



[RE-321] THEORETICAL BASES OF RADIO-ELECTRONIC COUNTERMEASURES TO RADIO TECHNICAL SYSTEMS

Curriculum of the academic discipline (Syllabus)

Course details

Level of higher education	First (bachelor's)
Field of knowledge	17 - Electronics, Automation, and Electronic Communications
Specialization	172 - Electronic Communications and Radio Engineering
Educational program	All educational programs
Discipline status	Elective (F-catalog)
Form of higher education	Full-time
Year of training, semester	Available for selection starting from the 4th year, spring semester
Scope of the discipline	4.0 credits (Lectures 18 hours, Practical classes 36 hours, Laboratory work 36 hours, Independent work 66 hours)
Semester	
Control/control measures	Credit
Class schedule	https://schedule.kpi.ua
Language of instruction	Ukrainian
Information about the course coordinator/teachers	Lectures: V. O. Chmelov , Lab: V. O. Chmelov , Independent work: V. O. Chmelov
Course location	

Curriculum

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

Description of the course. During the course, students will study the theoretical foundations of countering radio engineering systems, the principles of construction and features of the use of electronic warfare means to reduce the effectiveness of radio engineering systems, radar, radio navigation, radio control, radio communication, and others. The principles of electromagnetic environment analysis, detection, identification, and classification of electromagnetic radiation sources are studied. The types and methods of creating active interference with radio systems are studied. The forms and methods of their application are determined. Software and hardware means of implementing radio countermeasures are considered. Various scientific and technical solutions for improving the effectiveness of radio countermeasures are studied, a comparative analysis is carried out, and their advantages and disadvantages are determined.

The aim of the course is to teach students to select the type and parameters of active jamming, the method of its formation, based on the given tactical and technical characteristics of the target, to develop a radio countermeasure system, to formulate requirements and technical characteristics for devices and instruments that are part of the radio countermeasure system, and to evaluate the effectiveness of the technical solutions adopted.

Subject of study: fundamentals of the theory of countering radio-technical systems, principles of constructing electronic warfare means and their structures. Methods of countering radio-technical systems, adaptation of radio countermeasure systems to countermeasures that attempt to reduce their effectiveness.

The main objectives are:

In accordance with the requirements of the course, after mastering the course material, students should demonstrate the following learning outcomes:

knowledge:

- current trends in the development of radio-electronic countermeasures and prospects for their use in various fields;
- methods of generating active radio interference;
- principles of creating radio countermeasures systems .

skills:

calculate the main technical characteristics of radio countermeasures systems; methods of using radio countermeasures systems to provide electromagnetic cover;

adapt the operating modes of the radio countermeasure system according to the characteristics of the target.

Process experimental data obtained through statistical modeling on a computer to evaluate the effectiveness of radio-technical computerized systems.

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

Prerequisites: the discipline is based on knowledge of the following disciplines: "Electrodynamics and Radio Wave Propagation."

Post-requisites: The discipline provides additional competencies in the field of modern radar system development

3. Course content

Training module No. 1. Fundamentals of the theory of construction and application of radio countermeasure systems. Topic 1. Basic concepts of radio-electronic countermeasures.

Topic 2. Types of active radio interference.

Topic 3. Theoretical foundations of the construction of "super-powerful" electronic countermeasure devices

Topic 4. Methodology for determining the characteristics of the target – radio-technical system.

Topic 5. Features of methods and means of radio countermeasures against radar systems.

Topic 6. Features of methods and means of radio countermeasures against wireless information transmission systems.

Topic 7. Features of methods and means of radio countermeasures against radio-controlled moving objects. Topic 8. Formation of a complex of radio-electronic countermeasures

Topic 9. Prospects for the development of radio countermeasures systems.

4. Teaching materials and resources

Basic literature:

1. Electronic Warfare and Radar Systems Engineering Handbook by Avionics Department.
2. OCTOBER 2013 NAVAL AIR WARFARE CENTER WEAPONS DIVISION POINT MUGU, CA 93042
3. ELECTRONIC WARFARE FUNDAMENTALS. Det 8, ACC TRSS 4349 Duffer Drive, Ste 437. Nellis AFB NV 89191-700.
4. Theory of Radar Systems (second edition): textbook/ B.F. Bondarenko, V.V. Vishnevsky, V.P. Dolgushin et al.; edited by S.V. Lenkov. - Kyiv: Publishing and Printing Center "Kyiv University," 2011. – 383 p.
5. Theory of Radar and Radio Navigation Systems: Textbook for University Students Majoring in Radio Engineering / Ya. I. Lepikh; Odessa National Maritime Academy. Odessa: Ecology, 2008. – 224 p.

Additional literature:

1. Serhii Zhuk, Viacheslav Chmelov, Oleksandr Tereshchenko Development of an adaptive multi-channel correlation sidelobe canceller for active noise interference based on the Gram-Schmidt orthogonalization procedure // Eastern-European Journal of Enterprise Technologies" Vol. 6 No. 5 (132) (2024): Applied physics. 33-40 p. DOI: <https://doi.org/10.15587/1729-4061.2024.319253> (SCOUPUS)
2. Chmelov V. O., Nazarov I. S. APPROACHES TO IMPROVING METHODS FOR DETECTING DRONE SIGNALS AGAINST THE BACKGROUND OF ADDITIVE NOISE // XIII International Scientific and Technical Conference "Radio Engineering Problems, Signals, Devices, and Systems" (RTPAS). Kyiv, November 27-28, 2024: conference materials – Kyiv, 2024. pp. 72-75.

Educational content

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

Lectures

Lecture 1. Subject and content of the discipline. General principles of radio countermeasures theory. The concept of radio interference. Classification of radio interference

Literature: [1,2]

Assignments for independent study. Study of frequency range standards for radio engineering systems. Basic parameters of radio interference, their characteristics.

Lecture 2. Methods of forming blocking radio interference. Formation of simulated interference. Construction of complex interference. The principle of constructing super-powerful radio interference to knock out radio engineering systems.

Literature: [1,3]

Assignments for independent study. Effectiveness of radio countermeasures. Theory of radio transition, its resistance to external electromagnetic influence.

Lecture 3. Theoretical foundations of radio-electronic reconnaissance for detecting targets. Methods of spectral analysis of radio engineering system signals. Determination of signal characteristics and radio signal modulation laws.

Literature: [2]

Assignments for independent study. Statistical criteria for detecting radio system signals. Detection algorithm. Signal spectrum reproduction based on observation results.

Lecture 4. Study of radar systems as objects of radio countermeasures. Systems for protecting radar systems from the negative effects of active radio interference.

Literature: [4,5]

Assignments for independent study. Basic parameters of radar systems, spatial selection of sources of electromagnetic radiation.

Lecture 5. Theoretical foundations of radio interference for disrupting the operation of radar systems. Analysis of wireless information transmission systems. Identification of vulnerabilities and critical conditions for their effective operation.

References: [3,1]

Assignments for independent study. Correlation reception of radio signals. Information transmission quality indicators.

Lecture 6. Formation of radio interference to create unfavorable conditions for data transmission in a radio communication network. Formation of simulated interference for radio communication means.

Literature: [1,2]

Assignments for independent study. Signal-to-noise ratio as a critical condition for data transmission. Method of overloading the bandwidth of a communication system.

Lecture 7. Detection of remote radio control systems for unmanned platforms. Methods of disrupting radio navigation systems for unmanned platforms.

Literature: [3]

Assignments for independent study. LoRa command transmission system for FPV drones. Substitution of GPS navigation coordinates.

Lecture 8. Method of creating combined interference in a remote radio control system. Methodology for planning organizational and technical measures of radio countermeasures.

Literature: [1,4,6]

Assignment for independent study. Complex radio signals. Development of comprehensive plans for the use of radio countermeasures.

Lecture 9. Adaptation of radio countermeasures systems to the conditions and tasks of radio-electronic cover. Monitoring of the electromagnetic environment. Trends in the development of radio countermeasures systems. New areas of application.

References: [1,2,3]

Assignments for independent study. Evaluation of the effectiveness of radio countermeasures systems. Radio-electronic cover.

Laboratory classes

•	Name of laboratory work	Number of hours
1.	Laboratory work "Methods of detection and direction finding radio engineering systems"	4
2.	Laboratory work "Spectral analysis of signals of electromagnetic radiation sources"	4
3.	Laboratory work "Detection and radio countermeasures against wireless surveillance cameras"	4
4.	Laboratory work "Detection of radio data transmission networks. Formation of jamming interference for communication systems communication system"	4
5.	Laboratory work "Suppression of satellite navigation systems navigation system in a specific location"	4
6.	Laboratory work "Detection and disruption of remote radio control systems"	4
7.	Laboratory work "Investigation of methods for forming active noise interference"	4
8.	Laboratory work "Disruption of the in a specific area"	4
9.	Laboratory work "Methods of forming complex targeted interference"	4
	Total	36

6. Independent work by the student

	Title of the topic for independent study	Number hours of independent work
1	Study of frequency range standards for radio engineering systems.	1
2	Basic parameters of radio interference, their characteristics.	1
3	Effectiveness of radio countermeasures.	1
4	Theory of radio transition, its resistance to external electromagnetic influence.	1

5	Statistical criteria for detecting radio system signals. Detection algorithm.	1
6	Reconstruction of the signal spectrum based on observation results.	1
7	Basic parameters of radar systems,	1
8	Spatial selection of electromagnetic radiation sources.	1
9	Correlation reception of radio signals.	1
10	Information transmission quality indicators.	1
11	<i>Signal-to-noise ratio as a critical condition for data transmission.</i>	1
12	<i>Method of overloading the bandwidth of a communication system.</i>	1
13	<i>LoRa command transmission system for FPV drones.</i>	1
14	<i>Replacement of GPS navigation coordinates.</i>	1
15	<i>Complex radio signals.</i>	1
16	<i>Development of comprehensive plans for the use of radio countermeasures</i>	1
17	<i>Assessment of the effectiveness of the radio countermeasures system.</i>	1
18	<i>Radio-electronic cover.</i>	1
19	Preparation of a laboratory work report	22
20	<i>Preparation for the module test</i>	6
21	Preparation for the test	10
	Total	6

Policy and control

7. Policy of the academic discipline (educational component)

Recommended teaching methods: studying the main and supplementary literature on the topics of the lectures, performing laboratory work. Students are advised to take detailed notes during lectures. An important aspect of high-quality assimilation of the material and mastery of methods and algorithms for solving the main tasks of the discipline is independent work. It includes reading literature, reviewing literature on the topic, preparing for classes, tests, and exams. The purpose of laboratory work is to deepen and consolidate theoretical knowledge, acquire modeling skills using computer technology, acquire skills in assessing the reliability of the results obtained, and preparing documents. The software is implemented in the Matlab and Mathcad computing environments for scientific and engineering calculations.

Rules for attending classes. Attendance at lectures and laboratory classes is assessed. Students are encouraged to attend classes, as they cover theoretical material and develop the skills necessary to complete semester tests. The assessment system is focused on awarding points for the timely completion of laboratory work by students, as well as the completion of tasks that develop practical skills and abilities.

During lectures, it is forbidden to distract the teacher from teaching the material; all questions, clarifications, etc. should be asked at the end of the lecture during the time allotted for this purpose.

Assignment of incentive and penalty points. Incentive points are awarded for: active participation in competitions, preparation and publication of scientific articles and abstracts of reports at scientific conferences, participation in research work on a topic that corresponds to the topics of the discipline. **The number of incentive points is limited to 10.**

Penalty points may be awarded for late submission of laboratory work. **The number of penalty points shall not exceed 10.**

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, see: <https://kpi.ua/code>.

Ethical conduct standards Ethical conduct standards 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 details, please visit: <https://kpi.ua/code>.

Foreign language instruction The academic discipline is taught in Ukrainian.

Students have the opportunity to gain knowledge on specific topics and sections of the academic discipline through courses on the Coursera platform (<https://www.coursera.org>), Prometheus (<https://prometheus.org.ua>), etc., as blended or additional learning in accordance with the Regulations on the recognition of learning outcomes acquired in non-formal/informal education at Igor Sikorsky Kyiv Polytechnic Institute (<https://osvita.kpi.ua/node/179>).

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

8.1. Types of control

Current control: carried out through questioning during laboratory classes and when performing MCW.

Calendar control: carried out twice per semester as monitoring of the current status of syllabus requirements fulfillment.

Semester assessment: Credit.

8.1. Calendar interim assessment of students is carried out based on the student's current rating at the time of assessment. If the rating is not less than 50% of the maximum possible at the time of assessment, the student is considered certified. The condition for a positive first assessment is to receive at least 8 points. The condition for a positive second assessment is to obtain at least 22 points.

8.2 Rating system for assessing learning outcomes.

The first type of RS involves assessing the results of the applicant's academic activity during the semester – passing or completing certain types of work provided for by current control measures (hereinafter – RS-1).

8.2. Rating system for assessing learning outcomes.

1. Learning outcomes are assessed on a 100-point scale and then converted to grades on the university scale.
2. The applicant's rating consists of points received by the applicant based on the results of current control measures and incentive/penalty points.
3. The rating assessment is communicated to applicants during the penultimate class of the semester.
4. The regulations on the rating system for assessing academic performance are communicated during the first class of the discipline.
5. The RS for a discipline, for which semester control is provided in the form of an exam, consists of two components: initial – intended for assessing current control measures throughout the semester; the exam component, designed to assess individual questions (tasks) on the exam (clause 3.17 of the REGULATIONS on the system of assessing learning outcomes at Igor Sikorsky Kyiv Polytechnic Institute).

8.3. Criteria for awarding points.

1. Nine laboratory works are performed during the semester. The total number of points for completing and defending a laboratory work report is 10 points.
2. Completion and defense of laboratory work - **9x10=90 points.**
3. Modular control of MCR - **10 points.**
4. Completion of the test - **100 points.**

Modular control (MCR) has 2 questions. Points are

calculated separately for each question. As a result,

the MCR score is:

- full answer - **10 points**
- complete answer with minor errors - 8 points
- complete answer with significant errors - 6 points
- incomplete answer - 4 points,
- content of the answer does not relate to the essence of the question, or there is no answer to the MCR question - 0 points

Report on the completion of laboratory work.

The student is not allowed to defend the report if it is not formatted in accordance with the requirements. As a result of the report defense:

- full answer - **10 points**
- Complete answer with minor errors - 8 points
- complete answer with significant errors - 6 points
- incomplete answer - 4 points
- content of the answer does not relate to the essence of the laboratory work, or the results of the research during the laboratory work were not obtained - 0 points.

Assessment of the test (R_E).

Students provide written answers to questions.

The grading system for answers to questions:

- "excellent", complete answer (at least 90% of the required information) - 95-100 points;
- "Very good," sufficiently complete answer (at least 85% of the required information, or minor inaccuracies) – 85-94 points;
- "Good," a sufficiently complete answer (at least 80% of the required information, or minor inaccuracies) – 75-84 points;
- "Satisfactory," incomplete answer (at least 70% of the required information and some errors) - 65-74 points;
- **"sufficient"** 60-64 incomplete answer (at least 65% of the required information and gross errors)
- "unsatisfactory," unsatisfactory answer - 0 points, **the test is considered failed.**

The maximum possible number of points for control measures (items 1-3) during the semester (R_c) is 100 points.

The RS for a discipline, the semester assessment of which is provided in the form of a test, for full-time education is developed according to the RS-1 type and includes the assessment of current assessment measures for the discipline during the semester.

The applicant's rating consists of points received by the applicant based on the results of current control measures, incentive and penalty points.

The rating is communicated to applicants during the penultimate class of the semester.

Applicants who have fulfilled all the conditions for admission to the exam and have a rating of 60 points or more receive a grade corresponding to their rating without additional tests.

For applicants who have fulfilled all the conditions for admission to the exam and have a rating of less

than 60 points, as well as those applicants who wish to improve their rating, the teacher conducts a semester test in the form of a test at the last scheduled class of the discipline in the semester.

After completing the test, if the test score is higher than the rating, the applicant receives a grade based on the test results.

If the grade for the test is lower than the rating, the following option applies:

"strict" RS - the applicant's preliminary rating (excluding points for the semester individual assignment) is canceled and he/she receives a grade based on the results of the test.

Grades for the educational component are determined according to the table:

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

Number of points	Grade
100-95	Excellent
94-85	Very good
84-75	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)

- The provisions of the grading system are explained during the first class of the discipline.
- The preliminary rating assessment for the discipline is communicated to students during the penultimate class of the discipline in the semester.
- Calendar assessment of students in the discipline is carried out by teachers based on the student's current rating at the time of assessment t . If the value of this rating is not less than 50% of the maximum possible (R_t) at the time of assessment $RD_t \geq 0.5R$, the student is considered to have passed. Otherwise, the assessment record will show "not assessed."
- Distance learning course at: <https://do.ipk.kpi.ua/course/view.php?id=6372>

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

Laboratory stands for studying the theoretical foundations of the discipline are located in room 215 of the Department of Radio Engineering Systems, academic building No. 17

Work program of the academic discipline (syllabus):

Compiled by [V. O. Chmelov](#);

Approved by the RTS Department (Minutes No. 06/2024 dated 06/27/2024)

Approved by the methodological commission of the faculty/research institute (protocol No. 06/2024 dated 28.06.2024)