

National Research University Higher School of Economics
Syllabus "Basics of designing electronic means"
Direction 211000.62 "Design and technology of electronic means"
Baccalaureate program

Federal State Autonomous Educational Institution of Higher Professional
Education

"National Research University Higher School of Economics"

Department of "Electronics and Telecommunications"

Syllabus "Basics of designing electronic means"

for directions 211000.62 "Design and technology of electronic means"
Baccalaureate program

Cours Type - compulsory

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Abstract

course "Fundamentals of designing electronic means"

Discipline devoted to the study of theoretical and practical issues of designing electronic means, to protect against the destabilizing effects of EM, as well as the study of methods and means of providing protection for the design of EM, based on modern technological advances and design techniques.

The course examines the impact of internal and external factors affecting the EM, in the operation, transport and storage for the purpose of informed choice of design measures to protect against thermal, mechanical, radiation, etc.. Influences. Study of the principles of protection of EM and their theoretical justification based on the provisions of theoretical mechanics, thermodynamics, and aerohydrodynamics to ensure high productivity and quality of protection designed EM. The course examines the study and engineering methods of calculation systems of vibration - and heat protection and a comprehensive analysis of thermal and vibration-based electromechanical and electrothermal simulation using computers and CAD. Constructive measures to protect a wide class of EM, including microelectronic devices. We study the basic concepts in the theory of reliability EM, EM issues to improve reliability by using redundancy and reliability prediction questions.

Goals and objectives of the discipline:

Explore methods of designing electronic means to ensure their functioning in accordance with the requirements of reliability and operating conditions, to acquire knowledge and skills to the design of electronic equipment.

Basic didactic units (sections):

Structure and classes of electronic equipment. Design engineering. Typical load-bearing structures. Protection from ES destabilizing factors. Construction of EM with regard to electromagnetic compatibility and radiation resistance. Mechanical effects and protection against them. Construction of protection against vibration and shock impacts. Energy ratio in systems with vibration and shock protection means. Electromechanical analogy. Simulation and calculation of parameters of protection against vibration and shock impacts. System criteria of technical level and product quality. Basic concepts in the theory of reliability. Nomenclature and properties of reliability of non-renewable ES. Indicators of reliability of EM law for the distribution used in reliability theory. Indicators of reliability of electronic means with instant recovery. Calculation of reliability of non-renewable electronic means. Improving the reliability of electronic means using the backup. Planning and calculation of replacement elements. Predicting the reliability of electronic equipment. General characteristics of the heat - and mass transfer in the radio-electronic systems. Basic concepts and laws of transport of energy and matter. Heat equation and boundary conditions. Elements of the theory of thermal circuits. Stationary thermal field temperatures with energy sources. Fundamentals of the theory of similarity. Non-stationary thermal regime of the body with a uniform temperature field. Weight - and moisture exchange. Methods of providing heat and humidity conditions ES. Construction of EM with the mechanical and thermal effects.

As a result of the discipline "Fundamentals of Electronic Design means "a student must:

know: design features and distinctive characteristics of electronic funds for different purposes; factors that determine the construction of electronic means; environmental factors; systemic factors; factors of interaction in the system "man-machine"; analytical and modeling methods for compiling electronic means (cells, modules, blocks, cabinets); system of basic load-bearing structures, the unification of structures; thermal and mechanical properties of structures; electromagnetic compatibility; moisture protection and sealing; radiation resistance of electronic means; assess the quality and reliability of designs of electronic means; the basic definitions and concepts of the theory of reliability of electronic means; mathematical models of reliability, methods of analysis and calculation of the indicators of reliability of electronic means; methods and technical means to ensure the reliability of a given electronic means, the reliability characteristics elements and units of EM; methods and tools for predicting the reliability of electronic means and obtain statistical estimates of the reliability of EM;

be able to: analyze and optimize the electrical schematic diagram of the complexes and devices from the point of creating a design; develop design systems and devices; execute the design documentation in accordance with ESKD; build a model of reliability of radio electronic equipment operating in the specified conditions; form the technical requirements to ensure the reliability of a given EM, choose the most reliable technical solutions and tools; analyze the causes of failure, the ways and means to address them, preventing the consequences of failure; exercise test on reliability, process the results and make specific practical conclusions to ensure reliability;

own: the skills of working with electronic media, instrumentation, non-destructive testing, with application packages for designing electronic devices, the design of printed circuit boards, the calculation and maintenance of reliability of electronic means for the development of design provides the necessary thermal regime, operating and servicing radio-electronic means.

Kinds of study: lectures, practical classes, laboratory work, course work.

1. Field of application and normative references

This program is an academic discipline establishes minimum requirements for knowledge and skills of the student and determines the content and types of studies and reports.

The program is designed for teachers, leading this discipline, teaching assistants and students areas of training / specialty "211000.62" Design and technology of electronic means "enrolled in the program baklavariata for the discipline" Fundamentals of design of electronic means. "

The program was developed in accordance with:

- OS MIEM HSE

- Educational programs for directions 21000.62 Design and technology of electronic means.

Working curriculum of the University in the direction of training / specialty "211000.62 Design and technology of electronic means".

1.1. Targets for discipline

- Training of specialists in the field of sustainable design of electronic systems and facilities as a result of teaching students to modern methods of construction designs ES;
- Study of the effect on the efficiency of wireless devices and systems design techniques EM from the viewpoint of ensuring a high level of technical and operational characteristics and processability.

As a result of studying the course and on the basis of pre-studied disciplines student receives knowledge and practical skills of designing the optimal design based on a systematic approach, in accordance with the objectives of improving the efficiency of the production and use of electronic means.

1.2. Tasks of the discipline:

- To teach students the essence of modern construction methods of electronic means to allow for purposeful synthesis and systematic analysis of structural and electronic systems;
- Instill future specialist systematic approach in solving problems related to the construction of electronic tools and systems.

Competence of student generated as a result of the development of the discipline

As a result of the development of the discipline the student should know:

- the basis of a systematic approach, the general principles and methods of construction of ES;
- principles of integrated ES miniaturization and design features of microelectronic components;
 - the construction of the modern hierarchy of ES on structural and technological at-signs and its basic structural levels;
- operational requirements for stationary, transportable and airborne ES and principles of their design software;
- mechanisms of action mechanisms of the effect of thermal loads, radiation, climatic and mechanical factors on the ES and their design elements and methods of protection, cushioning and cooling units and blocks of ES in order to ensure optimal conditions for their operation;
 - sources of interference occurring in the EU, and methods to improve the noise immunity and ensure electromagnetic compatibility EM;
- the fundamentals of technical and aesthetic principles of art and ergonomic design.

In result of development of the discipline the student should be able to:

- constitute specification for the construction of EM in accordance with applicable regulations;

- determine the optimum hierarchy constructing EM in accordance with the terms of reference;
- perform basic calculations to determine the parameters of design, reliability, noise immunity, mechanical strength and thermal modes of EM;
- in accordance with the rules of the art design and industrial design to determine the configuration of the EM and design meet the requirements of the operating conditions and ergonomics;
 - perform computer simulations of designs EM and analyze their parameters;
 - to offer new areas of research and development, new metodolocheskie approaches to solving problems in the field of professional activity;
- use of modern information and computer technology, communications, improve the efficiency of the scientific sphere of activity;
- predict and analyze the socio-economic implications of scientific discoveries and new technical solutions.

Have the skills (to gain experience) in a written reasoned statement of their own point of view;

- skills to work with the documentation;
- computer simulation of physical processes in the transmission of information;
- knowledge about the prospects of designing and technology of electronic means.

Place of the subject in the structure of the educational program

Discipline refers to professional cycle oriented with the formation of a common high professional culture razrabotchika- designer and organizer of the design and manufacturing (manager). Discipline "Basics of designing electronic means" is used to perform SRS and further work, research activities. This discipline is a basic part of the professional cycle distsip-ling and block courses that provide training for bachelors.

The study of this discipline is based on the following disciplines:

1. physical fundamentals of microelectronics;
2. engineering Graphics
3. applied Mechanics
4. materials and supplies EM
5. automation Design and Technology Design EM
6. physical fundamentals of microelectronics, fundamentals of EM.
7. basics of Radio Electronics and Communications
8. devices functional electronics and electric radio
9. design and application of circuits and microassemblies

The main provisions of the discipline should be used to further the study of the following disciplines:

- mathematical methods in electrodynamics modeling of technical systems;
- micro- and nanotechnology;

2. Course Plan

(Thematic plan of cours)

№	section title	Total hours	Contact hours			independent work
			lectures	seminars	practical exercises	
1	Module 1: Basics for the design of EM		4		4	9
2.	Module 2: Electrical connections EM		4		4	9
3.	Module 3: Protection of RES from environmental factors		4		4	6
4.	Module 4: Thermal regime structures EM		4		5	6
5.	Module 5: Protection of structures EM on the dynamic mechanical effects		4		5	6
6.	Module 6: Designing EM with the requirements of ergonomics and industrial design		4		4	6
7.	Module 7: Design Features Electric microwave frequencies		3		4	6
8.	Module 8: Design Features of ground and airborne EM range of the bass and treble frequency		3		4	6
	Total	106	30		34	62

Forms of control of students' knowledge

Type of control	Form of control	3		parameters
		3	4	
interim	control work	8 week		7 jobs. 1h 20 min.
Final	offset	offset		Up to 5 thousand Words
Final	exam		exam	

Criteria for assessing the knowledge, skills

Measures of performance in practical classes: knowledge of the material, the ability to communicate with, the material, the ability to complement the answers, the ability to ask important questions and to formulate the problem, the ability to prepare and present reports, attendance.

Criteria for assessing the response to the exam: the presence of set-off, the presence of surrendered just abstract, knowledge of the material (the essence of the basic theories, approaches, methods, criticism), you skill-sharing essential, the ability to logically and convincingly present the material. Evaluation of all forms of monitoring are set on a 10-point scale.

Criteria for assessing the response to the competition (availability of credit, availability of donated time course work, knowledge of the material (the essence of the basic theories, approaches, methods, criticism), the ability to identify significant, the ability to logically and convincingly present the material)

Rating	Criteria
excellent 10	This evaluation may be made only if the answer to all compliance requirements and higher scores on all criteria.
excellent 8, 9	These estimates can be set only if the answer to all compliance requirements and appreciation for all the criteria.
good 7, 6	. "7" - This evaluation may be made only with the full compliance with the answer 4 of 5 requirements and criteria 1 (except for offset and essay) test can be performed partially. "6" - This evaluation may be made only with the full compliance with the answer 3 (except for offset and essay) requirements criteria.
satisfactory 5, 4	"5" - This evaluation may be made only with the full compliance of the record-2 (except for offset and essay) requirements and criteria 2 criteria may be met in part. "4" - This evaluation may be made only with the full compliance of the record-2 requirements criteria.
Unsatisfied 3, 2, 1	The answer does not meet most requirements criteria
No Credit 0	Not passed the exam.

Evaluation of all forms of monitoring are set on a 10-point scale.

The procedure for forming estimates of the discipline

Teacher evaluates the student's work in seminars, attendance of lectures and practical classes, the abstract, the student's answer to the final exam.

Measures of performance in practical classes: knowledge of the material, the ability to communicate with, the material, the ability to complement the answers, the ability to ask important questions and to formulate the problem, the ability to prepare and present reports, attendance. Estimates for the work on the practical classes the teacher puts in the work

sheet. Accumulated score on a 10-point scale for their work in seminars and workshops is determined before the interim or final control.

Criteria for evaluation of independent work: the ability to find in this country and abroad will-gal literature and highlight the most important work on the subject, the most comprehensive and co-operation relating to time; the ability to structure the presentation of the theme, level of concepts. Estimates for the independent work of the student teacher puts in papers-I feel a statement. Accumulated score on a 10-point scale for independent work is determined to intermediate or final control.

Evaluation criteria of the essay: the ability to clearly explain the problem and the structure of being-Rowan describe the problem, the ability to discuss the proposed theories, concepts and models, creative approach to solving problems. Estimates for the independent work of the student teacher puts in the work sheet. Accumulated score on a 10-point scale for independent work is determined to intermediate or final control.

Criteria for assessing the response to the competition: The presence surrendered just abstract knowledge of the studied material, the ability to identify significant, the ability to logically and convincingly present the material.

Cumulative assessment of the current control takes into account the results of the ongoing monitoring of the student as follows:

The method of rounding cumulative assessment of the current control – arithmetic

The resulting score for the interim (final) control by recognizing you-ance with the following formula, where - for the evaluation of work directly on the standings:

The method of rounding cumulative assessment of the intermediate (final) control in the form of zacheta- arithmetic.

The method of rounding cumulative assessment of the intermediate (final) control in the form of the exam - the arithmetic.

On retake student the opportunity to receive an additional point for assessing compensation for the current control if there are good reasons pass the appropriate classes (sick leave, sick leave per child, force majeure), the student demonstrates that excellent (good) owns the material is able to operate reflexively, to think logically, to discuss the problems.

On standings student can get an additional question (additional practical problem to solve to retake the homework), the answer to which is valued at 1 point. Thus, the resulting estimate for the interim (final) control in the form of credit, obtained by re-take, exhibited by the formula.

$$O_{\text{промежуточн.}} = 0,4 \cdot O_{\text{зачет}} + 0,5 \cdot O_{\text{текущий}} + 0,1 \cdot O_{\text{доп.вопрос}}$$

At the exam the student can get an additional question (additional practical problem to solve to retake the homework), the answer to which is valued at 1 point. Thus, the resulting estimate for the interim (final) control in the form of the examination, obtained by re-take, exhibited by the formula

$$O_{\text{итог.}} = 0,4 \cdot O_{\text{зачет}} + 0,25 \cdot O_{\text{промежуточн.}} + 0,15 \cdot O_{\text{текущи.}} + 0,1 \cdot O_{\text{аудиторн}} + 0,1 \cdot O_{\text{доп.вопрос}}$$

In the diploma are graded for the final control, which is the resultant evaluation on a subject matter.

WARNING: assessment for final control blocking, when not the final assessment it is equal to the resultant.

The content of the discipline

Module 1: Basics for the design of EM

The organization of the design process of EM. Radio-electronic means as little more than a system. Systematic approach in the construction of EM.

Systematic approach in the construction of EM.

The use of computers in the design and production of EM.

Functional mathematical model of the structure.

Standardization of designs EM.

Structural system EM.

The specifics of the design documentation, made-tion with the help of automated methods.

Standardizing control design documentation

Design EM as to production.

Techno-economic analysis of the design-time processing

Module 2: Electrical connections EM.

Effect of compounds on electrical design parameters EM.

Design intercontact electrical connections on the basis of PCB.

Design intercontact compounds from the bulk of the wire.

Constructions of contact connections.

Electromagnetic compatibility of digital nodes.

Mitigation methods in electrical connections digital nodes.

Development designs the electrical connections on the basis of printed circuit boards.

Electromagnetic compatibility analog units.

Electromagnetic compatibility amplifier circuits.

ElectroMagnetic Compatibility analog units

Screening.

Design analysis circuitry EM.

Module 3: Protection of RES from environmental factors

General. Determination of the kind of security RES.

Moisture and dust protection. Choose how you zaschi-metal parts and assemblies RES with regard to the conservation of electrical conductivity. Selecting a method of the dielectric protection: fill, impregnation, coating.

Selecting a method of protection against radiation.

Selecting a method of protection against thermal effects.

Selecting a method of protection against mechanical impacts

Module 4 Heat mode designs EM

Influence of thermal regime on the efficiency and quality of construction EM.

Thermal control system EM.

Convection heat sink.

Heat sink heat pipes.

Heat sink thermal conductivity.

Heatsink radiation.

Heatsink using the thermoelectric effect.

Methods for absorbing heat. manufacturability of designs TCS.

Module 5: Protection of structures RES from dynamic mechanical effects.
Influence of dynamic mechanical stress on the reliability and quality of EM.

Protection against mechanical impacts EM using vibration
Providing strength and stiffness of the structural elements of EM.

Module 6: Construction of CEA with the requirements of ergonomics and industrial design.
Impact of ergonomic and industrial design on the efficiency and quality of EM. Decoration design EM. Basics of composition.

Features external design professional and home EM. Ergonomics.

Module 7: Design Features Electric microwave frequencies
Functional features of EM microwave.

Design of passive microwave and semiconductor structures Elements.

Construction of functional assemblies, modules and RF unit.

Module 8: Design Features of ground and airborne RES range of the bass and treble
Factors affecting the character designs EM.

Design features of terrestrial stationary EM.

Design features ground transported EM.

Design features of terrestrial mobile EM.

Design features ground wearable EM.

Design features onboard EM.

educational technology

The implementation of various kinds of academic work in the discipline, the following educational technology: lectures, practical tasks and dialogues with the audience. Through dialogue, the bachelors are able to master the ways of the refractive index of conceptual models and theoretical categories in the practice of self-awareness and counseling

Topics workshops

№1. protection principles RES from mechanical and thermal effects.

№2. Calculation of vibration on vibration exposure.

№3. Calculation vibration isolation system on shock effects

№4. Calculation of vibration on the combined effect of

№5. Calculation of heat sinks to cool the RES

№6. Calculation of thermal regimes RES units of various designs.

№7. Structural analysis of thermal bridges

№8. Calculation of thermal regimes of thermally loaded nodes RES.

№9. Fundamentals of metrology in the tests RES. Instruments, stands and equipment

№10. calculation of electromagnetic shielding.

№11. methods and means to improve noise immunity EN.

№12. Quality assessment layout EM from the viewpoint of ergonomics and industrial design.

Questions to assess the quality of the development of the discipline

1. The subject of study, the aims and objectives of the course.
2. based on the concept of designing effective EM.
3. Factors that cause the reaction EM.
4. Classification of factors and general characteristics.
5. Terms of Reference (TOR) for the design.
6. Development of specifications.
7. General characteristics of the mechanical effects.
8. Mechanical resonance in the vibration loads.
9. Acceleration, shock, acoustic impact and their characteristics.
10. Climatic factors and their impact on the EM.
11. Climatic zones and their characteristics.
12. Effects on EM temperature, humidity, pressure, biological and aggressive environments.
13. Radiation exposure and their characteristics.
14. Specificity of components and the current trends in the design of EM.
15. Classification EM Object Position.
16. Obschie design and technological requirements for EM.
17. Particular requirements for structures EM.
18. levels of disaggregation structures EM.
19. Obschie principles, goals and objectives of EC design.
20. The role of formal and creative action in the design.
21. Stages of development of EM.
22. The life cycle of the product.
23. Technical Proposal.
24. The preliminary design.
25. Technical project.
26. Detailed design.
27. ESKD - types and complete CD.
28. Rules for making a CD. An Example of the course project.
29. The use of BT in the development of CD.
30. Interaction factors in the "man-machine".
31. Obschie ergonomic requirements in the "man-machine".
32. Osnovnye ergonomic features of the human operator.
33. Formation and receiving control signals in the "man-machine".
34. The problem of determining a preliminary determination of the embodiment - a problem layout.
41. Systems BNK. Unification BNK.
42. Materials used BNK.
43. Classification of methods for interconnecting structural levels of EM.
44. Contacting detachable, Permanently, partially detachable.
45. Printing and displacement connection.
46. Design and print bulk compounds.
47. The use of software packages for automated design installation.
48. wires used for Internal Equipment and Rack Mount.
49. Fiber-optic wiring in the ES.
50. Methods of protection of EM from the environment.
51. Classification of methods of protection from the environment.
52. Sealing - types and their characteristics.
53. Full, partial and combined sealing.

54. The design of the sealing joints with sealing.
55. Protective coatings and their qualifications.
56. Types of materials and coatings.
57. Concept of vibration and impact-resistant EM.
58. Principles and ways to improve security of EM from mechanical influences.
59. Constructive realization of the vulnerability of EM from mechanical influences.
60. The calculation of the natural frequency of the mechanical resonance of the simplest designs.
61. Amortization of EM.
62. Principles and methods of protection from EM thermal loads.
63. Physical phenomena of heat dissipation structure in EM.
64. Constructive ensure the proper implementation of the thermal regime in the EM.
65. Mathematical Methods for analysis of the thermal regime of EM.
66. Methods of pre-selection method of heat removal in the EM.
67. The concept of electromagnetic compatibility.
68. The causes of interference and their qualifications.
69. Characteristics of the electromagnetic environment functioning EM.
70. Interference in ES with the "long" and "short" links.
71. Principles and methods of providing noise immunity in the EM.
72. Constructive implementation to ensure the noise immunity in the EM.
73. Interference power circuits and methods for reducing them.
74. The use of screens to protect against electromagnetic interference.

Educational-methodical and informational support discipline

Basic textbooks

1. Nenashev AP Construction RADIOELECTRONIC sredstv.- M .: High School, 1990.-432 p.
2. Savelyev AJ, Ovchinnikov VA Designing computer systems and Textbook for high schools on spec. "Res. Mach., Cpl., Chem., And networks." - 2nd ed., Rev. and ext. – M .: Higher. School, 1989 - 312 p.
3. Gell PP, Ivanov-Esipovich NK Design and microminiaturization electronics. A.: Energoatomizdat, 1984
4. Presnukhin LN, Shakhnov VY, VY Scrubs Construction of computers and systems. - M .: Higher. wk., 1986 - 572 with 10 Reference Design CEA: General principles for design / ed. RG Varlamov. - M .: Owls. radio, 1980 - 480 p.
- 15 Structures electronics / PI Ovsishcher, Y. Golovanov, VP Kovesnikov et al. / Ed. PI Ovsishcher. - M .: Ra-dio and communication, 1988 - 232.
5. Kuzemin AY Design and microminiaturization electronic computing equipment. – M .: Radio and communication, 1985 - 280 p.

Additional textbooks and teaching materials

1. Presnukhin LN, Shakhnov VY, VY Scrubs Construction of computers and systems. - M .: Higher. wk., 1986 - 572 p.
2. Reference Design CEA: General principles for design / ed. RG Varlamov. - M .: Owls. radio, 1980 - 480 p.

3. Structures electronics / PI Ovsishcher, Y. Golovanov, VP Koveshnikov et al. / Ed. PI Ovsishcher. - M.: Radio and communication, 1988 - 232.
4. Kuzemin AY Design and microminiaturization electronic computing equipment. - M.: Radio and communication, 1985 - 280 p.
5. Structural design of electronic equipment: Proc. manual for schools / EM Parfenov, EN Kamyshnaya, VP Moustache. - M.: Radio and communication, 1989 - 272 p.
6. Knyazev AD, Kechiev LN, Petrov BV Construction of electronic and computer equipment with regard to electromagnetic compatibility. - M.: Radio and communication, 1989 - 222 p.
7. Sarafanov AV Tregubov SI Computer-aided design RES: Textbook. - Krasnoyarsk: KSTU, 1999 - 183 p.
8. The layout and design of microelectronic devices / Ed. BF Vysotsky, VB Pestryakova and OA Patlina. M.: Radio and Communications, 1982. - 208.
9. Belinsky VT and others. practical tool for the design of educational CEA. - Kiev: Vyshcha School, 1992 - 592 p.
10. Develop and design engineering documentation of electronic equipment: Directory / TE Romanycheva, AK Ivanov, AS Kulikov and others; / Ed. TE Romanycheva. - 2nd ed., Rev. and ext. - M.: Radio and communication, 1989 - 448.
11. Kalenkovich, NI RES Designing with the mechanical stress / NI Kalenkovich. - Mn.: BSUIR, 1999.
- 12 Design-engineering design of electronic equipment: a textbook for high schools / KI Bilibin [et al.] under the total.
Ed. VA Shahnova. - Moscow: Publishing House of the MSTU. Bauman, 2002.
- 13 Investigation of the thermal characteristics of the methods of mathematical RRES modeling: Monograph / V.V.Goldin, V.G.Zhuravsky, V.I.Kovalenok etc. ; Ed. A.V.Sarafanova. - M.: Radio and communication, 2003 - 456 p.
- 14 Vibrations in Technology: A Handbook. In the 6-m ..- M Engineering, 1978
- 15 Karpushin VB Vibration and shock in radioapparature.-M, Sov.radio, 1971.
- 16 Il'inskii VS Privacy CEA and precision equipment from dynamic effects, TH, Radio and Communication, 1982.
- 17 Surovtsev YA Amortization of electronic equipment, TH, Sov.radio, 1974.
18. Tokarev MF Talitskii EN, Frolrv VA Mechanical impact and protection of electronic equipment, TH, Radio and communication, 1984.
- 19 GN Dulnev Heat and mass transfer in electronic equipment: Textbook for high schools, TH, Graduate School, 1984.
- 20 Rotkop LL Cool YE Thermal control in the design of CEA-M, Sov.radio, 1976.
- 21 Dulnev GN, Tarnowski NN Thermal modes of electronic equipment, M, Energy, 1971.
- Kraus 22 AD Cooling of electronic equipment, - M, Energy, 1971.
- 23 MA Mikheev, Mikheev KM Fundamentals of heat transfer, TH, Energy, 1973.
- 24 Myrova LO, ChepizhenkoA.Z.Obespechenie radiation resistance of communications equipment, -M.Radio and communication, 1983.