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 3 meaningful subdivisions, namely:

1. Asynchronous micromotors with single-phase power supply: executive and general industrial

Topic 1.1 Introduction. The role and place of asynchronous micromotors in single-phase power supply in electromechanics and modern technology. The main trends in the development of this class of EM. General classification of asynchronous micromotors with single-phase power supply. Areas of their practical application.
Topic 1.2 The principle of operation of an induction motor with a short-circuit rotor in single-phase and three-phase modes. Additional losses in BP in single-phase mode.
Topic 1.3. Dependences of torque of single-phase and three-phase BP on sliding at different values of rotor circuit resistance. Energy diagram of BP in three-phase and single-phase mode.
Topic 1.4. Dependences of torques on straight and rotating fields, the resulting sliding moment.
Topic 1.5. Comparison of BP performance in single-phase and three-phase mode.

2. Information electric micromachines of automatic devices

Topic 2.1. Types of information electric micromachines of automatic devices. Measuring devices for measuring the speed, angle, acceleration and torques of electric motors.
Topic 2.2. Functional devices: rotating transformers, indicator electric machines-selsiny. Basic requirements for information electric machines.
Topic 2.3. Design, principle of operation, characteristics of asynchronous DC tachogenerator.
Topic 2.4. Design, principle of operation, characteristics of asynchronous tachogenerator of alternating current. Errors of tachogenerators of direct and alternating currents.

Topic 2.5. Acceleration sensors (accelerometers). Rotating transformers, design, principle of operation. Main characteristics.
Topic 2.6. Rotating transformer in LOT mode and coordinate converter.

3. Synchronous micromotors of different types for automation systems
Topic 3.1. Classification of synchronous micromotors. General vortex for parametric moment. The principle of operation of the simplest synchronous jet engine, components of the average electromagnetic moment.
Topic 3.2. Designs of modern synchronous jet engines.
Topic 3.3. Synchronous jet gear motors. The principle of operation of synchronous jet gear motors.
Topic 3.4. Synchronous motor with permanent magnets. Features of asynchronous start of synchronous motor with permanent magnets.
Topic 3.5. Hysteresis micromotors, classification, design. The nature of the hysteresis moment. The principle of operation of the hysteresis motor, its mechanical characteristics.
Topic 3.6. Vector diagram and performance of a hysteresis motor. Disadvantages and advantages of the hysteresis motor.

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	***Single-phase asynchronous motors for general industrial use (ZAD).****ZAD at various phase-shifting elements. Asynchronous motor with shielded pole. Features of modes of asynchronous micromotors at power supply from a single-phase network. Starting torque and methods of analysis of asymmetric induction motor.* *Literature: [4], p.253-260, [3], p. 123- 127, [6], p. 12- 17*
3	***Executive asynchronous motors (VAD).*** *Requirements for VAD. Control schemes: AU, FU, AFU. The principle of speed control VAD. Features of parameters and characteristics of BAD in comparison with ZAD.* *Literature: [2], p.101-187; [3] p. 139-148.*
4	***General questions of calculation of asymmetric modes of induction motors at single-phase power supply.*** *Selection of values of phase shifting elements K and C to obtain a circular field in different modes. Method of forward and reverse fields of two-phase motors for calculations of currents in windings. Substitution schemes and their parameters. Energy diagram. Calculation of costs, cosφ, moments, capacities.* *Literature: [1] p.269-273, [3] p.34-46, [5] p.234-246*
5	***Analytical study of the characteristics of the ideal dietary supplement in amplitude control (AU).*** *Methods and means of regulation of VAD and their comparison. Features of the theory of VAD. Power consumed for excitation and control. Capacitor WAD.* *Literature: [1] p.269-273, [2] p.84-96, [5] p.247-261*
6	***Designs of bipolar and multipole rotary transformers (OT).*** *Functions performed by OT in automation systems. The principle of operation of bipolar sinus OT in idle mode. Errors of reproduction of the sinusoidal output characteristic, determined by the design and*

	response of the load current. CKOT at secondary and primary balancing of windings. Input and output parameters of CKOT in both cases of balancing. *Literature: [1] p.298-310; [2] p.298-310; [4] p. 190-234.*
7	***Synchronous communication systems on single-phase selsins (OS) and rotating transformers (inductosins, reductosins).*** *Constructions and principles of single-phase selsins for sensors, receivers, differential selsins of contact and contactless types. Block diagrams and principles of operation of indicator and transformer circuit of synchronous communication on single-phase selcines.* *Literature: [1] p.310-316, [2] p.210-216; [6] p.21-26*
8	***Special windings of a usual design for realization of the set forms of a field in an air interval of cars of alternating current.*** *Winding function. Properties and performance of a sinusoidal winding. Areas of application.* *Literature: [1], p.216-232; [3] p. 231-238*
9	***Synchronous communication indicator scheme.*** *Quasi-static mode of operation. Errors. Q-factor. Ro6ota when rotating the sensor and the sensor itself on N receivers. Dynamic mode of operation of the indicator circuit. Electromagnetic moment - the calculation formula. Transformer circuit of synchronous communication. The principle of operation, the initial characteristics. Errors of working off of corners in following schemes.* *Literature: [1], p.324-328; [3], p. 61-65, [4], p. 115-129*
10	***Differential selsins in indicator and transformer circuits of synchronous communication. Magnesins - constructions, work in the indicator scheme.****Design of differential selsin with three-phase symmetric winding. The moment of coordination. Constructions and purpose of magnesines.* *Literature: [1], p.328-344; [3], p. 66-73, [4], p. 131-149.*
11	***General characteristics of synchronous motors of different types used in automation systems or have a general industrial purpose.*** *Comparative analysis of properties and areas of application. Synchronous jet engine, design, principle of operation, areas of application, disadvantages and advantages. General formula of parametric moment.* *Literature: [1], p.344-350; [2], p. 76-83, [5], p. 101-109.*
12	***Synchronous jet engine.*** *The physical nature of the parametric moment. The general formula for calculating the parametric moment when powering the windings of the constriction with direct or alternating current. Parametric motors of different types. Parametric (jet) motors of single-phase or three-phase current (SRD). Constructions of CPD rotors - usual type and with improved characteristics: segmental and plate types.* *Literature: [1], p.28-44; [2], p. 102-113; [4] p. 66-73*
13	***Subsynchronous (low-speed) jet engines (SSD).*** *The principle of operation, the concept of electromagnetic reduction on the example of a three-phase design of a subsynchronous motor. Features of asynchronous and synchronous start of engines of this type. Examples of series execution. Areas of application.* *Literature: [1], p.236-252; [3] p. 240-248; [4] p. 166-173*
14	***Synchronous motors with permanent magnets (SDPM).*** *Typical constructions and parameters, technical characteristics. Modern designs of one- and two-package CDM with single-phase power supply. Features of asynchronous SDPM start-up, selection of the magnetization index of permanent magnets for start-up.* *Literature: [1], p.45-54; [2], p. 115-123; [5] p. 176-183* ***Modular control work*** *- 2 hours*
15	***Three-phase and single-phase hysteresis motors (GD).*** *The nature of the hysteresis moment. Designs and materials of GD rotors. Vector diagram of the operating mode and*

	its interpretation. Working and mechanical (starting) characteristics of GD. Literature: [1], p.55-64; [2], p. 125-133; [5] p. 186-193
16	***Synchronous electric motors of discrete action.*** *General provisions on the operation, design, characteristics and properties of stepper motors as actuators in discrete automation systems. Examples of the use of stepper motors for the current generation of trajectories and state coordinates in digital automation systems. Literature: [1], p.65-74; [3], p. 251-263; [4] p. 94-98*
17	***Designs of stepper motors with active and jet rotor.*** *Angular static characteristics. Dynamics of rotor movement during engine operation on the whole range of operating frequencies. Resonant phenomena. Ways to troubleshoot. Examples of schemes of simpler electronic switches. Characteristics of pickup. Literature: [1], p.75-87; [3], p. 271-283; [4] p. 101-108*
18	***Operating modes of stepper motors.*** *Magnetic fixation mode. Single step mode. Limits of stable motion of the rotor of a stepper motor. Characteristics of the frequency of the pickup of the stepper motor. Literature: [1], p.265-274; [3], p. 271-283; [4] p. 264-278*

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. Test of the contactless valve motor of a direct current.

Laboratory work №2. Investigation of an induction motor powered by a frequency converter.

Laboratory work №3. Research of the unipolar stepper motor on the basis of the microcontroller.

Laboratory work №4. Testing of a DC generator with a claw-like rotor.

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)