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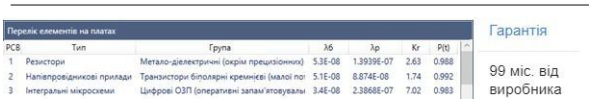
Національний технічний університет України
«КИЇВСЬКИЙ ПОЛІТЕХНІЧНИЙ ІНСТИТУТ
імені ІГОРЯ СІКОРСЬКОГО»

[RE-272] RELIABILITY OF RADIO ELECTRONIC EQUIPMENT



Work program of the academic discipline (Syllabus)

Course details

Level of higher education	First (bachelor's)
Field of knowledge	G - Engineering, manufacturing, and construction
Special	G5 - Electronics, electronic communications, instrument engineering, and radio engineering
Educational program	All educational programs
Subject status	Elective (F-catalog)
Form of higher education	Full-time
Year of training, semester	Available for selection starting from the 2nd year, fall semester
Scope of the discipline	4 credits (Lectures 16 hours, Practical classes 30 hours, Laboratory work 74 hours)
Semester Control/control measures	Credit
Class schedule	https://schedule.kpi.ua
Language of instruction	Ukrainian Information
about course coordinator/teachers	
Course location	

Course program

1. Description of the academic discipline, its purpose, subject matter, and learning outcomes

Improving the reliability of radio-electronic equipment is becoming an urgent task. The relevance is due to the contradiction between the requirements of regulatory and technical documentation regarding the maintenance of reliability indicators and the natural factor of an increase over time in the number of failures of these objects, which continue to be operated for three to four decades, and in some cases, for five decades for objects of high value. The issue is exacerbated by economic reasons, which significantly slow down the replacement with new models.

Modern scientific works contain solutions, the implementation of which allows improving reliability indicators, namely, increasing the mean time between failures and reducing the mean time to repair. The main focus is on developing methods that allow obtaining and determining the appropriate diagnostic parameter for each of them, on the basis of which a decision is made about the technical condition at the level of typical replacement elements. At the same time, the prediction of reliability indicators is based more on statistical data on the average operating time and recovery time than on the values of diagnostic parameters.
The situation is complicated by the natural inability to determine the reliable value of the diagnostic parameter at levels above typical replacement elements, which negatively affects the first and third functions of technical diagnostics—determining the technical condition and excess resource, respectively.

The above factors have led to a contradiction between the requirements of regulatory and technical documentation for maintaining reliability indicators and the possibility of implementing these requirements in modern conditions. The contradiction can be resolved by developing new solutions, the implementation of which will make it possible to predict gradual failures with a given degree of reliability and maintain the availability coefficient of objects as a comprehensive indicator of reliability at a given level, as well as predict its value at a predetermined time. This, in turn, necessitates the use of physical diagnostics for radio engineering systems and the development of a mathematical apparatus for calculating the readiness coefficients of the construction levels of these facilities based on information technologies.

2. Prerequisites and post-requisites of the discipline (place in the structural-logical scheme of training under the relevant educational program)

The discipline "Reliability of Radio Electronics" is based on the disciplines: "Higher Mathematics," "Computer Science," "Software Tools in Intelligent Radio Electronics," "Circuit Engineering," "Practical Foreign Language Course. Parts 1, 2, 3."

As a result of studying the discipline "Reliability of Radio-Electronic Equipment," students acquire the skills of qualified specialists in the development of stable radio-technical systems and will be able to use them in the following disciplines: "Design of Elements of Intelligent Radio-Electronic Systems," "Printed Circuit Board Design," "Design and Production Technologies for Intelligent Radio Electronics," "Pre-diploma Internship," "Diploma Design."

3. Course content

Topics covered in lectures

Topic 1. The problem of reliability and its significance for modern electronics. Technical, economic, and social aspects.

Topic 2. Mathematical foundations of the science of reliability: mathematical statistics and probability theory.

Topic 3. Basic provisions of reliability theory, definitions and concepts.

Topic 4. Failure – the basic concept of reliability theory. Classification of failures. Examples of failures in radio-electronic equipment.

Topic 5. Quantitative characteristics of the reliability of non-replaceable radio-electronic products. Concepts of probability of failure-free operation and probability of failure. Algorithms for their determination and calculation.

Topic 6. The concept of failure rate and failure rate function; mean time between failures; failure intensity. The dependence of the failure intensity of a radio product on the operating conditions of radio-electronic equipment. Failure intensity is a passport characteristic of a radio element, radio device,
radio system.

Topic 7. Quantitative characteristics of the reliability of renewable radio-electronic products – average number of failures, failure rate, etc.

Topic 8. Laws of distribution of normal operating time of radio equipment (characteristics, their changes over time).

Topic 9. Laws of distribution of operating time in the final period of operation.

Topic 10. Reliability of system elements (structural reliability of devices and systems).

Topic 11. Redundancy of radio elements, radio components, and devices as an effective way to improve reliability.

Topics of practical classes

Topic 1. Ways and methods of ensuring the reliability of radio-electronic equipment at the design stage. Selection of the necessary operating modes; operation of radio-electronic equipment within wide tolerances of element ratings.

Topic 2. Redundancy of radio-electronic equipment and its components: types and kinds of redundancy; redundancy indicators. Comparative characteristics of different types and kinds of redundancy.

Topic 3. Ensuring reliability at the stage of radio equipment production.

Topic 4. Measures to achieve the required level of equipment reliability at the stage of its operation.

Topic 5. Comparative effectiveness of methods for ensuring the required level of reliability of radio equipment at different stages of its life cycle.

Topic 6. Examples of achieved service life levels of modern radio-electronic equipment for various purposes from different manufacturers.

Topic 7. Reliability of individual elements of radio-electronic equipment: relays, transformers, chokes, inductance coils, electrical connectors; mechanical components – reducers, bearings, etc.

Topic 8. Methods for detecting failures and failed equipment components

4. Teaching materials and resources

Basic literature

1. Korenivska O.L. "Reliability, operation, and repair of radio-electronic and telecommunications equipment." Textbook [Electronic edition] / O.L. Korenivska, V.B. Benedytskyi. – Zhytomyr: Zhytomyr Polytechnic, 2020. – 185 p.

2. Vasilevsky O.M. Standardization of technical equipment reliability indicators: textbook / O.M. Vasilevsky, O.G. Ignatenko. – Vinnytsia: VNTU, 2023. – 160 p.

Additional literature

3. Zaluzhny, A.M. Reliability and Diagnostics of Technical Systems: Textbook. Zhytomyr: ZHITI, 2022.
- 356 p. 250 copies.

4. Physical foundations of reliability of medical devices and systems: lecture notes for students of all forms of training in instrument-making specialties / Compiled by: T.Yu. Kisel, R.V. Trembovetska, V.V. Tychkov – Cherkasy: Cherkasy State Technological University, 2021 – 55 p.

Educational content

5. Methodology for mastering the academic discipline (educational component)

Fundamentals of the theory of reliability of radio-electronic equipment

Topic 1. Reliability of radio-electronic equipment. Basic concepts and definitions.

Topic 2. Reliability indicators. Reliability indicators for non-renewable equipment. Reliability indicators for renewable equipment. Comprehensive reliability indicators.

Topic No. 3. Basic laws of distribution in reliability theory. Reliability indicators for different distribution laws. Weibull distribution. Rayleigh distribution. Normal distribution. Gamma distribution. Poisson distribution.

Topic 4. Factors determining the reliability of electronic equipment and methods for improving the reliability of electronic equipment. Circuit design factors. Production and technological factors. Operational factors. Methods for improving reliability in the design and production process. Ensuring reliability during operation and repair. Failure prediction.

Methods for calculating reliability

Topic 5. Methods for calculating reliability. Classification of methods for calculating the reliability of electronic equipment. Analytical methods for calculating reliability. General concepts of logical circuits of devices.
Calculation of reliability using graph methods. Transition from a logical model to a graph method. Calculation of reliability in case of sudden and parametric failures.

Topic 6. Calculation of reliability of non-repairable systems Types of reliability calculations for systems with serial and parallel connections. Methods for calculating systems with non-basic types of connections. "m out of n" circuits. Methods for calculating systems with non-basic connection types. Bridge circuits. Calculating the reliability of complex systems.

Basic information about redundancy

Topic 7. System redundancy as a method of improving reliability. Basic concepts and types of redundancy. Methods of activating redundancy. Calculation of circuits with general and separate redundancy. Calculation of reliability and redundancy for open circuit and short circuit failures. Determination of the reliability of redundant circuits for two types of failures.

Topic No. 8. Optimal reservation. Gradient method. Lagrange's method of undetermined factors. Direct search and dynamic programming methods.

Topic 9. Calculation of the reliability of repairable systems. Calculation of repairable systems. Calculation of availability and downtime coefficients. Features of calculating redundant systems.

Basics of operation and repair of radio-electronic equipment

Topic No. 10. Operation tasks, their components and characteristics. General provisions and definitions.

Topic 11. Assessment of the operational properties of radio-electronic equipment based on the results of operation. Features of assessing the performance indicators of radio-electronic equipment. Assessment of indicators of reliability, durability, preservability, and maintainability.

Topic No. 12. Fundamentals of maintainability of radio-electronic equipment. Repair of radio-electronic equipment. Basic concepts, types, parameters, and calculations. Labor intensity of repairs.
Maintainability of radio-electronic equipment. Concepts, types, parameters.
Factors affecting maintainability. Calculation of maintainability of radio-electronic equipment. Technical maintenance, methods of routine repairs. Labor intensity of technical maintenance. Technical utilization coefficient. Efficiency of technical

maintenance. Distribution of time for routine repairs. Frequency and scope of preventive maintenance on continuously operating equipment, single-use equipment, and standby equipment.

Topic No. 13. Searching for faulty elements in equipment. Methods and techniques for searching for faulty elements in equipment.

6. Independent work by students

Lecture-based learning — in particular, multimedia lectures with detailed presentation of educational material, combining passive learning methods with elements of active and interactive approaches — forms the basis for developing independent learning skills in higher education students.

Lectures are supplemented by practice-oriented forms of work, including laboratory tasks performed on personal computers. This approach allows students to apply the theoretical knowledge they have acquired to solve specific practical situations.

An important role in the development of independence is played by preparation for lectures and laboratory work, as well as taking into account the teacher's comments when analyzing completed tasks or the work of other students. This contributes to the formation of self-learning skills, improves the ability to plan time effectively, set priorities, and distinguish between the main and secondary.

In addition, students must learn to use the results of their own research, analysis, and synthesis of information from various sources, which develops critical thinking and provides a foundation for further professional growth.

Policy and control

7. Academic discipline (educational component) policy

System of requirements for students:

Academic integrity. Compliance with academic integrity by students requires:

- independent completion of educational tasks, current and final assessment of learning outcomes (for persons with special educational needs, this requirement applies taking into account their individual needs and abilities);
- references to sources of information when using ideas, developments, statements, information;
- compliance with copyright and related rights legislation;
- provision of reliable information about the results of one's own educational (scientific, creative) activities, research methods used, and sources of information.

The following are considered violations of academic integrity:

- academic plagiarism - the publication (in whole or in part) of scientific (creative) results obtained by other persons as the results of one's own research (creativity) and/or the reproduction of published texts (published works of art) by other authors without indicating authorship;
- self-plagiarism - the publication (in whole or in part) of one's own previously published scientific results as new scientific results.

For violations of academic integrity, students may be subject to the following academic penalties:

- - retaking an assessment (test, exam, credit, etc.);

- - retaking the relevant educational component of the educational program.

Late submission policy. A penalty of 10 points from the total number of points for the assignment will be imposed for late completion of assignments.

Note: Exceptions may be made for assignments submitted late for valid reasons.

Attendance policy. Attendance at classes is mandatory. For objective reasons (e.g., pandemic, illness, international internship), training may take place online in agreement with the course instructor.

Lectures and practical classes are held in accordance with the current regulations of Igor Sikorsky KPI. Attendance at classes is mandatory. To pass the exam automatically, you need to score more than 60 points, which can be obtained by completing mandatory tasks (completing coursework, practical work, and writing a module test) and systematically attending lectures (passing a quick test based on the lecture materials).

Points for work during the lecture are awarded based on a quick quiz. Each test contains two questions on the lecture material, and the correct answer to each question is worth two points.

The modular test is conducted in writing. Each task in the test contains 2 theoretical questions and 1 problem, the correct answers to which will earn up to 100 points for each theoretical question and 100 points for the practical question. The final grade is the average of the points received.

An individual assignment (DKR) is the solution of 5 homework control tasks during the semester (one task for each subsequent class), the correct solution of which will earn up to 100 points for each task. It is performed in writing during independent work hours.

The test is written. The questions consist of 3 tasks (2 theoretical questions and 1 task) on the topics covered in the classroom and separate questions for independent study.

8. Types of assessment and the learning outcomes assessment rating system (LOAS)

A student's grade for a course consists of the points they receive during the semester:

1. average score for attendance and answers in lectures;
2. average score for completing modular, independent, and homework assignments;
3. average score for completing and defending laboratory and practical work;
4. the sum of incentive and penalty points.

Completion and defense of all practical and laboratory work, as well as a positive grade on tests on individual sections, are prerequisites for admission to the final exam.

Practical, laboratory, modular test, homework, and independent test:

"excellent", comprehensive answer (at least 95% correct information) from 95 to 100 points;

"very good", complete answer, minor inaccuracies possible (at least 85% correct information) from 85 to 94 points;
"good," complete answer, minor inaccuracies possible (at least 75% correct information) from 75 to 84 points;

"satisfactory," incomplete answer (but no less than 60% correct information) and minor errors, 60 to 74 points;

"Unsatisfactory," unsatisfactory answer (incorrect solution to the problem), requires mandatory rewriting at the end of the semester, from 0 to 59 points.

The average score out of 100 is calculated for all work throughout the semester.

Bonus points

In total, no more than 10:

– for creative work in the credit module (e.g., participation in faculty and institute competitions in academic disciplines, participation in contests, preparation of reviews of scientific works, etc.); successful completion of a recommended distance learning course (corresponding to the topics of the discipline) with the receipt of a corresponding certificate; for active participation in lectures (important questions, additions, comments on the lecture topic) from 1 to 5 points;

– presentation on the topic of independent study – from 1 to 5 points.

Credit:

The condition for admission to the exam is the completion of all laboratory and practical work, and a semester starting rating of 54 ≤ Raverage ≤ 80.

Students who have fulfilled the admission requirements may take the exam if they are not satisfied with their overall (average) grade for the semester.

Credit assessment system:

The exam is graded on a scale of Rexam up to 40 points. The exam consists of four tasks. Each task is graded according to the following criteria:

"*excellent*" – comprehensive answer (at least 95% correct information), relevant justifications provided – 10 points;

"*A06re*" – complete answer (at least 80% correct information) that meets the requirements for the "skills" level, or contains minor inaccuracies – 8 points;

"*Incorrect*" – incomplete answer (at least 60% correct information and some errors) – 6 points;

"*Incomplete*" – no correct answer – 0 points.

The rating sum (Rtotal = Raverage + Rcredit + Rincentive-Rpenalty) is converted to a grade according to the table:

Table of correspondence between rating points and grades on the university scale

Number of points	Grade
100-95	Excellent
94	Very good
84	Good
74-65	Satisfactory
64-60	Sufficient
Less than 60	Unsatisfactory
Admission requirements not met	Not admitted

9. Additional information on the discipline (educational component)

List of study questions

1. Basic terms and definitions of reliability theory. Types of failures.
2. Classification of reliability indicators.
3. Reliability indicators for non-renewable equipment.

4. Reliability indicators for renewable equipment.

5. Comprehensive reliability indicators.

6. The influence of various factors on reliability indicators.

7. Ensuring reliability. Ways to improve reliability (at different stages of REA operation).

8. Basic laws of distribution in reliability theory.

9. Laws of distribution of random variables. Poisson distribution.

10. Laws of distribution of random variables. Normal distribution.

11. Laws of distribution of random variables. Weibull distribution.

12. Laws of distribution of random variables. Rayleigh distribution.

13. Classification of reliability calculation methods. Analytical calculation methods and complete calculation of systems.

14. Compiling logical diagrams for reliability calculations. Calculating reliability using the graph method. Transition from a logical model to the graph method.

15. Calculation of reliability in case of sudden and parametric failures.

16. Calculation of reliability and redundancy in the event of open circuit and short circuit failures.

17. Determining the reliability of redundant circuits with two types of failures.

18. Types of reliability calculations.

19. Reliability of electronic components (relays, diodes, etc.).

20. Redundancy. Basic concepts and types. Methods of activating redundancies. Calculation of circuits with general and separate redundancy.

21. Calculation of the reliability of a system with redundancy. Systems with constant load and systems with active redundancy with absolutely reliable switches.

22. Calculation of system reliability with redundancy. Systems with active unstressed redundancy and lightened redundancy.

23. Calculation of system reliability with redundancy. Variable redundancy.

24. Optimal redundancy. Concepts and types.

25. Methods for calculating systems with serial and parallel connections.

26. Methods for calculating systems with non-basic connection types. "m out of n" schemes.

27. Methods for calculating systems with non-standard connection types. Bridge circuits.

28. Calculation of the reliability of complex systems.

29. Operational tasks. Its phases and characteristics.

30. Repair of radio-electronic equipment. Basic concepts, types, parameters, and their calculation.

31. Technical maintenance of radio-electronic equipment. Basic concepts, types, parameters, and their calculation.

32. Effectiveness of maintenance and cost of maintenance and operation of radio-electronic equipment. Technical utilization coefficient.

33. Calculation of repairable systems. Calculation of readiness and downtime coefficients.

34. Features of calculating redundant systems.

35. Search for faulty elements in equipment.

36. Basic concepts of REA spare parts kit configuration. Criteria for spare parts kit adequacy.

37. Basic equation of spare parts provision processes. Mathematical model of spare parts provision for equipment of one type and model.

Description of material, technical, and information support for the discipline

The discipline involves the use of tools, equipment, and software located in lecture and training rooms, as well as a specialized computer lab.

Work program of the academic discipline (syllabus):
Compiled by Stepanov M. M.;
Approved by the PRE Department (Minutes No. 06/2025 dated 24.06.2025)
Approved by the methodological commission of the faculty/research institute (protocol No. 06/2025 dated 25.06.2025)