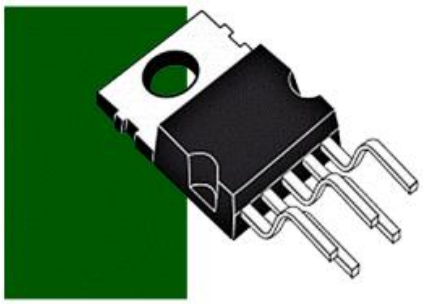
Національний технічний університет України
«КИЇВСЬКИЙ ПОЛІТЕХНІЧНИЙ ІНСТИТУТ
імені ІГОРЯ СІКОРСЬКОГО»

Applied Radio Electronics

[RE-115] CIRCUIT DESIGN. PART 2.



Work program of the academic discipline (Syllabus)

Course details	
Level of higher education	**First (bachelor's)**
Field of knowledge	**G - Engineering, manufacturing, and construction**
Special	**G5 - Electronics, electronic communications, instrument engineering, and radio engineering**
Educational program	**172B RTS - Radio Engineering Information Technologies (EDEBO id: 6842)172B ROS - Radio Communications and Signal Processing (EDEBO id: 6364)172B ITR - Intelligent Technologies of Radio Electronics (EDEBO id: 49229)172B ITMR - Intelligent technologies of microsystem Radio Electronics (EDEBO id: 5627)172B ICR - Information and Communication Radio Engineering (EDEBO id: 49228)172B RCS - Radio Engineering Computerized Systems (EDEBO id: 49227)172B ITRET+ - Intelligent technologies of radio-electronic engineering (EDEBO id: 57907)172B ICRI+ - Information and Communication Radio Engineering (EDEBO id: 57910)172B RTKS+ - Radio engineering computerized systems (EDEBO id: 57920)172B TREB - Radio-electronic warfare technologies warfare (EDEBO id: 63920)G5B TREB - Radio-electronic warfare technologies warfare (EDEBO id: 83615)G5B ITRET - Intelligent technologies electronic engineering (EDEBO id: 83616)G5B ICRI - Information and Communication Radio Engineering (EDEBO id: 83618)G5B RTKS - Radio Engineering Computerized Systems (EDEBO id: 83620)**
Status of the discipline	Regulatory
Form of study	Full-time
Year of training, semester	2nd year, fall semester
Scope of the discipline	4 credits (Lectures 30 hours, Practical classes 30 hours, Laboratory classes 16 hours, Independent work 44 hours)
Semester control/control measures	Credit

Class schedule	https://rozklad.kpi.ua
Language of instruction	Ukrainian
Information about course director / teachers	Lecturer: Ph.D., Prof. Andrii Valeriovych Movchanuk, tel. 0677443441 e-mail – movchanuk@rtf.kpi.ua Practical: PhD, Nikita Valeriyovych Yezersky, e-mail – billytalent7777@gmail.com Laboratory: PhD., Andriy Pavlovych Seredin, e-mail –ceredin.a@gmail.com
Course location	Link to remote resource: Moodle https://do.ipo.kpi.ua/course/view.php?id=6417

Curriculum

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

The purpose of the credit module is:

- Analyze circuit solutions for individual amplification stages and amplification devices for various purposes;
- Develop technical specifications for the design of electronic devices;
- Develop structural and schematic diagrams of amplifying devices for various purposes;
- Design amplification stages and amplification devices for various purposes;
- Determine and measure the main parameters and characteristics of amplifying devices. The subject of the credit module is:
- Principles of circuit design and calculation of amplification cascades and amplifiers for various purposes, and analog signal processing devices. The discipline covers their circuitry, manufacturing technology, and features of use in modern radio engineering systems, their characteristics and properties.

In accordance with the educational and professional program, the discipline provides

General competencies (GC):

- The ability to apply acquired knowledge in practical situations (GC 02).
- Knowledge and understanding of the subject area and understanding of professional activity (GC 04).
- Ability to learn and master modern knowledge (GC 07).
- Ability to identify, set, and solve problems (GC 08).

Professional competencies (PC):

- Ability to perform computer modeling of devices, systems, and processes using universal application software packages (PC 04).
- Ability to install, debug, configure, adjust, test, and commission telecommunications and radio engineering structures, facilities, and equipment (PC 10).
- 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 15).

Programmed learning outcomes (PLO):

- Analyze, argue, and make decisions when solving specialized tasks and practical problems in telecommunications and radio engineering, which are characterized by complexity and incomplete certainty of conditions (PLO 01).
- 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 02).
- Explain the results obtained from measurements in terms of their significance and relate them to the relevant theory (PLO 04).
- Adapt to changes in information and communication networks, telecommunications and radio engineering systems (PLO 06).
- Competently apply the terminology of the telecommunications and radio engineering industry (PLO 07).
- Application of understanding of the basic properties of the component base to ensure the quality and reliability of telecommunications, radio engineering systems and devices (PLO 14).
- Understanding and compliance with domestic and international regulatory documents on the development, implementation, and technical operation of information and telecommunications networks, telecommunications and radio engineering systems (PLO 17).

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

Interdisciplinary connections: the discipline is based on knowledge from the disciplines "Fundamentals of Metrology" and "Higher Mathematics. Part 1. Differential and Integral Calculus of Functions of One Variable," "Higher Mathematics. Part 2. Differential and Integral Calculus of Functions of Several Variables, Differential Equations," "Higher Mathematics. Part 3. Series and Functions of a Complex Variable," "General Physics. Part 2," "Fundamentals of Circuit Theory," "Circuit Engineering. Part 1" and is the basis for studying disciplines and all subsequent special disciplines, which together form the foundation of circuitry and design training in the G5 specialty - Electronics, Electronic Communications, Instrument Engineering, and Radio Engineering, and is used as a basis for studying disciplines related to analog and digital circuitry.

Contents of the academic discipline

Topic 1. Introduction. Tasks of analog circuitry. The place of circuitry in the training of modern specialists. Purpose and objectives of the discipline. Learning outcomes.

Topic 2. Principles of amplification by electronic devices. Equivalent circuits for alternating and direct currents. Classes of operation of amplifier stages. Element base of analog circuitry. Historical overview. Stages of designing analog electronic devices. Simulation packages.

Topic 3. Main characteristics of analog devices. Frequency response, phase response. Logarithmic characteristics. Frequency response and phase response of passive circuits.

Topic 4. Feedback. Classification. Basic definitions (useful and parasitic feedback, feedback loop, single- and multi-loop feedback, loop gain, feedback depth, frequency-dependent and frequency-independent feedback). Block diagrams of amplifiers with different methods of

introducing and removing feedback. Effect of feedback on amplifier parameters (gain, gain instability, input and output impedance, linear and nonlinear distortion, self-noise level). Examples of circuit implementation of ZZ in amplifiers.

Topic 5. Idealized operational amplifiers. The principle of calculating circuits on operational amplifiers. Main functional units on OAs.

Topic 6. Bipolar transistor bias circuits. Fixed voltage and fixed current circuits. Bias circuits for field-effect transistors with an insulated gate. Bias circuits for field-effect transistors with an integrated junction.

Topic 7. Constant current sources on bipolar and field-effect transistors. Current mirrors. Reference voltage sources.

Topic 8. Active element switching circuits. Circuit analysis. Power supply circuits.

Topic 9. Analysis of frequency response in the low, medium, and high frequency ranges. Correction of amplitude-frequency characteristics. Calculation of frequency distortions. Calculation of nonlinear distortions.

Topic 10. Noise factor, equivalent input power of amplifier stage noise. Amplifier noise band. Noise models of BT and PT. Calculation of noise characteristics of transistor stages. Ensuring low-noise operation of AE. Circuitry of low-noise amplifier stages. Noise factor of multistage amplifiers. Noise of a differential stage.

Topic 11. Composite stages on BT and PT. Active load. Differential amplifier. Circuitry and analysis.

Topic 12. Multistage amplifiers. Interstage coupling.

Topic 13. Push-pull amplifiers.

Topic 14. Resonant amplifiers. Stability of resonant amplifiers. Stability coefficient, stable gain coefficient, calculation methods. Methods for increasing stability. Schemes with neutralization.

Topic 15. Control in analog signal processing devices. Gain control. Mode control. Control with interstage attenuators. Passband control. Types, circuit implementation. Control of the frequency response curve.

Teaching materials and resources

Basic

1. Sedov, S. O. Analog signal processing. Circuitry. Calculations [Electronic resource]: textbook / S. O. Sedov; Igor Sikorsky KPI. – Electronic text data (1 file: 4.93 MB). – Kyiv: Igor Sikorsky KPI, Polytechnika Publishing House, 2018. – 298 p.
2. Signal processing based on operational amplifiers. Circuitry. Calculations: Textbook / Serhii Oleksiiovych Sedov. – Kyiv: Igor Sikorsky Kyiv Polytechnic Institute, 2017. – 132 p.: ill.
3. The Art of Electronics by Paul Horowitz, Winfield Hill, 3rd edition, 2015, 1220 pages, ISBN-10: 978052180926
4. Learning the Art of Electronics: A Hands-On Lab Course - Hayes, Thomas C., Horowitz, Paul, 2016, ISBN: 9780521177238

5. The Art of Electronics: The x Chapters - Horowitz, Paul, Hill, Winfield, 2020, ISBN: 9781108499941
6. Joseph D. Greenfield / Practical Transistors and Linear Integrated Circuits Paperback - January 1, 1988. P.233
7. Jones M. H. et al. A practical introduction to electronic circuits. – Cambridge University Press, 1995.
8. Baker B. A Baker's Dozen: Real analog solutions for digital designers. – Elsevier, 2005.

Supplementary

1. Kaufman M., Seidman A. H. (ed.). Handbook of electronics calculations for engineers and technicians. – McGraw-Hill Companies, 1988.
2. Boylestad R. L., Nashelsky L. Electronic devices and circuit theory. – Prentice Hall, 2012.
3. Fish P. J. Electronic noise and low noise design. – Macmillan International Higher Education, 2017.
4. Palumbo G., Pennisi S. Feedback amplifiers: theory and design. – Springer Science & Business Media, 2002.
5. Schubert Jr T. F., Kim E. M. Fundamentals of Electronics: Book 2: Amplifiers: Analysis and Design. – Morgan & Claypool Publishers, 2015.
6. Pryschepa M. M., Pogrebnyak V. P. Microelectronics. In 3 parts. Part 1. Elements of Microelectronics: Textbook. / Edited by M. M. Pryschepa. - Kyiv: Vyshcha Shkola, 2004. - 431 p.: ill.
7. Pryschepa M. M., Pohrebnyak V. P. Microelectronics: In 3 parts. Part 2. Elements of Microcircuit Technology: Textbook. / Edited by M. M. Pryschepa. - Kyiv: Vyshcha Shkola, 2006. - 503 p.: ill.
8. Sukhov, M. E. / Circuitry for High-Quality Sound Reproduction [Text] / M. E. Sukhov, S. D. Bat, V. V. Kolosov, O. G. Chupakov. - Kyiv: Technika, 1992. - 127 p.
9. Asadi F. Essential Circuit Analysis Using Ni Multisim (tm) and MATLAB®. – Springer Nature, 2022.
10. Báez-López D., Guerrero-Castro F. E., Cervantes-Villagómez O. D. Advanced circuit simulation using Multisim Workbench //Synthesis Lectures on Digital Circuits and Systems. – 2012. – Vol. 7. – No. 1. – P. 1-144.
11. Asadi F. Electric and Electronic Circuit Simulation using TINA-TI®. – CRC Press, 2022.
12. Bruun E. CMOS Integrated Circuit Simulation with LTspice. – 2017.
13. Mohindru P., Mohindru P. Electronic Circuit Analysis Using LTSpice XVII Simulator: A Practical Guide for Beginners. – CRC Press, 2021.
14. Asadi F. Simulation of Electric Circuits with LTspice® //Essential Circuit Analysis using LTspice®. – Springer, Cham, 2023. – P. 1-175.

Educational content

Methodology for mastering the academic discipline (educational component)

Lectures (30 hours) are conducted in accordance with the content of the academic discipline in offline mode in accordance with the dean's schedule or in online mode in Zoom.

List of questions covered in lectures (30 hours)

No	Lecture topic and list of main questions

1	Introduction. Tasks of analog circuitry. The place of circuitry in the training of modern specialists. Purpose and objectives of the discipline. Learning outcomes.
2	Principles of amplification by electronic devices. Equivalent circuits for alternating and direct currents. Classes of operation of amplifier stages. Component base of analog circuitry. Historical overview. Stages of designing analog electronic devices. Simulation packages.
3	Basic characteristics of analog devices. Frequency response, phase response. Logarithmic characteristics. Frequency response and phase response of passive circuits.
4	Feedback. Effect of feedback on parameters.
5	Idealized operational amplifiers. Principle of calculating circuits based on operational amplifiers.
6	Bipolar transistor bias circuits. Fixed voltage and fixed current circuits. Insulated gate field effect transistor bias circuits. Integrated junction field effect transistor bias circuits.
7	Constant current sources on bipolar and field-effect transistors. Current mirrors. Reference voltage sources.
8	Active element switching circuits. Circuit analysis. Power supply circuits.
9	Analysis of frequency response in the low, medium, and high frequency ranges. Correction of amplitude-frequency characteristics. Calculation of frequency distortions. Calculation of nonlinear distortions.
10	Calculation of noise characteristics of transistor cascades. Noise models.
11	Composite stages on BT and PT. Active load. Differential amplifier. Circuitry and analysis.
12	Multistage amplifiers. Interstage coupling.
13	Push-pull amplifiers. Principles of construction and circuitry.
14	Resonant amplifiers. Stability of resonant amplifiers.
15	Control in analog signal processing devices.

Laboratory classes (16 hours)

The purpose of laboratory classes is to experimentally verify theoretical knowledge, acquire skills in calculation, research, measurement, and evaluation of specific parameters of amplifying devices and their cascades.

Laboratory classes are conducted in the form of a laboratory workshop on models in the laboratory. For distance learning, these laboratory works are adapted for use in the NI Multisim simulator program.

Students receive assignments for laboratory work in advance. Before the start of the class, a survey is conducted to assess the student's readiness to perform the work. After completing the work, the results are defended and discussed. A report on the laboratory work is prepared.

The following laboratory work is performed:

1. Lab work #1: Measuring the parameters of an audio frequency amplifier;
2. Laboratory work No. 2: Investigation of the parameters of an amplifier with negative feedback;
3. Laboratory work No. 3: Investigation of transistor cascade bias circuits;
4. Laboratory work No. 4: Investigation of transistor amplifier cascades in the mid-frequency range.

In distance learning mode, laboratory work is carried out in the form of a computer workshop on a home personal computer in accordance with the requirements set out in the distance learning course *https://do.ipo.kpi.ua/course/view.php?id=6417*.

The following tasks are performed:

1. Bias circuits for transistor stages;
2. Bipolar transistor switching circuits;
3. Analysis of the frequency response of a transistor amplifier;
4. Investigation of an amplifier on an integrated circuit.

Additional work is carried out in familiarization mode using relevant materials (text documents with photos and videos on YouTube, explanations in Zoom).

Laboratory work begins with an introductory session on Zoom and is then carried out by students independently. When working in the laboratory, classes are held on laboratory models in room 512-17.

Practical classes (30 hours)

Practical classes (30 hours) are conducted in accordance with the content of the academic discipline in offline mode in accordance with the dean's office schedule or in online mode in Zoom.

1	Logarithmic units and their use
2	Logarithmic units and their use
3	Calculation of parameters of an equivalent transistor replacement circuit
4	Calculation of parameters of the equivalent circuit of a transistor
5	Calculation of circuits based on operational amplifiers
6	Calculation of circuits based on operational amplifiers
7	Calculation of transistor bias circuits
8	Calculation of transistor bias circuits
9	Calculation of transistor cascades
10	Calculation of transistor cascades
11	Calculation of low-noise amplifiers
12	Calculation of low-noise amplifiers
13	Calculation of the output stage of a power amplifier
14	Calculation of the output stage of a power amplifier
15	Calculation of selective amplifiers

Individual assignments are planned for the study of the discipline (homework test on section 1). The purpose of this individual assignment is:

- to master the curriculum in its entirety;
- acquiring skills in working with literature, preparing technical documentation in accordance with DSTU 3008-2015, preparing short abstracts for publication at scientific and technical conferences, performing calculations and evaluating their results;
- to deepen and expand on the material presented in the lectures.

Individual assignments are completed on topics individually assigned to students.

The student has the right, in agreement with the teacher, to choose another topic related to the subject matter, or to clarify the list of questions selected from the list.

The deadlines for submitting work are specified in Moodle.

Independent work

Students are allocated 44 hours for independent work.

- Reviewing lecture materials – 15 hours;
- Preparation and study of practical class materials – 9 hours;
- preparation for laboratory work, performing the necessary calculations and completing laboratory work reports, preparation for the defense of laboratory work – 8 hours;
- Completion of RGR – 10 hours;
- preparation for modular tests – 2 hours.

Policy and control

Policy of the academic discipline (educational component)

System of requirements that the teacher sets for the student:

- **rules for attending classes** – all classes are held in the classroom or remotely, lectures and laboratory work are conducted in accordance with the schedule provided by the dean's office. Control is exercised by the teacher during the class, if it is held in the classroom, or based on the results of tests and the submission of reports on the completion of laboratory work, if it is remote. Class attendance is mandatory.
- **Rules of conduct during classes** – it is necessary to follow the generally established rules of conduct during classes. During tests, cheating and the use of laptops and phones are not permitted. During laboratory work, the use of these devices is permitted and desirable.
- **Rules for defending** laboratory work and individual assignments are specified in the section on the rating system for assessing learning outcomes. Bonus points are awarded for active participation in department seminars, and penalty points are awarded for late submission of tests and laboratory reports.
- **Deadlines for submitting materials** are set individually and communicated to students in Moodle and sent to the students' group email or messenger group. Students who have earned a rating of less than 60 points for the semester may improve their rating before the start of the session within a timeframe agreed upon with the instructor and be admitted to the exam.

The academic integrity policy is the responsibility of the students and is monitored by the instructor by comparing the content of individual assignments.

Students have the opportunity to gain knowledge on specific topics and sections of the academic discipline in training courses on the Sikorsky distance learning platform (*https://do.ipo.kpi.ua/course/view.php?id=6417*) as part of blended or additional learning in accordance with the Regulations on the recognition of learning outcomes acquired in non-formal/informal education at Igor Sikorsky KPI (https://osvita.kpi.ua/node/179).

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

A student's rating in a discipline consists of points that he or she receives for:

1. Completion and defense of 4 laboratory works.
2. Completion of an individual assignment (RGR).
3. Modular control. Nine MCRs lasting 10 minutes each are performed.

Current assessment: completion and defense of laboratory works (10x4 points), ten MCRs (10x4 points), ITA (20x1 points)

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

Semester assessment: test.

Conditions for admission to semester assessment: a minimum passing grade for individual assignments and completion of all laboratory work. The total semester rating must be more than 60 points.

The rating for the RD discipline is formed as the sum of the points for current academic performance and is calculated on a 100-point scale.

Items 1-3 constitute the sum of points for current academic performance and are the basis for the discipline rating. The rating can be improved by completing an additional individual assignment.

Rating point system and assessment criteria:

1. Laboratory work.

Points are awarded for each LR class:

- preparation of a report in accordance with the requirements and timely defense of the results (within a week after completion of the work) – 10 points; preparation of a report in accordance with the requirements and late submission (more than a week after completion of the work) – 8 points; preparation of a report in accordance with the requirements and incomplete answers during the defense – 6 points; preparation of the report in accordance with the requirements and inappropriate answers during the defense – 4 points; preparation of the report in accordance with the requirements – 1 point.

The maximum number of points for the LR is 40 points.

2. The MCR modular control has 4 questions. Points are awarded for each question:

- complete answer – 1 point;
- no answer, incorrect answer - 0 points.

The maximum number of points for one MCR is 4 points.

The total number of points for ten MCRs is 40 points.

3. Individual (RGR) work is performed in the form of a calculation work in the form of solving 10 problems of increased complexity.

It is assessed as follows:

- Complete solution of the problem – 2 points;
- Partial solution of the problem – 1 point;
- Incorrect solution or no solution – 0 points.

Maximum number of points – 20 points

The maximum possible number of points for tests (items 1-3) during the semester is: RD= 40+40+20= 100 points.

To be admitted to the exam, the total rating must be at least 60 points.

Exam

The final grades for the course are entered into the grade book and transcript.

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

Additional information on the discipline (educational component)

The distance learning course is available on the distance learning platform "Circuitry. Part 2" https://do.ipo.kpi.ua/course/view.php?id=6417

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

For effective assimilation of the material, the following laboratory work is carried out:

For effective assimilation of the material, the following laboratory work is carried out:

Name of laboratory work:

- Measuring amplifier parameters (8 models)
- Feedback in different variants. (8 models)
- Study of offset circuits (8 models)

- Study of switching circuits (8 models)

They provide in-depth and consolidation of theoretical knowledge; acquisition of experimental research skills; acquisition of skills in working with measuring equipment; assessment of the reliability of the results obtained; acquisition of document preparation skills

Work program for the academic discipline (syllabus):
Compiled by Movchanuk A.V.
Approved by the Department of Applied Radio Electronics (Minutes No. 06/2025 of June 25, 2025)
Approved by the Methodological Commission of the Faculty/Institute[1] (Minutes No. 06/2025 of June 26, 2025)

[1] The university's methodological council – for university-wide disciplines.