Національний технічний університет «КИЇВСЬКИЙ ПОЛІТЕХНІЧНИЙ І імені ІГОРЯ СІКОРСЬКОГО»

Departmen of Computer Engineering

# COMPUTER ELECTRONICS

## Sylabus

## Реквізити навчальної дисципліни

| | |
|---|---|
| **Cycle of Higher Education** | **First cycle of higher education (Bachelor's degree)** |
| **Field of Study** | 12 Information Technologies |
| **Specialty** | 123 Computer Engineering |
| **Education Program** | Computer Systems and Networks |
| **Type of Course** | General |
| **Mode of Studies** | full-time |
| **Year of studies, semester** | Second year, first semester |
| **ECTS workload** | 54credits (ECTS) / 120 hours |
| **Testing and assessment** | exam |
| **Course Schedule** | //rozklad.kpi.ua/ |
| **Language of Instruction** | English |
| **Course Instructors** | Lector: Vinogradov Y.<br>Labs: Vinogradov Y. |
| **Access to the course** | Lectures: comsys.kpi.ua<br>comsys.kpi.ua |

## Program

1. Description of the educational discipline, its purpose, subject of study and learning outcomes

The course "Computer Electronics" is the theoretical basis of the set of knowledge and skills that form the circuit-technical profile of a specialist in the field of computer hardware and is decisive in the formation of the professional level of specialists in the field of computer technology.The purpose of the discipline is to reveal modern scientific concepts, concepts, methods and technologies for creating schematic components of computing equipment and to study modern means of using electronic devices in the design of devices for information technologies.The tasks of studying the discipline are:

- mastering the basics of the physical principles of the principle of operation and structure of electronic devices and the properties of the p-n junction, contact phenomena in it;
- mastering the principle of operation, parametric relationships and switching schemes of semiconductor and photoelectronic devices
- diodes, thyristors, bipolar and field-effect transistors with a p-n junction and with isolated gates, photo resistors, photo and LEDs, photo transistors and photo multipliers.

- mastering the principles of analysis and synthesis of typical electronic components and devices; amplifying cascades, operational amplifiers, comparators, signal generators and timers, information transmission and display schemes, modulation and demodulation.

- studying and mastering the method of calculating the main characteristics and parameters of typical logical and digital nodes, memory devices, structures of logical elements with programmable characteristics, analog-digital and digital-analog converters and their application in electrical and computing devices.

- mastering the principles of operation, methods of calculation and protection of power sources and current conversion schemes.

The subject of the educational discipline is the basic concepts and laws of the electromagnetic field and the theory of electric circuits for the construction of computing devices and transient processes in them; calculation methods of circuit elements and analysis of electromagnetic and energy processes in these devices; modern methods of analysis and synthesis of established circuit-technical elements using software; modern packages of application programs for calculation and modeling of computing devices

1. Program learning outcomes (LP):
2. General (Z) and professional (F) competencies (K):
3. (ZK1) – the ability to communicate in the state language both orally and in writing; (ZK05) – the ability to search, process and analyze information from various sources; (ZK06) – the ability to identify, pose and solve problems; (ZK07) – ability to work in a team; (ZK08) – the ability to work autonomously.
4. (FC 1) the ability to use the knowledge of mathematics in the amount necessary for the analysis of the modes of operation of circuit-technical elements and nodes in computer systems and networks; (FC 2) the ability to apply knowledge of computer electronics to the extent necessary to understand processes in devices and computer systems and networks; (PC 4) the ability to apply various methods of analysis and schematic modeling that are common in computerized devices to assess the quality of their functioning; (FC 5) the ability to justify the choice of circuit elements, understanding of their principles of operation, properties, technical characteristics, taking into account operational requirements for computer systems and networks; (FC 10) the ability to take into account the requirements of labor protection and electrical safety during the formation of technical solutions; (FC12) - the ability to solve practical problems involving the methods of mathematics, physics and computer electronics.
5. Knowledge: (PR02) – to know and understand the theoretical foundations and technologies of construction, operation and application of modern devices of analog, pulse and digital electronics;

6. (PR03) – to know the principles of choosing methods of analysis and synthesis of electronic devices with given statistical and dynamic characteristics, to create a modern elemental base of computing technology; (PR05) – to know the basics of the theory of synthesis and analysis of digital automata, calculation methods of radio-electronic circuit devices of computer technology and to be able to use them to solve practical problems in professional activities.
7. Ability: (PR09) to independently perform calculations of various electronic devices with the organization of a data bank for further automation of the process of selection and justification of the optimal parameters of the device; (PR10) independently design and adjust typical devices and elements of electronic and computing equipment; (PR11) - communicate freely about professional problems in national and foreign languages orally and in writing, discuss the results of professional activity with specialists and non-specialists, argue one's position on debatable issues; (PR18) – to be able to learn independently, acquire new knowledge and improve skills in working with modern equipment, measuring equipment and application software;
8. Experience: classroom and independent work when learning new material; use of acquired knowledge when solving problems of a typical nature; independent implementation of practices

**2,. Pre-requisites and post-requisites of the discipline (place in the structural and logical scheme of training according to the relevant educational program)**

the study of the discipline is based on the knowledge obtained from the courses:

Higher mathematics - sections: matrix algebra, differential equations, theory of functions of a complex variable, Fourier and Laplace transforms, numerical methods of solving algebraic and differential equations.

Physics - sections: electricity and magnetism.

Theory of electric and magnetic circuits

In turn, the discipline "Computer Electronics" as a whole and individual sections of the course are used when studying disciplines from cycles of professional and practical training students and disciplines of the university's choice. The following credit modules should be included in the list of secured ones:

Computer circuitry;

Reliability of computer systems

Real-time computer systems

Computer modeling;

Hybrid computer systems;

Computer systems;

Fundamentals of labor protection.

Chapter No. 1 "Fundamentals of analog and pulse electronic devices"

Topic 1.1 Computer electronics, modern classification, basic principles and definitions

Topic 1.2 Linear circuits of electronic devices and their characteristics. Properties of real passive components.

Topic 1.3 Basic properties of p-n junctions and their models. Semiconductor diodes and their varieties.

Topic 1.4 Bipolar transistor, its models and circuit features.

Topic 1.5 Field-effect transistors, features of its switching schemes.

Topic 1.6 Photoelectronic devices and information display devices.

Topic 1.7 Basic properties of analog amplifier devices.

Topic 1.8 Bipolar cascades with a common base (SB) and emitter repeaters (circuits with a common collector - SC)

Topic 1.9 Cascades on field-effect transistors.

Topic 1.10 Sources of current and voltage. Current mirrors.

Topic 1.11 Differential cascades

Topic 1.12 Complementary and quasi-complementary schemes

Topic 1.13 Operational amplifiers (OP). Dynamic properties of the OU.

Topic 1.14 Converters of analog signals on operational amplifiers.

Topic 1.15 Functional converters based on an operational amplifier.

Topic 1.16 Modular control work #1

Section #2 "Digital electronic devices"

Topic 2.1 Operation of semiconductor devices in key mode.

Topic 2.2 Trigger and generator devices.

Topic 2.3 Basic logical elements.

Topic 2.4 Semiconductor memory devices.

Topic 2.5 Logic devices with programmable characteristics.

Topic 2.6 The main ways and concepts of the development of computer electronics

## 3. Educational materials and resources

**Basic:**

1. 1.Patterson . Computer Organization and Design - 5th editionPublisher: William Kaufmann, Inc. 2014
2. David Kerns and J. Irwin Essentials of Electrical and Computer Engineering, Prentice Hall, Inc.2014

3 Stephen Brown, Fudamentals of Digital Logic with VHDL Design – 2018.

## Educational content

## 4. Methods of mastering an educational discipline (educational component)

| Chapters | Hours | | | | |
|---|---|---|---|---|---|
| | In total | Lectures | | Labs | SRS |

| 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|
| ***Chapter 1. Fundamentals of analog and pulse electronic devices*** | | | | | |
| *Topic 1.1 Computer electronics, modern classification, basic principles and definitions.* | *6* | *1,0* | *-* | *2* | *3,0* |
| *Topic 1.2 Linear circuits of electronic devices and their characteristics. Properties of real passive components.* | *4* | *1,0* | *-* | *-* | *3,0* |
| *Topic 1.3 Basic properties of p-n junctions and their models. Semiconductor diodes and their varieties.* | *8* | *2,0* | *-* | *-* | *6,0* |
| *Topic 1.4 Bipolar transistor, its models and circuit features.* | *4* | *1,0* | *-* | *-* | *3,0* |
| *Topic 1.5 Field-effect transistors, features of its switching schemes.* | *4* | *1,0* | *-* | *-* | *3,0* |
| *Topic 1.6 Photoelectronic devices and information display devices.* | *8* | *2,0* | *-* | *-* | *6,0* |
| *Topic 1.7 Basic properties of analog amplifier devices.* | *4* | *1,0* | *-* | *-* | *3,0* |

| | | | | | |
|---|---|---|---|---|---|
| *Topic 1.8 Bipolar cascades with a common base (SB) and emitter repeaters (circuits with a common collector - SC)* | *6* | *1,0* | - | *2* | *3,0* |
| *Topic 1.9 Cascades on field-effect transistors.* | *6* | *1,0* | - | *2* | *3,0* |
| *Topic 1.10 Sources of current and voltage. Current mirrors.* | *4* | *1,0* | - | - | *3,0* |
| *Topic 1.11 Differential cascades* | *8* | *2,0* | - | *2* | *6,0* |
| *Topic 1.12 Complementary and quasi-complementary schemes* | *8* | *2,0* | - | - | *6,0* |
| *Topic 1.13 Operational amplifiers (OP). Dynamic properties of the OU.* | *10* | *2,0* | - | *2* | *6,0* |
| *Topic 1.14 Converters of analog signals on operational amplifiers.* | *10* | *2,0* | - | *2* | *6,0* |
| *Topic 1.15 Functional converters based on an operational amplifier.* | *8* | *2,0* | - | - | *6,0* |
| *1.16 Modular control work #1* | *8* | *2,0* | - | - | *6,0* |
| *Total in 1* | *114* | *24* | - | *12* | *78* |
| **Section #2 "Digital electronic devices"** | | | | | |
| *Topic 2.1 Operation of semiconductor devices in key mode* | *7,0* | *2,0* | | *4* | *3,0* |
| *Topic 2.2 Trigger and generator devices.* | *8,0* | *2,0* | | *2* | *4,0* |
| *Topic 2.3 Basic logical elements.* | *8,0* | *2,0* | | *2* | *4,0* |

| | | | | | |
|---|---|---|---|---|---|
| *Topic 2.4 Semiconductor memory devices.* | *5,0* | *2,0* | | | *3,0* |
| *Topic 2.5 Logic devices with programmable characteristics.* | *6,0* | *2,0* | | | *4,0* |
| *Topic 2.6 The main ways and concepts of the development of computer electronics* | *2,0* | *2,0* | | | |
| *Total in semester 2* | ***36*** | ***12*** | ***-*** | ***6*** | ***18*** |
| *In total* | ***150*** | **36** | | ***18*** | ***96*** |
| *Total in semester* | ***150*** | **36** | | ***18*** | ***96*** |

## 5. **Lectures (Full-time)**

The educational content of the discipline consists of lectures and laboratory works.

Lectures.

Lecture 1.

Topic 1.1: Computer electronics, modern classification, basic principles and definitions.

Stages of development of electronics. Classification of electronic devices. Analog and digital form of information presentation. Analog electronic devices. Discrete electronic devices. Digital electronic devices.

Topic 1.2: Linear links of electronic devices and their characteristics. Properties of real passive components.

Equivalent generators and simple circuits. Description of linear systems in the frequency and time domains. Basic dynamic parameters of digital signals. Properties of real passive components.

Lecture 2.

Topic 1.3. Basic properties of p-n junctions and their models. Semiconductor diodes and their varieties.

Basic properties of p-n junctions. Model of p – n transition of Moll – Ebers. Volt is the ampere characteristic of a diode. Resistance and capacitance of the diode. Schemes on diodes. Manufacturing technology of semiconductor diodes. Classification of diodes.

Lecture 3.

Topic 1.4. Bipolar transistor, its models and features of circuit engineering.

Physical model of a bipolar transistor. Circuit diagrams and basic parameters of a bipolar transistor. Equivalent circuits of a bipolar transistor. Dependence of bipolar transistor parameters on frequency. Classification of bipolar transistors.

Lecture 4.

Topic 1.5. Field-effect transistors, features of its switching schemes.

Field effect in devices with semiconductors. The principle of operation of the field-effect transistor. The main parameters of the field-effect transistor. Temperature dependence of the characteristics of field-effect transistors. Equivalent circuits of field-effect transistors. Distinguishing features of a field-effect transistor from a bipolar one. Marking of transistors.

Lecture 5.

Topic 1.6. Photoelectronic devices and information display devices.

Semiconductor sensors and indicator devices. Semiconductor temperature sensors. Magneto-semiconductor devices. Devices with charging connection. Photoelectric devices Features of optoelectronic devices. Indicator devices

Lecture 6.

Topic 1.7. The main properties of analog amplifier devices.

General information, classification and main characteristics of the amplifier (amplification factor, bandwidth, input and output resistance, output power of the amplifier, coefficient of nonlinear distortions, transient characteristics). Typical functional stages of a semiconductor amplifier. Feedback (parallel and series voltage feedback, parallel and series current feedback). The influence of feedback on the characteristics of the amplifier.

Lecture 7.

Topic 1.8. Common-base bipolar cascades and emitter-followers (common-collector circuits)

Principle of operation and main parameters. The concept of amplification classes of amplifier cascades. Methods of stabilizing the operating point of the amplifier. The influence of negative feedback on the properties of amplifier circuits.

Lecture 8.

Topic 1.9. Cascades on field-effect transistors.

Amplifying cascade according to the scheme with a common drain, substitution schemes and features of calculating the circuit engineering parameters. Stock repeater.

Lecture 9.

Topic 1.10. Sources of current and voltage. Current mirrors.

Current sources on bipolar transistors. Current sources on field effect transistors. Sources of constant voltage. Current mirror scheme.

Lecture 10.

Topic 1.11 Differential cascades

The scheme of the differential cascade and the principle of its operation. Differential amplifier parameters. Typical schemes of differential cascades (controller with a nonlinear bipolar in the emitter circuit, controller with dynamic load, controller with asymmetric input and output, controller on

compound transistors). Schemes of the differential cascade on field-effect transistors, their features and parameter calculations.

Lecture 11

Topic 1.12. Complementary and quasi-complementary schemes

Complementary emitter repeater. Schemes of two-stroke repeaters. Cascades with transistors of different types of conductivity. Complementary circuits on field-effect transistors. Integrated circuits, their technology and classification.

Topic 1.13. Operational amplifiers (OP). Dynamic properties of OP.

Operational amplifiers, general information and classification. Structural diagram of the operational amplifier. Basic parameters of operational amplifiers. Frequency properties of the operational amplifier.

Lecture 12

Topic 1.14. Converters of analog signals on operational amplifiers.

OP schematics. Voltage repeater. Inverting amplifier. The influence of operational amplifier parameters on its operation. Temperature errors of the output voltage of the operational amplifier. Amplifier with differential input. AC amplifiers. Sources of current and voltage.

Lecture 13

Topic 1.15. Functional converters based on an operational amplifier.

Inverting adder. Scheme of addition - subtraction. Integrator. Differentiator. Logarithmic and exponential amplifier. Non-linear converters. Voltage level limiters.

Lecture 14

Topic 2.1 Operation of semiconductor devices in

Laboratory classes (Face-to-face)The purpose of laboratory work is to acquire the skills and abilities to apply in practice the methods of analysis and synthesis of circuits and devices of computer electronics. Laboratory classes can be performed both on self-created laboratory mock-ups (stands) and with the use of simulation systems on computers.

## 6.Chapter No. 1 "Fundamentals of analog and pulse electronic devices"

Laboratory work No. 1 Oregano programming environment, its composition and electronic component modeling technology. Research of linear circuits of electronic devices, construction and analysis of their characteristics.

Laboratory work #2 Schematics of bipolar transistors. Research of bipolar cascades with a common base (SB), common emitter (CE) and emitter repeaters (circuits with a common collector - SC )

Laboratory work No. 3 Schematics of field-effect transistors, features of their switching schemes. Research of cascades on unipolar transistors with a common gate (SZ), common drain (SS) and drain repeaters (circuits with a common drain - SV )

Laboratory work #4 Construction of a differential cascade on bipolar and unipolar transistors.

Laboratory work No. 5 Study of the characteristics of a differential cascade.

Laboratory work No. 6 Schematics of operational amplifiers. Study of the main characteristics of operational units with different switching schemes of the operational amplifier

Section #2 "Digital electronic devices"

Laboratory work #7 Semiconductor devices operating in the key mode Study of static and dynamic characteristics of a digital key on bipolar and unipolar transistors.

Laboratory work #8 Generators of harmonic oscillations. Pulse generators.

T and D schemes of triggers. Study of circuitry and characteristics of trigger and generator circuits on transistors

Laboratory work #9 Basic logical elements. Study of diode-transistor logic and transistor-transistor logic circuits

Laboratory classes (correspondence form)

Laboratory work No. 1 Schematics of bipolar transistors. Research of bipolar cascades with a common base (SB), common emitter (CE) and emitter repeaters (circuits with a common collector - SC )

Laboratory work #2 Semiconductor devices operating in the key mode Study of static and dynamic characteristics of a digital key on bipolar and unipolar transistors.

## *7.* Student's independent work (full-time)

| *№* | *Themes* | *Hours* |
|---|---|---|
| *1* | Computer electronics, modern classification, basic principles and definitions | *6* |

| | | |
|---|---|---|
| *2* | Linear circuits of electronic devices and their characteristics. Properties of real passive components. | *6* |
| *3* | Basic properties of p-n junctions and their models. Semiconductor diodes and their varieties. | *3* |
| *4* | Bipolar transistor, its models and circuit features. | *3* |
| *5* | Field-effect transistors, features of its switching schemes. | *6* |
| *6* | Photoelectronic devices and information display devices. | *3* |
| *7* | The main properties of analog amplifier devices | *3* |
| *8* | Bipolar cascades with a common base (SB) and emitter repeaters (circuits with a common collector - SK ) | *3* |
| *9* | Cascades on field-effect transistors | *3* |
| *10* | Sources of current and voltage. Current mirrors | *3* |
| *11* | Differential cascades | *6* |
| *12* | Complementary and quasi-complementary schemes | *6* |
| *13* | Operational amplifiers (OP). Dynamic properties of the OU. | *6* |
| *14* | Converters of analog signals on operational amplifiers. | *6* |
| *15* | Functional converters based on an operational amplifier. | *6* |
| *16* | Modular control work | *6* |
| *17* | Робота напівпровідникових приладів у ключовому режимі | *3* |
| *18* | Operation of semiconductor devices in key mode | *4* |
| *19* | Basic logical elements. | *4* |
| *20* | Semiconductor memory devices. | *3* |
| *21* | Semiconductor memory devices | *4* |
| | *In total* | *96* |

## 8. Policy and control

### 1. Policy of academic discipline (educational component)

During classes in the academic discipline "Computer Electronics", students must adhere to certain disciplinary rules:

- t is forbidden to be late for classes;

- when the teacher enters the classroom, students stand up as a sign of greeting;

- extraneous conversations or other noise that interferes with classes are not allowed;

- it is allowed to leave the classroom during the lesson only with the teacher's permission.

- it is not allowed to use mobile phones and other technical means without the teacher's permission.

### 9. Types of control and rating system for evaluating learning outcomes (RSO)

Types of control in the educational discipline "Computer Electronics" include:

Laboratory works:

Independent performance of nine laboratory works is planned. The topics of laboratory works are coordinated in time and content with the topics of lectures. Carrying out laboratory work in full allows you to acquire practical skills in calculation and creation of devices and assemblies of electronic devices

Semester control

The exam is conducted in the form of an interview with the student to objectively determine the level of knowledge, skills and practical skills acquired during the semester

The student's semester rating consists of the points he receives for the types of work according to the table.

Table Evaluation of individual types of student academic work (in points)

| Work | Balls |
|---|---|
| Performance and protection of laboratory work № 1 | 6 |
| Performance and protection of laboratory work № 2 | 6 |
| Performance and protection of laboratory work № 3 | 6 |
| Performance and protection of laboratory work № 4 | 6 |
| Performance and protection of laboratory work | 6 |
| Performance and protection of laboratory work | 6 |
| Performance and protection of laboratory work | 6 |
| Performance and protection of laboratory work № 8 | 6 |

| | |
|---|---|
| Performance and protection of laboratory work № 9 | 6 |
| **Rп** | **54** |
| **Exam (Re)** | **46** |
| Total in semester (**R= Rп + Re**) | **100** |

The student's individual current rating (Rп) consists of the points he receives for performing laboratory work and MKR. During the semester, students perform 9 laboratory works. The maximum number of points for each laboratory work is 6. Points are awarded for:

- theoretical component – 3 points,
- practical component - 3 points.

The maximum possible score for laboratory work is 6 points. The maximum number of points for all laboratory work is 9 x 6=54 points.

Calculation of the scale size (R) of the rating.

The sum of the weighted points of control measures during the semester is:

R=Rp + Re, where Rp is the student's semester rating for laboratory work).

The size of the rating scale for the academic discipline is:

R=Rп+ Rз = 54 + 46 = 100 points.

A necessary condition for a student's admission to the exam is his individual semester rating (Rp), not less than 60 points, and the absence of laboratory work arrears. If the mentioned requirements are not met, the student will not be admitted to the credit.

Table of correspondence of rating points to grades on the university scale:

| *Balles* | *Rating*<br>*y* |
|---|---|
| 100-95 | *Perfectly* |
| 94-85 | *Very good* |
| 84-75 | *Okay* |
| 74-65 | *Enough* |
| 64-60 | *Satisfactoril* |

| | |
|---|---|
| *<60* | *Unsatisfactorily* |
| Admission conditions not met | *Not allowed* |

Working program of the academic discipline (syllabus):

Compiled by . teacher Yury Mykolayovych Vynogradov

Approved by the Department of Computing (Protocol No. 10 dated 05/25/2022)

Agreed by the Methodical Commission of the faculty (protocol No. 10 dated 06.9.2022)

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