National Technical University of Ukraine
Igor Sikorsky Kyiv Polytechnic Institute "

Department of
Electromechanical Systems
Automation and Electrical
Drives

AUTOMATED ELECTRIC DRIVE

Working program of the academic discipline (Syllabus)

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	*Normative*
Form of education	*Daytime*
Year of training, semester	*3rd year, spring semester*
Scope of the discipline	*150 hours / 5 ECTS credits*
Semester control/ control measures	*Credit/MKR/RGR*
Class schedule	*http://roz.kpi.ua*
Language of teaching	*Ukrainian*
Information about the head of the course / teachers	*Lecturers* : *Ph.D. Krasnoshapka Natalia Dmitrivna, 0681262902* *Ph.D. Vitaly Ivanovich Teryaev , 0957555224*
Placement of the course	*https://classroom.google.com/u/1/c/MTUwODIzMjg3MDYw*

Program of study discipline

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

The program of the study discipline "Automated electric drive" was compiled in accordance with the educational program "Electromechanical systems of automation, electric drive and electromobility " of the bachelor's training, specialty 141 - Electric power, electrical engineering and electromechanics.

The purpose of the educational discipline is to develop the following *skills and professional competences in students :*

Z K02 – Ability to apply knowledge in practical situations; ZK03 – Ability to communicate in the state language both orally and in writing; Z K05 – 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); FK02 - Ability to solve practical problems involving the methods of mathematics, physics and electrical engineering; FK05 - Ability to solve complex specialized tasks and practical problems related to the operation of electric machines, devices and automated electric drives; FK07 - Ability to develop projects of electric power, electrotechnical and electromechanical equipment in

compliance with the requirements of legislation, standards and specifications; FK08 - Ability to perform professional duties in compliance with the requirements of the rules of safety, labor protection, industrial sanitation and environmental protection; FK09 - Awareness of the need to increase the efficiency of electric power, electrotechnical and electromechanical equipment; FK10 - Awareness of the need to constantly expand one's own knowledge about new technologies in electric power, electrical engineering and electromechanics; FK12 - Ability to use mathematical methods and methods of the theory of automatic control in the study of linear and nonlinear systems, analyze quality indicators, synthesize regulators, compile and analyze structural diagrams of automatic control systems; FK15 - Ability to perform calculations of the mechanical part of the electric drive, mechanical transients, calculate the parameters of DC and AC motors, perform their modeling and analysis; FK16 - The ability to solve complex problems related to the control of automated electric drives of various technological applications with direct and alternating current electric drives.

Educational subject disciplines *are processes transformation energy in electromechanical systems; methods definition power electric drives depending from modes works ; methods formation given static and dynamic characteristics in open and closed electric drive systems ; laws management of the movement of performers bodies working machines.*

Program learning outcomes that the discipline aims to improve:

PRN03 - Know the principles of operation of electric machines, devices and automated electric drives and be able to use them to solve practical problems in professional activity; PRN07 - Analyze processes in electric power, electrotechnical and electromechanical equipment, relevant complexes and *systems; PRN08 - Choose and apply suitable methods for the analysis and synthesis of electromechanical and electric power systems with specified indicators; PRN18 - To be able to learn independently, master new knowledge and improve skills for working with modern equipment, measuring equipment and application software; PRN22 - Know and understand the basics of coordinate transformation and the principles of frequency and vector control of electromechanical systems; PRN25 - Know ways to improve the efficiency of algorithms for controlling electric drives, electromechanical systems, the basics of electromobility theory ; PRN27 - Know the equation of motion of an electric drive for different types of masses; methods of calculating the mechanical part of the electric drive; methods of controlling DC and AC motors; methods of selecting electric motors by power; 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. Pre-requisites and post-requisites of the discipline (place in the structural and logical scheme of training according to the relevant educational program)

To successfully master the discipline, the student must have knowledge of the disciplines "Higher mathematics", "General physics", "Theoretical foundations of electrical engineering", "Electric machines", "Electric drive", "Theory of automatic control", "Synthesis of logical circuits", "Automation systems ". Competences, knowledge and skills acquired in the process of studying the credit module are necessary for further study of the disciplines "Control of electric drives", "Electromechanical systems of typical technological applications", as well as for the high-quality performance of the final certification work (diploma project).

3. Content of the academic discipline

*The discipline is structurally divided into **2 parts** :*

Part 1 Theory of an electric drive

Chapter 1. Energy modes and energy losses in an electric drive
Chapter 2. Methods of power calculation and selection of electric motors
Chapter 3 . Dynamics of open electromechanical systems

Part 2 Control of electric drives

Open control systems
Chapter 1 . Relay- contactor control of electric drives when powered from the network. Typical protection, blocking and signaling nodes
Closed control systems
Chapter 2. Speed and torque control of a DC motor in a summing amplifier system
Chapter 3 . Control of the speed and torque of the electric motor in the subordinate regulation system
Chapter 4 . Control of the position of the electric drive

4. Educational materials and resources

Main information resources for part 1:

1. *Krasnoshapka , N. D. Automated electric drive. Section 1. Electric drive theory [Electronic resource]: a 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; compiled by: N. D. Krasnoshapka . – Electronic text data (1 file: 1.76 MB). – Kyiv: KPI named after Igor Sikorskyi, 2023. – 101 p. Access mode: https://ela.kpi.ua/handle/123456789/57270*
2. *Electric drive theory / Edited by M.G. Popovicha/ Textbook. - K.: Higher School, 1993. -496p.*
3. *Zelenov A.B. Electric drive theory: Electric drive design methodology: Textbook. – Luhansk: "Knowledge " Publishing House , 2010. – 670 p.*
4. *Electromechanical automatic control systems and electric drives / Edited by M.G. Popovicha and O.Yu. Lozynskyi / Study guide for students of higher educational institutions who study in the field of "Electromechanics". - K.: Lybid, 2005. -680 p.*
5. *"Theory of electric drive-2" synopsis of lectures from the credit module for full-time students of the field of study 6.050702-"Electromechanics" specialty "Electromechanical systems of automation and electric drive"/ Comp. S.P. Kolesnichenko. - K.: NTUU "KPI", 2011. - 103 p.*
6. *Theory electric drive : Textbook / Ed. M.G. Popovich - K.: V ischa school, 1993. - 494 p.*
7. *A. A. Vydmysh , L. V. Yaroshenko. Foundations electric drive . Theory and practice. Part 1. / Educational guide . – Vinnytsia : VNAU, 2020. – 387 p.*

Additional informational resources for part 1:

1. *Leonhard W. Control of Electrical Drives . Berlin : Springer-Verlag , 2001.*

Main information resources for part 2:

1. *Electromechanical automatic control systems and electric drives / Edited by M.G. Popovych and O. Yu. Lozynskyi / Study guide for students of higher educational institutions who study in the field of "Electromechanics". - K.: Lybid, 2005. -680 p.*
2. *Electric drive theory / Edited by M.G. Popovicha / Textbook. - K.: Higher School, 1993. - 496p.*
3. *Electromechanical systems of automation and electric drive (Theory and practice) / M.G. Popovych, V.I. Kostrytskyi et al. Study manual with the handle of the Ministry of Education and Culture of Ukraine. - K.: KNUTD. 2008. - 408 p.*

4. Development and research of electromechanical automation systems and electric drive components / M.G. Popovych, V.I. Kostrytskyi et al. - Study guide with the Ministry of Education and Culture of Ukraine. - K: KNUTD, 2011. - 492 p.

5. Software and monitoring motion control systems [Electronic resource]: textbook for students of specialty 141 "Electroenergetics, electrical engineering and electromechanics", specialization "Electromechanical systems of automation, electric drive and electric mobility " / V.I. Teryaev , S.V. King. – Kyiv: KPI named after Igor Sikorskyi, 2021. – 150 p.

Additional informational resources for part 2:

6. Richard Crowder . Electric Drives and Electromechanical Systems : Applications and Control / Richard Crowder . – Newnes , Published Date : 2006. – 312 p.

7. Elements of an automated electric drive / M.G. Popovych, V.A. Gavrilyuk, O.V. Kovalchuk, V.I. Teryaev . - K.: UMVK VO. - 1990. – 260 p.

Methodological materials for part 2:

8. Automated electric drive part 2 [Electronic resource]: study guide for students of the educational program "Electromechanical systems of automation, electric drive and electric mobility " specialty 141 "Electric power, electrical engineering and electromechanics" / V.I. Teryaev . – Kyiv: KPI named after Igor Sikorskyi, 2022. – 204 p.

9. Elements and devices of electromechanical systems and electric drives-1: text of lectures for students of the specialty "Electromechanical systems of automation and electric drives / Compiler: V.I. Teryaev . - Kyiv: NTUU "KPI", 2011. - 324 p.

10. Methodical instructions for performing the laboratory work "Research of dynamic modes of the relay- contactor scheme of automatic control of a direct current electric motor with independent excitation" for students of the specialty "Electromechanical systems of automation and electric drive" / Incl . V.I. Teryaev . - K.: KPI, 2013. – 24 p.

11. Methodical instructions for laboratory work in the discipline "Control systems of electric drives" for students of the specialty "Electromechanical systems of automation and electric drive". Study of the static and dynamic characteristics of the speed control system of the DC motor with independent excitation based on the structure with the summing amplifier. / O.I. Kiselichnyk , V.I. Teryaev , M.Ya. K. Ostroverkhov : "Polytechnic", 2007 - 32 p.

12. Methodical instructions for the performance of laboratory work from the credit module "Automation of electromechanical systems" on the topic "Investigation of static and dynamic modes of a direct current motor with independent excitation based on the DCS800 control -transformer device" for students of the specialty "Electromechanical automation systems and electric drive" / S.M. . Peresada, O.I. Kiselichnyk , V.I. Teryaev , M.V. Pushkar - K.: KPI, 2012. – 92 p.

13. Methodical instructions for practical classes in the discipline "Control systems of electric drives" for full-time students of the specialty "Electromechanical systems of automation and electric drive" / O.I. Kiselichnik . - K.: NTUU "KPI", 2002. - 48 p.

Educational content

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

Lecture classes

Part 1. THEORY OF THE ELECTRICAL DRIVE

(references to sources correspond to the list of information resources in part 1)

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	*Power balance in an electromechanical system with a single-motor electric drive. Energy characteristics. Characterization of the operating modes of the electric drive from the energy point of view. Economical operation of the electric drive. Efficiency of conversion and energy consumption. Literature [1], [2], [4].*
2	*Energy losses in stable and transient processes of the electric drive. Permanent and variable losses. Power losses in AC and DC electric drives. Literature [1], [2], [4].*
3	*Analysis of energy losses in different operating modes of the electric drive. Energy losses in transient modes. Energy losses in an asynchronous motor. Energy losses during soft start of the electric motor. Energy saving. The main methods of energy saving in the electromechanical system. Literature [1], [2], [4].*
4	*Heating and cooling of engines. Heat balance equation. Structural diagrams of thermal models of engines. Engine overheating. Heating and cooling time constants. Effect of temperature on the service life of electrical insulation. Literature [1], [2], [4].*
5	*Nominal operating modes of electric motors. Long-term, short-term, repeated-short-term regimes. Engine load charts. Load diagrams of mechanisms of cyclic and continuous action. Construction of load diagrams and tachograms. Taking into account the influence of the moment of inertia of the mechanism on the load diagrams. . Literature [1], [2], [4].*
6	*Methods of equivalence of thermal regimes. Equivalent load. Method of average losses. Methods of equivalent current, moment and power . Features of choosing electric motors by power. Calculation of power and selection of engines of nominal long-term operation. Calculation of engine power for different types of load diagrams. Checking the correctness of the engine selection. Literature [1], [2], [4].*
7	*Calculation of power and selection of engines of nominal short-term mode of operation . Checking the correctness of the engine selection. Coefficient of thermal overload. Calculation of power and selection of motors of nominal repetitive short-term operation mode. Checking the correctness of the engine selection. Recalculation of power to the standard PV value. Determination of the admissible switching frequency of asynchronous motors with a short-circuited rotor. Calculation of energy losses per cycle. Taking into account the deterioration of heat transfer. Energy balance equation. Increasing the permissible switching frequency . Literature [1], [2], [4].*
8	*Differential equations and a structural diagram of a generalized electromechanical system. Dynamic properties of an open electromechanical system depending on the type of roots of the characteristic equation. Literature [1], [3], [4].*
9	*Typical transient processes of an electromechanical system at a constant speed of ideal idling. A system of differential equations that describes the motion of the system. The equation of motion of the system in terms of speed, acceleration and moment depending on the type of roots of the characteristic equation. Literature [1], [3], [4].*
10	*Transient processes during loading, reversal during active static moment. Transient processes during reversing with reactive static moment, dynamic braking with active static moment, dynamic braking with reactive static moment. Literature [1], [3], [4].*
11	*Transient processes when the electrical resistance of the armature or rotor is increased by a jump, the speed of the ideal idling speed is increased by a jump, rheostatic starting of the*

	engine. The concept of optimal transient processes of an electromechanical system . Literature [1], [3], [4].
12	*Electromechanical transient processes during a smooth change of control action. The equation of motion of the system. Static and dynamic error. Typical transient start-up processes with reactive static torque, Literature [1], [3], [4].*
13	*Typical transient processes of reversal with active static moment, reversal with reactive static moment . The concept of electric drive damping of elastic mechanical vibrations. Literature [1], [3], [4].*

Part 2. CONTROL OF ELECTRICAL DRIVES
(references to sources correspond to the list of information resources in part 2)

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)*
14	*General requirements for controlling the movement of an electric drive. The main indicators of the quality of regulation by electric drives in static and dynamic modes. The concept of optimal laws of motion of electric drives. Optimization criteria. Motion modes of electric drives.* *Literature [1] - [4], [8].*
15	*Control of electric drives when powering engines from the network. Features of the use of relay- contactor devices for controlling electric drives.* *Literature [1] - [4], [8].*
16	*Direct current electric motor control schemes. Typical control units for starting, braking, and reversing DC motors as a function of time, speed, and current.* *Literature [1] - [4], [8], [9].*
17	*Schemes of control of asynchronous electric motors. Typical nodes of control schemes for starting, braking and reversing asynchronous electric motors as a function of time, speed, and current.* *Literature [1] - [4], [8] - [10].*
18	*Schemes of control of synchronous electric motors. Typical nodes of control schemes for starting, braking and reversing synchronous electric motors as a function of speed and current.* *Literature [1] - [4], [8] - [10].*
19	*Typical protection, blocking and signaling nodes. Nodes of electrical protection of engines and control circuits. Selection of settings of electrical devices.* *Literature [1] - [4], [8] - [10].*
2 0	*Speed control in the system is a controlled converter - a direct current motor with a summing amplifier. Functional diagram. Derivation and analysis of the generalized equation of the electromechanical characteristic when applying feedback on voltage, current and speed.* *Literature [1] - [4], [8], [9], [11].*
2 1	*Torque control of a DC motor in a controlled converter-motor system. Functional and structural diagrams. Derivation of the electromechanical characteristic equation . Analysis of static and dynamic characteristics.* *Literature [1] - [4], [8], [9], [11], [13].*
22	*Control of the speed and torque of the electric motor in the subordinate regulation system. General principles of building subordinate control systems, standard settings and optimization of control circuits.* *Literature [1] - [4], [8], [9], [12], [13].*

23	*Single-zone two-circuit system of subordinate coordinate regulation with current and speed regulation circuits. Synthesis of the armature current regulator. Torque control of a DC motor based on a closed current loop. Synthesis of the speed regulator when setting the circuit to a modular and symmetrical optimum. Static and dynamic characteristics of the subordinate regulation system.* *Literature [1] - [4], [8], [9], [12], [13].*
24	*Single-circuit system of subordinate speed regulation of DPS and AD with amplitude and frequency control . Optimization of the speed contour by the method of sequential correction. Static and dynamic characteristics of the system.* *Literature [1] - [4], [8], [9], [12], [13].*
25	*Two-zone independent excitation DC motor speed control system. Functional and structural diagrams of the control system, static and dynamic characteristics. Procedure for the synthesis of regulators.* *Literature [1] - [4], [8], [9], [12], [13].*
26	*Formation of transient processes of the electric drive. Intensity settings .* *Soft start power devices. Dynamics of speed control systems when using intensity setters and soft start devices.* *[1] - [4], [8].*
27	*Controlling the position of the direct current motor according to the principle of subordinate coordinate adjustment. Adjusting the position contour to a modular and symmetrical optimum . Errors of the tracking (positioning) electric drive during standard actions.* *Literature [1] - [4], [8], [9], [13].*

Practical classes

No s/p	*Name of the subject of the lesson and list of main questions*
1	*Energy losses in the electric drive . Determining the value of losses during typical transient processes without load*
2	*Energy losses in the electric drive . Determining the value of losses during typical transient processes under load*
3	*Construction of a tachogram and engine loading diagram*
4	*Power calculation methods and selection of electric motors .*
5	*Transient processes with a linear mechanical characteristic of an electromechanical system at a constant speed of ideal idling. Transient processes during engine start-up, increase and decrease with a jump in the electrical resistance of the armature or rotor circuit. Modular control work*
6	*Transient processes with a linear mechanical characteristic of an electromechanical system at a constant speed of ideal idling. Transient processes during reversing with active static torque, reversing with reactive static torque, dynamic braking with active static torque. dynamic braking with reactive static moment.*
7	*Transient processes with a linear mechanical characteristic of an electromechanical system at a constant speed of ideal idling. Transient processes when increasing or decreasing the ideal idle speed by a jump.*
8	*Optimal transitional processes*
9	*Transient processes with a smooth change of control action.*

Laboratory classes

No	***List of laboratory works***	***Number***

s/p		audio hours
1.	**Laboratory work No. 1.** Study of transient processes in electric drives	4
2.	**Laboratory work No. 2.** Study of the heating process of an electric motor.	4
3.	**Laboratory work No. 3.** Study of static and dynamic modes of a two-circuit speed control system of a direct current motor with independent excitation based on the DCS800 control and conversion device.	4
4.	**Laboratory work No. 4.** Study of static and dynamic modes of a two-zone system of subordinate speed regulation of a direct current motor with independent excitation based on the DCS800 control - transformer device.	4
5.	**Laboratory work No. 5.** Study of static and dynamic characteristics of a DC motor with independent excitation in the torque source mode based on the DCS800 control and conversion device.	2

Calculation and graphic work (RGR)

As an individual task, students perform calculation and graphic work (RGR). The purpose of RGR is to consolidate theoretical knowledge of the discipline, students to acquire practical skills of independent solution of problems in the calculation and research of the electric drive. Students perform one calculation and graphic work (RGR), which contains the following questions: construction of the load diagram of the electric drive; determination of engine power and its selection, checking of the selected engine for heating and overload capacity, calculation and construction of static mechanical characteristics of the electric drive, selection of equipment for the power part of the electric drive.

6. Student's independent work

No. z/p	Type of independent work	Number hours of SRS
1	Preparation for lectures	13
2	Preparation for practical classes	9
3	Preparation for laboratory classes	13
4	Preparation for MKR	4
5	Implementation and protection of RGR	15
6	Preparation for the test	6
	Together	60

Policy and control

7. Policy of academic discipline (educational component)

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

- *rules for attending classes: in accordance with Order 1-273 dated 14.09.2020, it is prohibited to evaluate the presence or absence of the winner at the classroom class, including the awarding of*

incentive or penalty points. According to the RSO of this discipline, points are awarded for the corresponding types of educational activity in lectures and practical classes;

- *rules of behavior in classes: the student has the opportunity to receive points for the appropriate types of educational activity in lecture classes, provided for 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;*
- *policy of deadlines and rescheduling: if a student did not pass or did not appear at the MKR (without a good reason), his result is evaluated at 0 points;*
- *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 "Automated electric drive";*
- *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, to be polite and limit communication to the working hours of the teacher.*

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

Current control *: express survey at lectures, answers at practical classes, performance and defense of laboratory work, MKR.*
Calendar control *: is carried out twice a semester as a monitoring of the current state of meeting the requirements of the syllabus .*
Semester control: *assessment.*
Conditions for admission to semester control *: semester rating of more than 36 points, completed and protected laboratory work.*

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

- *answers during express surveys at lectures, work in practical classes, performance and defense of laboratory work, performance and defense of calculation and graphic work;*
- *execution of two modular control works (MKR).*

Express survey	Performance and protection of laboratory work	Work in practical classes	RGR	MKR	Together
13.5	30	9	23.5	24	100

Answers during express surveys at lectures

The weighted point of the lecture is 0.5.
The maximum number of points for all lectures is 0.5 points x 27 lectures = 13.5 points.
Evaluation criteria

- *correct answers to questions during the survey - 0.5 points .*
- *a student who missed a lecture for valid reasons can be additionally questioned on the topic of the missed lecture and, in case of a correct answer, receive 0.5 points .*

Work in practical classes

The weighted score of the lesson is 1.
The maximum number of points for all practical classes is 1 point x 9 classes = 9 points.
Evaluation criteria

- *active participation and correct independent solution of the problem - 1 point;*

Laboratory work

The weighted score of the laboratory work is 6.

Performance and protection of laboratory work:

The maximum number of points for 5 laboratory works is 6 points x 5 labs . works = 30 points.

Evaluation criteria

Working out

- *working out the work 1*

Protection:

- *the protocol is prepared without errors, the answers to the questions are clear and meaningful -5;*
- *the protocol was prepared with some inaccuracies , the answers to the questions have minor errors - 4;*
- *the protocol is prepared with errors, the answers to the questions are unclear and have significant errors - 3;*
- *the protocol is prepared with errors, the student does not actively participate in the performance of laboratory work, the answers to the questions are incorrect. Laboratory work requires additional practice - 0*
- *protection of laboratory work beyond the prescribed period without a good reason - fine 1;*

Individual semester assignment (calculation and graphic work)

According to the working curriculum, each student performs calculation and graphic work.
The maximum number of points for the execution of the RGR is 23.5 and consists of the maximum point for registration – 3.5 points, for protection – 20 points.

Evaluation criteria

For registration:

- compliance with registration requirements or minor deviation - 3.5 points;
- slight deviation from the requirements for registration - 3–2.5 points;
- significant deviation from the registration requirements - 2 points;
- RGR is not properly executed - 0 points and is returned for processing.

For protection:

- understanding of the presented material, complete answers to questions for the defense - 18–20 points;
- understanding of the presented material, complete answers to the defense questions with some inaccuracies - 14–17 points;
- incomplete answers to defense questions - 12-13 points;
- the work is completed with significant errors, the student cannot give an answer to the defense - 0 points.
Untimely protection of the RGR without a good reason - a penalty of 5 points

Modular control work

The number of MKRs is 2, each lasting 1 academic hour.
The MKR weight score is 12.
The maximum number of points for two MKRs is 12 points x 2 MKRs = 24 points

Evaluation criteria

- *complete answer to the question (more than 90% of the material) - 11 - 12 points;*
- *incomplete answer to the question (from 75 to 90% of the material) - 9-10 points;*

- *incomplete answer (contains less than 50% of the necessary information) – 7-8 points;*
- *the answer contains less than 50% of the necessary information - 0 points.*

For active work in practical and lecture classes during the semester, in-depth study of individual topics of the discipline, the teacher has the right to give the student up to 10 incentive points
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 form of semester control is credit

The maximum amount of points makes up 10 0.

A necessary condition for admission to the credit is the defense of all laboratory work, execution and defense of calculation and graphic work, and a starting rating of at least 36 points. In order to receive a credit from the educational component "automatically", you need to have a rating of at least 60 points, as well as the conditions for admission to the credit.

Students who have fulfilled the admission requirements at the end of the semester, but have a rating of less than 60 points, as well as those who want to improve their grade in the ECTS system, complete a credit test. At the same time, the points scored by the student are canceled, except for the points for the calculation and graphic work, and the grade for the credit control work is final.

***Credit work** Credit work is conducted at the last lecture session and consists of two theoretical questions and a problem.*

Credit assessment criteria

Each theoretical question is worth 22 points, and the practical question is worth 32.5 points.

The evaluation system of theoretical questions:

- "excellent", complete answer (at least 90% of the required information) - 20-22 points;
- "good", a sufficiently complete answer (at least 75% of the required information), or a complete answer with minor inaccuracies - 17-19 points;
- "satisfactory", incomplete answer (at least 50% of the required information) and minor errors - 13 - 16 points;
- "unsatisfactory", unsatisfactory answer less than 50% of the required information and significant errors) - 0 points.

Evaluation system of the practical task :

- "excellent", complete problem-free solution - 29 - 32.5 points;
- "good", complete solution of the task with insignificant inaccuracies - 24 - 28 points;
- "satisfactory", the task was completed with certain shortcomings - 19 - 23 points;
- "unsatisfactory", task not completed - 0 points.

The sum of starting points and points for the examination control work is transferred to the examination grade according to the table:

Number of points	*Rating*
95-100	*Perfectly*
85-94	*Very good*
75-84	*Good*
65-74	*Satisfactorily*
60-64	*Enough*
Less than 60	*Unsatisfactorily*
The conditions for admission to the semester control have not been met	*Not allowed*

9. Additional information on the discipline (educational component)

List of topics that are submitted for semester control

According to part 1 of the discipline

1. Power balance in an electromechanical system with a single-motor electric drive. Energy characteristics. Characterization of the operating modes of the electric drive from the energy point of view. Economical operation of the electric drive. Efficiency of conversion and energy consumption.

2. Energy losses in stable and transient processes of the electric drive. Permanent and variable losses. Power losses in AC and DC electric drives.

3. Analysis of energy losses in different operating modes of the electric drive. Energy losses in transient modes. Energy losses in an asynchronous motor.

4. Energy losses during soft start of the electric motor. Energy saving. The main methods of energy saving in the electromechanical system.

5. Heating and cooling of engines. Heat balance equation. Engine overheating. Heating and cooling time constants. Effect of temperature on the service life of electrical insulation.

6. Nominal modes of operation of electric motors S1-S8. Long-term, short-term, repeated-short-term regimes.

7. Engine load charts. Load diagrams of mechanisms of cyclic and continuous action. Construction of load charts and tachograms. Taking into account the influence of the moment of inertia of the mechanism on the load diagrams.

8. Methods of equivalence of thermal regimes. Equivalent load. Method of average losses. Methods of equivalent current, torque and power.

9. Calculation of power and selection of engines of nominal long-term operation. Calculation of engine power for different types of load diagrams. Checking the correctness of the engine selection.

10. Calculation of power and selection of engines with a nominal short-term operating mode. Checking the correctness of the engine selection. Coefficient of thermal overload

11. Calculation of power and selection of engines of nominal repeated short-term operation mode. Checking the correctness of the engine selection. Recalculation of power to the standard PV value.

12. Determination of the permissible switching frequency of asynchronous motors with a short-circuited rotor. Calculation of energy losses per cycle. Taking into account the deterioration of heat transfer. Energy balance equation. Increasing the permissible switching frequency.

13. Differential equations and a structural diagram of a generalized electromechanical system. Dynamic properties of an open electromechanical system depending on the type of roots of the characteristic equation.

14. Typical transient processes of an electromechanical system at a constant speed of ideal idling. A system of differential equations that describes the motion of the system. The equation of motion of the system in terms of speed, acceleration and moment depending on the type of roots of the characteristic equation.

15. Transient processes during loading, reversal during active static moment, reversal during reactive static moment, dynamic braking during active static moment, dynamic braking during reactive static moment, jump increase in electric resistance of armature or rotor circle, jump increase in ideal idle speed, rheostat start engine.

16. Optimal speed transients with engine torque limitation. Optimal speed transients with acceleration limitation. Optimal speed transients with moment and jerk limitation.

17. Electromechanical transient processes during a smooth change of control action. The equation of motion of the system. Static and dynamic error. Typical transient processes of starting with reactive static torque, reversing with active static torque, reversing with reactive static torque.

18. Structural diagram of an electromechanical system with an elastic mechanical connection. Analysis of the characteristic equation of the system. The influence of stiffness of the mechanical characteristics of the system on damping of oscillations.

Part 2 of the discipline

1. Basic definitions and indicators of the quality of control of electric drives.

2. Control principles and main functions of an automated electric drive.

3. Principles and features of the use of relay- contactor devices for controlling electric drives.

4. Schemes of relay- contactor control of direct current electric motors.

5. Schemes of relay- contactor control of alternating current electric motors.

6. Typical units of protection, blocking and signaling in electric drives.

7. Typical structures of electric drive control systems.

8. Speed control in the system is controlled by a converter - motor with a summing amplifier.

9. Torque control in the system is controlled by a converter - engine.

10. Subordinate systems for adjusting the coordinates of the electric drive. Optimization of control contours.

11. Single-zone two-circuit system of subordinate coordinate regulation with current and speed regulation circuits.

12. Single-circuit system of subordinate speed regulation of DPS and AD with frequency control.

13. Adaptive current and speed regulators of complete DC electric drives.

14. Dual zone speed control of a DC motor with independent excitation.

15. Control of the position of the electric drive according to the principle of subordinate coordinate adjustment.

16. settings . Dynamics of speed control systems when using intensity setters .

***Certificates of completion of distance or online courses on the relevant subject may be credited subject to the fulfillment of the requirements specified in** ORDER NO. 7-177 DATED 01.10.2020 ON APPROVAL OF THE REGULATION ON RECOGNITION IN KPI NAMED AFTER IHOR SIKORSKYI OF LEARNING RESULTS ACQUIRED IN NON-FORMAL/ INFORMAL EDUCATION*

Working program of the academic discipline (syllabus):

Compiled by associate professors of the Department of Automation of Electromechanical Systems and Electric Drives of the FEA Krasnoshapka N.D. and V.I. Teryaev

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)