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

Radioengineering Faculty
Radioengineering Department

STATISTICAL RADIO ENGINEERING (PN-09)

Curriculum of the academic discipline (Syllabus)

Course details

Level of higher education	***First (bachelor's)***
Field of knowledge	*G Engineering, manufacturing, and construction*
Specialization	*G5 Electronics, electronic communications, instrument engineering, and radio engineering*
Educational program	*Information and communication radioengineering*
Status of discipline	*Compulsory for professional training*
Form of study	*Full-time and accelerated full-time*
Year of training, semester	*3rd year, 5th semester (full-time)* *2nd year, 3rd semester (full-time accelerated)*
Scope of the discipline	*Total: 4 ECTS credits / 120 hours* *Lectures: 16 hours* *Laboratory classes: 14 hours* *Practical classes: 20 hours.* *Self-study by students (SS): 70 hours.*
Semester control/control measures	*Modular tests, credit* *Ongoing assessment/defense of laboratory work*
Class schedule	*Lectures (once every two weeks starting from week 1* *Laboratory work (once every two weeks, preferably after the lecture)*
Language of instruction	*Ukrainian*
Information about the course supervisor/teachers	*Lecturer: Ph.D.,* *Associate Professor of the RED* ***Serhii Litvintsev*** *(Litvintsev.Sergii@LLL.kpi.ua),* *+38 094 821 37 72* *Laboratory work:* *Ph.D., Associate Professor, RED* ***Sergii Litvintsev*** *Ph.D., Associate Professor, RED* ***Elena Guseva*** *Practical classes:* *Ph.D., Associate Professor, RED* ***Elena Guseva***
Course location	*The course is available on the Sikorsky distance learning platform:* *https://do.ipo.kpi.ua/course/view.php?id=2529*

Curriculum

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

The academic discipline "Statistical Radio Engineering" is one of the basic disciplines that any radio engineer needs to know. This subject is the foundation on which all subsequent knowledge and skills necessary for working with random signals and the results of any measurements are built.

After completing the course, students should demonstrate the following learning outcomes:

1) Knowledge: random event, random variable, integral distribution function, probability density, moments, mathematical expectation, variance, random process, moment functions, characteristic function, covariance and correlation functions, spectral power density, white noise, Gaussian normal process, internal noise, optimal filtering.

2) Skills: perform statistical processing of measurement results, determine the parameters of a random process, perform correlation analysis of signals and spectral analysis of random signals, take into account the effect of various internal noises on the useful signal, be able to determine a random signal at the output of linear and nonlinear circuits, and create an optimal filter in the presence of noise of various nature.

3) Experience: freely use statistical tools to process measurement results and the theory of statistical processing when calculating random signals against a background of various noises.

In accordance with the professional educational programs (PEP) of the first "bachelor's" level of higher education, after mastering the academic discipline, students should acquire **the** following program **competencies**:

General competencies (GC)

GC-2 – Ability to apply knowledge in practical situations.

GC-7 – Ability to learn and master modern knowledge.

GC-8 – Ability to identify, pose, and solve problems.

Professional competencies (PC)

PC-17 – Ability to apply modern CAD systems for design, structural synthesis, and highly efficient multi-parameter optimization of antennas, active and passive microwave devices.

Program learning results (PLR)

According to the first "bachelor's" level of higher education, as a result of mastering the academic discipline, students must demonstrate **the** following **program learning results**:

PLR1 – Analyze, argue, and make decisions when solving specialized tasks and practical problems of statistical radio engineering, which are characterized by complexity and incomplete certainty of conditions;

PLR28 – Conduct engineering assessments and develop recommendations to ensure electromagnetic compatibility of multiple microwave systems.

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

In the structural-logical scheme of the professional educational program for training specialists of the first (bachelor's) level of higher education, the academic discipline "Statistical Radio Engineering" is included in the list of compulsory disciplines aimed at forming the professional competencies of a specialist.

Prerequisites – the academic discipline is specialized and is taught in the 3rd year, 5th semester of the educational program "Information and Communication Radio Engineering" of the first (bachelor's) level of higher education. To master this discipline, knowledge of the following disciplines is required: "Mathematical Analysis," "Fundamentals of Circuit Theory," "Fundamentals of Electronic Communications and Radio Engineering. Part 2. Signals and Processes in Radio Engineering," "Processes in Linear Electronic Circuits."

Post-requisites: – knowledge gained in this discipline will ensure mastery of the following disciplines: "Digital Signal Processing," "Electromagnetic Compatibility," "Signal Generation, Modulation, and Coding."

It is an integral part of the first (bachelor's) level of higher education.

3. Contents of the academic discipline

Section 1. Random events and quantities
- Topic 1.1. RSA
- Topic 1.2. Random event
- Topic 1.3. Terminology
- Topic 1.4. Four probability theorems
- Topic 1.5. Random variable
- Topic 1.6. Integral distribution function
- Topic 1.7. Probability density
- Topic 1.8. Moments, mathematical expectation, and variance

Section 2. Random Process and Its Parameters
- Topic 2.1. Random process
- Topic 2.2. One-dimensional distribution function
- Topic 2.3. One-dimensional probability density
- Topic 2.4. Moment functions and their properties
- Topic 2.5. Characteristic function and its properties

Section 3. Multidimensionality, correlation, ergodicity
- Topic 3.1. Two-dimensional and multidimensional probability density
- Topic 3.2. The concept of correlation
- Topic 3.3. Stationarity
- Topic 3.4. Ergodicity
- Topic 3.5. Physical meaning of moments of ergodic random processes

Modular test on sections 1-3

Section 4. Correlation analysis
- Topic 4.1. ACF of a deterministic signal
- Topic 4.2. VCF of a deterministic signal
- Topic 4.3. Mutual energy spectrum of signals
- Topic 4.4. Covariance and correlation functions
- Topic 4.5. VCF of random processes

Topic 4.6. Correlation coefficient
Topic 4.7. Correlation interval
Topic 4.8. Energy spectrum
Topic 4.9. Spectral power density
Topic 4.10. Effective spectrum width

Chapter 5. Spectral Analysis
Topic 5.1. Wiener-Khinchin formulas
Topic 5.2. White Noise
Topic 5.3. Experimental determination of statistical characteristics m1, m2, dispersion
Topic 5.4. Characteristics of harmonic voltage with random phase
Topic 5.5. Experimental determination of statistical characteristics W
Topic 5.6. VCF of signals
Topic 5.7. Mutual energy spectrum of signals and its properties
Topic 5.8. Correlation receiver
Topic 5.9. Coherent receiver

Section 6. Gaussian process and internal noise
Topic 6.1. Gaussian normal process and its properties
Topic 6.2. Thermal noise
Topic 6.3. Nyquist's theorem
Topic 6.4. Generalized Nyquist theorem
Topic 6.5. Thermal noise of an oscillating circuit
Topic 6.6. Fractional noise
Topic 6.7. Flicker noise
Topic 6.8. Methods of equivalent representation of noise

Modular test on sections 4-6

Section 7. Random signals and linear circuits
Topic 7.1. Passage of random signals through linear circuits. Normalization effect
Topic 7.2. The stability property of the normal law
Topic 7.3. Lyapunov's central limit theorem
Topic 7.4. Spectral correlation characteristics of a random signal at the output of a linear circuit
Topic 7.5. Spectral method
Topic 7.6. Time method
Topic 7.7. Differentiation of a random signal
Topic 7.8. Integration of a random signal

Section 8. Random signals and nonlinear circuits
Topic 8.1. What is a nonlinear inertia-free transducer (NIT)?
Topic 8.2. One-dimensional W at the output of the NIT
Topic 8.3. Linear detector as an example
Topic 8.4. Moments and characteristic function at the output of the NIT
Topic 8.5. Two-dimensional W at the output of the NIT
Topic 8.6. Spectral correlation characteristics of a random signal at the output of an NIT
Topic 8.7. Direct method for determining the ACF
Topic 8.8. Characteristic function method (Reiss method)
Topic 8.9. Derivative method (Price method)

Section 9. Optimal filtering
Topic 9.1. Amplitude detection of Gaussian narrowband noise
Topic 9.2. Linear detector

Topic 9.3. Quadratic detector
Topic 9.4. Frequency detector
Topic 9.5. Optimal filtering
Topic 9.6. Optimal filter against white noise
Topic 9.7. Optimal filter against non-white noise

Final test

4. Teaching materials and resources

Basic and additional literature (hereinafter referred to as literature) is used to prepare for lectures, laboratory classes, modular tests, self-study, etc. The literature required for mastering the discipline is studied by students independently using Internet resources, on the Sikorsky distance learning platform using the Moodle platform. In the context of distance learning, students can use literature available in electronic form on university and external media.

Basic recommended literature

1. Vasilyev V. M. Probability Theory in Radio Engineering: Textbook / V. M. Vasilyev, S. Ya. Zhuk. — Kyiv: Igor Sikorsky KPI, 2023. — 352 p.
2. Kostenko, P. Yu. Fundamentals of Statistical Theory of Information and Measurement Radio Engineering Systems: Textbook / P. Yu. Kostenko, S. Ya. Falkovich. — Kharkiv: Kharkiv National University of Radio Electronics, 2021. — 612 p.
3. Voloshchuk V. I. Signals and Processes in Radio Engineering. — Vol. 1 / V. I. Voloshchuk. — Kharkiv: SMIT Company, 2003. — 580 p.
4. Statistical Radio Engineering: Lecture Notes / Compiled by O. S. Makarenko, S. M. Litvintsev. — Kyiv: Igor Sikorsky Kyiv Polytechnic Institute, 2023. — 89 p.
5. Methodological guidelines for laboratory work in the discipline "Radio Engineering Circuits and Signals" for students majoring in "Radio Engineering." Part III // Compiled by F. D. Lyubich, Yu. G. Kuleshov, O. S. Makarenko. — Kyiv: KPI, 1993. — 36 p.

Recommended supplementary reading

1. Filippsky Yu. K. Random processes in radio engineering circuits: textbook for students of higher educational institutions / Yu. K. Filippsky. — Odessa: AO BAKHVA, 2012. — 176 p.
2. Koval Yu. O. Fundamentals of circuit theory: textbook for students of higher educational institutions. Part 1 / Yu. O. Koval, L. V. Grinchenko, I. O. Milyutchenko. – Kharkiv: KNURE; Collegium, 2004. – 436 p.

Educational content

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

To study the academic discipline, eight lectures, seven practical classes, and six laboratory classes are planned, during which students must complete modular tests and defend their laboratory work after completion.

Lectures

No	Lecture topic and list of main questions
1	RSA, random event, terminology, four probability theorems, random variable, integral distribution function, probability density Random process, one-dimensional distribution function, one-dimensional probability density, moment functions and their properties, characteristic function and its properties
2	Multidimensionality, correlation, ergodicity, two-dimensional and multidimensional probability density, concept of correlation, stationarity, ergodicity, physical meaning of moments of ergodic random processes
3	ACF of a deterministic signal, AFC of a deterministic signal, mutual energy spectrum of signals, covariance and correlation functions, AFC of random processes, correlation coefficient, correlation interval, energy spectrum, spectral power density, effective spectrum width
4	Wiener-Hinchin formulas, white noise, experimental determination of statistical characteristics m1, m2, dispersion, characteristics of harmonic voltage with random phase, experimental determination of statistical characteristics W, FFT of signals, mutual energy spectrum of signals and its properties, correlation receiver, coherent receiver
5	Gaussian normal process and its properties, thermal noise, Nyquist theorem, generalized Nyquist theorem, thermal noise of an oscillating circuit, fractional noise, flicker noise, methods of equivalent representation of noises
6	Passage of random signals through linear circuits, normalization effect, stability property of the normal law, Lyapunov's central limit theorem, spectral-correlation characteristics of a random signal at the output of a linear circuit, spectral method, time method, differentiation of a random signal, integration of a random signal
7	What is a nonlinear inertia-free transducer (NIT), one-dimensional W at the output of the NIT, a linear detector as an example, moments and characteristic function at the output of the NIT, two-dimensional W at the output of the NIT, spectral correlation characteristics of a random signal at the output of the NIT, direct method for determining the ACF, method of characteristic functions (Reiss method), method of derivatives (Price method)
8	Amplitude detection of Gaussian narrowband noise, linear detector, quadratic detector, frequency detector, optimal filtering, optimal filter against white noise, optimal filter against non-white noise

Practical classes

No	Name of the topic and list of main questions
1	Basic concepts and theorems of probability theory
2	Random process and its statistical characteristics
3	Correlation and spectral analysis of signals

	MT-1
4	Correlation functions and energy spectra. Correlation time. Effective spectrum width
5	Noise
6	MT-2 Passage of random signals through linear circuits
7	Passage of random signals through inertia-free nonlinear circuits Optimal filter

Laboratory classes

No.	Name of the topic and list of main questions	Hours
1	Experimental measurement of signal probability density	4
2	Study of the main characteristics of random processes (computer workshop)	2
3	Passage of signals and interference through linear circuits	4
4	Passage of signals and interference through linear circuits (computer workshop)	3
5	Interference resistance of communication systems with amplitude modulation	4
6	Noise immunity of communication systems with amplitude modulation (computer workshop)	3

Distance learning platform

For better assimilation of the subject matter during remote work, we use email, the Sikorsky distance learning platform with Moodle, and the Google Meet and ZOOM platforms for online meetings, which make it easier to post methodological recommendations, teaching materials, literature, etc.

- simplify the placement of methodological recommendations, training materials, literature, etc.;
- provide feedback to students on learning tasks and the content of the academic discipline;
- completed assignments are checked and evaluated;
- keep track of students' progress in the course, adherence to the schedule for submitting educational/individual assignments, and their assessment.

6. Self-study of students (SS)

Self-study includes: preparation for lectures and laboratory classes; self-assessment of acquired knowledge; study of recommended sources and literature; preparation for modular tests; preparation for exams, etc. ISW involves working through certain theoretical issues, which are set during the lecture.

Preparation for lectures

To prepare for lectures, students must study the planned basic and supplementary literature and recommended sources. Before lectures, students must review the theoretical material that was presented in previous lectures or assigned in advance. Students are allocated approximately 1 hour for each topic of the discipline.

Preparation for practical classes

To prepare for practical classes, students must study the planned basic and supplementary literature and recommended sources on the topic covered in the current practical class. Homework assignments given in practical classes must be completed before the next class.

Preparation for laboratory classes

Students must prepare for laboratory classes in advance. Homework assignments for laboratory classes are listed in the corresponding methodological guide. Assignments must be completed before the start of the corresponding laboratory class.

Modular test (MT)

Up to 2 hours are allocated for preparation for the MT. The MT is conducted during the current practical class, following the completion of all topics covered in the planned MT. A list of questions for preparation for the MT is provided in Appendix B.

Credit

The exam is held during the exam week at the end of the academic semester. After students have completed their module tests, they write an exam based on their semester grades or at the discretion of the instructor. Six hours of class time are allocated for preparation for the exam. A list of questions for exam preparation is provided in Appendix A. During the distance learning period, the exam may be conducted according to the session schedule using Moodle and the Google Meet and ZOOM online meeting platforms.

Policy and control

7. Academic discipline (educational component) policy

Class attendance

Attendance at lectures, practical classes, and laboratory classes is in accordance with the Regulations on the Organization of the Educational Process at Igor Sikorsky KPI. At least once every two weeks, the instructor holds consultations on various issues related to the credit module. During consultations, the instructor can provide assistance in studying the material of classes that students have missed for various reasons and must master on their own.

In any case, students are encouraged to attend all types of classes, as they cover theoretical material and develop the skills necessary for completing homework, tests, and calculations.

Rules for completing assignments

When studying the material of the course "Statistical Radio Engineering," students:

1) during lectures:

- take periodic quick tests of residual knowledge from sections of the course, which may include creative tasks on topics not covered in lectures, or quick test tasks (lasting 5–10 minutes using tests on the Sikorsky platform);

1) during practical classes:

- complete modular tests either in person or using the Sikorsky platform;
- solve practical problems and save the solutions obtained to prepare for the test;

2) in laboratory classes:

- prepare homework assignments based on their own tasks based on the study of sources and literature;
- complete the tasks set for mandatory completion in accordance with the methodological guide;
- save the results obtained for further preparation of reports on the results of laboratory work.

Tasks and materials for quick tests/creative assignments are developed by the instructor based on the course material and submitted in Google Classroom or in another form.

Rules of conduct in class

When studying the material of the academic discipline "Statistical Radio Engineering," students listen attentively to the lecturer during lectures and, if necessary, write down important information, periodically complete express tests in written form (within 5–10 minutes) and modular tests (MTR) using the Sikorsky platform or in person. Dialogue between students and the teacher in the form of questions and answers is allowed.

During practical classes, students and the teacher discuss practical tasks and try to find the best solution through discussion.

During laboratory classes, students complete mandatory tasks. The student's work involves participation in interactive forms of organizing the training session (answering questions asked by the teacher or students). Each student is expected to be prepared for all questions of the laboratory session, supplement the reports of other students, and express their own opinion during the discussion of issues that arose during the performance of tasks.

Students are allowed to use their own written notes and summaries. The use of laptops, tablets, and phones for educational purposes is permitted. At the same time, students should try to express their own opinions rather than read out other people's texts. The teacher critically analyzes the presentations, comments on mistakes, and moderates discussions between students.

The topics of lectures, practical and laboratory classes are covered in the course syllabus, which is available on the Electronic Campus, the website of the Radio Engineering Department, and the Sikorsky platform (Moodle, Google Classroom).

Incentive and penalty points

Bonus points. Students are encouraged to independently study topics that are not included as mandatory in the course of this subject (use of such technology when performing laboratory work +5 points maximum).

Student participation in solving problems that many students encounter when performing practical and/or laboratory tasks is encouraged (+1 point for solving one problem).

Students are encouraged to create new teaching materials (new test questions, suggestions for improvement, etc.) and to find errors in existing teaching materials (+1 point for each suggestion/error found).

Missed tests

The result for a student who did not attend an assessment is zero. If a student misses an assessment for a valid reason, they are given the opportunity to complete it (write an MT, complete laboratory work) in the presence of the teacher. If the absence occurred without a valid reason, especially with regard to laboratory work, the issue of its completion is decided with the teacher in agreement with the department management. A missed test is not counted regardless of the reasons for the absence; in this case, the student receives a "did not appear" mark, and if they are eligible to take the test, they must take it during an additional session.

Announcement of test results

The results of the MT are announced after the results of the check. When communicating in person, at the student's request, they can receive an explanation in which they can see their grade according to certain assessment criteria.

The results for the completed laboratory work are posted after its completion and defense.

Academic integrity

The policy and principles of academic integrity are defined in Section 3 of the Code of Honor of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute." For more details, please visit: https://kpi.ua/code.

Ethical standards

The standards of ethical conduct for students and employees are defined in Section 2 of the Code of Honor of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute." For more information, visit: https://kpi.ua/code.

8. Types of control and rating system for assessing learning outcomes (RSA)

Ongoing assessment

Ongoing assessment is carried out during classes and aims to check the level of student preparation for classes. During practical and laboratory classes, students are surveyed on topics related to the subject. Modular tests are conducted twice per semester to assess residual knowledge of the most important sections of the academic discipline. Express control in the form of tests is conducted after lectures.

Calendar control

Calendar control is conducted twice per semester to monitor the current status of syllabus requirements. There are two possible results of calendar control: certified (c) and not certified (n/c). The result depends on the number of points scored at the time of calendar control in accordance with the requirements of Igor Sikorsky KPI.

Semester control

Semester control is considered a final test.

Assessment and control measures

A student's grade for a course consists of points earned for:

1) assessment of residual knowledge by completing express test tasks on the materials of 8 lectures using tests on the Sikorsky platform;

2) work in 7 practical classes;

3) work in 6 laboratory classes;

4) modular tests.

Information on the above points is summarized in the table

No.	Assessment	Maximum score	**Number**	**Total**
1	Attendance at lectures (test after lecture)	1	8	8
2	Work in practical classes	3	7	21
3.	Work in laboratory classes	10	6	60
4.	Modular test (MT)	5.5	2	11
6.	Bonuses	10	1	10
7.	Credit (if you did not score 60)	40	1	40
	Total without bonuses			100
	Total with bonuses			110

In order to receive the highest rating, students must actively participate in practical and laboratory classes, actively supplement the answers of other students, clearly and logically express their own position on discussion issues, and complete coursework and quick tests in a timely manner. Students are given a one-time opportunity to complete coursework and quick tests.

The following factors lead to a decrease in a student's rating: failure to complete assignments and quick tests; inadequate preparation for practical and laboratory classes; inaccuracies, incompleteness, errors in answers, or reliance on unreliable sources.

The instructor evaluates the student's work in each practical and laboratory class and enters the grades for the work and results of the MT and express controls into the "Current Control" module of the Electronic Campus. The results of the first and second calendar controls depend on the student's current rating and are entered by the teacher into the "Calendar Control" module of the Electronic Campus in the eighth and sixteenth weeks of study, respectively (see Appendix C).

The student may appeal the teacher's assessment by submitting a complaint to the teacher no later than the day after the student has been informed of the assessment given by the teacher. The complaint will be considered in accordance with the procedures established by the university.

Conditions for admission to semester control

A minimum of 40 points.

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)

A recommended list of questions for semester assessment (test) is provided in Appendix A to the syllabus.

Recommendations for students

During lectures, students should write down key terms and concepts, note the main events of the topic, and summarize the generalizations and conclusions made by the instructor. This material will be useful when preparing for practical and laboratory classes, MT, tests, and quick checks.

When preparing for a practical or laboratory class, students must study the lecture material on a specific topic and, preferably, familiarize themselves with additional resources on the Internet. If questions arise or unclear points are identified, they should be discussed with the lecturer. During practical and laboratory classes, each student should try to master the practical skills that can be mastered on their own. Students should not refuse to answer the teacher's questions. Even if a student does not know the answer, it is advisable to try to answer, express their opinion based on their own knowledge, experience, logic of the question, etc. However, it is important to remember that not knowing the subject matter is a significant shortcoming in a student's work and will negatively affect their overall grade. A responsible attitude toward preparing for each practical and laboratory class allows students not only to properly master the material, but also to save effort when taking semester exams.

Students may be credited for a course topic if they have certificates of completion of distance or online courses on the relevant subject.

Distance learning

Synchronous and asynchronous distance learning is possible using video conferencing platforms (Google Meet, Zoom, etc.) and the Sikorsky distance learning educational platform (Moodle).

Inclusive learning

Inclusive learning is permitted.

Work program for the academic discipline (syllabus):

Compiled by: Associate Professor of the RED, Sergii Litvintsev

Approved by: the RED (Minutes No. 06/2025 dated June 17, 2025).

Approved by: the REF Academic Council (Minutes No. 06/2025 dated 26.06.2025).

10. Appendix A

Semester control is carried out by means of a test. The test consists of answering three questions, which are included in the test ticket and approved at a meeting of the department. Two questions are theoretical, the third question is practical and requires solving a problem related to the module topic.

A sample test paper is provided below.

Sample final test

NATIONAL TECHNICAL UNIVERSITY OF UKRAINE
"IGOR SIKORSKY KYIV POLYTECHNIC INSTITUTE"

Level of higher education **first (bachelor's)**
(degree name)

Specialty ***G5 Electronics, electronic communications, instrument engineering, and radio engineering***
(code and name of the field of study)

Educational program ***Information and Communication Radioengineering***
(code and name of specialty)

Academic discipline ***Statistical Radio Engineering***
(name)

TEST SHEET No. ____

1 *Questions from Block I*

2 *Questions from Block II*

3 *Task from section III*

Approved at a meeting of the Department ***of Radio Engineering***
(name of department)

Minutes No. _____ dated " " 202

Head of the Radioengineering Department
(signature) (First name LAST NAME)

The exam consists of two theoretical questions and one problem, each of which is worth 20 points. In case of an ambiguous situation, an additional question in the form of a problem may be added, which is worth 20 points.

Theoretical question

- complete answer (at least 90% of the required information) — 25–30 points;
- sufficiently complete answer (at least 75% of the required information or minor inaccuracies) — 19–24 points;
- incomplete answer (at least 60% and some errors) — 12–18 points;
- unsatisfactory answer — 0 points.

Practical task

The practical task requires the student to solve a problem related to the module topic.

- correct answer with all necessary intermediate results and calculations (at least 90% of the required information) — 35–40 points;
- correct answer with partial calculations (at least 75% of the required information or minor inaccuracies) — 24–34 points;
- partially correct answer with partial calculations (at least 60% and some errors) — 12–23 points;
- incorrect answer — 0 points.

Additional question

- correct solution — 19–20 points;
- correct solution with minor errors — 15–18 points;
- correct solution path, incorrect answer — 10–14 points;
- incorrect solution — 0 points.

Questions for creating exam papers

Questions from Block I

1. Random event, impossible, reliable, incompatible, opposite.
2. First addition theorem.
3. Second addition theorem.
4. First multiplication theorem.
5. Second multiplication theorem.
6. Total probability formula.
7. Bayes' formula.
8. Integral distribution function F.
9. Probability density W.
10. Mathematical expectation.
11. Variance, standard deviation.
12. Random event vs. random process.
13. Initial moment functions.
14. Central moment functions.
15. Covariance function K.
16. Correlation function R.
17. Characteristic function θ.
18. Stationary random process.
19. Ergodic random process.
20. Correlation interval.
21. Wiener-Khinchin formula.
22. Average power of a stationary random process.

23. Energy spectrum width Δω.
24. 3σ rule

Questions from question block II

1. The normalization property of a linear circuit.
2. Normal (Gaussian) random process.
3. White noise.
4. Thermal, fractional, flicker noise.
5. Noise coefficient and noise temperature.
6. Noise resistance and noise conductivity.
7. Interrelation of noise properties.
8. Transmission coefficient of an optimal filter against a background of white noise.
9. Transmission coefficient of an optimal filter against a background of non-white noise.
10. Impulse response of a matched filter.
11. Signal at the output of a matched filter.
12. Optimal filter for a rectangular video pulse.
13. Optimal filter for a rectangular radio pulse.
14. Optimal filter for a sequence of impulse signals.

Tasks from Block III

1. Calculate the mathematical expectation of a random signal
2. Calculate the variance of a random signal
3. Perform a correlation analysis of a known signal
4. Perform a correlation analysis of an unknown signal
5. Calculate the thermal noise of the device
6. Calculate the fractional noise of the device
7. Calculate the flicker noise of the device
8. Calculate the passage of a random signal through a linear circuit
9. Calculate the energy spectrum of a random signal after passing through a linear circuit
10. Calculate the parameters of the filter that is optimal for this signal

The sum of points is converted into a grade according to the table:

Semester or credit points	**Credit grade**
95–100	Excellent
85–94	Very good
75–84	good
65–74	satisfactory
60–64	sufficient
less than 60	unsatisfactory
Not protected All laboratory work	not allowed

11. Appendix B

MODULAR TEST

in the academic discipline
STATISTICAL RADIO ENGINEERING
of the first (bachelor's) level of higher education

form of study ***full-time***

During practical classes, after completing certain topics, students are given a one-time opportunity to write a midterm exam, which consists of test questions. Two midterm exams are held during the module, each of which is graded on a scale of 0 to 6 points.

Assignments for the MT

The test tasks for the MT are formed from the following blocks:

MT-1

1. Random event, impossible, reliable, incompatible, opposite.
2. First addition theorem.
3. Second addition theorem.
4. First multiplication theorem.
5. Second multiplication theorem.
6. Total probability formula.
7. Bayes' formula.
8. Integral distribution function F.
9. Probability density W.
10. Mathematical expectation.
11. Variance, standard deviation.
12. Random event vs. random process.
13. Initial moment functions.
14. Central moment functions.
15. Covariance function K.
16. Correlation function R.
17. Characteristic function θ.

MT-2

1. Ergodic random process.
2. Correlation interval.
3. Wiener-Khinchin formula.
4. Average power of a stationary random process.
5. Energy spectrum width Δω.
6. 3σ rule
7. Normalization property of a linear circuit.
8. Normal (Gaussian) random process.
9. White noise.
10. Thermal, fractional, flicker noise.
11. Noise coefficient and noise temperature.
12. Noise resistance and noise conductivity.
13. Interrelation of noise properties.

12. Appendix C

RATING SYSTEM FOR ASSESSING LEARNING OUTCOMES

in the academic discipline
STATISTICAL RADIO ENGINEERING
of the first (bachelor's) level of higher education

form of study ***full-time***

1. The student's grade for the academic discipline consists of points awarded for:

- assessment of residual knowledge in 8 lectures;
- work in 7 practical classes;
- work in 6 laboratory classes;
- modular tests (MT).

Distribution of teaching time by type of class and tasks from the credit module according to the working curriculum:

Semester	Teaching time		Distribution of teaching hours				Control measures	
	Credits	academic hours	Lectures	Practical	Lab work	SS	MT	Semester assessment
5	4	50	16	14	20	70	2	Credit

The student's rating for the credit module consists of points awarded for:

1) Attendance at lectures (test after the lecture) — maximum number of points — 1x8= 8;
2) Completion and defense of 6 laboratory works, maximum number of points — 6x10=60;
3) Attendance and work in practical classes, number of points 7x3 = 21;
4) Two module tests (MT), divided into two one-hour control works, maximum number of points — 5.5x2 = 11;

Rating point system

1. Testing of knowledge level after each lecture

1.1. Testing is conducted immediately after the lecture. Testing time — 72 hours.

1.2. Testing is conducted by taking tests in the Moodle system on the Sikorskii platform (https://do.ipo.kpi.ua).

1.3. The questions in the tests correspond to the topic of the lecture.

1.4. The maximum possible number of points for one lecture is 1 point.

2. Laboratory work

2.1. Completion of homework on laboratory work — 1 point (availability of a homework file or its presence in the report when performing offline).

2.2. Completion of laboratory work.

— When performing the work in person: 2 points for all completed and working tasks. Confirmation of completion is provided by screenshots in the report.

— When performing the work online: 1 point for one mandatory task (presence of a file for the task).

— Preparation of a report on the results of the laboratory work.

2.3. Defense of laboratory work (there is an option to defend through testing):

– complete mastery of the material during the defense (at least 90% of the required information) — 5 points;

– partial mastery of the material (at least 80%) — 6 points;

– partial mastery of the material (at least 70%) — 5 points;

– satisfactory mastery of the material (at least 60%) — 4 points;

– unsatisfactory mastery of the material (less than 60%) — 0 points;

Defense on the day of completion or at the next class — +1 point for one lab report (bonus).

Well-designed laboratory work report (presence of all graphical constructions, thorough conclusions) — 1 point.

Late defense of the work — −1 point.

The laboratory work is considered successfully defended if the student scores 6 points out of a possible 10. If the student scores less than 6 points, the work must be defended again.

3. Modular test (MT)

– complete answer (at least 90% of the required information) — 5.5 points;

– complete answer (at least 80% of the required information) — 5 points;

– sufficiently complete answer (at least 70%) — 4 points;

– incomplete answer (more than 60%) — 3 points;

– unsatisfactory answer — 0 points.

4. Practical classes

Attendance:

– attendance at practical classes — 1 point for each class;

Participation in problem solving:

– solving a problem at the blackboard — graded from 0 to 5. All grades are summed up and converted to rating points with a coefficient of 0.2;

– answering from your seat "for a plus" — 1 "plus" for each correct answer. All "pluses" are summed up and converted with a coefficient of 0.5 to rating points.

5. Incentive and penalty points

Penalty points (not counted during wartime):

– late submission of laboratory work — −1 point for each;

– late writing or rewriting of MT — −2 points for each.

Bonus points:

– original solution of the MT;

– original solution of laboratory work, or solution of a task in addition to the one provided;

– proposed own version of tests.

A student cannot receive more than 10 penalty points or 20 bonus points!

The maximum number of points is 100. The defense of all laboratory work is a prerequisite for admission to the exam.

Students who have earned more than 60 points during the semester are entitled to receive an "automatic" grade; points are converted into grades according to the table.

Students who have earned less than 60 points, as well as those who want to improve their grade, take the exam. In this case, points for passing the exam are awarded regardless of the work done during the semester, and this rating is final, i.e., during the exam, it is possible to earn fewer points than before.