National Technical University of Ukraine «IGOR SIKORSKY KYIV POLYTECHNIC INSTITUTE»

Department of Biomedical engineering
Faculty of Biomedical engineering

# ANALOG AND DIGITAL ELECTRONICS -2.

# DIGITAL ELECTRONICS

## Working program of the academic discipline (Syllabus)

| Requisites of the discipline | |
|---|---|
| **Level of high education** | ***First cycle of higher education (bachelor degree)*** |
| **Branch of knowledge** | *16 Chemical and bioengineering* |
| **Specialty** | *163 Biomedical engineering* |
| **Educational program** | *Medical engineering* |
| **Status of the discipline** | *Normative* |
| **Learning form** | *Full-time (day-time)/ Full-time (part-time) /Distance/Mixed* |
| **Semester** | *Third year, spring semesters* |
| **Course scope** | *7 ECTS credits / 210 hours* |
| **Semester control / control measures** | *Midterm exam, exam* |
| **Schedule** | *According to the schedule on the website http://rozklad.kpi.ua/* |
| **Language** | *English* |
| **Information about course supervisor and lecturers** | ***Lecturers:*** *Associate Professor Viktor Zubchuk Зубчук, PhD, e-mail – granyt@i.ua, Viber – 050-381-5763 Senior lecturer Mohammad Delavar Kasmai, PhD, e-mail m.delavar@kpi.ua http://bme.fbmi.kpi.ua/lectors/* |
| **Course placement** | *Google classroom* |

## Curriculum of the discipline

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

*The main purpose of the discipline "Analog and digital circuitry-2 Digital circuitry" is to study methods of construction, operation and mathematical description of elements, functional units and devices of digital systems used in various sectors of the economy and, including biomedical engineering..*

*The development of modern microelectronics and, in particular, digital circuitry is associated with the widespread use of digital technologies in diagnostic and therapeutic medical devices. This necessitates the appropriate training of specialists with knowledge of analog and digital circuitry. Such a specialist must have appropriate competencies in the methods of mathematical description of functional units at the logical and electrical levels, know the modern component base of digital circuitry, be fluent in industrial series of integrated circuits and prospects for their further development, have methods of constructing digital devices and systems, including means of microprocessor technology.*

*The level of development in digital circuitry largely depends on the completeness and modernity of training tools, which, in turn, determine the efficiency and quality of design and operation of devices and systems for biomedical purposes. The series of lectures on the discipline "Digital Circuitry" examines modern methods of construction, mathematical description and operation of digital circuits of the*

*combination type, sequential digital circuits (with memory), as well as analog-to-digital and digital-to-analog converters.*

*The syllabus is constructed in such a way that for each subsequent task students need to apply the skills and knowledge acquired in the previous. The final task is to write a course work with mandatory public defense, for which students use theoretical knowledge and apply practical skills acquired during all types of tasks and active participation in classroom practices and computer practices. Particular attention is paid to the principle of encouraging students to active learning, according to which students should work on practical thematic assignments that will further solve real problems and tasks in the field of biomedical engineering.*

*The purpose of teaching the discipline is to provide students with theoretical knowledge and the formation of their practical skills in the design and operation of modern digital biomedical devices.*

*The tasks of studying the academic discipline are:*

- *mastering general methods of building digital systems;*
- *mastering the technological bases of digital technology;*
- *mastering the methods of analysis and synthesis of digital circuits of combinational and sequential type;*
- *mastering the skills of combining individual functional units into structures designed to perform a given algorithm of operation;*
- *mastering the knowledge of the main types of functional units designed for the construction of digital diagnostic and physiotherapeutic devices.*

*The discipline is the second part of the course "Analog and digital circuitry" and for its mastering it is necessary to master the basics of electrical engineering, discrete algebra and analog circuitry.*

***General competencies (****OPP was put into effect by the Rector's Order NON / 89/2021 of 19.04.2021****):***

***GC 1 -*** *Ability to apply knowledge in practical situations.*
***GC 2 -*** *Knowledge and understanding of the subject area and understanding of professional activity.*
***GC 6 -*** *Ability to search, process and analyze information from various sources.*
***GC 7 -*** *Ability to generate new ideas (creativity).*
***GC 9*** *- Ability to communicate with representatives of other professional groups of different levels (with experts from other fields of knowledge / types of economic activity)*

***Special (professional) competencies*** *(OPP was put into effect by the Rector's Order NON / 89/2021 of 19.04.2021):*

***PC 2 -*** *Ability to provide engineering expertise in the process of planning, development, evaluation and specification of medical equipment.*
***PC 6 -*** *Ability to effectively use tools and methods for analysis, design, calculation and testing in the development of biomedical products and services.*
***PC 13 -*** *Ability to ensure and monitor compliance with safety and biomedical ethics when working with medical equipment.*

***The program learning outcomes*** *after studying the discipline "Analog and digital circuitry" are (OPP put into effect by the Order of the Rector NON / 89/2021 from 19.04.2021):*

***PLO 1 -*** *Understanding of fundamental-applied, medical-physical and bioengineering bases of technologies and equipment for research of processes of a human body.*
***PLO 2 -*** *Possession of engineering methods of calculation of elements of devices and systems of medical appointment and a choice of classical and newest constructional materials.*
***PLO 4 -*** *Knowledge of methods of designing digital and microprocessor systems for medical purposes.*
***PLO 5 -*** *Knowledge of research methods and techniques used in the design of medical equipment.*

***PLO 7 -*** *Understanding of scientific and technical principles that underlie the latest advances in biomedical engineering.*
***PLO 15 -*** *Use of technical systems of automated designing taking into account features of their components.*
***PLO 24 -*** *Apply knowledge of the basics of mathematics, physics and biophysics, bioengineering, chemistry, engineering graphics, mechanics, resistance and strength of materials, properties of gases and liquids, electronics, computer science, obtaining and analyzing signals and images, automatic control, systems analysis and decision making methods needed to solve the problems of biomedical engineering.*
***PLO 25 -*** *Formulation of logical conclusions and substantiation of recommendations on assessment, operation and implementation of biotechnical, medical-technical and bioengineering means and methods.*
***PLO 30 -*** *Engineering support, service and maintenance in the operation of laboratory and analytical equipment, medical diagnostic and therapeutic complexes and systems, as well as the preparation of standard documentation for the types of work in accordance with the Technical Regulations for medical devices.*
***PLO 31 -*** *Understanding of theoretical and practical approaches to the creation and management of medical equipment and medical equipment.*
***PLO 45 -*** *Improving the technical elements of medical devices and systems and medical devices in the process of professional activity.*

## 2. Prerequisites and postrequisites of the discipline (place in the structural and logical scheme of education according to the relevant educational program)

*The academic discipline "Analog and digital circuitry-2 Digital circuitry" refers to the cycle of professional training and has an interdisciplinary nature. It integrates according to its subject knowledge from other disciplines: "Introduction to the profession", "Fundamentals of Informatics", "Fundamentals of Discrete Mathematics", "Electrical Engineering and Electronics". According to the structural and logical scheme of the training program, the discipline "Analog and digital circuitry-2. "Digital Circuitry" is the basis for the study of disciplines "Microprocessor Engineering", "Biomedical devices, apparatus and complexes", "Devices for monitoring physiological parameters of man", preparation of theses in the specialty and in further practical work in the specialty.*

## 3. The content of the discipline

*The main sections and topics that will be considered in the process of studying the course:*

***Section 1. Elements and combination devices of digital electronics***

*Subject 1.1. Logic switches; Mathematical apparatus of digital circuitry. Diode switches. Logic circuits on diodes.*
*Subject 1.2. . Logic switches; Switches by bipolar transistors.*
*Switches by Schottky transistors. Switches by unipolar transistors*
*Subject 1.3. Logic elements in DTL, TTL technology: Diode-transistor logic elements (LE). Basic LE NAND. Elements NOR, AND-OR-NOT. Typical parameters DTL, TTL.*
*Subject 1.4. Logic elements in $I^2L$, CMOS technology: LE by MOS and CMOS transistors. LE NAND, NOR. Implementation of PDNF, PCNF by CMOS transistors. Typical parameters of LE by CMOS-transistors.*
*Subject 1.5. Code Converters (CC): CC Synthesis. Examples of CC implementation in the given bases of LE.*
*Subject 1.6. Encoders and decoders: encoders, priority encoders.*

*Decoders - linear, pyramidal, matrix. Minimization of incomplete decoders. Synthesis of CC based on the decoder-encoder system.*
*Subject 1.7Multiplexers and demultiplexers: Gating, use of decoders in them. Analog multiplexer-demultiplexer. Combination shift devices on multiplexers.*
*Subject 1.8. Arithmetic devices: Semi-adders. Full adders. Subtractors. Subtractor adders.*
*Subject 1.9. Arithmetic devices: Binary-decimal adder. Multi-bit adders with sequential transfer. Multi-bit adders with accelerated transfer. Combination multipliers.*
*Subject 1.10. Digital comparators (DC): Principles of construction of single-digit and multi-digit DC. Binary subtractor comparators. Sectioned multi-bit comparators.*
*Midterm exam -1.*

***Section 2. Digital sequential functional nodes***

*Subject 2.1. Asynchronous and synchronous triggers: Asynchronous and transparent synchronous RS-triggers. Varieties of RS-flip-flops (R-, S-, E-flip-flops). RS-triggers such as "latch" and MS.*
*Subject 2.2. Asynchronous and synchronous triggers: D-triggers such as "latch" and MS. Universal JK-triggers such as "latches" and MS. Varieties of T-flip-flops.*
*Subject 2.3. Registers: Parallel registers. Sliding registers. Reversible shift registers. Ring registers. Register - "Johnson's counter".*
*Subject 2.4. Asynchronous counters: Asynchronous and synchronous counters. Reversible counters. Frequency dividers.*
*Subject 2.5. Synchronous counters: Binary-decimal counters. Counters with controlled enumeration ratio.*
*Subject 2.6. Pulse devices: Pulse edge detectors. Pulse expanders. Trigger pulse generators.*
*Subject 2.7. Pulse generators: Single Pulse generators by logic elements NAND, NOR and by operational amplifiers.*
*Subject 2.8. Digital-to-analog converters (DACs): DACs based on analog adder, resistive structure R-2R, current switches.*
*Subject 2.9. Analog-to-digital converters (ADC): ADC serial deployment. ADC tracking deployment. Bit-by-bit balancing ADC.*
*Subject 2.10. Analog-to-digital converters (ADC) ADC with double integration. Parallel ADCs. Conveyor ADC.*
*Midterm exam -2.*

## 4. Training materials and resources

***Basic literature:***


1. *Лебедєв О.М., Ладик О.І. Цифрова техніка. – К.: ІВЦ «Видавництво «Політехніка»», 2004 р.*
2. *Бабич Н.П., Жуков И.А. Компьютерная схемотехника- К.: «МК-Пресс», 2004 г.*
3. *Рябенький В.М., Жуйков В.Я., Гулий В.Д. Цифрова схемотехніка: Навч. посібник. - Львів: «Новий Світ-2000», 2009.-736 с.*
4. *Опадчий Ю.Ф., Глудкин О.П., Гуров А.И. Аналоговая и цифровая электроника. Учебник для вузов. – М.: XXX.-2000 г.*
5. *Зубчук В.И., Попов А.А., Фесечко В.А. Комп'ютерна схемотехніка:Методичні вказівки до курсового проектування для студентів напрямків 6.050101 –"Комп'ютерні науки", 6.051003- "Приладобудування". НМУ № Е9/10-225,18.03.2010 р.*

***Additional literature:***


1. *Справочник по цифровой схемотехнике / В.И. Зубчук, В.П. Сигорский, А.Н. Шкуро. – К. «Техніка», 1990 р.*
2. *Титце У., Шенк К. Полупроводниковая схемотехника.- М.: Мир, 1982 г.*
3. *Преснухин Л.Н., Воробьев Н.В., Шишкевич А.А. Расчет элементов цифровых устройств. -М.: Высш. шк. 1982 г.*
4. *Сигорский В.П., Зубчук В.И., Шкуро А.Н. Элементы цифровой схемотехники. Уч. пособие.- Киев УМК ВО 1990 г.*
5. *Зубчук В.И., Шкуро А.Н. Функциональные узлы цифровой схемотехники. Уч. пособие.- Киев УМК ВО 1992 г.*
6. *Зубчук В.І., Захарчук Н.В. «Цифрова схемотехніка» [Електронний ресурс]: практикум з дисципліни «Електроніка» для студентів спеціальностей 6.051402 -«Біомедична інженерія», та 6.051003 «Приладобудування» НТУУ «КПІ» , 2016. – 194 с. – Назва з екрана. – Доступ: http://ela.kpi.ua/handle/123456789/19696.*
7. *Зубчук В.І., Делавар-Касмаі М. Цифрова схемотехніка. Конспект лекцій до вивчення кредитного модуля «Цифрова схемотехніка» [Електронний ресурс]: навчальний посібник для студентів, які навчаються за спеціальностю 163 - Біомедична інженерія, спеціалізацією «Клінічна інженрія». НТУУ «КПІ ім. Ігоря Сікорського» , 2019. – 184 с. – Назва з екрана. – Доступ: http://ela.kpi.ua/handle/ 123456789/27856*


## Educational content

## 5. Methods of mastering the discipline (educational component)

***Lectures***

*Students are provided with a summary of numbered lectures in electronic form. After the text of each lecture there are control questions, with which the student after studying the lecture material must check themselves for the quality of its mastering. If questions arise, the student can ask the teacher questions at the next lecture. Thus, each subsequent lecture begins with questions and answers on the material of the last lecture, after which the teacher provides the material of the next and focuses on its main issues.*

***Practices***

*Practical classes consider methods for solving synthesis problems, mathematical description of the main functional units of digital systems in accordance with the topics of lectures, provide examples of solving specific problems. Each practical lesson ends with a control example, for the solution of which the student receives rating points.*

*In practical classes in the middle and at the end of the semester midterm exam-1 and midterm exam-2 are carried out, which cover the material studied for the corresponding period and are estimated by the corresponding rating points.*

| *s/n.* | *Subject* | *Program learning outcomes* | *The main tasks* | |
|---|---|---|---|---|
| | | | *Control measure* | *Deadline* |
| *Third year, spring semesters, 7 ECTS credits / 210 hours* | | | | |
| *1.* | *Logic switches* | *PLO 1*<br>*PLO 2*<br>*PLO 3* | *Practical work (PW)* | *second week* |
| *2.* | *Integral logic elements* | *PLO 1*<br>*PLO 3* | *PW* | *4th week* |
| *3.* | *Code converters (CC)* | *PLO 4*<br>*PLO 5* | *PW* | *5th week* |

| | | | | |
|---|---|---|---|---|
| | | *PLO 7* | | |
| *4.* | *Encoder and decoder* | *PLO 15*<br>*PLO 24*<br>*PLO 45* | *PW* | *6th week* |
| *5.* | *Multiplexers and demultiplexers* | *PLO 15*<br>*PLO 24*<br>*PLO 45* | *PW* | *7th week* |
| *6.* | *Arithmetic devices* | *PLO 15*<br>*PLO 24*<br>*PLO 45* | *PW* | *8th week* |
| *7.* | *Midterm exam* | *PLO 24*<br>*PLO 45* | | *8th week* |
| *8.* | *Triggers and registers* | *PLO 30*<br>*PLO 31* | *PW* | *9th week* |
| *9.* | *Counters* | *PLO 30*<br>*PLO 31* | *PW* | *10th week* |
| *10.* | *Pulse devices and generators* | *PLO 30*<br>*PLO 31* | *PW* | *12th week* |
| *11.* | *Digital-to-analog converters* | *PLO 30*<br>*PLO 31*<br>*PLO 45* | *PW* | *14th week* |
| *12.* | *Analog-to-digital converters* | *PLO 30*<br>*PLO 31*<br>*PLO 45* | *PW* | *17th week* |
| *13.* | *Midterm exam* | *PLO 24*<br>*PLO 45* | | *17th week* |

## 6. Independent student work

*The independent work of the student for 42 hours includes the study of lecture material for the next lecture; the formation of answers to control questions on the studied section, preparation for practical classes on the topic listened to in the previous lecture and preparation midterm exam.*

*An important component of independent work is the implementation of course work on topics agreed with the teacher. 30 hours of independent work are planned for the course work.*

**Policy and control**

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

***Attending classes***

*Attendance at lectures is optional. Attending practical classes is desirable, as they are used to write express tests / tests, as well as to defend practical work.*

*The grading system is focused on obtaining points for student activity, as well as performing tasks that are able to develop practical skills and abilities.*

***Control measures missed***

*Missed control measures (defense of practical work) must be practiced in the next classes, provided that the task is scheduled for the current lesson, or in consultations.*

*Omissions of writing a midterm exam and express test are not fulfilled.*

***Calculation and graphic work, which is submitted for inspection in violation of the deadline is evaluated with a decrease in the number of weight points***.

***Violation of deadlines and incentive points***

| *Encouragement points* | | *Penalty points ** | |
|---|---|---|---|
| *Criterion* | *Weight points* | *Criterion* | *Weight points* |
| *Improving practical work* | *1 points (for each practical work)* | *Untimely implementation and test of practical work* | *From -0.5 points to -5 points (depending on the delivery date)* |
| *Passing distance courses on topics that are agreed with teachers* | *5 points* | *Untimely execution and test of calculation and graphic work* | *From -2 points to -20 points (depending on the construction period)* |
| *Registration of scientific work for participation in the competition of student scientific works* | *10 points* | | |
| *Writing abstracts, articles, participation in international, national and / or other events or competitions on the subject of the discipline* | *5 points* | | |

** if the control measure was missed for a good reason (illness, which is confirmed by a certificate of the established sample) - penalty points are not accrued.*

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***Academic integrity***

*The policy and principles of academic integrity are defined in Section 3 of the Code of Honor of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute". Read more:* https://kpi.ua/code.

***Norms of ethical behavior***

*Normative principles of behavior of students and employees, defined in sections 2 of the Code of Honor of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute". Read more: https://kpi.ua/code.*

***Procedure for appealing the results of control measures***

*Students have the opportunity to raise any issue related to the control procedure and expect it to be addressed according to predefined procedures.*

*The student has the right to appeal the results of the control measure according to the approved provision on appeals in the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute" (approved by the order №NON/128/2021 from 20.05.2021) - https://osvita.kpi.ua/index.php/node/182*

***Inclusive education***

*The discipline "Medical Microprocessor Systems" can be taught to most students with special educational needs, except for students with severe visual impairments who do not allow to perform tasks using personal computers, laptops and / or other technical means.*

***Distance learning***

*Distance learning takes place through the Sikorsky Distance learning Platform «Sikorsky».*

*Distance learning through additional online courses on certain topics is allowed subject to agreement with students. If a small number of students wish to take an online course on a specific topic,*

*studying the material with such courses is allowed, but students must complete all the tasks provided in the discipline.*

*The list of courses is offered by the teacher after the students have expressed a desire (because the bank of available courses is updated almost every month).*

*The student provides a document confirming the completion of the distance course (in the case of a full course) or provides practical tasks from the distance course and subject to an oral interview with the teacher on the topics can receive grades for control measures provided for the studied topics (express control / test tasks, practical work).*

*Performance of practical works, and also performance of settlement and graphic work, is carried out during independent work of students in a remote mode (with a possibility of consultation with the teacher through e-mail, social networks).*

***Learning a foreign language***

*Teaching in English is carried out only for foreign students.*

*At the request of students, it is allowed to study the material with the help of English-language online courses on topics that correspond to the topics of specific classes.*

## 8. Monitor and evaluate the system of evaluation of learning outcomes (*Rating System of Evaluation*):

***Evaluation system (current control):***

| *s/n* | *Control measure* | *%* | *Weight points* | *Number* | *Total* |
|---|---|---|---|---|---|
| *1.* | *Express control works / test tasks* | *16* | *2* | *8* | *16* |
| *2.* | *Execution and protection of computer practical works* | *24* | *3* | *8* | *24* |
| | | | | | |
| *1+2* | *Express control works / test tasks* | *40* | *4* | *10* | *40* |
| | | | | | |
| *3.* | *Midterm exam* | *20* | *10* | *2* | *20* |
| *5.* | *Exam* | *40* | *40* | *1* | *40* |
| | ***Total*** | | | | *100* |

*The applicant receives a positive credit score for the results of the semester, if he has a final rating for the semester of at least 60 points and has met the conditions of admission to the semester control, which are determined by the RSE (Rating System of Evaluation).*

*With applicants who have met all the conditions of admission to the test and have a rating of less than 60 points, as well as with those applicants who want to increase their rating, in the last scheduled lesson in the semester, the teacher conducts semester control in the form of test or interviews.*

*After performing the test, if the score for the test is higher than the rating, the applicant receives a score based on the results of the test.*

*If the grade for the test is lower than the rating, a "hard" RSE is used - the previous rating of the applicant (except for points for the semester individual task) is canceled and he receives a grade based on the results of the test. This option forms a responsible attitude of the applicant to the decision to perform the test, forces him to critically assess the level of his training and carefully prepare for the test.*

***Calendar control** (CC) - is performed twice a semester as monitoring of the current state of compliance with syllabus requirements.*

*The purpose of calendar control is to improve the quality of student learning and monitor the implementation of the schedule of the educational process by students.*

| Criterion | | | The first CC | The second CC |
|---|---|---|---|---|
| Deadline of calendar controls | | | 8th week | 14th week |
| Conditions for obtaining a positive result from the calendar control | Current rating | | ≥ 12 points | ≥ 24 points |
| | Execution practical work | PW № 1- 4 | + | + |
| | | PW № 5-7 | - | + |
| | Express control works / test tasks | At least 4 of any lectures | + | - |
| | | At least 10 of any lectures | - | + |
| | Midterm exam | Estimated Midterm exam | - | + |

*In case of detection of academic poor quality during training - the control measure is not credited.*

***Semester certification of students***

| Mandatory condition for admission to the test | | Criterion |
|---|---|---|
| 1 | Current rating | RD ≥ 30 |
| 2 | Obtaining a positive assessment for the performed calculation and graphic work | More than 6 points |
| 3 | All practical works are tested | More than 10 points |
| 4 | Writing at least 6 express tests / tests | More than 6 points |

*The results are announced to each student separately in the presence or remotely (by e-mail). Also recorded in the system "Electronic Campus".*

*Optional conditions for admission to closure:*

1. *Activity in practical classes.*
2. *Positive result of the first attestation and the second attestation.*
3. *Attending 50% of lectures.*

*Table of translation of rating points to grades on a university scale:*

| Number points | Assessment on the university scale |
|---|---|
| 100-95 | Perfectly / Відмінно |
| 94-85 | Very good / Дуже добре |
| 84-75 | Good / Добре |
| 74-65 | Satisfactorily / Задовільно |
| 64-60 | Enough / Достатньо |
| Less 60 | Unsatisfactorily / Незадовільно |
| Admission conditions are not met | Not allowed / Не допущено |

## 9. Additional information on the discipline (educational component)

*The list of questions for preparation for modular control work, and for preparation for credit is given in appendix 1.*

*Distance learning through additional online courses on certain topics is allowed subject to agreement with students. If a small number of students wish to take an online course on a specific topic, studying the material with such courses is allowed, but students must complete all the tasks provided in the discipline.*

*The list of courses is offered by the teacher after the students have expressed a desire (because the bank of available courses is updated almost every month).*

*The student provides a document confirming the completion of the distance course (in the case of a full course) or provides practical tasks from the distance course and subject to an oral interview with the*

*teacher on the topics can receive grades for control measures provided for the studied topics (express control / test tasks, practical work).*

***Work program of the discipline (syllabus):***

***Compiled by:*** *Associate Professor of Biomedical Engineering, PhD, Zubchuk Viktor,*

*Senior Lecturer, Department of Biomedical Engineering, PhD, Delavar Kasmai Mohammad.*

***Approved by*** *the Department of Biomedical Engineering (protocol № ___ to _____)*

***Approved by the*** *Methodical Commission of the Faculty of Biomedical Engineering (protocol № __ to _____)*

***Appendix 1*** *to the syllabus of the discipline*

*«Analog and digital circuitry-2 Digital circuitry»*

***The list of questions for preparation for midterm exam,***

***And also for preparation for exam***

***Questions I*** *on subjects 1 - 6*

1. *Explain the use of logic algebra and standard forms of functions.*
2. *Justify the minimization of logical functions. Karnaugh -Weich method.*
3. *Compare diode switches and logic circuits by diodes.*
4. *Evaluate the efficiency of switches by bipolar transistors.*
5. *Write a switch analysis by Schottky transistors.*
6. *Explain the efficiency of switches on unipolar transistors.*
7. *Analyze the diode-transistor (DTL) logic elements (LE).*
8. *Basic LE NAND. DTL-elements NOR, AND-OR-NOT.*
9. *Compare the parameters of the elements DTLSCH. Typical parameters of DTL.*
10. *Write an analysis of transistor-transistor LE (TTL).*
11. *Justify the basic LE NAND. TTL-elements NOR, AND-OR-NOT.*
12. *Explain the LE with a free collector and with three output states.*
13. *Compare the typical parameters of TTL, TTLSCH.*
14. *Analyze the base LE with current supply.*
15. *Evaluate the effectiveness of the elements of integrated injection logic ($I^2L$).*
16. *Justify the implementation of logical functions OR / NOR, AND / NAND.*
17. *Analyze the conjugation of $I^2L$ - elements with TTL.*
18. *Analyze the logic elements on the MOS and CMOS transistors.*
19. *Compare the logical elements NAND, NOR.*
20. *Compare the implementation of MDNF, MCNF by CMOS transistors.*
21. *Analyze buffer amplifiers by CMOS transistors.*
22. *Explain the methods of CMOS LE protection from static electricity.*
23. *Justify the conjugation of CMOS -elements with TTL.*
24. *Compare the typical parameters of CMOS -elements.*
25. *Explain CC synthesis. Examples of CC implementation in the given bases of LE.*
26. *Analyze the schemes of encoders and decoders. Unitary code.*
27. *Write an analysis of priority encoders.*
28. *Compare decoders - linear, pyramida and matrix.*
29. *Explain the minimization of incomplete decoders.*
30. *Justify the synthesis of CC on the basis of the decoder-encoder system.*
31. *Compare multiplexers and demultiplexers.*
32. *Explain the synthesis of multiplexers and demultiplexers.*
33. *Justify gating in decoders.*
34. *Analyze analog multiplexer-demultiplexer.*
35. *Evaluate the efficiency of the shear device on multiplexers.*
36. *Explain the implementation of logic functions by multiplexers*
37. *Analyze the circuit of a half-adders.*
38. *Explain the principle of synthesis of full adders.*
39. *Analyze the circuits of subtractors and adder-subtractors.*
40. *Explain the circuits of a binary-decimal adder.*
41. *Write an analysis of multi-bit adders with sequential transfer.*
42. *Compare multi-bit adders with accelerated transfer.*
43. *Evaluate the effectiveness of combinational multiplier circuits.*
44. *Analyze digital comparators - single-bit and multi-bit.*
45. *Evaluate the efficiency of comparators based on the binary subtractor.*
46. *Evaluate the efficiency of partitioned multi-bit comparators.*

***Questions I** on subjects 8 -12:*

1. *Implement asynchronous and synchronous RS-flip-flops.*
2. *Compare types of RS-flip-flops (R-, S-, E-flip-flops).*
3. *Analyze RS-triggers such as "latch" and MS.*
4. *Compare D-flip-flops asynchronous and transparent synchronous.*
5. *Analyze D-triggers such as "latch" and MS.*
6. *Explain the operation of D-flip-flops in the counter mode.*
7. *Analyze the universal JK-triggers type "latch".*
8. *Analyze the universal JK-triggers type MS.*
9. *Evaluate the main parameters of the triggers.*
10. *Analyze the circuits of parallel registers.*
11. *Write an analysis of shift registers.*
12. *Compare the schemes of reversible shift registers.*
13. *Analyze ring registers and register - "Johnson counter".*
14. *Analyze asynchronous and synchronous counters.*
15. *Justify reversible counters.*
16. *Explain the synthesis of counters - frequency dividers.*
17. *Analyze binary-decimal counters.*
18. *Evaluate counters with a controlled enumeration factor.*
19. *Explain the synthesis of counters with an arbitrary table of transitions.*
20. *Analyze the detectors of the pulse edges.*
21. *Justify pulse expanders.*
22. *Explain trigger pulse generators by bipolar transistors.*
23. *Evaluate trigger pulse generators on unipolar transistors.*
24. *Analyze trigger pulse generators on logic elements.*
25. *Substantiate the trigger pulse generators by amplifier.*
26. *Explain self-oscillating pulse generators on logic elements.*
27. *Analyze pulse generators on operational amplifiers.*
28. *Substantiate generators and generators of linear AC voltage.*
29. *Explain the DAC based on an analog adder.*
30. *Compare the DAC based on the resistive structure R-2R.*
31. *Evaluate the efficiency of the DAC based on current switches.*
32. *Analyze DAC errors.*
33. *Justify sampling and storage devices.*
34. *Explain ADC unfolding balancing.*
35. *Compare the ADC of the tracking balance.*
36. *Compare the ADC bitwise balancing.*
37. *Analyze ADC parameters with double integration.*
38. *Justify parallel ADCs.*
39. *Explain conveyor parallel ADCs.*
40. *The concept of delta-sigma ADC.*

***Questions III** on subjects **: Problem part 1***

1. *Find MDNF and MCNF of the logical function LF1, given in vector form, and implement it by logical elements of type DTL.*
2. *Find MDNF and MCNF of the logical function LF1, given in vector form, and implement it on logical elements of type TTL.*
3. *Find MDNF and MCNF of the logical function LF1, given in vector form, and implement it on logical elements of the type CMOS.*
4. *Find the MDNF and MCNF of the logical function LF1, given in vector form, and implement its logical elements of type $I^2L$.*
5. *Find the MDNF and MCNF of the logical function LF1, given in vector form, and implement it on logical elements of the type emitter coupled logic, ECL.*

6. *Find MDNF and MCNF of the logical function LF2, given in vector form, and implement it on logical elements of type DTL.*
7. *Find MDNF and MCNF of the logical function LF2, given in vector form, and implement it on logical elements of type TTL.*
8. *Find MDNF and MCNF of the logical function LF2, given in vector form, and implement it on logical elements of the type CMOS.*
9. *Find MDNF and MCNF of the logical function LF2, given in vector form, and implement it on logical elements of type $I^2L$.*
10. *Find the MDNF and MCNF of the logical function LF2, given in vector form, and implement its logical elements of the ECL type.*
11. *Find MDNF and MCNF of the logical function LF3, given in vector form, and implement it on logical elements of type DTL.*
12. *Find MDNF and MCNF of the logical function LF3, given in vector form, and implement it on logical elements of type TTL.*
13. *Find MDNF and MCNF of the logical function LF3, given in vector form, and implement it on logical elements of the type CMOS.*
14. *Find MDNF and MCNF of the logical function LF3, given in vector form, and implement it on logical elements of type $I^2L$.*
15. *Find the MDNF and MCNF of the logical function LF3, given in vector form, and implement its logical elements of the ECL type.*
16. *Find MDNF and MCNF of the logical function LF4, given in vector form, and implement it on logical elements of type DTL.*
17. *Find MDNF and MCNF of the logical function LF4, given in vector form, and implement it on logical elements of type TTL.*
18. *Find MDNF and MCNF of the logical function LF4, given in vector form, and implement it on logical elements of the type CMOS.*
19. *Find MDNF and MCNF of the logical function LF4, given in vector form, and implement it on logical elements of type $I^2L$.*
20. *Find the MDNF and MCNF of the logical function LF4, given in vector form, and implement its logical elements of the ECL type.*

### *Питання IV Задача №2*

1. *Implement the code converter $X_n$ to code $Y_n$ on logical elements of type NAND.*
2. *Implement the code converter $X_n$ to code $Y_n$ on logical elements of type NOR.*
3. *Implement the code converter $X_n$ to code $Y_n$ on logical elements of type OR-AND-NOT.*
4. *Implement an asynchronous counter-frequency divider by $K_{cnt} = 2n + 1$ based on JK- triggers.*
5. *Implement a synchronous counter with a transition table Tab.2 by RS-triggers.*
6. *Implement a synchronous counter with a transition table Tab.2 by D-triggers.*
7. *Implement a synchronous counter with a transition table Tab.2 by JK-triggers.*
8. *Implement a synchronous counter with a transition table Tab.3 by RS-triggers.*
9. *Implement a synchronous counter with a transition table Tab.3 by D-triggers.*
10. *Implement a synchronous counter with a transition table Tab.3 by JK-triggers.*
11. *Implement a synchronous counter with a transition table Tab.4 by RS-triggers.*
12. *Implement a synchronous counter with a transition table Tab.4 by D- triggers.*
13. *Implement a synchronous counter with a transition table Tab.4 by JK-triggers.*
14. *Implement a synchronous counter with a transition table Tab.5 by RS-triggers.*
15. *Implement a synchronous counter with a transition table Tab.5 by D-triggers.*
16. *Implement a synchronous counter with a transition table Tab.5 by JK-triggers.*

Tab. 1

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **$Q_1$** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **$Q_2$** | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 |
| **$Q_3$** | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 |
| **$Q_4$** | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 |
| **$N_{10}$** | **1** | **3** | **5** | **7** | **9** | **11** | **13** | **15** | **1** |

Tab. 2

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Q1** | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Q2** | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 |
| **Q3** | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 0 |
| **Q4** | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| **$N_{10}$** | **0** | **8** | **1** | **3** | **7** | **15** | **9** | **12** | **14** | **6** | **2** | **4** | **0** |

Tab. 3

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **$Q_1$** | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| **$Q_2$** | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 |
| **$Q_3$** | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 0 |
| **$Q_4$** | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| **$N_{10}$** | **0** | **1** | **3** | **7** | **15** | **8** | **12** | **14** | **9** | **6** | **2** | **4** | **0** |

Tab. 4

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **$Q_1$** | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 0 |
| **$Q_2$** | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 |
| **$Q_3$** | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 0 |
| **$Q_4$** | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| **$N_{10}$** | **0** | **2** | **7** | **8** | **12** | **14** | **9** | **6** | **1** | **3** | **4** | **15** | **0** |

Tab. 5

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **$Q_1$** | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| **$Q_2$** | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 |
| **$Q_3$** | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 0 |
| **$Q_4$** | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| **$N_{10}$** | **1** | **3** | **7** | **15** | **8** | **12** | **14** | **9** | **6** | **2** | **4** | **1** |