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

Automation of electrotechnical and mechatronic complexes

Computer control of technological processes, experiments, equipment

Working program of the educational discipline (Syllabus)

Detail of educational discipline	
Level of higher education	***Second (Master's)***
Branch of knowledge	*14 Electrical engineering*
Specialty	*141 Power engineering, electrical engineering and electromechanics*
Educational program	*Engineering of intelligent electrotechnical and mechatronic complexes*
Discipline status	*Normative*
Form of education	*daytime*
Year of training, semester	*1st year, autumm semester*
Scope of the discipline	*5 credits 150 hours*
Semester control/ control measures	*Exam/ calculation and graphic work (CGW), modular control work MCW)*
Schedule	*Th 08:30, 10:25.*
Language of teaching	*English*
Information about course teachers	Lecturer: Ph.D. (Eng), associate professor, Anton V.Toropov, tel. 066-736-54-53, email: toropovtosha@ukr.net Practical / Seminars: Ph.D (Eng), associate professor, Anton V.Toropov, tel. 066-736-54-53, email: toropovtosha@ukr.net
Placement of course	https://classroom.google.com/c/NTkwMjQwMzQ2NzQ1?cjc=d7okhuh

Program of educational discipline

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

This discipline is a continuation of students' acquaintance with computer technology and programming. Integrated systems of computer mathematics are used to solve various educational, scientific and engineering tasks with the help of special mathematical computer programs. These programs represent 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 mathematical problems, object-oriented computer modeling is of interest. Structural models solve equations represented by individual modules and blocks.

The goal of studying the discipline can be the formation of students' theoretical knowledge and practical skills in using software systems when solving problems of synthesis of logical laws of various classes. The study of the material of this discipline is exclusively focused on the wide application of computer technology and programming.

The subject of the educational 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 tasks of electric power, electrical engineering and electromechanics; (C19) Ability to use software for computer modeling, automated design, automated production and automated development or construction of elements of electric power, electrotechnical and electromechanical systems; (C22) Ability to develop means, methods and methods of science and technology aimed at automating existing and creating new automated and automatic technologies and productions.

Abilities: (PR14) To master new versions or new software designed for computer modeling of objects and processes in electric power, electrotechnical and electromechanical systems; (PR16) Choose the element base of electromechanical and mechatronic systems, complete electric and hydraulic drives, means of control, protection, automation of power supply systems of machines and installations, production districts and enterprises; (PR17) To create intelligent and adaptive systems of automated regulation and control of the technical condition of electromechanical equipment based on using of programmable logic controllers.

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

The educational 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 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 tasks in the field of automation of electrical engineering and mechatronics and when completing a master's thesis.

3. Content of the educational discipline

The educational discipline "Computer control of technological processes, experiments, equipment" consists of 5 chapters:

Chapter 1. Computer automation systems.

Topic 1.1. Programmable logic controllers and their use in computer control systems of technological processes.

Topic 1.2. The computer as an element of the automation system.

Topic 1.3. Input/output devices and data collection systems 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. Graphic programming languages according to IEC 61131-3.

Chapter 3. Industrial networks and levels of industrial networks.

Topic 3.1. Industrial networks and levels of industrial networks.

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

Chapter 4. Standard serial interfaces.

Topic 4.1. Coding of information.

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

Chapter 5. Communication protocols.

Topic 5.1. Basic protocols of industrial networks.

Topic 5.2. Modbus protocol.

4. Educational materials and resources

Primary literature:

1. Computer control of technological processes, experiments, equipment. Methodical instructions for calculation and graphic work [Electronic resource]: study guide for master's degree holders of the educational program "Engineering of intellectual electrical and mechatronic complexes" / A. V. Toropov, A. V. Bosak, L. V. Toropova; KPI named after Igor Sikorsky. – Electronic text data (1 file: 3.14 MB). – Kyiv: KPI named after Igor Sikorskyi, 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]: study guide for master's degree holders in the educational program "Engineering of intellectual electrical and mechatronic complexes" / A. V. Toropov, A. V. Bosak, L. V. Toropova; KPI named after Igor Sikorsky. – Electronic text data (1 file: 5.42 MB). – Kyiv: KPI named after Igor Sikorsky, 2022. - 90 p. – Title from the screen. https://ela.kpi.ua/handle/123456789/47784

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

4. Elements of an automated electric drive: Training manual/ A.P. Kalinov, V.O. Melnikov – Kremenchuk: Publishing House PP Shcherbatyh 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. Sidletskyi, S.M. Shwed. — K.: Lira-K Publishing House, 2015. — 378 p.

Secondary literature:

7. Goncharenko B.M., Osadchyi S.I., Vykhrova L.G., Kalich V.M., Didyk O.K. Automation of production processes. – Kirovohrad: V.F. Lysenko, 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" of full-time and part-time forms of education. - K.: NUHT, 2011. - 67 p.

Literature, the bibliography of which is provided with a link, can be found on the Internet. Literature whose bibliography does not contain references can be found in the library of KPI named after Igor Sikorsky. Certain sections of the basic literature [1]-[3] are required reading. Sections of the basic literature, which are mandatory for reading, as well as the connection of these resources with specific topics of the discipline are given below, in the methodology of mastering the educational discipline. All other literary sources are optional, it is recommended to read them.

Educational content

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

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

No.l/p	***Content of educational work***
1-2	**Lecture 1.** Prerequisites for the widespread use of programmable logic controllers in modern technological process control systems. Basic characteristics of programmable logic controllers. **Literature:** [1,3,6]. **Lecture 2.** Networks of automated control systems of technological processes. Structure of ACS TP. **Literature:** [1,3].
3-4	**Lecture 3.** The computer as an element of the automation system. Visualization and control systems and their characteristics. **Literature:** [4,5]. **Lecture 4.** Visualization of technological processes. Emulation of technological processes when checking the functionality of algorithms. **Literature:** [1,2].
5-6	**Lecture 5.** Specialized functional modules. Processing of high-speed signals. Processing of strain gauges. **Literature:** [3,6]. **Lecture 6.** Basic controller programming languages. Structured text language. Language of instructions list. **Literature:** [1,2].
7-8	**Lecture 7.** Language of functional blocks diagram. The language of ladder diagrams. Literature: [1,2]. **Lecture 8.** Methods of synthesis of logic circuits based on programmable logic controllers. Carnot map method. **Literature:** [1,2]. **Modular control work (part No.1).**

9-10	**Lecture 9.** Algorithms and visualization of technological processes based on transition graphs. **Literature:** [1,2]. **Lecture 10.** The difference between industrial and computer data transmission networks. General information about industrial networks. **Literature:** [1,7].
11-12	**Lecture 11.** OSI and TCP/IP reference models. OSI model layers. **Literature:** [3,7]. **Lecture 12.** Implementation of the physical level of industrial networks. **Literature:** [3].
13-14	**Lecture 13.** Methods of information coding. **Literature:** [3]. **Lecture 14.** Standard serial interfaces. **Literature:** [1,3].
15-16	**Lecture 15.** Standard serial interfaces for differential voltage signal transmission. **Literature:** [1,3]. **Lecture 16**. AS-I protocol. The main advantages, features of the interface application. **Literature:** [3,4].
17-18	**Lecture 17.** CAN interface. CANopen protocol and its features. **Literature:** [3,5]. **Lecture 18.** Modbus protocol. Difference between ASCII and RTU versions. Literature: [3,7]. Modular control work (part No. 2).

Practical lessons:

No.l/p	Content of educational work
Practical lesson No.1	Synthesis of control algorithms of the barrier electric drive by the method of Carnot maps.
Practical lesson No.2	Synthesis of valve control algorithms by the clock divider method
Practical lesson No.3	Synthesis of algorithms for controlling the electric drive of a plasma cutting machine by the method of Carnot maps.
Practical lesson No.4	Synthesis of the polarized relay working algorithm
Practical lesson No.5	Synthesis of the control system for pressing parts using the RS-trigger method with internal cycle realization
Practical lesson No.6	Implementation of the automatic reserve supply system based on the programmable logic controller
Practical lesson No.7	Synthesis of a temperature control system with a positional regulator
Practical lesson No.8	Supply air temperature control system using software PID - regulator
Practical lesson No.9	Pressure control system using a frequency inverter with a built-in PID regulator

6. Independent work of the student

Independent work of the student involves:
preparation for classroom lessons - 54 hours;
preparation for the modular control work - 2 hours;
execution of CGW - 10 hours;
preparation for the exam - 30 hours

Policy and control

7. Policy of educational discipline (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), and the course "Computer control of technological processes, experiment, equipment" must be opened on the "Google Classroom" platform (the access code to the course to students at the first lesson according to the schedule should be given). Syllabus; lecture material; tasks for each practical session; variants of modular control work; tests to be completed after lectures; methodical recommendations for practical lessons and calculation graphic work; variants of exam work are posted on the "Google Classroom" platform and in the "KPI Electronic Campus" system.

During studying of discipline "Computer control of technological processes, experiments, equipment", students are obliged 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 the completion of each task in the discipline "Computer control of technological processes, experiments, equipment" on the "Google Classroom" platform are specified. The presence of students of higher education at practical classes is mandatory. Lessons missed for valid reasons ought to be made up.

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

8. Types of control and rating system for evaluating learning outcomes (RSE)

Current control: MCW (divided into 2 parts, each part of MCW has to be done before the calendar control during the second half of lecture at the end of first and second part semester in the presence of the teacher, 10 points), CGW (50 points). Each part of the MCW should be 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 class, the work on the MCW ends and cannot be rewritten. Each part of the MCW is evaluated in 5 points according to the following criteria:

- "excellent" - a complete answer (at least 90% of the required information), relevant justifications and a personal opinion are provided - 5 points;
- "good" - a sufficiently complete answer (at least 75% of the required information), which is completed in accordance with the requirements for the "skills" level or contains minor inaccuracies - 4 points;
- "satisfactory" - an incomplete answer (at least 60% of the required information), completed in accordance with the requirements for the "stereotype" level and containing some errors - 3 points;
- "unsatisfactory" - unsatisfactory answer - 0 points.

The requirements for writing the 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 provided - 43 - 50 points;
- "good" - the work contains certain inaccuracies (at least 75% of the required information), the provided justifications are not complete enough -36-42 points;
- "satisfactory" - the work contains significant inaccuracies (at least 60% of the required information), the work is performed in accordance with the requirements for the "stereotypical" level and contains significant errors - 30-35 points;
- "unsatisfactory" - the algorithm proposed in the work is unworkable or there are gross inaccuracies in the developed electrical circuit - 0 points. The requirements for writing the RGR 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: is held twice a semester as a monitoring of the current state of fulfillment of the syllabus requirements. 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 corresponding calendar control.

Semester control: Exam

Conditions for admission to the semester control: completed and enrolled CGW

RC(max) = 10 + 50 = 60 points

RC(min) = 0 + 30 = 30 points

At the exam, students perform a written test. The exam paper is valued at 39 points. The control task of this paper consists of three theoretical questions from the list provided in the appendix to the syllabus. Each question is evaluated in 13 points (in case of receiving 39 points for each question, 1 point is added to the evaluation) according to the following criteria:

- "excellent" - a complete answer (at least 90% of the required information), appropriate justifications and a personal view are provided - 13 points;

- "good" - a sufficiently complete answer (at least 75% of the required information), completed in accordance with the requirements for the "skills" level or containing minor inaccuracies - 11-12 points;

- "satisfactory" - an incomplete answer (at least 60% of the required information), completed 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 MCW, CGW and for the examination work is transferred to the final grade according to the table. The exam paper is valued at 39 points, as well as for full-time education. The evaluation criteria are given above.

For correspondence education

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

Semester control: exam. Conditions for admission to the semester control: completed and enrolled CGW. Students who have fulfilled the conditions for admission to the exam perform the examination work.

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

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

Number of points	Rating
100-95	Excellent
94-85	Very good
84-75	Good
74-65	Satisfactory
64-60	Enough
Less than 60	Unsatisfactory
The conditions of admission are not fulfilled	Not allowed

9. Additional information on the discipline (educational component)

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

A student of higher education has the opportunity to take an online course(s) on one or more topics provided by the work program of the educational 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 valued at 0.83 points. The maximum number of hours that can be credited based on the results of non-formal education is 12 hours, accordingly the maximum number of points for such results is 10 points.

Recommendations for the implementation of an individual semester assignment

The studying of the credit module "Computer control of technological processes, experiments, equipment" involves students performing calculational graphic work. Students have to:

1) carry out the synthesis of the automation system, according to the task number, using one of the well-known methods of synthesis of logical circuits (the method of Carnot maps, the method of RS-triggers, the method of graphs)$
2) implement an automation program on a programmable logic controller using the 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) Propose a technical solution for the implementation of data visualization and archiving, according to the variant;
5) Select electrical equipment that allows you to solve the necessary task of automation;
6) Develop an electrical assembly diagram of the equipment;
7) Provide a list of elements.

The content of calculational graphic work.

1. Introduction.
2. Description of the synthesis procedure of the automation system control algorithm.
3. Description of the algorithm of the automation system.
4. Description of the technological process visualization screen.
5. Description of the equipment that should be used for automation task solution.
6. Electrical assembly diagram on A3 format drawing.
7. List of elements.
8. Conclusions.
9. A file with the program of the automation algorithm (on a flexible disk, on a USB-drive), which is compiled and can be edited by teacher in Codesys x.x.

Working program of the educational 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.15 from 31.05.23).

Agreed by: Methodical Commission of Educational and scientific institute of energy saving and energy management (Protocol No.xx from xx.06.23).

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