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

Department of Applied Radio Electronics

[RE-345] COMMUNICATION METHODS IN INTELLIGENT RADIO ELECTRONIC SYSTEMS

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	Intelligent technologies of radio electronics
Discipline status	Regulatory
Form of higher education	Full-time
Year of training, semester	3rd year, spring semester
Scope of the discipline	5 credits (Lectures 30 hours, Practical work 30 hours, Laboratory work 16 hours, Independent work 74 hours)
Semester control/control measures	Exam
Class schedule	https://rozklad.kpi.ua
Language of instruction	Ukrainian
Information about the course coordinator/teachers	Lecturer: Antypenko R. V., Practical training: Titenko O. T.,
Course location	

Curriculum

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

The curriculum for the academic discipline "Communication Methods in Intelligent Radio-Electronic Systems" has been developed in accordance with the educational program of the first (bachelor's) level of higher education in the specialty 172 Electronic Communication and Radio Engineering.

The academic discipline belongs to the normative disciplines. Subject of the academic discipline:

Theory of information transmission, fundamentals of digital communications.

The aim of the credit module is to develop students' abilities to:
solve basic issues of primary signal processing for transmission, taking into account the requirements for the quality indicators of message transmission.

As a result of studying the discipline, students should **know**:

a generalized diagram of information transmission systems and the purpose of their main components;

generalized characteristics of information transmission channels;

characteristics of interference in information transmission channels;

basics of information coding, construction of redundant and non-redundant codes in information transmission systems, their characteristics;

typical transmission codes in information transmission systems;

principles of constructing information transmission networks.

As a result of studying the discipline, students should **be able to**:

calculate the bandwidth of information transmission channels;

determine the structures of non-redundant and redundant codes, taking into account the requirements for error-free transmission and the characteristics of communication channels;

General competencies

GC 01 Ability to think abstractly, analyze, and synthesize

GC 04 Knowledge and understanding of the subject area and understanding of professional

activity.

GC 07 Ability to learn and master modern knowledge.

Professional competencies

PC 01 Ability to understand the essence and significance of information in the development of a modern information society

PC 03 Ability to use basic methods, techniques, and tools for obtaining, transmitting, processing, and storing information.

PC 04 Ability to perform computer modeling of devices, systems, and processes using universal application software packages

PC 12 Ability to perform work on managing the load flows of information and telecommunications networks

PC 14 Readiness to study scientific and technical information, domestic and foreign experience on the subject of investment (or other) projects in the field of telecommunications and radio engineering.

PC 15 Ability to perform calculations in the process of designing structures and means of information and telecommunications networks, telecommunications and radio engineering systems, in accordance with technical specifications using both standard and independently developed methods, techniques, and software tools for design automation

PC 16 Ability to apply standard calculation methods in the design of telecommunications and radio engineering devices and systems

PC 20 Ability to select methods and means of information processing using intelligent technologies

PC 21 Ability to apply a comprehensive approach to the development of radio-electronic equipment

Program learning outcomes

PLO 01 Analyze and make informed decisions when solving specialized tasks and practical problems in telecommunications and radio engineering, which are characterized by complexity and incomplete certainty of conditions

PLO 02 Apply the results of personal research and analysis of information to solve qualitative and quantitative problems of a similar nature in information and communication networks, telecommunications and radio engineering systems;

PLO 13 Apply fundamental and applied sciences to analyze and develop processes occurring in telecommunications and radio engineering systems

PLO 14 Apply understanding of the basic properties of the component base to ensure the quality and reliability of telecommunications and radio engineering systems and devices.
PLO PRN 20 Explain the principles of construction and operation of hardware and software complexes of control and maintenance systems for the development, analysis, and operation of information and telecommunications networks, telecommunications and radio engineering systems.

PLO 23 Explain the principles of construction and operation of hardware and software complexes of control and maintenance systems for the development, analysis, and operation of information and telecommunications networks, telecommunications, and radio engineering systems.

PLO 24 Implement methods of digital signal processing at the software and hardware levels.

PLO 25 Select and implement means and methods of information transfer in communication networks and apply network technologies

PLO 26 Design and implement elements of intelligent technologies using software-configurable equipment

PLO 27 Apply basic methods and techniques for obtaining information

PLO 29 Select the configuration, structure, main components, nodes, and elements of radio-electronic equipment depending on its purpose

PLO 30 Apply a comprehensive approach to the design of telecommunications and radio-electronic equipment

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

The discipline "Communication Methods in Intelligent Radio-Electronic Systems" is based on the following courses: "Microwave Devices and Antennas," "Design of Intelligent Radio-Electronic System Components," "Programmable Devices in Intelligent Radio-Electronic Technology."
"Digital Signal Processing."

The knowledge gained while studying the discipline "Communication Methods in Intelligent Radio-Electronic Systems" is necessary for students when studying the discipline "Communication Means in Intelligent Radio-Electronic Systems" and completing a term paper on this discipline.

3. *Contents of the academic discipline*

Topic 1. Elements of information theory.

Information as a universal category, attributive and functional approaches to defining information, information science on absolute and relative, natural and artificial information. Hartley's measure of information. Units of information (bit, nat, hartley). Amount of information, entropy, conditional entropy.

Topic 2. Fundamentals of probability theory.

Basic concepts and theorems of probability theory, repeated independent trials, laws of distribution of random variables, basic laws of distribution.

Topic 3. General information about transmission systems.

Structure of an information transmission system. Interference and errors in communication channels. Transmission of information through interference-free channels. Transmission of information through channels with interference. Generalized structural diagram of an information transmission system.

Topic 4. Signals in transmission systems.

General information about signals in transmission systems. Speech signals: speech spectrum, formant spectrum, amplitude composition, dynamic and frequency range, formant distribution. Audio speech signals. Television signals, basic image parameters, visual assessment of television image quality, television signal spectrum, dynamic range.

Topic 5. Information transmission channels.

One-way and two-way simplex and duplex channels. Analog communication channels: bandwidth, dynamic range, residual attenuation, relative level points, nonlinear distortion, group delay deviation. Signal and channel volume. Tone frequency channels. Digital communication channels. Bit error rates. Evaluation of communication channel quality according to international standards: error-affected second, highly error-affected second, residual error rate. General definitions of information transmission channels. Analog information transmission channels. Digital information transmission channels. Advantages of digital transmission methods over analog ones.

Topic 6. Analog-to-digital conversion of primary signals.

Principles of analog-to-digital conversion. Conversion of speech signals. Comparative characteristics of PCM, DPCM, ADPCM. Frequency vocoders, using the linear prediction method. Linear prediction coding. Speech quality. Sensitivity to transmission errors. Signal processing requirements. Information compression methods. Music signal conversion.
signals. Image signal conversion.

Topic 7. Coding in information transmission systems.

Concept of code, code combination, elements of code combinations. Structural characteristics of codes. Characteristics of code signals. Elements of code combinations. Redundant and non-redundant codes. Uniform and non-uniform codes. Continuous and block, separate and non-separate redundant codes. Systematic and non-systematic separate block codes.
Systematic cyclic codes. Code length, code base, code power, total number of code combinations, number of information symbols, number of check symbols, code redundancy, transmission rate, code combination weight, code distance, weight characteristic, probability of error detection, optimality, false transition coefficient. Construction of simple binary codes, mirrored binary codes, binary-decimal codes, self-complementary binary-decimal codes. International telegraph codes, codes for input and output from computers. Conditions for constructing binary-decimal codes. Types of binary-decimal codes. Aiken code. Code with redundancy 3. Gray code. Shannon-Fano and Huffman codes.

Topic 8. Redundant codes.

Basic provisions on redundant codes. Conditions for the expediency of using redundant codes. Error-correcting codes. Classification of error-correcting codes. Relationship between code correction capability and code distance. Types of error protection. Error detection and correction codes. Recommendations for code selection. Viterbi algorithms.

Topic 9. Transmission codes.

Functions of transmission codes. Principles of coding Transmission codes used in practice: NRZ code, RZ code, bi-level code, two-level code with inversion of pulses, three-level codes – AMI, HDB-3, alphabetic transmission codes – 3B2T, 4B3T, 2B1Q, TC-PAM, VFM-4, VFM-8, QAM, CAP.

Topic 10. Methods of message delivery.

Message delivery. Direct channel. Channel switching. Message switching. Packet switching. Hybrid switching. Comparison of switching methods. Network synchronization.

Topic 11. Definition of information transmission channels and networks.

Concept of information transmission channels. Concept of an information transmission network and its components. Communication network management. Management system architecture. Organizational and technical communication network management systems

Topic 12. Communication lines.

General provisions. Electrical lines for transmitting information. Fiber optic lines for transmitting information.

Topic 13. Wired communication systems.

Linear path of digital transmission systems via electrical cables. Transmission systems via optical cables. Methods of compressing fiber optic communication lines.

RECOMMENDED TOPICS FOR PRACTICAL CLASSES

1. Quantitative measure of information

2. Information characteristics of discrete message sources.

3. Information characteristics of continuous message sources.

4. Information characteristics of telecommunication channels

5. Potential capabilities of information transmission via communication channels

3. Encoding of discrete message sources.

4. Information characteristics of continuous message sources.

5. Information characteristics of telecommunication channels (discrete).

6. Encoding of information sources and communication channels.

7. Encoding of continuous messages

8. Binary cyclic codes

9. Channel (linear, signal) codes

RECOMMENDED LIST OF LABORATORY WORKS

The main objectives of the laboratory work cycle are to develop the relevant skills and experience in students.

Laboratory classes are conducted on models of digital transmission system modules and in the form of a computer workshop in accordance with the "Methodological guidelines for performing laboratory work in the discipline "Fundamentals of Information Transmission and Coding Theory."

Topics of the classes:

1. Studying methods for measuring the parameters of digital transmission system joints

2. Studying the principles of designing and modeling communication networks based on the NETCRACKER PROFESSIONAL software tool

3. Modeling a simple communication network

RECOMMENDED INDIVIDUAL ASSIGNMENTS

The main objectives of the tests are to encourage students to work consistently throughout the semester and to check their acquired knowledge. One test is planned. Individual test assignments are formed according to the relevant sections of the discipline and are assessed in points, which constitute one of the components of the starting rating.

4. Teaching materials and resources Recommended reading

Maidanyuk, V. P. Fundamentals of Information Theory and Coding: Electronic Tutorial for Combined (Local and Network) Use [Electronic resource] / Maidanyuk V. P., Romanyuk O. N., Tuzhansky S. E. – Vinnytsia: VNTU, 2022. – 133 p.

Kovalenko, A. E. Theory of Information and Coding: Lecture Course [Electronic resource]: textbook for bachelor's degree students majoring in 124 "System Analysis" / Igor Sikorsky KPI; compiled by: A. E. Kovalenko. Electronic text data (1 file: 5.758 MB). Kyiv: Igor Sikorsky KPI, 2020. 248 p.

Prykhodko, S. I., Trubchaninova, K. A., Bataev, O. P. Fundamentals of Information Theory and Coding: Textbook. – Kharkiv: UkrDUTZ, 2017. – 109 p., table 51.

O. V. Nechyporenko, Ya. V. Korpan Data Systems and Their Compact Representation Lecture Notes Ministry of Education and Science of Ukraine, Cherkasy State Technological University. – Cherkasy: ChSTU, 2018. – 240 p.

Naiko D.A., Shevchuk O.F. Probability Theory and Mathematical Statistics:
Textbook. / D.A. Naiko, O.F. Shevchuk – Vinnytsia: VNAU, 2020. – 382 p.

Sianov O.M., Marchenko S.V. Methodological guidelines for practical work in the discipline "Theory of Information Transmission" for second (master's) level higher education students majoring in specialty – 172 "Telecommunications and Radio Engineering." /Compiled by: Sianov O.M., Marchenko
S.V. – Kamyanske; DDTU, 2018. – 42 p.

Sianov O.M. Methodological guidelines for practical work in the discipline "Theory of Information Transmission" for second (master's) level higher education students majoring in "Telecommunications and Radio Engineering." /Compiled by: Sianov O.M., Marchenko S.V. - Kamensk; DDTU, 2018. – 42 p.

International Telecommunication Union (ITU-T), Recommendations G.703, G.712, G.726, G. 821, V.16, V.19, V.27, V.29, V.33.

International Telecommunication Union (ITU-R), Report No. 1053

Bernard Sklar Digital Communications: Fundamentals and Applications, 3rd Edition. 2020.

P. Bocker Datenübertragung: Nachrichtentechnik in Datenfernverarbeitungssystemen. ...

Educational content

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

No	Lecture topic and list of key questions
1	**Topic 1. Elements of information theory.** Information as a universal category, attributive and functional approaches in defining information, information science on absolute and relative, natural and artificial information. Hartley's measure of information. Units of information (bits, nat, hartley). Amount of information, entropy, conditional entropy.
2	**Topic 2. Fundamentals of probability theory.** Basic concepts of probability theory, basic theorems of probability theory.
3	**Topic 2. Fundamentals of probability theory (continued).** Repeated independent trials, laws of distribution of random variables.
4	**Topic 2. Fundamentals of probability theory (continued).** Basic distribution laws.
5	**Topic 3. General information about transmission systems.** Structure of an information transmission system. Interference and errors in communication channels. Transmission of information through interference-free channels. Transmission of information through channels with interference. Generalized structural diagram of an information transmission system.
6	**Topic 4. Signals in transmission systems.** General information about signals in transmission systems. Speech signals: speech spectrum, formant spectrum, amplitude composition, dynamic and frequency range, formant distribution. Audio speech signals. Television signals, basic image parameters, visual assessment of television image quality, television signal spectrum, dynamic range.
7	**Topic 5. Information transmission channels.** Basic definitions of information transmission channels. Analog information transmission channels. Digital information transmission channels. Advantages of digital transmission methods.
8	**Topic 6. Analog-to-digital conversion of primary signals.** Principles of analog-to-digital conversion. Conversion of speech signals. Comparative characteristics of PCM, DPCM, ADPCM. Frequency vocoders, using the linear prediction method.
9	**Topic 6. Analog-to-digital conversion of primary signals (continued).** Linear prediction coding. Speech quality. Sensitivity to transmission errors. Signal processing requirements. Information compression methods.
10	**Topic 6. Analog-to-digital conversion of primary signals (continued).** Conversion of musical signals. Conversion of image signals.
11	**Topic 7. Encoding in information transmission systems.** Discrete signal codes and their elements, information coding, basic concepts. Classification of binary codes. Basic characteristics of codes. Fundamentals of constructing redundancy-free codes.
12	**Topic 7. Encoding in information transmission systems (continued).** Basics of constructing redundancy-free codes, simple uniform codes, mirror codes, Shannon-Fano and Huffman non-uniform codes.
13	**Topic 7. Redundant codes.** Basic principles of redundant codes. Conditions for the expediency of using redundant codes. Error-correcting codes, classification of error-correcting codes. Relationship between code correctability and code distance. Types of error protection.
14	**Topic 8. Redundant codes (continued).** Error detection and correction codes. Parity check codes. Code with an even number of units. Code with doubled elements. Inverse code. Construction of systematic codes. Hamming codes.
15	**Topic 8. Redundant codes (continued).** Cyclic codes. Bose-Choudhury-Hawking codes (BCH). Recursive codes. Modern high-efficiency error correction codes. Recommendations for code selection.

16	**Topic 9. Transmission codes.** Transmission codes (frequency-compact codes), transmission code functions.
17	**Topic 9. Transmission codes (continued).** Transmission codes used in practice: NRZ code, RZ code, bi-level code, two-level code with inversion of pulses, three-level codes – AMI, HDB-3.
18	**Topic 9. Transmission codes (continued).** Transmission codes used in practice: alphabetic transmission codes – 3B2T, 4B3T; multilevel codes – 2B1Q, TC-PAM, VFM-4, VFM-8, QAM, CAP.
19	**Topic 10. Methods of message delivery.** Message delivery. Direct channel. Channel switching. Message switching. Hybrid switching. Classification of telecommunications networks.
20	**Topic 11. Determination of channels and networks for information transmission.** The concept of information transmission channels. The concept of an information transmission network and its components.
21	**Topic 11. Definition of information transmission channels and networks (continued).** Communication network management. Management system architecture. Organizational technical systems for managing communication networks SUMZ.
22	**Topic 11. Determination of information transmission channels and networks (continued).** Network synchronization.
23	**Topic 12. Communication lines.** General provisions. Electrical communication lines.
24	**Topic 12. Communication lines (continued).** Fiber optic communication lines.
25	**Topic 13. Wired communication systems.** Linear path of digital transmission systems via electrical cables. Industrial equipment for digital information transmission systems.
26	**Topic 13. Wired communication systems (continued).** Optical cable transmission systems. Generalized block diagram of a digital fiber-optic transmission system. Classification of fiber-optic transmission systems. Principles of constructing two-way linear lines of fiber-optic transmission systems.
27	**Topic 13. Wire communication systems (continued).** Methods of compressing fiber-optic communication lines.

Practical classes

Practical classes are held for better assimilation and in-depth study of the lecture material. The topic of the practical class is communicated to students in advance, at the previous class or lecture.

At the end of the class, each student may receive an individual assignment to be completed independently on the topic of the practical class to assess the quality of their understanding of the material.

No.	**Name of the class topic and list of main questions**
1	Quantitative measure of information
2	Information characteristics of discrete message sources.
3	Information characteristics of two sources of discrete messages.
4	Encoding of discrete message sources.
5	Information characteristics of a continuous message source.
6	Information characteristics of telecommunication channels (discrete).
7	Encoding of information sources and communication channels.
8	Binary cyclic codes.
9	Channel (linear, signal) codes

Laboratory classes

The main objectives of the laboratory classes are to develop the relevant skills and experience in students.

Laboratory classes are conducted in accordance with the "Methodological guidelines for performing

laboratory work in the discipline Fundamentals of Information Transmission and Coding Theory."

No.	**Name of the topic and list of main questions**
1	Studying methods for measuring the parameters of digital transmission system joints
2	Studying the principles of designing and modeling communication networks based on NETCRACKER PROFESSIONAL software
3	Modeling a simple communication network

Independent work

No.	**Title of the topic for independent study**
1	**Topic 1. Elements of information theory.** ***Independent study assignment:*** Hartley's measure of information. Amount of information, entropy, conditional entropy.
2	**Topic 2. General information about transmission systems** ***Assignment for independent study:*** Generalized structural diagram of an information transmission system.
3	**Topic 3. Signals in transmission systems** ***Assignment for independent study:*** Television signals. Telegraph signals.
4	**Topic 4. Information transmission channels.** ***Assignment for independent study:*** Error-affected second, highly error- affected second, residual error rate.
5	**Topic 5. Analog-to-digital conversion of primary signals.** ***Assignment for independent study:*** MPEG standards.
6	**Topic 6. Encoding in information transmission systems.** ***Assignment for independent study:*** Gray code conversion schemes.
7	**Topic 7. Redundant codes.** ***Assignment for independent study:*** Viterbi algorithms.
8	**Topic 8. Transmission codes.** ***Assignment for independent study:*** Transmission codes used in practice.
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10	**Topic 10. Methods of message delivery.** ***Assignment for independent study:*** Message switching. Packet switching.
11	**Topic 11. Definition of information transmission networks.** ***Assignment for independent study:*** Classification of communication networks by topological features.
12	**Topic 12. Information transmission lines.** **Assignment for independent study:** Electrical information transmission lines
13	**Topic 13.** Wired communication systems**.** **Assignment for independent study:** Methods of compressing fiber-optic communication lines

6. Independent work by students

Policy and control

7. Academic discipline (educational component) policy

Rules for attending classes (both lectures and practical/laboratory classes)

Laboratory work is compulsory. If these classes are missed, they must be made up during consultations or with other groups. If lectures are missed, tests on the material covered in the missed class must be taken and passed. Lecture materials and videos are posted on the LMS.

Defense of laboratory work

Laboratory work is defended on the day the laboratory work is completed. The student receives two grades. The first is for activity and initiative during the laboratory work and individual class. The second is for the defense and answers to control questions.

Defense of individual assignments

As part of their independent work, students complete assignments based on lecture materials. Based on the results of the review, course participants receive comments from the instructor and a grade. Individual assignments are not retaken.

Incentive and penalty points and academic integrity policy

The most active students and students who perform individual tasks in an exemplary manner can receive up to 10 points towards their semester rating.

Penalty points are applied in cases of passing off someone else's work as one's own, with mandatory subsequent reworking.

Deadline and resit policy

If the deadlines for submitting assignments are missed, the maximum score for the assignments is reduced by 10%.

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

A student's rating in a discipline consists of points awarded for:

1) Attendance at lectures.

2) Attendance and independent work in practical classes.

3) Completion and defense of laboratory work.

4) Completion of modular control work.

5) Completion of calculation work.

6) Taking exams.

A prerequisite for admission to the exam is the absence of outstanding debts for the course, as well as **a starting rating of** at least 30 points.
A student who scores less than 10 points on the exam (or scores 0 points on one of the three questions) is considered to have received a final grade of "unsatisfactory" regardless of their semester rating.

The student's **calendar assessment** is based on the current rating at the time of assessment. If this rating is at least 50% of the maximum possible at the time of assessment, the student is considered to have passed.

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* exam *questions

1. Elements of information theory
2. The concept of information
3. Amount of information
4. Basic concepts of probability theory
5. Basic theorems of probability theory
6. Repeated independent trials.
7. Bernoulli's diagram and formula
8. Distribution laws of random variables
9. Basic laws of distribution
10. General information about transmission systems
11. Structural diagram of an information transmission system
12. Interference and errors in communication channels
13. Information transmission over interference-free channels
14. Information transmission over channels with interference
15. Generalized structural diagram of a communication system
16. Signals in transmission systems
17. General information about signals in transmission systems
18. Voice signals
19. Image signals
20. Data signals
21. General definitions of information transmission channels
22. Analog information transmission channels
23. Digital information transmission channels
24. Advantages of digital transmission methods compared to analog
25. Principles of analog-to-digital conversion
26. Conversion of speech signals
27. Image signal conversion
28. Methods of information compression
29. Discrete signal codes and their elements
30. Information coding. Basic concepts
31. Classification of binary codes
32. Basic characteristics of codes
33. Basics of constructing non-redundant codes
34. Simple uniform codes
35. Binary-decimal codes
36. Self-complementary binary-decimal codes
37. Mirror codes
38. Non-uniform Shannon-Fano and Huffman codes
39. Basic principles of redundant codes
40. Conditions for the expediency of using redundant codes
41. Noise-resistant codes. Classification of noise-resistant codes.
42. The relationship between the corrective ability of a code and the code distance
43. Types of error protection
44. Error detection and correction codes
45. Systematic codes
46. Cyclic codes
47. Continuous codes
48. Recommendations for code selection

49. Functions of transmission codes
50. Transmission codes used in practice
51. Alphabetic codes.
52. Methods of message delivery
53. Message delivery
54. Direct channel
55. Channel switching
56. Message switching
57. Packet switching
58. Hybrid switching
59. Comparison of switching methods
60. Definition of communication networks
61. Concept of a communication network and its components
62. Classification of telecommunications networks
63. Classification of communication networks by topological features
64. Communication lines General provisions
65. Electric communication lines
66. Fiber optic communication lines
67. Wired communication systems
68. Linear path of digital transmission systems via electrical cables
69. Optical cable transmission systems

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

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Work program for the academic discipline (syllabus):
Compiled by Antypenko R. V.; Titenko O. T.;
Approved by the PRE Department (Minutes No. 06/2025 dated 06/25/2025)
Approved by the methodological commission of the faculty/research institute (protocol No. 06/2025 dated 26.06.2025