National Technical University of Ukraine “Igor Sikorsky Kyiv Polytechnic Institute”

Automation of Electrical Engineering and Mechatronic Complexes

Engineering of Electrical and Mechatronic Systems

Course Work Program (Syllabus)

Course Requisites

Level of higher education	*Second (Master's)*
Field of knowledge	*G Engineering, Manufacturing and Construction*
Specialty	*G3 Electrical Engineering*
Educational program	*Engineering of Intelligent Electrical and Mechatronic Complexes*
Course status	*Mandatory*
Form of study	*Full-time*
Year of study, semester	*Year 1, fall semester*
Course workload	*5 ECTS credits, 150 hours (30 hrs lectures, 16 hrs practical classes, 14 hrs laboratory classes, 90 hrs independent study)*
Semester assessment / control measures	*Exam / Module Test (MT)*
Class schedule	*https://schedule.kpi.ua/*
Language of instruction	*Ukrainian*
Course instructor information	*Lecturer: PhD in Engineering, Associate Professor Alla Vasylivna Bosak, tel. 050-729-50-67, email: alla_koz@ukr.net* *Practical / Seminar classes: PhD in Engineering, Associate Professor Alla Vasylivna Bosak, tel. 050-729-50-67, email: alla_koz@ukr.net*
Course platform	https://do.ipo.kpi.ua/user/index.php?id=3670

Course Program

Course description, goal, subject of study and learning outcomes

Goal and objectives of the course. The goal of the course “Engineering of Electrical and Mechatronic Systems” is to familiarize students with the fundamentals of consulting and investment-construction engineering. During the course, students master the basics of organizing design work, become acquainted with the main electric drive schemes, and learn methods of organizing construction-installation and commissioning works in the construction of electrical and mechatronic complexes.

Competencies: (FC3) Ability to perform analysis of technical and economic indicators and expert assessment of design and engineering solutions in the field of power engineering, electrical engineering and electromechanics; (FC5) Ability to understand and take into account social, environmental, ethical, economic and commercial considerations affecting the implementation of technical solutions in power engineering, electrical engineering and electromechanics; (FC6) Ability to manage projects and evaluate their results; (FC11) Ability to formulate technical requirements for developed products and technologies, determine technical conditions for operation and maintenance of new equipment, prepare technical specifications for research and development, identify key technological parameters of developments and determine their target or normative values in the field of engineering.

Program learning outcomes: (PLO01) Reproduce processes in power engineering, electrical engineering and electromechanical systems through computer modeling; (PLO02) Outline a plan of measures to improve reliability, operational safety and extend the service life of power engineering, electrical and electromechanical equipment and related complexes and systems; (PLO03) Analyze processes in power engineering, electrical and electromechanical equipment and related complexes and systems; (PLO05) Master methods of mathematical and physical modeling of objects and processes in power engineering, electrical and electromechanical systems; (PLO08) Take into account legal and economic aspects of research and innovation activities; (PLO10) Justify the choice of direction and methodology of scientific research taking into account current problems in the field of power engineering, electrical engineering and electromechanics; (PLO15) Perform physical and mathematical modeling, static and dynamic analysis of structures, mechanisms, materials and processes at the design stage, and investigate system reliability using modern computer tools.

Prerequisites and postrequisites of the course (place in the structural-logical scheme of study for the corresponding educational program)

Interdisciplinary connections: The course “Engineering of Electrical and Mechatronic Systems” is taught based on material from the courses “Automated Electric Drive of Machines and Installations,” “Computer Modeling of Processes in Electromechanical Systems,” “Digital and Nonlinear Electric Drive Control Systems,” “Intelligent Decision-Making Systems,” and others, which students have studied earlier or in parallel.

The knowledge and skills gained while studying “Engineering of Electrical and Mechatronic Systems” are necessary for every specialist in this field who solves engineering tasks in the automation of electrical engineering and mechatronics, and in completing the master's thesis.

Course Content

The course “Engineering of Electrical and Mechatronic Systems” consists of 5 sections:

Section 1. Introduction to Engineering of Electrical and Mechatronic Systems

Topic 1.1. **Basic concepts and definitions.**

System life cycle. System management.

Topic 1.2. **Main provisions of engineering activity.**

Section 2. Content of Engineering Activity

Topic 2.1. **Systems engineering.**

Scope of systems engineering. Participants in the system life cycle and their relationships. Standardization methods.

Topic 2.2. **Electrical engineering.**

Objects and characteristics of electrical engineering. Regulatory and technical documents.

Topic 2.3. **Engineering of electromechatronic systems.**

Development of electric drives for electrical complexes using standard automation tools. Evaluation and determination of the optimal system variant. Synthesis of electromechatronic system tools. Development of automation systems with decentralized architecture.

Topic 2.4. **Strategy for developing new equipment and modernizing existing equipment.**

Market research. Identifying key product/service characteristics that meet consumer needs. Studying and comparing technologies used by competitors. Analysis of consumer requirements for quality, price and volume of goods or services.

Topic 2.5. **International standards systems. Certification and licensing. Legal relations.**

International standards systems. Certification of compliance with technical regulations, standards, and contract terms. Legal relations in the field of engineering activity. Licensing of certain activities in Ukraine. Contractual relations in engineering activity. Legal relations in the intellectual property market. Organizational structure of an enterprise.

Section 3. Design of Electromechatronic Systems

Topic 3.1. **Main design stages. Technical specification.**

Design stages and project composition. Technical specifications, requirements and conditions.

Topic 3.2. **Feasibility study of design solutions.**

Economic analysis of design solution efficiency.

Topic 3.3. **Selection of electrical equipment.**

Selection of electrical equipment according to operating conditions.

Topic 3.4. **Ensuring electromagnetic compatibility of electrical equipment.**

Higher harmonics in current and voltage curves. Their impact on electrical equipment. Methods of ensuring electromagnetic compatibility.

Section 4. Overview of Technical and Software Tools for Electromechatronic Systems

Topic 4.1. **Technical tools for automated electric drive systems.**

Controlled converters for low-voltage electric drive systems. High-voltage electric drives. Electric motors and gear motors. Switching and protective equipment, chokes and filters. Soft-start and braking devices for asynchronous motors. Tools for modernizing existing DC drives. Cables and wires. Sensors in electric drive systems.

Topic 4.2. **Calculation of operating modes and selection of automated electric drives.**

Calculation and selection of complete electric drives and their components. Determination of current and voltage harmonics in the power grid feeding the frequency converter. Continuous-duty electric drives without braking energy recuperation to the grid. Cyclic-duty electric drives with braking energy recuperation to the grid.

Topic 4.3. **Software tools for electrical systems.**

Library of standard control function programs. Software for parameterization, monitoring and commissioning of electric drives.

Topic 4.4. **Selection of technical and software tools for automation systems.**

Programmable logic controllers and industrial computers. Information networks and their components. Control panels and terminals.

Section 5. Computer Technologies for Designing Electromechatronic Systems

Topic 5.1. **Design tools.**

Overview of software tools. Selection and evaluation of design tools.

Topic 5.2. **Preparation of technical documentation.**

General rules for electrical drawings and diagrams. Drawing execution rules. Diagram execution rules. Electrical product drawings. General view drawings. Assembly drawings. Structural and functional diagrams. Electrical schematic diagrams. Features of schematic diagram execution. Schematic diagrams of automated single-motor electric drives of mechanisms. Schematic diagrams of automated multi-motor electric drives of mechanisms. Automation system diagrams. Connection, wiring and layout diagrams. Electrical connection diagrams. Electrical wiring diagrams. Electrical layout diagrams.

Learning Materials and Resources

Core literature:

1. Bosak, A. V. Engineering of Electrical and Mechatronic Systems [Electronic resource]: textbook for master's degree students in specialty 141 Power Engineering, Electrical Engineering and Electromechanics / A. V. Bosak, A. V. Toropov, L. V. Toropova; Igor Sikorsky Kyiv Polytechnic Institute. — Electronic text data (1 file: 7.43 MB). — Kyiv: Igor Sikorsky Kyiv Polytechnic Institute, 2024. — 251 p. https://ela.kpi.ua/handle/123456789/71628

2. Chermalykh, O. V. Engineering of Electrical and Mechatronic Systems. Laboratory Workshop [Electronic resource]: study guide for students majoring in 141 “Power Engineering, Electrical Engineering and Electromechanics,” specialization “Engineering of Intelligent Electrical and Mechatronic Complexes” / O. V. Chermalykh, A. V. Bosak, D. D. Muhenov; Igor Sikorsky Kyiv Polytechnic Institute. — Electronic text data (1 file: 8.56 MB). — Kyiv: Igor Sikorsky Kyiv Polytechnic Institute, 2021. — 141 p. https://ela.kpi.ua/handle/123456789/41535

3. Engineering of Electrical and Mechatronic Systems [Electronic resource]: workshop: study guide for master's degree students in the educational program “Engineering of Intelligent Electrical and Mechatronic Complexes,” specialty G3 Electrical Engineering / Igor Sikorsky Kyiv Polytechnic Institute; comp.: A. V. Bosak, A. V. Toropov, L. V. Toropova. — Electronic text data (1 file: 1.46 MB). — Kyiv: Igor Sikorsky Kyiv Polytechnic Institute, 2025. — 68 p. https://ela.kpi.ua/handle/123456789/74283

4. Shapoval S. L. Building Engineering: workshop: study guide / S. L. Shapoval, O. O. Paliienko, N. M. Pleshkan; ed. A. A. Mazaraki. Kyiv: KNTEU, 2018. — 231 p. Elements of Automated Electric Drive: study guide / A. P. Kalinov, V. O. Melnykov. — Kremenchuk: Shcherbatykh O.V. Publishing House, 2014. — 276 p.

5. Automation of Production Processes: textbook / I. V. Elperin, O. M. Pupena, V. M. Sidletskyi, S. M. Shved. — Kyiv: Lira-K Publishing House, 2015. — 378 p. https://sites.google.com/site/iasunuft/biblioteka/novi-vidanna

6. Shevchuk, N. A. (2019). Startup Project. Study guide for completing the “Startup Project Development” section of the master's thesis. Igor Sikorsky Kyiv Polytechnic Institute.

Supplementary literature:

6. Ukraine. Ministry of Education and Science, Lutsk National Technical University, Vakhovych, I. M., & Polishchuk, V. H. (2014). Financial Management and Financial Engineering of Business Processes: master's course: study guide in 2 volumes (2nd ed.). Lutsk: Zh. V. Hadiak.

7. Loveikin V.S., Romasevych Yu.O., Chovnyuk Yu.V. Mechatronics. Study guide. — Kyiv, 2012. — 357 p.

8. DBN A.2.2-3-2014 Composition and Content of Design Documentation for Construction. https://dbn.co.ua/load/normativy/dbn/dbn_a_2_2_3_2014/1-1-0-1168

9. DBN A.3.1-5-2016 Organization of Construction Production. https://dbn.co.ua/load/normativy/dbn/1-1-0-294

Literature with a reference link can be found online. Literature without a reference link is available in the library of Igor Sikorsky Kyiv Polytechnic Institute. Core literature [1]–[4] is mandatory reading. All other literary sources are optional and recommended for review.

Learning Content

Methodology for mastering the course (educational component)

Active learning strategies are applied, defined by the following methods and technologies: problem-based learning methods (research method); personality-oriented technologies based on such forms and methods of teaching as visualization and information and communication technologies, including electronic presentations for lectures. Teaching is conducted in the form of lectures, laboratory and practical classes.

Week	Content of learning activity
1–2	**Lecture 1.** Topic 1.1. Basic concepts and definitions. System life cycle. System management. **Literature:** [1,3]. **Lecture 2.** Topic 1.2. Main provisions of engineering activity. **Literature:** [1,3].
3–4	**Lecture 3.** Topic 2.1. Systems engineering. Scope of systems engineering. Participants in the system life cycle and their relationships. Standardization methods. **Literature:** [1,4]. **Lecture 4.** Topic 2.2. Electrical engineering. Objects and characteristics of electrical engineering. Regulatory and technical documents.

	Literature: [1,2].
5–6	**Lecture 5.** Topic 2.3. Engineering of electromechatronic systems. Development of electric drives for electrical complexes using standard automation tools. Evaluation and determination of the optimal system variant. Synthesis of electromechatronic system tools. Development of automation systems with decentralized architecture. Building distributed automation systems. **Literature:** [1,4]. **Lecture 6.** Topic 2.4. Strategy for developing new equipment and modernizing existing equipment. Market research. Identifying key product/service characteristics that meet consumer needs. Studying and comparing technologies used by competitors. Analysis of consumer requirements for quality, price and volume of goods or services. **Literature:** [1,5].
7–8	**Lecture 7.** Topic 2.5. International standards systems. Certification and licensing. Legal relations. International standards systems. Certification of compliance with technical regulations, standards, and contract terms. Legal relations in engineering activity. Licensing of certain activities in Ukraine. Contractual relations in engineering activity. Legal relations in the intellectual property market. Organizational structure of an enterprise. **Literature:** [1,3]. **Lecture 8.** Topic 3.1. Main design stages. Technical specification. Design stages and project composition. Technical specifications, requirements and conditions. **Literature:** [1,3].
9–10	**Lecture 9.** Topic 3.2. Feasibility study of design solutions. Economic analysis of design solution efficiency. **Literature:** [1,3]. **Lecture 10.** Topic 3.3. Selection of electrical equipment. Selection of electrical equipment according to operating conditions. **Literature:** [1,3].
11–12	**Lecture 11.** Topic 3.4. Ensuring electromagnetic compatibility of electrical equipment. Higher harmonics in current and voltage curves. Their impact on electrical equipment. Methods of ensuring electromagnetic compatibility. **Literature:** [1,4]. **Lecture 12.** Topic 4.1. Technical tools for automated electric drive systems. Controlled converters for low-voltage electric drive systems. High-voltage electric drives. Electric motors and gear motors. Switching and protective equipment, chokes and filters. Soft-start and braking devices for asynchronous motors. Tools for modernizing existing DC drives. Cables and wires. Sensors in electric drive systems. **Literature:** [1,3].
13–14	**Lecture 13.** Topic 4.2. Calculation of operating modes and selection of automated electric drives. Calculation and selection of complete electric drives and their components. Determination of current and voltage harmonics in the power grid feeding the frequency converter. Continuous-duty electric drives without braking energy recuperation to the grid. Cyclic-duty electric drives with braking energy recuperation to the grid. **Literature:** [1,4]. **Lecture 14.** Topic 4.3. Software tools for electrical systems. Library of standard control function programs. Software for parameterization, monitoring and commissioning of electric drives. Topic 4.4. Selection of technical and software tools for automation systems. Programmable logic controllers and industrial computers. Information networks and their components. Control panels and terminals. **Literature:** [1,4].

15	**Lecture 15.** Topic 5.1. Design tools. Overview of software tools. Selection and evaluation of design tools. Topic 5.2. Preparation of technical documentation. General rules for electrical drawings and diagrams. **Literature:** [1,3,4].

Practical classes:

No.	Content of learning activity
Practical Class №1	Market research in developed countries near and far abroad and in Ukraine on the course project (CP) topic
Practical Class №2	Analysis and selection of an automated control system for the selected object on the course project topic
Practical Class №3	Selection of electrical equipment. Calculation of operating modes and selection of electric drive components
Practical Class №4	Evaluation of energy performance indicators of the selected electric drive control system, using the example of a hybrid power supply system for a pumping station, with implementation of an energy management model based on zone regulation of the common DC bus voltage
Practical Class №5	Selection of technical and software tools for automation systems
Practical Class №6	Synthesis of the selected control system in the MATLAB environment
Practical Class №7	Development of an electric drive wiring diagram
Practical Class №8	Feasibility study of the design solution. Preparation of graphic materials. Module Test (MT)

Laboratory classes:

No.	Content of learning activity
Laboratory Class №1	Investigation of a frequency-controlled asynchronous electric drive with vector control of a pumping unit cascade based on fuzzy logic (Fuzzy Logic Controller)
Laboratory Class №2	Investigation of a frequency-controlled asynchronous electric drive with magnetic flux control
Laboratory Class №3	Investigation of a frequency-controlled asynchronous electric drive with direct torque control
Laboratory Class №4	Investigation of a synchronous valve electric drive
Laboratory Class №5	Investigation of a frequency-controlled synchronous electric drive with vector control
Laboratory Class №6	Investigation of a brushless DC electric drive with a permanent-magnet synchronous motor

Laboratory Class №7	Investigation of a DC electric drive system with a reversible single-phase controlled thyristor converter

Independent Student Work

Independent student work includes:

- preparation for classroom sessions — 56 hours;
- preparation for the module test — 4 hours;
- preparation for the exam — 30 hours.

Policy and Control

Course policy (educational component)

At the time of each class, both lecture and practical, the student must have the Zoom application installed on the device they are working from (in case of distance learning), and must have the course "Engineering of Electrical and Mechatronic Systems" open on the "Moodle" platform (course access code is provided to students at the first class according to the schedule). The syllabus, lecture materials, assignments for each practical class, module test variants, tests to be completed based on lectures, methodological recommendations for completing laboratory work, and exam test variants are posted on the "Moodle" platform and in the "KPI Electronic Campus" system.

While taking the course "Engineering of Electrical and Mechatronic Systems," students must adhere to the general moral principles and rules of ethical conduct specified in the Code of Honor of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute." Deadlines for completing each assignment are specified in the course "Engineering of Electrical and Mechatronic Systems" on the "Moodle" platform. Attendance of higher education students at practical classes is mandatory. Classes missed for valid reasons must be made up.

All students without exception must comply with the requirements of the Regulation on the Academic Plagiarism Prevention System at the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute."

8. Types of Control and Rating System for Assessing Learning Outcomes (RSO)

Current control: The Module Test (MT) is conducted in week 15, during a practical class in the presence of the instructor (18 points); 7 laboratory classes (6 points per laboratory class = 6 × 7 = 42). The MT is performed as a written answer to a theoretical question from the lecture material. Upon completion of the class, work on the MT ends and cannot be resubmitted. The MT is assessed at 18 points according to the following criteria:

- "excellent" — complete answer (at least 90% of required information), with appropriate justification and personal perspective — 18–16 points;
- "good" — sufficiently complete answer (at least 75% of required information), performed according to "skills"-level requirements or containing minor inaccuracies — 15–11 points;
- "satisfactory" — incomplete answer (at least 60% of required information), performed according to "stereotypical"-level requirements and containing some errors — 10 points;
- "unsatisfactory" — unsatisfactory answer — 0 points.

Laboratory class assignments are assessed at 6 points according to the following criteria:

- "excellent" — fully completed work (at least 90% of required information), with appropriate justification and personal perspective — 6 points;
- "good" — the work contains certain inaccuracies (at least 75% of required information), justification is insufficiently complete — 5–4 points;
- "satisfactory" — the work contains significant inaccuracies (at least 60% of required information), performed according to "stereotypical"-level requirements and containing significant errors — 3.5 points;
- "unsatisfactory" — the algorithm proposed in the work is non-functional, or the developed electrical scheme contains gross inaccuracies — 0 points.

Calendar control: conducted twice per semester as monitoring of the current status of syllabus requirement completion. The condition for a positive first and second calendar control is obtaining at least 50% of the maximum possible rating at the time of the respective calendar control.

Semester control: exam.

Conditions for admission to semester control: completed MT and laboratory classes.

RC(max) = 18 + 42 = 60 points

RC(min) = 6 + 24 = 30 points

At the exam, students complete a written test. The exam paper is assessed at 40 points. The exam assignment consists of two theoretical questions from the list provided in the syllabus appendix, and one problem. Each question is assessed at 13 points (the problem at 14 points) according to the following criteria:

- “excellent” — complete answer (at least 90% of required information), with appropriate justification and personal perspective — 14–13 points;
- “good” — sufficiently complete answer (at least 75% of required information), performed according to “skills”-level requirements or containing minor inaccuracies — 12–11 points;
- “satisfactory” — incomplete answer (at least 60% of required information), performed according to “stereotypical”-level requirements and containing some errors — 10–8 points;
- “unsatisfactory” — unsatisfactory answer — 0 points.

Table of correspondence between rating points and grades on the university scale:

Number of points	**Grade**
100–95	Excellent
94–85	Very good
84–75	Good
74–65	Satisfactory
64–60	Sufficient
Less than 60	Unsatisfactory
Admission conditions not met	Not admitted

Additional Course Information (Educational Component)

The list of questions for semester control is provided in the syllabus appendix.

Students have the opportunity to take online course(s) on one or several topics covered by the course work program. Students may choose an online course independently or upon instructor recommendation — for example, the course “Introduction to Systems Engineering” on the Coursera platform. 1 hour of course content completed is assessed at 0.83 points. The maximum number of hours that can be credited for results of informal education is 12 hours; accordingly, the maximum number of points for such results is 10 points.

Course work program (syllabus):

Compiled by: Associate Professor, PhD in Engineering, Alla Vasylivna Bosak

Approved by the Department of Automation of Electrical Engineering and Mechatronic Complexes. Minutes №15 dated 04.06.25.

Approved by the Methodological Commission of the Educational-Scientific Institute of Energy Saving and Energy Management. Minutes №30 dated 25.06.25.

Appendix to the Course Syllabus

"Engineering of Electrical and Mechatronic Systems"

List of Questions for Semester Control

1. Define the concepts of engineering and electromechatronics.

2. Formulate the main types of activity in the engineering of electromechatronic systems (electric drives and automation systems).

3. Give examples of possible types of engineering activity for young specialists.

4. Explain the content of the following commonly accepted terms: creation stage, creation phase, article, product, manufacturing, plant (factory), enterprise, firm, organization.

5. Give examples of systems engineering objects; the main stages of the process of product development and putting a product into production.

6. State the main functions of the customer, developer, and manufacturer.

7. Give examples of unification, aggregation, and typification techniques in systems engineering.

8. Formulate the main objects and components of electrical engineering.

9. Formulate the main provisions to be followed when executing power equipment projects; the procedure for resolving issues in design according to technical specifications.

10. What do the main regulatory documents used in electrical engineering govern?

11. Give options for creating automated electric drives; principles of building modern automated technological complexes (typical structure).

12. Explain general issues of calculation, selection, and design of automated electric drives.

13. Explain the main options for implementing modernization projects for existing equipment in automated electric drives.

14. State the main requirements for analysis and selection of the optimal electromechatronic system variant.

15. Define the concept of synthesis of electromechatronic system tools (electric drives and automation systems).

16. Explain the main stages, goals, and results of creating distributed automation systems.

17. Give an example of a scheme of modern integrated automation system tools.

18. Explain the purpose and structure of an investment project business plan.

19. Explain the content of market research.

20. Define the concept of a standard; the goals of standardization.

21. State the main concepts and provisions regarding certification.

22. Define the concept of licensing certain types of activities.

23. Give examples of the organizational structure of modern engineering firms.

24. Define the concept of agreements and contracts, and their content.

25. Define the concept of intellectual property protection under competitive conditions: patent, objects of patent law, patent owner, trade secret. Legal relations in the intellectual property market.

26. State the design stages and project composition: technical proposal, preliminary design, technical design, working design documentation. Nomenclature of design documents.

27. Define the concepts of: technical specifications, requirements, and conditions (purpose and content).

28. State the stages and phases of the industrial product life cycle.

29. Define the concept of investment projects. Evaluation of design solution efficiency using a system of interrelated indicators.

30. State the stages of selecting electrical equipment according to performance requirements and operating conditions.

31. Higher harmonics in current and voltage curves, their impact on electrical equipment; main measures for ensuring electromagnetic compatibility.

32. State power quality indicators; harmonic composition of current and voltage; damage from higher harmonics to electrical equipment.

33. Explain methods and devices for ensuring electromagnetic compatibility.

34. Define the concept of electromechanical compatibility of electric motors with semiconductor converters.

35. State the main concepts and tasks of ensuring reliability of electromechatronic systems.

36. Define the concept of an estimated calculation of the reliability level of electrical equipment.

37. Controlled converters for low-voltage electric drive systems and their components.

38. High-voltage electric drives: scope of application; main technical solutions in practical implementation.

39. Switching and protective equipment, chokes, and filters: purpose; general and local connection schemes.

40. Tools for modernizing existing DC drives: general approaches; example of a typical scheme.

41. Cables and wiring: main provisions; example of a general connection scheme. Sensors in electric drive systems.

42. State the calculation and selection of complete electric drives and their components: relevance of the task, main factors, and how they can be addressed.

43. Determination of current and voltage harmonics in the power grid with frequency converters.

44. Calculation and selection of continuous-duty electric drives without braking energy recuperation to the grid.

45. Cyclic-duty electric drives with braking energy recuperation to the grid.

46. Rules for drawings and diagrams. Examples of drawing execution.

47. Structural and functional electrical diagrams. Execution examples.

48. Features of schematic diagram execution. Example of an automation system diagram.

49. Diagrams of automated single-motor and multi-motor electric drives: execution procedure and depiction examples.

50. Connection, wiring, and layout diagrams: execution procedure and depiction examples.