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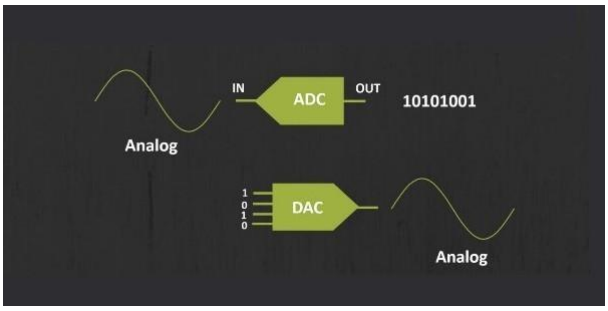
Національний технічний університет України
«КИЇВСЬКИЙ ПОЛІТЕХНІЧНИЙ ІНСТИТУТ
імені ІГОРЯ СІКОРСЬКОГО»

[RE-202] COMBINED ANALOG-DIGITAL 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, fall 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 director / teachers	Lecturer: O. Titenko
Course location	

Curriculum

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

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

The program of the academic discipline Combined Analog-Digital Systems (CADS) is compiled in accordance with the educational and professional program of the first (bachelor's) level of higher education in the specialty 172 Telecommunications and Radio Engineering.

The academic discipline is elective.

Subject of the academic discipline:

Studying the basics of combined analog-digital systems, methods of connecting signal sensors, their analog-digital conversion, principles of analog-digital equipment design.

The aim of the credit module is to develop students' abilities:

understand the principles of operation and differences between various types of analog-to-digital converters; understand the principles of operation of digital-to-analog converters; develop technical specifications for the development of radio-electronic devices; design (develop) components of combined analog- digital systems and telecommunications equipment.

Upon completion of the course, students should **know**:

the principles of operation and differences between various types of analog-to-digital converters; the principles of operation of digital-to-analog converters; the principles of constructing analog-to-digital equipment nodes; the principles of designing combined analog-to-digital systems.

Upon completion of the course**,** students should **be able to:**

create projects in a simulation environment focused on the use of integrated circuits; design (develop) analog-to-digital equipment nodes.

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, means 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 take 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 search 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 20 Explain the principles of construction and functioning 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 transmission 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)

Before starting the course, it is desirable to complete the disciplines "Analog Circuitry" and "Digital Devices" or "Digital Circuitry.

3. Contents of the discipline

Topic 1. *Introduction. General information about combined analog-digital systems. Main differences between analog and digital circuitry. Organizational aspects of design. Areas of application.*

Topic 2. *Analog-to-digital converters. Main parameters of ADCs. Classification of analog-to-digital converters. Digital low-pass filter.*

Topic 3. *Application of analog-to-digital converters in automation systems. Use of ADCs with pressure, temperature, fire alarm, and photosensors.*

Topic 4. *Signal filtering. Main parameters of analog low-pass filters. Main parameters of analog low- pass filters. Implementation of analog filters*.

Topic 5. *Application of operational amplifiers when working with ADCs. Application of basic OA connection schemes. Basics of OA operation on direct current.*

Topic 6. *Digital processing of analog signals. Digital-to-analog converters. Classification of DAC circuits. Pulse width modulator as a digital-to-analog converter.*
Parameters of analog low-pass filters for DACs based on PWM.

Topic 7. *Design of combined analog-digital systems. Power supplies. Voltage conversion. Component noise. Printed circuit board layout. Ground plane in digital and analog circuits. Influence of parasitic parameters.*

Practical work

The discipline "Combined Analog-Digital Systems" belongs to **the disciplines** in which considerable attention is paid to the practical component of training. The main purpose of practical work is to test theoretical knowledge and acquire design skills.

Approximate topics of practical work:

1. Analog-to-digital converter: parameters, definitions, and formulas.
2. Serial approximation ADC.
3. Sigma-delta converters.
4. Choosing an ADC.
5. Signal filtering.
6. Parameters, definitions, and calculation formulas for operational amplifiers.
7. Operational amplifiers in circuits with ADCs.
8. Features of printed circuit board layout for analog and digital circuits.

4. Teaching materials and resources

1. O. M. Vorobyova, V. D. Ivanchenko. Fundamentals of Circuit Design: Textbook. - [2nd ed.]. - Odessa: Phoenix, 2009. - 388 p. . - Bibliography: ISBN 978-966-438-204-
2. Baker, Bonnie. A Baker's dozen: real-world analog solutions for digital designers / by Bonnie Baker. ISBN 0-7506-7819-4
3. Walt Kester, Editor with the technical staff of Analog Devices. Data Conversion Handbook.

Educational content

5. Methodology for mastering the academic discipline (educational

component) Lectures

No No	Title of the lecture topic and list of main questions (list of teaching aids, references to literature and assignments for independent study)
1	Topic: "Introduction" General information about combined analog-digital systems Main differences between analog and digital circuitry
2	Topic: "Introduction" (continued) Key differences between analog and digital circuitry; Organizational aspects of design; Areas of application.
3	Topic: "Analog-to-digital converters" Classification of analog-to-digital converters; Basic parameters of ADCs
4	Topic: "Analog-to-digital converters" (continued) Successive approximation ADCs.
5	Topic: "Analog-to-digital converters" (continued) Sigma-delta ADCs; Digital low-pass filter.
6	Topic: "Analog-to-digital converters" (continued) Integrating ADCs (frequency-pulse conversion ADCs)
7	Topic: "Application of analog-to-digital converters in automation systems." Types of input signals; Use of ADCs with temperature sensors
8	Topic: "The use of analog-to-digital converters in automation systems." (continued) Use of ADCs with pressure sensors; Use of ADCs with photo sensors;
9	Topic: "Signal filtering" Basic parameters of analog low-pass filters; Theory of filters that eliminate the effect of spectrum overlap; Implementation of an analog filter; Operational amplifier for the filter.
10	Topic: "Application of operational amplifiers when working with ADCs" Parameters and definitions for operational amplifiers; Basic OP connection diagrams; Application of basic OP connection circuits; Operational amplifier in a linear system.
11	Topic: "The use of operational amplifiers when working with ADCs" (continued) Features of op-amp operation on direct current; Determining system stability.
12	Topic: "Digital processing of analog signals" Digital-to-analog converters; Classification of DAC circuits; Basic DAC circuits. Methods of practical implementation of DACs; DACs with weighted current summation; DACs based on R-2R resistive matrices.
13	Topic: "Digital processing of analog signals" (continued) Pulse width modulator as a digital-to-analog converter; Parameters of an analog low-pass filter for a DAC based on PWM.
14	Topic: "Designing combined analog-digital systems" Power supplies; Voltage conversion; Component noise
15	Topic: "Designing combined analog-digital systems" (continued) Printed circuit board layout; Ground plane in digital and analog circuits; Influence of parasitic parameters.

5 Practical (laboratory) classes

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

No.	Lesson topic and list of key questions
1	Analog-to-digital converter: parameters, definitions, and formulas.
2	Successive approximation ADC.
3	Sigma-delta converters.
4	ADP selection.
5	Signal filtering.
6	Parameters, definitions, and calculation formulas for operational amplifiers.
7	Operational amplifiers in circuits with ADCs.
8	Features of printed circuit board layout for analog and digital circuits.

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6. Independent work by students

Policy and control

7. Policy of the academic discipline (educational component)

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 I_M5.

Defense of laboratory work

Laboratory work is defended on the day of completion. Students receive two grades. The first is for activity and initiative during laboratory work and individual classes. The second is for 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 assessment, 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 complete individual assignments in an exemplary manner can receive up to 10 points towards their semester rating.

Penalty points are applied in cases of plagiarism, with mandatory rewriting of the work.

Deadline and resit policy

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

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

Rating system

- Lectures/Webinars - 36 hours; (*1 MCR x 25 points*)
- SRS (2 tasks x 5 points)
- Practical work / Training - 18 hours; (*9 assignments x 5 points*) • Homework assignment (*1 project x 20 points*)

A prerequisite for admission to the exam is the absence of outstanding debts for the course.

The student's calendar assessment is based on their current rating at the time of assessment. If this rating is not less than 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)

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

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Working program of the academic discipline (syllabus):
Compiled by O. Titenko;
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)