National Technical University of Ukraine
Igor Sikorsky Kyiv Polytechnic Institute "

Department of
Electromechanical Systems
Automation and Electrical
Drives

AUTOMATION SYSTEMS. PART 1. PROGRAMMABLE LOGIC INTEGRATED CIRCUITS

Work program (Syllabus) of the educational component

Details of the academic discipline	
Level of higher education	***First (undergraduate)***
Discipline	*14 "Electrical engineering"*
Specialty	*141 "Electric power engineering, electrical engineering and electromechanics"*
Educational program	*Electromechanical automation systems, electric drive and electric mobility*
Discipline status	*Mandatory*
Form of education	*Daytime*
Year of training, semester	*II year, spring semester (full-time)* *I course, spring semester (full-time accelerated)*
Scope of the discipline	*6 ECTS credits /180 hours (36 hours of lectures, 36 hours of laboratory work, 18 hours of practical classes)*
Semester control/ control measures	*Examination, testing, MKR, RGR, performance and defense of laboratory work, performance of tasks for practical classes*
Class schedule	*1 lecture (2 hours) once a week;* *1 laboratory work (4 hours) 2 times a week.* *1 practical lesson (2 hours) 2 times a week.*
Language of teaching	*Ukrainian*
Information about the head of the course / teachers	*Lecturer* : *Ph.D. Serhiy Oleksandrovich Buryan , 0508403155* Practical classes: *Zemlyanukhina Hanna Yuriivna, 0973875085* Laboratory works: *Oleh Vyacheslavovich Sergienko , Yevhen Oleksiiovych Nikonenko*
Placement of the course	*https://do.ipo.kpi.ua/course/view.php?id=321* ***(certified)***

Program of study discipline

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

Syllabus of the educational component " Automation systems. Part 1 " was compiled in accordance with the bachelor's educational program " Electromechanical systems of automation, electric drive and electromobility " (version of 2024) specialty 141 - Electric power engineering, electrical engineering and electromechanics.

The purpose of the educational discipline *there is the formation and consolidation of students' following competencies: (Z K01) Ability to abstract thinking, analysis and synthesis; (ZK03) Ability to communicate in the state language both orally and in writing; (ZK05) Ability to search, process and analyze information from various sources; (ZK06) Ability to identify, pose and solve problems; (ZK07) Ability to work in a team; (ZK08) Ability to work autonomously ; (FK01) Ability to solve practical problems using automated design and calculation systems (CAD); (FC14) Ability to solve complex problems of logical synthesis related to the operation of discrete automation systems and microprocessor devices.*

The subject of the educational discipline *is advanced methods of synthesis of multi-cycle automation schemes, which are used in their technical implementation in the form of control algorithms for programmable logic integrated circuits.*

Program learning outcomes, the formation and improvement of which the discipline is aimed at: *(PRN06) Apply application software, microcontrollers and microprocessor technology to solve practical problems in professional activities ; (PRN08) Choose and apply suitable methods for the analysis and synthesis of electromechanical and electric power systems with specified indicators; (PRN10) Find the necessary information in scientific and technical literature, databases and other sources of information, evaluate it relevance and reliability; (PRN11) 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; (PRN18) To be able to learn independently, acquire new knowledge and improve the skills of working with modern equipment, measuring equipment and application software; (PRN21) Know and understand the principles of operation of integrated microcircuits, programmable logic controllers and programmable logic integrated circuits; (PRN23) To be able to apply the laws of algebra-logic, code conversion, Carnot maps, the basis of transition tables, graph transitions , cyclograms and multiplexers -selectors for the synthesis of logic control schemes for automation systems; (PRN24) To be able to apply the methods of synthesis of discrete automation circuits to compile programs for programmable logic relays and programmable logic integrated circuits, to select equipment when designing discrete automation systems, to compile logic circuits on microcircuits using a modern element base; (PRN28) Develop design and construction documentation for control schemes of electromechanical systems; program microprocessors, microcontrollers, programmable logic integrated circuits and logic controllers and use them to implement algorithms for controlling electric drives.*

2. Prerequisites and postrequisites of the discipline

To successfully master the discipline, the student must possess the educational components "Computer technology and programming", "Engineering graphics" and "Synthesis of logic circuits". Competences, knowledge and skills acquired during the study of the educational component are necessary for further study of the educational components of "Automation systems. Part 2", "Automation systems. Course project", "Automated electric drive" and "Electromechanical systems of typical technological applications".

3. Content of the academic discipline

Chapter 1 . Synthesis of schemes based on graph transitions

Topic 1.1. Synthesis of schemes based on graph transitions . Part 1. Asynchronous circuits on RS flip-flops. Basic concepts

Topic 1.2. Synthesis of schemes based on graph transitions . Part 2. Asynchronous circuits on RS-triggers. Examples of synthesis

Topic 1.3. Synthesis of schemes based on graph transitions . Part 3. Synchronous circuits on JK flip-flops

Topic 1.4. Synthesis of schemes based on graph transitions . Part 4. Synthesis of synchronous single-input circuits based on JK flip-flops

Topic 1.5. Synthesis of schemes based on graph transitions . Part 5. Features of the synthesis of synchronous single-input circuits in the presence of repeating numbers

Chapter 2. Synthesis of schemes on multiplexers -selectors

Topic 2.1. Synthesis of schemes on multiplexers -selectors. Part 1. Synthesis of single-cycle circuits

Topic 2.2. Synthesis of schemes on multiplexers -selectors. Part 2. Synthesis of multi-stroke circuits

Chapter 3 . Complex synthesis of schemes for automation systems

Topic 3.1. An example of the synthesis of a complex system of automation of several technological objects

Topic 3.2. Peculiarities of using different methods of synthesis of automation systems

Chapter 4 . Typical integrated circuits for automation systems

Topic 4.1. Use of counter microcircuits in automation systems

Topic 4.2. Digital microcircuits: encoders, decoders and registers

Topic 4.3. Integral timer and its use in automation systems

Topic 4.4. Application of D - triggers in automation systems

Chapter 5 . Programmable logic integrated circuits

Topic 5.1. Programmable logic integrated circuits. Part 1. Simple programmable logic integrated circuits

Topic 5.2. Programmable logic integrated circuits. Part 2. Complex programmable logic integrated circuits

Topic 5.3. Programmable logic integrated circuits. Part 3. User-programmable gate arrays

Topic 5.4. Programmable logic integrated circuits. Part 4. Programmable logic circuits with combined architecture

Topic 5.5. Programmable logic integrated circuits. Part 5. Programmable systems on a crystal

4. Educational materials and resources

Basic literature

1. Distance course "Automation systems-1" for bachelors of the 2nd year of the specialty 141 "Electric power engineering, electrical engineering and electromechanics", - certificate DK Series No. 0002, author-developer S.O. Buryan, - Electronic data - Kyiv: KPI im. . Igor Sikorskyi, 2022 (approved by the Methodical Council of the Igor Sikorskyi KPI, protocol No. 2 dated September 30, 2022). Placement address: https://do.ipo.kpi.ua/course/view.php?id=321.

2. Kovalchuk O.V. Logical synthesis of discrete automation schemes: a study guide - K.: NTUU "KPI", 2008. - 168 p. ISBN 978-966-622-294-0.

3. Automation systems. Laboratory practice. Part 1 [Electronic resource]: study guide for bachelor's degree holders in the educational program "Electromechanical systems of automation, electric drive and electric mobility" specialty 141 "Electric power, electrical engineering and electromechanics" / KPI named after Igor Sikorskyi; edited by: S. O. Buryan, G. Yu. Zemlyanukhina , R. S. Volyanskyi . – Electronic text data (1 file: 7.56 MB). – Kyiv: KPI named after Igor Sikorskyi, 2022. – 255 p. – Name from the screen (access via the link https://ela.kpi.ua/handle/123456789/48594).

4. Automation of technological processes, installations and complexes - 1 [Electronic resource]: a course of lectures for students of the training direction 6.050702 "Electromechanics" of the specialty "Electromechanical systems of automation and electric drive" full-time study / NTUU "KPI"; structure. O. V. Kovalchuk, S. O. Buryan. – Electronic text data (1 file: 26.3 MB). - Kyiv: NTUU "KPI", 2011. - Title from the screen (access via the link https://ela.kpi.ua/handle/123456789/932).

5. Automation of technological processes, installations and complexes - 2 [Electronic resource]: synopsis of lectures from the credit module for students of the training direction 6.050702 "Electromechanics", specialty "Electromechanical systems of automation and electric drive" full-time

study / NTUU "KPI"; structure. O. V. Kovalchuk, S. O. Buryan. – Electronic text data (1 file: 7.63 MB). – Kyiv: NTUU "KPI", 2010. - Title from the screen. (access via the link https://ela.kpi.ua/handle/123456789/821).

6. I.M. Bondarenko, O.V. Borodin, V.P. Karnaushenko Modern component base of electronic systems: training . a guide for students of higher education institutions. / I.M. Bondarenko, O.V. Borodin, V.P. Karnaushenko . – Kharkiv: Khnure, 2020. – 268 p. (access via the link https://openarchive.nure.ua/bitstream/document/14062/3/SKB_2020.pdf).

7. Senko V. I. and others. Electronics and microcircuit technology : In 4 vols. Volume 3. Digital devices: Textbook/Ed. VI Senka //K.: Caravela. - 2008.

8. Design of computer systems based on microcircuits of programmable logic [Text]: monograph / S.A. Ivanets, Yu.O. Zuban , V.V. Kazimir, V.V. Litvinov. - Sumy: Sumy State University , 2013. - 313 p. (access via the link http://essuir.sumdu.edu.ua/handle/123456789/33465).

9. V. Ya. Semenyuk Classification of modern programmable logic integrated circuits / V. Ya. Semenyuk, M. V. Voskresenskyi, O. I. Miskevich . // Scientific journal "Computer-integrated technologies: education, science, production". – 2013. – No. 12. – pp. 180–183. (access via https://cutt.ly/OOoJhE3) .

10. Altera Cyclone II. Device Family Overview (access by link https://cutt.ly/1OoJbm4).

11. Altera MAX300A. Programmable Logic Device Family (access via the link https://cutt.ly/KJUTy6e).

12. Intel Max 10 GPGAs Device Overview (access via the link https://cutt.ly/AOoLKxT).

13. Intel DE10-Lite Board. Documentation (access via the link https://cutt.ly/WOoZUqH).

Additional literature

14. Kovalchuk, O. V., Buryan, S. O. (2010). Application of various methods in synthesis for complex programs for logical programmable controllers. Promelectro information collection . "Industrial electronics and electrical engineering". (4). 51–53 (access via link https://ela.kpi.ua/bitstream/123456789/38235/1/09.pdf).

15. Buryan S.O. Logical synthesis of discrete automatic control systems using programmable low-level relays / S.O. Buryan, M.V. Pechenyk , G.Yu. Zemlyanukhina , I.S. Epifantsev // Collection of Scientific Works of Admiral Makarov National Shipbuilding University. – 2021 - #1 (484). – P. 54-60 (access via link https://doi.org/10.15589/znp2021.1(484).7) .

16. Bruno, F. (2021). FPGA Programming for Beginners. Packt Publishing Ltd, Birmingham-Mumbai. ISBN 978-1-78980-541-3.

17. Zeidman, B. (2002). Designing with FPGAs and CPLDs. Elsevier, CMP Books Lawrence, Kansas. ISBN: 1-57820-112-8.

18. Grout, I. (2008). Digital Systems Design with FPGA and CPLD. Elsevier. ISBN-13: 978-0-7506-8397-5.

19. Vingron , SP (2012). Logic circuit design : Selected methods . Springer Science & Business Media .

20. Darren Ashby and others (2008). Circuit Design. Elsevier. ISBN: 978-1-85617-527-2.

21. Intel DE1-SoC Board. Documentation (access via the link https://cutt.ly/JOoC6PI).

22. Brock J. LaMeres (2017). Introduction to Logic Circuits & Logic Design with VHDL. Springer . ISBN 978-3-319-34194-1 .

23. Valery Sklyarov , Iouliia Skliarova , Alexander Barkalov , Larysa Titarenko (2014). Synthesis and Optimization of FPGA-Based Systems. Springer . DOI 10.1007/978-3-319-04708-9

24. Jivan S. Parab , Rajendra S. Gad , GM Naik (2018). Hands-on Experience with Altera FPGA Development Boards. Springer . DOI 10.1007/978-81-322-3769-3.

25. F. Basile , P. Chiacchio and D. Gerbasio , " On the Implementation of Industrial Automation Systems Based on PLC," in IEEE Transactions he Automation Science and Engineering ,

vol . 10, no . 4, pp . 990-1003 , Oct. 2013, doi : 10.1109/TASE.2012.2226578 (accessed by reference https://ieeexplore.ieee.org/document/6381490) .

Educational content

5. Methods of mastering an educational discipline (educational component)

Lecture classes

No s/p	*The name of the topic of the lecture and a list of main questions (list of didactic tools, links to information sources)*
1	***Topic 1.1. Synthesis of schemes based on graph transitions . Part 1. Asynchronous circuits on RS flip-flops. Basic concepts*** *Basic questions: general information about triggers; the truth table of the RS-trigger; the concept of " graph transition " and its elements; rules for placing "vertex codes" for graph transitions of different sizes; method of synthesis of automation schemes based on graph transitions ; the rules for recording conditions for turning on and resetting triggers; rules for writing equations for output elements and timers.* *Video lesson: https://youtu.be/07DG55_zvoc* *Supporting materials*: https://do.ipo.kpi.ua/mod/folder/view.php?id=111355*
2	***Topic 1.2. Synthesis of schemes based on graph transitions . Part 2. Asynchronous circuits on RS-triggers. Examples of synthesis*** *Main issues: drawing up circuits on logic elements using RS-triggers; peculiarities of the organization of input and output signals when designing circuits on integrated microcircuits; assembling a circuit on integrated microcircuits using RS-triggers; an example of the synthesis of a problem on a graph transition with three triggers; minimization of expressions for output variables, using Carnot maps.* *Video lesson : https://youtu.be/B-V2mVz_BCc* *Supporting materials*: https://do.ipo.kpi.ua/mod/folder/view.php?id=114450*
3	***Topic 1.3. Synthesis of schemes based on graph transitions . Part 3. Synchronous circuits on JK flip-flops*** *Basic questions: notation of the JK flip-flop and its truth table; peculiarities of the synthesis of circuits on graph transitions when using JK-triggers; drawing up circuits on logical elements using JK-triggers; taking into account the "rattling" of contacts when applying a synchronization pulse; peculiarities of designing circuits of electrical principles in the MultiSim environment using microcircuits of JK-triggers; time diagrams of the operation of the scheme on JK-triggers; an example of the synthesis of a problem on a graph transition with three triggers; using a decoder to reduce the equations of the output signals.* *Video lesson : https://youtu.be/cLfzvvfaB5Q* *Supporting materials*: https://do.ipo.kpi.ua/mod/folder/view.php?id=115431*
4	***Topic 1.4. Synthesis of schemes based on graph transitions . Part 4. Synthesis of synchronous single-input circuits based on JK flip-flops*** *Basic questions: the concept of single-input circuits and the JK flip-flop correspondence map; the task of generating binary numbers; compilation of the table of states for the generator of binary numbers; compilation of Carnot maps based on the table of states; timing diagrams of the binary number generator scheme; drawing up a scheme for generating binary numbers on logical elements; seven-segment indicators and their use for displaying numbers; electrical schematic diagram of the binary number generator in the MultiSim environment .* *Video lesson: https://youtu.be/3vMqyc1JqGw* *Supporting materials*: https://do.ipo.kpi.ua/mod/folder/view.php?id=116083*
5	***Topic 1.5. Synthesis of schemes based on graph transitions . Part 5. Features of the synthesis of synchronous single-input circuits in the presence of repeating numbers***

	Main questions: the task of synthesizing a generator of a sequence of binary numbers in which there are repeating numbers; peculiarities of choosing the number of intermediate variables for synthesis; filling in the table of states taking into account an additional intermediate variable; peculiarities of filling Carnot maps for intermediate variables; drawing up a circuit based on logical elements, taking into account an additional intermediate variable; timing diagrams of the binary number generator scheme; double two-digit seven-segment indicators; output of two decimal numbers on two seven-segment indicators; assembling a circuit on integrated microcircuits using JK flip-flops. *Video lesson: https://youtu.be/VEAUt1lXRlA* *Supporting materials*: https://do.ipo.kpi.ua/mod/folder/view.php?id=120105*
6	***Topic 2.1. Synthesis of schemes on multiplexers -selectors. Part 1. Synthesis of single-cycle circuits*** *Main questions: general information about multiplexers -selectors; designation of different types of multiplexers, truth tables and their internal structure; typical microcircuits of multiplexers; mathematical description of multiplexer operation ; types of single-cycle circuits when synthesizing them on multiplexers ; synthesis of one-stroke circuits on multiplexers using a simplified method; assembling a scheme on multiplexers in the MultiSim environment ; synthesis of single-cycle circuits on multiplexers according to the usual method.* *Video lesson: https://youtu.be/y-yiKb3K-vo* *Supporting materials*: https://do.ipo.kpi.ua/mod/folder/view.php?id=122496*
7	***Topic 2.2. Synthesis of schemes on multiplexers -selectors. Part 2. Synthesis of multi-stroke circuits*** *Main questions: the task of synthesis of multi-cycle circuits on multiplexers -selectors; rules for combining selector lines of multiplexers ; method of synthesis of multi-cycle circuits on multiplexers -selectors; an example of the synthesis of a circuit with two multiplexers ; drawing up a circuit based on logic elements based on the results of the synthesis of a multi-cycle circuit; development of a multi-clock circuit on multiplexers in the MultiSim environment ; an example of the synthesis of a scheme whose conditions are given by a cyclogram; development of a multi-cycle circuit on multiplexers with three selector lines in the MultiSim environment .* *Video lesson: https://youtu.be/Kci37pv1NWY* *Supporting materials*: https://do.ipo.kpi.ua/mod/folder/view.php?id=123147*
8	***Topic 3.1. An example of the synthesis of a complex system of automation of several technological objects*** *The main questions: the condition of operation of a complex automation system of several technological objects; tool, conveyor and manipulator control subsystems; preliminary functional scheme of the automation system; synthesis of logical equations for tool, conveyor and manipulator control subsystems; functional scheme of the automation system; program in the FBD language in the Quartus II environment based on the developed functional scheme; simulation results of the developed automation system by the time diagram method.* *Video lesson: https://youtu.be/GytYxdd-A38* *Supporting materials*: https://do.ipo.kpi.ua/mod/folder/view.php?id=123857*
9	***Topic 3.2. Peculiarities of using different methods of synthesis of automation systems*** *Main questions: general information about combined methods of synthesis; the task of deriving a sequence of numbers with the possibility of reversal; the use of "buses" (harnesses) in the design of electrical principle schemes; drawing up an electrical schematic diagram in the MultiSim environment using "buses"; combined synthesis method based on*

	graph transitions and cyclograms; combined method of synthesis based on transition tables and Carnot maps and multiplexers-selectors. *Video lesson: https://youtu.be/qP8QYBJqMXY* *Supporting materials*: https://do.ipo.kpi.ua/mod/folder/view.php?id=124396*
10	***Topic 4.1. The use of microcircuits of counters in automation systems*** *Basic questions: general information about counters; counter chips 74LS192 and 74LS193; multi-bit counter based on 74LS193 microcircuits; an example of the synthesis of a scheme for an automation system using counters; a microcircuit for converting a binary code into a code for a seven-segment indicator; an example of using a microcircuit of a counter, a decoder and a code converter; other microcircuits of counters.* *Video lesson: https://youtu.be/risY-uITLuq* *Supporting materials*: https://do.ipo.kpi.ua/mod/folder/view.php?id=125068*
11	***Topic 4.2. Digital microcircuits: encoders, decoders and registers*** *Basic questions: general information about ciphers; 74LS147 and 74LS148 encoder chips; an example of the synthesis of a scheme for an automation system using an encoder; general information about decoders; decoder chips 74LS42, 74LS145, 74141 and 74LS138; general information about registers; register microcircuits 74LS174, 74LS175, 74LS164; 74198 shift register chip.* *Video lesson: https://youtu.be/XBqQykN3CGA* *Supporting materials*: https://do.ipo.kpi.ua/mod/folder/view.php?id=125437*
12	***Topic 4.3. Integral timer and its use in automation systems*** *The main questions: a microcircuit for generating setting pulses 74LS123; simulation of the operation of the 74LS123 chip in the MultiSim environment ; LM339 comparator chip; simulation of the operation of the LM339 chip in the MultiSim environment ; integrated timer chip NE555; connecting the NE555 microcircuit to receive a signal of a given duration; connecting the NE555 microcircuit to receive a signal delayed for a certain time; implementation of a rectangular pulse generator based on the NE555 chip.* *Video lesson: https://youtu.be/Ms0yx8WJRhk* *Supporting materials*: https://do.ipo.kpi.ua/mod/folder/view.php?id=126285*
13	***Topic 5.1. Programmable logic integrated circuits. Part 1. Simple programmable logic integrated circuits*** *Main questions: general information about programmable logic integrated circuits (PLCs); FPGA programming tools; programmable non-volatile memory devices (PLDs); simulation of PPZP operation in the Multisim environment ; programmable logic matrices (PLM); implementation of logical functions in parentheses in PLM; programmable logic matrices (PML); expansion of PLM and PML opportunities; general properties of simple programmable logic integrated circuits.* *Video lesson: https://youtu.be/ZoIvd-x-3D0* *To intermediate materials*: https :// do . ipo kpi ua / mod / folder / view . php ? id = 127024*
14	***Topic 5.2. Programmable logic integrated circuits. Part 2. Complex programmable logic integrated circuits*** *Main issues: classification of modern programmable logic circuits; general information about complex programmable logic circuits (CPLD); CPLD structure with macrocells ; CPLD communication system ; CPLD input/output blocks; CPLD architecture on the example of the MAX3000 microcircuit; configuration and programming of CPLD chips.* *Video lesson: https://youtu.be/6KUai7f1_kq* *Supporting materials*: https://do.ipo.kpi.ua/mod/folder/view.php?id=127202*
15	***Topic 5.3. Programmable logic integrated circuits. Part 3. User-programmable gate arrays***

	Main questions: general information about user-programmable gate arrays (FPGA); FPGA logic blocks based on transistors and multiplexers; FPGA microcircuits on " large-grained " logic blocks; programmable input/output block of FPGA chips; FPGA interconnection system ; examples of FPGA microcircuits of medium complexity. *Video lesson: https://youtu.be/xrmI7J4at6w* *Supporting materials*: https://do.ipo.kpi.ua/mod/folder/view.php?id=127452*
16	***Topic 5.4. Programmable logic integrated circuits. Part 4. Programmable logic circuits with combined architecture*** *Main questions: general information about programmable logic circuits with combined architecture; microcircuits of the MAX II, MAX V and MAX 10 families; matrix logic block and logic element of the MAX family of microcircuits; input/output elements; non-volatile FPGA MAX 10 family; scope of application of PLIS MAX 10.* *Video lesson: https://youtu.be/DGR9q4il60s* *Supporting materials*: https://do.ipo.kpi.ua/mod/folder/view.php?id=127727*
17	***Topic 5.5. Programmable logic integrated circuits. Part 5. Programmable systems on a crystal*** *Basic questions: general information about programmable systems on a crystal; advantages of programmable systems on a crystal; Nios II processor core of Altera chips ; FPGA type programmable "system on a crystal" with a uniform structure; programmable systems on a chip with FPGA: Arria GX; programmable systems on a chip with FPGA: Cyclone ; programmable systems on a crystal with built-in processor units; a programmable system on a Cyclone V SoC FPGA type crystal with embedded processor systems.* *Video lesson: https://youtu.be/rSxH2Mikz-c* *Supporting materials*: https://do.ipo.kpi.ua/mod/folder/view.php?id=127943*
18	***Topic 4.4. Application of D-triggers in automation systems*** *Basic questions: general information about D-triggers; microcircuits of D-triggers 74LS74, 74LS75, 74LS174, 74LS175; register implementation based on D-triggers; counter implementation based on D-triggers.* *Video lesson: https://youtu.be/e2KgiqklSUQ* *Supporting materials*: https://do.ipo.kpi.ua/mod/folder/view.php?id=128187*

Practical classes

No s/p	*Name of the subject of the lesson and list of main questions*
1	***Practical lesson No. 1. Fundamentals of designing circuits of electrical principles in the environment of Dip Trace*** *Basic questions: rules of operation in Dip software Trace for designing schemes of electrical principles; circuit design on integrated microcircuits; basics of "air" connection between elements; creating a list of elements and stamps.* *Video lesson: https://youtu.be/m44c2eim_Ss* *Supporting materials*: https://do.ipo.kpi.ua/mod/folder/view.php?id=113704*
2	***Practical lesson #2. Creating your own library of elements in the Dip environment Trace*** *Main issues: creation of own library of elements necessary for designing schemes of electrical principles; binding of microcircuits to the body; design of the electrical principle scheme on the own library of elements.* *Video lesson: https://youtu.be/fmHN3OkE5jk* *Supporting materials*: https://do.ipo.kpi.ua/mod/folder/view.php?id=114160*
3	***Practical lesson No. 3. Basics of work in the FPGA programming environment Quartus II*** *Basic questions: the basics of working in the Quartus II environment; creating a project file and a program file; an example of creating a program to implement a simple logical function " Exclusive OR"; purpose of foams ; creating a simulation file; simulation of circuit operation based on time diagrams; an example of creating a program and simulation for a logic function described by a cycle diagram.* *Video lesson: https://youtu.be/emnYTw9_jSQ* *Supporting materials*: https://do.ipo.kpi.ua/mod/folder/view.php?id=119660*
4	***Practical lesson No. 4. Working with triggers in the FPGA programming environment Quartus II*** *Main issues : creating an RS-trigger block in the Quartus II environment; formatting of the appearance of the block; creation of a program in the FBD language based on the results of synthesis by the method of graph transitions based on RS-triggers; simulation of the results of the scheme by the method of time diagrams; creating a program in the FBD language in the Quartus II environment based on the results of the synthesis of the automation problem by the method of graph transitions on JK-triggers; creation of a clock pulse generator based on the RS-trigger block; copying blocks to different projects; features of simulating the results of the circuit using the time diagram method using a synchronizing pulse; creating a program for generating binary numbers based on JK-triggers; simulation of the results of the binary number generator.* *Video lesson part 1: https://youtu.be/6r3DUgEYWfg* *Video lesson part 2: https://youtu.be/qC3Sr28GYZ8* *Supporting materials*: https://do.ipo.kpi.ua/mod/folder/view.php?id=119775*
5	***Practical lesson No. 5. Working with multiplexers -selectors in the Quartus II environment*** *Main questions : creation of multiplexer-selector blocks for two and three selector lines in the Quartus II environment; formatting the appearance of blocks; creating programs in the FBD language based on the results of the synthesis of single-cycle circuits on multiplexers with two and three selector lines; simulation of circuit results by the time diagram method; creation of programs in the FBD language based on the results of the synthesis of multi-clock circuits on multiplexers with two and three selector lines (including circuits whose operating conditions are specified by a cyclogram); simulation of the results of the schemes by the method of time diagrams.* *Video lesson part 1: https://youtu.be/H9wZ894KU-M* *Video lesson part 2: https://youtu.be/KiUrjTqvyAk*

	Supporting materials: https://do.ipo.kpi.ua/mod/folder/view.php?id=122646*
6	***Practical lesson No. 6. Creation of electrical schematics on triggers and multiplexers in the DipTrace environment*** *Main issues: creation of microcircuits of RS-, JK-triggers, multiplexers-selectors for two and three selector lines; creation of other elements of automation systems: relay, optocoupler , three-phase contactor, three-phase motor, microcircuit ULN2004; creation of an electrical circuit diagram in the DipTrace environment using RS-triggers and other elements of automation systems (optocouplers , sensors, relays, motors, etc.); creation of an electrical principle diagram in the DipTrace environment using multiplexers -selectors and other elements of automation systems (optocouples , buttons, connectors, three-phase motor, contactors, relays, logic chips, etc.).* *Video lesson part 1: https://youtu.be/5SrcK5VJ2Q0* *Video lesson part 2: https://youtu.be/7sp1WSUlI_U* *Video lesson part 3: https://youtu.be/WF0XG5XF6E8* *Supporting materials*: https://do.ipo.kpi.ua/mod/folder/view.php?id=123282*
7	***Practical lesson No. 7. Creating projects in Quartus II, MultiSim and DipTrace environments using buses*** *Main questions: creation of a program in the FBD language in the Quartus II environment using buses based on the results of the synthesis of a single-cycle circuit on multiplexers - selectors with three selector lines; creation of a program in the FBD language in the Quartus II environment using buses based on the results of the synthesis of a multi-clock circuit on RS-triggers; creation of a project of an electrical principle scheme on triggers using tires in the Multisim environment ; creation of a project of an electrical principle scheme on triggers using tires in the DipTrace environment ; creation of a program in the FBD language in the Quartus II environment using buses based on the results of the synthesis of a multi-clock circuit on RS-triggers (a method without creating buses in the form of arrays - direct addressing of signals).* *Video lesson part 1: https://youtu.be/BPre1tu0B70* *Video lesson part 2: https://youtu.be/Lrqax6os05E* *Video lesson part 3: https://youtu.be/HfQ8tfcLUDk* *Video lesson part 4: https://youtu.be/Fq86Gu91bek* *Supporting materials*: https://do.ipo.kpi.ua/mod/folder/view.php?id=124677*
8	***Practical lesson #8. Fundamentals of FPGA programming in the Verilog HDL language*** *Main questions: basics of programming in the Verilog HDL language in the Quartus II environment; creating a program module, input and output variables, program body; creating a program for simple logical expressions; creation of a program for logical equations obtained on the basis of synthesis by the cyclogram method; creation of programs for single-cycle circuits synthesized on a multiplexer with two and three selector lines.* *Video lesson: https://youtu.be/UR_QzZ5TjBk* *Supporting materials*: https://do.ipo.kpi.ua/mod/folder/view.php?id=126859*
9	***Practical lesson No. 9. Development of programs for FPGAs in the Verilog HDL language using multiplexers and triggers*** *Main questions : creation of a program in Verilog HDL language for a multi-clock circuit, which is synthesized by the method of multiplexers-selectors; creating an RS-trigger module; creation of a Verilog HDL program for a multi-cycle circuit synthesized by the method of RS-triggers; creating a JK-trigger module; creation of a Verilog HDL program for a multi-clock circuit synthesized by the method of JK flip-flops.* *Video lesson part 1: https://youtu.be/LzOV_z0s1yo* *Video lesson part 2: https://youtu.be/TTaOz0w5BqU*

	Video lesson part 3: https://youtu.be/t6ZoCYt6R6w *Supporting materials*: https://do.ipo.kpi.ua/mod/folder/view.php?id=127299*

** Supporting materials for lectures and practical classes are available for download only to applicants who are registered for the distance course "Automation Systems-1" on the Distance Learning Platform "Sikorsky" (link to the distance course in the Moodle environment https://do.ipo.kpi.ua/course/view.php?id=321).*

Laboratory work

No s/p	*List of laboratory works*
1	***Laboratory work #1. Logical synthesis and research of automation schemes on discrete logical elements*** *The purpose of the work is to practically test various methods of synthesis of single-cycle and multi-cycle circuits, to acquire the skills of transition from algebraic expressions to circuits on integrated microcircuits, to master the methods of synthesis on cyclograms and transition tables, to learn how to make electrical schematics and integrated microcircuits using circuit boards, buttons, LEDs and resistors.*
2	***Laboratory work #2. Logical synthesis and research of automation circuits and triggers and multiplexers*** *The purpose of the work is to practically check various methods of synthesis of single-cycle and multi-cycle circuits on triggers and multiplexers , to learn how to make electrical circuits and integrated microcircuits of triggers and multiplexers using circuit boards, buttons, LEDs and resistors.*
3	***Laboratory work #3. Study of relay-contactor schemes of automation*** *The purpose of the work is to practically check various methods of synthesis of single-cycle and multi-cycle circuits, to learn how to build relay- contactor circuits based on synthesized logic equations, to acquire the ability to work with industrial relays, to configure time relays, to make circuits using them and to practically check the operation of such circuits*
4	***Laboratory work #4. DE10-lite board input and output devices*** *The goal of the work is to learn how to program in the FBD language in the Quartus environment Prime and use the I/O peripherals of the DE10-Lite developer board with Altera MAX 10 FPGAs to implement single-cycle and multi-cycle schemes of industrial machinery automation systems.*
5	***Laboratory work #5. Work with seven-segment indicators and timers*** *The goal of the work is to acquire the ability to synthesize logical schemes of automation systems using seven-segment indicators, to learn how to develop programs in the FBD language in the Quartus environment Prime using timers and clock generators and practically test them with the DE10-Lite developer board.*
6	***Laboratory work #6. Synthesis and research of circuits on triggers based on the DE10-Lite board*** *The purpose of the work is to deepen the ability to solve practical problems of the synthesis of logical expressions for automation systems by the method of RS-triggers, to learn to develop programs based on these expressions in the FBD language in the Quartus program Prime and check their performance on the DE10-Lite developer board.*
7	***Laboratory work #7. Study of pulse counters*** *The purpose of the work is to acquire practical skills in synthesizing circuits for automation systems using microcircuits of counters, to compile appropriate programs in the FBD*

	language in the Quartus II environment, and to practically check their performance on the basis of the DE10-Lite developer board.
8	***Laboratory work #8. Logical synthesis and research of automation schemes of typical industrial mechanisms based on programmable logic integrated circuits (PLCs)*** *The purpose of the work is to deepen the practical skills of synthesizing single-stroke and multi-stroke circuits, to learn how to build programs in the FBD language based on the obtained logical expressions in the Quartus II environment, to program the FPGAs of the Cyclone II family , and to practically check the performance of the developed circuits for automation systems.*
9	***Laboratory work #9. Study of the operation of the integral timer NE555*** *The purpose of the work is to acquire the ability to develop and configure circuits using the NE555 integrated timer chip, to learn to develop rectangular pulse generator circuits and circuits with time delays, to practically check the performance of the developed circuits using integrated circuits, circuit boards, buttons, LEDs and resistors.*

Calculation and graphic work (RGR)

As an individual task, students perform calculation and graphic work (RGR). The purpose of RGR is to consolidate students' practical skills in developing control schemes for automation systems according to the given operating conditions of the technological process. The RGR task is issued after mastering topics 1.1-1.3.

The structure of the RGR

No. z/p	*Title of the section*
1	Issuance of a task for RGR
2	Chapter 1. Analytical overview of the field of use of FPGA
3	Chapter 2. Formulation of the coursework task and its detailing
4	Chapter 3. Development of the functional scheme of the control system and determination of all its signals
5	Chapter 4. Synthesis of logic functions and control algorithms

Student's independent work (SRS)

No. z/p	*Type of independent work*	*Number of hours of SRS*
1	*Preparation for laboratory work*	*22*
2	*Preparation for practical classes*	*18*
3	*Testing on the lecture material*	*3*
3	*Preparation for MKR*	*2*
4	*Implementation of RGR*	*15*
5	*Preparation for the exam*	*30*
	Total hours of SRS	***90***

6. Control work

The purpose of the test work is to consolidate and verify theoretical knowledge from the educational component, students to acquire practical skills of independent problem solving and the compilation and compilation of programs.

The modular control work (MKR) is completed after studying Sections 1-3 and completing practical classes 1-5. Control work is carried out in the Moodle environment . Each student receives an individual task, according to which it is necessary to perform the synthesis of a multi-clock circuit on multiplexers and triggers, to compile programs in the Quartus II environment and to perform a simulation using the timing diagram method.

Policy and control

6. Policy of academic discipline (educational component)

The system of requirements that the teacher sets before the student:

- *rules for attending classes: it is forbidden to evaluate the presence or absence of the winner in the classroom class, including the awarding of incentive or penalty points. According to the RSO of this discipline, points are awarded for the relevant types of educational activity in lectures, practical classes and laboratory work.*
- *rules of behavior in classes: the student has the opportunity to receive points for the appropriate types of educational activity in lectures, practical classes and laboratory work provided by the RSO of the discipline. The use of means of communication to search for information on the teacher's Google Drive, on the Internet, in a distance course on the Sikorsky platform is carried out on the condition that the teacher instructs;*
- *while working with teachers in practical classes, laboratory works, as well as during the direct defense of works provided by the RSO, the student must be connected to the appropriate conference with the camera constantly on.*
- ***deadline and rescheduling policy:***
  - *if the student did not pass or did not appear at the MKR (without a good reason), his result is evaluated at 0 points. Redrafting of the MKR is not foreseen;*
  - *in the absence of a student at a practical lesson or laboratory work, he receives a personal task from the teacher;*
  - *any defenses of laboratory works and tasks from practical classes are not possible during the additional session, if the student did not attend more than 50% of the relevant classes;*
- *policy on academic integrity: the Code of Honor of the National Technical University of Ukraine "Kyiv Polytechnic Institute" https://kpi.ua/files/honorcode.pdf establishes general moral principles, rules of ethical behavior of individuals and provides a policy of academic integrity for persons working and studying at the university, which they should be guided by in their activities, including when studying and preparing control measures in the discipline "Automation Systems";*
- *when using digital means of communication with the teacher (mobile communication, e-mail, correspondence on forums and social networks, etc.), it is necessary to observe generally accepted ethical norms, in particular, be polite and limit communication to the working hours of the teacher;*
- *recognition of learning results acquired in non-formal/informal education is carried out in accordance with the "Regulations on recognition in KPI named after Igor Sikorskyi of learning outcomes acquired in non-formal/informal education". Courses (including online), seminars, trainings, etc. related to the subject of this discipline may be recognized.*

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

Current control *: exercises in lecture classes, testing, performance of RGR, MKR, performance of tasks for practical classes, performance and defense of laboratory works.*

Calendar control *: carried out twice a semester as a monitoring of the current status of meeting the syllabus requirements.*

Semester control: *exam.*

Conditions for admission to semester control *: completed and defended laboratory work, completed tasks for practical classes, semester rating of more than 30 points.*

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

Number of points	Rating
95-100	Perfectly
85-94	Very good
75-84	Good
65-74	Satisfactorily
60-64	Enough
Less than 60	Unsatisfactorily
Less than 30	Not allowed

The student's overall rating after the end of the semester consists of points obtained for:

- *performance of exercises at lectures;*
- *testing for each lecture session;*
- *performance of tasks for practical classes;*
- *performance and protection of laboratory work;*
- *execution of calculation and graphic work;*
- *execution of modular control work (MCR);*
- *exam answers.*

General distribution of maximum points

Performing exercises at lectures	Testing by lectures	Practical classes	Laboratory work	MKR	RGR	Additional points	Exam
9	9	9	18	5	10	until 10	40

Testing on the materials of lecture classes

Weight score 0.5. *The maximum number of points for testing is 0.5 points * 18 lectures = 9 points.*

Testing is conducted in the Moodle distance learning system and is available within 5 working days after the end of the current lecture. In some cases, the term of passing the test can be extended by the lecturer. The duration of one test is 10 minutes. The number of attempts is one. In some cases, related to technical problems of students, a re-attempt for individual tests may be given .

Each test contains 10 questions of different formats (choosing the correct option from the list; true/false; matching; numerical answer; choosing the missing words; dragging on the image, etc.).

Evaluation criteria

- *questions such as "choosing the correct option from the list", "true/false", "numerical answer" are evaluated unambiguously: a correct answer - 0.05 points, an incorrect answer - 0 points;*
- *questions that do not have one specific answer, such as "determine the correspondence", "select the missing words", "drag to the image" are evaluated according to the number of elements in the test (for example, if you need to insert 4 words into the text, then the student will receive 0 .0125 points for one correctly inserted word, and for all 4 correctly inserted words he will receive 0.05 points respectively) - incorrect answer - 0 points, partially correct answer - 0.005-0.045 points, correct answer 0.05 points.*

Exercises during lectures

Weight score 0.5. *The maximum number of points for the exercises is 0.5 points * 18 lectures = 9 points.*

Exercises are conducted only during lectures and are available only at the time specially allocated by the teacher. At other times, regardless of the circumstances, the exercises are not available. Exercises are performed by students in the Moodle distance learning system. The duration of one exercise is from 2 to 5 minutes, depending on its complexity. The duration of the exercise is pre-announced by the teacher. The number of attempts is one. After each exercise, a short discussion of its results is held.

Each exercise is a test that contains 1 task of a different format (choosing the correct option from the list; true/false; matching; numerical answer; choosing the missing words; dragging on the picture, etc.).

Evaluation criteria

- *questions such as "choosing the correct option from the list", "true/false", "numerical answer" are evaluated unambiguously: a correct answer - 0.05 points, an incorrect answer - 0 points;*
- *questions that do not have one specific answer, such as "determine the correspondence", "select the missing words", "drag to the image" are evaluated according to the number of elements in the test (for example, if you need to insert 4 words into the text, then the student will receive 0 .0125 points for one correctly inserted word, and for all 4 correctly inserted words he will receive 0.05 points, respectively) - incorrect answer - 0 points, partially correct answer - 0.01-0.49 points, correct answer 0.5 points.*

Practical classes

Weight point 1 *. The maximum number of points for all practical classes is 1 point * 9 classes = 9 points.*

At practical classes, students receive personal tasks on the subject of the practical class and solve them under the guidance of the teacher.

Evaluation criteria

- the homework was solved correctly and passed in the practical lesson - 1 point;

- the homework was solved correctly and passed within 2 weeks after the practical lesson - 0.8 points;

- the homework was solved correctly, but it was submitted more than 2 weeks after the practical lesson - 0.5 points;

- the homework was solved with minor errors and passed in the practical lesson - 0.8 points;

- the homework was solved with minor errors and passed within 2 weeks after the practical lesson - 0.5 points;

- the homework was solved with minor errors and was submitted more than 2 weeks after the practical session - 0.2 points;

- the homework is solved with significant errors - it is returned for revision.

WARNING! *Solving and submitting all homework assignments is a condition for admission to the exam. Students who have not passed the homework at the time of the consultation before the exam are not allowed to take the main exam and are preparing for a retake.*

WARNING! *In order to be allowed to retake the exam, you must hand in all homework assignments for practical classes within the deadline set by the teacher.*

Laboratory work

Weight score. Laboratory works have a weighting point of 2. *The maximum number of points for all laboratory works is 2 points * 9 works = 18 points.*

In laboratory work, students check the functionality of written programs or schemes based on previously solved tasks at home. For admission to current laboratory work, it is necessary to have

a Protocol drawn up in accordance with the norms of drawing up technical documentation, which must contain all the necessary points, in accordance with the Methodological Instructions. ***Also, for admission to laboratory work (except for the 1st), it is necessary to protect the previous one*** *. Students who have not defended the previous laboratory work may not be allowed to perform the next one. Laboratory works 1, 2 and 8 are performed by each student individually, laboratory works 3-7 and 9 are performed by a team.*

Criteria for evaluating laboratory work:

- correctly completed synthesis of all tasks, demonstrated efficiency of all programs (schemes), correct answers to defense questions - 2 points;

- correctly completed synthesis of all tasks, demonstrated efficiency of all programs (schemes), answers to defense questions have inaccuracies - 1.5-1.9 points;

- the synthesis of all tasks is completed, but some of them contain errors or inaccuracies, the functionality of not all programs (schemes) is demonstrated, the answers to the defense questions have inaccuracies - 1-1.4 points;

- the synthesis of not all tasks was performed, the performance of not all programs (schemes) was demonstrated, the answers to the defense questions were inaccurate - 0-0.9 points;

- the laboratory work is not completed or the protocol is not submitted - it is returned for revision or revision.

WARNING! *Defense of all laboratory work is a condition for admission to the exam. Students who, at the time of the consultation before the exam, have not defended the laboratory work, are not allowed to take the main exam and are preparing for a retake.*

WARNING! *In order to be allowed to retake the exam, it is necessary to pass all laboratory work debts within the deadline set by the teacher.*

Calculation and graphic work

The weighted score is 5. *The maximum number of points for the RGR is 10 .*

The task for calculation and graphic work (RGR) is issued to students after mastering topics 1.1-1.3.

In order to receive the maximum score, students have to fulfill the deadline set by the teacher all sections of the RGR and issue it in accordance with the established requirements.

RGR evaluation criteria:

- the task was completed correctly, the RGR was completed in accordance with the requirements, the student answered the question correctly - 10 points;

- the task was completed with insignificant inaccuracies , the RGR was drawn up in accordance with the requirements with some comments, the student answered the question correctly - 6-9 points;

- the task was completed with significant inaccuracies , the RGR was not prepared according to the requirements, the student answered the questions with errors - 3-5 points;

- the task was completed with significant inaccuracies , the RGR was not prepared according to the requirements, the student answered the questions with errors - 0.5-2 points.

WARNING! *Defense of the RGR is a condition for admission to the exam. Students who, at the time of the consultation before the exam, have not defended the RGR, are not allowed to take the main exam and are preparing to retake it.*

WARNING! *In order to be allowed to retake the exam, one must defend the RGR within the deadline set by the teacher.*

Modular control work

The weighted score is 5. *The modular control work (MCW) is performed during the semester in one of the practical classes after studying Section 1 and completing practical classes 1-5.*

Evaluation criteria for modular test work:

The student completes 2 tasks in the modular control work. Each task is evaluated from 0 to 2.5 points:

- correctly performed synthesis, compiled program, performed simulation using the time diagram method meets the condition - 2.5 points;

- a correctly performed synthesis, a compiled program, a simulation performed by the time diagram method partially meets the condition - 2-2.4 points;

- the synthesis was performed with errors, the program was compiled, the simulation performed using the time diagram method does not meet the condition - 1-1.9 points;

- the synthesis was performed with errors, the program was compiled incorrectly or only the synthesis was performed correctly - 0.5-0.9 points;

- the synthesis was made with errors, the program was not completed - 0-0.4 points.

In task 1, it is necessary to perform logic synthesis using the graph transition method on JK - or RS -triggers according to the given cycle diagram, build a circuit in the Quartus II environment and make a visualization using the time diagram method. In task 2, it is necessary to carry out a synthesis on multiplexers with two (or three) selector lines according to the given Carnot map , build a circuit in the Quartus II environment and perform a simulation using the timing diagram method.

Calendar control

Calendar control is based on the current rating. A condition for a positive assessment is the value of the student's current rating of at least 50% of the maximum possible at the time of assessment. The score required to obtain a positive calendar control is made known to the students by the teacher no later than 2 weeks before the start of the calendar control.

Additional (bonus) points

The rating system provides additional points for completing additional tasks. One student cannot receive more than 10 bonus points in a semester. Bonus points can be obtained for the following types of work: " Events ", "Additional lectures".

Events . *Events are special events for students who want to get extra points for solving difficult tasks. Events are activated at a specified time (usually Monday) and are active for one week (until the following Monday). Additional points are awarded only to those students who correctly completed the tasks and uploaded their answers within the time limit set by the event . The number of points for additional tasks is determined by each event separately. One student cannot receive more than 5 bonus points for events .*

Additional lectures. *Additional lectures are topics for independent study, which will provide students with a strengthening of theoretical knowledge of the discipline.* ***Weight score 0.5.*** *One student cannot receive more than 5 bonus points for additional lectures. Scorers receive points for completing tasks or testing based on the materials of the lecture.*

The form of semester control is an exam

The maximum number of points for work in the semester is 60. The necessary conditions for admission to the exam are:

- *all laboratory work is completed and protected;*
- *completed tasks for all practical classes;*
- *protected RGR;*
- *semester rating of at least 30 points.*

The exam includes two components: theoretical and practical. ***The theoretical component*** *is aimed at checking students' knowledge acquired as a result of studying the educational component in the form of testing based on the lecture material of the semester. Each test contains 20 questions of different formats (choosing the correct option from the list; true/false; matching; numerical*

*answer; choosing the missing words; dragging on the picture, etc.). The maximum number of points for testing is 20 questions * 1 point = 20 points.* ***The practical component*** *involves checking the acquired skills of students to synthesize, design and check according to the conditions of the task of developing automation systems. Each student is given a separate task, according to the conditions of which it is necessary to perform a synthesis, to compile a program in the Quartus environment II and perform a simulation using the timing diagram method. The maximum number of points per problem is 20 points.*

Evaluation criteria of the theoretical component

- *questions such as "choosing the correct option from the list", "true/false", "numerical answer" are evaluated unambiguously: a correct answer - 1 point, an incorrect answer - 0 points;*
- *questions that do not have one specific answer, such as "determine the correspondence", "select the missing words", "drag to the image" are evaluated according to the number of elements in the test (for example, if you need to insert 4 words into the text, then the student will receive 0 .25 points for one correctly inserted word, and for all 4 correctly inserted words he will receive 1 point respectively) - incorrect answer - 0 points, partially correct answer - 0.1-0.9 points, correct answer 1 point.*

Evaluation criteria of the practical component

- correctly performed synthesis, compiled program, performed simulation using the time diagram method meets the condition - 20 points;

- a correctly performed synthesis, a compiled program, a simulation performed by the time diagram method partially meets the condition - 15-19 points;

- the synthesis was performed with errors, the program was compiled, the simulation performed by the time diagram method did not meet the condition - 10-14 points;

- the synthesis was performed with errors, the program was compiled incorrectly or only the synthesis was performed correctly - 5-9 points;

- the synthesis was made with errors, the program was not completed - 0-4 points.

Working program of the academic discipline (syllabus):

Compiled by an associate professor of the Department of Automation of Electromechanical Systems and Electric Drives of the FEA , Ph.D. Buryan S.O.

Approved by the Department of Automation of Electromechanical Systems and Electric Drives of the FEA (Protocol No. 15 dated 13.06.2024)

Agreed by the Methodical Commission of the faculty (protocol No. 10 dated 06/20/2024)