Національний технічний університет України
«КИЇВСЬКИЙ ПОЛІТЕХНІЧНИЙ ІНСТИТУТ
імені ІГОРЯ СІКОРСЬКОГО»

Department of
Electromechanics FEA

ELECTRIC MACHINES OF AUTOMATION SYSTEMS

Work program of the discipline (Syllabus)

Details of the discipline	
Level of higher education	***Second***
Branch of knowledge	*14 "Electrical Engineering"*
Specialty	*141 "Electric power, electrical engineering and electromechanics"*
Educational program	*ELECTRIC POWER ENGINEERING, ELECTRICAL ENGINEERING AND ELECTROMECHANICS*
Discipline status	*Normative*
Form of study	*Eye (day)*
Year of preparation, semester	*1 course, autumn semester*
The scope of discipline	*105 hours / 3.5 ECTS credits*
Semester control / control measures	*Offset / MCR*
Timetable	*http://rozklad.kpi.ua*
Language of instruction	*Ukrainian / English*
Information about the course leader / teachers	Lecturer: Ph.D. Chumak Vadim Vladimirovich, tel. 0502083843
Course placement	*Distance course in the Moodle system* *https://do.ipo.kpi.ua/login/index.php*

Curriculum

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

The program of the discipline "Electric machines of automation systems»Compiled in accordance with the educational program" Electric Power, Electrical Engineering and Electromechanics "training of masters majoring in 141 - Power Engineering, Electrical Engineering and Electromechanics.

The purpose of the discipline*is the study by students of the system of abilities and skills to perform the duties, production functions and typical tasks of the specialist. As a result of studying the credit module, students gain knowledge of the design, principle of operation, essence of physical phenomena and processes in electrical machines of automation systems, typical mathematical methods for calculation and research, the main characteristics of electrical machines of automation systems.*

The subject of the discipline *- there is a system of properties of electric machines of automation systems - their design, principle of operation, parameters, characteristics and modes of operation.*

Program learning outcomes:

Competences:on the choice of methods, schemes, equipment of experimental researches of a scientific and technical task; on processing, analysis and generalization of research results.

Knowledge:awareness of the place and role of electric machines of automation systems in modern technical and technological complexes; principles of construction of functional regularities

underlying the development of diversity of this class of electric machines; features of design, electromagnetic processes and working properties of the main types of electric machines of automation systems; typical mathematical research methods and basic characteristics of electric machines of automation systems.
Skills:choose the types of electrical machines of automation systems for specific conditions of practice; to create physical and mathematical models with the use of modern applications for the calculation of electrical machines of automation systems.

2. Prerequisites and postrequisites of the discipline (place in the structural and logical scheme of education according to the relevant educational program)

The value of the credit module "Electric machines of automation systems" in the training of specialists of educational qualification level (EQF) "bachelor" in the field of knowledge 14 Electrical engineering specialty 141 Electrical engineering, electrical engineering and electromechanics specialization "Electrical machines and devices" on the performance of duties, production functions and typical tasks of the specialist. As a result of studying the credit module, students gain knowledge of the design, principle of operation, essence of physical phenomena and processes in electrical machines of automation systems, typical mathematical methods for calculation and research, the main characteristics of electrical machines of automation systems.
In the structural and logical scheme of the training plan, the credit module "Electric machines of automation systems" provides communication with credit modules of such special disciplines as "Electric machines", "Fundamentals of automated design of electric machines", "Production and operation of electric machines", "Electric machines of automation systems", "Technology of production of electric machines", "Special electric machines" ..

3. The content of the discipline

The discipline structurally consists of 2 meaningful subdivisions, namely:

1. *Stepper electric motors*
Topic 1.1. Basic definitions and classification of stepper motors. The main types of stepper motors.
Topic 1.2. The main types of control circuits for stepper motors. Power supply circuit and switching of the control winding of unipolar current pulses.
Topic 1.3. Power supply circuit and switching of the control winding of multipolar current pulses. Types of switching stepper motors.
Topic 1.4. Modes of magnetic fixation and single steps. Limits of stable rotation of the rotor of a stepper motor.
Topic 1.5. Characteristics of the frequency of the intake of the stepper motor
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2. Features of designing micromachines of automation systems

Topic 2.1. Features of design and calculation of DC actuators with permanent magnets of cylindrical shape using the data of a structural prototype.
Topic 2.2. Analysis of catalog data of external and internal geometry of a series of DIIM and DPR engines. Choice of the basic sizes for an individual task of course work. Choice of brand of magnetically conductive material. Features of calculation of the state diagram of a ring permanent magnet of the executive motor of a direct current.
Topic 2.3. Features of design and calculation of stepper motors with active rotor (KDA). Analysis of the geometry of a series of engines of structural prototypes SDA 2 ... 7. Selection of the basic sizes taking into account results of the analysis of geometry of prototypes.

Topic 2.4. Features of calculation of stator control windings and permanent magnets of "star" type. Methods of calculation of frequency characteristics of SDA pickup according to formulas, normalized standard characteristics and computer programs. Comparative analysis of methods and obtained calculation results.
Topic 2.5. Features of design and calculation of three-phase synchronous jet engines (SRD). Selection of basic dimensions and electromagnetic loads based on the dimensions of induction motors with a short-circuited rotor of a single series 4A, taken as structural prototypes.
Topic 2.6. Choice of basic sizes, final choice. Choice of rotor design. Comparative analysis of structures of equal-sized CPD and asynchronous motor of the prototype. Mathematical model of computer calculation of substitution schemes parameters Zd (jS) and Zq (jS), as well as asynchronous mechanical characteristics. Analysis of forms of mechanical characteristics of SRD acceleration.
Topic 2.7. Features of design and calculation of the executive asynchronous motor (VAD) with an auxiliary non-magnetic rotor. The choice of the basic sizes on the set electromechanical constant of time and other data defined in TK.
Topic 2.8. Features of calculation of the engine on parametric schemes of replacement. Mathematical model for computer calculation of the main characteristics of VAD, which works on the scheme of amplitude-phase control.
Topic 2.9. Efficiency of design and calculation of universal single-phase collector motor with sequential excitation (UCD). Fundamentals of the theory of UCD work. Choice of electromagnetic loads and engine sizes. Definition of a constructive prototype.
Topic 2.10. Features of electromagnetic calculation when supplied with alternating currents. Oco6livocti characteristics of UKD.
Topic 2.11. Features of design and calculation of single-phase induction motors (OAD) with short-circuited rotor, which are fed according to schemes with different phase-shifting elements on the basis of structural prototypes of the AOL series.
Topic 2.12. Selection of basic loads and engine sizes. Optimization of parameters and phase-shifting elements. Mathematical model for computer calculation of operating and starting characteristics of OAS. Features of the calculation program on the computer. Thermal calculation

4. Training materials and resources

Main information resources:

1. Yuferov FM Electric machines of automatic devices - a textbook for universities - M., VSh, 1988. - 471 p. - NTB.
2. Khrushchev VV Electric machines of automation systems - student for universities - L., 1985. - 363 p. - NTB.
3. Ermolin NP Low power electric machines. - L., VSh, 1967. - 450 s.
4. Discrete electric drive with stepper motors - ed. Chilikina MG - M., 1971. - 480 p. - NTB.
5. Lopukhina EM, Somikhina TS Calculation of asynchronous micromotors of single-phase and three-phase current. M., 1961. - 312 p. - NTB.
6. Microelectric motors for automation systems - ed. Lodochnikova ZA, Yuferova FM, M., 1969. - 272 p. - NTB.
7. Karpenko BK, Larochenko VI, Prokofiev Yu.A. Stepper motors. Kiev, "Technology", - 215 p. - NTB.

8. Davydov AN, Orlov NI, Prokofiev Yu.A., Timchenko VV Laboratory work on the course "Electric machines", part I, Kiev - KPI, 1973. - 106 p. - method office of the department. Electromechanics. INTRANET website.
9. Prokofiev Yu.A., Davydov AN, Orlov NI Laboratory works on the course "Electric machines", part II, Kiev ¬– KPI, 1973. - 104 p. - method office of the department. Electromechanics. INTRANET website.
10. Yu. Postnikov IM, Ralm VV Synchronous jet engines, Kiev, "Technology", 1970. - 148 p. - NTB.
11. Theory of automatic control. The use of visual modeling for the analysis of automatic control systems [Text]: guidelines for laboratory work in the discipline for students. electromechanical special. / Compiled by: Yu.A. Гайденко, B.B. Chumak. - K .: NTUU "KPI", 2008. - 68p. - method office of the department. Electromechanics. INTRANET website.
12. Electric machines of automation systems. Information electric machines [Text]: methodical instructions for laboratory work for students. electromechanical special. / Compiled by: MG Anpilogov, OM Davydov, EM Dubchak, VV Chumak. - K .: NTUU "KPI", 2008. - 92 p. - method office of the department. Electromechanics. INTRANET website.
13. Electric machines of automation systems. Executive electric micromachines [Text]: methodical instructions for laboratory work for students. electromechanical special. / Compiled by: MG Anpilogov, OM Davydov, EM Dubchak, VV Chumak. - K .: NTUU "KPI", 2010. - 68 p. - method office of the department. Electromechanics. INTRANET website.

Educational content

5. Methods of mastering the discipline (educational component)

Lectures

№ s / n	*The title of the lecture topic and a list of key issues (list of teaching aids, links to information sources)*
1	***Introduction***. ***Review and classification of electrical machines of automation systems.****Specifics of electric machines of automation systems. Classification of electrical machines of automation systems by type of current and their operating properties, applications and functions. Special requirements for electrical machines of automation systems, specific design features.* *Literature: [1], p.240-253; [3], p. 110- 122.*
2	***Electric machine generators (EMG) as elements of automation systems.****EMG at idle (mathematical models). Assumptions of a mathematical model.* *Literature: [1], p.344-350; [2], p. 76-83; [4], p.253-260, [3], p. 123- 127, [6], p. 12- 17*
3	***Electric machine generators (EMG), continued.*** *Definition of transient characteristics. Amplifier quality factor. Methods for solving nonlinear problems of systems. Method of cousin-linear approximation, nonlinear approximation.* *Literature: [2], p.101-187; [3] p. 139-148*
4	***The electromagnetic constant of time.*** *Oscillograms of the transient process of*

	excitation. The principle of feedback. The transfer function of the node with feedback. *Literature: [1] p.269-273, [3] p.34-46, [5] p.234-246.*
5	***Generator with self-excitation.*** *Calculation of the transient process of self-excitation. Derivation of a nonlinear differential equation with separate variables.* *Literature: [1] p.269-273, [2] p.84-96, [5] p.247-261*
6	***EMG operation under load.*** *Obtaining a transfer function and a second-order operator equation with constant coefficients.* *Literature: [1] p.298-310; [2] p.298-310; [4] p. 190-234*
7	***EMG as a power amplifier.*** *Signal transmission and conversion function and signal amplification function.* *Literature: [1] p.310-316, [2] p.210-216; [6] p.21-26*
8	***EMU of the transverse field.*** *Advantages of EMU transverse field. EMU design of the transverse field. The principle of operation and the main relations in the EMU of the transverse field.* *Literature: [1], p.216-232; [3] p. 231-238*
9	***Transverse field EMU performance.*** *External characteristics. Full compensation mode. Overcompensation mode.* *Literature: [1], p.324-328; [3], p. 61-65, [4], p. 115-129*
10	***Analysis and degree of reliability of the obtained expressions of the dynamic mode of operation of the EMU of the transverse field.*** *Parameters of the obtained transient characteristic. Taking into account incomplete compensation. Conclusions on the topic.* *Literature: [1], p.328-344; [3], p. 66-73, [4], p. 131-149.*
11	***Electric motors as elements of automation systems.*** *General requirements for electric motors of automation systems. Executive DC motor (VDPS). Performance properties and characteristics of VDPS at anchor control method. Family of mechanical and regulatory characteristics.* *Literature: [1], p.45-54; [2], p. 76-83, [5], p. 101-109.*
12	***Dynamic properties of VDPS at an anchor way of regulation.*** *Drawing up a dynamic model of VDPS work. Determining the nature of the transient process of dispersal of VDPS. The concept of dynamic capacity.* *Literature: [2], p. 102-113; [4] p. 66-73.*
13	***Dynamic properties of VDPS at pole control.*** *Family of mechanical and regulatory characteristics of VDPS with pole control. Static characteristics of VDPS with pole control.* *Literature: [1], p.236-252; [3] p. 240-248; [4] p. 166-173*
14	***Dynamic properties of VDPS at pole control.*** *Drawing up a dynamic model of VDPS work. Determining the nature of the transient process of dispersal of VDPS.* *Literature: [2], p. 115-123; [5] p. 176-183* ***Modular control work*** *- 2 hours*
15	***High-speed VDPS for automation systems.*** *Engine with disk printed armature. The main advantages of the engine with a disk printed armature. Engine with damping torque.* *Literature: [2], p. 76-83; [4], p. 11- 22; [7], pp.14-23; [10], pp.4-7.*
16	***Magnetoelectric excitation systems (MEZ) VDPS.*** *Types and properties of permanent magnet materials. Designs of magnetic systems of VDPS with permanent magnets.* *Literature: [1], p.65-74; [3], p. 251-263; [4] p. 94-98*
17	***Specifics of the working process in electric machines with MEZ.*** *Features of the anchor reaction in MEZ. Electric machine with soft magnetic pole pieces.* *Literature: [1], p.75-87; [3], p. 271-283; [4] p. 101-108.*
18	***Contactless DPS (BDPS).*** *BDPS block diagram. Operation of the basic simplified scheme of*

	BDPS of the non-reversible engine. *Literature: [1], p.88-91; [4], pp.25-27; [7], p. 27-33; [10] p. 10-18.*

Laboratory work

The main purpose of laboratory work is to provide students with practical skills in experimental testing and research of electrical machines of automation systems. The analysis of the obtained experimental results deepens the theoretical knowledge and promotes a deeper and systematic understanding of electric micromachines. In the course of laboratory work students study and master the methods and control schemes of electric machines of automation systems, schematic diagrams and equipment of experimental research in the scientific and technical task on the topic, process, analyze and summarize the results of experimental research. Each laboratory lesson is designed for 4 classroom hours. Topics of laboratory classes:

Introductory lesson. Safety instruction. Getting acquainted with the features of devices and equipment

Laboratory work №1. Research of the rotary transformer

Laboratory work №2. DC actuator test.

Laboratory work №3. Testing of single-phase transformer.

Laboratory work №4. Investigation of a contactless synchronous generator with permanent magnets with axial magnetic flux in autonomous mode.

Laboratory work №5. Investigation of a contactless synchronous motor with permanent magnets with axial magnetic flux.

6. Independent work of student

Distribution of hours for independent work by students:

№з / п	*Type of independent work*	*Number hours of CPC*
1	*Preparation for classroom classes*	*13*
2	*Execution of RGR*	*26*
3	*Preparation for MCR*	*8*
4	*Exam preparation*	*18*
	Total	*66*

Policy and control

7. Course policy (educational component)

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

- *rules of attendance: in accordance with Order 1-273 of 14.09.2020, it is prohibited to assess the presence or absence of the applicant in the classroom, including the accrual of incentive or penalty points. According to the RSO of this discipline, points are awarded for the relevant types of educational activity in lectures and practical classes.*
- *rules of conduct in the classroom: the student has the opportunity to receive points for the relevant types of educational activities in lectures and practical classes provided by the RSO 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 under the guidance of the teacher;*

- *policy of deadlines and rearrangements: if the student did not pass or did not appear at the MCR (without good reason), his result is evaluated at 0 points. Interpretation of MCR results is not provided;*
- *Academic Integrity Policy: 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 conduct of individuals and provides a policy of academic integrity for people who work and study at the university, which they should be guided in their activities, including the study and preparation of control measures in this discipline;*
- *when using digital means of communication with the teacher (mobile communication, e-mail, correspondence on forums and social networks, etc.) it is necessary to adhere to generally accepted ethical norms, in particular to be polite and limit communication during the teacher's working hours.*

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

Current control*: express survey, MCR.*
Calendar control*: conducted twice a semester as a monitoring of the current state of compliance with the requirements of the syllabus.*
Semester control: *test.*
The rating system for assessing the learning outcomes of students involves determining the number of points obtained by the student during the study of the discipline.
Conditions of admission to semester control*: the current semester rating must be at least 30 points.*
The current semester rating of the student consists of the points received on:

- *answers during express surveys at lectures;*
- *performing modular control work (MCR).*

Answers during express surveys at lectures
*Weight score - 3. The maximum number of points in all lectures is: 3 points * 2 = 6 points.*
Evaluation criteria:
3 points - a complete reasonable answer,
1… 2 points - insufficiently substantiated answer,
0 points - no or incorrect answer.
Modular control
*Weight score - 15. The maximum number of points for all tests is: 15 points * 2 = 30 points.*
Evaluation criteria:
15 points - a complete reasonable answer,
8… 10 points - insufficiently substantiated answer,
6… 7 points - the presence of 1-2 errors,
3 points - unreasonable answer with errors.
Work in the laboratory
*Weight score - 2. The maximum number of points in all laboratory work - 2 points * 2 = 4 points.*
Laboratory work
Weight score - 5.
The maximum number of points for all laboratory work is 4 × 5 = 20 points.
For each laboratory you can get points according to the following rating:
Execution of the experimental part of the work, high-quality processing of experimental data, registration of the protocol in accordance with the standards and a complete, reasonable answer in the defense of the work - 5 points.

Processing of experimental data with insignificant errors or poor-quality protocol design - 3… 4 points.
Significant errors in experimental data but a full understanding of the topic and material of laboratory work - 1… 2 points.
Laboratory work is generally unprotected - 0 points.

The sum of weight points of control measures during the semester (starting rating) is:

RC = 4 + 6 + 30 + 20 = 60 points.

The examination component of the scale is 40% of R, namely:

Rs = 40 points.

The rating scale for the discipline is:

R = Rc + Rc = 60 + 40 = 100 points.

Form of semester control - credit

The final evaluation of learning outcomes is carried out according to the stobal rating scale.The credit component of the scale is equal to 40% of the overall rating scale, ie RZ = 40 points. A necessary condition for admission to the exam is a complete syllabus of lectures, completed and defended laboratory work and MCR.

Exam work consists of two theoretical questions

Credit evaluation criteria

– complete answer (complete, error-free problem solving) Rs = 39 - 40 points;
- answer with some insignificant errors Rз = 30 - 38 points;
- answer without significant errors, but not with the full amount of information required Rs = 20 - 29 points;
- incomplete answer with certain errors Rз = 12-19 points;
- incomplete answer with a significant number of errors, but which are not fundamental Rz = 8-11 points;
- completely incorrect answer or no answer - 0 points.
The total number of rating points is defined as RP = RC + Rз
The table of correspondence of total rating points to estimations on the following scale:

Total number of points R_P	*Rating*
95-100	*Perfectly*
85-94	*Very good*
75-84	*Fine*
65-74	*Satisfactorily*
60-64	*Enough*
Less than 60	*Unsatisfactorily*
Less than 30	*Not allowed*

Work program of the discipline (syllabus):

FoldedAssociate Professor of Electromechanics FEA, Ph.D. Chumakom VV

ApprovedDepartment of Electromechanics FEA (protocol № 11 from 24.06.2021)

AgreedFEA Methodological Commission (Minutes № 11 of 25.06.2021)