National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute"

Automation of electrical and mechatronic complexes

Computer control of technological processes, experiments, equipment

Working program of the educational discipline (Syllabus)

Details of the discipline	
Level of higher education	***Second (Master's Degree)***
Field of knowledge	*14 Electrical Engineering*
Speciality	*141 Electric Power Engineering, Electrical Engineering and Electromechanics*
Educational program	*Engineering of intelligent electrotechnical and mechatronic complexes*
Discipline status	*Normative*
Form of study	*daytime*
Year of preparation, semester	*1st year, autumn semester*
Scope of discipline	*5 credits 150 hours*
Semester control / control measures	*Exam / Calculation and Graphic Work (CGW), Modular Control Work (MCW)*
Schedule	*rozklad.kpi.ua*
Language of teaching	*English*
Information about course teachers	Lecturer: *Ph.D., Associate Professor, Toropov Anton Valeriyovych, tel. 066-736-54-53, email: toropovtosha@ukr.net*
Placement of course	*https://classroom.google.com/c/Njk3NjkwMTkyMjAw?cjc=okzic5p*

The program of the discipline

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

This discipline is a continuation of students' acquaintance with computing and programming. Integrated systems of computer mathematics are used to solve various educational, scientific and engineering problems with the help of special computer programs of mathematical direction. These programs are a set of theoretical, algorithmic, hardware and software tools and are specially created for the most effective solution of certain mathematical problems. To solve most automation problems, the object-oriented way of programming is of interest. Structural models solve equations mapped by individual modules and blocks.

The purpose of studying the discipline is to form students' theoretical knowledge and practical skills in building digital control systems for technological processes and electromechanical equipment. The study of the material of this discipline is exclusively focused on the wide application of computer technology and programming.

The subject of the discipline is microprocessor automation systems with industrial data transmission networks.

Program learning outcomes:

Competencies: (C11) Ability to apply existing and develop new methods, techniques, technologies and procedures to solve engineering problems of electric power, electrical engineering and electromechanics; (C19) Ability to use software for computer modelling, computer-aided engineering, computer-aided manufacturing and computer-aided design or construction of elements of electric power, electrical and electromechanical systems; (C22) Ability to develop means, ways and methods of science and technology aimed at automating existing and creating new automated and automatic technologies and productions.

Abilities: (PR14) Master new versions or new software designed for computer modeling of objects and processes in electric power, electrical and electromechanical systems; (PR16) Select the element base of electromechanical and mechatronic systems, complete electric and hydraulic drives, control, protection, automation of power supply systems for machines and installations, production sites and enterprises; (PR17) To create intellectually adaptive systems of automated control and control of the technical condition of electromechanical equipment on the basis of the use of programmable logic controllers.

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

The discipline "Computer Control of Technological Processes, Experiments, Equipment" is taught on the basis of knowledge and skills acquired by students during the study of credit modules at the first level of education in such disciplines as "Higher Mathematics", "Physics", "Fundamentals of Programming", etc.

The knowledge and skills acquired in the process of studying the credit module "Computer Control of Technological Processes, Experiments, Equipment" are necessary for every specialist of this specialty, who solve engineering problems in the field of automation of electrical engineering and mechatronics and in the performance of a master's thesis.

3. The content of the discipline

The discipline "Computer Control of Technological Processes, Experiments, Equipment" consists of 5 sections:

Chapter 1. Computer Automation Systems.

Topic 1.1. Programmable logic controllers and their use in computer process control systems.

Topic 1.2. Computer as an element of the automation system.

Topic 1.3. I/O facilities and systems for collecting data of technological and experimental parameters.

Chapter 2. Programming of computer systems.

Topic 2.1. Text programming languages according to IEC 61131-3.

Topic 2.2. Graphical programming languages according to IEC 61131-3.

Chapter 3. Industrial networks and industrial network layers.

Topic 3.1. Industrial networks and industrial network layers.

Topic 3.2. Implementation of industrial networks at the physical level.

Chapter 4. Standard serial interfaces.

Topic 4.1. Information encoding.

Topic 4.2. Communication interfaces of industrial controllers and computerized control systems.

Chapter 5. Communication protocols.

Topic 5.1. Standard industrial network protocols.

Topic 5.2. Specialized industrial network protocols.

4. Training Materials & Resources

Basic literature:

1. Computer control of technological processes, experiments, equipment. Methodical instructions for calculation and graphic work [Electronic resource]: textbook for applicants for a master's degree in the educational program "Engineering of intelligent electrical and mechatronic complexes" / A. V. Toropov, A. V. Bosak, L. V. Toropova; KPI them. Igor Sikorsky. – Electronic text data (1 file: 3.14 MB). – Kyiv: Igor Sikorsky KPI, 2022. – 44 p. – Title from the screen. https://ela.kpi.ua/handle/123456789/47788

2. Computer control of technological processes, experiments, equipment. Methodical instructions for practical classes [Electronic resource]: textbook for applicants for a master's degree in the educational program "Engineering of intelligent electrical and mechatronic complexes" / A. V. Toropov, A. V. Bosak, L. V. Toropova; KPI them. Igor Sikorsky. – Electronic text data (1 file: 5.42 MB). – Kyiv : Igor Sikorsky KPI, 2022. – 90 p. – Title from the screen. https://ela.kpi.ua/handle/123456789/47784

3. Pupena O.M., Elperin I.V., Lutska N.M., Ladaniuk A.P. Industrial networks and integration technologies in automated systems: Textbook. Kyiv: Lira-K Publishing House, 2011. – 552 p.

4. Elements of Automated Electric Drive: Textbook / A.P. Kalinov, V.O. Melnikov. – Kremenchuk: Publishing House PE Shcherbatykh O.V. 2014-276p.

5. Drive Solutions Mechatronics for production and logistics. Edited by E.Kiel.–Berlin : SpringerVerlag, 2008. – 542 p.

6. Automation of production processes: textbook. / I.V. Elperin, O.M. Pupena, V.M. Sidletsky, S.M. Shved. — K.: Lira-K Publishing House, 2015. — 378 p.

Supporting Literature:

7. Goncharenko B.M., Osadchyi S.I., Vikhrova L.G., Kalich V.M., Didyk O.K. Automation of production processes. – Kirovohrad: Lysenko V.F., 2016 – 352 p

8. O.M. Pupena. Industrial networks and integration technologies: A Course of Lectures for Students. direction 6.050202 "Automation and Computer-Integrated Technologies" full-time and part-time forms of study. Kyiv: NUFT, 2011. – 67 p.

References, the bibliography of which is given with a link, can be found on the Internet. Literature, the bibliography of which does not contain references, can be found in the library of Igor Sikorsky Kyiv Polytechnic Institute. Igor Sikorsky. Separate sections of basic literature [1]-[3] are required reading.

Sections of basic literature that are mandatory reading, as well as the connection of these resources with specific topics of the discipline, are given below, in the methodology of mastering the discipline. All other literary sources are optional, it is recommended to read them.

Educational content

5. Methods of mastering the discipline (educational component)

Active learning strategies are used, which are determined by the following methods and technologies: problem-based learning methods (research method); student-centered technologies based on such forms and methods of teaching as visualization and information and communication technologies, in particular electronic presentations for lectures. Teaching is carried out in the form of lectures and practical classes. When performing calculation work, the problem-search method is used.

Salary No.	***The content of the educational work***
1-2	**Lecture 1.** Prerequisites for the widespread use of programmable logic controllers in modern process control systems. Main characteristics of programmable logic controllers. **References:** [1,3,6]. **Lecture 2.** Networks of automated process control systems. Structure of APCS. **References:** [1,3].
3-4	**Lecture 3.** Computer as an element of the automation system. Visualization and control systems and their characteristics. **References:** [4,5]. **Lecture 4.** Visualization of technological processes. Emulation of technological processes when checking the performance of algorithms. **References:** [1,2].
5-6	**Lecture 5.** Specialized functional modules. High-speed signal processing. Machining of strain gauges. **References:** [3,6]. **Lecture 6.** Basic controller programming languages. Structured text language. The language of the instruction list. **References:** [1,2].
7-8	**Lecture 7.** Language of functional blocks. Relay Diagram Language. **References:** [1,2]. **Lecture 8.** Methods of synthesis of logic circuits on the basis of programmable logic controllers. Carnot Map Method. **References:** [1,2]. **Modular control work (part 1).**
9-10	**Lecture 9.** Algorithms and visualization of technological processes based on transition graphs. **References:** [1,2]. **Lecture 10.** The difference between industrial and computer data networks. General information about industrial networks. **References:** [1,7].
11-12	**Lecture 11.** OSI and TCP/IP reference models. OSI model levels. **References:** [3,7]. **Lecture 12.** Implementation of the physical layer of industrial networks. **References:** [3].
13-14	**Lecture 13.** Ways to encode information. **References:** [3]. **Lecture 14.** Standard serial interfaces.

	References: [1,3].
15-16	**Lecture 15.** Standard serial interfaces for residual voltage signal transmission. **References:** [1,3]. **Lecture 16.** AS-I protocol. The main advantages, features of interface application. **References:** [3,4].
17-18	**Lecture 17.** CAN interface. CANopen protocol and its features. **References:** [3,5]. **Lecture 18**. Modbus protocol. Difference between ASCII and RTU versions. **References:** [3,4]. **Modular control work (part No2).**

Practical classes:

Salary No.	The content of the educational work
Practical lesson No1	Synthesis of algorithms for controlling the electric drive of the barrier by the method of Carnot maps.
Practical lesson No2	Synthesis of Valve Control Algorithms by Clock Distributor Method
Practical lesson No3	Synthesis of algorithms for controlling the electric drive of a plasma cutting machine by the method of Carnot maps.
Practical lesson No4	Synthesis of the algorithm for testing a polarized relay
Practical lesson No5	Synthesis of the control system for pressing parts by the RS trigger method with the implementation of an internal cycle
Practical lesson No6	Implementation of an automatic reserve input system based on a programmable logic controller
Practical lesson No7	Synthesis of a Temperature Management System with a Positional Controller
Practical lesson No8	Supply air temperature control system using a software PID regulator
Practical lesson No9	Pressure control system using frequency converter with integrated PID regulator

6. Student's independent work

Student's independent work involves:
preparation for classroom classes – 60 hours;
preparation for the modular test – 2 hours;
execution of CGW – 10 hours;
preparation for the exam – 24 hours.

Policy & Control

7. Academic discipline policy (educational component)

At the time of each lesson, both lecture and practical, the student must have the Zoom application installed on the device from which he works (in the case of distance learning), as well as the course "Computer Control of Technological Processes, Experiments, Equipment" on the "Google Classroom" platform (the access code to the course is provided to students at the first lesson according to the schedule). Syllabus; lecture material; tasks for each practical lesson; options for modular tests; tests to be completed by lectures; methodical recommendations for the implementation of practical work and calculation and graphic work; Variants of the test are posted on the "Google Classroom" platform and in the "KPI Electronic Campus" system.

During the course "Computer Control of Technological Processes, Experiments, Equipment", students are required to adhere to the general moral principles and rules of ethical behavior specified in the

Code of Honor of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute". The deadlines for each task are specified in the course "Computer Control of Technological Processes, Experiments, Equipment" on the Google Classroom platform. The presence of higher education students in practical classes is mandatory. Classes missed for valid reasons must be worked out.

All students, without exception, are obliged to comply with the requirements of the Regulations on the System for the Prevention of Academic Plagiarism at the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute". Types of control and rating system for assessing learning outcomes (CRO)

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

Current control: MCW (divided into 2 parts, each part of the MCW is carried out before the calendar control at the lecture on the second half-class in the presence of the teacher, 10 points), CGW (50 points). Each part of the ICR is performed in the form of an answer to a theoretical question from the lecture material of the first and second half of the semester, respectively. At the end of the lesson, the work on the ICR is completed and is not subject to rewriting. Each part of the ICR is valued at 5 points according to the following criteria:

− "excellent" – full answer (at least 90% of the required information), appropriate justifications and personal opinion – 5 points;

− "good" – a sufficiently complete answer (at least 75% of the required information), which is made in accordance with the requirements for the level of "skills" or contains minor inaccuracies – 4 points;

− "satisfactory" – an incomplete answer (at least 60% of the required information), made in accordance with the requirements for the "stereotypical" level and containing some errors – 3 points;

− "unsatisfactory" – unsatisfactory answer – 0 points.

Requirements for writing CGW are provided in the form of methodological recommendations and are posted on the "Google Classroom" platform and in the "KPI Electronic Campus" system. CGW is estimated at 50 points according to the following criteria:

− "excellent" – fully completed work (at least 90% of the required information), appropriate justifications and personal opinion – 43 – 50 points;

− "good" – the work contains certain inaccuracies (at least 75% of the required information), the justifications provided are incomplete – 36-42 points;

− "satisfactory" – the work contains significant inaccuracies (at least 60% of the required information), the work was performed in accordance with the requirements for the "stereotypical" level and contains significant errors – 30-35 points;

− "unsatisfactory" – the proposed algorithm is inoperable or contains gross inaccuracies in the developed electrical circuit – 0 points. Requirements for writing CGW are provided in the form of methodological recommendations and are posted on the "Google Classroom" platform and in the "KPI Electronic Campus" system.

Calendar control: it is carried out twice a semester as a monitoring of the current state of fulfillment of the requirements of the syllabus. The condition for a positive first and second calendar control is to obtain at least 50% of the maximum possible rating at the time of the relevant calendar control.

Semester control: : exam.

Conditions for admission to semester control: completed and credited CGW

RC(max) = 10 + 50 = 60 балів

RC(min) = 0 + 30 = 30 балів

In the exam, students complete a written test. The exam paper is worth 39 points. The control task of this work consists of three theoretical questions from the list provided in the appendix to the syllabus. Each question is worth 13 points (in case of receiving 39 points for each question, 1 point is added to the score) according to the following criteria: − "excellent" – complete answer (at least 90% of the required information), appropriate justifications and personal opinion – 13 points; − "good" – a sufficiently complete

answer (at least 75% of the required information), which is made in accordance with the requirements for the level of "skills" or contains minor inaccuracies – 11 – 12 points; − "satisfactory" – incomplete answer (at least 60% of the required information), made in accordance with the requirements for the "stereotypical" level and containing some errors – 10 points; − "unsatisfactory" – unsatisfactory answer – 0 points.

The sum of points for MKR, CGW and for the examination work is transferred to the final grade according to the table. The exam paper is estimated at 39 points, the same as for full-time education. The evaluation criteria are listed above.

For part-time studies

Current control: MCW (conducted directly at the lecture, in the presence of the teacher, 10 points), CGW (50 points). The MCW is performed in the form of an answer to two theoretical questions from the lecture material. The structure of the CGW and MCW questions, the requirements for them and the evaluation criteria are similar to those for full-time education and are given above.

Semester control: exam. Conditions for admission to semester control: completed and credited RGR. Students who have fulfilled the conditions for admission to the exam complete the examination work.

The sum of points for MKR, CGW and for the examination work is transferred to the final grade according to the table. The exam paper is estimated at 39 points, the same as for full-time education. The evaluation criteria are listed above.

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

Score	Score
100-95	Perfectly
94-85	Very good
84-75	Well
74-65	Satisfactory
64-60	Enough
Less than 60	Disappointing
Admission conditions are not met	Not allowed

8. Additional information on the discipline (educational component)

The list of questions that are submitted for semester control is given in the appendix to the syllabus.

A higher education applicant has the opportunity to take an online course(s) on one or more topics provided for by the curriculum of the discipline. The applicant can choose an online course independently or on the recommendation of a teacher, for example, the course "From Wire to PLC , A Bootcamp In Industrial Automation" on the Udemy platform. 1 hour of the course is estimated at 0.83 points. The maximum number of hours that can be counted based on the results of non-formal education is 12 hours, respectively, the maximum number of points for such results is 10 points.

Recommendations for completing an individual semester assignment

The study of the credit module "Computer Control of Technological Processes, Experiments, Equipment" involves the performance of calculation and graphic work by students.

1. To synthesize the automation system, according to the problem number, one of the well-known methods of synthesis of logical schemes (Carnot map method, RS-trigger method, graph method).
2. Implement an automation program on a programmable logic controller using Codesys v.x.x application software, develop a visualization of the technological process.
3. Check the functionality of the algorithm in Codesys using the programmable logic controller emulation function.
4. Offer a technical solution for the implementation of data visualization and archiving, according to the option.
5. Select electrical equipment that allows you to solve the necessary automation task.
6. Develop a wiring diagram of the equipment.

7. Provide a list of items.

The content of the calculation and graphic work.

1. Entry.
2. Description of the procedure for synthesizing the algorithm of the automation system.
3. Description of the algorithm of the automation system.
4. Description of the process visualization screen.
5. Description of the equipment that will be used in solving the problem.
6. Electrical wiring diagram in an A3 drawing.
7. List of elements.
8. Conclusions from the work.
9. A file with an automation algorithm program (on a floppy disk, on a disk, on a USB flash drive) that is compiled and can be checked by the teacher in Codesys x.x.

Work program of the discipline (syllabus):

Developed by: Associate Professor of the Department of Automation of Electrical and Mechatronic Complexes, Ph.D., Anton V. Toropov

Approved by: Department of Automation of Electrical and Mechatronic Complexes. (Protocol No.18 from 24.06.24).

Agreed by: Methodical Commission of Educational and scientific institute of energy saving and energy management (Protocol No.21 from 25.06.24).

Appendix to the syllabus of the educational component of the course "Computer control of technological processes, experiments, equipment".

List of tasks submitted for semester control.

1. Formulate the basic provisions and definitions of computer process control systems.
2. Formulate the basics of building an OSI reference model. Formulate the structure of a modern ACS network.
3. Formulate the basics of the formation of a hierarchical model of enterprise management.
4. Formulate the main characteristics and principles of operation of the RS-422 interface.
5. Formulate the basics of data transmission using the Modbus ASCII protocol.
6. Formulate the basics for the formation of the OSI reference model. OSI layers.
7. Formulate the main characteristics and principles of operation of the "Current loop 20mA" interface.
8. Formulate the basics, how the physical layer of data transmission works.
9. Formulate the main characteristics and working principles of the RS485 interface.
10. Formulate the basics of data transmission using the Modbus RTU protocol.
11. Formulate the basic principles of data transmission over a metal wire.
12. Formulate the main characteristics and principles of operation of the RS232 interface.
13. Formulate the principles of data transmission via Modbus.
14. Formulate the basics, principles of data transmission using wireless communication.
15. Formulate the main characteristics and differences of industrial serial interfaces.
16. Formulate the basics for the formation of a modern ACS network.
17. Formulate the principles of data transmission over CANopen.
18. Articulate the differences between industrial and computer networks.
19. Articulate the main differences between standard industrial interfaces.
20. Formulate the principles of data transmission using the CAN interface.
21. Formulate the basic principles of data transmission using fiber optic cable.
22. Formulate the main characteristics and working principles of the AS-I interface.
23. Formulate and explain with examples the advantages of textual programming languages over graphic ones.
24. State the benefits of using computer-based visualization and control systems.