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

[RE-273] ELECTROMAGNETIC RESILIENCE AND INFORMATION SECURITY

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 3rd year, spring semester
Scope of the discipline	4 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 course coordinator / teachers	
Course location	https://do.ipo.kpi.ua/course/view.php?id=2703

Curriculum

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

Electromagnetic compatibility of radio-electronic equipment is its ability to perform functional and social tasks under the influence of electric, magnetic, and electromagnetic fields in any frequency ranges and various configurations, which are mostly not provided for by the circuitry and design of the device. The problem is complicated by the extreme electromagnetic overload of the modern environment (ether) in a wide range of electromagnetic wave frequencies (e.g., so-called industrial interference), the imperfection of radio equipment (circuitry,

structural, technological shortcomings), low energy efficiency (about 10%) of modern gadgets. The task of ensuring EMC is no less important than achieving high functionality, ensuring the necessary level of reliability, or further miniaturization; this task is complex in nature. The problem of ensuring EMC of radio-electronic equipment concerns almost all existing areas of modern radio electronics.

The aim of the discipline is to provide students with reliable and in-depth competencies in creating methodologies, methods, and techniques for engineering solutions for equipment that minimizes parasitic interference of a wide range of frequencies, forms, and power from electric, magnetic, and electromagnetic fields.

The result of training is the provision of highly qualified technical specialists to industry and society who are capable of creating sophisticated, modern, interference-resistant electronic equipment.

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

Interdisciplinary connections are determined by the place of the discipline "Electromagnetic Stability and Information Security of Radio-Electronic Equipment" in the program for training specialists in the field of electronics and telecommunications. It is based on the general training of students in physics, mathematics, and radio engineering. The professional disciplines that precede its study are "Electrodynamics and Radio Wave Propagation," "Fundamentals of Circuit Theory," "Signals and Processes in Radio Engineering," and "Elements of Microwave Engineering and Antennas."

The discipline "Electromagnetic Compatibility and Information Security of Radio Electronics" provides for the study of second-level (master's) higher education disciplines
"Computer Networks and Telecommunications," "Information Protection in Telecommunications Systems," etc.

3. Content of the discipline

The content of the discipline is presented in a tandem of "lecture-laboratory (practical)" classes, since the lecture material is inextricably linked to the tasks and topics of laboratory (practical) classes.

The objectives of laboratory (practical) classes are twofold: on the one hand, to consolidate the theoretical knowledge gained in lectures, and on the other, to solve practical tasks to achieve the required level of electromagnetic compatibility of specific radio devices, which reliably ensures the high-quality functioning of gadgets in conditions of "aggressive" external and internal interference (parasitic radio interference).

Name of sections	Number of hours			
	Total	including		
		Lectur	Lab. (practice)	Ind.work
CHAPTER 1. Electromagnetic interference and information security.				
Topic 1.1. Introduction. Structure of the discipline.	9	2	1	6
Topic 1.2. Permissible radiation standards and susceptibility of RES to radio interference	9	1	1	7
Total for section 1	18	3	2	13
Section 2. Effect of interference on RES.				
Topic 2.1. Effect of internal noise.	7	1	3	3
Topic 2.2. Performance and noise of digital electronic systems.	19	2	3	14
Total for Section 2	26	3	6	35
Section 3. Shielding.				

Topic 3.1. Characteristics of electromagnetic fields. Propagation of fields in space. Mechanisms of interaction between fields and screens.	27	3	6	18
Topic 3.2. Efficiency and shielding coefficient. Frequency characteristics of screens. Screen response, its frequency characteristics.	20	3	7	10
Topic 3.3. Magnetic and non-magnetic shields. Types of shielding. Multilayer shields. Features of shielding of electric and magnetic fields.	22	2	7	13
Total for Section 3	69	8	20	41
Section 4. Electromagnetic and information compatibility of digital electronic devices.				
Topic 4.1 Calculation of impulse interference levels in parasitic connection circuits digital devices.	12	2	4	6
Topic 4.2 Shielding of fields of impulse interference fields.	16	2	4	10
Total for section	28	4	8	16
Test	3			3
Credit	20			20
Total hours	184	18	36	128

4. Teaching materials and resources

Recommended literature:

Basic

1. Zinkovsky Y.F., Klymenko V.G. Electromagnetic, information security and compatibility of electronic devices: Textbook / Approved by the Ministry of Education and Science of Ukraine for students of higher educational institutions. – Zhytomyr: ZHITI, 1999, 374 p.

2. Shokalo V.M., Pravda V.I., Usin V.A., Vuntesmeri V.S., Gretskykh D.V. Electrodynamics and Radio Wave Propagation. Part 2. Radiation and Propagation of Electromagnetic Waves: Textbook for Students of Higher Educational Institutions. / Edited by edited by V.M. Shokalo and V.I. Pravda. - Kharkiv: KNURE; Collegium, 2010. - 435 p.

Supplementary

3. Zinkovsky Y.F., Klimenko V.G., Pilinskj V.V. Design Procedure of Electromagnetic Fields Shielding Effectiveness–Fourteenth International Wroclaw Symposium and Exhibition Electromagnetic Compatibility, 1998.

4. DSTU 3396. 0-96 Information Protection. Technical Protection of Information. Basic Provisions. - K.: State Standard of Ukraine, 1996. - 14 p.

5. National Commission for State Regulation in the Field of Communications and Informatization Decision No. 844 of 23.12.2014 On Approval of the List of Radio Electronic Means and Emitting Devices. (With amendments No. 78 of 2018, No. 94 of 2019, No. 391 of 2020, No. 125 of 2021).

6. Regulations (requirements) of Part Eight of Article 30 of the Law of Ukraine "On Radio Frequency Resources of Ukraine" No. 94 dated February 26, 2019.

Educational content

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

No. Lecture topic and list of main questions (List teaching aids. Assignments for independent study).

Section 1. Electromagnetic interference and information security.

Topic 1.1. Systemic nature of the concept of electromagnetic compatibility: electromagnetic environment and source interference, interference receptors. Standardization of interference levels (energy and frequency). Internal and external sources of interference in radio-electronic devices; noise in radio elements and devices.
Information security of computer networks. Information characteristics (entropy values) of random EMC factors.

Independent work assignment: national and international regulatory documents on electromagnetic and information protection against unforeseen interference.

References: /1.6,7,8/.

Topic 1.2. Permissible norms for interference emissions and susceptibility to them by electronic equipment.

Devices that are sources of industrial radio interference. Effects that determine the EMC of radio-electronic equipment.

List of parameters and classification of technical characteristics of EMC of electronic equipment. Conductive interference of computer systems (computers). Standardization of susceptibility to radio interference; susceptibility parameters.

Assignment for independent work: methodology for experimental assessment of the energy and frequency state of electromagnetic fields in the surrounding environment.

Literature: /1,2,4,7,8/

Section 2. **Effect of interference on RES. Topic 2.1**. **Effect of internal**

noise.

Noise of passive elements. Noise characteristics of semiconductors and amplifiers. Discretization and quantization noise.

Assignment for independent work: effective thermal noise voltage; the concept of "white" noise.

References: /1,2/.

Topic 2.2. Performance and noise of digital electronic systems.

Types and sources of fluctuation noise in radio equipment. Noise in antennas and input links of terrestrial and cable television. Noise in digital electronic systems with pulse code modulation. Ensuring electromagnetic and information protection of computer networks.

Independent work assignment: sources of internal noise and background noise in digital television and magnetic recording equipment.

Literature: /1,3/.

Section 3. Shielding.

Topic 3.1. Mechanisms of interaction between fields and screens between fields and screens.

The mechanisms of interaction between electromagnetic fields and screens are: absorption, reflection, electromagnetic induction effect; effective field penetration depth; field compensation principle. Wave impedance of fields. Near and far fields, dependence of the level of electric and magnetic (near and far) fields on source. Field impedances at low and high frequencies. Field propagation in dielectrics and metals. Electrical impedances of magnetic and non-magnetic materials. Maxwell's equations in differential form. Displacement current density. Material equations of electrodynamics.

Independent work assignment: Maxwell's equations in integral form; magnetic field in a medium; the fundamental law of electromagnetic induction.

Literature: /1.2/

Topic 3.2. Screen efficiency; screening coefficient.

Using Maxwell's equations when a field interacts with a flat screen. Solving equations for the electric and magnetic components of a field. Efficiency and shielding coefficient, their frequency characteristics. Screen response, its dependence on frequency (at low and high frequencies). Units of measurement of the shielding coefficient.

Assignments for independent work: cylindrical and spherical screens; basic trigonometric hyperbolic functions; relationship between units of measurement , "decibel," and "neper."

References: /1,2,3/

Topic 3.3. Magnetic and non-magnetic screens.

Metal screens – characteristics of non-magnetic and magnetic materials, their frequency characteristics; low frequency range. Comparative characteristics of non-magnetic and magnetic screens, their capabilities in reflecting and absorbing electromagnetic energy fields. Multilayer screens, principles of operation, their efficiency and shielding coefficient. Electrodynamic model of a three-layer screen. Composite material screen. Materials for multilayer screens.

Independent work assignment: develop a formula for the efficiency of a three-layer screen; technology for manufacturing composite electromagnetic screens.

Literature: /1.5/

Section 4. Electromagnetic and information compatibility of digital electronic devices.

Topic 4.1. Calculation pulse interference in parasitic connection circuits of digital devices.

Equivalent circuits of parasitic coupling loops of impulse noise. Noise in the input circuits of integrated circuits. Noise immunity of logic elements. Amplitude-time characteristics of TTL logic elements. Impulse noise in capacitive parasitic coupling loops. Grounding options for shielded connections. Equivalent circuit of a capacitive connection of a shielded circuit.

Independent work assignment: spectral composition of a rectangular pulse; basic concepts of "Fourier series" and "Fourier integral."

Literature: /2/.

Topic 4.2. Shielding of impulse interference fields.

Complex transmission coefficient of a non-magnetic metal screen of various geometric shapes—flat, cylindrical, spherical—for different frequencies. Use of the spectral method of Fourier transforms and the operator method of transforms.
Carson (Laplace).

Transmission coefficient of pulsed magnetic fields of rectangular enclosures – screens. Intensity of pulsed magnetic field depending on amplitude-time parameters of interference fields, their dependence on structural characteristics of enclosures – screens.

Assignment for independent work: inverse Fourier transform; Carson (Laplace) transform method; electromagnetic compatibility of RES and CTF interfaces.

Literature: /1.2/.

Laboratory classes (or partially practical classes in distance learning mode).

Class 1. Assessment of the susceptibility of a television antenna to interference from a car ignition system. Proposal for the required design and radio technical parameters of an interference-resistant antenna.

Lesson 2. Permissible frequency instability of a tape-drive generator in a pulse-synchronized television receiver.

Lesson 3. Ensuring electromagnetic compatibility of a ten-digit binary counter assembled on logic microcircuits on a printed circuit board (foil glass-fiber laminate).

Lesson 4. Determination of the characteristics of impulse noise in equipment under the influence of lightning. Determination of noise parameters in the power supply circuit of a microchip amplifier.

Lesson 5. Based on EMC criteria, calculate the dimensions of blocks and design options for digital circuits based on the criterion of minimum length of interface lines.

Lesson 6. Implementation of a grounding circuit with common-mode interference. The relationship between the differential signal voltage and the common-mode interference.

Lesson 7. Pulse action of narrowband and broadband interference (fluorescent lamp and internal combustion engine) on a computer amplifier. combustion engine) on a computer amplifier.

Lesson 8. Effect on the low-frequency amplifier of an electromechanical amplifier as a source of magnetic field. Selection and calculation of the effectiveness of protection against the effects of magnetic fields.

Lesson 9. Mutual influence of low-frequency high-power signals and high-frequency low-power signals simultaneously transmitted via cable communication lines.

Lesson 10. Evaluation of the effectiveness of cable grounding. Determination of grounding resistance. Conditions for the occurrence of interference on cable channel wires.

Lesson 11. Using low-frequency filters to suppress interference in the receiver (frequency range 2-30 MHz).

Lesson 12. Protection of the receiver input (operating band 2-30 MHz) from the effects of a television transmitter (UHF range).

Lesson 13. Creation of a high-pass filter (HPF) (multi-stage), cutoff frequency 1 MHz, with a given frequency response.

Lesson 14. Creation of a bandpass (Baterworts) filter with an average frequency of 15 MHz (passband 3 MHz with 3 dB attenuation).

Lesson 15. Measurements in the field of electromagnetic compatibility.

Lesson 16. Practical selection of pairs "interference source – interference receptor" based on amplitude (energy) and frequency characteristics, as well as their propagation paths in modern radio equipment.

Lesson 17. Finding the coefficients of propagation of a plane electromagnetic wave.

Lesson 18. Electrodynamic characteristics of vacuum and magnetodielectric media. Characteristic (wave) impedance, attenuation coefficient.

Lesson 19. Means of measuring the levels of electromagnetic fields in the radio frequency range, which provide information about the purpose of the device, its operating frequency range, the measured parameter, the measurement range, and the measurement error.

Lesson 20. National (Ukraine) standards for industrial interference emissions (including cellular telephony).

Lecture material is required to complete each laboratory (practical) assignment. The entire course is divided into four sections; accordingly, all lectures and laboratory (practical) classes are divided as follows and are presented in the table below:

<table>
<tr><td>lab practice, lecture</td><td>1, 2</td><td>3, 4</td><td>5, 6</td><td>7, 8</td><td>9, 10</td><td>11, 12</td><td>13, 14</td><td>15, 16</td><td>17, 18</td></tr>
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6. Independent work by students

Independent work by students includes materials (questions) that are formulated as tasks for students in each topic lecture classes.

The teacher checks the student's completion of the materials assigned for independent work during lectures.

The course program includes a test, which is given to students in the 10th week of classes. The test contains four questions for each student, which are based on the nine topics of the course program. The recommended length of the written answer is 4-4.5 pages of A4 paper (font size 12). The deadline for completing the test is 2 weeks after it is given. The test completed by the student is graded (maximum) 20 points. The results of the test are communicated to students one week after the test is submitted.

Policy and control

7. Academic discipline policy (educational component)

At the beginning of the semester, a Telegram chat is created for the discipline for prompt interaction between students and teachers. All students must be present in the chat
;

- Attendance at lectures and laboratory/practical/ classes is mandatory ;
- Students are encouraged to ask questions to the lecturer during classes;
- All completed assignments must be submitted to the instructor for review by the specified deadlines; 3 points will be deducted for late submission of assignments; •

Bonus points are awarded to students for:

1. active participation in lectures (questions to the lecturer, answers to questions, suggestions, comments, etc.);
2. no absencesclasses without valid reasons;
3. high-quality completion of test assignments;
4. participation in student scientific conferences;
5. productive independent work
6. Submission to the Dean's Office or the curator of the study group.

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

- Test work, provided that it is completed correctly and submitted on time, is worth 20 points;
- Absenceof class absences (without valid reasons) – 10 points;
- Active participation in classes – 10 points;
- Student scientific conferences – 10 points.

Semester assessment: credit.

Conditions for admission to semester control: completion of all types of work in the discipline.

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

Number of points	Grade
10	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 questions:

1. Electromagnetic and information security of radio-electronic elements and devices, system properties.
2. Devices that are sources and receptors of electromagnetic industrial and radio interference.
3. Model of systemic interaction processes between radio devices and systems.
4. The impact of electromagnetic interference and noise on the performance of radio equipment.
5. Ways of interference propagation in radio equipment.
6. Interference shielding, principles and mechanisms.
7. Electromagnetic compatibility parameters, harmonics, interference spectra.
8. Susceptibility of receiving devices to unexpected electromagnetic fields, cross distortion, intermodulation.
9. Jumps in DC and AC voltage as a source of interference.
10. The mechanism of electromagnetic energy absorption by a screen.
11. Screen reaction coefficient.
12. Electromagnetic screen efficiency.
13. Complex shielding coefficient (in nperas and decibels).
14. Solution of Maxwell's equations in cases of flat and cylindrical screens.
15. Frequency characteristics of the shielding coefficient.
16. Magnetic and non-magnetic screens.
17. The principle of operation of multilayer screens.
18. Characteristics and parameters of wave shielding modes.
19. Ensuring electromagnetic compatibility of digital technical equipment.
20. Electromagnetic compatibility of interfaces.
21. Shielding of impulse interference in digital equipment.
22. Electromagnetic compatibility of shared lines, public trunk channels, electronic equipment interfaces, and local computer networks.
23. Probabilistic nature of electromagnetic and information protection and compatibility of electronic equipment.
24. Internal noise of radio components as a factor in the formation of an interference environment.

List of questions on the topics of practical classes:

1. Electromagnetic environment (current state).
2. National and international documents on electromagnetic and information security.
3. Permissible interference emission standards. Standardization of electromagnetic fields according to the susceptibility of electronic equipment to industrial interference.
4. Operability and noise of digital circuits.
5. Ensuring electromagnetic and information security of computer networks and satellite communication systems.
6. Field structure. Spherical and plane waves.
7. Sources of electric and magnetic fields. Dependence of field strength on distance from the source.
8. Influence of parasitic parameters of printed circuit boards and microcircuits.
9. Characteristics of screens.
10. Electromagnetic induction, effective penetration depth.
11. Materials of multilayer screens.
12. Frequency characteristics of multilayer screens.
13. Difference in the actions of the front and rear faces of the screen.
14. Examples of the characteristics of shielding electrical, magnetic, and electromagnetic fields.
15. Calculation of impulse interference in the presence of parasitic inductive, capacitive, and ohmic circuits.

connections.

16. Grounding of electronic equipment.
17. Shielding of ultra-high frequency fields.
18. Features of shielding electrostatic and magnetostatic films.

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

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

Work program for the academic discipline (syllabus):
Compiled by Novosad A. A.;
Approved by the PRE 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)