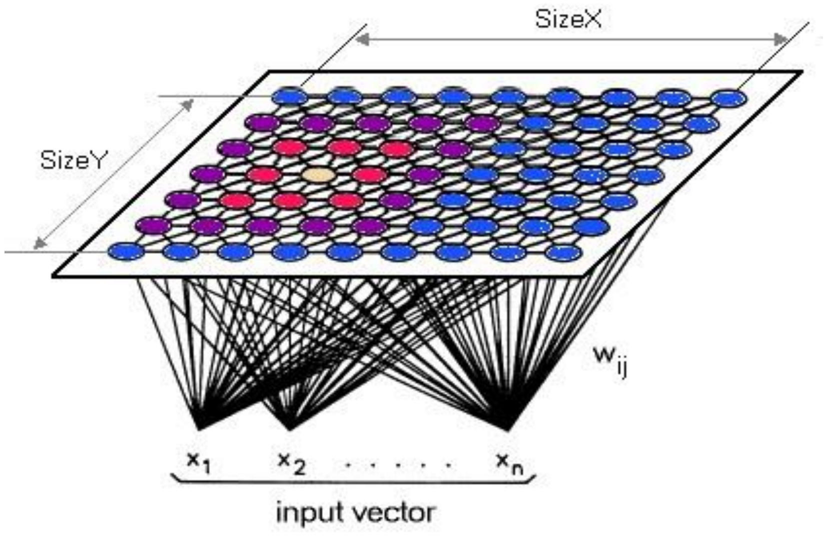


Figure 2. The SOM network.

The structural diagram of the avionics method of thermal diagnostics by SOM method is shown in fig 3. The diagram consists of two "branches". The first branch is the result of measurement of parameters of the diagnosed avionics, made on specialized equipment, the second - characteristics of avionics system obtained as a result of simulation in SolidWorks. By the identity of the parameters obtained on the measuring equipment and the simulation results, one can judge the correctness of the developed thermal model of electronic equipment and a high degree of reliability of the results.

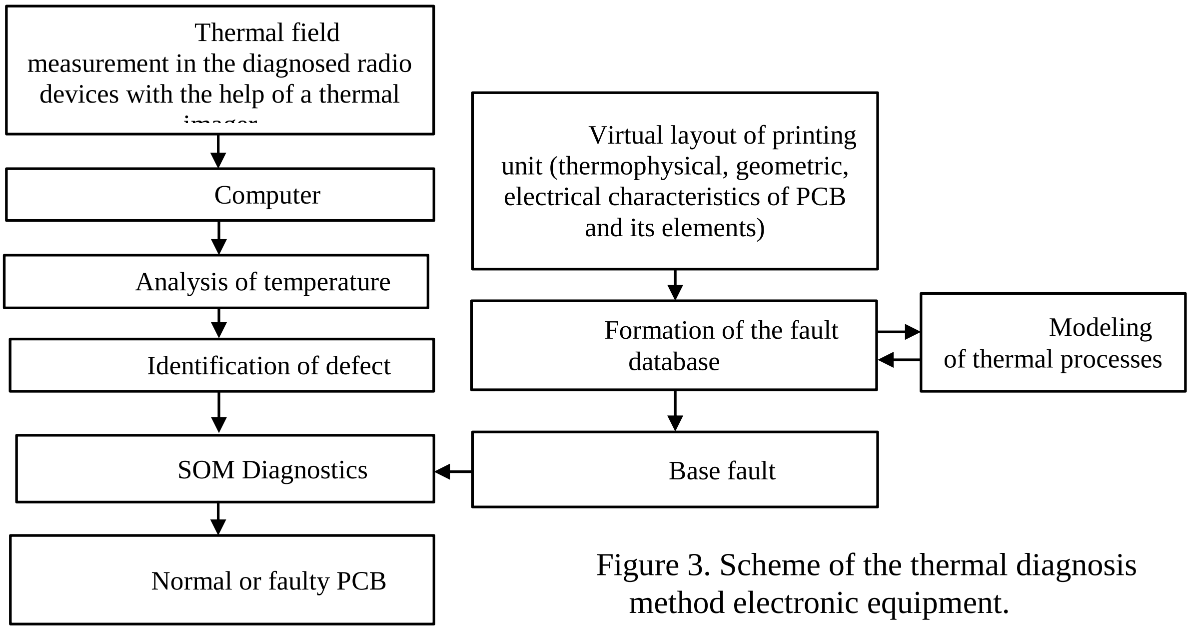


Figure 3. Scheme of the thermal diagnosis method electronic equipment.

During the simulation, a preliminary analysis of the electrical circuit diagram of the diagnosed electronic equipment in Multisim was performed. Its results are presented in fig. 4.

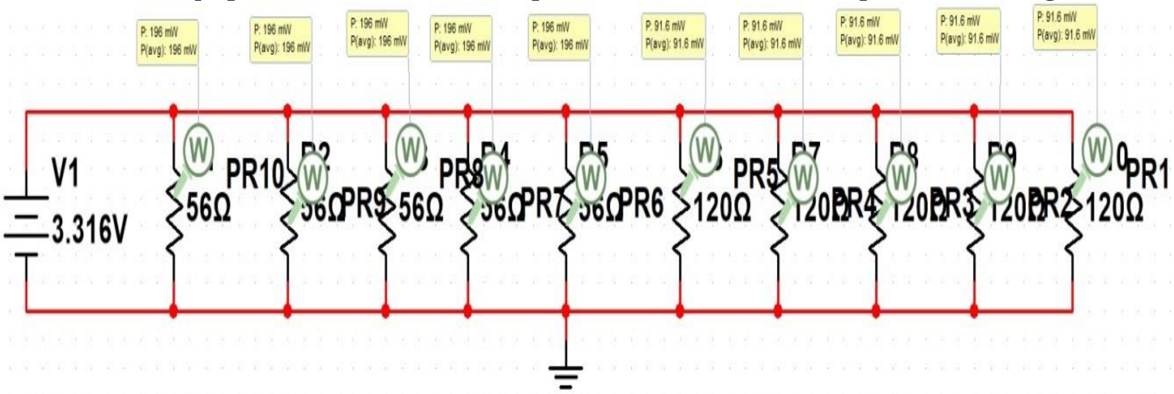


Figure 4. Schematic diagram of the printed circuit board

In this study, a 3D PCB model was developed to analyze temperature fields (fig. 5).

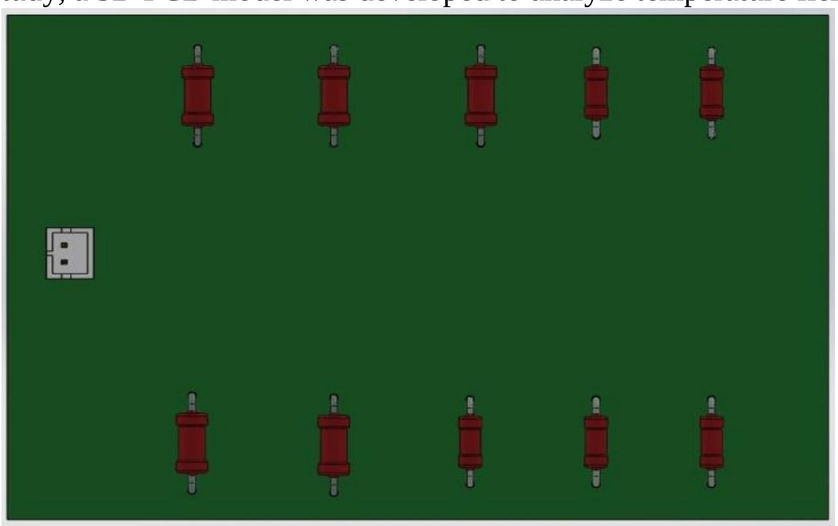


Figure 5. 3D model of the printed circuit board

Modeling PCB with solidworks flow simulation, thermography is obtained as shown in fig 6 and temperature profile of resistors as shown in fig 7. From the analysis of the color field, you can judge areas that have overheating. Next, the temperature of the resistors was examined in detail (table 1).

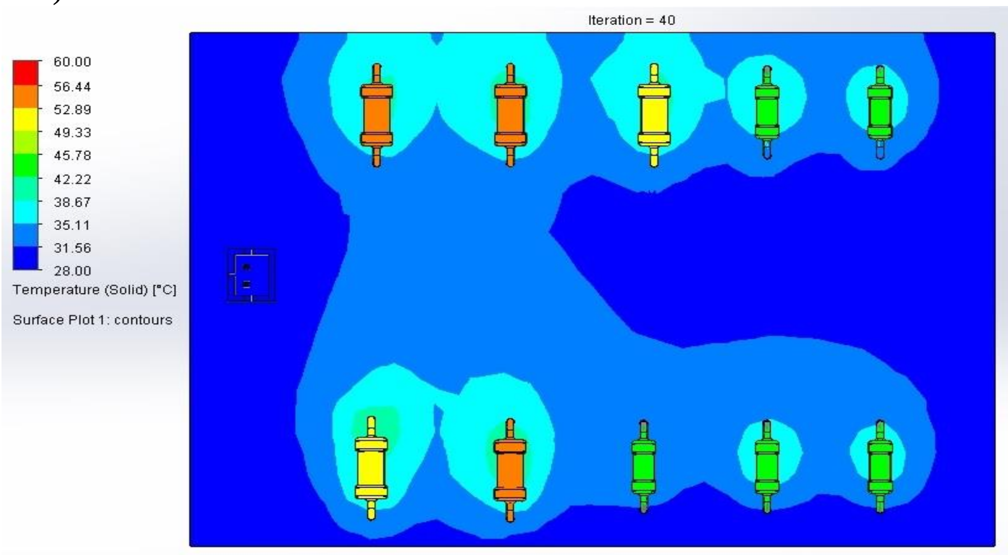


Figure 6. Thermal image on a printed circuit board.

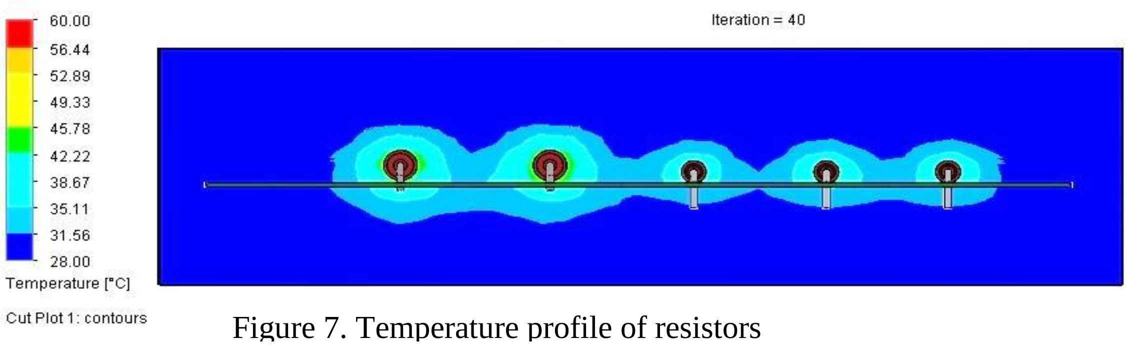


Figure 7. Temperature profile of resistors

Table 1. Resistor Temperature

Goal Name	Unit	Maximum Value
VG Max Temperature (Solid)_R1	[°C]	52.02479645
VG Max Temperature (Solid)_R2	[°C]	50.44388401
VG Max Temperature (Solid)_R3	[°C]	53.1734781
VG Max Temperature (Solid)_R4	[°C]	53.75080788
VG Max Temperature (Solid)_R5	[°C]	52.48862344
VG Max Temperature (Solid)_R6	[°C]	39.90029914
VG Max Temperature (Solid)_R7	[°C]	40.34293743
VG Max Temperature (Solid)_R8	[°C]	41.27342164
VG Max Temperature (Solid)_R9	[°C]	39.79676725
VG Max Temperature (Solid)_R10	[°C]	41.80353172

If there are defects on the board, for example, the resistor R1 does not work, the simulation in solidworks reflects the change in the thermography of the board, as shown in fig 8, and the temperature on the resistors, as in table 2.

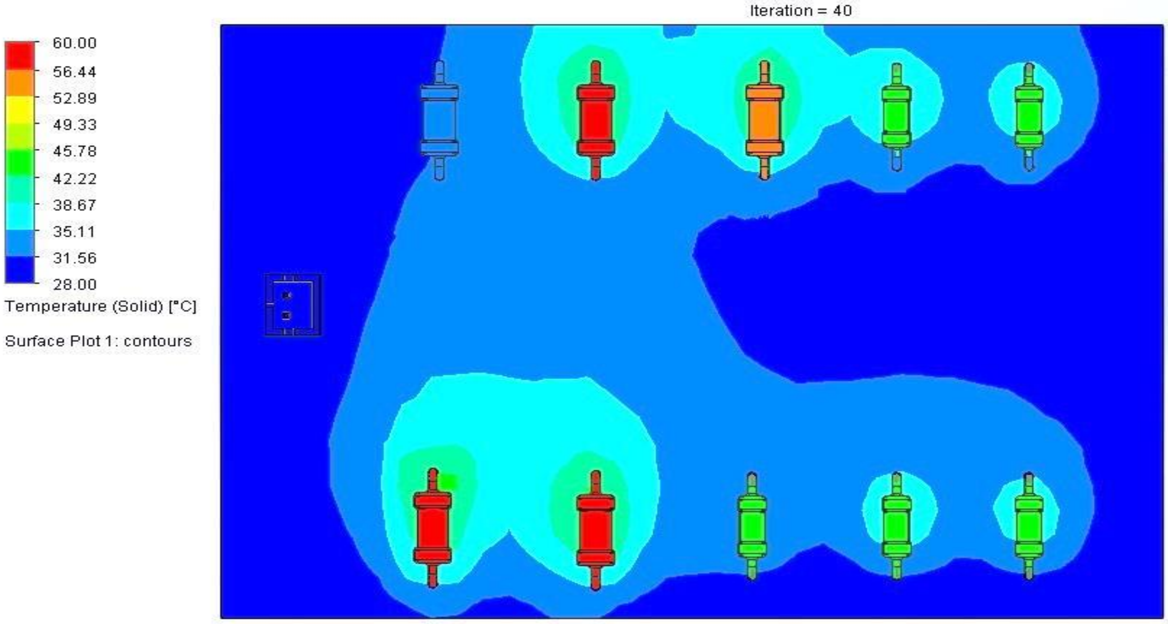


Figure 8. Thermal image on a printed circuit board (where R1 does not work)

Table 2: Temperature of resistors (where R1 does not work)

Goal Name	Unit	Maximum Value
VG Max Temperature (Solid)_R1	[°C]	31.76728954
VG Max Temperature (Solid)_R2	[°C]	57.36928092
VG Max Temperature (Solid)_R3	[°C]	59.71499187
VG Max Temperature (Solid)_R4	[°C]	60.02802062
VG Max Temperature (Solid)_R5	[°C]	56.29877033
VG Max Temperature (Solid)_R6	[°C]	43.72406501
VG Max Temperature (Solid)_R7	[°C]	44.91741406
VG Max Temperature (Solid)_R8	[°C]	44.56468861
VG Max Temperature (Solid)_R9	[°C]	44.6541288
VG Max Temperature (Solid)_R10	[°C]	43.83647485

When you set statistics, you can compare simulation results in two cases: in the absence of defects and in the presence of certain groups of defects with thermography of the actual board. The set of such data is the basis for creating a self-learning neural network allowing for diagnostic tasks.

CONCLUSIONS

Diagnostics of PCB defects of radio-electronic devices based on temperature characteristics in combination with artificial neural networks is a new method, combining high accuracy of obtained results, possibility of interpretation of fuzzy data, expansion of functionality of traditional diagnostics system. Proposing a self-organizing map algorithm to analyze and diagnose PCB thermography will improve diagnostic accuracy. This work confirms the presence of a significant difference in the infrared thermography image patterns of the printed circuit board in the presence of defects from the thermography of the working system. In addition, the possibility of using a neural network to analyze printed circuit boards is shown, which is undoubtedly a pressing task of modern electronics.

REFERENCES

1. Kohonen, Self-Organizing Maps, Springer-Verlag, Berlin, 1995.

2. N. Otsu, A Threshold Selection Method from Gray-level Histograms, IEEE Transactions on Systems, Man, and Cybernetics, vol. 9 no. 1, Jan. 1979, pp. 62-66.

3. B. Chanda, D.D Majumder, Digital Image Processing and Analysis, New Delhi: Prentice-Hall of India Private Limited, 2000.

4. Achmad Widodo, Djoeli Satrijo, Muhammad Huda, Application of Self Organizing Map for Intelligent Machine Fault Diagnostics Based on Infrared Thermography Images, Sixth International Conference on Bio-Inspired Computing: Theories and Applications, 2011

5. S.P.Suleymanov, Thermal method of diagnosing of radio-electronic means / S.P. Suleymanov, N.M. Chernov, A.A. Podkopayev, A.V. Dolmatov//System problems of quality, mathematical modeling, information, electronic and laser technologies: сб. тр. Mezhdunar. науч. - техн. конф. also Grew. науч. шк. – M.: GNPO "Agate", 2001. – Part 2. – Page 36-43.

6. Reference book on SolidWorks 2017. [Electronic Resource] URL: http://help.solidworks.com/2013/russian/SolidWorks/cworks/c_Thermal_Analysis.htm (date of the address: 12.10.2017)

JTAG-TECHNOLOGY AS A TOOL FOR TESTING COMPLEX COMPONENTS OF PRINTED CIRCUIT BOARDS

Nguyen Van Tuan, Popova Tatiana Aleksandrovna, Uvaysova Svetlana Saygidovna
MIREA - Russian Technological University, Moscow, Russia,
+7(917)-560-73-35, tatiana241187@gmail.com

Abstract: Now that electronics have completely taken over our lives and become an integral part of all spheres of human activity, the question of ensuring high reliability and stable operation of all devices is unwittingly raised.

Unfortunately, no even state-of-the-art production can guarantee the production of absolutely ideal systems, so the issue of ensuring diagnosis and detection of defects at the early stages of production is extremely relevant.

This paper provides an overview of edge scanning techniques that allow you to verify complex digital, analog, and hybrid printed circuit boards. This method converts complex diagnostic analysis into relatively simple structured tasks. In addition, such technologies will avoid the problem of having to physically access component leads or contact sites.

Such a system allows to test the product in automatic mode, obtaining reliable results on serviceable or defective condition of printing units.

KEYWORDS: Edge scanning technology, microelectronics testing, peripheral scanning, printed circuit boards, integrated circuits.

INTRODUCTION

Modern hardware systems are not thought-able without the use of programmable logic integrated circuits (PLD), and given the desire to minimize and integrate, the issue of debugging and diagnostics of such systems is acute. Methods used previously, with the connection of oscilloscopes or logical analyzers, cannot be used physically at present. For complex systems built on integrated microelectronics, including multiprocessor computing complexes, memory units and microcontrol systems require particularly careful diagnostic approaches, due to the inability to visually assess defects. Many developers of the electronic equipment look for the decision, developing the specialized testing schemes and the software allowing to exclude hit of the rejected products in finished goods.

There are currently many tools used to diagnose electronic component errors. One of the most popular and popular technologies in PLIS is JTAG technology. A large number of electronic products on the market use this technology. Further development of JTAG is projected in the future.

APPLYING EDGE SCANNING METHODS

It is now widely used to test complex components such as PLD, microprocessor, controller, etc., JTAG technology. This technology is quite simple and understandable to most users. Using this technology to test printed circuit boards can save resources, time, and test efficiency. Structural testing is carried out using many specialized tools. These tools were developed by the JTAG vendor with a simple and convenient user interface. Input will be provided by the device manufacturer.

The technical level of PCB creation, when the density of installation is minimal and the number of pins of some components is measured by thousands, access to diagnostic points is extremely difficult, and in some places it is impossible. Recently, a promising and widely used method, such as a nail bed machine, does not appear to diagnose electronics. Such techniques are generally unacceptable for multi-layer boards with BGA components in which miniature solder balls are present on the contact pads of the chip due to the inability to provide physical access to the terminals of the components or to individual contact pads. Therefore, the relevance of the development of diagnostic systems operating on the principle of peripheral scanning is undeniable. One of the standards approved as early as the 1990s is the IEEE 1149.1 Peripheral Scan Standard, but the JTAG (Joint Testing Action Group) standard, which has the name of the group developing it, was the most common.

Diagnosis of the printing unit is performed in stages. Initially, a short circuit test is performed. Further, the main supply voltage is estimated by taking the consumption current. After that, go directly to the boundary scan using JTAG technology. Note that JTAG technologies analyze only the correctness of circuit installation.

JTAG TECHNOLOGY

The basic concept of this method is that the components already locked to the printed circuit board are tested without destructive impact. Testing shall also be provided without affecting the operability of the investigated system. Despite the wide range of problems, hardware support for JTAG technology is simple (Figure 1). In order to carry out diagnostics, it is assumed that the exchange between the reader and the test tools built into the integrated circuit is provided. Let 's look at a JTAG system running on 4 external contacts of a Test Access Port (TAP):

• TDI (Test Data Input) - contact to obtain serial data, which is interpreted by the control circuit.

• TDO (Test Data Output) - serial data output pin. Data read from the LIC is transmitted to an external diagnostic device;

• TCK (Test Clock Input) - pin used to synchronize signals transmitted to the reader;

• TMS (Test Mode Select) - the contact responsible for tracking the signal direction: commands from the diagnostic system, or data read from the integrated circuit. Besides, there can be a contact providing dumping of the controller of internal automatic machine TAP an initial condition of TRST (Test ReSeT).

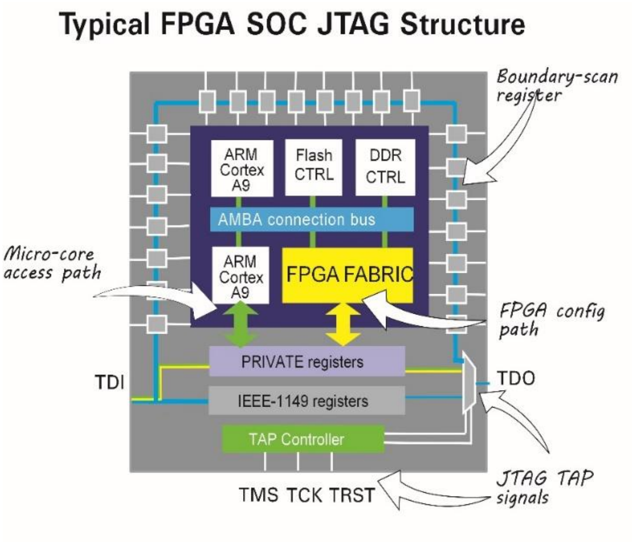


Fig. 1. Generalized diagram of an IC comprising a BS structure.

The TAP controller is a state detection unit whose diagram, containing 16 variations, is shown in Fig.2. It provides data loading and command loading according to operating modes.State transitions are made according to the value of the TMS signal indicated on the respective arcs of the diagram and are synchronized by the front edge of the TCK console. TAP operation is performed by switching on some serial circuit in the form of a set of triggers. Обратите внимание, что 14 государств распределены в две симметричных колонки и отличаются только суффиксом их этикеток, которые соответствуют, какая группа регистров эти государства связаны - IR или DR. The reset state means that the TAP controller is reset to TLR (Test-Logic-Reset). The asynchronous reset of the controller is always performed when the signal level/TRST is low, and if the signal level of the TMS is high and synchronizes with more than five TCK, the controller will be reset synchronously. The need to reset the controller may arise, for example, after the power supply to the PCB. Note that powering up the IE will automatically reset the controller to TLR.

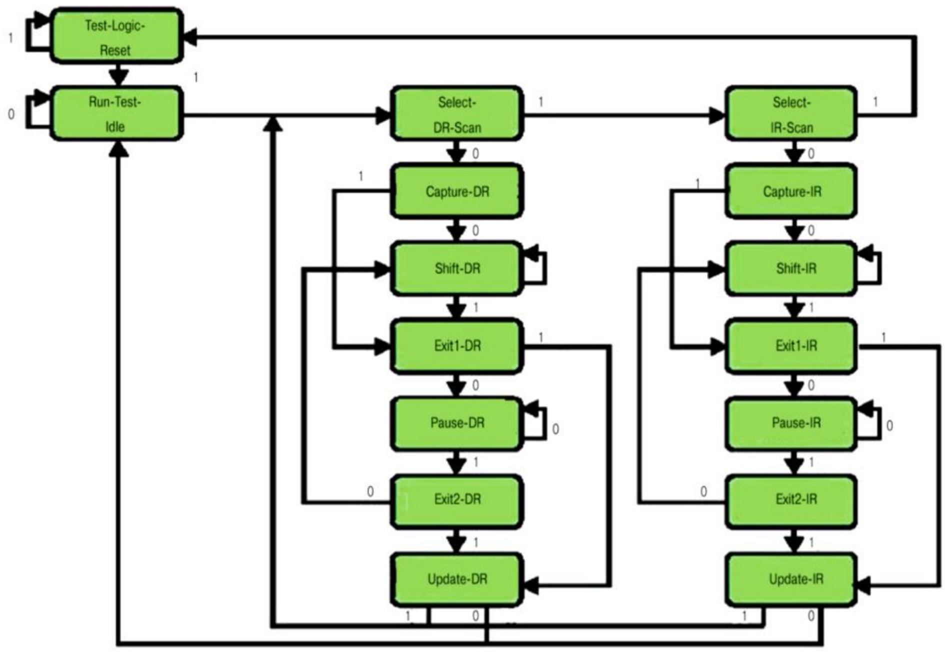


Fig. 2. TAP Controller Status Diagram

TOOLS FOR GENERATING TEST APPLICATIONS AND TESTING AND PROGRAMMING BOARDS AND SYSTEMS

Peripheral scanning is built on automated test sequence creation and is inextricably linked to the concept of ATPG (Automatic test pattern generation). Create and run tests using a connected computer with specialized software installed. One such software product is JTAG ProVision, which automatically creates and runs tests and analyzes results. To do this, preenter data from the PCB CAD as a Netlist, BDSL files for each peripheral scanning component, and test models of components that do not support JTAG.

Netlist is a list of electrical connections. That is, it contains information about connections between components (electrical elements).

The BDSL file contains information about the structure of the component 's edge scan system. It describes outputs that can work as test inputs and outputs, JTAG controller instructions, etc. Non-functioning components are identified by comparison with the fault library, in case of simple system diagnostics, or when complex components are checked, functional models that take into account key parameters are used. This system allows you to extend research boundaries because it supports importing component models created in different formats.

Based on all available information, test vectors are created, that is, digital data, which are displayed on outputs of components supporting peripheral scanning, and sequence of interrogation of these components.

Thus, the JTAG ProVision software allows you to create different types of tests using application wizards, in which all parameters of the test program are set in stages. In addition, it is possible to make adjustments to an existing project by adding circuits or components or, on the contrary, removing unnecessary data to best solve the problem of diagnosing a printing node. If you test multiple boards simultaneously, you can use the Interconnect Editor to describe the relationships between boards. It is also possible to use multiple TAP ports or, conversely, to combine them if there are fewer ports at the edge scanning station than at the product. [1]

Upon completion of diagnostics, after finding the values on the tested outputs of electrical circuits, the information is presented in table form, and the established defects will be identified and shown up to the indication of the specific circuit (Fig.3). The renderers allow to superimpose the obtained information on the circuit board topology or circuit diagram (Fig.4), thus it is possible to visually assess the presence of defects.

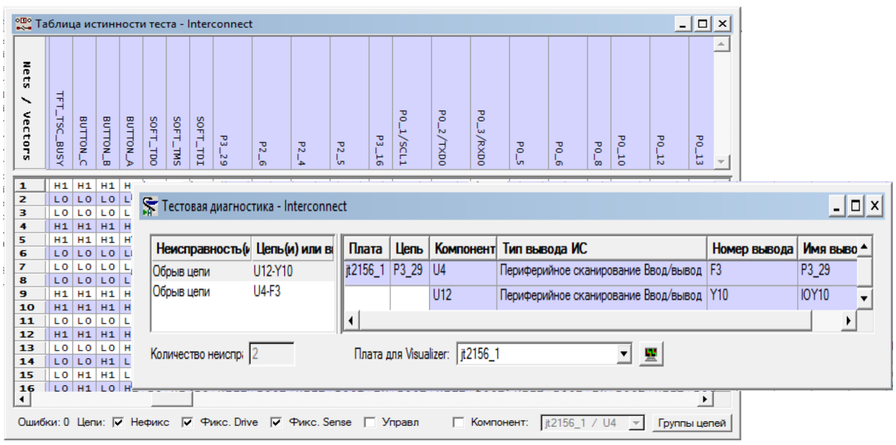


Fig. 3. Displaying Test Results as a Truth Table

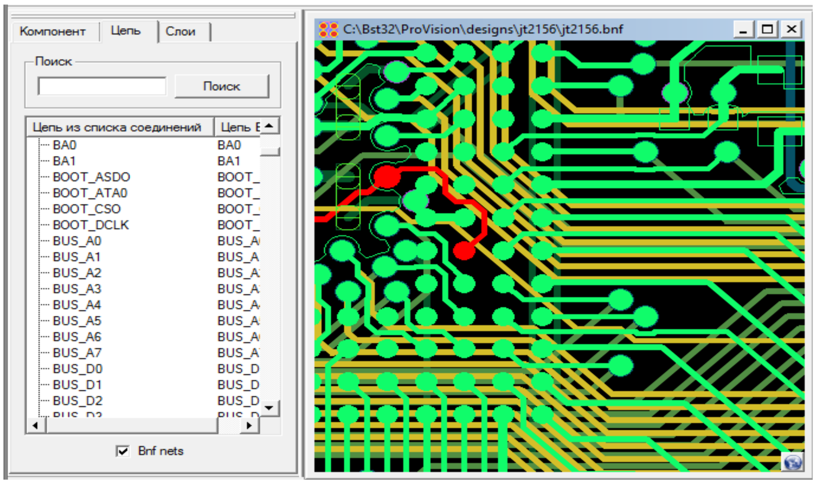


Fig. 4. Visualization of results of testing

In addition to JTAG ProVision there is a variation of JTAG Live-AutoBuzz, which allows to test the product in automatic mode, at the same time comparison of the obtained results with reference ones, which were obtained in advance when examining a serviceable product. Clip allows you to create test vectors and check the logic of the chips. This software is based on BSDL file data.It can automatically collect information about serviceable circuits and compare with the faulty circuit.

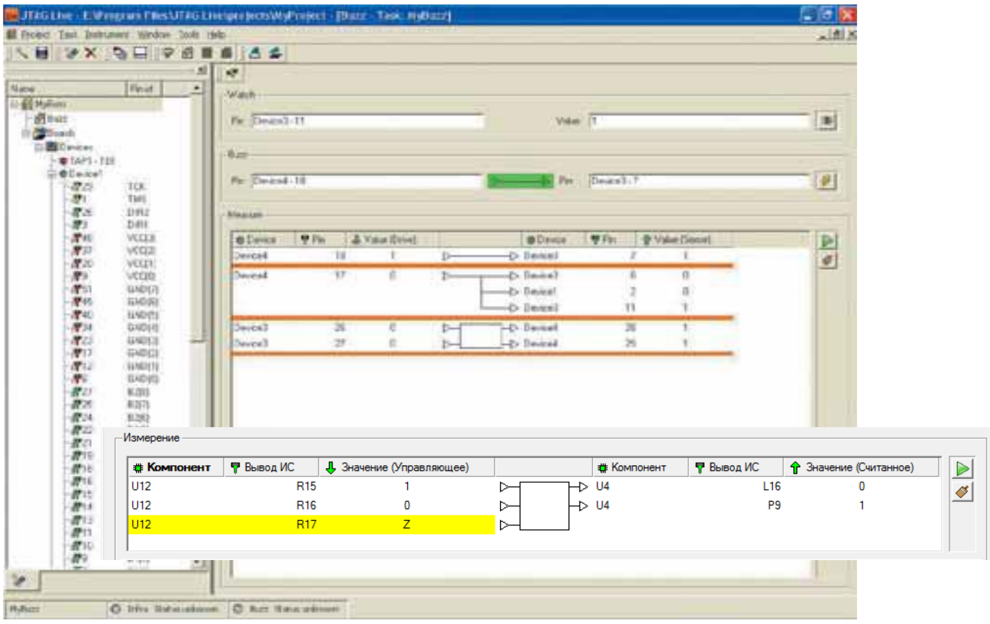


Fig.5. Application JTAG Live Buzz

Based on the scanning principle, the ability to test a board using edge scanning methods is determined by its integrity. Both straight circuit systems and resistive branches can be tested, and if there are any interface connectors on the board, it is possible to diagnose interfaces of this kind. After the diagnosis, the clusters that did not support the transfereal scan are generally examined. Such systems may include digital, and hybrid chips.

JTAG technology is popular enough to diagnose components of electronic systems. An example of Russian products supporting JTAG technology for component testing is presented in Table 1.

Table 1. Russian chips supporting IEEE 1149.1 (January 2020)

ВЗПП-С	5576ХС1Т, 5576ХС4Т, 5576ХС6Т, 5576ХС7Т, 5578ТС014, 578ТС024, 5578ТС034, 5578ТС084, 5578ТС094
Миландр	1967ВЦ2Ф, 1967ВЦ3Т, 1986ВЕ94, 1986ВЕ8, 1986ВЕ91Т, 1986ВЕ1Т микросборка «Осведомленность», микросборка «Flipchip».
МЦСТ	1891ВМ8Я (Эльбрус-4С), 1891ВМ10Я (Эльбрус-8С), R1000, 1991ВГ2Я (КПИ2), 1891ВМ11Я (Эльбрус 1С+)
Модуль	1878ВМ3, 1879ВМ5Я, 1879ВМ6Я, 1879ВЯ1Я, 1879ВМ7Я, 1888ВС048, 1888ТХ01
НИИИС	1914ВА018А
НИИСИ РАН	1890ВГ2Т, 1890ВГ3Т, 1890ВГ4Т, 1890ВГ5Т, 1890ВГ6Т, 1890ВГ8Т, 1890ВГ9Т, 1890ВГ10Т, 1890ВГ12Т, 1890ВГ14Т, 1890ВГ15Т, 1890ВГ18Я, 1890ВГ19Я, 1890ВК018, 1890ВК028, 1890ВМ2Т, 1890ВМ3Т, 1890ВМ5Ф, 1890ВМ6Я, 1890ВМ7Я, 1890ВМ8Я, 1890ВМ9Я, 1890ВМ108… **Для полного списка обратитесь во ФГУП НИИСИ РАН или JTAG Technologies**
НИИЭТ	1887ВЕ7Т, 1867ВЦ2АТ, 1867ВЦ4Т, 1867ВЦ8Ф, 1867ВЦ9Т, 1906ВМ016
НПП Цифровые Решения	5023ВС016 (Процессор «Спутник») (Производитель: Ангстрем)
ЭЛВИС	1892ХД4Ф, 1892ВМ15Ф, 1892ВМ14Я

CONCLUSION

Thus, it can be said with certainty that edge scanning capabilities offer new opportunities for rapid evaluation of manufactured electronic products. JTAG methods allow to check the integrity of the system, and to assess the correctness of operation of all buses linking components to each other. The JTAG interface also allows the PLD to be programmed. As a result, even for a board that has only one component supporting peripheral scanning, it can provide up to 90% of the test coating of the product. JTAG Technologies test systems are today the most promising in terms of their reliability and automated research. JTAG development companies are constantly improving the tool system to support working with JTAG to create a simple and convenient work environment for users and save time and cost during component testing. In the future, according to experts in the field of diagnostics of printed circuit board components, JTAG will be the best choice for its new products.The continuous development of auxiliary tools further facilitates the application of JTAG.

REFERENCES

1. Ivanov A. V. New Options for Testing Boards Using Edge Scanning//Components and Technologies. 2010. № 5.
2. The first conference of users of peripheral scanning systems in Russia, June 2, 2015 in St. Petersburg.
3. Alexey Ivanov. Tools for edge scanning: testing boards and debugging function nodes.
4. Ivanov A.V. Report: Peripheral Scanning Technology//Seminar: JTAG, as a testing technology: from scheme development to serial production, advantages at all stages.
5. N. Klyukvin. Introduction to Edge Scan Technology Developer Description and Recommendations. 2013 №5 (00127).

SELECTION PARAMETERS OF SHOCK IMPULSE DURING MECHANICAL TESTS OF PRINTED CIRCUIT BOARD ASSEMBLIES

Pham Le Quoc Khanh, Saygid Uvaysovich Uvaysov, Tatyana Alexandrovna Popova, Sergey Demchenko
MIREA - Russian Technological University, Moscow, Russia
+7(917)-560-73-35, tatiana241187@gmail.com

Abstract: A method for assessing the dynamic properties of printed circuit board assemblies by dynamic characteristics is considered. They make it possible to evaluate the reliability of the system by identifying certain groups of problems. This method of automated diagnostics of printed circuit board assemblies is based on the creation of a mathematical model using dynamic characteristics.

The basic concept is reduced to the application of the study of the response to disturbing shock effects. It is shown that for certain groups of failures the impact will be decisive, the rendering of which will remove the reaction of the board after the impact. Moreover, on the basis of experimental studies, it was shown that different groups of defects manifest themselves in a change in the output signal. The paper presents an approach for finding an effective master signal, to which the greatest response will be noticeable in the presence of defects of a certain kind.

Key words: diagnosis, shock, reaction to shock, mechanical defects, mathematical modeling.

INTRODUCTION

The main objective of the tests for impact strength and impact resistance is to check the ability of the product to withstand the destructive effects of mechanical shocks of single or multiple action. In other words, the product must maintain the basic parameters during impact exposure within the limits specified in the standards and specifications after or during impact [1].

Mechanical tests with the help of impacts make it possible to control the quality of elements, equipment and other electrical products. Impact test data are key information about the manufactured product, since they allow you to evaluate whether the product is able to withstand in real conditions of work [1].

Distinguish force and kinematic shock effects on the studied system, which cause a reaction - shock motion. Impact motion is determined by impact acceleration, speed and displacement. Together, such effects and reactions are called shock processes.

Impact processes can be single, multiple (with a periodic or random sequence of strokes) and complex.

However, simple single shock pulses are widely used in shock testing.

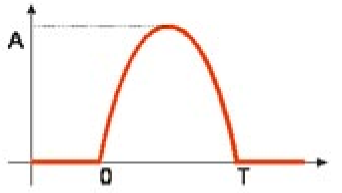
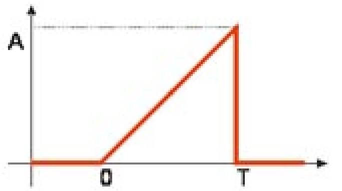
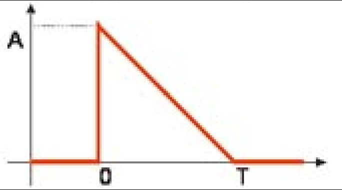
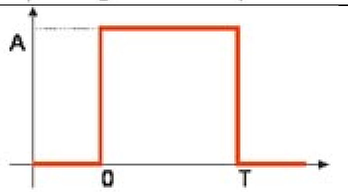
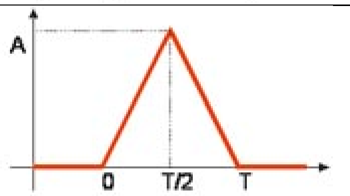
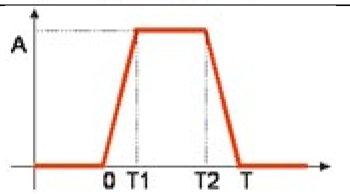
A mechanical shock is characterized by a rapid release of energy, resulting in local elastic or plastic deformations, stress waves, and other effects. The results of impact on the object depend on the characteristics of the impact and the mechanical properties of the structure

The shape of the impact is a wide range of frequencies and causes resonance simultaneously at several natural frequencies. In the case of impact tests using real short-term impacts on the test setup, various types of failures can be detected. [1]

Depending on the method of conversion of kinetic energy by a forming device, pulses of various shapes can be obtained. Typically, when exposed to a single blow, the nominal acceleration at the test point is approximated by a sawtooth pulse with a peak at the end, a half-sine wave, or a trapezoidal pulse. [1]

The initial objective of the study was to find the optimal shape of the master shock pulse

According to the article [2], such types of impulse are considered in detail:

Half-sine pulse	
Sawtooth rising pulse	
Sawtooth falling pulse	
Rectangular pulse	
Triangular pulse	
Trapezoidal pulse	

It should be noted that for a sawtooth rising pulse, a sawtooth falling pulse and a rectangular pulse, it is not possible to set a vertical front and a vertical fall, a sharp front and fall are set.

When conducting real experiments, it is impossible to set a rectangular pulse.

Computer simulation was performed with the parameters: A = 10 mm, T = 0.02 s, T1 = 0.005 s, T2 = 0.015 s and the following results were obtained:

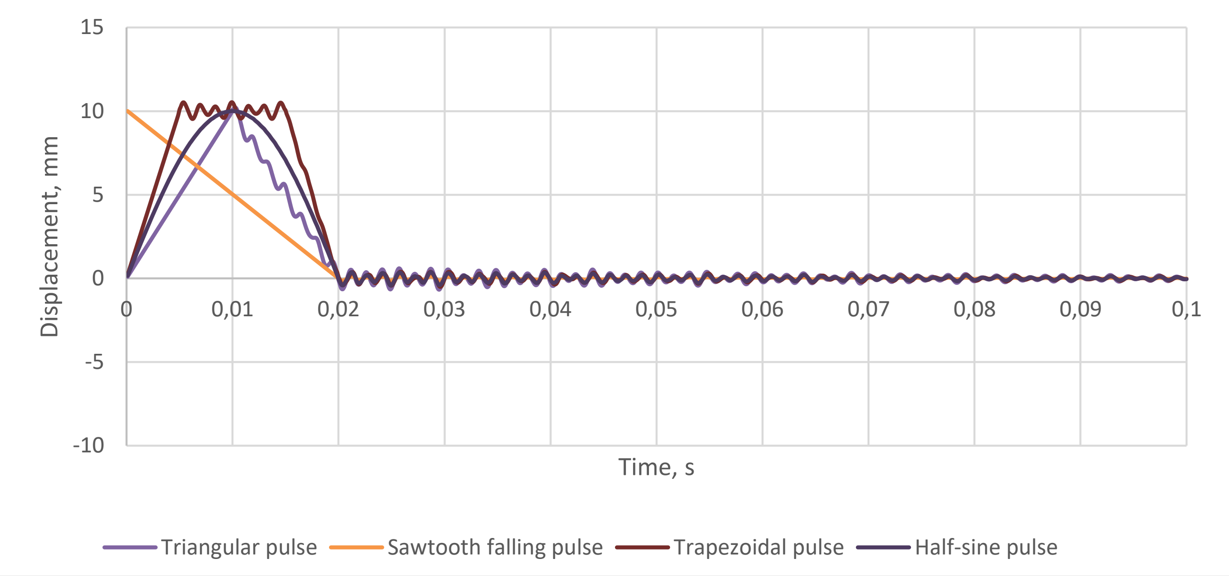


Fig. 1 Impact reaction of a triangular, trapezoidal, half-sine and sawtooth falling pulse

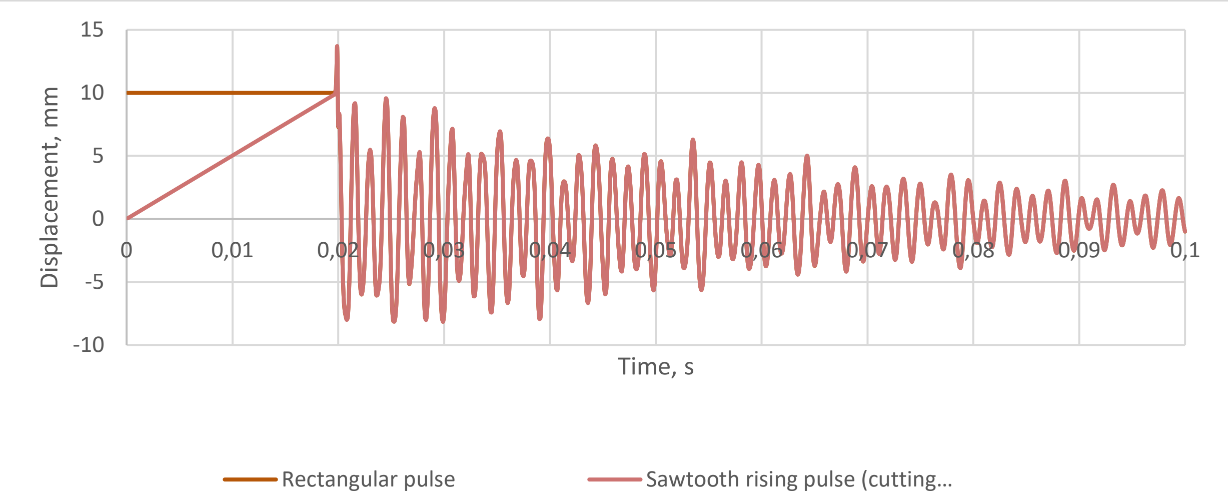


Fig. 2 Impact reaction of a sawtooth rising and rectangular pulse

Based on the results obtained (see Fig. 1, Fig. 2), it can be noted that:

- if we set a rectangular pulse or sawtooth rising pulse, we get an exciting wave with a large amplitude, which allows you to obtain the necessary data.

- the exciting wave does not depend on the front of the pulse, but only depends on the decline of the pulse.

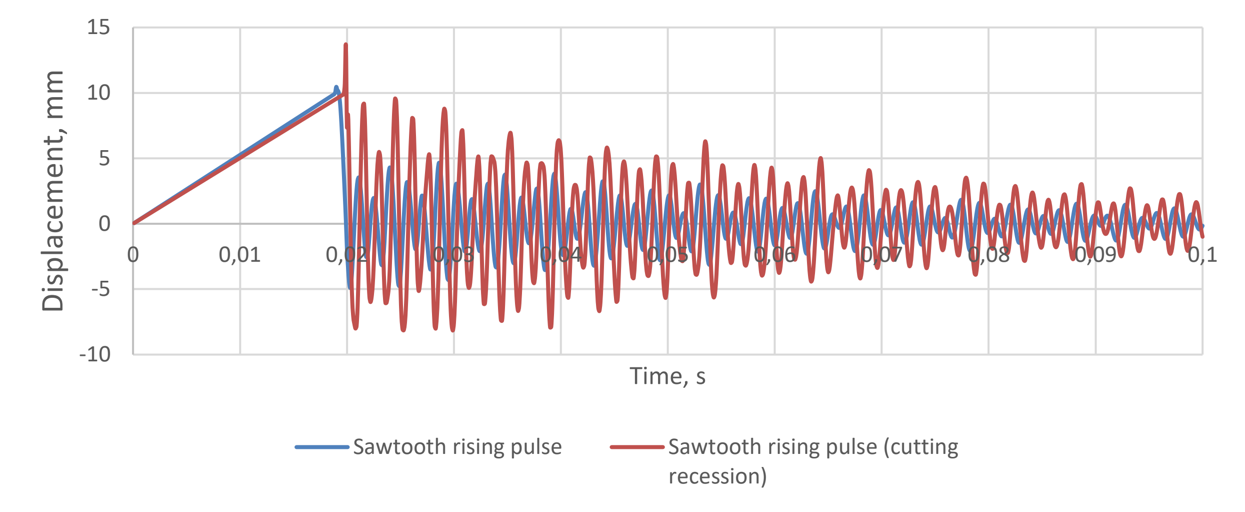


Fig. 3 Impact reaction of sawtooth rising pulse different decay times

Figure 3 shows the shock response at different durations of the decay of the input signal pulse. From figure (3) it follows that if the pulse decay tends to vertical, then the amplitude of the exciting wave is much larger.

Thus, we select a sawtooth rising pulse as the driving signal to simplify further studies.

To find the optimal value of the amplitude of the driving pulse, a simulation was carried out with an amplitude of 10 mm and 5 mm and fixed duration of the driving pulse of 0.01 s

From Figure (4) we see that a 2-fold increase in the amplitude of the input pulse (5 mm -> 10 mm) will also lead to a 2-fold increase in the amplitude of the exciting waves. Thus, it is necessary to set an impulse with an amplitude that is closer to the upper sensitivity range of the shock sensor and with such an amplitude of the shock effect at which it does not break the object under study.

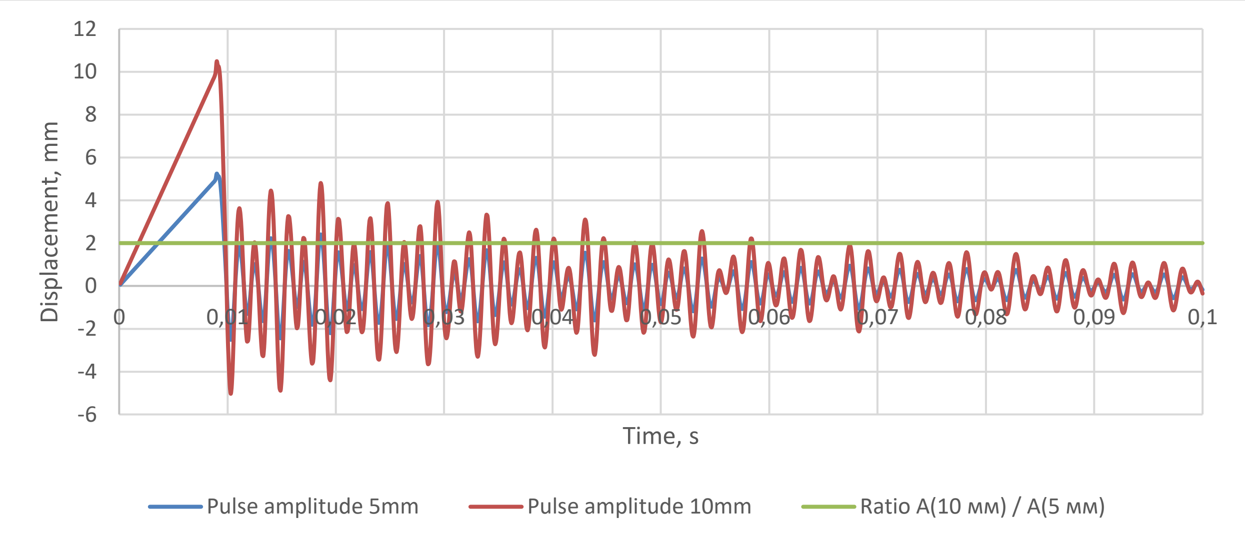


Fig. 4 The response of the system at different amplitudes of the input impact.

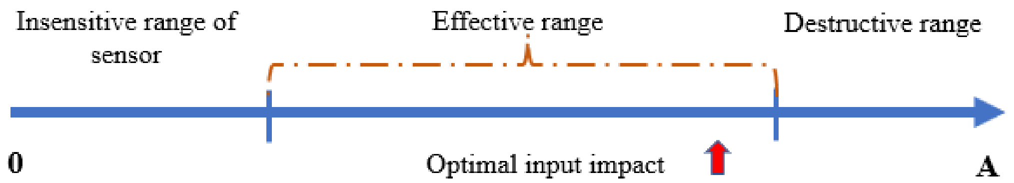


Fig. 5 Range of effects

Next, modeling was performed with a fixed amplitude of 10 mm and durations of 0.01 s; 0.02 s and 0.03 s

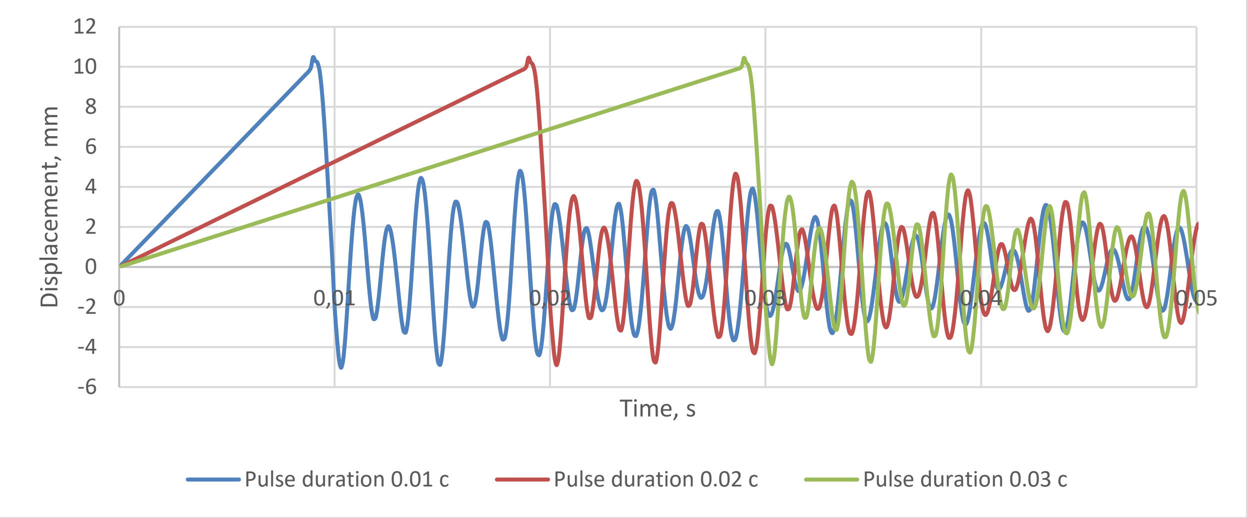


Fig. 6 Reaction at different pulse durations of the input impact.

Although the study was conducted at different input pulse durations (0.01 s; 0.02 s; 0.03 s), the period of the excited waves does not change (T ~ 0.0016 s)

Conclusion: changing the duration of the input pulse does not help to investigate easier.

CONCLUSION

Any design is an anisotropic heterogeneous structure with its own mechanical characteristics (mass distribution in the structure).

When the physical characteristic changes, the response pattern of the system changes due to changes in the mass distribution. Thus, when testing for impacts, certain dependencies can be distinguished. This method of automated diagnostics of printed circuit board assemblies is based on the creation of a mathematical model showing the amplitude-time dependence of the response of the system from shock. This approach carries the simplification of rejection of products and, as a result, reduces the risk of breakdown of finished products. Given the increasing requirements for product quality, as well as to reduce time spent on control, we consider automated diagnostics of the mechanical characteristics of printed circuit boards to be the best approach.

The choice of an effective input pulse signal is key in the matter of mechanical testing of electronic means. This is important to ensure the necessary reliability of the diagnostic results. Thanks to the results, it becomes possible to make a reasonable choice of the parameters of effective sawtooth pulses.

REFERENCES

1. Magazine “Equipment for testing for exposure to external mechanical factors” - Ostek-Test LLC, www.ostec-test.ru

2. “The shock spectrum and Duhamel integrals” /https://zetlab.com/udarnyiy-spektr-i-integralyi-dyuamelya/

IMPROVING OF THE NOISE IMMUNITY FOR SATELLITE ANTENNA SYSTEMS

Nefedov V.I., Trefilov N.A., Mirolyubova N.A., Markin A.A.
MIREA – Russian Technological University

Abstract - The article contains numerical methods of antenna design. The antenna reflector, the surface of which is divided into the MOM and CM areas, is considered. The results of each method are given.

Keywords – noise, antenna, method of moments, MOM.

The degree of noise immunity of satellite antenna systems depends on the decisions made at the design stages and on design errors. One of the main causes of design errors is the approximate nature of the mathematical model of antenna radiation. The main aperture design method does not allow to evaluate the lateral radiation of antennas, especially for deployable structures, therefore, numerical methods for antenna design based on solving integral equations for currents induced on the antenna reflector by the irradiator field are currently mainly used.

The method of moments (Method of Moments – MOM) used for discretization of integral equations is the most powerful and effective for a numerical approach in modeling radiation of antennas [1-3]. It is often used to solve small problems of radiation, diffraction, and scattering of radio waves [3]. However, the traditional implementation of MOM has significant limitations for both electrically small and large antennas, since its computational costs quickly increase with increasing antenna sizes. Satellite antenna systems use electrically very large conductive metal surfaces, having dimensions that are many wavelengths, and often with significant curvature of the edges. But also a significant part of such surfaces has a small curvature at the wavelength scale, and therefore such regions can be represented in a locally flat form. To reduce the computation time and RAM requirements, it is expedient to use MOM and numerical approximation methods [4–8] for the asymptotic analysis of electrically very large slightly curved conducting surfaces. The resulting accuracy of the analysis will be quite high due to application of MOM due to the accurate consideration of the influence of all surface areas with significant curvature. MOM can be combined with a high-frequency asymptotic current method (CM) of physical optics. In the current method for calculating antennas, the induced currents are directly related to the value of the tangential component of the magnetic field strength of the irradiator acting at the reflector surface [5]. In this case, some regions of the complex surface of the reflector will be described by MOM, and the remaining parts of the surface will be described by asymptotic methods. The use of asymptotic methods based on the current representation is preferred, since the MOM also determines the currents induced on the mirror. Therefore, when using the current approach, such a joint method will allow us to find currents on the entire surface, and then, using known currents, find the radiation field and antenna characteristics.

The theoretical basis of the joint method is a system of coupled surface integral equations with the integral equation of the electric field in the exact MOM and the integral equation of the magnetic field in the asymptotic current method. The proposed joint method is a generalization and extension of the Galerkin method [4] and is a higher order method. Approximately the same way, this is done in the fast method of moments proposed by V. Rokhlin [2], in which, taking into account the mutual influence of radiating currents, various geometric models of the surface are used, depending on the mutual distance. In the presented technique, combining the current method and the method of moments (CM-MOM), the entire radiating surface in the antenna in the CM regions is modeled by electrically large generalized curvilinear quadrangles of arbitrary shape due to the curvature of the antenna reflector. This allows you to maximize the overall efficiency and accuracy of the joint method.

But the use of curvilinear quadrangles as partitions of the lower cells makes it difficult to determine the normal vector to the cell surface in the calculation process. To avoid unnecessary difficulties in calculating the normal, the quadrangles are divided into two triangles by the diagonal, the surface of each triangle is approximated by a plane passing through the vertices of the triangle, which allows you to calculate the normal vector simply.

Since the quadrilateral cells of the splitting of the radiating surface have a higher order of geometric flexibility for modeling curvature, large curvilinear quadrangles with sizes of the order of λ in each coordinate, including up to hundreds of unit cells, can be used in the region of the asymptotic current approach. This means that the elements into which the radiating surface is divided can be two orders of magnitude larger than those used with the standard MOM, which significantly reduces the total number of unknowns, significantly improves computational performance, and reduces the computational errors of the proposed method.

Consider an antenna reflector formed by a perfectly conductive surface. Suppose that the surface is excited by an incident harmonic electromagnetic field E^n and H^n. This field may be the antenna feed field. First, we compose the integral equations for the distribution of the induced electric current arising on the surface under the influence of the incident field. We divide the surface into the MOM region and the CM region (Fig. 1). The surface conductivity current densities flowing in the MOM and CM regions are denoted by $\boldsymbol{J}_S^M$ and $\boldsymbol{J}_S^{TM}$, respectively. Induced currents flowing over areas of the regions create their own fields E, H. The total electromagnetic fields, consisting of the incident field and the field created by the induced currents, satisfy the boundary conditions for the tangential components of the complex amplitudes of the electric and magnetic fields on an ideally conducting surface.

$$\vec{n}_0\left[\vec{E}_0\left(J_S^M\right)+\vec{E}_0\left(J_S^{TM}\right)+\vec{E}_0^{i}\right]=0, \tag{1}$$

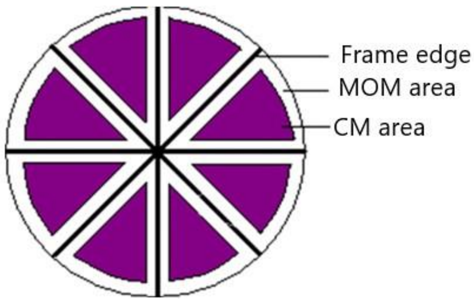


Fig. 1. Identification of surface areas considered by the current method and the method of moments

$$\vec{J}_S^M+\vec{J}_S^{TM}=2\vec{n}_0\left[\vec{H}_0\left(J_S^M\right)+\vec{H}_0\left(J_S^{TM}\right)+\vec{H}_0^{i}\right], \tag{2}$$

Where $\vec{n}_0$ is the unit vector of the external normal to the surface, $\vec{H}_0$ the total value of the complex amplitude of the magnetic field strength, provided that the observation point for which the boundary conditions are recorded is located directly on the surface S. Note that the $\boldsymbol{J}_S^M$ current exists only in the MOM area and on its border.

The first boundary condition allows us to write the integral equation of the electric field for the induced current, which is used in the MOM region, and the second condition allows us to obtain the integral equation of the magnetic field for the induced current in the CM region. The radiated electric and magnetic fields are expressed from the Macswell equations in terms of the magnetic vector potential and the scalar electric potential φ

$$\dot{\vec{E}}_0=-j\omega\mu_0\,rot\,\vec{A}-grad\,\varphi, \tag{3}$$

$$\dot{\vec{H}}_0=rot\vec{A}. \tag{4}$$

The potentials of the field at the observation point represented by the radius vector are related to the induced currents through the Green's function by the source view

$$\vec{A}(\vec{r}) = \int_S G\vec{J}_s dS, \tag{5}$$

$$div\vec{A} + j\omega\varepsilon_0\varphi = 0\,. \tag{6}$$

Here ε_0, μ_0 are the absolute permeability of free space, G is the Green's function of free space, defined by the expression

$$G = \frac{1}{4\pi}\frac{e^{-jkr}}{r}, \quad k = \omega\sqrt{\varepsilon_0\,\mu_0}\;, \tag{7}$$

where r is the distance between the source point at which the surface current value is measured and the observation point at which the boundary conditions are satisfied.

In this method, equation (2) is solved using the approximation of physical optics for surface currents, which neglects the mutual effects of the interaction of currents within the CM region. The decrease in complexity in the joint MOM-CM method can be compared with the complete MOM, if we do not take into account the mutual influence between the various surface elements in which the induced currents flow in the CM region

$$\vec{J}_S^M + \vec{J}_S^{TM} = 2\vec{n}_0\left[\vec{H}_0\left(J_S^M\right) + \vec{H}_0^{i}\right]. \tag{8}$$

The integral equation of the electric field can be written by substituting (5) in (3) and (1) expressing the operations in terms of the Hamilton operator ∇ in the following form

$$\vec{n}_0\left[\omega\mu_0\int_S\left(\vec{J}_S^M + \vec{J}_S^{TM}\right)GdS + \frac{1}{\omega\varepsilon_0}\vec{\nabla}\int_S\vec{\nabla}_S\left(\vec{J}_S^M + \vec{J}_S^{TM}\right)GdS + \vec{E}_0^n\right] = 0. \tag{9}$$

The integral equation of the magnetic field can be written as

$$\left(\vec{J}_S^M + \vec{J}_S^{TM}\right) = 2\vec{n}_0\left(\vec{\nabla}\int_S \vec{J}_S^M GdS + \vec{H}_0^n\right). \tag{10}$$

To solve the integral equations, various types of basis and weight functions are used, for example, piecewise constant or “roof” functions are used as the basis. The choice of functions determines the numerical complexity of the implemented solution algorithm. In the case under consideration, it is better to use basic functions that allow you to naturally combine currents flowing in the MOM and CM regions, and that allow you to combine individual cells of the grid of the surface partition into generalized quadrangles of a higher geometric order. We will search for currents using separate sets of basis functions for both MOM and CM regions and using separate weight functions for these two regions. The full hybrid integral equation in the matrix form can then be expressed as follows

$$\begin{bmatrix} Z_M^M & Z_{\mathrm{TM}}^M \\ Z_M^{\mathrm{TM}} & Z_{\mathrm{TM}}^{\mathrm{TM}} \end{bmatrix}\begin{bmatrix} I_M \\ I_{\mathrm{TM}} \end{bmatrix} = \begin{bmatrix} V^M \\ V^{\mathrm{TM}} \end{bmatrix}. \tag{11}$$

Here, the superscripts refer to the observation point, and the subscripts to the source point. The elements of the source matrix, determined by the falling field, can be written

$$V^M = \int_{S(w)} W^M\,\dot{\vec{E}}_0^{i}\,\mathrm{d}S^{(w)},$$

$$V^{\mathrm{TM}} = \int_{S(w)} W^{\mathrm{TM}}\left(\vec{n}_0\,\vec{H}_0^{i}\right)\mathrm{d}S^{(w)}. \tag{12}$$

The index w shows that the integration region coincides with the domain of determination of weight functions W for M and CM regions.

When using the linearity property of the system of equations of electrodynamics for fields created by various sources, the expressions for the elements of the impedance matrices are obtained in the form

$$Z_M^M = \omega\mu_0 \int_{s^w}\int_{s^b} W^M B^M G dS^b dS^w + \frac{1}{\omega\varepsilon_0}\int_{s^w}\int_{s^b}\left(\vec{\nabla}_S W^M\right)\vec{\nabla}_S B^M G dS^b dS^w, \tag{13}$$

$$Z_{TM}^M = \omega\mu_0 \int_{s^w}\int_{s^b} W^M B^{TM} G dS^b dS^w + \frac{1}{\omega\varepsilon_0}\int_{s^w}\int_{s^b}\left(\vec{\nabla}_S W^M\right)\vec{\nabla}_S B^{TM} G dS^b dS^w, \tag{14}$$

$$Z_M^{TM} = \frac{1}{2}\int_{s^w} W^{TM} B^M dS^w - \int_{s^w} W^{TM}\vec{n}_0\left[\vec{\nabla}\int_{s^b} B^M G dS^b\right]. \tag{15}$$

$$Z_{TM}^{TM} = \frac{1}{2}\int_{s^w} W^{TM} B^{TM} dS^w. \tag{16}$$

Here S^b, S^w are the domains of definition of basis and weight functions, respectively.

From the equation following from (11), when solving the system of equations by the method of successive exclusion, unknown currents in the CM region can be expressed as

$$I_{TM} = \left(Z_{TM}^{TM}\right)^{-1}\left(V^{TM} - Z_M^{TM} I_M\right). \tag{17}$$

Substituting this expression into the equation following from (11) leads to the following matrix equation

$$\left[Z_M^M - Z_{TM}^M\left(Z_{TM}^{TM}\right)^{-1} Z_M^{TM}\right] I_M = V^M - Z_{TM}^M\left(Z_{TM}^{TM}\right)^{-1} V^{TM}\ . \tag{18}$$

This equation must be solved regarding to currents in the MOM region. The numbering of mesh cells is done separately in each area. After finding these currents, the currents in the CM region can be found from (17).

To determine the currents on vibratory antennas, the method of induced EMF proposed by D. A. Rozhansky and Brillouin is used [5]. The method is applicable in the case of a known law of current distribution on conductors, determined only by the shape of the conductor. The complex amplitude of the current on the conductor can change under the influence of third-party or induced EMF. In computational methods used in the antenna theory, the surface of the reflector is divided into separate cells and it is assumed that in each cell there is a current created by an external field that creates a third-party EMF and induced current created by induced EMF due to the influence of currents flowing in other cells. Law of current distribution on the cell is the same for all cells and it is determined by the applied type of the basis functions, for example, piecewise constant, sinusoidal. The main assumption of the induced EMF method is carried out in numerical methods for calculating antennas that implement MOM; there are no obstacles to the application of the induced EMF method for calculating currents on the conductors of a network-reflector. Consider an isolated reflector cell containing a fragment of a net-wire. Under the influence of the electromagnetic field of the irradiator, an EMF and a primary current are created on it, the ratio between them can be compared with the intrinsic impedance of the emitter formed by a conductor fragment. Select two cells of the reflector grid containing two fragments of conductors arbitrarily located relative to each other. The currents flowing along them lead to the creation of a secondary field. The secondary field as a result of the mutual influence of the conductors on each other changes the primary distribution of currents, which can be compared with the appearance of induced impedances on the emitters. Induced impedances have the following components:

$$Z_{ij}^{í} = -\frac{1}{I_i I_i^*}\int_{l_i} I_i^* \vec{E}_{ji} d\vec{l}_i , \tag{19}$$

Where I_i is the current on the i-th emitter, $\vec{E}_{ji}$ is the secondary electric field created by the j-th emitter on the i-th emitter, $d\vec{l}$ is the vector that defines the orientation of the i-th emitter having a length l_i. If the primary currents have equal amplitudes, the induced resistances on the emitters are called mutual, it follows from (19) that

$$Z_{ij} = Z_{ij}^{í}\frac{I_j}{I_i} . \tag{20}$$

The introduction of induced resistance according to (19) is equivalent to the imposition of boundary conditions according to (1), (2),so, in this formulation, the method of induced EMF is equivalent to the MOM method. When taking into account the mutual influence of all fragments of conductors on all cells of the grid, the reflector canvases can be obtained on the basis of the Kirchhoff equation for the equivalent emitter circuit of the equation for the currents flowing through the cell emitters in the form of a matrix equation

$$\begin{bmatrix} U_1 \\ U_2 \\ . \\ U_N \end{bmatrix} = \begin{bmatrix} Z_{11} & \dots & Z_{1N} \\ . & & \\ Z_{N1} & \dots & Z_{NN} \end{bmatrix} \begin{bmatrix} I_1 \\ I_1 \\ . \\ I_N \end{bmatrix}, \tag{21}$$

where on the left side there is a matrix of EMF created by the field of the irradiator of the mirror antenna on individual fragments of conductors, and on the right side is a matrix of the sought currents. The relation (21) is equivalent to (11) in the previous approach. If piecewise constant basis functions are used for the emitter currents formed by individual fragments of the grid, then the emitter field included in (21) in the coordinate system

$$\dot{\vec{E}}_{ji} = \frac{I_j l_j k^2}{4\pi\omega\varepsilon_0\varepsilon}\frac{e^{-jkr_{ij}}}{r_{ij}}\left[\left(j + \frac{1}{kr_{ij}} - \frac{j}{(kr_{ij})^2}\right)\vec{\theta}_0 \sin\theta + 2\left(\frac{1}{kr_{ij}} - \frac{j}{(kr_{ij})^2}\right)\cos\theta \cdot \vec{r}_0\right] \tag{22}$$

Here the angle θ is counted from the direction of the emitter axis.

Own input impedance of the emitter is determined by the formula

$$Z_{ii} = \frac{\vec{n}_0 \vec{E}^{ï}\vec{l}_i}{\left|\vec{n}_0 \vec{H}^{ï}\right| 4\pi\rho}, \tag{23}$$

where ρ is the radius of the wire mesh.

The proposed approach allows us to significantly simplify the algorithm for finding currents on the emitter, as well as apply a more accurate physical model for the surface of the antenna reflector formed by a net-sheet, and reduce the amount of computation without combining MOM and CM or without introducing the concepts of fast MOM. It isn’t necessary to introduce integral equations into consideration, since in the proposed method for numerical implementation a solution scheme similar to MOM is immediately executed.

The volume of calculations is reduced due to the fact that (22) allows us to introduce simplified formulas for radiators included in the near ($kr_{ij} \ll 1$) and in the far zone of the field ($kr_{ij} \gg 1$). To take into account the influence of the fields of emitters located in the far zone, when the condition $r_{ij} \gg r_{im}$ is fulfilled, it is possible to group emitters, taking into account their total field when calculating the mutual resistances. In the equivalent circuit of the emitter circuit, in this case, individual impedances form the total impedance, and the impedance matrix in (21) acquires a block structure, as in fast MOM or in joint MOM-CM. Moreover, the group can include the number of emitters forming a total length of the order of λ. This assessment follows from the pattern of behavior Z_{ij} as they increase r_{ij}. The latter approach is greatly simplified when used for flat antennas.

REFERENCES

1. Harrington R.G. Field Computation by Moment Methods. - N.Y.: 1968. - pp. 230.
2. Rokhlin V. Rapid solution of integral equations of scattering theory in two dimensions // J. Comput. Phys., vol. 86. - – 1990. - – №2. - 414-439 pp.
3. Litvinov D.A., Trefilov N.A. Application of the induced EMF method for modeling strip antennas with a wide emitter // Radio Electronics Issues, a series of Radar Techniques, vol. 1, 2010.– p. 178-186Fletcher K. Numerical methods based on the Galerkin method. - Moscow: Mir, 1988. - – 352.
4. Kyung R. Microwave Antennas. - Moscow: Shipbuilding, 1967/.
5. Bouche D.P., Molinet F.A., Mittra R. Asymptotic and hybrid technique for electromagnetic scattering // Proc. IEEE. - vol. 81, №12, 1993. - – p.1658-1684.
6. Jacobus U., Meyer J.C. A hybrid physical optics method of moments numerical technique: Theory, in-vestigation and application // Proc. IEEE AFRICON'96. - vol. 1, Stelleboach, SA, 1996. - – p. 282 –287.
7. Obelliero F., Taboada J.M., Rodriges J.L. Hybrid moment method and physical optics for modeling the electromagnetic behavior of on-board antennas/ Microw. Opt. Technol. Lett. - vol.27, No. 2, 2000. - – p. 88 –93.

FOCUSING MIRROR ANTENNAS FOR EQUIPMENT RADIO WAVE NONDESTRUCTIVE TESTING

Abyshev S.V., Nefedov V.I., Trefilov N.A., Markin A.A.
MIREA – Russian Technological University

Abstract - The article describes the principle of focusing the antennas, a characteristic of the focusing aperture. Reflector diagrams are given. Focusing antenna parameters are calculated.
Keywords – focusing mirror antennas, radio, wawe, microwave.

In many technical and diagnostic applications, in particular microwave technologies for flaw detection and radio wave nondestructive testing, microwave antennas are used as sensors for the excitation of wave fields, which realize the principle of focusing radiation from antennas in the near zone (Fresnel zone) [1-3]. The principle of focusing antennas is to create an amplitude-phase distribution of the current at which the aperture is the source of a converging spherical wave. After passing the focal region, the wave transforms into a divergent wave. Within the focal region, the bulk of the wave power passes through a small area.

The main characteristic of the focusing aperture from the point of view of technological diagnostics is the distribution of the amplitude of the field created in the focal region passing through the geometric focus parallel to the aperture. To obtain this characteristic, a number of parameters are used in numerical expression: the width of the main maximum in the -3 dB level or in the level of the first minima, expressed in degrees relative to the aperture or in linear units; level, spin-off highs; The size of the site through which 95% of the probe wave passes. As additional parameters, the reflection coefficient from the antenna measured from the side of the geometric focus is often used and characterizes the matching of the antenna with free space; depth of field, showing the longitudinal size of the field of the focused field, within which the transverse dimensions of the probing beam do not exceed a given value; phase distribution of waves within the depth of field and others. All these parameters can be determined by knowing the distribution of the field of the aperture near the focus. In addition, it should be taken into account that effective focusing can be obtained only at distances comparable with the transverse dimensions of the aperture, limited to the Fresnel zone approximation [1-3, 6-7].

Consider the rectangular aperture shown in Fig. 1, where $\vec{x}_0, \vec{y}_0, \vec{z}_0$ - unit vectors in the direction of the axes *X, Y, Z*; *R* is the distance between the *OP* points; R_0 is the distance *OF*; *r* is the distance *pq*; *q* is the source point; *p* - point of observation; *F* - point of geometric focus; $\vec{r}_0$ - a single unit vector in the direction *qp*; *S* is the surface of the aperture.

The intensity of the electric field component at the observation point p, created by currents distributed along the aperture at points q, using the source-shaped representation has the form:

$$\vec{E}_p = \left(j/(4\pi\omega\varepsilon_0) \right) \int_S \left(k^2 G_{pq} \vec{I}_q^{\acute{y}} + \text{graddiv}_p G_{pq} \vec{I}_q^{\acute{y}} - j\omega\varepsilon_0 \text{rot}_{\eth} G_{pq} I_q^{\grave{\imath}} \right) dS, \qquad (1)$$

where ω is the circular frequency; $\vec{I}_q^{Э}$ - surface electric current in the aperture; $I_q^{М}$ - surface magnetic current in the aperture; $G_{pq} = \exp(-jkr)/r$.

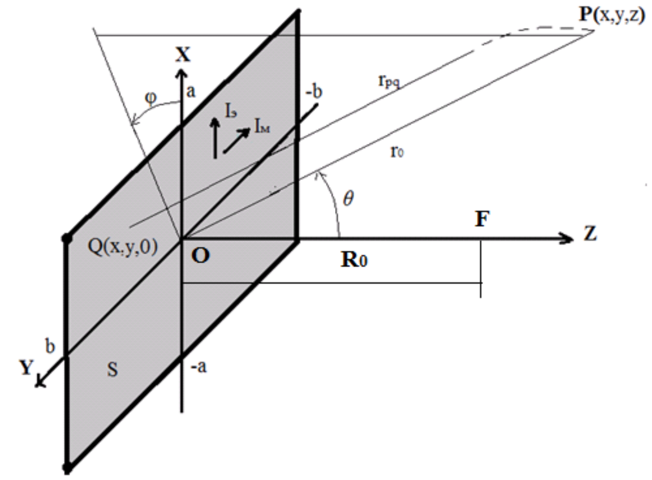


Fig. 1. The aperture coordinate system

Differential operators act on the coordinates of the observation point, and integration is performed on the coordinates of the points of the aperture. We introduce a coordinate system, as shown in Fig. 1, and consider separately the second and third terms in the integrand (1). It's obvious that

$$\text{grad}\,\text{div}_p G_{pq} \vec{I}_q^{\acute{y}} = \vec{\nabla}_{\eth} \vec{\nabla}_{\eth} G_{pq} \vec{I}_q^{\acute{y}} = \left(\vec{I}_q^{\acute{y}} \vec{\nabla}_{\eth} \right) \vec{\nabla}_{\eth} G_{pq}, \qquad (2)$$

where $\vec{\nabla}_p$ - is the Hamiltonian operator acting on the coordinates of *p*. Performing sequential operations in Cartesian coordinates, we obtain

$$\vec{\nabla}_{\eth} G_{pq} = -G_{pq} \left(jk + 1/r \right) \left(\frac{x_p - x_q}{r} \vec{x}_0 + \frac{y_p - y_q}{r} \vec{y}_0 + \frac{z_p - z_q}{r} \vec{z}_0 \right), \qquad (3)$$

where x_p, y_p, z_p, x_q, y_q, z_q – are the Cartesian coordinates of the point *p*, *q* respectively.

We denote the unit vector directed from point *q* to *p* through $\vec{r}_0$, then, taking into account the form of the scalar operator in brackets, we obtain the second term under the integral in (1) in the form

$$\text{grad div}\vec{I}_q^{\acute{y}} G_{pq} = \left(-k^2 + \frac{3jk}{r_{pq}} + \frac{3}{r_{pq}^{\;2}} \right)\left(\vec{I}_q^{\acute{y}}\vec{r}_0\right) G_{pq}\vec{r}_0 - \left(\frac{jk}{r_{pq}} + \frac{1}{r_{pq}^{\;2}} \right) G_{pq}\vec{I}_q^{\acute{y}}. \quad (4)$$

The third term of the integrand can be reduced to the form

$$j\omega\varepsilon_0 rot\vec{I}_q^{\grave{\imath}}\, G_{pq} = -j\omega\varepsilon_0\left(\vec{I}_q^{\grave{\imath}}\,\vec{\nabla}_p\right)G_{pq}. \quad (5)$$

Taking into account the vector operator written in brackets, expression (2) can be replaced by an equivalent

$$-j\omega\varepsilon_0 rot\vec{I}_q^{\grave{\imath}}\, G_{pq} = j\omega\varepsilon_0\left(jk + \frac{1}{r} \right) G_{pq}\left(\vec{I}_q^{\grave{\imath}}\,\vec{r}_0\right). \quad (6)$$

We rewrite (1), taking into account the changes made [7-11]:

$$\vec{E}_p = \frac{-j}{4\pi\omega\varepsilon_0}\int_s \left[\begin{array}{l} \left(1 - \frac{j}{kr} - \frac{1}{(kr)^2}\right) k^2\vec{I}_q^{\acute{y}} + \left(-1 + \frac{3j}{kr} + \frac{3}{(kr)^2}\right) k^2\vec{I}_q^{\acute{y}}\vec{r}_0^{\,2} + \\ + j\omega\varepsilon_0\left(j + \frac{1}{kr}\right) k\left(\vec{I}_q^{\grave{\imath}}\,\vec{r}_0\right) \end{array} \right] \text{G}_{pq} ds. \quad (7)$$

In the near-field radiation, the relation kr >> 1 is satisfied, therefore, in (7) it is possible to neglect the terms of the integrand having a small amplitude. We get

$$\vec{E}_p = \frac{-jk}{4\pi\sigma\varepsilon_0}\int_s \left[k\vec{I}_q^{\acute{y}} - k\left(\vec{I}_q^{\acute{y}}\vec{r}_0\right)\vec{r}_0 - \omega\varepsilon_0\left(\vec{I}_q^{\grave{\imath}}\,\vec{r}_0\right)\right] G_{pq} ds. \quad (8)$$

Usually linear-polarized fields are used in the process control systems, therefore it can be assumed that the currents on the aperture are excited by a linearly polarized transverse electromagnetic wave. The aperture currents are related to the field vectors of the exciting wave by the relations

$$\vec{I}_q^{\acute{y}} = \vec{n}_0\vec{H}, \qquad \vec{I}_q^{\grave{\imath}} = \vec{E}\vec{n}_0, \quad (9)$$

where $\vec{n}_0$ - is the unit vector of the normal to the aperture. If we take into account that for the chosen coordinates $\vec{n}_0 = \vec{Z}_0$, and in the transverse wave in free space

$$\vec{E}\vec{H} = \sqrt{\frac{\varepsilon_0}{\mu_0}} E^2\vec{Z}_0, \quad (10)$$

the aperture currents at the described excitation are related by the relation [1-5].

$$\vec{I}_q^{\grave{\imath}} = \sqrt{\frac{\mu_0}{\varepsilon_0}}\vec{Z}_0\vec{I}_q^{\acute{y}}. \quad (11)$$

Therefore, the last term under the integral in (8) is transformed:

$$-\omega\varepsilon_0\left(\vec{I}_q^{\grave{\imath}}\,\vec{r}_0\right) = k\vec{I}_q^{\acute{y}}\left(\vec{Z}_0\vec{r}_0\right). \quad (12)$$

Если считать $\vec{I}_q^{\acute{y}} = I_x^{\acute{y}}\vec{X}_0, I_x = g_q e^{j\xi q}$, тогда (8) принимает вид:

If assume $\vec{I}_q^{\acute{y}} = I_x^{\acute{y}}\vec{X}_0, I_x = g_q e^{j\xi q}$, then (8) takes the form:

$$\vec{E}_p = -\frac{j\omega\mu_0}{4\pi}\int_s I_x\Psi_{pq}\left[\left(1\frac{z_p - z_q}{r}\right)\vec{X}_0 - \frac{x_p - x_q}{r}\vec{r}_0\right] ds. \quad (13)$$

Here $\left(z_p - z_q\right)/r = \cos\theta_{pq}$, $\left(x_p - x_q\right)/r = \sin\theta_{pq}$.

Let us express the distance between the observation points and the source of the field through R and the angular coordinates shown in Fig. 1, restricting itself to expansion by quadratic terms. Then

$$r = R\left(1 - \frac{x_q x_p - y_q y_p}{R^2} + \frac{x_q^2 + y_q^2}{2R^2}\right). \tag{14}$$

We substitute (14) into (13), and taking into account that in accordance with the approximation of the Fresnel zone in the phase factor it is necessary to keep the quadratic terms of the distance, and in the amplitude factors, allowing a small error, one can discard the linear and quadratic terms of the distance, p moves in the focal region, which is characterized by small angles θ. Then

$$\begin{gathered}\vec{E}_p = -\vec{X}_0\left(1+\cos\theta\right)\frac{j\omega\mu_0}{4\pi}\frac{\exp\left(-jkR\right)}{R}\times \\ \times\int_s q_q \exp\left\{jk\left(x_q\sin\theta\cos\varphi + y_q\sin\theta\sin\varphi - \frac{x_q^2+y_q^2}{2R}\right) + j\xi_q\right\}ds.\end{gathered} \tag{15}$$

To ensure focusing of the field emitted by the aperture at a distance R0, the aperture points away from the center should be excited with the leading phase. Taking into account the approximation obtained, it is necessary to choose

$$\xi_q = jk\frac{x_q^2 + y_q^2}{2R_0}. \tag{16}$$

Finally, the expression defining the field created by the focusing aperture in the focal region (15) takes the form

$$\begin{gathered}E_p = -x_0\left(1+\cos\theta\right)\frac{j\omega\mu_0 \text{åõð}\left(-jkR\right)}{4\pi R}\times \\ \times\int_x\int_y q\left(x,y\right)\text{åõð}\left\{jk2RR_0\begin{bmatrix} x\sin\theta\cos\varphi + y\sin\theta\sin\varphi \\ +\left(x^2+y^2\right)\left(R-R_0\right)\end{bmatrix}\right\}ds.\end{gathered} \tag{17}$$

At the focal length from the aperture $R = R_0$, the last expression simplifies and takes on a form typical of the field of in-phase aperture antennas in the far zone:

$$\begin{gathered}\vec{E}_p = -\vec{x}_0\left(1+\cos\theta\right)\frac{j\omega\mu_0}{4\pi}\frac{\mathrm{e}^{-jkR_0}}{R_0}\times \\ \times\int_x\int_y q\left(x,y\right)\text{åõð}\left[jk\left(x\sin\theta\cos\varphi + y\sin\theta\sin\varphi\right)\right]dxdy.\end{gathered} \tag{18}$$

This allows to draw two conclusions on the design of focusing antennas (FA):

• the angular dependence of the intensity of the focusing field antenna emitted by the focusing field at a distance equal to the focal length has the same character as in the far zone of the equivalent in-phase antenna;

• The relationships obtained for the design of aperture in-phase antennas can be used to calculate the corresponding FA.

An in-phase antenna equivalent to FA means an antenna having a similar shape and opening size and subject to the same law of the amplitude distribution of the current in the aperture. When comparing the parameters of the FA and equivalent in-phase antennas, a fairly clear correspondence is found, given in Table.

Focusing antenna	*Equivalent in-phase antenna*
Angular dependence of the field amplitude in the focal plane $F(\theta,\varphi)$, $R=R_0$	Directional characteristic $F(\theta,\varphi)$, $R \geq \frac{2L^2}{\lambda}$
The angular width of the main maximum at a certain level $2\Delta\theta_u = 2\mathrm{arctg}\left(L_u / R_0\right)$	The width of the main lobe of the radiation pattern at the same level $2\Delta\theta_u$
The level of side maxima $N_Б$	Side lobe level $N_Б$

For a known angular dependence of the field amplitude near the focus, the radius of the area in the focal region through which 95% of the power passes passes through the formula

$$l_{0,95} = Rtg\theta_{0,95}, \tag{19}$$

where $\theta_{0,95}$ - is the root of equation

$$\int_0^{\theta_{0,95}} \int_0^{2\pi} E_p^2 d\varphi d\theta = 0,95 \int_0^{\pi/2} \int_0^{2\pi} E_p^2 d\varphi d\theta. \tag{20}$$

Here, $E_p\ (R,\theta,\varphi)$ must be determined by (13) in connection with the expansion of the possible values of the angle θ.

The characteristic graphs for different values of the coefficient on the right-hand side of (20) are shown in Fig. 2.

Depth of field is for different values of the distance R, which varies with respect to the focal distance R_0, and can approximately be found from Fig. 2. Based on the results obtained, it is possible to consider the design of the main types of FA. Mirror focusing antennas can be represented by different designs, but since they are used in process control systems, the issues of simplicity of their manufacture and convenience, operation are in the first place. Therefore, single-mirror FA with a reflector in the form of an ellipsoid of revolution are of practical interest. The diagram of the reflector is shown in Fig.3.

Such a reflector, formed by the rotation of an ellipse around a major axis, has the property of focusing rays emerging from one focus in another focus.

The focus is placed on the irradiator. When the irradiator wave is reflected from the reflector in its opening, a field is formed that has a quadratic phase distribution, which is focused near the second focus.

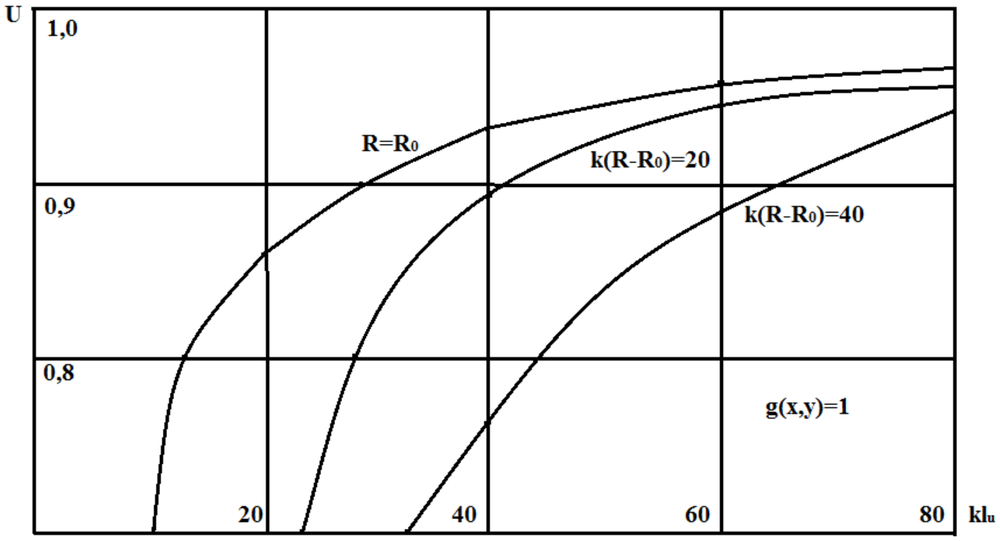


Fig. 2. To calculate the size of the focusing area

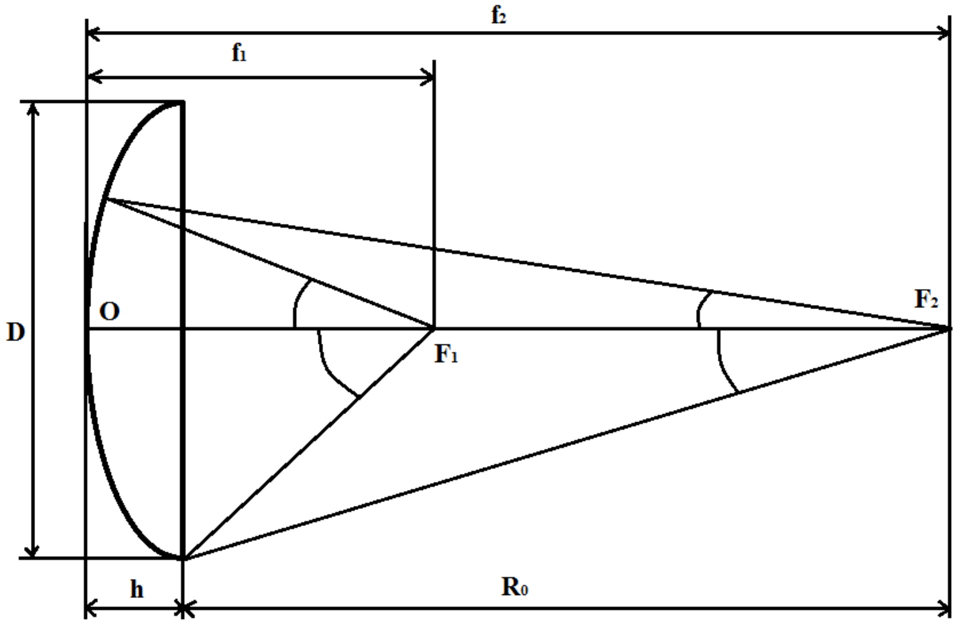


Fig. 3. Scheme of the focusing reflector

The profile of the generator of the reflecting surface of the reflector in the system coordinates, shown in Fig. 3, is given by the formula

$$Z = \frac{f_1 + f_2}{2}\left(1 - \sqrt{1 - \frac{x^2}{f_1 f_2}}\right), \tag{21}$$

where f_1, f_2 - are the distances from the top of the mirror to the near and far foci, respectively.

Calculation of the parameters of the mirror FA is carried out on the basis of the table. As initial values, the working wavelength λ, the width of the focal spot - the main maximum, at a certain level $2\Delta l_u$ and the side lobe level $N_Б$ are given. from the aperture table, the form of the amplitude distribution in the mirror opening is selected from the aperture table and the calculated expression for the angular width of the main maximum

$$2\Delta\theta_U = \alpha\, \lambda/D, \tag{22}$$

where α - is the slope corresponding to the selected amplitude distribution and the ratio

$$\frac{R_0}{D} = \frac{180}{\pi}\frac{2l_u}{\lambda}. \tag{23}$$

Based on the value of R_0/D, the size of the mirror opening and the distance R_0 are selected. It should be borne in mind that in the restrictions adopted in the previous paragraph, the relations $D >> \lambda$, $R_0 >> \lambda$ must be satisfied. With effective focusing of the field, the ratio (23) does not exceed 3.

The ratio calculated by (23) allows us to find the angle at which the mirror is opened is visible from the far focus:

$$2\Psi_0 = 2\mathrm{arctg} D/(2R_0). \tag{24}$$

The angle at which the mirror is revealed from the near focus $2V_0$ should be selected from the range of values realized by the available type of irradiator. To ensure a small shading, the exposure of the irradiator usually requires the fulfillment of the condition $V_0 > 2\Psi_0$. With the use of horn irradiators and a zero level of irradiation of the edge of the mirror, the angle lies in the range 60 ° - 80 °. Calculated and selected values allow to find other geometric dimensions of the mirror FA. The depth of the mirror - the distance from the top of the mirror to the opening - is calculated by the formula:

$$h = \frac{D}{4}\left(\frac{1}{\sin\psi_0} + \frac{1-\cos V_0}{\sin V_0}\right) - \frac{R_0}{2} \tag{25}$$

The auxiliary values for the determination of f_1 and f_2 follow from the relations

$$f_1 = h + \frac{D}{2tgV_0}, \qquad f_2 = h + R_0. \tag{26}$$

The geometric dimensions found allow us to determine the requirements for the irradiator of the antenna. The necessary characteristic of the directivity of the irradiator is determined taking into account the form of the amplitude distribution according to the formula:

$$F(V) = \frac{g(x)}{cos\psi}\sqrt{\frac{sin\psi}{sinV}\frac{d\psi}{dV}}\,, \tag{27}$$

Where $\frac{\sin(V-\psi)}{\sin V + \sin\psi} = b, \qquad \frac{d\psi}{dV} = \frac{\cos(V-\psi) - b\cos V}{\cos(V-\psi) + b\cos\psi}.$

These relationships make it possible to estimate the requirements for the width and shape of the radiation pattern of the irradiator, on the basis of which it is possible to choose the type and dimensions of the irradiator and determine its real directional characteristic [2].

Important for practical use of FA is the reflectivity from the antenna, obtained from measurements from the far focus. It depends on many factors and can be reduced by using tuning elements in the design of the irradiator. To reduce the reflection coefficient, it is possible to use a method consisting of placing between a reflector and the far focus of a sheet, an absorbing material with a damping of about 6-10 dB, playing the role of a spatial matching attenuator. Absorbent materials can be used in FA structures and to reduce the level of lateral radiation, for example, in the form of a cylindrical or conical band fastened to the edge of the mirror. The appearance of the stand for measuring the distribution of the field in the focal region of the focusing beam is shown in Fig. 4.

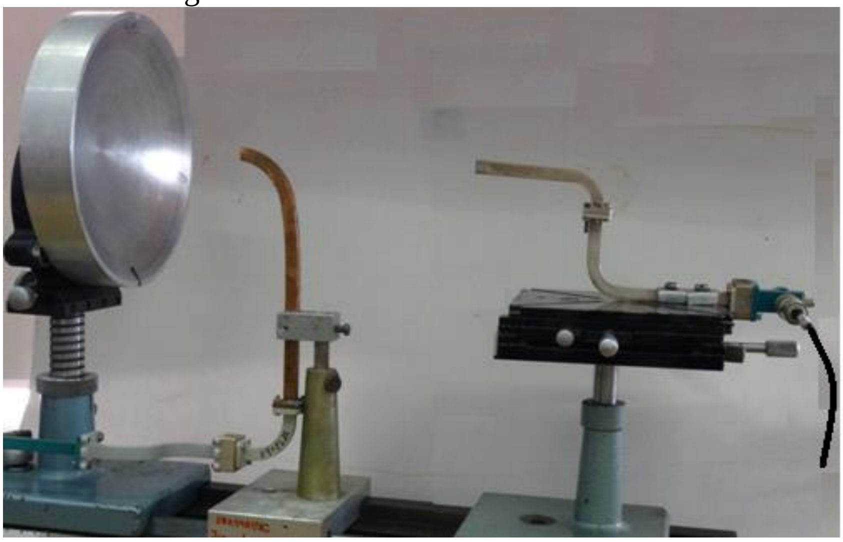


Fig. 4. The layout of the focusing antenna

The technology of manufacturing metal reflectors of mirror antennas is laborious, therefore they are expensive. In the standard measuring FA, reinforced, glued on the template mirrors are usually used, which can be metallized glass cloth or carbon plastics.

REFERENCES

1. Balashov V.M., Trefilov N.A. Measurement of dielectric parameters in the high-temperature region // Electronic equipment, Ser. Quality Management, No. 7, 1982.

2. Trefilov N.A. Technological control of radio-transparent dielectrics during heating. - Saratov: ed. SSU, 1989. - 84 p.

3. Basset H.L. An open microwave system with power focusing for measuring the complex dielectric permittivity of materials at temperatures above 2000 ° C // Scientific Research Instruments. 1971. Vol. 42, No. 2. Pp. 200-204.

4. V.I. Nefedov, D.Sc., D.N. Trefilov NA, A.N. Dementiev, V.V. Vetrova, S.M. Kolesnikov, A.V. Shpak. Integral equations for modeling cylindrical mirror antennas. Russian Technology Journal, 2017. Volume 5. № 3, P. 3-8.

5. Selenya K.A., Trefilov NA, Dement'ev AN, Trefilov DN, Nefedov V.I. Constructions of focusing mirror antennas. Sat. scientific works of the III International Scientific and Practical Conference "Actual problems and perspectives of the development of radio engineering and infocommunication systems". "RADIOINFOCOM - 2017", November 13-17, 2017, Moscow, Russia. P. 229-233.

6. Sedelnikov Yu.E. Antenna gratings in the Fresnel zone: the state of the theory and promising applications // Physics of wave processes and radio engineering systems. 2007. T. 10. - № 5. - P. 15-16.

7. 7. Luchnikov P.A., Sigov A.S., Trefilov N.A. Wave dielcometry of materials. - M .: Scientific World, 2014 - 300p.

8. Vorobiev EA, Mikhailov VF, Kharitonov AA Microwave dielectric under high temperature conditions. - Moscow: Soviet radio, 1977. - 208 p.

9. Born M., Wolf P. Principles of Optics. - Moscow: Nauka, 1970. - 856 p.

10. Esepkina N.A. About one method of measuring the high-resolution radio telescope DN. // Reports of the Academy of Sciences of the USSR. 1957. Vol. 113. No. I. Pp. 58-63.

11. Markov G.T., Chaplin A.F. Excitation of electromagnetic waves. - Moscow: Energia, 1969. - 376 p.

ANTENNA ELEMENT INTERPOSITION

Abyshev S.V., Trefilov N.A.
MIREA – Russian Technological University
+7 (925) 431-04-53, svabyshev@gmail.com

Abstract – The article deals with the method of the antenna array elements of interposition and shows graphs of normalized diagrams of direction of two and four elements of the antenna array for different ratios of inter-element distance to the wavelength.

Keywords – antenna array; directional diagrams; wavefront.

INTRODUCTION

Mutual arrangement of the antenna array elements has a significant impact on its characteristics. One of the most important characteristics of the array is its resolution capacity. By the resolution of the antenna array we will mean the minimum angular distance between the directions of arrival of the signals, at which they can be distinguished by spatial parameters – the angle of place and azimuth. The resolution capacity increases with increasing distances between the elements of the antenna array. Due to this it becomes possible to detect a useful signal against noises and interfering signals even when the angular dispersion between signal sources and interference is small. *N*, which is an elemental antenna array, has *N*-1 degrees of freedom which makes it possible to form *N*-1 independent zeros of the directional diagram.

CONSIDERATION

Let's consider a two-element antenna array, consisting of two non-directional antenna elements, located at a distance *d* from each other (Fig. 1). The figure shows that if the front of the electromagnetic wave affecting the antenna array is at an angle α to normal, the signal at the output of the 1st antenna element is delayed relating to the second by the value:

$$\tau = (d \sin \alpha)/c \tag{1}$$

Assuming that the signal affecting the array is narrowband with a wavelength λ_0, the time delay is reduced to a phase shift $\Delta\varphi$ equals to

$$\Delta\varphi(\alpha) = 2\pi(\frac{d}{\lambda_0}) \sin \alpha \tag{2}$$

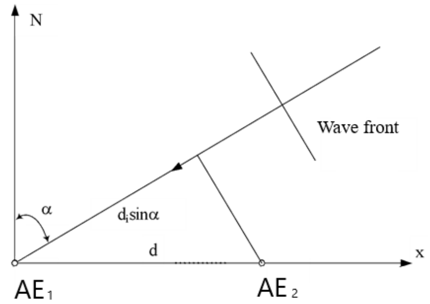


Fig. 1 Impact of a plane front on a 2-element antenna array

When weighing the signals from the antenna element outputs with unit weighting coefficients, the array output signal *y(t)* will be the sum of the signals from the antenna element outputs taking into account the phase shift:

$$y(t) = \sum_{i=1}^{2} x(t) e^{j(i-1)\Delta\varphi(\alpha)} \tag{3}$$

As known, the antenna array's directional diagram (array's multiplier) is determined by the expression:

$$A(\alpha) = \sum_{i=1}^{2} e^{j(i-1)\Delta\varphi(\alpha)} \tag{4}$$

The normalized directional diagram of the two-element antenna array, measured in decibels, is determined by the formula:

$$G(\alpha)_{дб} = 10\lg\{|A(\alpha)|^2/4\} \tag{5}$$

Fig. 2 shows graphs of normalized directional diagrams of the two-element antenna array for different ratios of the inter-element distance to the wavelength. At d/λ_0= 0,5 (Fig. 2,*a*) the array has a main lobe with a width of 60⁰ on the level of 3 dB and zeros of the directional diagram at an azimuth α = ±90°. The main lobe characterises the interference maximum resulting from the in-phase addition of signals from the antenna elements' outputs. Zeros of directional diagram from directions equal to α = ±90° are formed due to the wavefront passes a distance between elements equals to $\lambda/2$. It corresponds to a phase shift of 180°, i.e. signals from the antenna element outputs are added to each other in the antiphaseand when added up, a mutual compensation (total suppression) occurs. If the distance between the elements is smaller, whichever the direction of the wavefront arrival, there is no complete suppression of the signal. With a further decrease in the distance between the elements, the antenna array acquires more properties of the non-directional vibrator (Fig. 2,*b*).

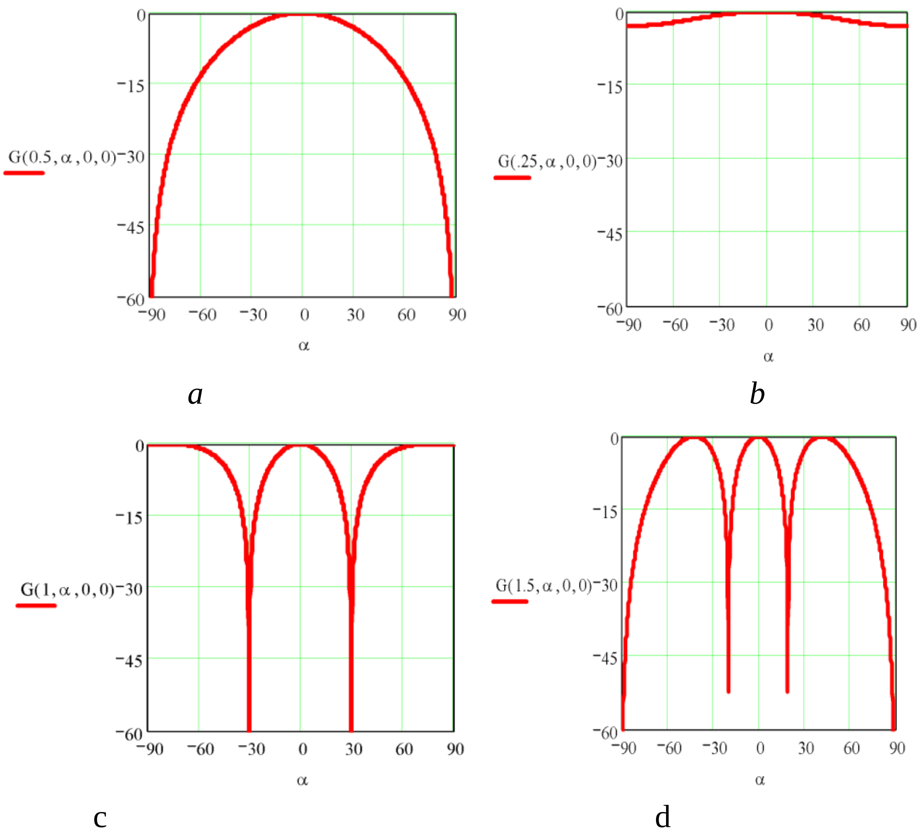


Fig. 2 Variants of directional diagrams of the 2-element antenna array:
a) d/λ = 0,5 ; b) d/λ = 0,25 ; c) d/λ = 1,0; d) d/λ = 1,5.

When the distance between the elements increases, the zeros of the diagram are shifted to the middle of the graph and reach the values $\alpha = \pm 30°$ at $d/\lambda = 1.0$ (Fig. 2,c). At such angles of the wavefront influence on the antenna array, the phase shift between the signals from the first and second elements turns out to be 180º again, which leads to a complete suppression of the output signal. Also, along with the main lobe of the directional diagram, two side lobes with maximums when $\alpha = \pm 90°$. At these angles, the phase shift between the signals equals to 360°, which, like in the main lobe, results in a syphase addition of the signals.

At further increase of the interelement distance the width of the main lobe decreases, additional side lobes and zeros of the directional diagram occurs. An example of such a directional diagram for the ratio $d/\lambda = 1.5$ is shown in Fig. 2,d. The two-element antenna array is a particular case of a linear equidistant antenna array containing in the general case N antenna elements located at an equal distance along one straight line. The signal at the output of the N-element array when weighing with unit weights coefficients is determined by the formula:

$$y(t) = \sum_{i=1}^{N} x(t) e^{j(i-1)\Delta\varphi(\alpha)} \qquad (6)$$

and the multiplier of the array by the formula:

$$A(\alpha) = \sum_{i=1}^{N} e^{j(i-1)\Delta\varphi(\alpha)} \qquad (7)$$

The multiplier of the array $A(\alpha)$ has the maximum value at $\sin(\Delta\varphi(\alpha))=0$, or at $\Delta\varphi(\alpha)=k2\pi$. The multiplier will be equal to zero at $\Delta\varphi(\alpha)=2\pi/N$. This condition is illustrated in Figure 3. Indeed, the multiplier of the array can be represented for a fixed value $\Delta\varphi$ as the sum of vectors on the complex plane.

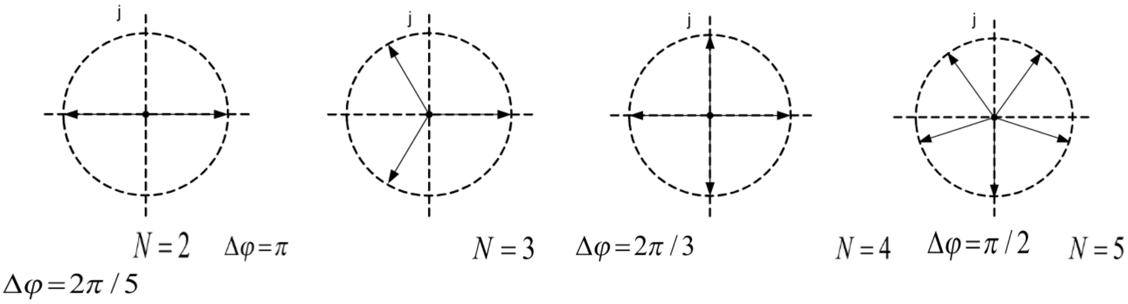


Fig. 3 Array multiplier as a sum of complex vectors

Taking into account the formula (2), we will rewrite the condition of equality of the multiplier of the directional diagram to zero as follows:

$$2\pi\left(\frac{d}{\lambda_0}\right)\sin\alpha = \frac{2\pi}{N} \tag{8}$$

which corresponds to the directions of α that meet the condition:

$$\sin\alpha = (\frac{\lambda_0}{d})/N \tag{9}$$

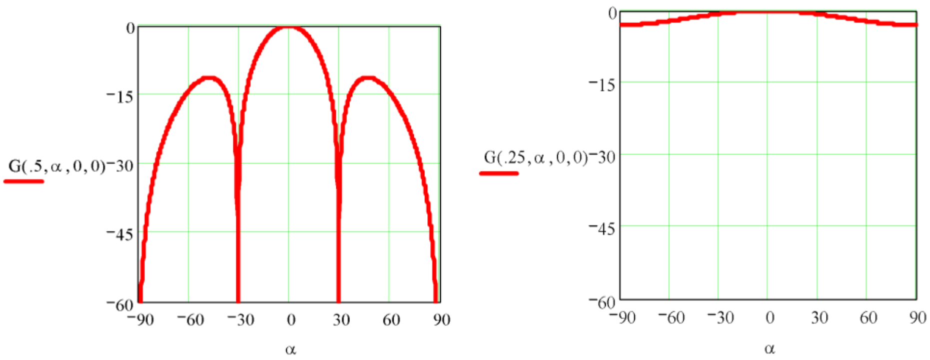
By denoting the length of the array as L, and considering that L = (N-1)d, we obtain an expression for determining the directions in which the zeros of the directional diagram of the linear equidistant antenna array are formed:

$$\alpha = \arcsin(\frac{\lambda_0}{L+d}) \tag{10}$$

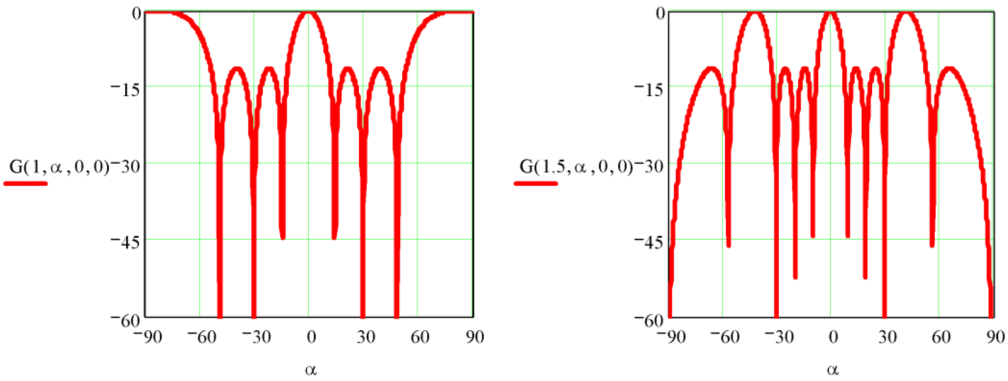
Respectively, a normalized directional diagram will be determined by the formula:

$$G(\alpha)_{дб} = 10\lg\{|A(\alpha)|^2/N^2\} \tag{11}$$

Fig. 4 illustrates the models of the directional diagram of the 4-element antenna array depending on the ratio d/λ. Similar to the case of a 2-element array, with a ratio d/λ<0.5 (Fig. 4,b), the antenna array happens to be ineffective - the zeros of the directional diagram are strongly diffused. In the case when the ratio d/λ equals to 0.5 (d/λ=0.5) under the influence of the wavefront on the array from the directions α=±30, deep zeros of the directional diagram occurs, due to the antiphase signal addition. It should be noted that the level of side lobes in this case is about 12 dB lower than the maximum of the main lobe. This is explained by the fact that a complete in-phase addition of signals from the antenna element outputs, in contrast to the 2-element antenna array, is possible only when there is the wavefront from the direction of α=0.



a *b*



c d

Fig. 4. Variants of directional diagrams of the 4-element antenna array:
a) d/λ = 0,5 ; b) d/λ = 0,25 ; c) d/λ = 1,; d) d/λ = 1,5

As the d/λ_0 ratio increases, the width of the main and side lobes decreases, the number of side lobes and the diagram zeros increases. There occur side lobes equaled to the level of the main one, the diagram takes the form typical to an interferometer. This is explained by the fact that with the growth of the d/λ_0 ratio there occur conditions for the appearance of interference maximums when the wavefront comes not only from zero azimuth, but also from other directions.

REFERENCES

1. Interference immunity of radio systems with complex signals. G.I.Tuzov, V.A.Sivov, V.I.Prytkov, etc.; Edited by G.I.Tuzov. -M.: Radio and Communication, 1985. -264 p.
2. UHF devices non-destructive method of control. S.V. Abyshev, Universum: Technical Sciences, International Scientific Journal, 2019.
3. Phase direction finders / V.P. Denisov, D.V. Dubininin. - Tomsk: Tomsk State University of Control Systems and Radioelectronics, 2001.- 251 p.

DEVELOPMENT OF EQUIVALENT ELECTRICAL LOAD TO SIMULATE OPERATION OF LAPTOPS COMPONENTS

Sedov K.D., Sosnin A.I.
National Research University Higher School of Economics
+7 (905) 549-69-36, kdsedov@edu.hse.ru; +7 (916) 204-70-47, aisosin@edu.hse.ru

The general purpose of this paper is to develop the electrical load equivalent necessary for automatic control of the secondary power supplies the main characteristics. The major research problem could be framed as follows: developing a universal portable automated system for monitoring the electrical parameters of secondary power supplies. To solve this issue, it is necessary to determine the technologies applied in the electrical load equivalents. This work is devoted to the usage of MOSFET transistor as the way to create the electrical load. As a result, using this method the collaboration of software and printed board assembly based on the transistor will be developed.

Keywords— electrical parameters; electrical load equivalent; MOSFET transistor; secondary power supply; laptop; MyRIO.

INTRODUCTION

In order to converse alternating voltage to constant with the provision of the required characteristics, secondary power supplies are traditionally used. Their technical condition affects the functioning of the product as a whole. There are two stages of power supplies parameters control [1]. The first one is carried out by the manufacturer and called output control. The second is executed by the customer and called input control. Usually, this procedure is performed with instrumentation which requires manual adjustments such as voltmeter, ammeter and oscilloscope. This makes it impossible to cover all the controlled characteristics. Therefore, it becomes relevant to develop an automated electrical load equivalent as a part of an instrumentation complex.

So, enterprises have some issues regarding electrical parameters control, what develop an interest in creation of an innovative and universal management system of these indicators. The use of the developed system for monitoring the electrical parameters of secondary power supply products at enterprises will improve the efficiency and quality of control. This will contribute to reducing the complexity of procedures for assessing key parameters and minimising the impact of the human factor [2]. The use of National Instruments equipment will allow reducing the overall dimensions of the whole system and the cost of production, by analysing the measured parameters and characteristics is carried out by built-in software.

PROBLEM STATEMENT

The use of field MOSFET transistors is a modern approach to solve the problem of designing electrical load equivalent due to their characteristics and the principle of operation. The principle of the field transistor is to control the current using an electric field. This is its advantageous difference from bipolar transistors, where large output current is controlled using a small input current.

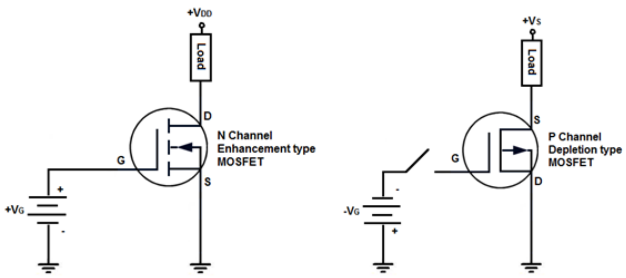


Fig. 1 Field effect transistors: n-, p-channel

Consider a simplified model of the operation of a field-effect transistor. This type of transistor contains a semiconductor channel, which performs the function of one capacitor plate, the second plate is a metal electrode, which is located through the dielectric layer. At the moment of supplying voltage to the gate, a capacitor charges, an electric field appears, which attracts charges to the channel. As a result of this, movable charges form an electric current, and the resistance between the drain and the source drops sharply. In this case, there is dependence. The higher is the voltage the more charges and lower the resistance.

The key advantage of the MOSFET transistor is its low control power, because the voltage is applied to the gate and, due to the presence of a dielectric, the current value is zero. The MOSFET transistor consumes voltage only during switching, when the capacitor is charging and discharging.

Thus, based on the image of MOSFET transistors in (Fig. 1), it can be assumed that the principle of operation of these components is based on controlling the I_D (drain current) through the drain-source channel by changing the value of the gate voltage.

It should be noted that the MOSFET transistor in the electrical load equivalent has to work in the key mode. Which means that field-effect transistor should function in the pulse mode, which is provided by the implementation of pulse-width modulation (PWM). Pulse width modulation is achieved by changing the duty cycle of the pulses. An illustration of PWM is shown in (Fig 2).

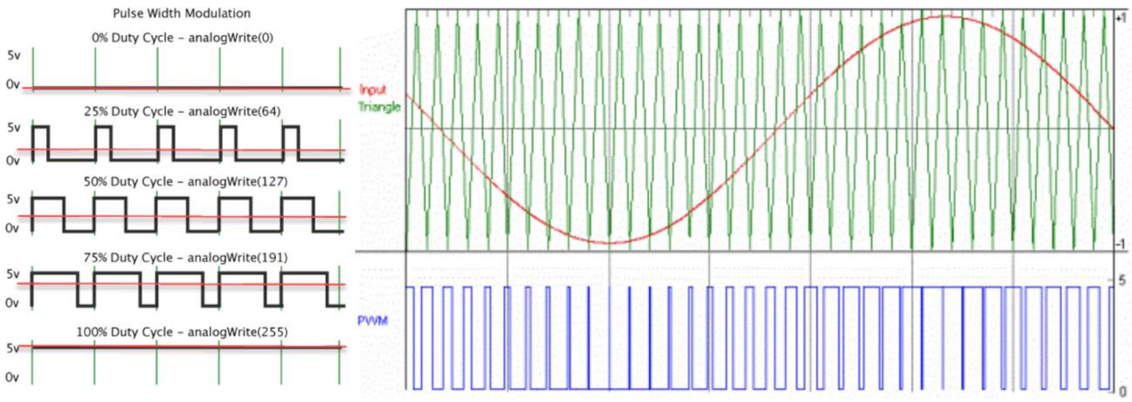


Fig. 2 PWM principle of operation

Pulse-width modulation is an effective way to control the power supply to the load, the implementation of which is to change the pulse duration at a constant pulse rate. This method is used to solve problems of increasing the efficiency of electrical converters that form the basis of secondary power supplies.

The relative pulse duration S is an important PWM parameter and is determined by the ratio of the period T to the duration τ (action time) of the pulse in it.

$$s = \frac{T}{\tau} = \frac{1}{D} \tag{1}$$

The operating load factor D determined by the expression (2).

$$D = \frac{\tau}{T} \tag{2}$$

In the key operating mode, the MOSFET transistor is characterized by two main states – open and closed. There is also an intermediate state that lasts for tens of nanoseconds. During this time, the power allocated to the key is too small compared to the switched power, and therefore, in the ideal case, this state can be neglected. This mode significantly contributes to the reduction of heat generation, since the resistance of the open channel of the transistor (drain-source) $R_{DS} = 0$, which indicates that it is in saturation mode. In this regard, based on expression (3), the allocated power $P_{mp} = 0$.

$$P_{mp} = I_{DS}^2 \cdot R_н \tag{3}$$

The moment when the transistor is in cut-off mode means that it is closed and its resistance (drain-source) tends to infinity. As a result, the allocated power is zero, since no current flows through the closed channel.

Thus, in the ideal case of a pulsed transistor operation mode, the allocated power is zero $P_{mp} = 0$. However, in practice, when the transistor is open, there is a resistance in small sizes. In the closed state, small current flows at the drain-source terminals, and therefore the power dissipated by it in the static mode is negligible. Based on this, we can conclude that in the dynamic mode, a huge power of losses is dissipated in the MOSFET transistor, which could level all the necessary parameters of the key mode. However, as stated earlier, the duration of the transistor in dynamic mode is much shorter than the time in static mode. This fact provides a high efficiency of the transistor cascade (93% - 98%) operating in the key mode.

Based on the MOSFET transistor principle of operation described in this chapter, the equivalent electrical load and related software is developed.

SOLUTION OF THE PROBLEM

To solve this problem, a system based on the MOSFET transistor is developed, which consists of a personal computer (PC), multifunctional platform and electrical load equivalent scheme. As a multifunctional platform NI MyRIO is selected. The principle of this platform operation is shown in Figure 3. The testing secondary power supply is connected to utility power (220 V). The secondary power supply output is connected to the load equivalent, which simulates the load from the components of a laptop such as a motherboard, video card, processor, etc. The equivalent, in turn, connects to MyRIO, which receives data from the equivalent, as well as performs the necessary manipulations, interacting with the PC, where the process is controlled using the developed software [3].

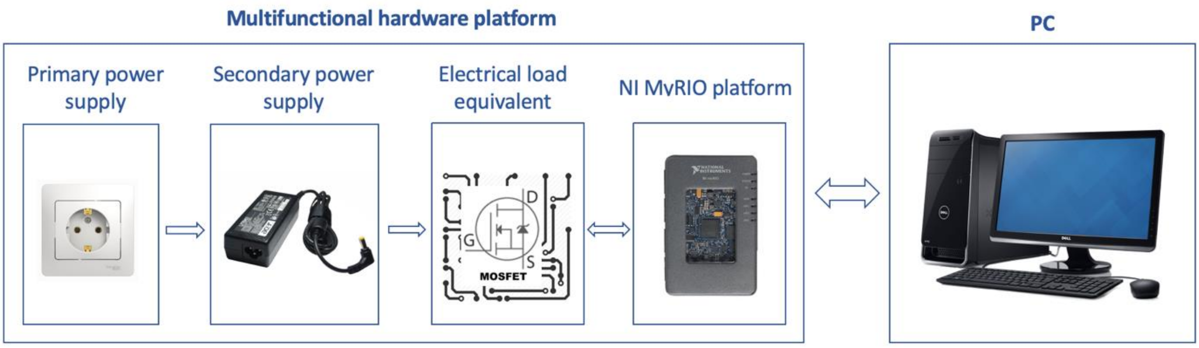


Fig. 3 The operating principle of the electrical load equivalent

The developed system is controlled by PC on which special software is installed that is compatible with the NI MyRIO. Since LabVIEW meets this requirement, this software is chosen for the development of the virtual appliance [4]. LabVIEW is a system-design platform and development environment which allows to program NI MyRIO platform and to conduct a detailed analysis of the data obtained according to the results of tests of input control. A distinctive feature of this software is the ability to create informative control systems due to the graphical interface of virtual appliance, as well as a block diagrams of the program code.

NI MyRIO is an intermediate link between a PC and an electrical load equivalent. However, it plays a key role in the entire system: it receives information through the input ports, generates a waveform and delivers the necessary effects through the output ports, transfers information via Wi-fi technology.

As stated above, the developed electrical load equivalent scheme is based on MOSFET transistors and connects testing secondary power supply and NI MyRIO. Since the NI MyRIO has PWM outputs that are programmed using LabVIEW, the MOSFET transistor opening/closing and, as a result, the load current are controlled by commands from these NI MyRIO outputs. The essence of management is changing relative pulse duration. The values of the load currents are different, depending on test and secondary power supply types. As for laptops, the load currents value is variable from a few mA to 7 A. Channel separation ensures smooth adjustment of load current values. These channels are characterized by bandwidth in a certain limited range due to load resistances (resistors of different ratings). The schematic diagram of the developed electrical load equivalent is presented in the figure 4.

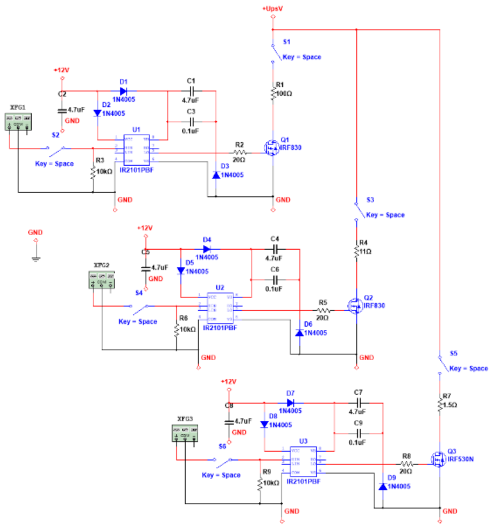


Fig. 4 Schematic diagram of the developed electrical load

This circuit is designed via Multisim which integrates with LabVIEW to emulate the circuit in different operating modes. For the interaction of the Multisim and LabVIEW, special software tools have been developed, such as: Co-simulation; Instrumentation implemented using LabVIEW and operating in a Multisim environment; Multisim Connectivity Toolkit. This software tool integrates with LabVIEW and interacts with Multisim [5]. Installation of the optional Control Design & Simulation Module for LabVIEW is required.

Thus, by integrating the electric load equivalent circuit designed in Multisim with LabVIEW, a virtual appliance has been developed that displays the electrical parameters of the testing object (laptop secondary power supply) during the input/output control and allows changing the circuit operating modes.

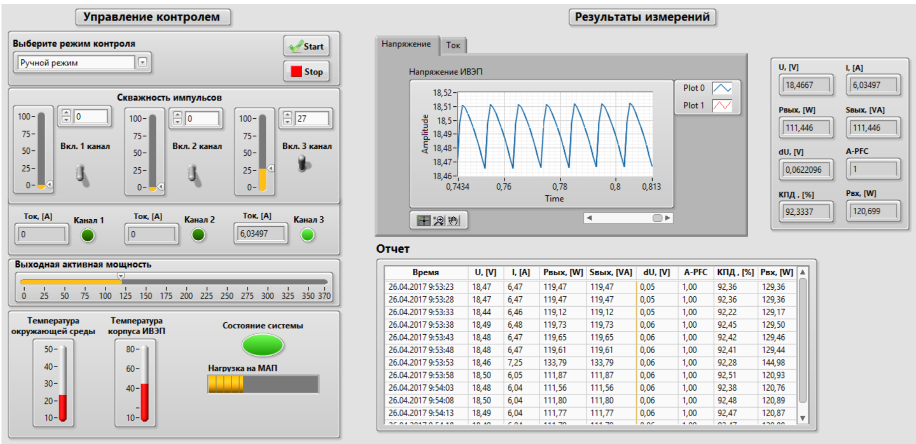


Fig. 5 User interface of the developed software

CONCLUSION

The proposed platform is aimed to make electrical parameters control more automated and universal. The electrical load equivalent based on the MOSFET transistor is developed. To measure electrical parameters of the secondary power supply and manage test mode the software in LabVIEW is developed. The proposed hardware and software system should increase the efficiency of monitoring the electrical characteristics of secondary power supplies by increasing the accuracy of their assessment, reducing the overall dimensions and weight of this equipment.

REFERENCES

1. Dobrynin O.A. Comparative testing of power supplies, or the whole truth about energy efficiency. [Online]. Available: http://compress.ru/article.aspx?id=20557.
2. ATX12V Power Supply Design Guide. Version 2.2. p.45, March 2005.
3. Zapotylok V.A. Testing of 11 power supply units with the declared power of 350 W - Introduction, briefly about the test procedure. [Online]. Available: http://www.microtech.ru/UserFiles/File/Press/23-05-2006.pdf.
4. User Guide And Specifications NI MyRIO-1900. National Instruments. August, 2013.
5. Conference materials «National Instruments Week 2013». Do you speak LabVIEW? [Online]. Available: http://www.electronics.ru/files/article_pdf/3/article_3951_799.pdf.

Section 3
INFORMATION TECHNOLOGIES IN SOCIAL-ECONOMIC SPHERE

CACHING METHODS AND SOME ASPECTS OF OFFLINE OPERATION OF DIGITAL SIGNAGE SYSTEMS BUILT ON HTML5

Filippov D.S.
Russian University of Transport
dsfilippov@ui-miit.ru

Abstract – The need for pre-caching of content elements using HTML5 standards on Digital Signage screens allows us to create an instant appearance effect and hide the lack of communication with the management server or other Internet resources. This article discusses HTML5 technologies: Application Cache API, CacheStorage API and Link Prerender - a set of methods that provide advanced control of caching and background loading of web application resources that build content on Digital Signage screens from different network sources in a browser. The pros and cons of each method and other features of cache management with respect to use in Digital Signage systems are also affected.

Keywords: Digital Signage; digital screens; HTML5; Application Cache API; AppCahe; CacheStorage API; Cache API; Service Workers; browser caching;

For high-quality operation of digital screens of the Digital Signage (DS) system, it is required to cache and download the content displayed on them in the background, especially if it is located on resources that require an Internet connection. There are many network problems that caching solves: power failure on intermediate network nodes, problems with network equipment, problems with software on remote resources, missing (or weak) signal when working through a mobile radio network, unavailability of one or more network resources, from which DS system is supposed to download content for the template (structure) received from the server, etc. Since it is supposed to place DS screens in crowded places, it is important to be sure that even in such situations the logic of a web application that compile/assembly/aggregates the final “picture” on the client side from different elements will work correctly.

The goal of using HTML5 on public screens is to use only standardized technologies (by World Wide Web Consortium) to “compile” audiovisual content using hypertext from various network sources and any web browser as the only client-side program (working in kiosk/fullscreen mode). This is a fundamental difference from the IPTV stream (formed on the server side) or from other proprietary solutions for the operation of Digital Signage systems.

We denote several definitions. By “the managing server” we mean the server on which the schedule for displaying information on screens and templates (structures) is stored, which are transferred to the screen (client) for further independent “assembly” in its browser. By the client we will designate the computer connected to the Digital Signage screen and the browser running on it in fullscreen mode.

Let's determine which caching tools are definitely not suitable for storing a lot of elements that build the overall picture of Digital Signage screens using web-technologies and hypertext.

Firstly, this is the standard browser cache. Each browser developer can decide for himself what he wants to cache and how much he wants to store. Together with the returned data, the management server can send an HTTP header indicating whether this data should be cached and by how much. But the client-side browser (the computer on which the DS system is running) can ignore this server’s recommendation, so we should not rely on this method.

Secondly, caching using .htaccess instructions used by the Apache web server or using nginx.conf in the Nginx web server also affects only the standard browser cache and cannot guarantee savings of certain resources for multiple use or offline work.

And thirdly, the use of a local proxy server on the client side. No instructions can be transmitted from third-party software for or from the browser (and even more so from the management server), and we will not be able to manage these file resources from the browser, because for security reasons it limits its scope: it is impossible to "say" what exactly needs to be cached and what it's time to delete; we can't give instructions for the background loading of resources before directly displaying content on the screen, etc. As a result, we cannot be completely sure that the resources we need will be in the proxy server's cache, – lack of flexibility in the interaction.

I also note that, despite all its simplicity, offline storage methods such as LocalStorage and sessionStorage will not be mentioned in this article, since these "web storages" are designed to store a text key-value pair, i.e. in fact, they are a modern replacement for HTTP cookies, but not a way to store massive files, such as photos, audio or video, necessary for the full functioning of the latest Digital Signage systems. In theory, we can assume that, for example, the image as a base64 string (data:image/jpg;base64) can be saved in LocalStorage, however, these types of storages are limited to only 2-10 megabytes depending on the browser, which according to today's it's completely inadequate and generally contradicts the very specifics of these storage methods for which they were developed. Even storing fonts, client scripts, or stylesheets (CSS) encoded in base64 is not rational for the same reason.

For statistics, it should be clear that the above methods will not allow us to store more than 85% of static files in the cache (in the ideal case) [8]. Also, the standard cache slower (compared to the methods listed below) returns large static files [1], which the Digital Signage industry focuses on.

Before HTML4, the only guaranteed way was to save each web element manually. HTML5 provides more elegant solutions. The first that may be suitable for solving the indicated problems is the Application Cache API (also known as the AppCache API). The management server, together with the template transfer, can accurately list the resources that should be cached on the side of the Digital Signage screen. In fact, in each template, we can specify which elements of the overall screen should be cached. Thus, even having lost contact with the management server or with the Internet, the browser-client will still "compile" the final image properly. This type of caching has several advantages. It's not using the standard browser cache, but another "storage". This is the name used in browser settings interfaces to indicate where Application Cache is stored. The size of the storage is not specified in the standard and can potentially be equal to the size of free space on the computer's disk connected to the Digital Signage screen. The mechanisms of operation of AppCache and the standard browser cache are different and that is why they require independent placement of content. The differences between the two types of caching are:

- All data placed in the standard cache can be automatically (i.e. without a command from the user or server) deleted when the disk is full or the expiration date specified in the file headers expires. Data stored in the Application Cache can only be deleted at the command of a user who administers the public screen or at the command of a remote management server.
- Only files downloaded during the process of "compiling" the content for the screen are added to the standard cache, but not before the download itself. In AppCache, we can put any files downloaded from the server according to the manifest statement [Figure 1]. The key difference from the standard browser cache is that through AppSache (in the .manifest file) we can specify which resources (including any other domains that are relevant for Digital Signage) should be saved, while the standard cache can only save pages, which have already been visited once.

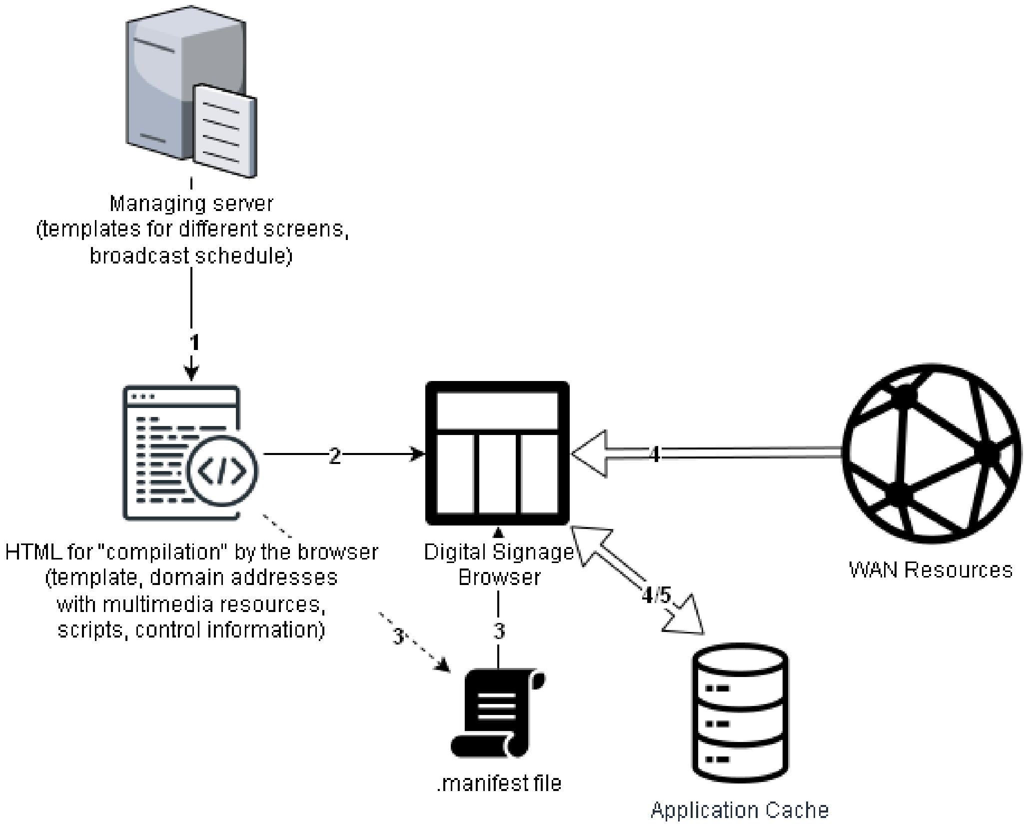


Fig.1 Application Cache working with manifest file

The advantage of using AppCache is that we now have significantly more programm control over the cache, which gives us much more confidence and control over how the client logic of Digital Signage screens will behave offline. We can have several backup templates for different screen scenarios that share the same Application Cache memory, we can use the API to determine the state of the Application Cache memory, and then force it to update - anyway, these differences have a significant impact on the caching mechanisms, which will briefly reviewed below.

The mechanism that allows multimedia content to be available when there is no connection to the Internet in general and to the management server in particular is very simple: we must specify the manifest attribute in the html tag of the template. The attribute value must be a hyperlink to the .manifest file, which contains the rules for caching. It is worth remembering that data is downloaded from AppCache even if we have access to the Internet [Figure 2].

The manifest file consists of three sections. In addition to explicitly caching specific files in the CACHE section, we need to pay attention to the NETWORK and FALLBACK sections. In fact, if our DS template is associated with a manifest file, then all network traffic of its files is blocked, and these files must either be downloaded from AppCache or refuse to be downloaded. The NETWORK section makes exceptions to this rule. We can use the section to declare which screen elements should not be cached so that they are always downloaded from the management server and never were part of AppCache. The FALLBACK section indicates what the browser (which is offline) should display when accessing resources that were not cached.

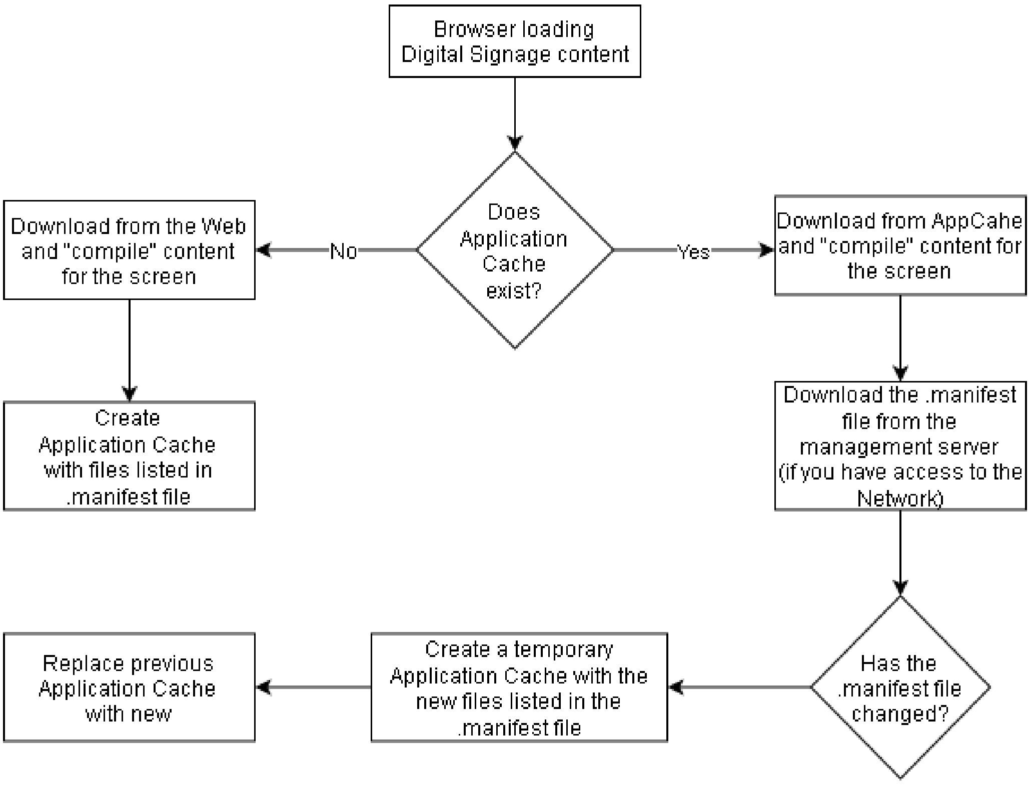


Fig. 2 Application Cache workflow and updates

Application Cache has a peculiarity - the template on which the .manifest file is declared always gets into the cache. That is, the client-side logic compiling the picture will behave as if there is no connection to the network, and the files will always be taken from the Application Cache, even if there are no problems with communication with remote resources. But how to determine if a connection to the Internet (and the management server) is present or absent? To do this, the HTML5 specification defines two events, "online" and "offline", which are called when a connection is created and dropped. We can also use the "online" property of the "navigator" object: window.navigator.onLine. This property returns true if there is a connection and false if it is absent. As a result, we need to remember that when sending a template to the client browser in hypertext format, we need to send JavaScript instructions with initialization to check this property and then build the work based on its value. Testing the network before updating the screen template is important not only as part of the caching issue. This will allow content to be displayed in HTML5 regardless of network conditions. Let the screen display slightly outdated content better than the error message that all (or part) of the resources are inaccessible due to the lack of communication with the network.

Another important point to note is that the cache is bound to the domain, not to the URL of the template on which the .manifest file is declared. The resources stored in the cache will be used for all templates of this domain received from the management server, even if they no longer have a link to the .manifest file. This is quite convenient - according to the broadcast schedule of a screen, we can pre-determine the cached resources of the Digital Signage system, and then do not worry about caching them on other templates received from the server.

Now about the problems. At the first download (for "compiling" the image on the screen from the HTML template), the background loading of cached data (photos, videos, scripts, styles, documents, fonts) automatically starts. On a weak or unstable channel, as well as on computers with a weak processor, the display of "heavy" content containing a large number of animations, transitions, high-resolution photos or high bitrate videos may be accompanied by twitches or freezes. Such freezes can occur before the background download is complete, especially if the size and number of files for caching is large.

The second point is the lack of flexibility when using adaptive templates (containing CSS Media Queries) that allow the same hypertext content to be displayed on Digital Signage screens of different diagonals, different aspect ratios or different orientations (vertical or horizontal). Since adaptive content implies a single template (but different rules in CSS), the .manifest file will be the same for all screens, which means that it is necessary to cache all elements for all types of screens, despite the fact that some elements may not be used.

The third point - there is a problem of data synchronization on the managing server and client. Changing data on the server does not change the data stored in the client's cache. We must initiate the update procedure. Up to this point, the browser will download old versions of resources, and we can update the cache in the following ways:

- The screen administrator manually deletes the old cache data. It should be understood that by clearing the standard cache, we will not affect Application Cache. To clean up Application Cache, we need to use the functions of cleaning the "Storage" - a new settings item in modern browsers.
- Make changes to the .manifest file. Any changes initiate a new load of all cache resources and its subsequent update. Changes will take effect after reloading the screen template or changing it with a new template. To make changes to the instructions of the .manifest file, we can, for example, change a few commented out characters in it with the line "# VersionN". If we delete the manifest file from the server, the browser will delete all cached elements that were specified in it.
- Update using Application Cache API. When declaring the manifest attribute, we have the opportunity to work with the cache management object for this template - window.applicationCache. A set of functions and methods of working with this object form an API. For example, the window.applicationCache.update() method initiates the process of checking the .manifest file and then downloading the resources necessary for the screen, and window.applicationCache.swapCache() switches the Digital Signage client browser to use new cached files instead of old ones. However, the content will not be redrawn on the screen. It will happen only on subsequent access to cached files, when they will be taken from the updated cache.

Starting with Firefox 62 (since September 2018), the Application Cache API only works when using the secure HTTPS protocol [5]. But the development team has limited the use of AppCache since Chrome 52 since July 2016 [6].

The consortium of developers of HTML version 5.2 (and higher) suggests abandoning the Application Cache API for security reasons and because of debugging problems (conflict of several .manifest files, adding the .manifest file to the cache, etc.) in favor of a more flexible Service Workers API. It is worth noting that browsers will support the functionality of AppCache for an infinitely long time (unless, for example, a serious vulnerability is discovered), along with today's support for old tags from the first HTML specifications standardized by the W3C consortium.

Let's take a closer look at the proposed by W3C alternative - Service Workers API. It is proposed to use a layer that works between the browser and the network and makes it possible to intercept network requests and respond to them in various ways. Service Workers consist of several APIs. We are interested in the CacheStorage API and, compared to the Application Cache API, it supports flexible background synchronization.

However, Service Workers mechanisms have a significant drawback - the inability to work (including request and caching) with content hosted on domains other than those from which the DS template was received. The developers of this mechanism themselves, for security reasons, have banned cross-domain network requests [7]. The problem can be solved by transferring the Access-Control-Allow-Origin HTTP header [4] from the control server to the client (browser). Service workers are functionally similar to proxies - they allow us to modify requests and responses, replacing them with elements from own cache.

If in AppCache .manifest it is a simple file with instructions, then the Service Worker is a stand-alone program on the client side Digital Signage with JavaScript code (which, accordingly, must be transmitted during the transfer of the basic screen layout template) [Figure 3]. For service workers, only the secure HTTPS protocol is required. Opening and saving to the cache of static resources occurs through Cache.addAll([]). A detailed description of the syntax of the CacheStorage interface is not the goal of this article, however, working with it is much more complicated than the Application Cache API [2].

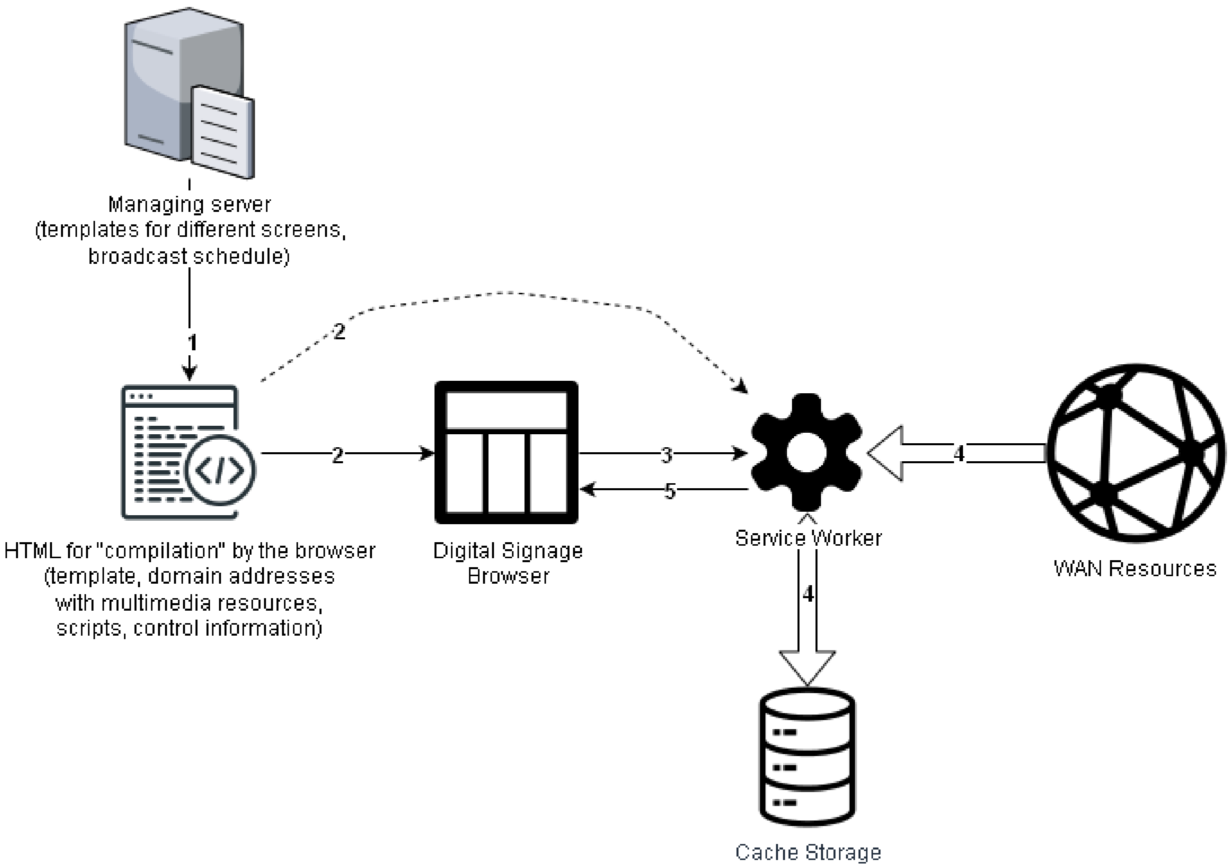


Fig. 3 Cache Storage and Service Worker workflow

Browser developers by default allocate to Service Workers mechanisms (including other APIs), as a rule, no more than 4% of the free space on the system disk [3].

So, we looked at two similar approaches to caching the resources needed to “compile” the audiovisual information from a template in hypertext format. But in the arsenal of HTML5 there is another completely different approach that will be very useful in public screen management systems - “HTML5 Link Prerender”. The <link> tag with the parameter (instruction) rel="prerender", placed in the template, loads the resource indicated in the tag (in the case of Digital Signage, this is the URL with the next scheduled broadcast template) and all its contents in the background. This is similar to opening a web page in the background tab of the browser invisibly to the user. The browser will download all resources, build the DOM, apply CSS and JS, load multimedia content, and when it comes time to change the contents of the Digital Signage screen, the hidden page will be replaced with the current one and load instantly. All questions related to caching disappear. It is not necessary to specify the <link> tag in the

<head> container; it can be generated from JavaScript via document.createElement("link") as needed for necessary templates or at the right time.

The pluses are obvious, but there is also a minus - browser support, unfortunately, as of December 2019 is very weak - only Google Chrome and derivative browsers on its engine (Blink). The nuances include the fact that Digital Signage systems can imply not only static display of content on the screen according to the schedule of the control server, but also interactive interaction with the user, for example, through a touch kiosk, and, as a result, the use of HTML5 Link Prerender becomes this scenario is useless because It doesn't allow us to load more than one page in the background, and it's impossible to predict the user's action in advance.

As part of the article, it is also worth mentioning the video, which can be one of the elements in the template. When broadcasting streaming video or video over IPTV, there is no concept of caching - in this case there is only the concept of buffering. When using hypertext, the concept of buffering is also present, but it is responsible for embedded video or audio and is controlled through the API interface via JavaScript. For example, we can configure the video to play at the moment when it is ready to play (event "canplay"). In this case, the video will not be cached either in the standard browser cache or in the alternative managed "storage", but will be saved in the browser's temporary files. Remotely, through server instructions, we can adjust the volume of the audio (this.volume). In IPTV, such functionality is not available and it is necessary to adjust the volume on the client's equipment, or re-prepare the stream with the necessary volume for one or another location of the Digital Signage digital screen. It is also possible through JavaScript to add interaction between several videos or show some kind of photo slide at the end of playback. Moreover, the template on the side of the browser client will do this on its own without the need to download another template from the management server.

Summing up, it is worth noting that the HTML5 specification implies several caching options, depending on the goals. One of the most simple and supported by all browsers Application Cache API, unfortunately, is no longer recommended for use by developers HTML 5.2 and higher. The alternative (CacheStorage API) implies wider and more flexible capabilities, but requires JavaScript skills, has more complex syntax and difficulties with cross-domain requests (which is important when working with Digital Signage, which may "compile" audiovisual content from different sources). One of the most interesting features of Link Prerender for HTML5 digital signage screens has not yet been implemented by developers of all popular browsers. So, if the use of a specific browser does not matter, then as a universal solution for Digital Signage systems, we can use HTML5 Link Prerender with the Chrome browser. If all content is supposed to be taken from one domain (which also hosts the management server), then we need to use the CacheStorage API. If the screen implies a frequent lack of access to the Internet and offline work is important, then, despite the lack of recommendations in the new standards, the Application Cache API will continue to perform its tasks for a long time.

REFERENCES

1. Dmitriy Nesteryuk. Chrome: Cache storage VS Disk cache // dev.to community. 2019 [Electronic resource]. URL: https://dev.to/dnesteryuk/chrome-cache-storage-vs-disk-cache-2f95 (assessed: 23.11.2019)

2. CacheStorage // Mozilla developers docs. 2019 [Electronic resource]. URL: https://developer.mozilla.org/en-US/docs/Web/API/CacheStorage (assessed: 23.11.2019)

3. Chris Love. What is the Service Worker? Cache Storage Limit? How Much Your Progressive Web App (PWA) Can Store // Love2Dev Blog. 2019 [Electronic resource]. URL: https://love2dev.com/blog/what-is-the-service-worker-cache-storage-limit/ (assessed: 23.11.2019)

4. Filip Bruun Bech-Larsen. Service worker and caching from other origins // Blog filipbech.github.io. 2017 [Electronic resource]. URL:

https://filipbech.github.io/2017/02/service-worker-and-caching-from-other-origins (assessed: 23.11.2019)

5. Jay Thakkar. Browser Watch: Firefox to Require HTTPS for Application Cache (AppCache) // Hashed Out team blog. 2018 [Electronic resource]. URL: https://www.thesslstore.com/blog/firefox-require-https-appcache/ (assessed: 23.11.2019)

6. Paul Kinlan, Joseph Medley. API Deprecations and Removals in Chrome 50 // Google Developers. 2019 [Electronic resource]. URL: https://developers.google.com/web/updates/2016/03/chrome-50-deprecations (assessed: 23.11.2019)

7. Same Origin Policy // World Wide Web Consortium. 2010 [Electronic resource]. URL: https://www.w3.org/Security/wiki/Same_Origin_Policy (assessed: 23.11.2019)

8. Xuanzhe Liu, Yun Ma, Yunxin Liu, Tao Xie, Gang Huang. Demystifying the Imperfect Client-Side Cache Performance of Mobile Web Browsing // IEEE Transactions on mobile computing. 2015, p. 4-7 [Electronic resource]. URL: http://taoxie.cs.illinois.edu/publications/tmc16-mobile.pdf (assessed: 23.11.2019)

THE CONCEPT OF QUALITY AND QUALITY COSTS

Khanova M. K.
MSTU «STANKIN» of Institute of Economics and technological management
+7(958) 816-70-56

Abstract - A system of accounting for the cost of product quality, by using all available opportunities to reduce costs. The main classifications of quality costs covering all stages of the product life cycle are given. The description of the approximate list of components of quality costs is given. It is concluded that the reports on the quality costs are an effective tool of quality management.

Keywords - quality, costs, control, products, services, standard.

INTRODUCTION

Quality is one of the fundamental categories that determine the lifestyle, social and economic basis for the successful development of a person and society.

Quality costs are costs aimed at satisfying the customer's requirements for product quality and maintaining the quality management system and at eliminating discrepancies of products and quality management system.

Quality costs are the difference between the actual cost of a product or service and its possible cost if no service below standard was provided or no defects appeared during manufacturing or after the delivery to consumers [2].

PROBLEM STATEMENT

In the modern market economy quality is the main factor of improving the standard of living (economic, social, environmental security, etc.). There are a large number of different interpretations of the concept of quality. The term "quality" is a very complex concept that characterizes all structural divisions of the company. This diversity is due to the fact that the concept of "quality" is multidimensional and complex.

Quality is a subjective concept. In modern management the concept of "quality" includes the current and possible needs of the consumer. The main provisions and dictionary define quality as: "the degree of compliance of the set of inherent characteristics with the requirements".

Today, various quality management systems are used in the world. But in order to be effective they must enable the implementation of the eight basic principles of systematic quality management, which have already been adopted by the most progressive international companies. These principles form the basis of ISO 9000 international quality management standards.

Quality plays an important role in the current conditions of market development . Companies in all developed countries of the world are looking for ways to improve the quality of their products and services, increase their competitiveness in the global and domestic markets. One of the most important conditions for solving this problem is an established management system.

To ensure an adequate level of quality, the costs of its maintaining should be born at every stage of the product life cycle.

The viability of an enterprise engaged in manufacturing or servicing depends entirely on the satisfaction of the consumer. Quite often many directors think that the key efficiency criteria are price and delivery time, while product values are not taken into account. However, value increase should be seen as a major factor in determining competitiveness. Most consumers see the value increase as something more important than price reduction. An efficient marketing strategy can bring clients in the conditions of competition with other companies, but only the quality of products or services determines whether the client places another order with this seller.

Information on the quality costs is essential for managers, as it is required for the following tasks:

- understanding the competitiveness of products or services in domestic and foreign markets;
- understanding the competitive advantages and disadvantages of the company both in price-related and non-price-related competition;
- calculation of the amount of financing aimed at improving of product quality;
- identification of critical areas to be improved;
- understanding if the quality costs correspond the requirements of standards;
- assessment of the conformity and effectiveness of QMS and if any changes are necessary [5].

Any quality cost accounting system should contribute to efforts to improve product quality by taking advantage of all available opportunities to reduce operating costs. The quality costs data allow for the following:

- develop a plan of activities aimed directly at defects to reduce them to zero;
- determine which actions need investment (actions to prevent defects and improve product quality);
- reduce assessment and monitoring costs as quality improves;
- continuously evaluate the results achieved and refocus efforts on the prevention of defects to further improve the quality level.

The main requirement for determining costs is to cover as fully as possible all costs related to and affecting product quality as well as their full characterics reflecting complexity and multifactor nature of the quality formation process. Therefore, the definition of costs should cover all stages of product creation and consumption and should include as many attributes as possible.

One of the main tasks is to determine quality costs, i.e. their composition and requirements for accounting, analysis and evaluation.

The most important requirement for the calculation of quality costs is to take full account of all costs directly related to and affecting product quality. Therefore, the calculation of costs should cover all stages of the product life cycle [5].

There are many classifications of quality costs.

By economic nature, the costs are divided into current and non-recurrent costs.

By the method of calculation, the costs are divided into direct and indirect costs.

There are some more classifications of quality costs. The most famous classification is by Juran-Feigenbaum which coincides with the BS 6143 classification. According to this classification, costs are divided into four groups:

1. costs aimed at reducing the possibility of defects, i.e. costs associated with an activity that reduces or completely prevents the occurrence of defects, or losses (costs of preventive measures);
2. control costs, i.e. costs of establishing and confirming the quality achieved;
3. internal defect costs - costs incurred by the company when the specified quality level is not reached, i.e. before the product was sold (internal losses);
4. external defect costs - costs incurred outside the organization when the specified quality level is not reached, i.e. after the product has been sold (external losses) [4].

The components of each of the four main categories of quality costs have been identified many years ago. The categorization of these elements is mostly conditional and small differences in details occur in different organizations. This is not critical, as the collection, classification and analysis of quality costs are only internal activities of the company. It is important that within the organization there is a mutual understanding and agreement on all issues.

Cost categories should be precisely defined, they should not be repeated; if any cost appears under one heading, it should not appear under the other, and thereafter, in all subsequent cases, this cost should appear under the same, original heading.

Another classification of quality costs was proposed by Ph. Crosby. He divides quality costs into only two categories:

Compliance costs — the cost of doing things right from the very beginning;

Non-compliance costs - all the costs that the company has to bear because not everything is done right from the very beginning [3].

Process costs are the total compliance and non-compliance costs for a specific process.

Compliance costs are the actual costs of producing products or services that meet the requirements of standards for the first time using a specified process, and the cost of non — compliance is the cost of error due to failure to perform the process in accordance with the required standard.

These costs can be measured at each stage of the process. Therefore it can be determined whether high nonconformity costs indicate the need for additional funding for failure prevention activities or excessive compliance costs indicate the need to redesign the process.

An illustrative list of components of quality costs.

- Prevention measures costs

1. Quality management
2. Process management
3. Quality planning by other units
4. Control and measurement equipment
5. Delivery quality assurance
6. Quality system audit
7. Quality improvement programme
8. Quality training
9. Other costs like:

- Control costs

1. Tests
2. Tests of delivered materials
3. Materials for tests
4. Process control
5. Customers' products acceptance
6. Raw materials and spare parts check

7. Product audit
- Internal costs in case of defect
1. Waste
2. Remakes and repairs.
3. Loss analysis
4. Mutual concessions
5. Quality decrease
6. Waste and remakes due to suppliers
- External costs in case of defect
1. Products rejected by consumers
2. Warranty
3. Product recall and modernization
4. Claims

SOLUTION OF THE PROBLEM

Quality costs are inevitable. In fact, it is impossible to completely exclude quality costs, but they can be brought to an acceptable level. Certain types of quality costs are obviously inevitable, while some can be avoided.

The following costs can be avoided:

- unused materials;
- remake and/or repair of defects (correction of defects);
- delays, excessive production time caused by the defective product;
- additional checks and control to detect the already known share of defects;
- risks, including warranty liabilities;
- sales losses associated with the dissatisfaction of consumers.

Inevitable costs are those that are necessary, such as insurance, even in case of extremely low defect levels. They are used to maintain the level of quality achieved, to ensure that the level of defects remains low.

In total, the division of costs into two or four categories is not fundamental, as the collection of cost information, its classification and analysis is mainly an internal affair of the company. What matters is that the cost structure is standard within the company. Cost categories should be constant and should not be repeated.

Quality costs are inextricably linked to all the activities of the company, which determine the quality of products.

Most of the enterprises that are engaged in production and service, bear high costs in the field of quality. Quality costs do not reduce profits, so they need to be identified, processed and presented to management like other costs. Many heads of Russian enterprises do not get full information about the level of quality costs because the company does not have a specific system for these data collection and analysis. The introduction of QMS is not an easy process. It is rather a time-consuming step-by-step process of building and improving the quality management system. Only the introduction of the QMS can solve global problems of this nature.

According to statistical data, the share of quality costs can vary from 2% to 20% of sales volume. Quality Cost Reports are an effective tool to manage quality management and the company as a whole.

The problem is the lack of a mandatory methodology for determining and analyzing quality costs. Currently, the Russian Federation uses the following legal documents to determine the quality costs:

- GOST R 52380.2-2005 "Guidelines for quality economics";
- Federal Law dated 6.12.2011 N 402-FZ "On Accounting";

- Order of the Ministry of Finance of Russia dated 06.05.1999 N 33н (as amended 06.04.2015) "On the approval of the Regulations on accounting "Company expenditures" PBU (ПБУ) 10/99";
- Order of the Ministry of Finance of Russia dated 09.06.2001 N 44н (as amended 16.05.2016) "On approval of the Regulations on accounting "Accounting of inventories" PBU (ПБУ) 5/01;
- Order of the Ministry of Finance of Russia dated 30.03.2001 N 26н (as amended 16.05.2016) "On approval of the Regulations on Accounting "Accounting of fixed assets" PBU (ПБУ) 6/01".

CONCLUSION

The basic standard of quality standards series is ISO 9000 "Standards for Quality Management and Quality Assurance. Guidelines on selection and application" [1].

In order to establish quality cost management system, the Quality Manual can be supplemented with the "Quality Cost Management" section, which will clearly define the costs accounting and analysis tasks, and principles of evaluation, planning and management. It is advisable to develop a company standard that would regulate the collection of information on all types of quality costs, methods of these data processing and analysis, as well as persons in charge.

Numerous studies show that 10-15% of the total revenue of the company is spent on maintenance of the existing quality management system, therefore, the cost of quality should be considered as an integral part of the implemented and functioning QMS. Thus, quality costs which have a significant impact on profits need to be given more attention.

REFERENCES

1. GOST ISO 9000 "Quality management and quality assurance standards. Guidelines for selection and application".
2. Afanasef V.A., Lebedev V.A., Monakhova V.P. Technical control and quality management. - M.: KD Librokom, 2013. - 256 pages.
3. Gerasimov B.N., Churikov Iu.V. Quality management. Tutorial. University book, NIC INFRA-M, 2013. - 208 pages.
4. Mikheeva, E.N. Quality management: Study book. - M.: Dashkov and Co, 2014. - 532 pages.
5. Quallity costs analysis [Electronic resource] https://www.cfin.ru/management/iso9000/iso9000_cost.shtml

APPLICATION OF MULTI-AGENT ALGORITHM FOR MODELING THE BEHAVIOR OF MEDICAL MICROROBOTS

Istomina T.V., Istomin V.V., Petrunina E. V., Trub N.V., Beloglazov A.A.
FGBOU IVO "MGGEU"
+7 (903) 228-16-13, istom@mail.ru+7 (903) 228-16-13, istom@mail.ru

Abstract — The problem of the impact of technical systems environmental factors is used to demonstrate the capabilities of developed computing tools and the current state of the problem of the development of multi-agent systems is analyzed.

Prediction of the behavior of self-organizing groups tasks arises in a wide range of fields including analysis and modeling of the basic principles of organization of living systems, complex tasks of remote diagnostics, therapy, and surgery facing modern high-tech medicine.

The main focus of this study is to consider the different principles of modeling multi-agent systems and their use in the field of biomedical applications.

An analytical description of the procedure for determining the optimal actions of a group of medical microrobots (MM) is considered. We propose a new approach for modeling the behavior of medical microrobots based on the multi-agent algorithm.

The structure characterizing the mechanisms that a medical microrobot must have to perform the target function has been developed.

To simulate the behavior of self-organizing groups of medical microrobots using modern computational methods, the proposed multi-agent algorithm was programmatically implemented in the Matlab.

This allowed us to gradually monitor the distribution of medical micro-robots in a certain field following the developed algorithm of behavior and present it graphically.

According to the results of the calculation procedures in the process of simulation, the average density of the placement of medical microrobots is obtained.

Based on the obtained data, an assessment was made of the reliability of predicting the behavior of self-organizing MMs groups, which made it possible to state the sufficient effect of the developed multi-agent algorithm.

Keywords: Multi-Agent algorithm, Medical Microrobots, Biomedical Systems, Behavior of Medical Microrobots, Swarm Artificial Intelligence.

INTRODUCTION

Prediction of the behavior of self-organizing groups is based on the algorithm of their management, using the mathematical apparatus of the theory of artificial intelligence (AI).

The theory that describes the behavior algorithms of self-organizing groups is developing in line with two main directions - distributed AI and artificial life. In the context of artificial life, we can distinguish such research areas as:

a) analysis and modeling of the basic principles of the organization of living systems [1];

b) the study of the dynamics of complex phenomena by the methods of the theory of cellular automata [2] and nonlinear differential equations;

c) modeling the evolution of artificial populations using the genetic algorithms of J. Holland and the construction of classifiers;

d) development of animates, i.e. autonomous agents, like animals, which are capable of adaptation and action in a poorly defined environment (in this area, the most interesting are the works of R. Brooks, J. Meyer, and S. Wilson.

In recent years, biomedicine has become one of the most promising areas for the potential use of distributed self-organizing robotic systems. It is assumed that a robotic system consisting of groups of miniature biomedical microrobots will be able to solve the complex tasks of remote diagnostics, therapy, and surgery facing modern high-tech medicine [3-6].

PROBLEM STATEMENT

The concept of self-organization of behavior in artificial intelligence appeared in 1989 and was proposed by the authors G. Beni and J. Wang in Swarm Intelligence in Cellular Robotic Systems [7]. It is based on the idea that to solve several problems it is impossible to build a centralized system, and all information is distributed between its elements. In each of these elements, only part of the information is stored, and the full effect is achieved only by using all the data stored in separate information elements, called autonomous agents.

An information model based on groups of autonomous agents successfully describes the behavior of both natural and man-made systems. Examples of natural systems include a swarm of bees, schools of fish, flocks of birds, anthill, termite mound, etc.

Particularly noteworthy are biological systems where self-organization manifests itself against the background of genetic algorithms, namely, the ecosystem of organisms during purification from oil pollution, etc. To solve such problems, a transition from centralized to distributed management is required, given the number of group members at the micro and nanoscale levels, which can reach hundreds of thousands.

Thus, the urgent task is to model the behavior of groups of autonomous agents (such as MMs) to describe biological and technogenic systems for various purposes. In particular, biomedical systems that potentially allow the treatment of cancer of a wide profile are of particular importance.

MMs mean a wide range of concepts, from modified microorganisms to synthesized molecular objects. Since biomedical systems consist of a large number of microrobots, it is possible to carry out only simulation modeling that describes only the functions of microrobots, while the results of mathematical modeling are refined on the simulation model.

To solve the tasks that are set for this study, it is necessary to establish some compromise between some critical factors as the physical size and the cost (i.e., manufacturing price) of MMs. Besides, for a wide practical application of microrobots in various medical applications, it is necessary to increase their autonomy while reducing their size. Such conditions require the simplification of their structure and the development of effective methods for the management of their behavior during the design process. We are proposing the application of an approach based on the swarm intelligence theory, which allows controlling the complex behavior of the entire group of robots while simplifying the operational algorithms for MMs at the individual level. In connection with the above, we suppose that it is important to approach our group of MMs as the Multiagent system using simulation modeling.

Thus, this work is devoted to the study of the behavior of biomedical systems based on micro-and nano-robots. The approach used is based on an information-structural model based on groups of autonomous agents. The purpose of modeling is to study their behavior, in particular, their demonstrated self-organization capabilities. Self-organization refers to the ability to act within a group to perform a targeted function.

As standard goals for biomedical systems, moving to a given point in the biomedical environment, taking into account its existing structure, physicochemical composition, and the like; identification of targets for exposure, for example, cancer cells; the implementation of these impacts following a predetermined program of action.

SOLUTION OF THE PROBLEM

To solve biomedical problems that are difficult or impossible to solve with a single robot or a monolithic system, it is advisable to use multi-agent systems formed by several interacting autonomous medical microrobots, independent, trained, self-organizing and adapt to changing circumstances, striving for an optimal solution to the problem without external intervention.

Achieving the goal that facing the group is carried out by performing certain actions by medical micro-robots. For the most effective, optimal achievement of the goal, the actions of individual robots of the group must be coordinated, that is, coordinated in a certain way.

Therefore, we should provide the developed group of medical microrobots with a control system. It will provide such actions for each of the robots that make up the group that meet some group criterion. The value of this criterion when achieving a group goal can be taken as optimal.

Such a group management system evaluates information about the purpose of the group, the state of the microrobots, and the external environment in which the group operates. Because of processing these data, a control vector $A(t)$ is formed for the actions that robots in the group must perform. As a result, the microrobots will deliberately change both the state of the environment E and the state of the group of robots themselves. These changes, in turn, are reflected in changes in the vector function $S(t)$.

A group goal should be achieved by repeating such actions. In the process of making changes, a group of robots controlled by an algorithm, interconnected with the environment, passes from a certain initial state to the final (target) state. Let a medical microrobot *R* function in some environment *E*, the state of which is described by a vector function

$$R(t) = [r_1(t), r_2(t), \dots, r_h(t)]^T, \tag{1}$$

and the state of the environment of the robot *E* – by a vector function

$$E(t) = [e_1(t), e_2(t), \dots, e_w(t)]^T \tag{2}$$

We can assume that the state of the external environment will change as a result of the action of any forces g (t) present in it, and not only as a result of the actions of the microrobots functioning in it. In this case, we consider it as non-stationary, and its state will be described by the function $E(t)= f_E(A(t), g(t), t)$.

Therefore, when describing changes in the state of microrobots, we must also take into account the influence of environmental forces $g(t)$, and describe the state of microrobots in dynamics by a vector function

$$R(t) = [r_1(g(t), E(t), t), r_2(g(t), E(t), t), \dots, r_h(g(t), E(t), t)]^T, \tag{3}$$

whose components will, in turn, be functions of the actions of microrobots, forces acting in the environment, state of the medium and time, i.e. $R(t) = f_R(g(t), E(t), t) =f_R(A(t), g(t), E(t), t)$.

In the general case, changes in the state of the "robot-environment" system are continuous and are described by a system of differential equations of the form

$$S' = f(A(t), R(t), E(t), g(t), t) = f(A(t), S(t), g(t), t), \tag{4}$$

where $S' = dS(t)/dt$ – time derivative of the vector function $S(t)$.

Consider the iterative procedure for determining the optimal actions of a certain group of medical micro-robots. Formally, such a procedure was described in [8-11] precisely based on a combination of iterative methods and principles of collective control.

The foreign literature has repeatedly discussed the approach of developing algorithms for the behavior of elements of self-organizing systems based on modeling [12, 13]. Prediction based on a model with results that can be obtained quickly enough is intended to support development at an early stage, before implementation on microrobots. The search for optimal values can even be carried out using complete sets of possible parameter values. Besides, the development and application of such models can provide a better understanding of the beneficial effects of processes related to a general understanding of the theory of self-organizing systems and its specific applications.

The algorithm for modeling the behavior of medical microrobots, proposed in this work, is described using accurate mapping of space and formal relationships between micro- and macro-levels. Prediction of the behavior of self-organizing groups is based on their control algorithm using the mathematical apparatus of AI theory.

To implement simulation modeling of the behavior of self-organizing groups of medical microrobots, their structure has been developed that characterizes the mechanisms that a microrobot must have to perform the target function. The structure takes into account the mechanisms of action of microrobots and is designed as a UML language deployment diagram (Fig. 1).

The algorithm of behavior of a team of medical microrobots is understood as a sequence of their joint actions aimed at achieving the desired result.

At the same time, it is necessary to ensure such level of self-organization of the team of microrobots, on which simple actions performed by each element will lead to the complex purposeful behavior of the entire team. In this study we are simulated the behavior of a group of MMs taking into account their interaction with each other and with the external environment.

The main interest for our study in the overall process of searching and locating the affected (target) area is in that moment when most robots have reached the affected area. For example, it may be the areas of various types of tumor tissue associated with cancer.

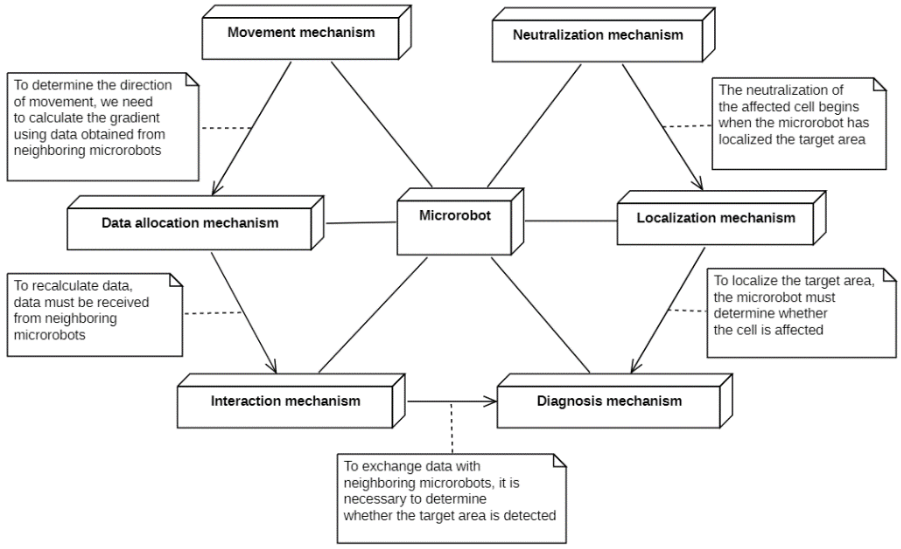


Fig. 1 The structure of microrobots described in the framework of simulation modeling of the behavior of self-organizing groups

In this study we didn’t have the task of a specific technical implementation of MMs, so some restrictions are adopted for the implementation of simulation modeling of the behavior of their team. They relate to the following items:

1) It is considered that MMs are already inside the body.

2) The duration of the simulation is determined by the working time of the team.

3) The work of each MM ends when it loses its energy reserve.

4) The entire team stop working when the last MM stops working.

We are assume that in the future such microrobots will have the ability to be biologically decomposed inside the body of a patient. Thus, the process of modeling the MMs team with the above restrictions indicates the importance of achieving the group goal by micro-robots before their resorption occurs.

Table 1 shows the parameters used in the simulation of the algorithm for collective localization and neutralization of affected cells. Distances are given in diameters of MM d; the values of time-dependent quantities are given in the iteration step Δt.

TABLE 1. PARAMETERS OF ITERATIVE MODELING

Parameter	Value
Number of MM	375
Arena Dimensions	$80d \times 40d$
Area of Target Zones r_{adi}	$1d$ and $5d$
MM Diameter	$1d$
Proximity Distance d_{prDist}	$3{,}5d$

Deviation Distance $d_{devDist}$	0,75d
MM Velocity	0,25d
Collection Rate r_{add}	50/Δt
Absorption Coefficient r_{absmpt}	0,01/Δt
Interaction Rate r_{inter}	0,5/Δt
Association Threshold δ_{aggr}	0

To implement a simulation and analytical description of the behavior of self-organizing MM groups using computational methods, we implemented the proposed multi-agent algorithm in the Matlab environment. Medical microrobots move along a limited rectangular field on which pre-installed arbitrary zones have located that act as clusters of diseased cells.

Based on the developed simulation model, we performed the simulation in the Matlab package. Each medical microrobot cannot measure field boundaries and determine its coordinates. Nevertheless, a self-organizing group of medical microrobots, using the strategy of trophallaxis, should be able to localize even complex, scattered and loosely connected areas by collective actions of the group.

In the case of placing areas of affected areas on the field of simulation, as shown in Fig. 2, it is possible to gradually monitor the distribution of medical microrobots in the field following the developed model and present it graphically, as shown in Fig. 3. The effectiveness of predicting the behavior of self-organizing medical micro-robots for collective localization and neutralization of affected cells, for analytical and simulation modeling, was evaluated. According to the results of the calculation procedures in the simulation process, the average density of the placement of medical microrobots was obtained, which amounted to 0,12/d^2.

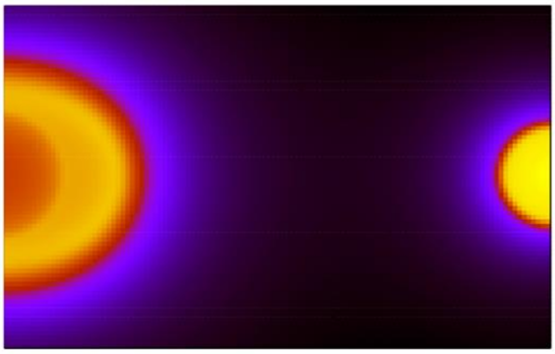
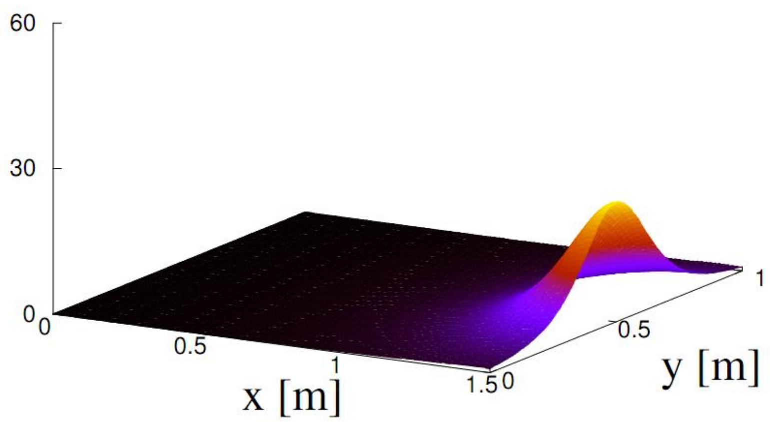
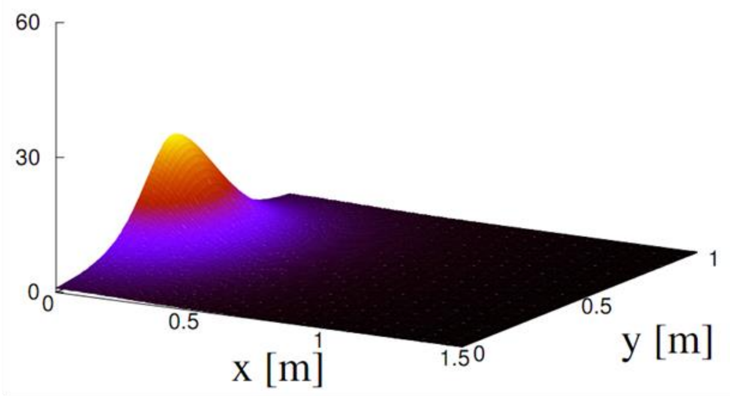


Fig. 2 An example of localization of areas of accumulation of affected cells



a) Initial stage - the introduction of medical microrobots on the field



b) Final stage - the withdrawal from the field of medical microrobots that have completed their task

Fig. 3 An example of modeling a phased quantitative distribution of medical micro-robots on the field during the execution of the algorithm with specified target areas

Based on the data obtained, the reliability of predicting the behavior of self-organizing groups of medical microrobots was assessed, which made it possible to state the sufficient effect of the developed multi-agent algorithm. Thus, the work creates the necessary scientific groundwork for further research and practical application of self-organizing groups of microrobots in biomedical systems.

CONCLUSION

A software implementation of the multi-agent algorithm for modeling the behavior of medical microrobots for use in BMS is proposed. We considered the results of a simulation study of the behavior model of self-organizing groups of MMs and assessed the effectiveness of forecasting, which was carried out according to the simulation results.

The developed algorithm was simulated using a group approach to determine the parameters of simulated microrobots, as well as taking into account the characteristics of real tumor tissues, which should become the proposed field of activity of MM. Such parameters of microrobots are adaptive aggregation based on collisions, collective perception, collective phototaxis, foraging (resource search) using virtual pheromones, as well as tree associations.

The required adaptation of the model to the corresponding situation is given by examples (changes in simulation states, choice of parameters, measurements, etc.). The achieved accuracy of the simulated forecasts is at a good level and is important for support at the stage of development of the algorithm.

REFERENCES

1. Wooldridge M. Intelligent Agents Text. / M. Wooldridge, G. Weiss // MultiAgent Systems Cambridge MA: MIT Press, 1999.

2. Hong Lin, Architectural Design of Multi-Agent Systems: Technologies and Techniques, Information Science Reference Hershey-New York, 2007.

3. Istomin V.V. The behavior algorithm of groups of autonomous intelligent agents for biomedical systems based on the theory of swarm intelligence [Text] // Caspian Journal: Management and High Technologies - Astrakhan, 2013, No. 3, pp. 54-62 (VAK).

4. Nikolsky A.E., Petrunina E.V., Istomina T.V. Modern methods and means of rehabilitation and social adaptation (physical and rehabilitation medicine) // LAMBERT Academic Publishing, 2019. ISBN: 978-620-0-28935-3.

5. Istomina T., Nikolsky A., Petrunina E., Bayramov E. Car Internet cyberbiological system for persons with disabilities (2019) 2019 International Seminar on Electron Devices Design and Production, SED 2019 – Proceedings - Prague, April 23–24, 2019. – IEEE Catalog Number: CFP19P59 – CDR. ISBN: 978-1-5386-6524-4. DOI: 10.1109/SED.2019.8798477.

6. Istomina T., Istomin V., Petrunina E., Nikolskiy A., Beloglazov A. Microscopic Image Recognition by Medical Multi-agent Systems. In: Antipova T., Rocha Á. (eds) Digital Science 2019. DSIC 2019. Advances in Intelligent Systems and Computing, vol 1114. Springer, Cham. Editors: Antipova, Tatiana, Rocha, Álvaro (Eds.) Proceedings of the 2019 International Conference on Digital Science (DSIC 2019), Cyprus, from October 11 to 13, 2019.

7. Beni, G., Wang, J.: Swarm Intelligence in Cellular Robotic Systems. Proceed. NATO Advanced Workshop on Robots and Biological Systems. Tuscany, Italy. (1989).

8. Kalyaev I. A., Gayduk A. R., Kapustyan S. G. Models and algorithms of collective control in groups of robots. - PHYSMATLITIS, 2009. – 280 p. - ISBN 978-5-9221-1141-6.

9. Kapustyan S. G., Bondarev U.P. Algorithms and a simulation model of local coordination of actions in large groups of microrobots // Artificial Intelligence. Intelligent and Multiprocessor Systems-2004: Materials of the International Scientific Conference. V.2. Taganrog: Publishing House TRTU, 2004. C. 391-395.

10. Adamatsky A.I., Holland O. Sweeping intelligence: representations and algorithms // Information Technologies and Computing Systems. – 1998. – №1. – P.45-53.

11. Shvetsov I.E., Nesterenko T.V., Starovit S.A. TAO - technology of active objects for the development of multi-agent systems // Information Technologies and Computing Systems. – 1998.–№1.–P.35-43.

12. H. Hamann. Space-Time Continuous Models of Swarm Robotic Systems, Cognitive Systems Monographs, volume 9, Springer-Verlag Berlin Heidelberg, 2010.

13. Russell, Stuart J.; Norvig, Peter, Artificial Intelligence: A Modern Approach. – 3rd ed. Upper Saddle River, New Jersey: Prentice Hall, 2010.

ALGORITHM AND METHODOLOGY OF MODELING BUSINESS PROCESSES OF RESTRUCTURING

Istomina T.V.[1], Kopylov A.M.[2], Kopylova E.V.[2], Trubacheev E. A.[1], Beloglazov A.A.[1]
[1] FGBOU IVO "MGGU", [2] Trade design JSC
+7 (903) 228-16-13, istom@mail.ru

Abstract— A method and algorithm for selecting the optimal strategy for enterprise restructuring based on a Pareto-optimal assessment of a set of parameters of specific critical factors have been developed. A user interface has been created that takes into account the dynamics of critical parameters of a particular enterprise in all its main areas of activity in relation with changes in environmental factors.

Keywords: modeling of business processes; priority areas of restructuring; Pareto-optimal evaluation; critical factors.

INTRODUCTION

In modern conditions of managing increasingly complex and accelerating business processes, new products are developed and implemented, economic niches and innovative methods of control are developed, so it makes the necessary rapid response of entrepreneurs and managers on the changing market environment of business. One of the most organizationally, technically and instrumentally complex tools for managing business processes is the mechanism for restructuring existing enterprises [1-3].

PROBLEM STATEMENT

The problem of choosing an effective method for modeling business processes is extremely relevant for an enterprise that implements a restructuring mechanism on its own. The difficulty lies in the fact that this choice creates a number of restrictions [4]. Let's list them.

1) Restrictions on the budget of the restructuring project. Modeling requires the purchase of software, and a specific modeling tool supports a limited number of uses. Therefore, the choice of product for modeling is limited by the choice of software, and the latter depends on the budget.

2) Restrictions on personnel. To perform correct modeling, you need qualified personnel who are able to work with a specific software product.

3) Restrictions on functions. Narrow nomenclature of solved problems of a particular modeling technique.

Currently, a whole series of software products are known and used that can significantly simplify the modeling of business processes. Let's list the main ones: first of all, BPW in 4.0, in addition, ARIS Toolset 5.0, as well as ORG-Master, etc. However, none of them allows you to optimize the restructuring strategy of a particular enterprise.

SOLUTION OF THE PROBLEM

In the process of selecting and evaluating specific software tools for modeling business processes, it is advisable to recommend that enterprises determine the most important characteristics of systems for solving specific tasks with the help of qualified experts [5].

In the course of research, the author developed an algorithm for selecting the optimal strategy for restructuring domestic enterprises, which allows determining its key areas, based on the principles of interactivity and decision support, which provides an individual selection of the list of critical parameters and their adaptation to the needs of a particular enterprise (Fig.1). The proposed algorithm works as follows.

1. The object of analysis and the list of restructuring directions are selected.
2. The analysis periods are determined (usually 2-5 years).
3. Select from the list of critical parameters for each of the restructuring directions defined in point 1.
4. Data is entered for the selected indicators and displayed as graphs.
5. A rating list of objects is compiled in descending order of values of critical parameters.
6. The total value of the critical parameters is determined and the shares of each parameter in the total amount are calculated.
7. The share of parameters from the total amount of parameters with the cumulative total is calculated. (The share with the cumulative total is calculated by adding the parameter to the sum of the previous ones).
8. The ranking is made of the critical parameters and build the corresponding graphical display.

Key areas of restructuring are identified.

The proposed author's algorithm is implemented in the Matlab package as a user interface of the decision support program in order to increase the efficiency of the restructuring process at domestic food industry enterprises, which is characterized by high adaptability to specific features of the analyzed objects, ease of operation and the presence of interactive tools for configuring all the main functionality.

This user interface allows you to take into account the dynamics of critical parameters of a particular enterprise in all its main areas of activity, its relationship with changes in environmental factors and determine the key areas of restructuring of this enterprise by applying the ranking principle, Pareto-optimal analysis and a decision rule based on fuzzy logic, which ensures the formation of analysis results at the current level of decision support systems.

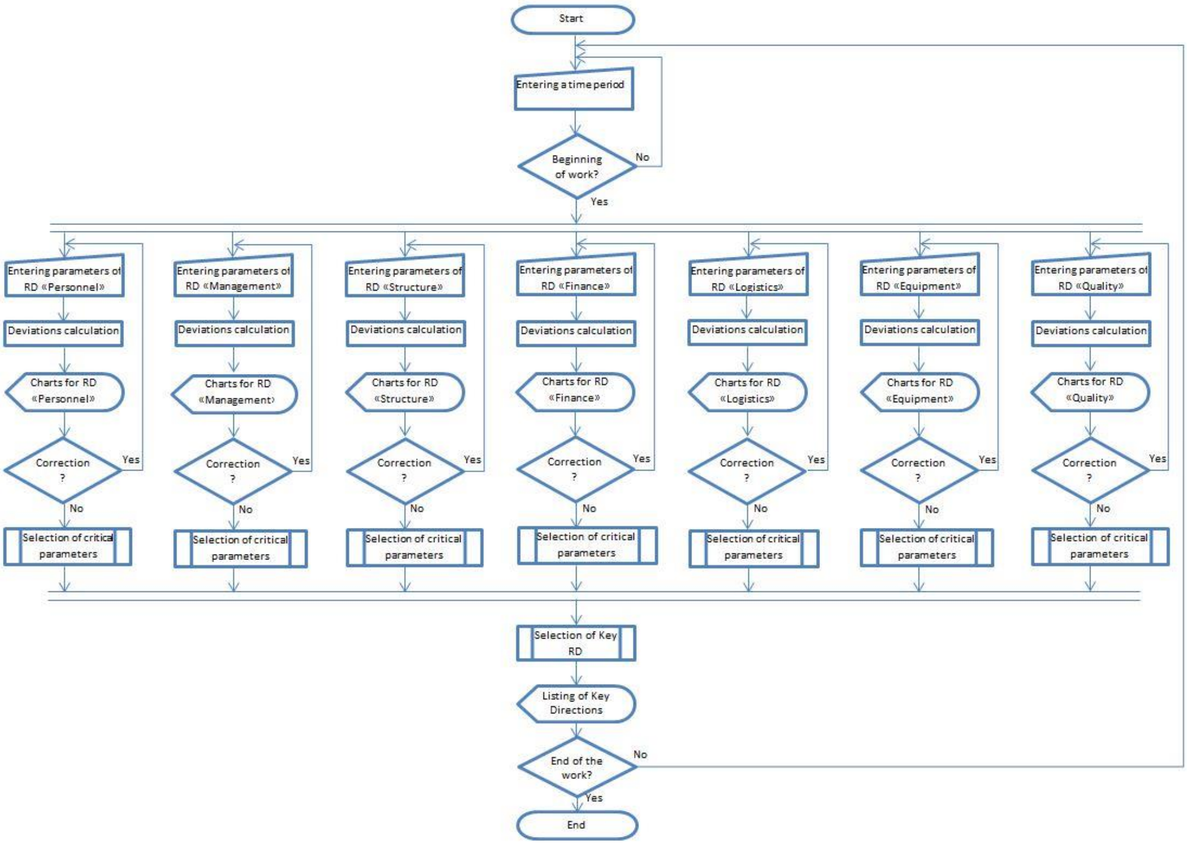


Fig.1 Algorithm for selecting key areas of restructuring

Let's consider the proposed Pareto-optimal method for determining the key areas of restructuring for this enterprise:

1.Select the period for monitoring the enterprise (critical parameters evaluation).

2.Selecting a list of the most important parameters for this company for each of the generalized strategic directions of restructuring.

3. Measurement of the selected parameters for the selected monitoring period of this enterprise.

4. Entering the measurement results of the selected parameters into the program and checking the correctness of the data on their visualization on the charts.

5. Program definition of critical parameters by their increments over years (comparison with the previous period) and construction of a Pareto chart.

6. Formation of the decisive rule for the analysis of critical parameters based on the theory of fuzzy logic.

7. Identification of three key areas of restructuring based on the Pareto method.

8. Formation of proposals for effective start of restructuring in the form of a list of three key Pareto-optimal directions adapted to the state of a particular enterprise.

9. Analysis of the company's results, if deviations are detected, the data is corrected (return to points 1-4 of the methodology), otherwise go to point 10.

10. Formation of the company's restructuring plan for the selected key areas.

TABLE I. MONITORING PARAMETERS FOR RESTRUCTURING DIRECTIONS

№	The restructuring directions "	Investigated Monitoring Parameters				
1	Personnel	Staff qualification over years, %	Labor productivity over years, %	Number of employees from 25 to 45 years over years, %	Professional development of personnel over years, %	Motivation of staff over years , %
2	Management	Average number of feedback facts, %	Labor productivity over years, %	Speed of decision - making over years, %	Internal management communication over years, %	Document flow over years, %
3	Finance	Average and total salary Fund over years, %	The volume of investments in the years, %	The amount of working capital over years, %	The average revenue for the years, %	Social payments to staff over years, %
4	Structure	Number of branches over years, %	Percentage of add-on over years, %	Capital structure, % of own funds	Form of ownership over years, %	Supplier structure over years, %
5	Logistics	Own premises over years, %	Own transport fleet over years, %	Foreign partners over years, %	Own production of packaging over years, %	Suppliers of spare parts/ components over years, %
6	Equipment	The performance of the equipment over yearss, %	Average number of failures over years, %	Percent of equipment depreciation for the years, %	The average time for planned downtime over years, %	The percentage of obsolescence of equipment in years, %
7	Quality	Marketing for the years/ Advertising for years, %	Age of employees over years, %	Professional development of personnel over years, %	Motivation of staff according to years, %	Claims over years, %

CONCLUSION

The company structure should optimally reflect the tasks that may change depending on market conditions. It should be based on optimal business processes.

The main business chain should consist of the following elements: marketing research → research and development → development and pilot production → mass production → advertising → implementation [6].

A multi-stage mechanism for improving the efficiency of a complex of enterprises should provide a phased restructuring of production in the selected priority areas, depending on the individual characteristics of the enterprise, raw materials and market needs.

The proposed system of parameters for selected generalized areas of enterprise restructuring, adapted to identify the dynamics of critical factors, should ensure the application of the Pareto principle in this area [7].

With respect to each individual enterprise at a particular stage of its development, scope, and industry niches (patient, violent, explerent, commutator), you must define a local model of the concentration of resources for each activity from the most important:

$$\begin{cases} \begin{pmatrix} \sum_{i=1}^{n} R_i = S_{j=1} \\ \cdots \\ \sum_{i=1}^{n} R_i = S_{j=m} \end{pmatrix} \\ \cdots \\ \sum_{j=1}^{m} (\sum_{i=1}^{n} (R_i * p_i))_j \to max \end{cases}, \qquad (1)$$

where n – the total number of significant activities of the enterprise;

m – the total number of types of resources available to the enterprise;

S_j – the total volume of the j-th type of enterprise resource (material-financial, intellectual-information, labor, etc.);

p_i -empirically determined specific weight of the j-type resource, which provides the company with the best result from the complex distribution of each type of resource.

In this case, the key task of optimizing the restructuring process is to determine the pi parameters. for this purpose, it is necessary to use economic-parametric models based on such methods as the method of expert assessments and correlation-regression analysis of restructuring practices in various fields of activity: by industry, by types of local markets, and in differentiation by other criteria selected by the company's managers.

The company structure should optimally reflect the tasks that may change depending on market conditions. It should be based on optimal business processes.

The main business chain should consist of the following elements: marketing research - research and development - development and pilot production-mass production-advertising-sales.

A multi-stage mechanism for improving the efficiency of a complex of enterprises should provide a phased restructuring of production in the selected priority areas, depending on the individual characteristics of the enterprise, raw materials and market needs.

The proposed system of parameters for selected generalized areas of enterprise restructuring, adapted to identify the dynamics of critical factors, should ensure the application of the Pareto principle in this area.

The developed methodology and algorithm for selecting the optimal strategy for enterprise restructuring, based on Pareto-optimal assessment of a set of parameters of specific critical factors, allowed creating a user interface that takes into account the dynamics of critical parameters of a particular enterprise in all its main areas of activity in relation to changes in environmental factors.

REFERENCES

1. Karlof, B. Delovaya strategiya. Perevod s anglijskogo, Moskva, “ECONOMIKA”, 1991.

2. Udin, M.A. Formirovanie gosydarstvennoi politiki restryktyrizacii promishlennogo proizvodstva [Tekst]: Monografiya. – Odessa, 2004. – 53 s.

3. Fransis J. Gyiyar, Dgeims N. Kelli Preobrazovanie organizacii, M. "Delo", 2007. – 289 s.

4. Kopilov, A.M. Restryktyrizaciya – neobhodimoe yslovie dlya yspeshnogo razvitiya predpriyatiya / T.V. Istomina, E.V. Istomina, A.M. Kopilov // Sbornik statej 6-oj naychno-prakticheskoj konferencii INFO – 2009 "Innovacii v ysloviyah razvitiya informacionno-kommynikacionnih tehnologij". – Sochi, 2009. – S.379 – 381.

5. Kopilov, A.M. K voprosy o metodike restryktyrizacii predpriyatij pischevoj promishlennosti / A.M. Kopilov // Sbornik statej VIII Vserossijskoj naychno-prakticheskoj konferencii "Socialno-ekonomicheskoe razvitie Rossii v XXI veke". Penza: Izd-vo PDZ, 2009. – S.34 – 37.

6. Kopilov, A.M. Metodicheskie aspecti processa restryktyrizacii predpriyatij promishlennosti / A.M. Kopilov // Jyrnal "Rossijskoe predprinimatelstvo". – 2009. - № 10, vipysk № 2. – S.67 – 70. – ISSN 1994-6937.

7. Kopilov, A.M. Aktyalnie problemi fynkcionirovaniya predpriyatij pischevoj promishlennosti Rossii / A.M. Kopilov // Jyrnal "Ekonomicheskie nayki". – 2009. - № 9(58) – S.138 – 141. – ISSN 2072-084X.

THE ROLE OF WOMEN IN THE DEVELOPMENT OF MODERN SCIENCE AND STEM EDUCATION

Kadyrkulova Zh.K.
Kyrgyz National University
+996707622159, kadyrkulova2011@mail.ru

Abstract — The paper discusses the role of women in the development of science. The problems of promotion and professional realization of women in the field of high technologies are identified, and the need to involve women in STEM education and in STEM employment and ways of encouraging more women to be in this field is discussed.

Keywords: women, science, gender stereotypes, UN resolution, STEM education, growth mindset.

INTRODUCTION

Women's path to science is long and thorny. But the pioneers met at all times. History knows about Hypatia of Alexandria, who was a mathematician in the Roman Empire. In the middle ages, universities began to appear in Europe, but women were not allowed to enter them. Ladies who were inclined to science were introduced to knowledge in monasteries. The age of enlightenment somewhat expanded the possibilities of European women, but only for representatives of the aristocracy. Thus, in the mid-eighteenth century, the physicist Laura Bassi became the first female Professor at a European University. The mathematician Sophie Germain, born in 1776 in France, made significant contributions to the development of geometry, number theory, and mechanics. But in general, these were, of course, exceptions to the rules.

In the nineteenth and early twentieth century, women's colleges were established in Great Britain and the United States. For the first time, women were able to get a formal education, but a significant factor was the support of a man-whether it was a brother, father, husband or colleague. The most famous example is Marie and Pierre Curie. In 1903, the couple received the Nobel prize in physics. Later, Marie Curie was awarded the Nobel prize in chemistry for the discovery of the radioactive elements polonium and radium. Thus, she became not only the first female recipient of this prestigious award, but also the first scientist to receive the award in two different fields.

Russian woman Sofia Kovalevskaya - the world's first female Professor of mathematics, was forced to organize a fictitious marriage in order to go abroad and enter a University there. She studied at the University of Berlin, where women, although accepted as students, were forbidden to attend lectures. The Professor, seeing the mathematical talent of Sofia Kovalevskaya, took over her patronage [1].

STEPS TO EQUAL CHANCES

The Soviet Constitution equalized the rights of women and men, and by the middle of the twentieth century, for example, in the USSR, women made up 40 percent of researchers. In Europe and the United States, the 60s of the twentieth century were also marked by the success of women's movements. Women in Europe and the United States were given equal rights with men, and the advent of effective family planning methods allowed women to combine marriage and work.

Legislation is a huge step forward, but even in the developed world, girls and women who are engaged in science still have to overcome stigma. Stereotypes that have existed for centuries also lead to the fact that girls do not seek to become scientists, researchers or inventors. According to UNESCO, only 30 percent of girls choose professions related to technical Sciences or mathematics. This statistic can be changed by removing barriers in the family, school, and workplace.

On December 22, 2015, the General Assembly adopted a resolution declaring February 11 the International day of women and girls in science. It was established in order to overcome obstacles and help the female half of humanity keep up with progress and choose the most popular specialties.

The resolution welcomed the UN's efforts to support women scientists and to encourage women and girls to access and participate in education, training and research in the fields of science, technology, engineering and mathematics at all levels.

According to the Secretary – General, who recorded a special video message for this day, the involvement of girls and women in the study of exact sciences is one of the most important factors in achieving the sustainable development goals, since "the world simply has no right to neglect the potential of half the world's population”.

The labor market is changing rapidly: 90 percent of the professions of the future are related to information technologies, and the most popular specialties are related to exact sciences. It is estimated that 58 million new jobs will be created in data processing and programming in the near future. However, women are still a minority in these professions. "The world simply has no right to neglect the potential of half the world's population," warns UN Secretary - General Antonio Guterres[2].

On February 11, the world and Kyrgyzstan celebrated the "international day of women and girls in science". Of course, setting memorable dates especially for certain specific occasions implies, among other things, reminding about certain problems and drawing attention to them. The topic "women and science" also falls into this category as a direction that needs to be developed and promoted. So, today, women have not yet been able to take their proper and desired place in science.

PROBLEM STATEMENT

If you look at the history of the Nobel prizes, among all the winners in the field of physics, chemistry and medicine-only 17 famous women against more than 570 men. The first example is known to be Marie Curie. In the past few years, it has even been widely discussed that there are almost no women Nobel laureates in these fields.

Women remain underrepresented in science, technology, engineering and mathematics, or STEM. In the field of engineering, for example, women earned fewer than 20 percent of doctorates in 2014. Such gaps, however, are not the result of differences in intellectual ability. There are a number of suggested reasons for the relatively low number of women in STEM fields. They can be broadly classified into social, psychological, and innate explanations. However, explanations need not be limited to just one of these categories. The small proportion of women STEM students who progress to STEM careers is similarly explicable. Whether by unconscious bias. A 2012 study found that science faculty members at research universities rated identical applications as more competent when men submitted them, or established culture, women find themselves in difficult academic and professional circumstances. Several factors influence the gender gap, and combined, can create a difficult environment for women to thrive.

According to Schiebinger, women are twice as likely to leave a job in science and technology as men. In the 1980s, researchers demonstrated a General evaluative bias against women. More than a third of the women surveyed felt pressured to play a traditional female role in their interactions with colleagues, and over half reported backlash for behaviors perceived as masculine, such as "speaking their minds directly or being decisive."

One study found that women steer away from STEM fields because they believe they are not qualified for them; the study suggested that this could be fixed by encouraging girls to participate in more mathematics classes. Out of STEM-intending students, 35% of women stated that their reason for leaving calculus was due to lack of understanding the material, while only 14% of men stated the same. Here is a curious pattern across STEM disciplines. While men account for the majority of all STEM students, the gender gap is much smaller in fields outside of engineering and computer science. Nearly half of the students majoring in math, statistics, physics, chemistry, geology, and astronomy are women, as are approximately 60 percent of biology graduates. The study reports that this difference in reason for leaving calculus is thought to develop from women's low level of confidence in their ability, and not actual skill. This study continues to establish that women and men have different levels of confidence in their ability and that confidence is related to how individual's performance in STEM fields. It was seen in another study that when men and women of equal math ability were asked to rate their own ability, women will rate their own ability at a much lower level. Programs with the purpose to reduce anxiety in math or increase confidence have a positive impact on women continuing their pursuit of a career in the STEM field.

In 2012, research, email requests were sent to meet professors in doctoral programs in the top 260 U.S. universities. It was impossible to determine whether exhibiting any particular individual in this study was discriminatory, since each participant only considered a request from one potential graduate student. However, the researchers found evidence of discrimination against ethnic minorities and women in relation to Caucasian men. In another study of the faculty of science, materials were sent to a student who was applying for the position of laboratory Manager at their University. The materials were the same for each participant, but each app was randomized by either a male or female name. The researchers found that teachers rated the male candidate as both more competent and more hirable than the female candidate, despite the applications being otherwise identical. If people give information about the applicant's gender, they can conclude that he or she has traits that match the stereotypes for that gender. A study conducted in 2014 found that men were favored in some areas, such as proficiency in biology, but most areas were gender-fair. The authors interpreted this to suggest that the underrepresentation of women in the faculty ranks is not only caused by sexist hiring, promotion, and remuneration.

According to the latest available data, women make up less than one-third of the world's researchers. In fact, the current picture shows that women are moving decisively towards higher education, and they account for more than half of University graduates. But if you take STEM education separately, a different situation arises. The abbreviation STEM stands for science, technology, engineering, and mathematics. STEM programs were created in order to attract people to the exact Sciences for the development of the country's competitiveness, including in the era of the arms race in the middle of the XX century. On the threshold of the sixth technological order, each leading country invests huge funds in the development of IT. However, people and their level of education are of paramount importance in the process of computerization[3]. For example, in the world, the representation of female students in STEM-related fields is slightly more than one-third. Moreover, if you look at the context of the industries included in this complex, it immediately catches the eye that these are disciplines that are usually not given preference.

In addition, the picture changes when it comes to postgraduate education. Women's strong interest in bachelor's and master's degrees does not mean that they intend to get a doctorate and continue working in the research field. In this regard, the representation of women in the global population of researchers does not reach even one third. One of the most important aspects to evaluate is cultural. Many women value a diverse environment, and they should look at the composition of both students and professors in departments under their consideration. Of course, this is an average value, and the size of this gap varies from one country and culture to another, depending on the level of development of the state. While the regions of South-Eastern Europe and Central Asia, where there is a high proportion of women among researchers, come out ahead, the South of Asia as a whole is inferior[4].

Accordingly, among the countries where women researchers have weight in the field of natural sciences, technology and medicine, some states make a stronger impression (for example, Azerbaijan, Romania, Ukraine, Brazil), others are in relatively average positions (Turkey and the EU), and a large number of countries, such as Saudi Arabia, Japan, Korea, and Senegal, are located on lower lines. This complex picture, which we have tried to describe on the basis of various statistical data, also indicates that there are many reasons for this huge gap between men and women in this area. These include a variety of dynamics, from economic development to discrimination, from prejudice against women to cultural aspects[5]. Still, I an optimistic, and believe that "culture can change."

SOLUTION OF THE PROBLEM

The lack of visible female role models continues to be a major problem. But the real problem is that the women working within STEM are hiding in plain sight. To be able to offer suggestions, we have to understand why women are outnumbered in STEM careers. At the beginning of school years, everyone starts associating languages with girls, and math with boys, and here is where those stereotypes begin. Peer pressure also stops girls from being more interested in STEM careers. At a young age, when they are developing their interest in STEM subjects, many girls are ridiculed and considered nerdy. This has a big impact on their confidence when in truth, young boys and girls are equally capable of learning math and science. By including girls more in science classes and encouraging them to try it and learn it, we are creating a different atmosphere which ultimately leads to breaking of those stereotypes since seeing girls in those classes becomes normal. Parents and educators are in a great position to help dispel stereotypes that discourage girls from becoming scientists. And one of the best ways to do that, we believe, is to create environments that promote the idea that science careers are within their reach. When girls and women believe they have a fixed amount of intelligence, they are more likely to lose confidence and disengage from science and engineering when they inevitably encounter difficulties in their course work. Negative stereotypes rest on the assumption that girls lack the innate ability needed for success. Therefore, in math and science, a growth mindset benefits women. When promoting a growth mindset, it’s essential to convey that effort and strategies build ability, and that this is true for everyone – not just girls.

One way to overcome this problem would be to spotlight examples of actual women succeeding in STEM which could inspire young women by giving them real-world examples to model themselves after. There is even research which shows that having women in STEM fields improves economic stability, simply because women are good for business.

It's important to highlight that it's not necessary to be a multimillionaire corporate celebrity to have an impact in STEM. Today's infrastructure, systems and services were primarily formed through the lens of men. Women can solve the greatest challenges by inducing a well-rounded, critical analysis. Since women make up a small portion of the overall STEM workforce, it's no surprise that many work environments in these fields leave a lot to be desired in terms of inclusiveness. In fact 30 % of women who have left the engineering profession cite organizational climate as the main reason. To put it simply, you can't expect any industry run by men and governed entirely by an all-male boardroom to be able to think like a woman, much less advocate for their interests.

Cultural stereotypes are one more reason why we don't see as many girls in STEM fields. By breaking them, we will change the traditional role girls have in our society. So, raising awareness and teaching girls about equality is crucial as well. For women to feel truly welcome in STEM workplaces, they need to gain more seats at the leadership table to fill gaps that companies may often miss on their own. Together, we can change the world to what it needs to be.

CONCLUSION

Therefore, the world must get rid of these erroneous phenomena, and new talents that have not yet been properly evaluated must be supported, encouraged, and given a path to them. That is why on February 11, according to the UN decision, the "international day of women and girls in science" is celebrated in order to shout to the whole world about these facts and needs and to arouse the interest of women in scientific activities.

We know that human resources can be the key to a successful future and a strong economy only if we have an effective, correct course and education. And the roots of the future, again, are laid by the current situation in STEM education.

Firstly, scientific research is more reliable when both genders are involved. Secondly, viewing the problem from different perspectives is one of the most effective ways of dealing with it. Besides, including women creates a larger talent pool to choose from and many more experts. Research findings are important for women in STEM because encountering obstacles and challenging problems is in the nature of scientific work.

The 21st century is a time of equality and overcoming gender differences. And what better place to start than education. Including, motivating and encouraging more girls to pursue a career in STEM fields will not only create equal status and break stereotypes, but also help improve science, and technological advancement.

REFERENCES

1. Peter A. Lawrence. Men, Women, and Ghosts in Science. Plos Biology, 2006. Vol. Four
2. International day of women and girls in science. https://www.un.org/ru/observances/women-and-girls-in-science-day.
3. Kalabikhina I. E. New approaches to measuring women's representation in STEM education and STEM employment in Russia / / Woman in Russian society-2017. No. 1. (82). P. 5-1
4. Women in STEM fields - Women in STEM fields - qwe.wikiru.qwe.wiki "wiki" Women_in_STEM_field.
5. Women and STEM in the digital age: employment policy in the megalopolis / / E. K. Zakharova, T. A. Mkhitaryan, O. B. Savinskaya [ed. by O. B. Savinskaya] / / ANO "Council for management and development". - Moscow: OOO "Variant", 2017. - 88 s

AN OVERVIEW OF FEATURES AND DIFFICULTIES OF OBJECT RECOGNITION VIA COMPUTER VISION

Khudyakov A.V.
Bauman Moscow State Technical University
+7 (916) 777-01-58, khudyakovav@student.bmstu.ru

Abstract — Computer vision is increasingly used in modern life. Along with the evolution of computers and smartphones, which reduced the cost of computing equipment, it became possible to create compact robots that interact with the environment through a camera. This article describes the difficulties of designing object recognition software and features of every step of the object recognition algorithm. There is an example of a system based on computer vision. Features of real-time detection are considered.

Keywords — computer vision; object recognition; real-time detection.

INTRODUCTION

"Computer vision" — technology that uses for data extracting statistical methods and models, built by using geometry, physics, and learning theory [1]. Computer vision based on:

- clear understanding about cameras and physical processes image formation;
- obtaining simple conclusions based on the study of a set of individual pixels;
- ability to summarize information obtained from many images;
- ordering a group of pixels to separate them or obtain shape information;
- object recognition using geometric information or probabilistic methods.

Computer vision is used widely both in relatively old areas, like control of mobile robots, industrial surveillance tools, military applications, and in new ones, like human-computer interaction, image recognition and search in digital libraries, analysis of medical images and realistic transmission of simulated scenes in computer graphics [2].

Today's development of computer vision systems is far from the realization of all its capabilities. However, this industry is developing rapidly and the range of its applications is expanding. The evolution of computer technology allows using pattern recognition technology in an increasing number of devices that people use every day.

PROBLEM STATEMENT

The main difficulty in computer vision practical use is the fact, that tasks of object recognition have no universal solution. It's extremely hard to make an algorithm that can recognize any inscription of any quality and in any situation. Objects that are considered equal in one task can be considered as different objects in others. Such difficulties arise because of lightning, scale, the context of the environment and many other reasons. For example, a street sign and a sheet of text are fundamentally different objects for the camera, but the text is perceived equally for people. Conversely, for most recognition algorithms, a mannequin and a person are the same objects when in fact it is different things. It is possible to make a universal algorithm for some tasks, but it requires a lot of time, big team and will consist of a dozen different routines [3].

Another problem is computing power limitations. The choice of used methods depends on the conditions under which recognition occurs: image, video or camera shooting, and what accuracy is needed: false positives can be critical in security systems or autopilot, or not, like in people interacting system. In order for the face recognition algorithm to work on a regular phone, it is necessary to carry out a number of optimizations in most recognition steps. For real-time algorithms, performing frame-by-frame processing with a camera frequency may be excessive or impossible. To increase efficiency algorithms may use information from previous frames to reduce calculations at each frame.

It is very difficult to form out universal tips or to tell how to create some kind of structure around which is possible to build a solution to arbitrary computer vision problems. Despite the fact that devices based on computer vision systems have a similar structure (see Figure 1), used methods always depend on the specific task.

Existing software packages (OpenCL, CUDA, MATLAB) implement parts of tasks and specific methods but still require configuration and refinement in the context of the problem being solved [4]. The choice of a specific package depends on the object recognition conditions. The purpose of this article is to structure things that can be used in object recognition tasks.

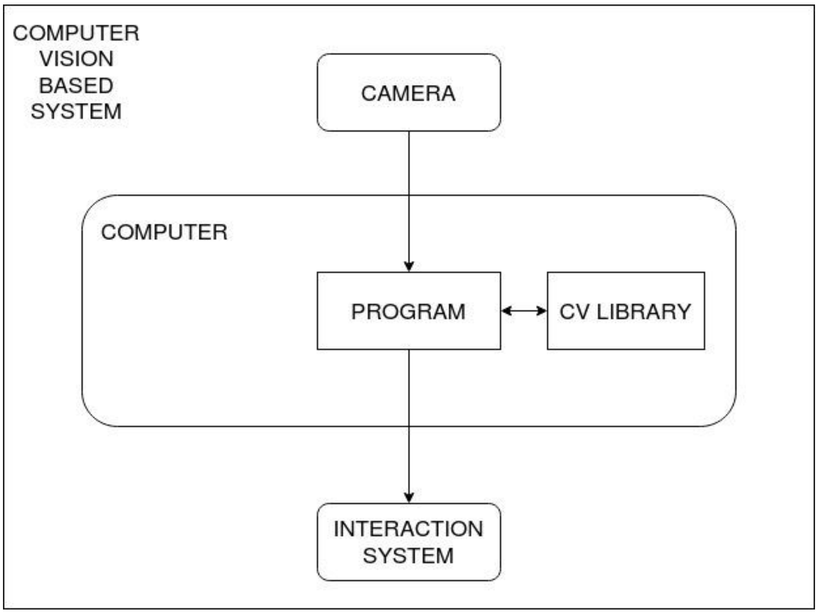


Fig.1 Architecture of a device based on Computer Vision

GENERAL PRINCIPLES OF OBJECT RECOGNITION PROCESS

In general, algorithms in the recognition process can be combined into two groups: image preprocessing and pattern recognition. To solve a problem, it is far from always necessary to apply all methods. The following section describes the general directions for a possible solution for common problems.

The image preprocessing group contains methods that allow selecting areas of interest on images without analyzing them. Most of these methods apply a universal conversion to all image pixels. At the filtering level, image analysis is not performed, but the points that pass through the filtering can be considered as areas with special characteristics. There is no using all the filters in the object recognition process. The choice of filters depends on the key features of an object and methods that will used be further. The list of methods used in image preprocessing is presented below.

- Threshold binarization: for some tasks, for example, highlighting objects on a plain background, a method can be used that selects pixels above a selected threshold. The choice of color and the threshold by which binarization occurs largely determines the process itself.
- Noise filtering: may cause image blurring, but useful in some tasks.
- Correlation: the result is the difference between the two images, used if object features can be distinguished from its movement.
- Contour filtration: contours are a very important part of objects, and if necessary, they can be distinguished. There are a number of algorithms that solve the problem of filtering circuits.

- Wavelet transform: the convolution between the image and some arbitrary characteristic function.
- Morphology: these are the simplest operations of building and erosion of binary images. These methods allow you to remove noise from the binary image by increasing or decreasing the available elements.
- Feature detection: are unique characteristics of an object that allow you to map an object to itself or to similar classes of objects. There are several dozen ways to highlight such points. Some methods highlight singular points in adjacent frames, some after a long period of time and when changing lighting, some allow you to find special points that remain so even when the object is rotated. These methods require a more complicated image analysis.

Pattern recognition methods perform the task of detecting objects in the image. This problem can be reduced to the classification problem (binary, multiclass, fuzzy). Based on the pre-processed images, a decision is made about the presence or absence of the object/objects in the image.

The objects that we are trying to recognize in the image have a certain set of features. The classifier identifies which features correspond to the object and which do not. During the operation of the detection algorithm, features highlighted on the processed image are compared with features that reflect the presence of an object, and if it matches, it is considered that the object is in the image. If the processing takes place in real-time, then such features may be the position of the camera, the range and the speed of a moving object, as well as information from buffer values: which objects were on the previous frames and where it was.

For some common tasks, such as recognition of a person/face/emotions, there are ready classifiers that can be used right out of the box.

EXAMPLE OF COMPUTER VISION BASED SYSTEM

As an example, consider the program of an android, which stands at the entrance to the restaurant and should greet people who stop in front of it with a pre-recorded phrase. The robot will need to store data about its environment, in particular, the coordinates of recognized people in the environment.

If the robot must recognize people, so initially the algorithm tries to capture moving objects. Being in the active-standby mode, the robot compares frames selected from the video stream with a certain interval, and if the difference between them exceeds the threshold value, the program switches to recognition mode.

The recognition process involves several steps. To minimize the effect of lighting and random shadows, the picture is converted to black and white. Using the Haar cascade classifier, which we use because of the speed and large existing base of trained classifiers, the robot is trying to determine whether a person is in the frame. If it’s true, then a person’s data is recorded and saved as an object with data on the position and distance to it, so that the system can distinguish one person from another. If a person is in the frame for a long time (for example, 5 seconds), then the robot reproduces the welcome phrase and marks the person as greeted. For the android under consideration, we select the entities and the relationships between them, represent them in the form of an ER diagram (see Figure 2).

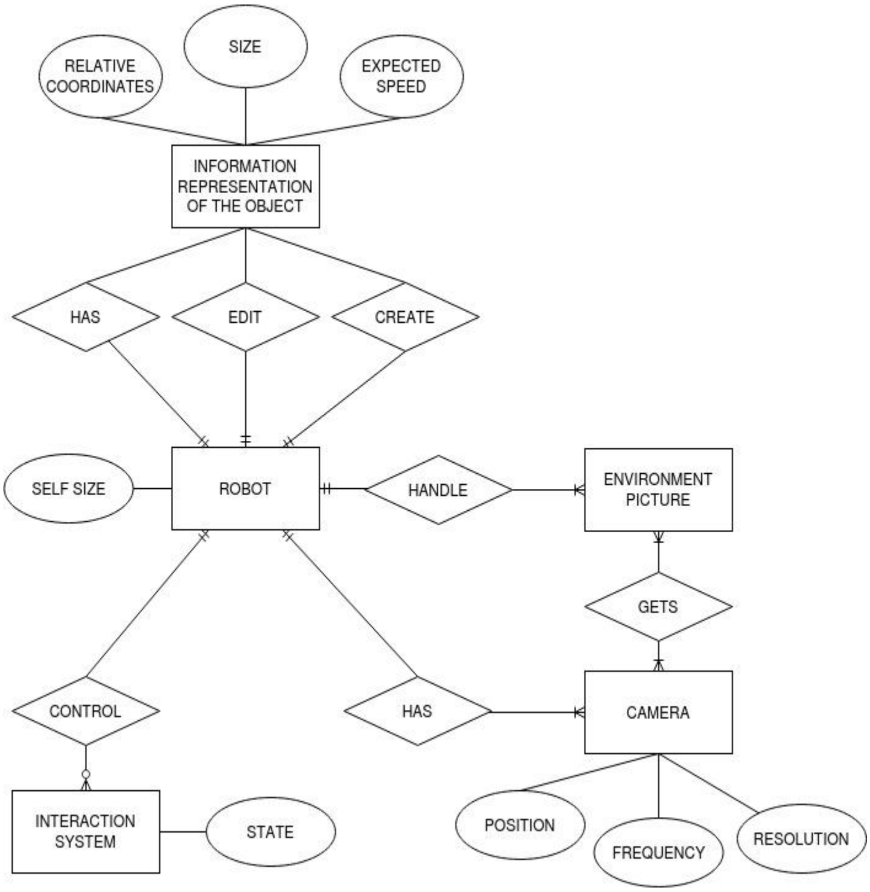


Fig.2 An example of a robot system with a camera and a system of interaction with the environment

CONCLUSIONS AND FUTURE WORK

This article shows that for all the initial complexity and vastness of the field of computer vision, its practical use is possible for the average user on most modern devices, but development can be extremely difficult, depending on the required quality and context of the applied task (recognizing a person, detecting his movements in the frame, including when one person in the frame closes another).

In the future, the presented example of the program of the doorman is planned to be implemented on the basis of the F-2 robot and an external recognition system with a video camera. It is possible to program certain sequences of actions and behavior, depending on information from an external system [5]. For such systems that must respond to the appearance of a person, data on recognized people and the duration of their stay in the frame should be stored; we need a modular structure of the "intelligence" of the robot, which is schematically represented in Figure 2. Using the methods discussed in the review, video stream frames will be processed.

REFERENCES

1. D.A. Forsyth, J. Ponce «Computer Vision: A Modern Approach» Williams, 2004, pp. 24 – 25.

2. «Komp'yuternoe zrenie: tehnologii, rynok, perspektivy» (Computer vision: technology, market, prospects). [e-resource] – URL: http://www.tadviser.ru (date of the application: 20.02.2020). (rus)

3. «Multi-digit Number Recognition from Street View Imagery using Deep Convolutional Neural Networks» [e-resource] – URL: https://arxiv.org/abs/1312.6082 (date of the application: 20.02.2020).

4. «Paru slov o raspoznavanii obrazov» (A few words about pattern recognition) [e-resource] – URL: https://habr.com/en/post/208090/ (date of the application: 20.02.2020). (rus)

5. «O robote F-2» (About the robot F-2) [e-resource] – URL: http://f2robot.com (date of the application: 20.02.2020). (rus)

APPLICATION OF ARTIFICIAL INTELLIGENCE METHODS IN THE IMPLEMENTATION OF PENSION LEGISLATION

Naykhanova L.V., Garmaev E.B., Khaptakhaeva N.B.
East Siberia State University of Technology and Management
obeka_nlv@mail.ru

Abstract –The article discusses some issues of applying knowledge engineering and machine learning methods to automate the accrual and payment process of pensions. The main automation system is built as a knowledge-based system. Machine learning algorithms are used to solve various problems. These include: the problem of automatic construction of ontologies and the automatic generation of knowledge bases, the calculation of non-insurance periods and others. The main results of the work are: the model of the knowledge-based system was created, which is designed to perform routine work on calculating pensions; the modification of this model was determined; machine learning methods were studied to extract knowledge about the situations described in the pension legislation, and satisfactory results were obtained.

Keywords – knowledge-based systems, knowledge base, ontology, machine learning, regulations, knowledge extraction.

INTRODUCTION

Knowledge engineering is the field of artificial intelligence science and is concerned with the creation, maintenance, and use of knowledge-based systems. In a broader sense, it is aimed at introducing knowledge into computer systems to solve complex tasks that usually require a rich human experience [2, 3, 5]. However, they have several major drawbacks [3, 11]. And the most common drawback is the problem "Knowledge acquisition". Getting the time of experts in the required field is difficult, experts are highly valued and in constant demand in their organization [5].

This and other problems limit the scope of knowledge-based systems. Solving this problem requires new approaches to knowledge acquisition, creating and updating knowledge bases.

For the implementation of knowledge-based systems, the areas of human activity in which regulations define the rules of work are ideally suited. An ideal example of such work is the activity of the Pension Fund, which is regulated by the pension legislation. The pension legislation describes all options for calculating and paying pensions.

In [6], a conceptual model of a knowledge-based system based on the type of production system is described. Its weak point is the processes of acquiring knowledge, creating and updating the knowledge base. Therefore, machine learning methods that are suitable for automatic extraction of knowledge from legal documents are currently being investigated.

In addition, there are tasks in the pension legislation for which it is inefficient to use production rules. These include, for example, the task "Accounting for non-insurance periods". The problem can be solved by a simple iteration of options, but the computational cost is high. The least squares method works well. However, this method also requires a large computational cost. In [7], the algorithm for constructing decision trees was studied. This method allows you to build a rating of periods (children) for each region. A suitable machine learning algorithm allows you to perform training for each region.

This article focuses on machine learning methods that can be used to find semantic relationships in text. At the beginning, we will briefly consider the conceptual model of this system.

CONCEPTUAL MODEL KNOWLEDGE BASED SYSTEM

The production system is designed to automate tasks that are strictly determined by legal acts: federal laws, government regulations, etc. Legal acts can determine not only the composition of tasks, but also the order and principles of their solution. An example is the pension legislation. In such cases, business process automation must be performed in strict accordance with current legislation. It should be noted that for this type of problem, creating a production system is an ideal solution, and it is unlikely that the use of other artificial intelligence tools will be the best solution.

Knowledge Based System (KBS) is a computer program that relies on artificial intelligence techniques and uses a knowledge base to solve complex problems. KBS has two main subsystems: the knowledge base and the logical inference machine. The knowledge base represents facts about the world, often in some form of ontology, as well as logical statements and conditions about the world, usually presented through the IF-THEN rules [10]. The inference machine is based on reverse deduction and cognitive modeling. Figure 1 shows a conceptual diagram of a knowledge-based system designed to automate the calculation and payment of pensions [6]. In addition to the main components, the system also includes the knowledge acquisition component, the explanation component, and the working memory loader.

Knowledge acquisition. The main component of the subsystem "Knowledge acquisition" is the knowledge base editor. The knowledge base needs to be correct; therefore, this subsystem also includes the module "Testing of knowledge base". The main objective of testing consists in checking the condition of the rule for uniqueness. In addition, the generator of interpreters of rules belongs to this subsystem.

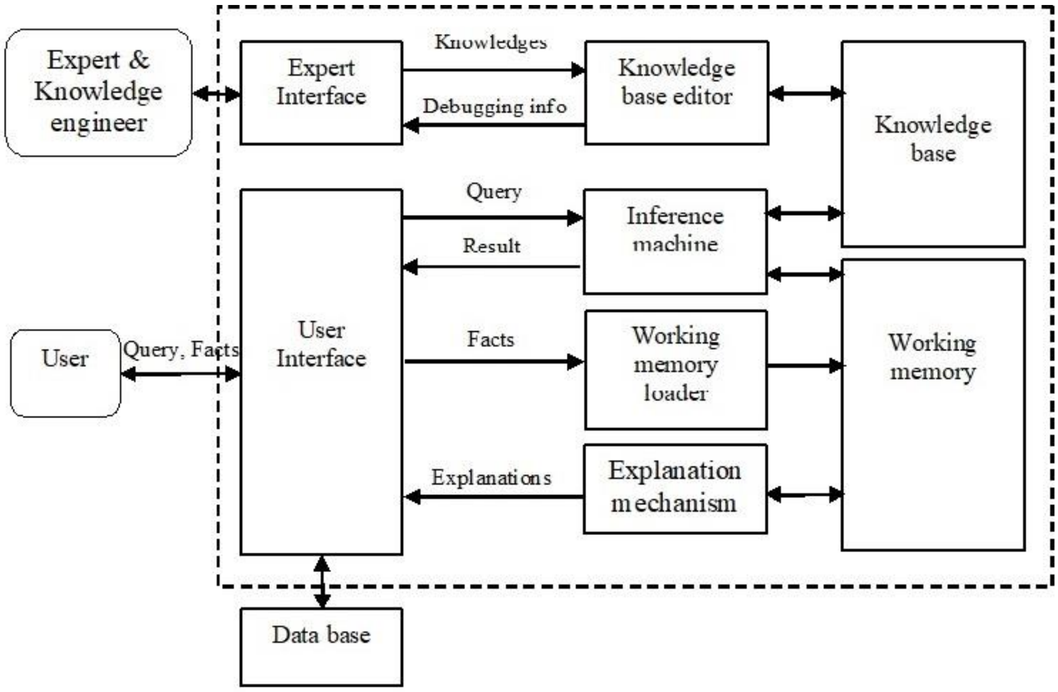


Fig. 1 Conceptual diagram of a knowledge-based system

Interface. The interface subsystem includes two modules: a expert UI and UI. The interface expert and the knowledge base editor need a mechanism to build and modify efficiently the knowledge base. In the user interface, databases requests, which are necessary for the decision of the current task, are automatically created and executed. A user shall realize the check of their execution.

Working memory. A working memory loader is intended for loading a start state of a working memory in a random access memory. The working memory is presented by data structures, in which the facts are stored. The facts are created from the information obtained from the user interface and different databases (The database containing reference information and information on regulations, Population Register, etc.).

Explanation mechanism. Any practical production system shall have an explanatory facility [2]. It is important that the production system was able to explain how the decision is obtained. The results of production system are:

- the calculated values of required parameters;
- the decision in the form of the applied rules sequence.

The found rules sequence allows creating a necessary explanation. The explanation subsystem uses ontology, in which the description of a situation and the article of the legislation are connected to each rule.

The testing based on real data confirmed operability of the system. When recognizing a situation, there is always only one rule. This fact shows that the technique of implementation of the rule base and the control strategy is developed correctly.

Basic system transformations. In the future, we expect to transform the knowledge acquisition subsystem, as shown in figure 2.

Subsystems must be developed for conversion: Extracting Quality Knowledge from the Natural Language Text of a legal document, Automatic Construction of Ontologies from Textual Resources, Automatic Knowledge Base Construction. It should be noted that this is not an easy task.

The main components of a knowledge-based system are the ontology and the rule base. The complexity of their creation is high, and there is no doubt that they need to be automatically generated. To date, there are techniques for automatically extracting concepts from the text. In principle, it is not so difficult to teach the system to extract semantic relations, but it is difficult to teach it to understand what they mean.

In [8], a study was conducted on the use of machine learning to solve the problem "Recognizing situations described in a regulatory document". The purpose of recognizing situations is to establish a procedure that must be followed later. Mobile learning is used to solve this problem. To understand how to recognize a situation, the recognition process is based on a situational approach [9]. In situational semantics, conclusions are drawn only within the context of the situation described in the text. The situation can be described by one or more sentences. In the situational approach, it is assumed that each situation corresponds to a finite number of different discrete one-step control actions. One-step actions constitute a procedure. This approach to describing situations and identifying appropriate procedures allowed us to create a training sample.

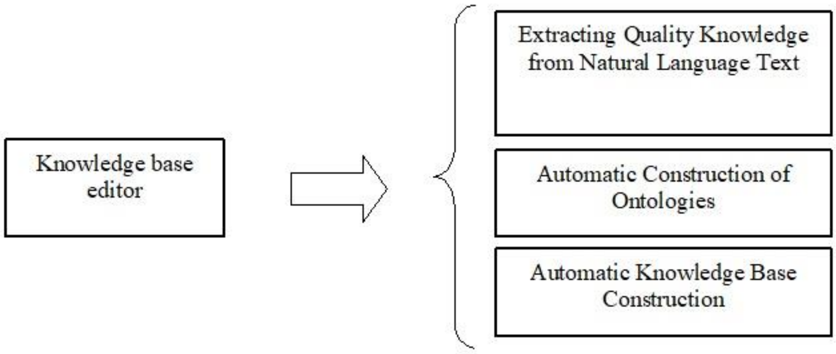


Fig. 2 The transformation scheme of the knowledge acquisition subsystem

A neural network library with open source code of the high-level programming language Python was used for research of types of neural networks. As a result, the following types of neural networks were selected for computational experiments: multilayer perceptron, convolutional and recurrent neural networks [1].

The situations of the Federal law "On insurance pensions" for six procedures were used to form the training sample variants [8]. The certification sample of the ball was formed for four procedures and twenty situations described in the Federal law "On labor pensions in the Russian Federation". Expert assessments were obtained for these situations.

The Pearson correlation coefficient was calculated to analyze the results. The observed value of the criterion (the value of a random error) – t_{obs} = 8.408 – was calculated using the known formulas [2]. According to the student's table with the significance level α=0.05 and degrees of freedom k=18, t_{crit} = 2.101 was found.

Since $|t_{obs}| > t_{crit}$, the resulting correlation coefficient value is considered significant. In other words, the correlation coefficient is statistically significant. Thus, the experiment showed that human judgments had a Pearson correlation of 0.89 with results obtained using a convolutional neural network.

DECISION TREE FOR CALCULATING CHILDREN'S RATING

One of the tasks of "Accounting for non-insurance periods" is to consider the period "child Care". The difficulty lies in the fact that the periods of "child Care" intersect with the periods of "Work" for a mother with many children. If a woman has many children and wages of different sizes, such cases require large computational costs, because they significantly increase the size of the data. A training sample was created to apply the "decision Trees" method [7]. The attribute space is based on the following source data: length of service, salary, data about children, and data about periods of work. Since all the data was modeled, the response variable was calculated using the derived dependency formula. To determine the limits of modeling each variable, calculations were performed on real data. The paper uses an algorithm for constructing a regression tree [12]. The results are shown in table 1.

TABLE 1. DATA QUALITY EVALUATION

micro avg	0.62	0.62	0.62	16
macro avg	0.42	0.39	0.40	16
weighted avg	0.69	0.62	0.65	16

The main conclusion of this study is that it is necessary to train on real data and use reinforcement learning. However, there are difficulties in obtaining big real data.

CONCLUSION

The conducted research allowed us to obtain the following results:

– a model of a knowledge-based system have been created to perform routine work on pension accrual;

– machine learning methods (recurrent, convolutional neural networks, etc.) have been studied to extract knowledge about the situations described in the pension legislation, and satisfactory results have been obtained showing that the feature space model is selected correctly.

Using machine learning provides better results when using big data. The results of the experiments prove this. In the future, the training sample should be formed based on an analysis of the entire pension legislation. This will significantly improve results.

As a result of the research, the following conclusions were made:

– there are tasks where the best automation solution is to create knowledge-based systems;

– to eliminate the main drawback of these systems, you must automatically create an ontology and knowledge base;

– to automatically create ontologies and knowledge bases, machine learning methods should be used.

REFERENCES

1. F. Chollet, Deep Learning with Python, Sankt-Peterburg: Piter, 2018. – 400 p.

2. T.A. Gavrilova, D.V. Kudryavtsev, D.I. Muromtsev, Engineering knowledge. Models and methods. – SPb: Lan', 2018. – 324 p.

3. P.H. Hendriks, D.J. Vriens. Knowledge-based systems and knowledge management: Friends or foes? // Information & Management – 1999. – V. 35, No 2, pp.113-125.

4. K.A. Jafarov, Theory of Probability and Mathematical Statistics, Novosibirsk: Publisher NSTU, 2015. 8. C. Grosan, A.Abraham. Intelligent Systems: Rule-Based Expert Systems. – 2011. – URL: https://link.springer.com/chapter/10.1007/978-3-642-21004-4_7. – 167 p.

5. S.L. Kendal, M. Creen. An Introduction to Knowledge Engineering. – London: Springer-Verlag Limited, 2007. – 287 p.

6. L.V. Naykhanova, I.V. Naykhanova Conceptual model of knowledge base system // IOP Conf. Series: Journal of Physics: Conf. Series N 1015 "International Conference Information Technologies in Business and Industry 2018", Tomsk, Russian Federation, (2018) 032097 / URL: http://iopscience.iop.org/issue/1742-6596/1015/3.

7. L.V. Naykhanova, A.A. Buldaev, N.N. Ausheeva, I.V. Naykhanova, N.B. Haptahaeva. A study of decision tree application in the problem of accounting for noninsured periods of a pensioner // IOP Conf. Series: Journal of Physics: Conf. Series N 1333 (2019) 032055 "International Conference Information Technologies in Business and Industry 2019", Novosibirsk, Russian Federation, (2019) 032055 / URL: https://iopscience.iop.org/article/10.1088/1742-6596/1333/3/032055/pdf.

8. L.V. Naykhanova, I.V. Naykhanova. Recognition of Situations Described in the Text of Legal Documents // IEEE Electronic Publication "2019 International Multi-Conference on Industrial Engineering and Modern Technologies (FarEastCon)", Vladivostok, Russia (2019) 8934044 / URL: https://ieeexplore.ieee.org/document/8934044.

9. D.A. Pospelov, Поспелов Д.А. Situational management: theory and practice, Moscow: Science, 1986. – 288 p.

10. N. Shan, W. Ziarko. Data based acquisition and incremental modification of classification rules // Computational Intelligence – 1995. – Vol.11, No 2, pp.357-370.

11. R.G. Smith. Knowledge-Based Systems: Concepts, Techniques, Examples / Schlumberger-Doll Research Old Quarry Road Ridgefield, CT USA 06877, 1985. – URL: http://www.reidgsmith.com/Knowledge-Based_Systems_-_Concepts_Techniques_Examples_08-May-1985.pdf.

12. C. Smith, M. Koning. Decision Trees and Random Forests: A Visual Introduction for Beginners. – Sheffield: Blue Windmill Media, 2017. – 160 p.

20 YEARS OF EXPERIENCE 1051 ESOPHAGOPLASTY WITH CANCER AND BENIGN STRICTURES. WAYS TO SUCCEED.

Aliev S.A., Magomedov S.M.
SBI RD "Scientific and Clinical Association" Dagestan Center for Thoracic Surgery "
+7(903) 4988094, gasanbekova73@mail.ru

Abstract – The basis of the work is the results of surgical treatment of 1051 patients with cancer of the esophagus and cardia, who were operated on from 2000 to 2019.

Strategic, tactical and technical aspects are outlined with the improvement of the immediate results of the operation. The contradictions to the indications of transpleural and transmediastinal operations in case of cancer of the thoracic esophagus are minimized. Mortality after the surgery of the Lewis type is 3%, after gastrectomy, gastroesophageal resections - 1.4%, esophageal extirpation - 2.08%

The main result of the work was the expansion of indications for esophagoplasty according to M.I. Davydov, which reduces the surgical risk of complications, in particular the failure of the esophageal anastomosis. The inclusion of a minimally invasive laparoscopic stage in the formation of the “chest stomach” avoids laparotomy during Lewis type operations.

Key words: surgical, esophagoplasty, cancer, esophagus, cardia, gastrectomy, gastroesophageal resections, esophageal extirpation

INTRODUCTION

High-tech, organ-preserving operations in functional surgical gastroenterology for oncological diseases are spreading more widely in world practice and are considered promising.

Despite the success of chemoradiation methods, the surgical method is the main one and is considered the “gold standard” in the treatment of esophageal and gastric cancer.

An aggressive strategy of surgical treatment for cancer of the esophagus with lymphadenectomy 2S, 2F, 3F isfollo wed by the oncologists of the leading centers of the world. Moreover, the immediate results of the operation are quite satisfactory, while the functional results and 5-year survival rate are disappointing. In light of the foregoing, there are priorities of improving organ-preserving surgery: vagus, splenitis, pylorosurgery, which virtually displaces standard gastroectomy from the status of the “gold standard” in the first and second stages of cancer of the cardia, proximal stomach. For these reasons, the feasibility and advantage of endosurgical interventions over standard techniques need further study.

Investigations in the oncosurgical strategy of cancer of the resected stomach, simultaneous, combined, primarily multiple tumor diseases of the cardia and esophagus were also independent tasks.

The aim of the study is to increase the efficiency and quality of surgical treatment for cancer of the esophagus and cardia, with the inclusion of endosurgical minimally invasive interventions.

MATERIALS AND METHODS

The clinical material includes 1051 patients, 801 of whom were operated on for cancer of the esophagus and cardia, and 250 for benign strictures, which are divided into 3 groups. The age of patients ranged from 19 to 94 years. More than 80% of the operated patients were over the age of 50 and had an additional pathology mainly of the cardiovascular and respiratory systems.

In the preoperative period, all patients underwent a standard set of diagnostic tests, including a general clinical examination (complaints, medical history, examination, general analysis of blood, urine, blood biochemistry), endoscopic examination with histomorphological examination of biopsy samples, polyposition x-ray examination, ultrasound of abdominal organs, retroperitoneal space and cervical-supraclavicular areas, computed tomography and quality of life testing.

Heterogeneous nosological units, which are different inetiopathogenesis, pathophysiological essence, morphological substrate, manifestedwith dysphagic, painful and rugurgitational signs. These units include neuromuscular diseases of the esophagus (NMDE), Barrett's esophagus, the stricturesof tumor, chemical, peptic, tuberculosis,collagenosisetiology. To determine surgical tactics, to optimize the treatment and diagnostic complex, the core problem was the differential diagnosis; according to the principle from simple to complex, from non-invasive methods that have screening significance to highly informative methods for the inclusion of MRI and CT, which allow a qualitatively formulated diagnosis.

The first group included: 355 patients with radical operations on the esophagus. They are divided into stages as follows:

I, II stage - 27%

III stage - 58%

III-IV stage - 15%.

They underwent operations of the Lewis type in the modification of M.I. Davydov with a postoperative mortality rate of 3.1% and (or) extirpation of the esophagus according to A.F. Chernousov (n = 48) with one fatal outcome.

General requirements for methods of forming esophageal anastomoses are reduced to high reliability of the technique, technical ease of implementation and functional advantages.

A large number of factors affect the development of leakage of esophageal anastomoses, however, the method of formation of anastomosis plays a leading role.

The second group was comprised of 446 patients with gastrectomy, gastroesophageal, resections with postoperative mortality of 1.4%.

They were divided into the following stages:

I, II stage - 11%

Stage III - 62%

III - IV stage - 27%.

The third group consisted of the patients (n = 250) with benign strictures with 1 fatal case (0.5%).

The immediate and long-term results of surgical interventions were studied.

The choice of postoperative follow-up dates corresponded to the stages of medical and social rehabilitation. So after 3 months, patients returned to work, by 6 months rehabilitation after surgery was over, and by the end of the year, adaptation to the consequences of surgery.

From the point of view of organ-saving and functional operations, pylorus-preserving operations with the inclusion of duodenal transit deserve attention, which practically displaces standard gastrectomy from the status of the “gold standard” in the first and second stages of cancer of the proximal stomach.

The role of pyloric pulp in the regulation of the digestive process does not cause discussion. The pyloric sphincter is a complex morphofunctional structure. An electromyographic study noted the non-synchronism of the supra-pyloric part of the stomach, the pyloric sphincter and the initial part of the duodenum, which indicates the functional autonomy of the pyloric pulp

We conducted 42 operations with preservation of the pyloric pulp, which allowed us to increase the functionality of the option of surgery with direct esophagoduodenal anastomosis with the resolution of post-gastro-resection syndrome (reflux esophagitis, dumping syndrome) which lead to improvement of quality of life.

A comparative evaluation of nutritional status and quality of life after gastrectomy with different methods of reconstruction. In the nutritional status included three integrative indicator - total protein, albumin and hemoglobin. The study of quality of life of patients was performed using a common questionnaire, MOS SF-36 includes the mental and physical health components of the 8 concepts and specific questionnaire GSRS (Gastrointestinal Symptom Rating Scale). The parameters were evaluated before surgery in the postoperative period and in the dynamics at 3, 6 and 12 months. Dynamically shows the change of indicators of nutritional status and quality of life of patients operated on according to the methods of reconstruction of the digestive tract. Proved significantly better indicators of nutritional status and high level of quality of life in patients with gastrectomy with preservation of the pyloric sphincter.

Gastrectomy with preservation of the pyloric sphincter is the most "physiologic" operation, among other methods of gastrectomy, as it allows to preserve the natural passage through the duodenum, to provide a la carte evacuation, warns duodeno-esophageal reflux, dumping syndrome. Expanding indications for esophago-duodenoanastomosis preserving gastrectomy with pyloric can prevent the development of complications after gastrectomy and gives good functional results in the long run.

Thus, the accumulated experience of 1051 operations with esophagoplasty with an overall low mortality rate indicates good, immediate results in specialized hospitals.

The concept of a systemic disease with primary generalization of the tumor process allows the use of low-traumatic transchiatal access in malnourished and elderly patients.

An effective method of prevention with a high risk index of pleuro-pulmonary and cardiovascular complications was the exclusion of the thoracotomy stage of the operation by the wider introducing esophagus extirpation in clinical practice according to A.F. Chernousov from abdomino-posterior mediastinal access. In 30% of patients with locally advanced cancer an aggressive strategy dominated with simultaneous super-radical operations (n = 65) removing from 3 to 8 organs, including a class of operations with synchronous and metachronous esophageal cancer: primary multiple synchronous and metachronous esophageal cancer, “refusal patients” and relapses of cardia and esophagus cancer.

FINDINGS

Expansion of indications for the implementation of esophagoplasty according to a modified technique of M.I. Davydov provides a solution to the problem with a decrease in the level of infectious complications, the failure of anastomotic sutures.

The most common complications in the early postoperative period during radical operations on the esophagus and cardia are pleuropulmonary, cardiovascular complications.

The results of a study of the nutritional status and quality of life have reliably revealed the advantage of transduodenal digestion with gastrectomy.

An effective method for the prevention of pleuro-pulmonary, cardiovascular complications was the exclusion of the thoracotomy stage of the operation through the wider introduction of “stripping operations”. The minimally invasive laparoscopic stage of the operation with the formation of the “chest stomach” avoids laparotomy by completing the operation with a thoracotomy access.

CONCLUSION

A dialectical view of this problem allows us to comprehend the current situation and determine the future development of surgery of the esophagus and cardia in the 21st century.

In the Republic of Dagestan, a weak social and economic status remains a problem. The standards for developing countries have not been implemented, the levels of horizontal and vertical power in health care have remained declarations, therefore, the indicators of early diagnosis with a shift in the structure of cancer in favor of I - II stages are low.

TABLE 1. CARDIA-ESOPHAGEAL CANCER SURGERY (N=446)

	Operation	**Number of patients**	**Mortality**
1	Transperitoneal cardio (gastro) esophagic resection with simultaneous esophagoplasty	**154(4)**	**2,2%**
2	Gastrectomy for M.I.Davydovu	**234(2)**	**1%**
3	Pylorus-preserved gastrectomy according to the technique accepted in the clinic	**41**	**-**
4	Extirpation of the stump of the resected stomach, combined advanced options	**17**	**-**
	Total	**446(6)**	**1,4%**

TABLE 2. SURGERY FOR CANCER OF THE ESOPHAGUS, CARDIA (N=355)

	Operation	**Number of patients**	**Mortality**
1	Transthoracic resection of the esophagus with simultaneous esophagogastroplasty (Lewis type surgery, modified by M.I. Davydov)	**275(9)**	**3,6%**
2	Extirpation of the esophagus with total isoperistaltic tubular esophagogastro (colo) plasty with anastomosis on the neck according to A.F. Chernousov	**49(1)**	**2%**
3	Gastrectomy combined with extirpation of the esophagus	**6**	**-**
4	Extirpation of the esophagus according to Dobromyslov - Torek	**3**	**-**
5	Reconstructive interventions for diseases of the operated esophagus	**22(1)**	**4,8%**
	Total	**355(11)**	**3,0%**

TABLE 3. EMERGENCY SURGICAL INTERVENTIONS PERFORMED WITH BENIGN STRICTURES OF THE ESOPHAGUS AND CARDIA

№	**Structure of nosologies and volume of operations**	**Number of patients**
1	Elimination of the grafted posttraumatic para-esophageal hernia with necrosis of the cardiofundal department with the restored stage of the operation	**9**
2	Operative removal of foreign bodies of the esophagus	**13**
3	Gastrectomy with preservation of pyloric pulp at the height of profuse bleeding from the hygienic ulcer of the stomach.	**1**
4	Emergency thymectomy at the height of the hypertensive crisis	**1**
5	Operations performed on the neck on the background of a compressed esophagus and stridorous respiration	**9**
6	Iatrogenic damage to the stricture of the esophagus with mediastinitis, with esophagus extirpation, esophagogastroplasty	**1**
	Total	**34**

	Lethality	-

REFERENCES

1. ASO Author Reflections: Cervicothoracoscopic Esophagectomy for Esophageal Cancer. Takahashi K, Okamura A, Watanabe M. Ann Surg Oncol. 2020 Mar 2. doi: 10.1245/s10434-020-08283-2.
2. Aoyama T, Atsumi Y, Hara K, Tamagawa H, Tamagawa A, Komori K, Hashimoto I, Maezawa Y, Kazama K, Kano K, Murakawa M, Numata M, Oshima T, Yukawa N, Masuda M, Rino Y. Risk Factors for Postoperative Anastomosis Leak After Esophagectomy for Esophageal Cancer. In Vivo. 2020 Mar-Apr;34(2):857-862. doi: 10.21873/invivo.11849.
3. Orringer M.B., Stirling M.C./Esophagectomy for esophageal disruption/II Ann Thorac. Surg-1990.-vol.49.-35-43
4. Davydov M.I., Stilidi I.S. / Cancer of the esophagus / Moscow, 2007, 387 p.
5. Kutushov M.V. / Cancer heal / Moscow, AST Publishing House, 2008, 512 p.
6. Miroshnikov B.I., Lebyadinsky K.M. / Surgery of cancer of the esophagus / St. Petersburg "Foliant", 2002, 303 p.
7. Chernousov A.F., Ruchkin D.V., Chernousov F.A., Balalykin D.A. / Diseases of the artificial esophagus / Moscow, Vidor, 2008, 673 p.

STRUCTURAL-ALGORITHMIC APPROACH TO THE SOLUTION OF PROBLEMS OF PROVIDING SERVICES IN SMALL BUSINESS

Malakaeva S. N.
Institute of system technologies, Makhachkala, Russia
kurbandin@mail.ru

The paper examines the challenge of providing services in small business, the system approach, model and procedures formalize this task in the context of digitalization of economic processes. It is also proposed that the algorithm for modeling of business processes with properties of adaptation process taking into account the services rendered

Keywords: business model, service, process, algorithm, system approach, efficiency, profitability, diagram, route.

RELEVANCE

It is known that the economic basis of any developed country are large corporations that determine the level of scientific and technical and production potential. However, the real the basis of life in the countries with market system of managing is small and medium business as the most mass, dynamic and flexible form the business of life. This sector creates and circulates the bulk of the national resources of the service sector, which are the breeding ground for medium and large businesses [1].

Small businesses are different in that their conditions of life and activities, as well as a producer and consumer at the same time the domestic market forcing them in daily life to increase ties with their customers and potential customers from various social groups.

For a comparative assessment of the level of development of small business in different countries it should be noted that in the world there was different approaches to the definition of a small enterprise (number employees; production of goods and services, the amount of capital etc.). Such approaches to the definition of the main parameters of small businesses depend on the current practices and objectives of public policy towards small business.

The social importance of small entrepreneurship is determined a massive group of small property owners, owners of small enterprises and their employees, the total number of which is one of the most significant quality characteristics any country with a developed market economy. This group the active population serves the bulk of the consumers, producing a range of products and services in accordance with the fast changing market requirements [2]. It is necessary to consider the following major social factors:

- the change in public psychology and vital reference points the bulk of the population;
- the decline in unemployment and social tension in the country;
-objective the desire of a growing number of citizens to engage in independent entrepreneurial activity;
-increase their well-being and quality of life, which is the basis of socio-economic reforms, the guarantor political stability and democratic development of society. The significant role of small business in the economic life of the countries with market economic system is determined by the fact that this sector operates the vast majority of enterprises, focused a large part of the economically active population and produced about half of gross domestic product. So, the share of small enterprises in the economic system of countries such as USA, Japan, Germany exceeds 95%.

The small business sector is the most dynamically developing new types of services and economic niches developing in industries unattractive to big business, etc. the most Important features of small business are the ability to accelerate the development of investments and high turnover of working capital. Another characteristic of small entrepreneurship is an active innovative activity, the accelerated development of various industries in all sectors of the economy.

Small businesses are usually more receptive to innovation than a large Corporation, it can quickly rebuild the production and to innovate. Because of financial constraints, he interested in the accelerated development of technical innovation projects. In countries with developed market relations are incentive mechanisms of risk initiatives, and active support the organization and activities of the venture (venture) enterprise at the expense of a progressive scientific and technical projects. Venture capital firms are rapidly developing and bring to the stage industrial design the majority of innovations[3]. The decision of such task small firms spend about four times less time than large enterprises.

DESCRIPTION OF THE SITUATION

Small business development is one of the most effective ways of Russia's economic growth in the near term [1].

Nowadays small business is designed to not only become the most important basis of economic restructuring, taking into account features of development of regions, but also to ensure the supply of local budgets.

Small business provides society with additional socio-economic effect, reducing state spending on employment of citizens, maintaining social stability, ecological balance, assistance to depressed regions and so on. Therefore, the cost of support of small business are not a charity, but a return to small business part created a macroeconomic effect.

This support should be implemented at both the Federal and primarily at the regional and municipal levels, taking into account regional differences [2].

Thus, for any economy activity of small firms is an important factor of increasing its flexibility. The level of development of small business experts even judge a country's ability to adapt to a changing economic environment [3].

The digitalization of the economy calls for changes in small business, particularly in business services for small businesses. These include:

- widespread introduction of new information technologies;
-distributed and virtual nature of the services rendered by which is meant, respectively, expansion of geography of services, the remote location of the link "supplier-consumer" and the lack of direct contact between supplier and consumer when providing services;
- the ability to optimize the service delivery process, the choice of the optimal variant of organization of services, which reduces costs for transport, select the best price;
- organization of services without a large capital investment that is most appropriate for its organization in a small business, small businesses.

STATEMENT OF THE PROBLEM

As previously underlined, a small business actively develops in sphere of services, it does not require large capital investments. However, small businesses need more flexibility and exposure to innovations that first requires use of the latest achievements of science and technology. This primarily concerns the introduction of information technologies in social sphere and in the sphere of consumption.

Optimization of activity of subjects of small business requires:
- operational optimization problems to reduce costs not only on the basis of current experience and traditions of doing business, but also the use of methods of mathematical simulation using the software tools of General and special purpose;
- use of network models of services with the aim of expanding business. A characteristic feature of which is the solution of the problems using graph and game models of the operational services;
- automatic selection of the optimal route of delivery of services with an extensive network with pre-selection of the source of services with an extensive network at a known destination (the consumer);
- the extension of the sphere of consumption and of the list of requests in connection with the increasing range of products and proposals in the social sphere, which in turn strongly influences the need for diversity of services in small businesses;
- the need for implementation of parallel relations between small businesses working in the same and different spheres of activities, to avoid failures in business organizations and provide services at the request of the consumer;
-the need for the combination along with the local schema network schema service delivery;
- the need for preliminary solving "conservation" and before receipt of the order to reduce terms of delivery of services to the recipient.

DESCRIPTION OF THE MODEL

Thus, the small businesses in the service sector can be represented as a branched network where the vertices refer, respectively, to consumers and producers of services and the relationships between them characterize the process of providing services. While implementing the procedure:
- the solution of the optimization problem and a decision about the choice of source of service and route delivery services (Fig.1.).
- the problem about differentiating services and its partitioning among the various subjects of small business;
- addressing the issue of joint provision of services by several small businesses when you receive complex applications.

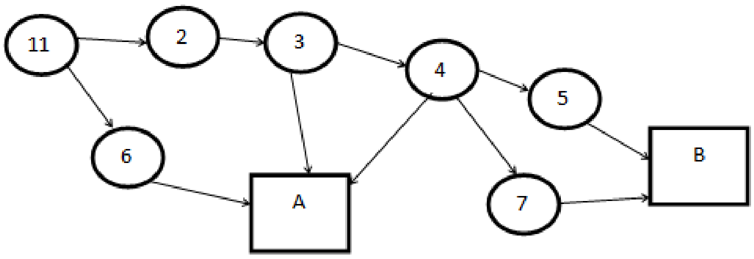


Fig. 1 Service delivery model (1,2,...7-suggestions of services A,B—the demand for services)

It is proposed the effectiveness of services assessed via the coefficient

K=Tobsch/(Tobsch+TPR),

where Tobsch total time of a small business entity, TPR - down time. The overall average coefficient of efficiency for network Cseti is estimated by the formula of

Xeti=(K1+K2+.....+Kn)/n

where n the number of small businesses.

ANALYSIS OF THE SERVICE DELIVERY PROCESS

The process of providing services can be represented in the form of a block diagram, where the result is the rendered service, and as starting components for the provision of services uses a text-based formulation of the services by the consumer, material and financial investments consumers and suppliers, Federal and municipal regulatory legal acts regulating business activities of business entities in the small business or other factors [5]. To the latter may apply customs duties, change in currency exchange rates, or force majeure (Fig.2.).

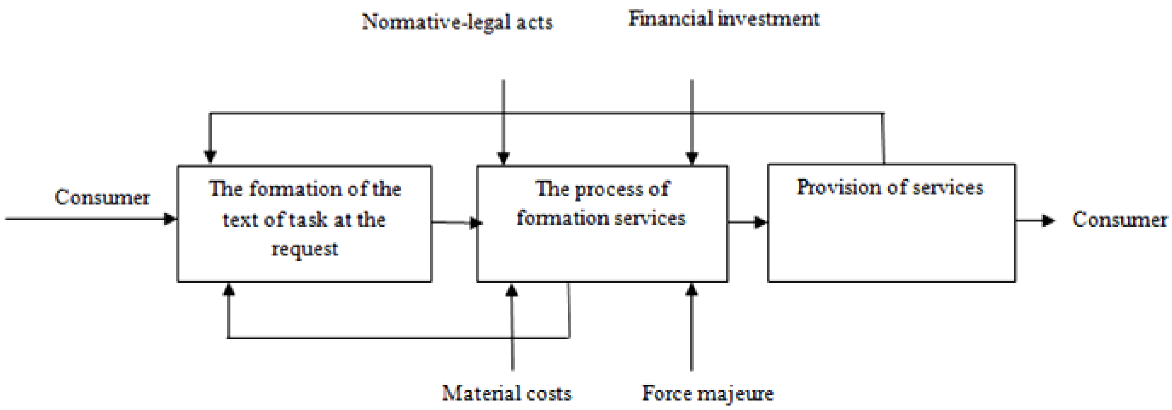


Fig. 2 Flow chart of the service delivery process

The introduction of information (digital) technology means in accordance with this scheme:

- to draft the services provided by the supplier and its agreement with the consumer;
- the choice of consumer option to receive services according to the principles of "time-quality", "time-cost" or "cost –quality;
- the possibility of intervention by the consumer in the process of formation of services and the selection of "route" of the service in its sole discretion;
- the possibility of reducing costs by the provider in the formation of services and the prevention of conflict situations in the relationship with the supplier [4].

The figure shows the multi-purpose nature of the service, which is primarily focused on quality satisfaction of the needs of the buyer or consumer. At the same time, without digital support for the process, there is a high probability of a failure, expressed in the delay of the service, loss of the application, and incorrect forwarding of the application, which can be attributed to the shortcomings of the introduction of information technologies. This scheme heavily loads the marketing system in the network organization of the service, where many parallel and sequential processes are involved.

The implementation itself resembles an automated information processing system with feedback, where a high degree of digitalization of the processes of providing a variety of services is used as a filling.

This realizes the following algorithm of rendering of services, which as shown in the block diagram, the presence of feedback in the automatic control system (Fig. 3) used to ensure the quality and timeliness of service.

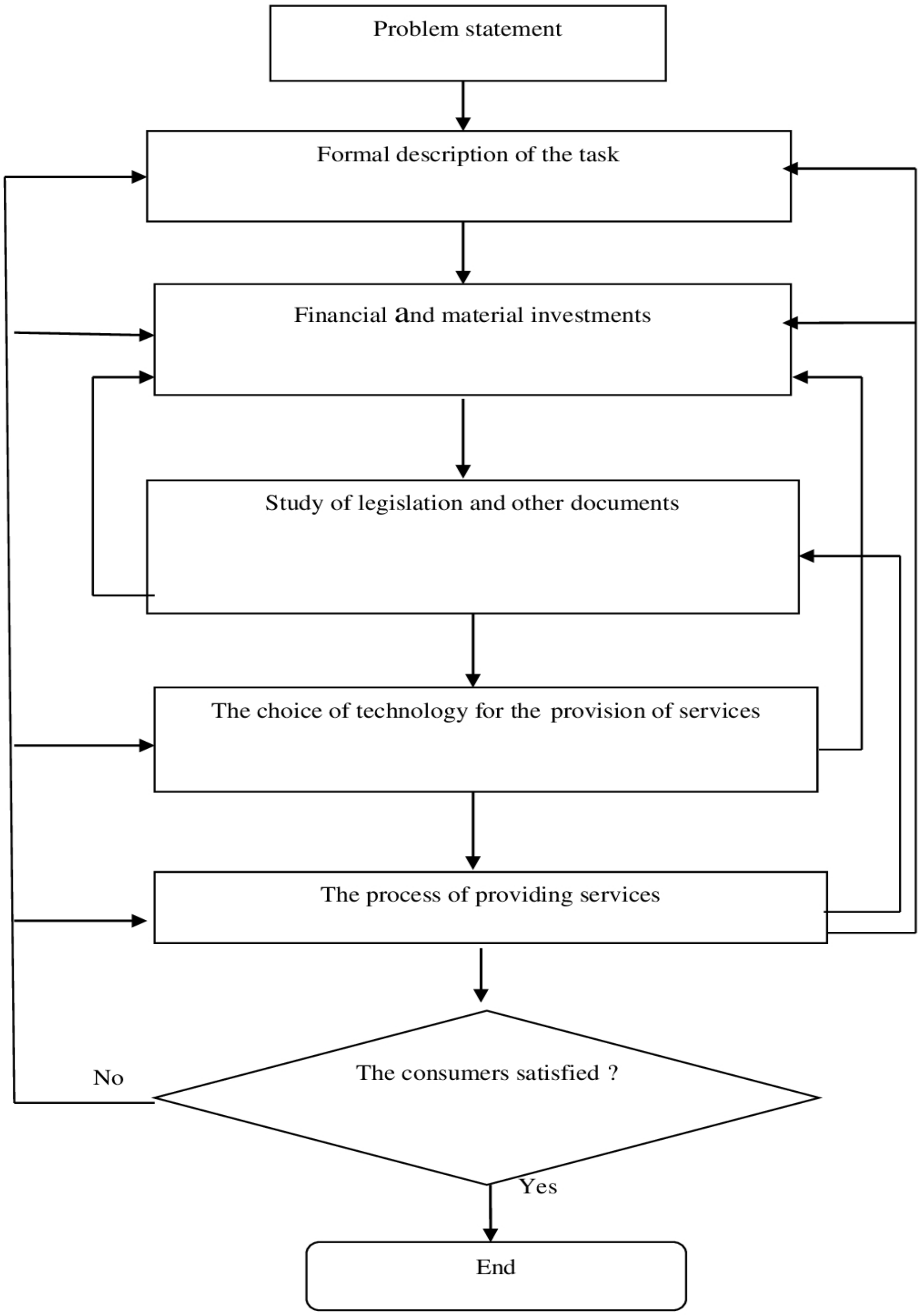


Fig. 3 The iterative algorithm of the provision of services

In conclusion, it should be noted that this traditional approach to providing services can be implemented partially, as without the use of information technology allows you to organize all the communications and the option of providing the service. These connections define a systematic approach to solving the problem of the provision of services and, ultimately, to achieve the effectiveness of providing the service and profitability of a small business.

REFERENCES

1. Romanova L. A. region's Economy: independence and state regulation // the a/R of a thesis for the degree of doctor of economic Sciences. – M, 2014.
2. Services: new concept development/ V. M. Rutgaizer, T. I. Koryagina, T. I. Arbuzova, and others – M.: Economics, 2005.
3. Regional regulation of business in market conditions: theory and practice./A. A. Gorbunov, V. G. Korotkov, V. V. Tomilov. Under the editorship of Gorbunova A. A. – St. Petersburg: ISEP ran, 2005 .
4. Abroskin A. services and economic development // Questions of statistics, 2016, No. 10 .
5. Volkov V. N., .Radchenko O. S. model of the process of rendering of electronic services to the population. // Information resources, systems and technologies, 2012. – 12. №1. – S. 5 – 8.

COMPARATIVE ANALYSIS OF POPULATION MORTALITY FROM INFECTIOUS DISEASES IN RUSSIA AND COUNTRIES OF THE WORLD COMMUNITY

Tikhomirova T.M., Sukiasyan A.G.
Plekhanov Russian University of Economics, Moscow
+7(916)294-13-89, t_tikhomirova@mail.ru

Abstract — The paper provides a comparative statistical analysis of countries of the world community, which are similar in accordance with the UN criteria levels of human development, in terms of mortality rates from certain communicable diseases, including HIV, viral hepatitis and tuberculosis. For the purpose of correct comparative analysis of countries, the method of applying mortality indicators to the standard age structure of the population is justified and presented. The dynamics of mortality rates from communicable diseases in the countries of the world community for the period 1990-2017 is analyzed.

Keywords: mortality, communicable diseases, HIV, viral hepatitis, tuberculosis, standard age structure of the population, statistical study.

INTRODUCTION

The social and economic well-being of the country depends on many factors, including the effectiveness of the health system, the main indicators of which are high life expectancy and low levels of premature mortality of the population and, above all, from communicable diseases, the reduction of mortality from which can be carried out by preventive measures carried out by health care institutions and other relevant organizations. Based on data from the Institute for Health Metrics and Evaluation (Global Burden of Diseases, GBD) for 1990-2017, a comparative analysis of the mortality in Russia and 38 countries of the world community, with similar levels of human development according to UN estimates, from infectious diseases such as HIV, viral hepatitis and tuberculosis, was carried out. The choice of the time period for cross-country comparisons was justified by the absence of age-related mortality rates for later years in the GBD and WHO information databases in most countries of the world community [1, 2].

In Russia from 1990 to 2017 non-communicable diseases (mainly diseases of the circulatory system and neoplasms) accounted for more than 85% of deaths from the main causes, 10-11% for injuries and 3-5% for communicable diseases. But in contrast to non-communicable diseases, which usually cause death in older age groups, deaths from communicable diseases occur in the working-age and younger population. It should be noted that the proportion of deaths from communicable diseases in Russia in 2017 compared to 1990 in the structure of mortality increased from 3,5% to 4,8%, while the proportion of deaths from non-communicable diseases and injuries decreased from 85,6% to 85,1% and from 10,9% to 10,1%, respectively.

Fig. 1 presents a graph of mortality trends in Russia from communicable diseases in terms of 100 000 people over the period 1990-2017. The lowest value of 39,4 deaths per 100 000 people in the standard population took place in 1990. The highest value of 68,1 deaths per 100 000 people was recorded in 2005, after which there was a decrease to 45,5 deaths per 100 000 people in 2017. In general, the growth rate of mortality from communicable diseases in Russia was 15,4% [1, 2].

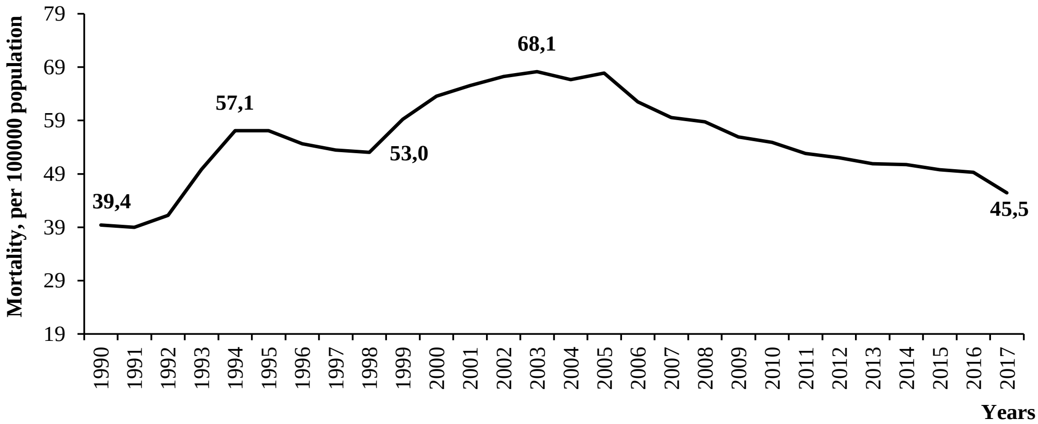


Fig.1 Trends in the mortality rate of the Russian population from communicable diseases in 1990-2017

PROBLEM STATEMENT

Due to the fact, that the mortality rate of the population depends significantly on the average age, thus, the more in a particular country in the age structure of the population of older ages, the higher is the mortality rate there, other things being equal. In this regard, in order to conduct a cross-country comparative analysis correctly of mortality rates from the causes under consideration, preliminary data on mortality should be adjusted for the age structure of their population. The need for this procedure is due to significant differences in the age structures of the countries of the world community, which affects the structure of mortality from various causes of death, since different age groups are characterized by certain causes of death [3, 4]. For this reason, comparing the mortality rate of the population based only on its number leads to distortion of the results and conclusions [5, 6]. As an example, consider the death rate of the population of Germany and Mexico from communicable diseases. According to estimates, based on Global Burden of Diseases (GBD) data, the mortality rate in Germany from this cause in 2017 was 40,2 deaths per 100 000 people, while in Mexico this figure was 45,6 deaths per 100 000 people [2]. However, the conclusion about the similarity of these countries in terms of mortality from infectious diseases is wrong due to the existing differences in the age structures of their population (see Table. 1). In general, the population of Mexico is significantly younger than the population of Germany, and therefore the structure of deaths due to causes in these countries will differ. The reduction of mortality rates to a single age structure will allow an objective comparison of these indicators for different countries of the world.

TABLE 1. AGE STRUCTURE OF POPULATION OF GERMANY, MEXICO AND RUSSIA IN 2017

Age groups	Germany, %	Mexico, %	Russia, %
0-4 years	4,4	9,5	7,3
5-14 years	9,1	18,0	14,5
15-24 years	10,7	17,4	14,4
25-34 years	13,0	15,5	14,2
35-54 years	28,2	24,7	26,2
55-74 years	23,7	12,0	19,1
75 years and older	11,0	2,8	4,3
Total	100,0	100,0	100,0

For further analysis, the mortality rates in all the countries under review were reduced to the age structure of the Russian population in 2015, which was taken as the standard age structure of the population.

The procedure for reducing mortality rates to the standard age structure was carried out on the basis of following expression [7, 8]:

$$\tilde{z}_i^h(t) = S^h \cdot \frac{Z_i^h(t)}{N_i^h(t)} \cdot 100000\,, \qquad (1)$$

where, $Z_i^h(t)$ is the number of deaths due to communicable diseases in the age group h for the country i in the year t, $N_i^h(t)$ is the population in the age group h for the country i in the year t, S^h is the standard proportion of population of the age group h.

The age-standardized mortality rates allowed us to conclude that in 2017, Mexico's mortality from communicable diseases was significantly higher than in Germany (48,0 versus 17,9 deaths per 100 000 people in the standard population).

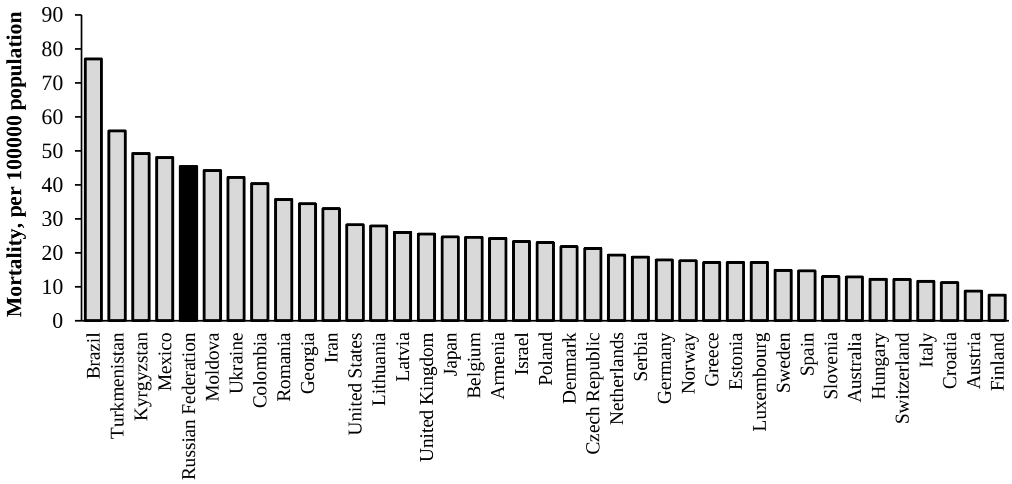


Fig. 2 Graduation of the world community countries by the level of mortality from communicable diseases in 2017

When comparing the countries of the world community with high and very high levels of human development according to age-standardized mortality rates from communicable diseases in 2017, we can conclude that Russia is on the fifth place among the countries with the highest level of mortality from this cause (45,5 deaths per 100 000 standard population), after Brazil, Turkmenistan, Kyrgyzstan and Mexico (77,0; 55,9; 49,2 and 48,0 deaths per 100 000 standard population, respectively). The lowest mortality rates from communicable diseases among the countries considered were recorded in Finland, Austria and Croatia (7,6; 8,7 and 11,2 deaths per 100 000 standard population respectively), which is 5-7 times lower than in Russia (see Fig. 2).

A more detailed analysis of country-specific mortality rates was conducted for certain infectious diseases such as HIV, viral hepatitis, and tuberculosis. Based on the results, presented in Fig. 3, it can be concluded that in terms of mortality from all types of viral hepatitis in 2017, Russia with a value of 0,13 deaths per 100 000 people of the standard population is among the countries with average mortality rates, along with Israel, Luxembourg, the Czech Republic and Lithuania (0,14; 0,13; 0,12; 0,11 deaths per 100 000 people respectively). The highest mortality rates from this cause in 2017 is observed in Iran, Turkmenistan and Georgia – 1,48; 1,46 and 0,84 deaths per 100 000 people respectively, which is 10 times higher than the average values. The lowest death rates were recorded in Finland and Slovenia (approximately 0,1 deaths per 100 000 people).

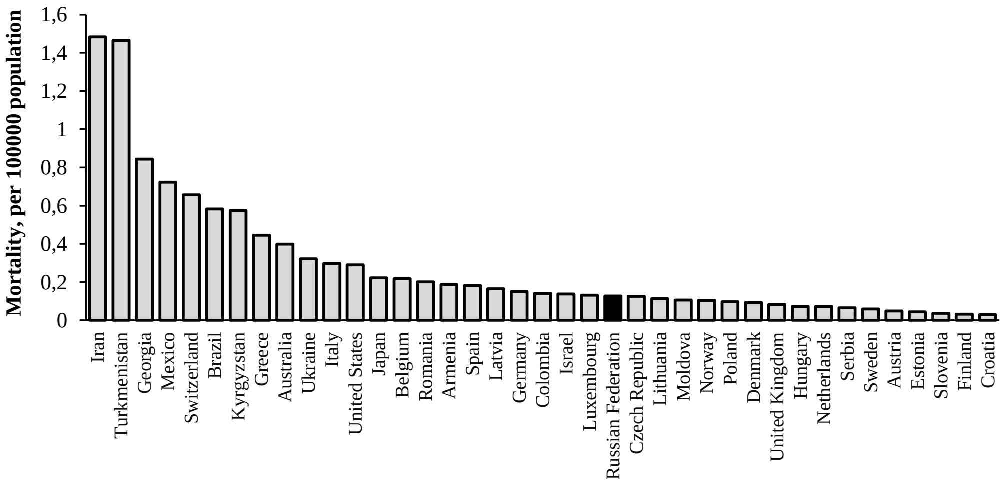


Fig. 3 Graduation of the world community countries by the level of mortality from viral hepatitis in 2017

By the death rate from tuberculosis (see Fig. 4) Russia with a value equal to 6,45 deaths per 100 000 people ranks fourth among the countries considered in the world community, ahead of countries such as Moldova and Lithuania (5,8 and 5,3 deaths per 100 000 people). The worst situation for this indicator in 2017 was observed in Turkmenistan, Kyrgyzstan, and Ukraine (11,9; 9,8 and 7,4 deaths per 100 000 people respectively). The lowest levels were recorded in the United States, Luxembourg, and Switzerland (~ 0,2 deaths per 100 000 people) (see Fig. 4).

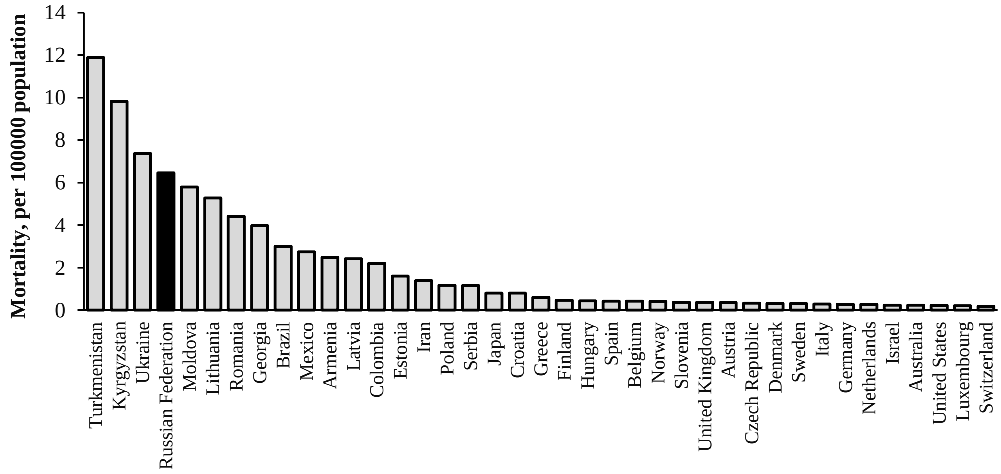


Fig. 4 Graduation of the world community countries by the level of mortality from tuberculosis in 2017

The graph, shown in Fig. 5, indicates, that in terms of mortality from HIV, Russia, with a level equal to 11,9 deaths per 100 000 people, is the leader among the countries under consideration, significantly ahead of Ukraine, Brazil and Latvia (10,2; 7,3 and 6,2 deaths per 100 000 people respectively). The lowest HIV mortality rates in 2017 were observed in Japan, Slovenia and Finland (0,14; 0,11 and 0,11 deaths per 100 000 people respectively).

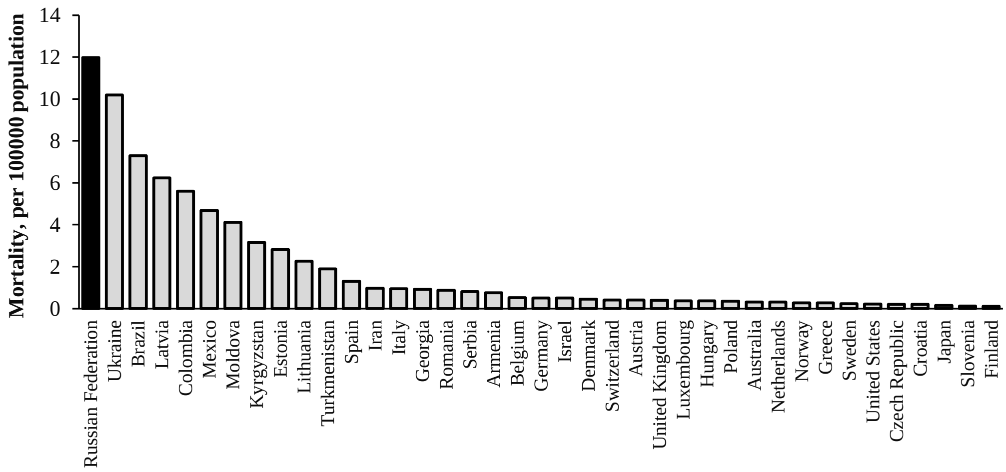


Fig. 5 Graduation of the world community countries by the level of mortality from HIV in 2017

It should be noted, that Russia is not only the leader in the number of deaths from HIV infections, but also it is the country, where in 1990-2017 there was a significant increase in this indicator among the population in the working age group. In the age groups from 15 to 54, the increase in mortality rates ranged from 231,4% to 993,3%, respectively. For comparison, in Germany in the period under review, there was a decrease in this indicator in all age groups by 11,5-90,0%, while in Mexico, although an increase was recorded, its highest value corresponds to the age groups of 70-74 years and 75-79 years – 358,7% and 323,1%, respectively.

Analyzing the changes in mortality rates from communicable diseases in general for the period 1990-2017, presented in Table 2, it can be noted that in all the countries under review, with the exception of Ukraine and Russia, there was a positive trend, i.e. the mortality decreased in some countries very significantly: by 80-60% in Finland, Croatia, Armenia, Hungary, etc., by 55-35% in Austria, Brazil, Colombia, Estonia, etc.

For viral hepatitis, negative dynamics by 2017 compared to 1990 were observed in Greece (an increase in mortality by 510%), Georgia, Switzerland (an increase by 258,9% and 195,9%, respectively), Italy (an increase by 41,8%), Australia, Norway, and Ukraine (an increase in mortality by more than 23%).

TABLE 2. CHANGES IN MORTALITY RATES FROM COMMUNICABLE DISEASES
IN THE COUNTRIES OF THE WORLD COMMUNITY IN 1990-2017

Countries	Growth for the period, %			
	Communicable diseased	Viral hepatitis	Tuberculosis	HIV
Armenia	-64,2	-22,8	-41,7	**1942,6**
Australia	-31,0	**23,8**	-62,1	-85,9
Austria	-55,2	-50,1	-82,1	-53,7
Belgium	-14,6	-44,4	-66,0	-60,9
Brazil	-51,7	-39,1	-67,2	**30,6**
Croatia	-66,0	-61,3	-89,9	**31,1**
Czech Republic	-28,5	-59,2	-82,1	**239,0**
Denmark	-26,7	-16,6	-66,2	-72,4
Colombia	-55,1	-78,6	-74,9	**229,0**
Estonia	-43,6	-81,2	-67,8	**7292,1**
Finland	-79,3	-58,1	-81,5	-64,4
Georgia	-52,7	**258,9**	-51,4	**2404,2**
Germany	-21,5	-41,9	-84,8	-74,5
Greece	-15,0	**510,0**	-64,9	-27,5
Hungary	-63,9	-63,1	-91,2	-77,0
Iran	-60,1	-47,5	-70,8	**822,9**
Israel	-15,4	-73,9	-78,3	-47,9
Italy	-46,8	**41,8**	-78,4	-71,3
Japan	-44,0	-80,6	-79,4	**115,4**
Kyrgyzstan	-57,6	-73,9	-24,9	**469,1**
Latvia	-23,1	-81,3	-55,7	**327,6**
Lithuania	-2,4	-51,0	-29,9	**408,5**
Luxembourg	-31,7	-31,3	-76,6	-72,1
Mexico	-64,1	-42,0	-83,6	**49,8**
Moldova	-22,6	-87,1	**10,1**	**358,4**
Netherlands	-20,8	**2,4**	-75,0	-84,6
Norway	-52,3	**23,4**	-67,5	-62,9
Poland	-46,3	-91,0	-82,8	**111,2**
Romania	-41,1	-68,6	-37,6	**2,3**
Russian Federation	**15,4**	-1,3	-16,2	**497,6**
Serbia	-55,9	-65,5	-68,3	**148,7**
Slovenia	-58,2	-48,2	-85,5	-51,6
Spain	-50,6	-53,9	-82,1	-74,6
Sweden	-47,1	-42,9	-76,0	-72,5
Switzerland	-58,2	**195,9**	-83,8	-82,7

Turkmenistan	-59,4	-62,6	-29,7	**19,2**
Ukraine	**18,4**	**26,8**	**27,7**	**241,4**
United Kingdom	-34,2	-51,0	-63,6	-52,4
United States	-34,4	-59,6	-74,8	-79,0

Mortality from tuberculosis increased in Ukraine and Moldova by 27,7% and 10,1%, respectively. In all other countries under review, there is a positive trend in this indicator for the period 1990-2017.

An extremely contradictory situation was recorded in terms of changes in the mortality rates from HIV. In some countries, mortality rates for this cause increased by several times between 1990 and 2017. In particular, in Estonia the growth was 7292,1%, in Georgia – 2404,2%, in Armenia – 1942,6%. In our opinion, this situation is caused by the lack of proper diagnosis of this cause of death in the last decade of the XX century in these countries.

CONCLUSION

The comparative analysis, conducted for the countries of the world community in terms of mortality rates from communicable diseases and certain diseases, based on the author's method of adjusting them to a single standard population structure, allowed us to identify the countries with the worst situation in this sphere. In general, for communicable diseases, the most unfavorable situation during the period 1990-2017 was observed in Brazil, Mexico, and countries of the former Soviet Union, such as Turkmenistan, Kyrgyzstan, Russia, and Moldova. The best situation was observed in the developed countries of the European Union. At the same time, the gap in mortality rates from infectious diseases in prosperous and disadvantaged countries exceeds by 10 times, in terms of mortality from viral hepatitis the difference is even greater – by 49,8 times, in terms of mortality from tuberculosis – by 66,2 times.

It should be noted that a significant differentiation on the indicators mortality from causes considered is observed in countries with the same (high) level of human development in accordance with UN estimates. Consequently, the objectivity of such assessments is challenged, and this justifies the need to take into account when obtaining the health state of the population.

ACKNOWLEDGMEN

This work was supported by RFBR (grant №20-010-00307)

REFERENCES

1. WHO Mortality Database // World Health Organization. – URL: http://www. http://apps.who.int/healthinfo/statistics/mortality/whodpms/, (ingl).
2. Global Health Data Exchange // Institute for Health Metrics and Evaluation (IHME). University of Washington. – URL: http://ghdx.healthdata.org/gbd-results-tool, (engl).
3. Sukiasyan A.G. K voprosu otsenki demograficheskogo potentsiala naseleniya regionov Rossii // Nauchnyye trudy Volnogo ekonomicheskogo obshchestva Rossii. – 2015. – Vol. 192. – pp. 410-424, (rus).
4. Tikhomirova T.M., Sukiasyan A.G. Otsenki poter ot prezhdevremennoy smertnosti muzhchin i zhenshchin v Rossii s uchetom nivelirovaniya vozrastnoy struktury // RISK: Resursy. Informatsiya. Snabzheniye. Konkurentsiya. – 2018. – pp. 2. – pp. 72-77 (rus).
5. Ahmad O.B., Boschi-Pinto, C., Lopez A.D. [et al.]. Age standardization of rates: a new WHO standard: In GPED is cushion Paper Series. – Geneva: World Health Organization, 2000, (engl).

6. Carnes B.A., Olshansky S.J. A Realist View of Aging, Mortality, and Future Longevity. Population and Development Review. – 2007. – Vol. 33. – No 2. – pp. 367-381, (engl).

7. T.M. Tikhomirova, V.I. Gordeeva, Assessment of health care cost-effectiveness considering a reduction in population health loss // Journal of Pharmaceutical Sciences and Research. – 2017. – Vol. 9. – No 11. – pp. 2204-2211, (engl).

8. Tikhomirova T.M., Sukiasyan A.G. Otsenka poter ot infektsionnykh i parazitarnykh bolezney v Rossii // Ekonomika prirodopolzovaniya. – 2018. – No 6. – pp. 88-98, (rus).

Section 4
ECONOMY OF INFORMATION SYSTEMS AND DIGITALIZATION

ORGANIZATION OF SEAMLESS TRANSPORTATION IN THE IMPLEMENTATION OF DIGITAL INTEGRAL ENVIRONMENT

Ivanova A.G.
Russian university of transport (MIIT)
+7 (916) 827-50-16, a.g.ivanova@miit.ru

Abstract — The possibility of creating digital services for seamless transportation is being considered. The modern consumer positively assesses the complexity of a multi-modal transport service. Demand has increased for transportation, which, in order to achieve one transportation goal, uses several modes of transport, with a sequential transfer from one type to another in passenger transport or transshipment of cargo to different vehicles in freight traffic. The development of seamless transport technologies predetermines increased interaction between organizations of various types of transport, not as competitors, but as partners with a high level of cooperation aimed at achieving the common goal of increasing traffic volumes.

Keywords — seamless transport system, multimodal transportation, unified transport space, unified information environment, commodity and transport technological infrastructure, digital integral environment, electronic service.

Transport today needs integration between its modes. Transport networks cover significant areas. Consumers need routes equipped with modern electronic services that will make these routes safe, transparent, multimodal, and reduce the time and cost of transportation. It is assumed that the main role here will be played by the integral digital environment with the appropriate computing infrastructure and regulatory framework.

In accordance with the text of the document “On the Transport Strategy of the Russian Federation”, the priorities of the state policy in the field of transport for the period until 2030 include ensuring the stability and predictability of the transport system. It is planned to create technological and infrastructural reserves with the help of which the transport system will be able to provide the population and business with safe, affordable and predictable transport services of the right quality at the right time and place.

To advance Russia's interests in the field of transport around the world, the Russian transport system will be strengthened in the global transport services market and a steady increase in the level of the country's transit potential will be realized.

One of the goals of the development of the transport system of Russia is the formation of a single transport space in Russia. It is designed to provide:

- functioning of a single balanced system of transport communications, integrated system of commodity transport technological infrastructure for all types of transport and cargo owners,
- application of uniform standards of technological compatibility of various modes of transport, optimizing their interaction, uniform standards for technical compatibility of various modes of transport and vehicles.

The unified transport space of Russia will create a unified information environment for the technological interaction of various modes of transport.

According to the transport strategy, much attention is paid to the issue of introducing multimodal transportation technologies. In this regard, it is planned to create a unified system and information environment for multimodal technological interaction of various modes of transport, cargo owners and other participants in the transport process, as well as customs and state control bodies.

To create a unified system and information environment for multimodal technological interaction of various modes of transport, cargo owners and other participants in the transport process, as well as customs and state control bodies, the following is provided:

- development and implementation of standards for information interaction of various modes of transport, participants in the transport process, as well as customs and other state control authorities involved in the implementation of the transportation process;
- creation of unified information services for the interaction of transport, logistics, forwarding, customs, border and other state control bodies;
- creation of an information environment for the construction of intelligent transport systems on federal highways and in large transport hubs [1].

Summarizing the above, we note the following. In order to increase the efficiency of transportation in Russia and abroad, including transit, it is necessary to introduce multimodal technologies for the interaction of various modes of transport. In this regard, it is necessary to form a unified information space, a part of which is a secure integral digital environment. It is necessary to ensure “seamless” transportation, harmonizing standards and removing administrative barriers at the border. It is necessary to organize information and navigation support for the transport complex.

What is meant by the words “seamless transport”? The signs of a seamless transport system should include a set of transport technological elements of transportation by various modes of transport as a single transport service that provides consumer expectations of passengers and cargo owners. And transportation carried out under such a system is a seamless transport service or product. All links in the seamless transport chain must ensure consistent quality [5].

Depending on the geographical location and socio-economic conditions for the development of transport complexes in different countries, there are priority combinations of modes of transport as technological elements of a seamless transport system. A key element of a seamless transport system for most developed countries is rail.

The success of the development of a seamless transport system will depend on the ability of transport companies to provide routes that provide reduced time, a high level of security, technical readiness, awareness and comfort. At the same time, any transactions on the route should be convenient for users [5].

In a digital integral environment, to determine routes, it is necessary to automate the process of evaluating their parameters and optimizing route networks. The result should be an electronic map with full information about the optimal route, the conditions for its observance, the state of traffic flows and other important information [3].

However, do not forget a few obvious things. Transport belongs to the category of industries where the impact of digitalization is difficult to fully evaluate and implement. Requires modernization of infrastructure and technological processes. Another bottleneck: you can get carried away with technology, and customer focus will fade into the background.

Digitalization creates the conditions for the implementation of a fundamentally new, ecosystem-based approach to the development of transport companies. The main characteristic of the transport ecosystem is the maintenance by digital technologies of stable flows of goods, passengers and money [4].

So, transport needs modern digital technologies in order to remain competitive in the global market. The "digit" comes in transport and logistics. Electronic tickets, online check-in for flights, “smart” navigation systems, calling a taxi through the application in your phone are already quite familiar things. Already today a number of large-scale projects to create a new generation of information systems are being implemented in the transport complex. Mention should be made of the Unified State Information System for Transport Security, which has been operating since 2013 (USIS TS). It allows you to control passenger traffic with detail to a specific person, to a specific vehicle. The system is recognized by foreign partners as the best among its peers.

The ERA-GLONASS state automated information system has been created and is functioning, the Platon system has been introduced and is effectively used. On their basis, the services necessary for the transport complex are developed that are not directly related to the collection of fees from heavy vehicles. These systems allow you to collect and save big data. The main task is to learn how to work with these Big Data arrays in order to create new services on their basis.

Several key areas in the field of digital transformation of transport have been identified, and work has already begun on each of them.

First. Optimization of multimodal freight transportation, the creation of platform solutions for seamless transportation, fast and high-quality clearance of goods, including cross-border traffic, their support at all stages of transportation using tracking systems and electronic shipping documents. Pilot projects for the use of electronic sealing devices and tracking during cross-border crossings have been worked out.

Second. Organization of multimodal passenger transportation. It is necessary to erase the borders between different modes of transport and provide the opportunity to get “door to door” along the optimal route with a guaranteed level of comfort and safety. The essence of digital services in this area is to harmonize schedules for different types of transport, to take into account the beginning and end of the transportation phase, to accompany baggage when a passenger uses a single ticket.

Work is underway on a single digital platform for multimodal passenger transport. Her task is to instantly choose the best routes for the passenger by any means of transport and in any combination.

The Government of the Russian Federation introduced a draft Federal Law “On Direct Mixed (Combined) Transportations” (prepared by the Ministry of Transport of Russia), which streamlines the work of various operators in one transport [2].

In the near future, a sharp increase in the use of unmanned aerial aircraft systems (UAS) in the field of logistics is expected. In the Russian Federation, they began to create a unified control system for UAS. It should include an end-to-end process: accounting, registration, training, creating customer-oriented interfaces, monitoring, planning, ensuring the safety of transport and critical infrastructure in connection with UAS activities, interacting with interested departments on transport, information and cybersecurity, including using USIS TS.

To create a trusted interaction space for all industry participants, it is necessary to form a digital platform for the transport complex, which will combine all of the above services and data arrays and become a kind of ecosystem for all participants in the transport process. On the basis of Russian software, it is necessary to create a “single window” of the state and business when performing all transportation. This platform will establish common standards, rules and regulations for information exchange, including legally relevant data on transport infrastructure and vehicles. The platform will act as an aggregator of transport data, which excludes the privatization of this data and guarantees non-discriminatory access to it for all interested participants in the transport industry. This platform is designed to maintain our national sovereignty over information flows in the country's transport complex [6].

REFERENCES

1. Rasporjazhenie Pravitel'stva RF ot 22.11.2008 № 1734-r (red. ot 12.05.2018) «O Transportnoj strategii Rossijskoj Federacii» // NPP: «Konsul'tantPljus»

2. Proekt Federal'nogo zakona «O prjamyh smeshannyh (kombinirovannyh) perevozkah» // NPP: «Konsul'tantPljus»

3. Goldovskij Ja.M., Zhelenkov B.V., Safonova I.E. Neobhodimost' sozdanija cifrovoj integral'noj sredy dlja obespechenija transportnyh perevozok // Innovacionnye, informacionnye i kommunikacionnye tehnologii. – 2019. - №1 – S. 39-42

4. Gulyj I.M. - Transportno-logisticheskie sistemy v cifrovoj jekonomike : – Vologda : FGBUN VolNC RAN, 2018. – 201 s.

5. Lapidus B.M., Lapidus L.V. Gladkaja besshovnaja transportnaja sistema – innovacionnaja model' budushhego: priroda, sushhnost', determinanty kachestva // Vestnik Moskovskogo universiteta. Serija 6: Jekonomika. – 2017. - № 2 - S. 45-64

6. O cifrovoj transformacii transportnogo kompleksa [Jelektronnyj resurs]. – http://government.ru/news/34821/. – (data obrashhenija: 09.04.2020)

CRYPTOCURRENCY AS A NORMAL CURRENCY EXCHANGE

Neverova N. V., Tikhonov Grig. G.
Moscow aviation institute (MAI)
+7 (910) 427-18-51, imp_ekakaf@mail.ru

Abstract – The article discusses the prospects for the development of cryptocurrency regulation in Russia. Significant attention is paid to possible approaches and methods for adapting cryptocurrency management in the banking sector. The article also discusses methods for collecting , summarizing and systematizing the necessary information for developing a mechanism for managing a cryptocurrency transaction.

Keywords: fiat money; the bitcoin system; payment systems; cryptocurrencies; and Bank transactions.

INTRODUCTION

The development of the global Internet and the emergence of e-Commerce cause significant changes in the economy and lead to changes in the traditional provisions of economic theory and practice. Information technology transcends borders, distances, and even time, thus being the main driving force of globalization. The distance between trading partners disappears. Technologies and standards for data transmission over the Internet have become universal means of exchanging commercial information, which have largely determined the principles of doing business in the field of e-Commerce.

Electronic money as an economic phenomenon and an Institution of law appeared in the early 90's. in Russia, they have been actively developing since the late 90's. full legal regulation of the turnover of electronic money in Russia appeared only in 2011 with the adoption of Federal law No. 161-FZ" on the national payment system " from 27.06.2011 (Hereinafter also law No. 161-FZ), previously limited only to certain regulatory legal acts of the Central Bank, concerning only certain aspects of the turnover of electronic money (prepaid financial products, prepaid cards). During this period, there was no proper legal study of the problem of electronic money turnover in Russia and abroad [5].

What is e-money and what is its essence?

Electronic money is a unit of value stored in electronic form on a hardware and software device, accepted as a means of payment when making payments and expressing the amount of the Issuer's obligations to the holder for the return of electronic money [4].

This definition reflects the three components of the concept of "electronic money" - economic, technical and legal.

From an economic point of view, electronic money is a measure of value and a means of payment. The fact that electronic money is a unit of value is the most "monetary" feature of it. For example, according to the Nobel laureate in Economics F. von Hayek, all the main functions of money are so interconnected that although at first glance different properties of money serve different purposes, in reality money performs a single function, acting as a unit of account. In this case, the payment instrument function is only one of the three derivatives. Moreover, since electronic money is rubles in digital form, it also has the status of legal tender.

In the article by Anureeva S. V. "the Problem of the essence of non-cash money", two main reasons for classifying electronic money as cash are highlighted. First, payment in electronic money is made by transferring funds from the payer to the recipient in the form of an electronic file without using a Bank account. And, secondly, the file transmitted from the payer to the recipient has a nominal value, which also allows you to attribute electronic money to cash.

Since 1990, electronic money has undergone a marked evolution from magnetic credit and debit cards to smart cards, thanks to the American chain of 7-Eleven stores. By 2000, such payment systems based on "network money" as ECash, CyberCoin and NetCash had successfully started functioning.

Similar payment systems have been formed in Russia. Their names are well known: PayCash and WebMoney. In addition to such electronic payment systems at the beginning of the XXI century, others began to operate: Rapida, Creditpilot, Nick-pay Calculations (NIKoil), etc.

The electronic money industry has quickly taken root in the Russian market. So after the crisis of 1998, the volume of payments in Russia increased by 20-30% annually.

From my point of view, all of the above definitions seem somewhat narrow. It is not quite correct to talk about electronic money only as an electronic form of recording and transmitting data - in banking operations, only the form of payment instruments changes, there is a simple transfer of funds from one source to another, and no new non-cash money appears.

In my opinion, electronic money is a new form of money that was formed as a result of the long evolution of money, a special type of credit money that serves as a means of payment that allows consumers to make payment transactions without requiring mandatory access to Bank accounts.

As a new systemically important financial and credit institution, electronic money should have a clear legal definition that could regulate its circulation in Russia.

The main factors in the progress of Russian electronic payment systems in recent years have been stable GDP growth and an increase in the purchasing power of the population, as well as, as I mentioned in the first part of this work, the availability of consumer credit and the use of credit and debit cards throughout the country.

Consider several electronic payment systems: "Yandex Money" and PayPal.

"Yandex Money" system (money.yandex.ru) appeared in 2002 thanks to the cooperation of the portal of the same name and the PayCash payment system. You do not need to enter your passport details when registering, but if you lose your password, you will not be able to get your money back. The user is immediately asked to choose how they prefer to manage their funds: via the web interface ("Yandex Wallet") or a special program ("Internet Wallet"). In both cases, access is possible from different computers. Functionally, the "wallets" are the same. But there is one subtlety — you can't use the program to get access to "Yandex Wallet", or use the web interface to get access to a local colleague. You need to choose one or have two different controls that are independent of each other.

The currency used in "Yandex Money" is the ruble. You can top up your account in this system using the usual methods: via an ATM, in cash via a terminal, as well as using a card, postal or Bank transfer. The user can convert electronic money into real money by transferring it to their Bank account, cashing it in Impexbank branches or branches of the contact payment system. "Yandex Money" also offers online store owners an affiliate program that optimizes payments using this system [6].

PayPal (www.paypal.com) is an American company founded in 1998 and located in California. The main advantages of its system are reliability and access to various foreign stores and services. For example, eBay auction announced PayPal as Its main payment tool after purchasing the company in 2002..

There are three types of PayPal accounts:

1. Personal accounts are intended only for individual use (for direct transfers to friends, relatives, and clients). This type of account does not accept payment from credit cards and is intended for internal transfers in the PayPal system. In addition, the monthly turnover limit for such an account is $ 500.;

2. Premier Accounts-for users who have a larger turnover than the personal account allows and must accept payments using credit cards or special PayPal tools (for example, integrating the PayPal payment service with the site);

3. Business accounts-accounts for firms issued on behalf of the company under its logo and with its details. These accounts can only be opened by organizations that have a tax ID (taxpayer number).

For all its advantages, PayPal has several significant disadvantages. In particular, until recently, this system did not register users from the Russian Federation. Currently, Russians can work in the system, but the features of PayPal are presented in a rather narrow form, for example, you can not accept payments [7].

Another nuance is the risk of losing your money if the service administration doubts the authenticity of the information provided during registration. There are quite a few such cases, but upon closer examination, it turns out that almost all of them were the result of voluntary or involuntary violation of the user agreement by the victims.

The most popular online payment systems in Russia today are payment systems that use conventional Bank cards. With this payment method, the buyer does not need to have a separate "e-wallet". The customer pays for the goods by Bank transfer from an account in a financial institution that is a member of the payment system, receiving statements as in a normal operation with Bank cards.

What is cyber Money? What is the difference between cyber money and electronic money?

Cyber money is a completely independent currency that no one can control. If e- money is characterized by a payment system (such as those mentioned above) that can track all transactions and, for example, inform security services, then cyber - money transactions will not be tracked.

Cyber money, where we will talk about a new and completely independent payment system Bitcoin .

The Bitcoin system is the first practical solution to a long-standing information problem-ensuring trust in the exchange of information, in the case when this information is transmitted between the parties over an unsecured communication channel. This digital currency was the first to enable the transfer of any property via the Internet, without involving external guarantors, and also providing a safe and reliable operation.

PROBLEM STATEMENT

An important component of the Bitcoin peer-to-peer payment system is a certain basic client program that contains open source code. Client programs running on a large number of computers are connected to a specific network [1]. Cryptographic methods are used to ensure high performance and good protection of the system. However, the entire transaction information block is not encrypted and is always available in plain text.

The first exchange of bitcoins for real goods took place in may 2010: a US citizen received two pizzas for 10,000 bitcoins.

Only one loophole was discovered in the Bitcoin system for all time: on August 6, 2010, it was revealed that before writing to the log, the number of bitcoins on the inputs and outputs of transactions was not checked, i.e. it was possible to form a transaction with any number of bitcoins on the output. On August 15 of the same year, the vulnerability was exploited by hackers, and 182 billion bitcoins were created. But just a few hours later, the failure was noticed, of course, the network was stopped, all errors from the transaction log were eliminated, and the program was released in a new, corrected version [2].

SOLUTION OF THE PROBLEM

Bitcoins in open and public form exist as records in a distributed database, indicating the bitcoin addresses of senders and recipients, but without information about the real owner of these addresses. The database does not keep a record of how many bitcoins are currently at a particular address, however, this can be easily calculated and found out. It is possible to see, for example, that one of the addresses received 1 bitcoin, and another, the next transaction to the same address received 2 bitcoins. Such calculations can be done mechanically by client programs, and the user may not notice the fragmentation of information at all.

Judging by the latest trends, the attitude to the Bitcoin system is also different in different countries. Some countries even officially allow transactions with this digital currency. They are presented as a commodity or investment asset and are subject to the relevant legislation for conducting transactions related to the sphere of taxation [3]. Sometimes bitcoins are recognized as a means of payment, but, for example, in China, transactions with bitcoins are prohibited or strictly limited.

However, even in one state, in one seemingly informational field, different municipal institutions, ministries, and courts may have completely different attitudes to bitcoin. In the US, for example, bitcoin is a "virtual currency". A relatively long time ago, back in March 2013, the then existing financial crimes Commission made an announcement that any transactions for the purchase and sale of any cryptocurrency and their exchange for cash should be regulated in the same way as a normal currency exchange. To do this, exchange offices must go through the registration process as financial service providers and immediately report suspicious transactions to law enforcement agencies.

After that, in November 2013, the us Senate held hearings on virtual currencies. At that time, cryptocurrencies were not banned, they decided to study them, and they also expressed their wishes to work on regulating and controlling this business. At about the same time, the United States held

On March 25, 2014, the U.S. internal revenue Service adopted and released a guide for taxing transactions related to bitcoin and other virtual currencies that are treated as property.

If we talk about our country, at the beginning of 2014, the Central Bank of the Russian Federation made a statement that operations with "virtual currencies" are speculative. Despite this fact, many chairmen of the Central Bank of the Russian Federation consider it possible to create a legal framework regulating cyber currencies.

The anonymity of the Bitcoin system prevents the state from controlling financial flows, including across the border. The Bank of England fears for the financial stability of its country if the Bitcoin system increases in popularity and is not regulated. As an extreme option, if all non-government payments (for example, except for tax payments) are made via bitcoin, this will lead to a division of the economy, and the Bank of England will lose control over inflation.

A collapse in the price of bitcoins can damage the financial system if they are used in large transactions, such as stock markets. Large purchases of bitcoins by a financial institution can make the interests of many market participants dependent on price fluctuations, even if they are not holders of the cryptocurrency.

CONCLUSION

Due to the fact that national authorities are not able to influence bitcoin (there is a possibility of complete anonymity), this attracts to the digital currency the shadow economic turnover of weapons, drugs, etc.Despite the fact that cash also has every chance to be used anonymously and transactions, similarly, can be uncontrolled, bitcoins are more suitable for fast remote payments, including international ones.

In The bitcoin digital currency system, it is impossible to appeal or cancel unauthorized transactions. If the payment is made, but the service or product is not delivered, there is no mechanism that would guarantee a refund.

The Central Bank of the Russian Federation believes that Russians should not use bitcoins, because " we do not have collateral for virtual currencies and legally obligated entities for them. Operations on them are speculative in nature, are carried out on so-called "virtual exchanges" and carry a high risk of loss of value".

Thus, it is impossible to say unequivocally how bitcoins will affect the economy of Russia or any other country. The bitcoin exchange rate is very unpredictable, and since the state cannot control the situation, it is logical to conclude that this will adversely affect the economic situation. As long as the state has the ability to control its own currency, it will do so, which means it will not allow the use of bitcoin.

It is difficult to assess how popular bitcoins are in Russia, but do not forget that there are a lot of electronic currencies in the world. This problem has two components: on the one hand, the development of electronic means gives a chance that such money will be created sometime, but I do not think that soon. On the other hand, money does not exist in pieces of paper, coins, or even in the form of software code. Money exists in people's minds, because for its full functioning, unconditional, “blind faith”is necessary. People still believe in gold as the most material embodiment of money. They also believe in Fiat money issued by strong States. Everyone believes in the power of these pieces of paper. It is difficult to believe in cyber money yet. As long as this does not happen, all these initiatives are experiments important, but still experiments. Money must perform all its functions, not just a narrow utilitarian exchange between community members, otherwise it is not money. What kind of currency is this, whose very existence can be compromised by a clever hacker?

REFERENGES

1. R. Camp, A book about big money. - M.: Veligor. 2014. - page 18

2. W. Cohen, Money and power. - M.: Alpina. 2013. - page 83

3. P. Noiset, A book about Bitcoin. ISBN 2954310103. 2012. - page 189

4. S. Moiseev, Additional Capitalization of banks / / Banking business. 2013. No. 8. - page 243

5. A. Pukhov, Electronic money in a commercial Bank./ / Practical guide. - M.: Tsipsir. 2015. – p. 201

6. A. Ryabykh, How to make money on the Internet./ / Benefit. - M.: Mann. 2012. - page 1

7. A. Shamraev, Electronic money./ / Online payments. –M.: CIPROFLOXACIN. 2011. - page 1

NETWORK INFRASTRUCTURE OF AN OPEN INTEGRATED DIGITAL ENVIRONMENT FOR TRANSPORT

Zhelenkov B.V., Goldovsky Y.M., Safonova I.E., Abramov A.V.
Russian University of Transport (MIIT)

Abstract — A brief description of the scientific task of developing an open integrated digital environment for transport is provided. It is shown that an open integrated digital environment for transport transportation is a complex software and hardware system, a modular structure of this system is presented, and particular problems are solved that are solved during its development. The analysis of the requirements for the network infrastructure of an open integrated digital environment for transport transportation is carried out and a block diagram of the network is presented.

Keywords: open integrated digital environment for transport; network structure; CloudComputing; data processing center; FogComputing.

Active work is underway to implement the Digital Economy program [1, 2]. There are problems with ensuring synchronization and interaction of these systems, their transfer to the sphere of customer focus. The issue of organizing the information space in which carriers and customers would feel comfortable remains relevant. The provision of transportation should focus not on any particular type of transport, but on their combination, necessary for the delivery of goods from the point of departure to destination. This is the target function of the concept of a digital integrated transport support environment.

It is proposed to create a digital integrated environment as a single information space to meet the needs for the transportation of passengers and goods in the form of a service portal.

At the same time, work in this space must be positioned as an electronic service.

All participants of the transportation process and companies providing various additional services interact in a single information space.

To ensure the operability of a single information space, it is necessary to create an information environment with the appropriate infrastructure and regulatory framework [1, 3, 4].

The concept of use involves the registration of a participant in the transportation process on the service portal as a client or as a representative of the carrier.

The open integrated digital environment for transport is a complex software and hardware system including thousands of the most diverse components, which is a special case of large systems and the general methods and principles that were formulated in the theory of large systems are applicable to its development [1, 2, 5, 6].

The system must have a modular structure (Fig.1). This will make it possible to connect new routes, new carriers, as well as representatives of related organizations to provide additional services.

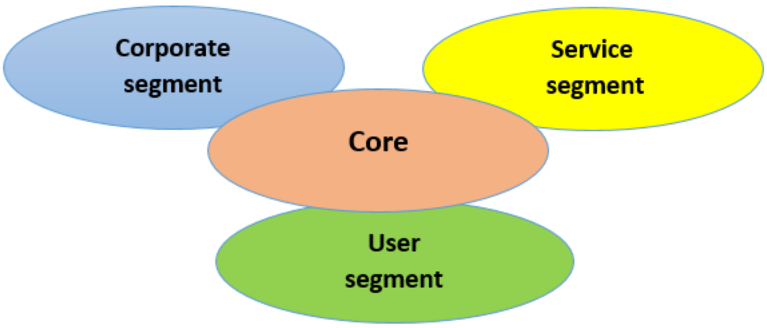


Fig.1 The structure of an open integrated digital environment for transport

It is based on the core of the system. To which carriers are connected, each of which represents its own corporate segment. They provide their services in the service segment. And clients connect to the user segment.

The client should be given the opportunity to choose transportation services based on his preferences. For example, if a cargo is being transported, the determining factors should be the parameters of this cargo, as well as customer preferences - price, delivery speed, etc. Based on this input, a route is constructed. On the route of the cargo, transshipment points are determined, and the client receives information about the route and the final cost of the service.

When implementing passenger transportation, it is also necessary to take into account the preferences of the client regarding the choice of possible intermediate points, with the possibility of forming a route map with the necessary transport documents.

It is advisable to present the task of creating an open integrated digital environment for providing transport services with a variety of private tasks:

$$Z \ = < Z_1, Z_2, \ldots, Z_m > , \tag{1}$$

with Z – general development task of open integrated digital environment for transport; Z_1, Z_2, …, Z_m – private tasks.

Particular tasks to be solved when developing an open integrated digital environment for transport transportation are as follows [1, 2, 3, 6]:

— Analysis of requirements for the network infrastructure of an integrated digital environment.

— Research of a server part for a client-server architecture of data processing in an integrated digital environment.

— Analysis of data storage and processing systems in an integrated digital environment.

— Standards for the exchange of information in an integrated digital environment.

— Study of safety requirements.

— and other tasks.

Ensuring the integrity of the information space in such a system is due to the network infrastructure.

The requirements for network infrastructure are determined by the requirements for the operation of an integrated digital environment.

An integrated digital environment should solve the problem of providing a service with high speed, reliability, 24/7. In addition, the distributed nature of the system must be taken into account.

The network should unite not only individual users or organizations, but also data processing centers, which are a single information space in which computing resources can be redistributed if necessary. Thus, data centers will become the basis of infrastructure [2, 3, 4].

A substantial part of the digital infrastructure is user mobile devices and on-board devices mounted on vehicles. The inclusion of these devices in a single digital environment greatly expands the possibilities of traffic management. At the same time, the location of vehicles and mobile users can not only change, but also, at some points, be unknown.

At the same time, the use of cloud technologies, centralized and distributed databases should not be overlooked.

Data processing in the cloud infrastructure pursues both the goals of the operational management of the transportation process, and the goals of an in-depth analysis of the parameters and results of the transportation process in order to increase its efficiency.

CloudComputing assumes that all computing processes must be performed in a virtual environment outside the object that generates information. This approach is convenient in solving problems that do not require an operational solution. Generators of information in FogComputing are moving objects [1, 2, 7]. The tasks being solved here require a high level of efficiency.

If we talk about an enlarged algorithm for solving problems associated with mobile objects, there is only one task - moving an object in space with an analysis of the necessary parameters.

Thus, the computational process is divided into two stages.

The first stage - the operational control phase in real time is implemented directly at the facility.

The second stage is the stage of analysis and adjustment (the formation of new patterns of behavior).

At the operational control stage, the device processes the received information in accordance with the algorithm (behavior model). A deep and comparative analysis at this stage is not necessary. Each object works offline, but transfers its parameters and environmental parameters to the cloud.

But at the same time, all objects are easily divided into groups according to the necessary software and hardware support for computing processes. For example, ground transport (moves in two-dimensional space), air transport (moves in three-dimensional space). It is possible to divide groups into subgroups, but this will no longer strongly affect the computational process.

The analysis stage is aimed at adapting the object to possible changes in the behavior model, as well as to calculate the operation of the entire object infrastructure and possible direct interaction of objects. These calculations are associated with the processing of large amounts of information according to the general program.

The most suitable technology that can implement this principle of operation is SPMD technology [2, 4].

Since the system is implemented in the cloud infrastructure, there is no need for binding to the hardware implementation of SPMD technology. All elements in it are virtual, which gives unlimited computational capabilities (cloud limitation). We can already talk about a new conceptual approach to this implementation - virtual technology SPMD (virtual SPMD - vSPMD) [2, 4, 5, 6].

The system includes:

- management module that distributes tasks controls the configuration. This module is located outside the cloud;
- vPi modules - virtual processors that are configured in the cloud;
- vSMi modules - virtual modules of operational shared memory;
- fog network - network equipment through which objects are connected.

This configuration allows you to implement any algorithm for the interaction of virtual processors with each other through RAM modules, which easily adapts the computing system to the task at hand, depending on the optimization criteria used.

The transport infrastructure, based on the use of digital technologies, is becoming a target for hacker attacks, both by private individuals and by hostile states. An integrated digital transportation environment should be based on [6, 7]:

- cloud technology;
- support for FogComputing;
- software-configured networks;
- information security technologies using digital hardware and software.

Based on this, we can conclude that in order to support the digital integrated environment, the network infrastructure must meet the following requirements:

- reliability;
- high throughput;
- the network must have a distributed structure using both local area network (LAN) technologies and wide area network (WAN) technologies.

All this creates an additional load on the servers and, consequently, on the network. In this case, it is necessary to provide traffic between servers at the same level (horizontal), this traffic is called east-west.

The classic three-level network architecture, including the level of access, distribution, and the core, cannot provide the required level of reconfiguration efficiency for transferring large amounts of data and is designed for vertical traffic transmission (north-south).

To solve this problem, the "network factory" or leaf-spine architecture is suitable. This architecture is adapted to transfer large amounts of data in the horizontal direction. This ensures the operational interaction of servers, which is extremely important in conditions of mass use of cloud technologies and FogComputing [7]. There are two levels here - the access level (leaf) and the kernel level (spine). At the leaf level, access switches are installed to which servers, firewalls and other terminal and network equipment are connected. Each leaf switch must connect to all spine network devices on a one-to-one basis. At the spine level, Layer 3 switches are used to support dynamic routing. Since there are only two levels in the architecture — switching and routing, there is no need to use the spanning tree (STP) protocol. This ensures high network stability, predictability and fault tolerance when transferring data inside a data center.

A three-tier architecture can be used to provide connectivity between data centers.

Thus, the network architecture should have a mixed architecture, which will provide operational interaction between the servers of one data center in the east-west direction, and between the remote data centers in the north-south direction (Fig.2).

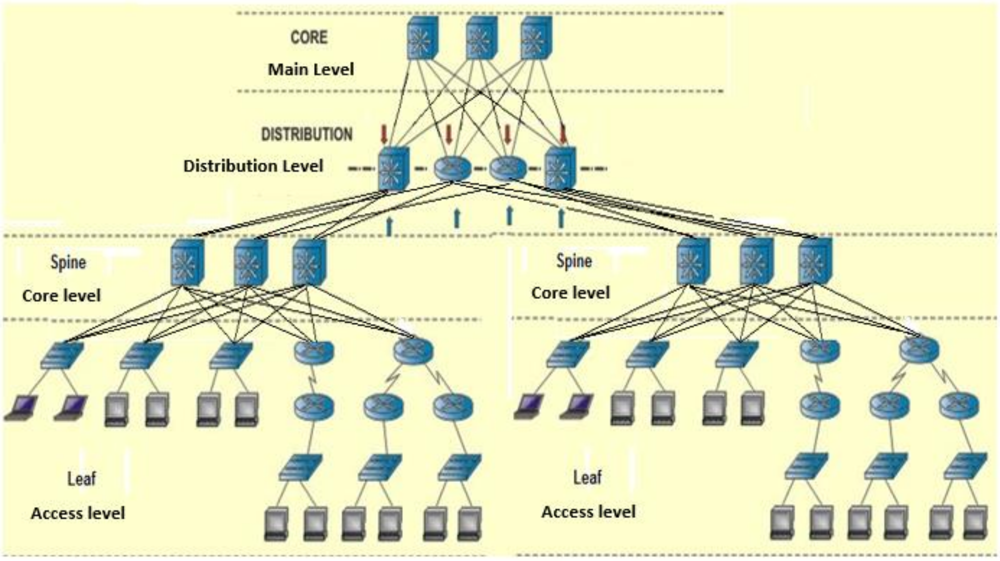


Fig. 2 Mixed architecture

Also, the challenge is to constantly increase throughput. Optical communication lines are used for data transmission. As one of the options for increasing bandwidth, we considered switching from 10G to 40G or 100G Ethernet. But the 25G standard was developed, which is more cost-effective. This can give speeds of 2X25 or 4X25 with lower costs and greater reliability.

WAN technologies are used for communication between data centers. There are two main ways to connect - the Internet and leased lines.

Communication using the services of an Internet provider is a low-cost and secure way to communicate in case of using VPN technology. But this does not provide the necessary speed of interaction between data centers and it is difficult to provide the required throughput.

At the same time, the use of leased lines based on DWDM-technology allows for high transmission speed and security.

At the level of connecting modules of customer customers or service providers, you can use the services of an Internet provider. In fig. 3 is a block diagram of a network for supporting an integrated digital transportation environment [8, 9, 10].

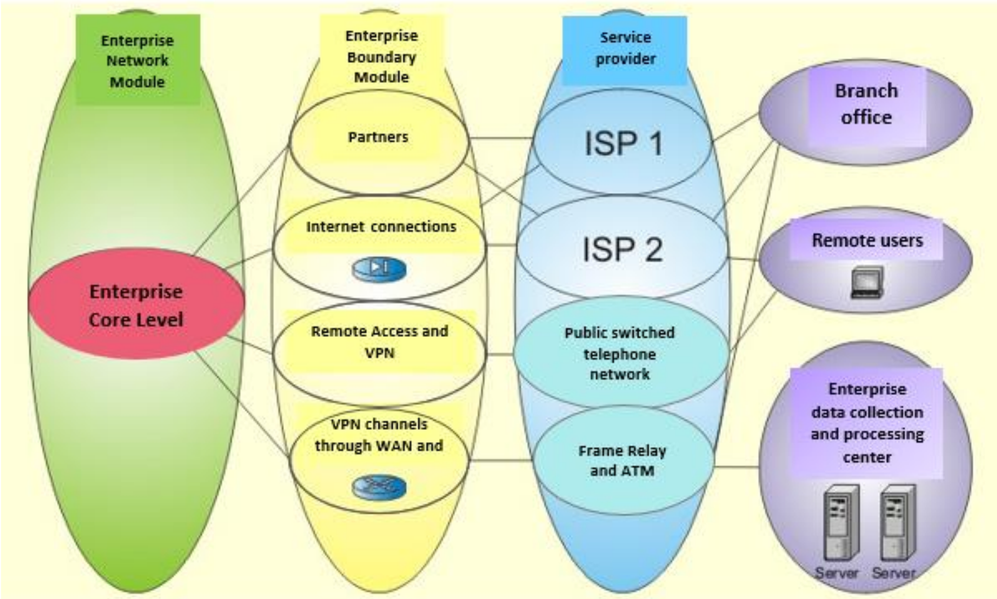


Fig. 3 Network block diagram to support an open integrated digital transport environment

The performance of an open integrated digital environment for transport can be assessed using the integral criterion, which includes system performance, reliability, security, extensibility, scalability, manageability, compatibility [7, 8, 9, 10]. Along with the above, organizational criteria can also be taken into account. Organizational criteria can be used as limitations in solving particular problems.

REFERENCES

1. I.Safonova, N.Kazansky, Yu.Nemtsov, K.Pankina “Application of 5G technology as an example of a heterogeneous network”, Automation, communications, computer science, 2019, № 10, pp. 18-21.
2. Y.Goldovsky, B.Zhelenkov, I.Safonova “On the approach to the implementation of FogComputing”, Telecommunications, 2018, № 6, pp. 13-15.
3. I.Safonova, Y.Goldovsky, B.Zhelenkov “Modeling a DBMS with limited circulation of segments”, World of Transport., 2014, V. 2, № 4 (53), pp. 32-44.
4. I.Safonova, A.Makarov, A.Morozov “An algorithm for determining the optimal number of channels in a data network with unreliable channels”, Telecommunications, 2013, № 12, pp. 02-03.
5. I.Safonova, B.Zhelenkov, Y.Goldovsky, K.Pankina “The architecture of the unmanned transport network”, Models of integration solutions to increase the competitiveness of domestic science, a collection of articles of the All-Russian Scientific and Practical Conference. Ufa, 2019.S. 39-43.
6. Y.Goldovsky, B.Zhelenkov, I.Safonova “The need to create a digital integrated environment for transport transportation”, Innovative, information and communication technologies: proceedings of the XV International Scientific and Practical Conference. / ed. S.U. Uvaisov - Moscow: Association of Alumni and Staff of VVIA named after prof. Zhukovsky, 2019, pp. 39-42.

7. D.Proferensov, I.Safonova "On the issue of FogComputing and the Internet of things", Educational resources and technologies - electronic periodical, 2017'(21), pp. 30-39.

8. I.Safonova, G.Telnov "The process of managing traffic flows of block passenger transport in the regions", Innovative, information and communication technologies, 2017, № 1, pp. 300-302.

9. D.Andrashitov, S.Galaev, M.Zaitsev, I.Kazeev, R.Kubova, S.Malikov, A.Rudko, I.Safonova, G.Telnov, "Models and technologies of management in socio-economic systems: a monograph" / under general ed. D.Andrashitov; Moscow Witte University. – M.: publishing house CHOUVO Moscow Witte University, 2017, – 142 p.

10. I.Safonova, D.Proferensov, D.Filippov "On one of the tasks of optimizing the topological structure of a corporate network", Innovative, Information and Communication Technologies: Proceedings of the XV International Scientific and Practical Conference / ed. S.U. Uvaisov - Moscow: Association of Alumni and Staff of VVIA named after prof. Zhukovsky, 2018, pp. 377-381.

ECONOMICS OF EDUCATION MANAGEMENT SYSTEMS IN THE CONTEXT OF DIGITAL TRANSFORMATION

[1]Efashkin I. G., [2]Kravchenko M. M., [3]Kravchenko E. I.
[1]Institute of Economics and Management of Industrial Enterprises, Moscow; [2]Gazprom, Moscow; [3]Moscow State University, Moscow
[1] efa@misis.ru; [2] krav4enko_marta@mail.ru; [3] krav4enko_elena@mail.ru

Abstract – In recent years, in higher education institutions education management systems (LMS - Learning Management System) have begun to be applied actively. Conceived initially for correspondence courses, they quickly penetrated into full-time education. Training using these systems yielded some results, but the interpretation of the results is far from obvious. The first part of the article discusses the changes that education outcomes have undergone since the introduction of LMS - systems in the educational process. The second part deals with economic aspects. Calculating the economic efficiency of LMS - systems was not a simple task. The lack of techniques, and the paradoxes of the performance of information systems, and the diversity of the systems themselves, and other factors also affect the result. Calculating the operating costs of LMS systems, we have to take into account not typical for classical costing aspects. The problems that arise during the operation of LMS - systems and the associated costs are discussed in the article.

Keywords: Education management systems, digital transformation, total costs, transaction costs, distance education, economic efficiency, effectiveness, profitability, education quality, search engine optimization, digital economy.

Performing tests and other control measures remotely provides students with well-known amenities: you can perform a test at any time at home or in a hostel - you only need a computer connected to the network [1]. On the other hand, as soon as distance tests appeared, the distribution of grades obtained during testing began to differ from the normal (Gaussian) distribution immediately. The grades "unsatisfactory" and "satisfactory" have practically disappeared. However, re-testing in traditional (written) form on this topic shows exactly the opposite pattern. A sample of 438 students of 1-3 courses was conducted in the disciplines of technical and humanitarian profiles. In fig. 1 the distribution of grades using education quality assessment tools is given.

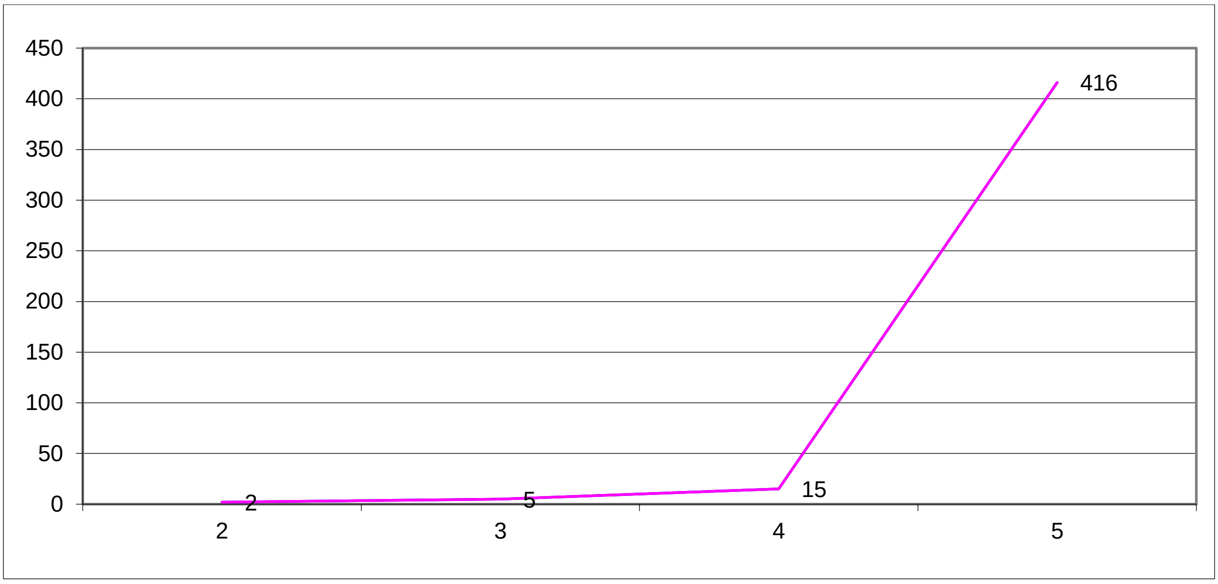


Fig. 1 Distribution of grades using distance testing tools

Figure 2 shows the distribution of grades in the same disciplines without use of distance testing tools, in a traditional way (control work in one of the practical classes).

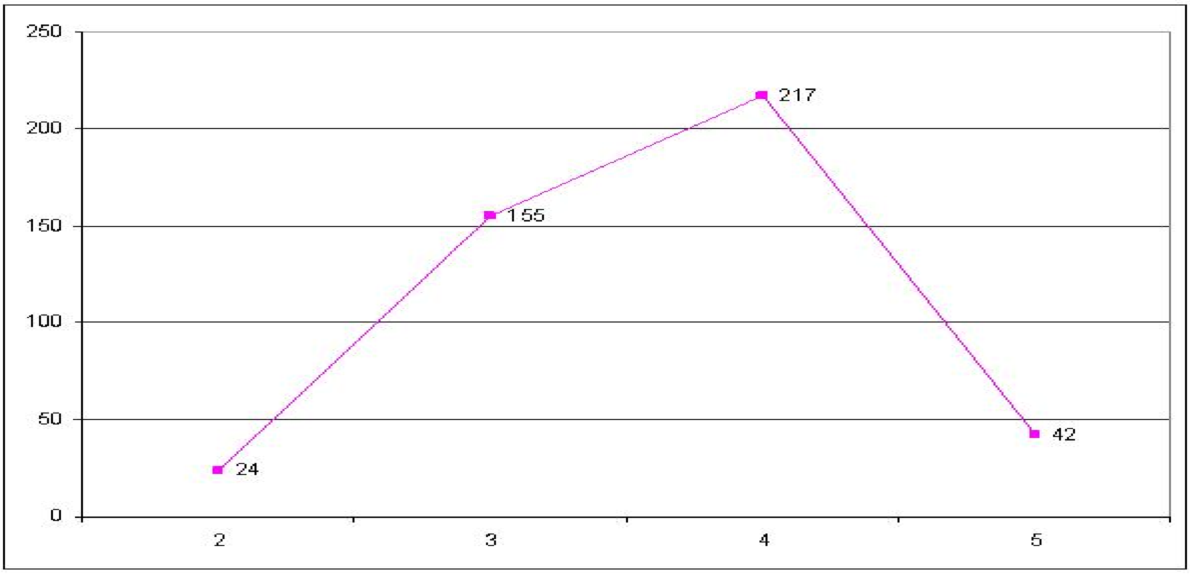


Fig. 2 Distribution of grades without the use of distance testing tools

As we can see at Figures 1 and 2, the distribution data for traditional methods of monitoring performance are closer to the normal (Gaussian) distribution. In fig. 1, there are practically no unsatisfactory and satisfactory ratings. There are also few good grades. On the contrary, there are a lot of excellent marks. As a rule, there are two reasons for this distribution of estimates, which is far from normal. Either the questions are poorly calibrated (too light), or students could use some extra data while performing the control event. The question of poor calibration in this case is no longer necessary, because in the case of traditional control, the distribution turned out to be close to normal. Consequently, the control event was not entirely honest on the part of the students.

After receiving and comparing the results of remote and traditional testing, measures were taken. In particular, it was said that after each remote testing there will be a traditional testing. The test results are shown in Fig. 3 and fig. 4.

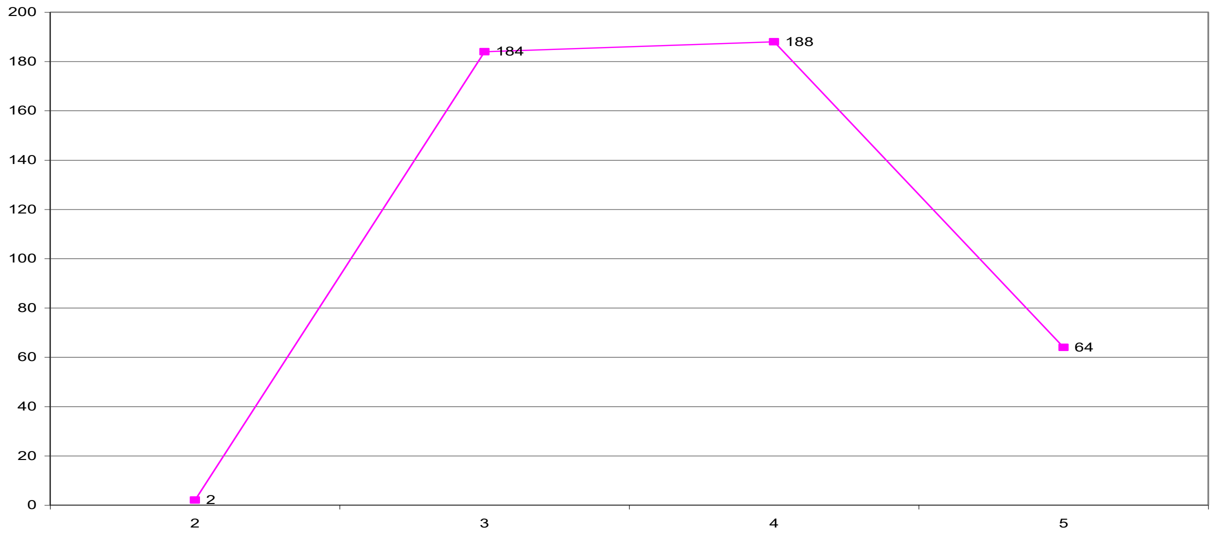


Fig. 3 Distribution of grades in remote testing with the prospect of re-traditional testing

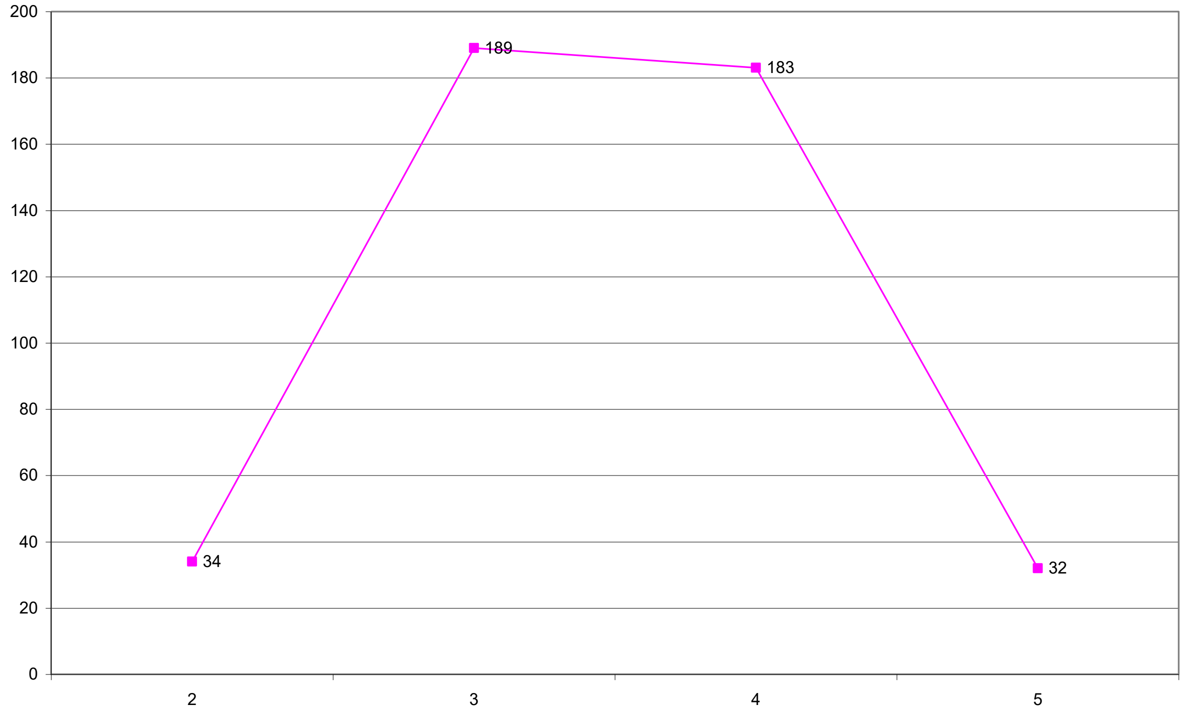


Fig. 4 Distribution of grades in repeated traditional testing

As follows from fig. 3 and 4, in case of remote testing with the prospect of repeated traditional testing and repeated traditional testing, the distribution of marks is closer to the normal distribution (Gaussian distribution). Certain discrepancies, certainly, do exist, but they apply to issues of technology, not principle.

Thus, the use of LMS - systems in the educational process affects both the technology of certification (exam, test) and the distribution of grades.

The use of education management systems also affects educational costs. First of all, it is necessary to note the variety of used systems. The classification of education management systems is given in [2] (Fig. 5).

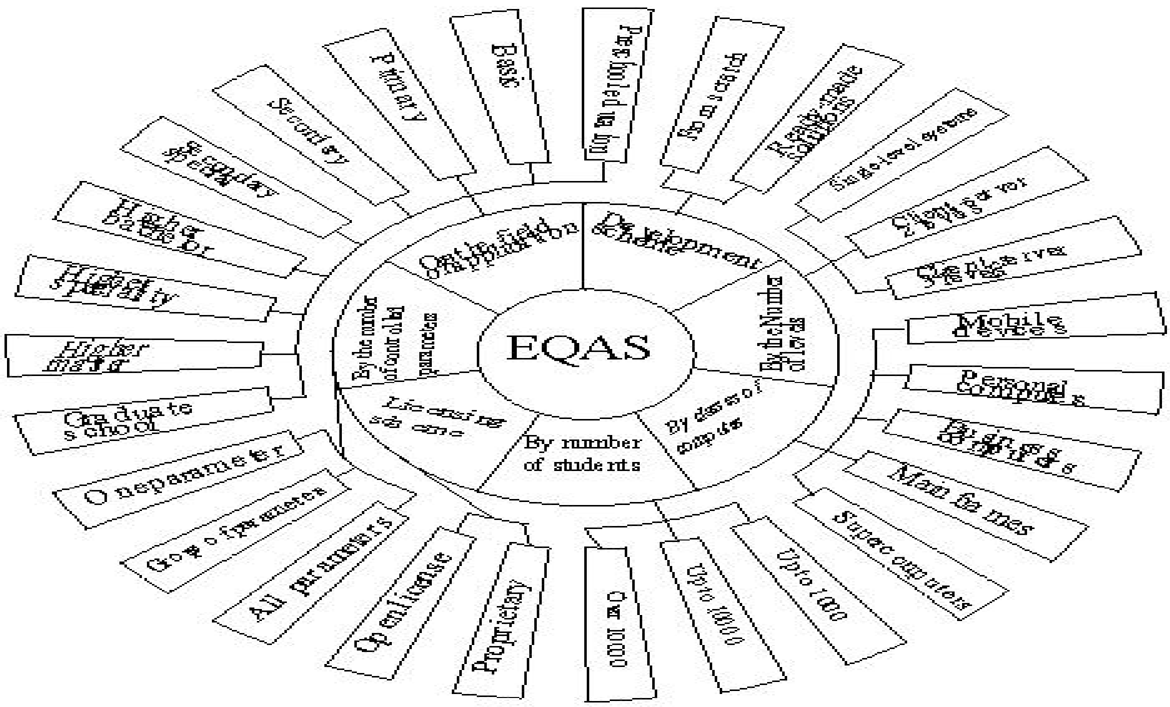


Fig. 5 Classification of education management systems

This classification was introduced in 2018. Over the past two years, it has been confirmed that almost all classes shown in Fig. 5 are present in practice. The structure of costs for education has changed. Formerly, in the cost structure there were such traditional items as the cost of teaching materials, electricity, salaries of professors and teachers, the costs of maintaining and operating educational equipment, however, with the use of education management systems, expenses related to the electronic support of the educational process were added to them. These ones include the cost of Web design of the training course, filling it with content, developing various tests, calibrating them, digitizing training materials, optimizing work programs for a specific specialty, direction or master's program, and some other expenses.

For example, let’s consider a basic mathematics course taught to students of all technical specialties and fields of education. Before you develop a curriculum for a course, you need to work out what practical examples are going to be given in lectures and practical classes. For students in the "Physics" direction in the "Derivatives" section, this will be the path, speed and acceleration. For students in the field of Economics, these will be Demand and Demand Elasticity, Labor Productivity.

In the basic course "Informatics", it is necessary to adapt the tasks to a specific programming language that is given to students. For example, if C or C ++ is read, then pointers will present in tasks on one-dimensional and two-dimensional arrays. If VBA (Visual Basic for Application) is given, then the tasks must include reading data from the cells of the spreadsheet and placing the results in cells.

All these optimization measures require time and money. The necessary information still needs to be found. Therefore, costs increase from year to year. In the USA, Borrell Associates analytic campaign calculated the dynamics of costs. The results are shown in Fig. 6.

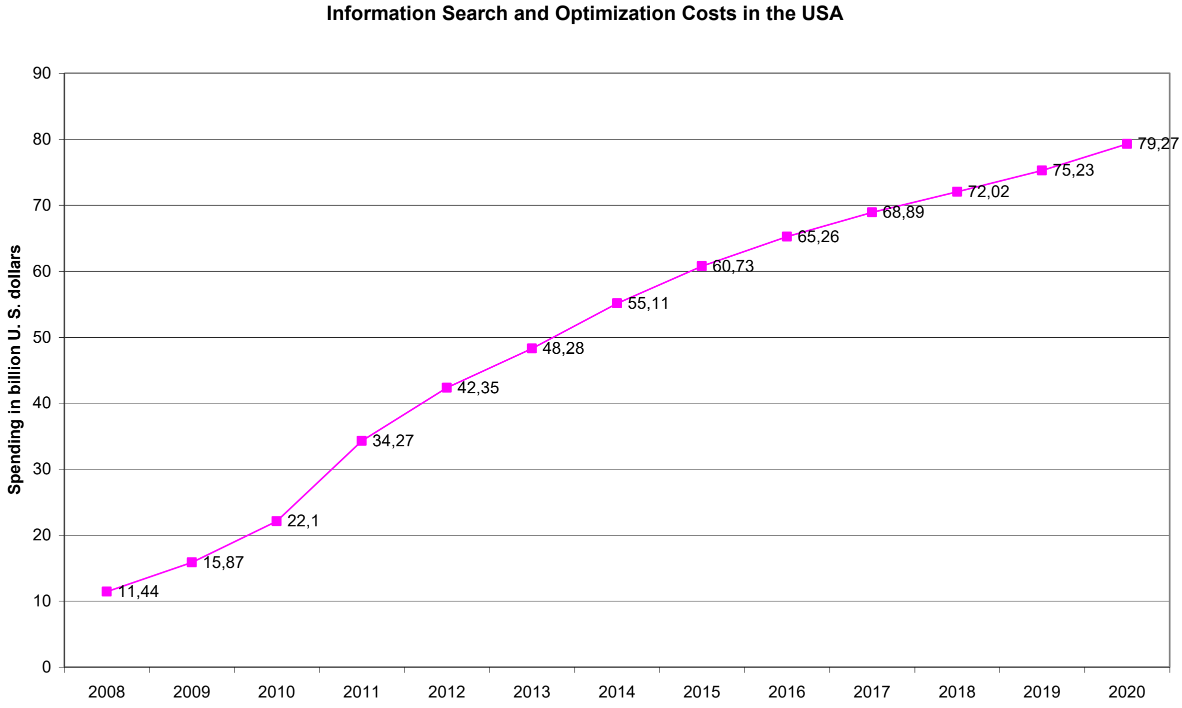


Fig. 6 Costs of information retrieval and cost optimization in the USA

It should be noted that these costs are common to all sectors of the economy. The examples are industry, healthcare, and education. If we take into account that in the United States the cost of education is comparable to the cost of healthcare, then the proportion of costs for search engine optimization will be approximately 24% of the total cost.

In Russia, in 2015, expenditures on culture, education and healthcare amounted to (in one block) 7% with total expenditures 15.4 trillion rubles. The cost of education, therefore, amounted to about 294.6 billion rubles. Of these costs, 77.5% are expenditures for higher education (Table 1). Since LMS - systems operate mainly in higher education institutions, all the costs of their maintenance will be accumulated in this expenditure item.

TABLE 1. COST STRUCTURE FOR HIGHER EDUCATION IN RUSSIA

Expenditures	Amount, billion rubles	Specific weight,%
Preschool education	2,6	0,9%
General education	3,4	1,2%
Primary vocational education	8,8	3,0%
Secondary vocational education	26,6	9,0%
Retraining and advanced training	4,8	1,6%
Higher professional Education	228,3	77,5%
Youth Policy and Children's Health	0,3	0,1%
Applied Research in Education	2	0,7%
Other educational issues	17,8	6,0%
Total:	294,6	100%

Thus, the costs of maintaining and operating education management systems will be concentrated basically in the costs of higher professional education. Nevertheless, an increasing number of secondary schools begins to apply education management systems to the educational process. So far, this is true for large cities. So, for example, the Moscow Lyceum of Information Technologies (1533) has been using the Ulysses system for several years, which is a variation of the Moodle course management system.

Moreover, in accordance with the global trend, the cost of finding information and optimizing costs will increase year by year.

The effect of the use of education management systems, in contrast to the effect of the construction or reconstruction of an industrial enterprise, will consist of several components. In addition to purely economic indicators (reduction from output of printed products), it is necessary to take into account the social aspect as well as the pedagogical one. Thus, the effect of the use of education management systems can be calculated by the formula:

$$Et=Ee+Es+Ep+Eecol \tag{1}$$

where Et is the total economic, social and pedagogical effect,

Ee - economic effect

Es - social effect

Ep - pedagogical effect

Eecol - environmental effect

The economic effect of the introduction of education management systems is formed by reducing costs, for example, by reducing the cost of issuing printed test materials, paying extra hours for checking control materials in a traditional paper version, etc.

The social effect is formed by the saturation of the labor market with more qualified specialists, their receipt of higher salaries, replenishment of the budget with taxes of higher paid specialists, a decrease in the share of low-paid workers and a reduction in social benefits.

The pedagogical effect is formed by improving the quality of education, the ability of teachers to approach the development of tasks selectively, taking into account the individual abilities of students and improvement of the working conditions of teachers.

The environmental effect is established due to a decrease in deforestation for paper-based printed products, as well as a reduction in atmospheric emissions and discharges into water from paper mills.

CONCLUSIONS

1. The use of education management systems has changed the methodology for conducting lecture and practical classes, as well as control measures (exams, tests, etc.).

2. While control measures in the traditional form (without the use of education quality management systems) are performed by an experienced teacher, the distribution of grades is close to the normal distribution (Gaussian distribution). It is necessary to develop such methods of conducting events so that the normal distribution is maintained in any case.

3. The effect of the application of education management systems is the sum of the economic, social, pedagogical and environmental effects.

REFERENCES

1. Skripkin K. G. Economic efficiency of information systems in Russia. – M .: MAKS Press, 2014 - 156 p.

2. Efashkin I. G. Classification and cost-effectiveness of educational quality assestment systems. International Scientific-Practical Conference “Information Innovative Technologies”. Prague, 23-28 April 2018, p. 628-632.

PRODUCTION COSTS IN DIGITAL ECONOMY

Kravchenko A. I.
NUST «MISiS», Institute of Economics and Management of Industrial Enterprises, (Moscow, Russia)
+7-985-063-94-10, krav4enkoai@mail.ru

Abstract – In recent years, the world has become increasingly digital. Digital education, digital economy, digital medicine. The turn came to such a fundamental concept as production costs. The classic definition of costs is the cost of production and sales. In addition to the main costs, there are transaction costs. Transaction costs are costs that do not relate directly to the production of products, but they are a kind of indirect costs for finding and collecting all the information necessary for the activity, conclusion of various transactions, contracts, agreements, etc.

It is transaction costs digitalization has the greatest impact on. How do search optimization costs change? What is the impact of transaction costs on total ones? How does the cost structure of the company change? An attempt to answer these and other questions is made in this article.

Keywords: Production costs, digital environment, transaction costs, digital economy, digitalization, search engine optimization, production costs, profitability, economic effect, current costs, capitalization.

The digital environment, in most cases, facilitates business management. A huge number of different ERP-systems, customer relationship management systems (CRM), supply chain management systems (SCM), product life cycle management systems (PLM), and finally, the most powerful business intelligence tools (BI), allow you to control all stages of the product's life. As you know, any product passes three main stages. The first stage is the product by design - when the entrepreneur realizes that there is a certain need, and at the moment there are no suitable goods to satisfy this need. A classic example is the need to move from one point to another. The second stage is goods in real execution. To meet the need, a specific product comes out. In our case, examples would be a steam locomotive, a car, transatlantic liners, and when there was a need for fast movement - airplanes, first with piston engines, then with turbojet engines, and after that supersonic airplanes. The last stage is goods with reinforcement. At this stage, along with the main product, additional goods or services come out, designed to increase the attractiveness of the main product.

With the help of PLM - systems it is possible to accumulate information at all stages of the product's life: development stage, market launch stage, growth stage, maturity stage and decline stage [1]. Each of the stages is characterized by its values of indicators of sales and profit margins (Fig. 1).

In the first two stages (the development stage and the stage of bringing the product to the market), the profit is negative, since the costs (capital investments) necessary to bring the product to the market are incurred. In the beginning, serious marketing research is carried out. It is necessary to determine the final type of product, to segment the market and to select one or more target segments. At the growth stage, profit emerges, which reaches its maximum at the stage of product maturity. Then the decline phase comes. PLM - systems [2] allow you to control all stages of a product's life, to record various marketing activities (both successful and unsuccessful) and to use the experience gained in developing and launching the following products on the market. Sometimes this process takes years and even decades. For example, a

Land Rover Defender was in production from 1948 to 2016. Using the accumulated experience, you can avoid mistakes introducing the sequent products to the market.

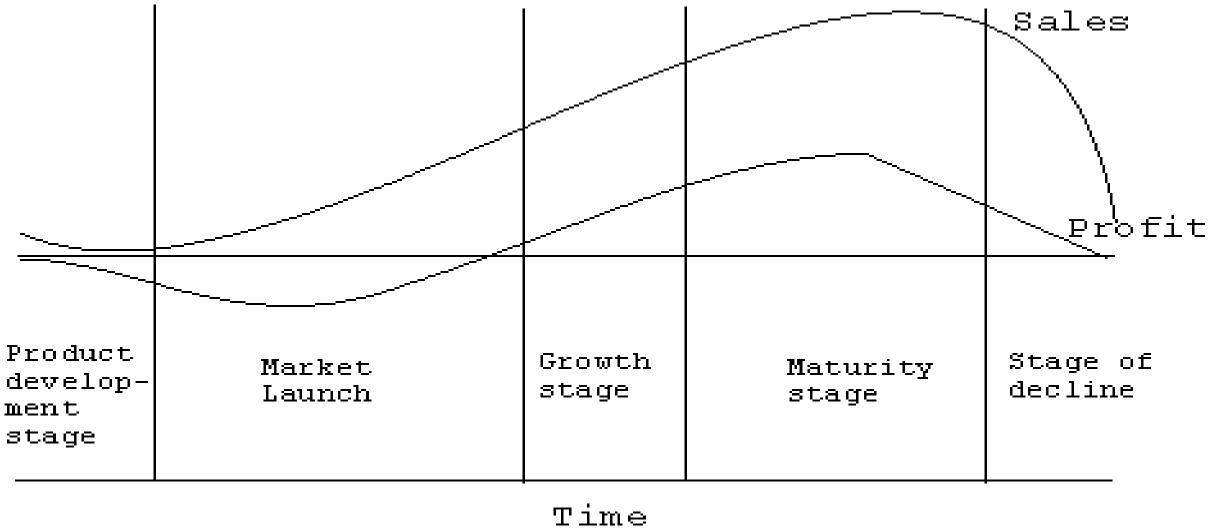


Fig. 1 Life Stages

With the help of scheduling systems, managing a project to develop and launch a new product on the market can be much more effective. Using the modified Gantt diagrams and the mathematical apparatus of network planning and management, you can quickly answer the questions: what will happen if there are any failures in the project? Will this lead to a disruption in the deadline for the implementation of the project, or, using temporary reserves, can the lag arising for one or another reason be nullified?

Finally, the use of ERP-systems allows you to receive almost any information on manufactured products quickly and adjust the production process promptly. Although, with complex production technology, sometimes quite large time lags [3] occur between sending a request and receiving a response from the system. To reduce the response time, even the "philosophy" of RTE (Real-Time Enterprise) [4] came up, but talking about it is beyond the scope of this article.

The production process itself has become deeply automated (Fig. 2).

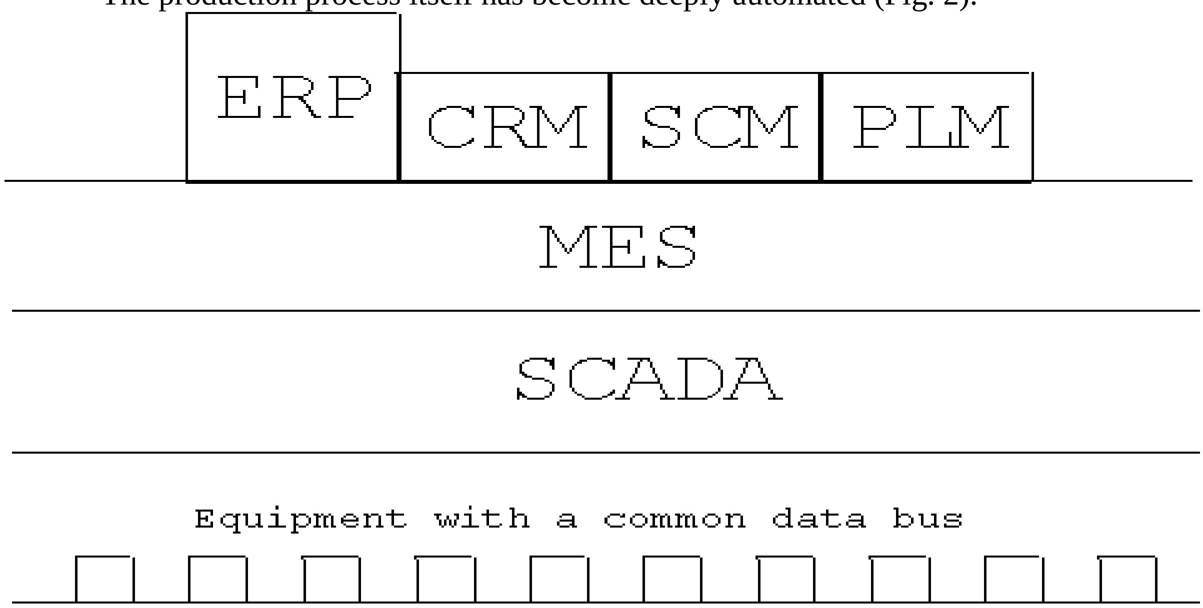


Fig. 2 Modern automated enterprise

Equipment (in the simplest case - a machine), working independently, is becoming a rarity. As a rule, all machines are united by a common data bus, through which information on the status of equipment is transmitted and commands are received [5]. Scada - system (Supervisory Control And Data Acquisition) works one floor above. As a rule, Scada - system controls one of the sections of the workshop. One more floor above is the MES-system (MES-Manufacturing Execution System). MES - system operates at the shop floor. Finally, on the top floor there are ERP - system (Enterprise Resource Planning), CRM - system (Customer Relationship Management), SCM - system (Supply Chain Management), PLM - system (Product Lifecycle Management).

Thus, modern digital platforms and digital tools can increase the profitability of production, primarily due to lower costs. Cost reduction occurs due to such items as reducing the cost of wages consequent on automation of production and reducing the number of employees, reducing the cost of materials as a result of decrease in the amount of waste and some other items. However, there are additional costs due to the widespread adoption of digital platforms. As we have already mentioned, these costs affect the transaction costs, which are costs that do not relate directly to the production of products, but they are a kind of indirect costs of finding and collecting all the information necessary for the activity, conclusion of various transactions, contracts, agreements, etc.

No modern enterprise can manage without a resource on the Internet. Finding information is costly. When costs increase, they need to be optimized. A robust phrase SEO (Search Engine Optimization) has emerged. To create a full-fledged website, you need to take care of the website's web design, implement HTML layout, fill it with content, think over a strategy for website development, calculate traffic taking into account peak loads, make an intuitive site map, decide on the use of cookies and many another things. SEO costs increase year by year (Fig. 3).

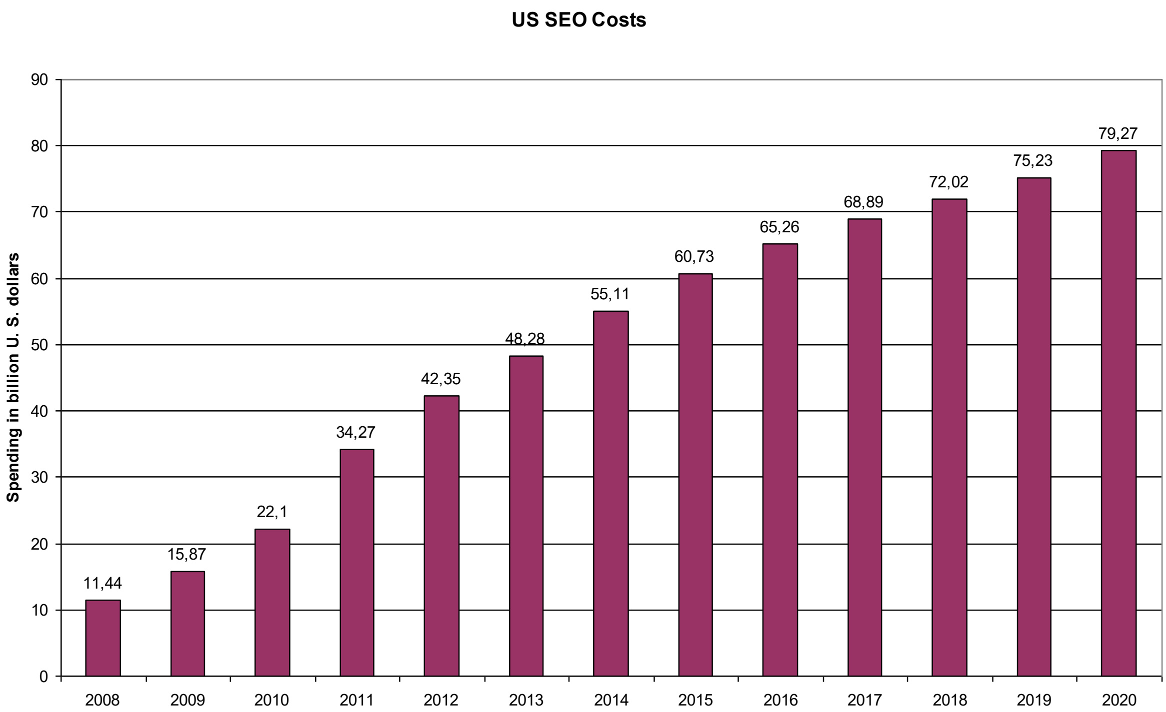


Рис. 3 Search engine optimization costs in the U.S.

According to research firm Borrell Associates, SEO spending in the U.S. increased from $ 11.44 billion in 2008 to nearly $ 80 billion in 2020. As it arises from fig. 3, the increase in SEO costs is uneven. Figure 4 shows the increase in SEO costs since 2009 compared to the previous year. Having its maximum reached in 2011 (an increase of 55.07%), the increase in SEO costs gradually began to decline, remaining at the level of five percent in recent years, but in absolute terms their value remains significant. Analysis of changes in SEO is beyond the scope of this article; we can only say that it is based on a number of objective and subjective factors. Thus, the cost of SEO increases the transaction costs of the company in accordance with the global trend. Unfortunately, the authors could not find information on SEO costs in Russia.

Other factors that can lead to increased costs are, for example, phishing - a fraudulent access to user's confidential data. The risk of phishing can lead to the loss of a company's reputation, a decrease in sales due to an outflow of customers, a decrease in the company's capitalization, and even lowering of brand value. For customers, direct financial losses are possible in case of, for example, theft of funds from bank cards.

Thus, two factors can be traced that work in opposite directions. On the one hand, the use of digital platforms reduces the costs of the enterprise, due to a more rational use of resources, reduction of salary costs, reduction of operational management costs, reduction of workshop and factory costs and some other costing items. On the other hand, there are costs that have been absent during the organization of production without the use of various digital platforms and digital tools (such as ERP - systems, customer relationship management systems, supply chain management systems, product life cycle management, business intelligence tools, scheduling systems (project management) and similar tools).

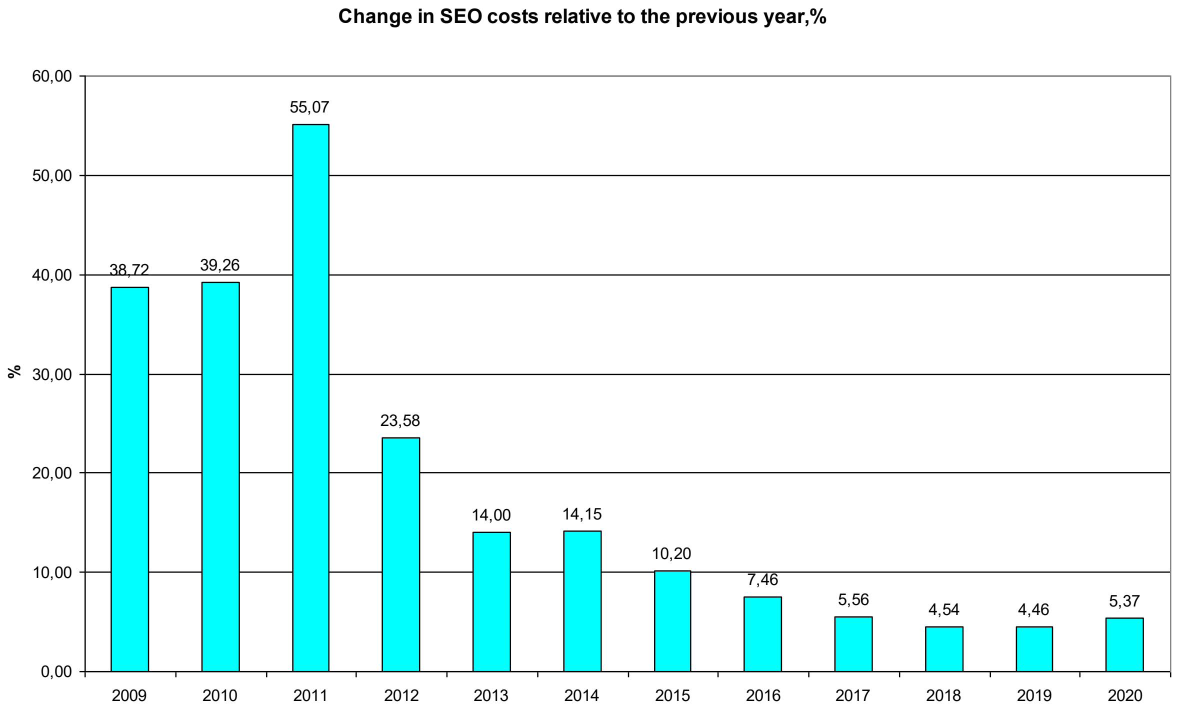


Fig. 4 Change in SEO Costs from Previous Year in the USA

The influence of these two factors on total costs is presented in Fig. 5. The diagram is based on data that the author was able to obtain from several Russian metallurgical enterprises.

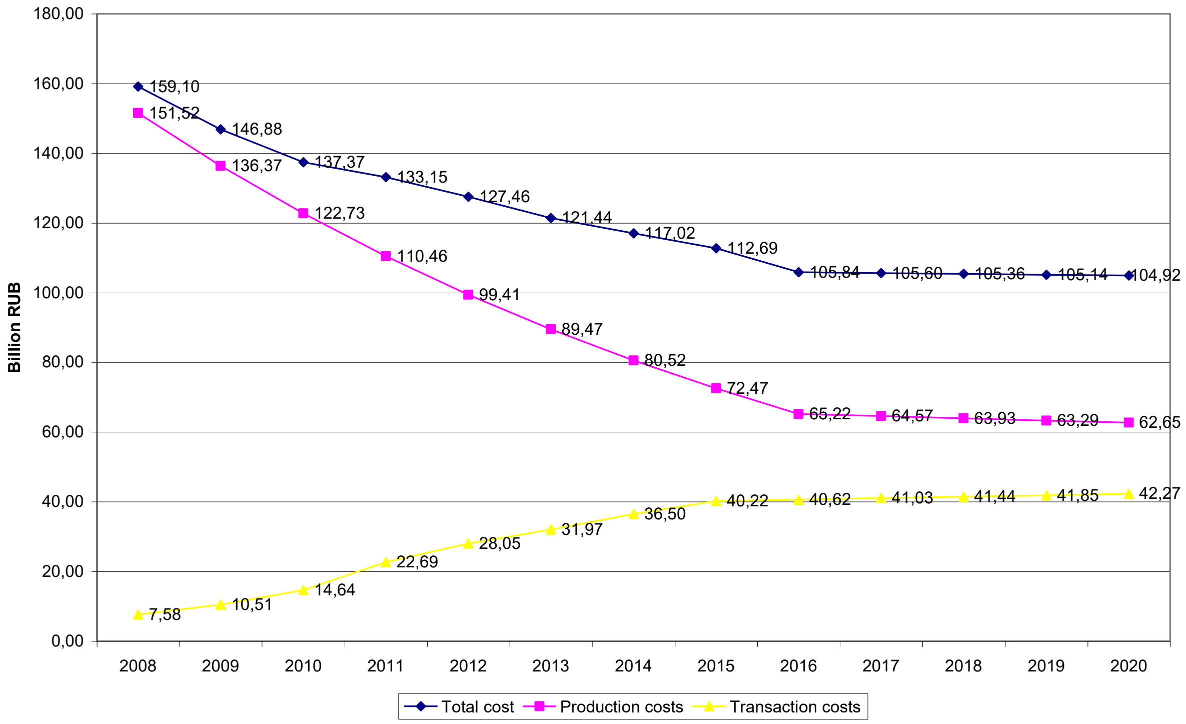


Fig. 5 Change in total, transaction and production costs by year

Certainly, as soon as data from other enterprises are obtained, quantitative parameters can be adjusted, but the general trend, according to the author, will continue.

CONCLUSIONS

1. Any product at the stage of its life cycle passes the stages of development, market launch, growth, maturity, decline. It is necessary to track production costs at each stage.
2. The use of digital platforms can increase transaction costs, so you need to consider them as part of the total costs.
3. Transaction costs in recent years have been steadily increasing, in particular, spending on SEO (Search Engine Optimization - search engine optimization) has been increasing.
4. While transaction costs occupy a small share in total costs, however, over time, transaction costs may begin to increase not only in absolute, but also in specific values.
5. If total costs begin to increase as a result of the growth of transaction costs, it will be necessary to take additional measures to reduce the total expences.

REFERENCES

1. F. Kotler. The basics of marketing. - S.-P.: Coruna, 1994 - 698 p.
2. Skripkin K. G. Economic efficiency of information systems in Russia. –M .: MAKS Press, 2014 - 156 p.
3. Efashkin I. G. Classification and cost-effectiveness of educational quality assessment systems. International Scientific-Practical Conference “Information Innovative Technologies”. Prague, 23-28 April 2018, p. 628-632.
4. Skripkin K. G. Economics of information products and services. - M.: "Prospect", 2020. - 192 p.
5. Brynjolfsson Eric, The Productivity Paradox of Information Technology // Communication of the ACM, v. 36, No 12 (Dec 1993), pp. 67-77.

MODERN AGE OF INFORMATION TECHNOLOGY AND CASHLESS PAYMENT SYSTEM

Uglova L. A., Tikhonov Georg. G.
Moscow aviation institute (MAI)
+7 (910) 427-18-51, imp_ekakaf@mail.ru

Abstract - The article analyzes the promotion of banking products for individuals based on plastic cards. The problems of the plastic card market are identified and the directions of improving the activity of banks in the field of using plastic cards are considered.

Keywords: plastic card, identification, chips, card business, credit.

INTRODUCTION

Together with the development of information technologies, the banking sector is rapidly developing, which is inextricably linked with new technologies and the search for tools that increase the efficiency and attractiveness of banking services.

Any commercial Bank conducts its own policy to meet the needs of its direct customers in the field of banking services. Banks are constantly adding or expanding their services.

Individuals and legal entities make all kinds of payments, for example, they pay for housing and utilities, taxes, mobile services, and use the money transfer system. By the way, the latter can be done even without opening your own account.

Commercial banks can offer us various types of deposits that allow us to earn income and can provide easy and convenient access to savings. For certain groups of the population, such as pensioners, there are deposits with an increased interest rate.

Banks also offer one of their main services – lending.

In the course of improving the banking system, the sphere of banking products and services is also being improved. With the help of the global Internet, the client can make payments, repay loans and perform simple operations without leaving home. Since the competition in the market of banking products is quite high, we can conclude that it is in the Bank's interests to form new services and products, improving the quality of service.

PROBLEM STATEMENT

Any commercial Bank has its own policy to meet the needs of its direct customers in the field of banking services. Banks are constantly adding or expanding their services.

Individuals and legal entities make all types of payments, for example, they pay for housing and utilities, taxes, mobile communication services, and use the money transfer system. By the way, the latter can be done even without opening your own account.

Commercial banks can offer us various types of deposits that allow us to earn income and can provide easy and convenient access to savings. For certain groups of the population, such as pensioners, there are deposits with an increased interest rate.

Banks also offer one of their main services – lending. A credit transaction is the main operation of a Bank. In the course of completing these tasks, I will consider the main types of loans: government, commercial and consumer.

We will examine the similarities and differences between a banking service and a banking product using four main approaches to defining these concepts.

Banking services and products are divided into traditional and non-traditional. Traditional operations include Deposit, credit and settlement operations. And all other types of operations, such as forfeiting, leasing, factoring, and trust, are non-traditional.

In the course of improving the banking system, the sphere of banking products and services is also being improved. With the help of the global Internet, the client can make payments, repay loans and perform simple operations without leaving home. Since competition in the market of banking products is quite high, we can conclude that it is in the Bank's interests to form new services and products, improving the quality of service.

In order to get a complete picture of the analysis, we will consider the organizational and economic structure and a detailed analysis of banking products and services.

Banks actively carry out various types of Deposit, credit and cash settlement operations, which ensures the effectiveness of their economic development. Banks also operate in the Russian consumer lending market, specializing in providing loans in customer service locations organized on the territory of retail zones of the Bank's partners, successfully combining the accumulated experience of Sberbank and innovative European technologies.

The relevance of the article is that the banking system is the core in the structure of the country's economy. At the moment, the development of banking products and services is very important, because more and more people are actively using them. The market system places the Bank among the most important elements of economic regulation. However, a completely new type of activity is emerging in the development of the banking system, which in the future may overshadow the entire banking system. We will talk about the space of cyber money, about a payment system called Bitcoin. The problem of cyber money is not well understood, but perhaps in the near future the world will get rid of cash and the position of the Central Bank will be put at risk.

The purpose of the article is to analyze the development of banking products and services in the banking system, as well as to identify the pros and cons of cyber currency, its impact on the system as a whole.

SOLUTION OF THE PROBLEM

So, summing up the results of the work done, it should be noted that the market of banking services and products is in constant development. Every year, banks create new products to ensure a sufficient influx of customers. It also helps them retain old customers to compete in the market.

After completing the first task-to consider the General characteristics of banking products and services, we learned that a banking service is a set of banking operations for customer service. Services, in turn, are divided into traditional and non-traditional.

Traditional services include Deposit, credit, cash and currency operations. Non-traditional operations include forfeiting, factoring, leasing, and trust operations.

Banking services and products are a direct result of the successful operation of the banking system, which is a two-level structure. The first level is directly the Central Bank, and the second includes commercial banks and non-Bank credit organizations.

In order to analyze the volume of banking products and services from the inside, we have reviewed in detail LLC "Setelem Bank". As of 2018, Setelem is a successful credit institution in the banking system of the Russian Federation. The Bank provides all types of services and products, and thanks to numerous Deposit and cash settlement operations, it occupies a leading position. The Bank has demonstrated significant results in the field of POS-lending and other types of consumer lending.

After analyzing the Bank's profitability, we found out that Setelem Bank LLC is a profitable organization (as of 2013). However, there are also a number of problems, such as the growth of overdue debt and the growth of debt on loans. I would like to note that, having identified these shortcomings, I have made suggestions on how to deal with them. For a stable increase in Commission income, it is proposed to develop a new product in the banking services market - a "package of banking services", which allows the Bank's clients to receive preferential terms of settlement and cash and remote Internet services. This will attract new customers and increase the Bank's profit.

Having analyzed in detail the essence of banking products and services and their development in the banking system, we have come to an important problem of our time, namely, the emergence of a new payment system that can replace the entire banking system.

As a result of the development of computer technologies, payment systems appear, which are designed to simplify the system of economic relations between the seller and the buyer.

Electronic money quickly gained popularity. The ability to pay for almost any product, anywhere in the world and at any time looks quite promising. You can link a Bank product, such as a Bank card, to certain payment systems.

However, in Russia, payment systems are not as popular as in the United States or Europe. This is caused by the population's distrust of payment systems and poor marketing of these systems. The consumer is forced to believe that cyberspace is not sufficiently protected by the state and the Central Bank, so cyberspace is a tasty morsel for fraudsters.

In 2007, the first mention of the Bitcoin system appeared. Bitcoin is a payment system that uses a special payment system. The advantages of the bitcoin system are obvious. The system is completely decentralized and anonymous. Even the best security services of States will not be able to track transactions. Bitcoins are not just able to replace money, but also become an international currency. They may be the only currency to be used among all countries in the world. Bitcoins are an absolutely uncontrolled payment system, while the bitcoin system does not provide a Commission and it is almost impossible to fake them.

Bitcoins can bring down the entire banking system, because the prospect of their development is quite high. State apparatuses of European countries have already begun to investigate the problem of bitcoins, but it has not yet been decided whether this system contributes to achieving stable economic growth or not.

After analyzing the system, it is impossible to accurately answer the question about the future fate of bitcoins. For all the advantages of cryptocurrency, it has significant disadvantages. But there is still no proper regulation between the States where bitcoins exist.

To sum up, we can make the following recommendations. Russia should have a clear position on the Bitcoin system. It is impossible to say unequivocally about their benefits, but you should not close yourself from this problem. I believe that this dissertation did the right research in the field of banking products against the backdrop of bitcoin's prospects. All the tasks and goals were achieved.

CONCLUSION

Having analyzed in detail the essence of banking products and services and their development in the banking system, we have come to an important problem of our time, namely, the emergence of a new payment system that can replace the entire banking system.

As a result of the development of computer technologies, payment systems appear, which are designed to simplify the system of economic relations between the seller and the buyer.

Electronic money quickly gained popularity. The ability to pay for almost any product, anywhere in the world and at any time looks quite promising. You can link a Bank product, such as a Bank card, to certain payment systems.

However, in Russia, payment systems are not as popular as in the United States or Europe. This is caused by the population's distrust of payment systems and poor marketing of these systems. The consumer is forced to believe that cyberspace is not sufficiently protected by the state and the Central Bank, so cyberspace is a tasty morsel for fraudsters.

The main factors holding back the growth of plastic business in Russia. These include [2]:

- imperfection of Russian legislation;
- high level of fraud;
- insufficient financial literacy of the population;

 predominance of cash over non-cash circulation;
 insufficient development of the acquiring network.

3. The adoption of a single regulatory document detailing fines for various types of violations in the plastic business will significantly reduce the cost of proving illegal activities and losses from fraud.

4. Cardholders ' compliance with security rules when performing non-cash transactions, as well as the introduction of contactless technologies in this area of banking will help reduce the level of fraud. Individual approach, full explanation to the client of all the nuances associated with non - cash payments, financial advice at enterprises-all this will help to improve the financial literacy of Russians.

5. The main measures that stimulate the growth of non-cash payments are: limiting cash payments by the state; conducting loyalty programs by banks; switching large stores, cafe chains and cinemas exclusively to the non-cash form of payments; reducing VAT for individuals who make payments using plastic cards.

6. The development of the acquiring network will be facilitated by reducing the volume of payments for servicing non-cash payments.

7. In General, the incentive for using plastic cards in Russia will be a combination of two conditions. First, the card payment mechanism should be no less convenient than using cash. Secondly, the use of cards must be profitable for the client.

There are three main directions of development of the card business:

1. Cartographic design (using new materials for making maps, creating a relief surface and flavoring).

2. New technologies (the introduction of NFC technology, which allows you to "attach" a payment card to a mobile phone and make any payments contactless, as well as the use of a new card with a display and keyboard - DisplayCard, which has various additional functions and has a high degree of protection).

3. Security (installation of biometric ATMs).

Speaking about the prospects for the development of the Bank card market, it is necessary to determine its priority areas, the development of which, in turn, will help to encourage potential users to make payments with plastic cards. It is also necessary to identify and take into account the factors that ensure the development of this market.

These factors include:

- the presence of a fully formed scientifically based and practically confirmed legal framework;
- economic and organizational activities of banks that have Bank cards in their Arsenal of services, as well as an increase in offers from banks in this area;
- the level of development of the terminal network in trade and service organizations and the expansion of the Card service infrastructure;
- increasing the level of public confidence in Bank cards by increasing the financial literacy of the population.

REFERENCES

1. Ginzburg A. I. Plastic cards. – SPb.: Peter, 2014. -128 PP.
2. Ishchenko S. V. State-legal regulation of Bank card circulation in the Russian Federation / / Law and Economics.- 2013. - No. 11.– p. 65-68
3. Kiryanov M. Bank card Market-problems and prospects/ / Banking.- 2014-No. 11.- pp. 94-96

SPECTRAL-TEMPORAL DECOMPOSITION OF THE MEASURED SERIES OF PACKET INTENSITY

Mirzakulova S. A.*, Sharshenaliev Z. S.**, Yussupova G. M.*, Annabayev A. S.*** Sadikova Gulnar****, Zhanalinova A.,* Assylbek T*.
University Turan, Almaty *, National Academy of Sciences, Bishkek **, JSC Transtelecom Direction of capital constraction ***, PhD student of the Department of Telecommunication Networks and Systems, Almaty University of Power Engineering and Telecommunications, Kazakhstan *****.
+7 (707) 224-00-61, gulbahar@mail.ru

Abstract— The paper analyzes the power spectrum of the measured real series of packet intensities based on the autoregressive assessment. In 1969 J.P. Burg proposed a modification of the Yule-Walker method, in which the value of the process at each moment of time is determined by the weighted values of the process at previous points in time with the addition of independent noise. At the same time, the Durbin-Levinson iterations still consistently increase the autoregression order. However, this time, with each increase in the order, these iterations are used only to change the old coefficients, and each new coefficient will be found from the condition of the maximum sum of squares of forecast errors one step forward and backward by virtue of the autoregressive model. The spectral-temporal analysis diagrams and the wavelet-packet decomposition of the initial series are constructed.

Keywords: time series; spectral-time analysis; wavelet transform; Wavelet-packet.

INTRODUCTION

A special feature of the time series is that it is a sequence of numerical indicators ordered in time, which characterizes the level of state and changes of the phenomenon under study. The values of the time series are formed under the influence of certain factors, which together form the general patterns in the development of events, which include:

- the factors shaping the trend of the series;
- factors that form seasonal changes in the level of the series with a constant period;
- factors forming a cyclic component with a change in the level of a series with a variable period;
- random factors.

It is not necessary that the elements of the time series represent the simultaneous action of all four factors — different combinations of them work under different conditions, but the presence of a random component is considered mandatory.

Time series models explain the behavior of a variable that changes over time, based only on its previous values. At the same time, depending on the presence of these factors, time series can be stationary and non-stationary. Levels of stationary rows are formed under the influence of random factors that act in different directions and with different intensity. A non-stationary series always has a tendency that is characterized by non-random factors in the processes represented by this time series. A time series is called nonstationary if its characteristics (mean, variance and autocorrelation functions) depend on time.

As for the real processes, they are usually not stationary.

In this paper, we study the structure of the measured of the series of packet intensity in various ways of spectral-time analysis.

MAIN PART

The properties of time series are usually analyzed in the time domain, although the same information can be effectively obtained when analyzing in the frequency domain, i.e. using spectral analysis. Any random process has both a time domain and a representation in the frequency domain. For identification of some properties, a study in the time domain is suitable and this is more suitable for other properties – the frequency domain may be more suitable. Spectral analysis characterizes the frequency composition of a series.

The application of the spectral method can improve the understanding of the structure and cyclic behavior of a series at different time scales.

Spectral analysis decomposes the original series into an infinite sum of periodic functions, each with a different frequency. Spectral methods typically encompass a class of algorithms that represent matrices using linear algebraic methods, involving the eigenvalues of the matrix vectors.

The Fourier transform of the original non-periodic function of arbitrary shape, which cannot be described analytically and relatively difficult to process and analyze, represents it as a set of sines or cosines with different frequencies and amplitudes. That is, a complex function is converted into a set of simpler sinusoids (or cosine) with a certain frequency and amplitude, resulting from the Fourier transform. These are the spectral components (harmonics) that form the Fourier spectrum [1]. Graphically, each spectral component is represented in the form of a reference, the position of which horizontally corresponds to its frequency, and the height to its amplitude.

Classical Fourier analysis is an unsurpassed tool for detecting stationary signals in time series data and is poorly suited for the study of non-stationary signals [2]. At the same time, their amplitude and frequency characteristics are evaluated.

Wavelet transform opens up a new way to describe signals. Basically, wavelets use mini waves as compared to Fourier series, where a sine or cosine wave is used, which propagates infinitely. That is, sine or cosine waves are not limited in time, while wavelets are limited in time. As for wavelets, these are short bursts of a wave that take the form of a rapidly damped mini-wave. Wavelets have the remarkable property of maintaining good resolution at different scales. Wavelets react differently when processing low and high frequencies. For high frequencies, the sine wave is compressed, and for low frequencies it is stretched.

The analyzed row displays the number of UDP packets (User Datagram Protocol) for every 10 seconds. This series has 1800 levels. This is the backbone network traffic (Fig. 1). Visually, the series has an uneven intensity (the spread of observations increases and decreases with time), there are pulsations of traffic intensity with significant dispersion, there are groupings in «packs» in some places or there are discharged sites in other time intervals where there are no or few packets.

The transition to increments makes the time series more stationary. To convert the original non-stationary series according to the mathematical expectation of a time series into a stationary series, differentiation is performed – taking finite differences of the series values (with low frequencies dominating) according to the formula:

$$y(t) = x(t+1) - x(t) \tag{1}$$

Due to the fact that the series under investigation has the properties of randomness, non-stationarity [3], let us estimate the power spectra of the time series under study and its first increment in the Spectra Analyzer [4] program using the Burg maximum entropy method using parametric autoregressive estimation, according to the autoregressive model of the order of $p \geq 0$ (AR(p)), which is described by the following equation [5, 6, 7]:

$$x(t) + \sum_{k=1}^{p} a_k x(t-k) = \varepsilon(t) + d \tag{2}$$

where a_k – auto regression coefficients (model parameters);

d – statistical offset parameter;

$\varepsilon(t)$ – white noise with zero mean and variance σ^2.

Next $(p+1)$-dimensional vectors are introduced:

$$Y(t) = (-x(t-1),\ldots,-x(t-p),1)^T, c = (a_1,\ldots,a_p,d)^T \tag{3}$$

Then (3) is written in the form:

$$x(t) = c^T Y(t) + \varepsilon(t) \tag{4}$$

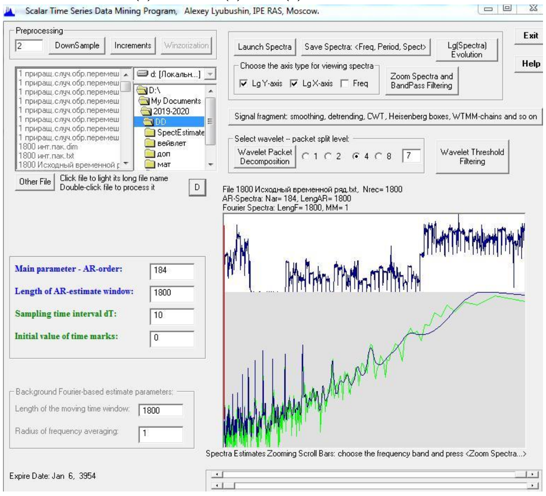


Fig.1 Maximum entropy estimate and «background» Fourier estimate of the source series

Fig. 2 shows a comparison of the estimated power spectra of the original time series and its increments. At the same time, you can see the presence of a high power trend with a long period in the initial time series and it is also with weakened power in the second increment graph. In addition, in Figure 2, eleven spectral peaks are visible, marked by values of periods with local maxima, which are the same for both series and are equal to the following values: 24,44 s; 27,13 seconds; 30,52 s; 34,95 s; 40,72 s; 48,88 s; 61,13 s; 81,27 s; 121,90 s; 243,81 and 585,14 s. That is, the increments series - noise is the signal, as described in [5].

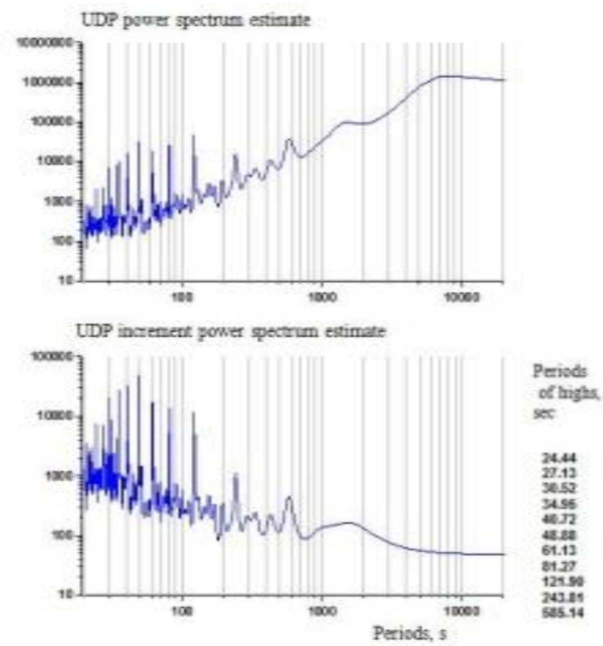


Fig. 2 Estimates of the power spectra of the original series and its increments

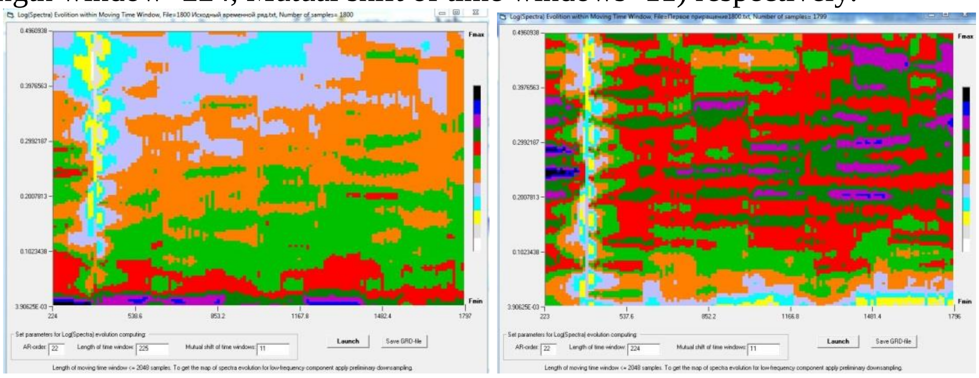
Next, we carry out a spectral time analysis, in which the spectra of variation are calculated on sliding time intervals (time window) and displayed in the form of diagrams [8]. The length of the window should not be too small, as this reduces the accuracy of spectral analysis, and also does not give a clear representation of low frequencies. However, an overestimated window length will also not receive all the information, since this will smooth out high-frequency oscillations. (ω,τ) The construction of two-dimensional maps or reliefs $S_{xx}(\omega,\tau|L)$ on the plane «frequency-time» refers to the spectral-temporal analysis. To do this for stationary time series, we previously used discrete Fourier transform of the sample in the current time window, built period grams, and averaged over frequencies in different ways to reduce the variance of the estimate.

Time and experience have shown that the use of the AR-model gives more stable results due to the fact that there are no side effects due to cyclicity, which took place in the discrete Fourier transform of the final sample. As for the method of spectral time analysis using the above-described spectral estimation algorithms based on the AR-model, it provides more stable results when processing non-stationary time series. This method of analyzing non-stationary time series is a local Fourier transform (STFT, Short-Time Fourier Transform), otherwise referred to as the window Fourier transform. The STFT method is aimed at working with non-stationary time series, as with a stationary series. At the same time, a preliminary dividing series into segments (windows), the statistics of which does not change with time [9].

The diagrams of the spectral-time analysis of non-stationary series are three-dimensional: the vertical represents the frequency, the horizontal the time and the spectral density of power [10]. In this case, the evolution of the logarithm of the power spectra in sliding time windows of a given length is estimated (Spectra Analyses-Estimates ofLg (Spectra) Evolution within time window using AR-model).

The output map is made in the form of a diagram of the distribution of spectral amplitudes. In addition, each column represents the Fourier amplitude spectrum calculated in a given sliding time window [11]. The darker areas on the diagrams correspond to a larger amplitude of the spectrum. On the spectral-time diagrams, the time in seconds is plotted on the horizontal axis, and the frequency is plotted vertically. The duration of a particular color represents the spectral power density.

Fig. 3 a, b show diagrams of the spectral-time analysis with the parameters that were selected by default by the Spectra Analyzer software for the original time series (AR-order=22, Length window=225, Mutual shift of time windows=11) and for a series of increments (AR-order=22, Length window=224, Mutual shift of time windows=11) respectively.



a) b)

Fig. 3 Diagram of the spectral-time analysis of the original series and a series of increments

These diagrams show the different sizes of areas that are colored in the corresponding colors, in the first of them these areas are slightly larger and the number of these areas is smaller than in the second, which indicates the dominance of both low-frequency and harmonic components. A more colorful diagram of the spectral time analysis of a series of increments indicates the dominance of the components of higher frequencies.

Another research method is the wavelet decomposition (orthogonal multiply-resolving analysis) described by the expression:

$$x^{(\alpha)}(s) = \sum_{j=-\infty}^{+\infty} b^{(\alpha)}\left(\tau_j^{(\alpha)}\right)\psi^{(\alpha)}\left(s - \tau_j^{(\alpha)}\right), \ \tau_j^{(\alpha)} = j \cdot 2^{\alpha} \qquad (5)$$

where α – level of detail;

$x(s)$ – continuous argument process s.

The wavelet packet decomposition, in contrast to the usual wavelet decomposition, makes it possible to partially eliminate the weak frequency resolution (Heisenberg principle) due to some deterioration in the time resolution. The implementation of packet splitting is based on a hierarchical scheme of successive wavelet transforms of the original $c_j^{(\beta)}$ coefficients. Orthogonal wavelet-packet decomposition of a signal can be written as a sum [12]:

$$z(t) = a_1^{(m)} + \sum_{\beta=m_q+1}^{m} z^{(\beta)}(t) + \sum_{\beta=1}^{m_q}\sum_{\gamma=1}^{q} z^{(\beta,\gamma)}(t) \qquad (6)$$

The value of q can be equal to 2, 4, 8, ..., that is, it has the form $q = 2^r$, r = 1, 2, 3 ... and determines the number of sublevels, with split levels of detail. A two-dimensional time-frequency map consisting of frequency-ordered Heisenberg boxes of modified coefficients $w_j^{(\beta,\gamma)}$ and paint each box in accordance with the palette, we get a diagram that visualizes the temporal dynamics of the main time scales of an unsteady signal (Figures 4 and 5).

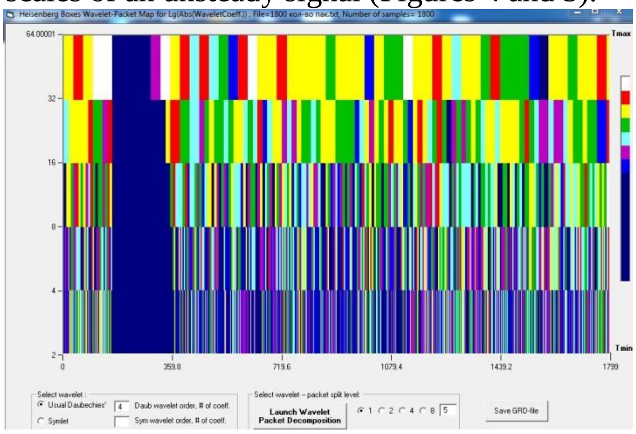


Fig. 4 Heisenberg boxes in five levels of detail

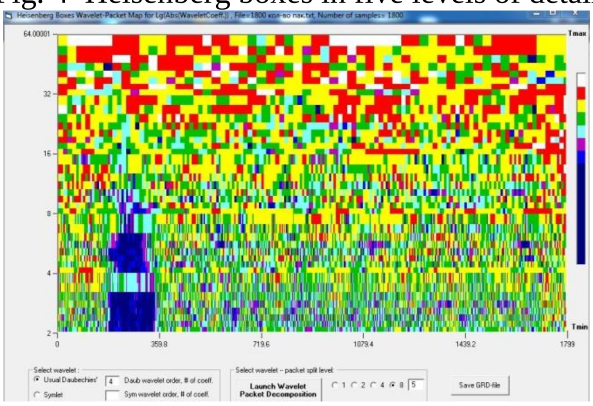


Fig. 5 Heisenberg boxes in five levels of detail with each splitting by 8 times

The splitting of each level by 8 times is shown in Figure 6.

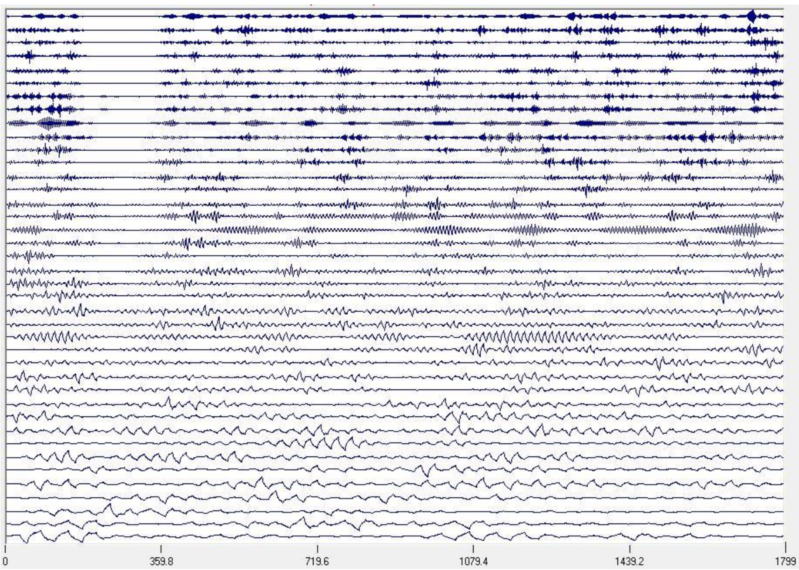


Fig. 6 Wavelet-packet decomposition with splitting of each level by 8 times

SOLUTION OF THE PROBLEM

Studies have shown that the series contains short local changes, which nevertheless make a certain contribution to the resulting signal spectrum. These fluctuations lead to a complex structure of the series. The identification of patterns of the occurrence of fluctuations and changes in their properties become the basis for solving forecasting problems. Therefore, the local properties of the series changes contain useful information.

CONCLUSION

In three-dimensional diagrams of the distribution of the spectral amplitudes of the spectral-temporal analysis, each column represents the amplitude Fourier spectrum calculated in a given sliding time window. **The physical meaning of the spectrum is that it shows the contribution of each harmonic to the total dispersion.** An analysis of the diagrams showed a change in the spectrum with time and that, in general, the process under study is not stationary. Variations in levels are characterized by a complex and irregular form. They consist of close in time, short-lived high-frequency components and long-term, close in frequency low-frequency components and have a trend, harmonic and chaotic components. Each vertical column represents the amplitude Fourier spectrum calculated in a given sliding time window. The tone depth in the diagrams corresponds to large spectral amplitudes; the amplitudes' values are represented by a level scale placed near the diagram. Moreover, if the sliding window is too large, then the frequency-time diagram does not respond to rapid changes in the spectral composition and to the presence of short-lived signals - bursts, but too small a window length leads to an increase in fluctuations in the current spectral estimates.

Heisenberg wavelet-packet boxes in comparison with traditional spectral-time diagrams give a more accurate and adequate idea of the time-frequency dynamics of nonstationary signal, consisting of many short-lived bursts of various scales, forms of which can differ greatly from harmonic oscillations of one or another frequency.

REFERENCES

1. https://wiki.loginom.ru/articles/spectral-analysis.html
2. Maksimchuk I.V., Gergel L. G., Osadchiy O.V. Comparative Fourier analysis and wavelet transform for analysis of photoplethysmogram signal // Modern research and innovation. – 2013. – №6.

3. Mirzakulova S.A., Zhanalinova A., Naushatova A. Stationary time series study – Educational system: innovations in the field of modern scientific knowledge MNE event of the Society for Science and Creativity. – Kazan, 02.2019 – 318-333 p.

4. Lyubushin A.A. A practical course in the analysis of multidimensional time series. Tutorial. – M: РГГУ – 113 p.

5. https://docplayer.ru/48849859-Issledovanie-sluchaynyh-fluktuaciy-geofizicheskih-poley-a-a-lyubushin-spektry-moshchnosti-i-spektralno-vremennye-diagrammy.html.

6. http://old.ifz.ru/scient_directions/data_moniroring/soft.htm

7. Sharshenaliev Z.S., Mirzakulova S.A., Yusupova G.M. Time series power spectrum evaluation // Materials of the scientific conference IITT KN MON RK "Innovative IT and Smart-technologies" – Almaty, 03. 2019. – 332-337 p.

8. Volchek A.A. Actual problems of nature management in the Brest region. – Minsk: Belarus. navuka, 2009 – 265 p.

9. https://old.computerra.ru/1998/236/193923/

10. Novopashina A.V., Sankov V.A., Buddo V.Y. Spatio-temporal analysis of seismic structures of the Baikal rift system // Volcanology and Seismology. – 2012, №4 – 55-64 p.

11. Agadjanyan N.A., Agadjanyan N.A., Aptikaeva O.I, Gamburtsev A.G., Grachev B.A. et al. Human health and the biosphere: integrated environmental health monitoring // Human ecology. – 2005, №4 – 9 p.

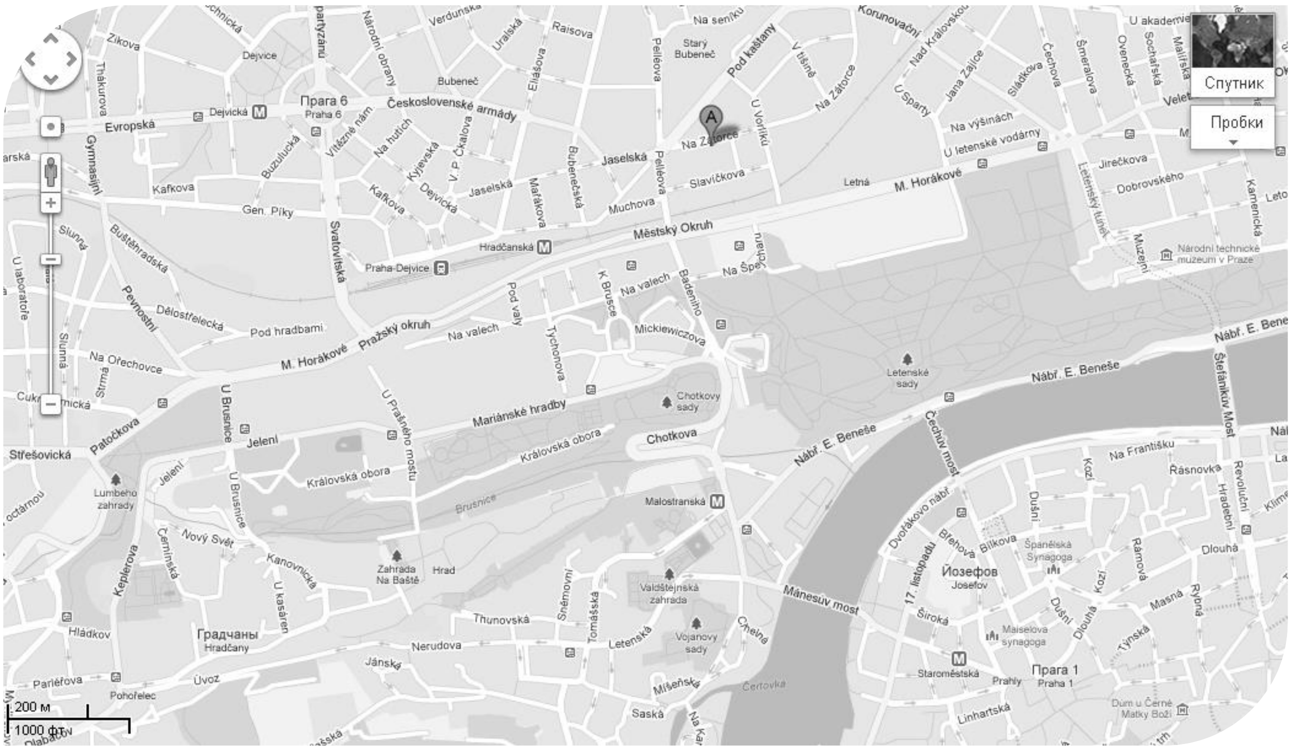
12. https://AlexeyLyubushin.narod.ru/Index.htm

CONTENTS

LOCATION

<u>Russian Science and Culture Centre in Prague</u>

Address: Na Zátorce str., 16.



CONTACTS

Organizing Committee: 119454 Moscow, Prospect Vernadskogo, 78, RTU MIREA, dep.KPRES
E-mail: ***i2t@diag.ru***

Contact information:

- ***General questions - Ilya A. Ivanov, tel.: +7 (926) -3830740***
- ***Chairman of the organizing committee - Saygid U. Uvaysov, tel.: +7 (916) -3360820***

E-mail: i2t@diag.ru

International Scientific – Practical Conference
«INFORMATION INNOVATIVE TECHNOLOGIES», 2020

Materials of
the International Scientific - Practical Conference
INFORMATION INNOVATIVE TECHNOLOGIES

Edited by S.U. Uvaysov;
Executive editor I.A. Ivanov

Printed in author's redaction

Signed to print 10.04.2020
Format 60x84/8. Paper «Pioneer»
Conventional quires 35,11 Print run 500 copies Order № 57

Prepared for publication
Association of graduates and employees of AFEA named after prof. Zhukovsky,
Moscow, the 4th st. March 8, 6A.
Nasledie-vvia.ru

Printed in the printing house of HSE
Moscow, Kochnovsky fare, 3
hse.ru