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

Department of Automation of Electromechanical Systems and Electric Drive FEA

SCIENTIFIC INTERDISCIPLINARY RESEARCH OF ELECTROMECHANICAL SYSTEMS

Work program of the discipline (Syllabus)

Details of the discipline	
Level of higher education	***Second (master's)***
Branch of knowledge	*14 "Electrical Engineering"*
Specialty	*141 "Electric power, electrical engineering and electromechanics"*
Educational program	*Electromechanical automation systems, electric drive and electric mobility*
Discipline status	*Selective*
Form of study	*Eye (day)*
Year of preparation, semester	*II course, autumn semester*
The scope of discipline	*225 hours / 7.5 ECTS credits*
Semester control / control measures	*Exam / MCR / RGR*
Timetable	*http://rozklad.kpi.ua*
Language of instruction	*Ukrainian / English*
Information about the course leader / teachers	Lecturer: *Dr, prof. Sergei Peresada, Dr. Serhii Kovbasa, 0674351881* Practical: *Dr., prof. Sergei Peresada, Dr. Serhii Kovbasa, 0674351881*
Course placement	

Curriculum

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

The syllabus of the discipline "Scientific interdisciplinary research of electromechanical 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 *there is a formation in students of the following abilities: ability to apply knowledge in practical situations;ability to learn and master modern knowledge; ability to identify and assess risks.*

The subject of the discipline *- electromechanical systems of various technological applications, as well as issues of modern research in the field of electromechanical systems.*

Program learning outcomes:

Competences: (FC2) ability to develop and implement measures to improve the reliability, efficiency and safety in the design and operation of equipment and facilities of electricity, electrical engineering and electromechanics; (FC3) the ability to analyze technical and economic indicators and examination of design decisions in the field of power engineering, electrical engineering and electromechanics; (FC8) the ability to demonstrate awareness and ability to use regulations, norms, rules and standards in power engineering, electrical engineering and electromechanics; (FC9) the ability to use software for computer modeling, computer-aided design, automated production and automated development or design of elements of electrical, electrical and electromechanical systems;

Skills:(PH01) to reproduce processes in electric power, electrotechnical and electromechanical systems at their computer modeling; (PH04) to reconstruct existing electrical networks, stations and substations, electrical and electromechanical complexes and systems in order to increase their reliability, efficiency operation and life extension; (PH06) to search for sources of resource support for additional training, research and innovation; (PH11) to communicate freely orally and in writing in state and foreign languages on modern scientific and technical problems of electric power, electrical engineering and electromechanics; (PH14) to master new versions or new software designed for computer modeling of objects and processes in electrical, electrical and electromechanical systems;

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

To successfully master the discipline, the student must have a "Practical course of foreign language business communication", as much of the new scientific results and new technologies are described in the scientific literature in English. Competences, knowledge and skills acquired in the process of studying the credit module are necessary for further internship for a master's thesis.

3. The content of the discipline

The discipline is structurally divided into 2 sections, namely:

Section 1. Current issues of modern electromechanical systems.

Topic 1.1. Mathematical models of typical electromechanical control objects.
Lecture 1. Mathematical models of typical electromechanical control objects.
Lecture 2. Determining the parameters of mathematical models.
Lecture 3. Reducing the order of mathematical models.
Topic 1.2. Algorithms for controlling typical electric machines of alternating current.
Lecture 4. Algorithms for vector control of induction motors.
Lecture 5. Algorithms for vector control of synchronous motors with excitation from permanent magnets.
Lecture 6. Algorithms for vector control of synchronous jet engines.

Topic 1.3. Robustness of typical vector control systems. Adaptive and robust control.
Lecture 7. Robustness of vector control algorithms for induction motors.
Lecture 8. Adaptive algorithms for vector control of AC motors.
Lecture 9. Self-commissioning in vector control systems for AC motors.

Section 2. Aspects of practical implementation of electromechanical systems and performance of experimental researches

Topic 2.1. The concept of rapid prototype testing. Methodology of experimental research.
Topic 2.2. Experimental installations for the study of control algorithms for AC motors.
Topic 2.3. Experimental determination of parameters of AC motors.

Topic 2.4. Problems of using pulse-width modulation in electromechanical systems.
Topic 2.5. Inverter dead time problem in standalone voltage inverters. Dead time compensation algorithms.
Topic 2.6. The latest electromechanical converters and semiconductor devices for electromechanical systems.
Topic 2.7. Features of the hearth of the signal measurement system from current and voltage sensors.
Topic 2.8. Methods of digital signal processing in electromechanical systems.
Topic 2.9. Features of practical implementation of vector control algorithms for AC motors on digital signal processors.

4. Training materials and resources

1. Zagirnyak MV, Klepikov VB, Kovbasa SM, Mikhalsky VM, Peresada SM, Sadovoy OV, Shapoval IA Energy efficient electromechanical systems for a wide range of technological purposes. Kyiv: NAS of Ukraine, 2018. 310 p.

2. Methods of robust adaptive control of electromechanical systems with increased dynamic and energy performance: GDR report. NTUU "KPI". № DP 0115U000381. Kyiv, 2017. 506 p.

3. Development of energy-efficient electromechanical electric bus system based on adaptive vector-controlled asynchronous electric drive with battery-supercapacitor power supply: report on GDR / NTUU "KPI". № DP 0117U004284. Kyiv, 2018. Volume 1. 472 p.

4. M. Ehsani, Y. Gao, S. Longo, KM Ebrahimi Modern Electric, Hybrid Electric, and Fuel Cell Vehicles. Third edition. - CRC Press, 2018, –573p.

5. Kovbasa SM Development of the theory of gearless vector control of electromechanical systems with asynchronous motors .: Dis. Dr. tech. Science: 05.09.03. Kiev. 2020

6. J. Larminie, J. Lowry Electric vehicle technology explained. –WILEY. 2012. –328p.

7. A. Emadi Handbook of Automotive Power Electronics and Motor Drives. –CRC Press. 2005. –668p.

8. Theory of electric drive / Ed. M.G. Popovich.- K .: Higher school, 1993.-494 p.

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	*Topic 1.1. Mathematical models of typical electromechanical control objects. Lecture 1. Mathematical models of typical electromechanical control objects.*
2	*Lecture 2. Determining the parameters of mathematical models.*
3	*Lecture 3. Reducing the order of mathematical models.*
4	*Topic 1.2. Algorithms for controlling typical electric machines of alternating current. Lecture 4. Algorithms for vector control of induction motors.*
5	*Lecture 5. Algorithms for vector control of synchronous motors with excitation from permanent magnets.*
6	*Lecture 6. Algorithms for vector control of synchronous jet engines.*
7	*Topic 1.3. Robustness of typical vector control systems. Adaptive and robust control. Lecture 7. Robustness of vector control algorithms for induction motors.*

8	Lecture 8. Adaptive algorithms for vector control of AC motors.
9	Lecture 9. Self-commissioning in vector control systems for AC motors.
10	Topic 2.1. The concept of rapid prototype testing. Methodology of experimental research.
11	Topic 2.2. Experimental installations for the study of control algorithms for AC motors.
12	Topic 2.3. Experimental determination of parameters of AC motors.
13	Topic 2.4. Problems of using pulse-width modulation in electromechanical systems.
14	Topic 2.5. Inverter dead time problem in standalone voltage inverters. Dead time compensation algorithms.
15	Topic 2.6. The latest electromechanical converters and semiconductor devices for electromechanical systems.
16	Topic 2.7. Features of the hearth of the signal measurement system from current and voltage sensors.
17	Topic 2.8. Methods of digital signal processing in electromechanical systems.
18	Topic 2.9. Features of practical implementation of vector control algorithms for AC motors on digital signal processors.

Practical training

№ s / n	The name of the topic of the lesson and a list of main questions
1	Decrease in order of mathematical models of electromechanical converters of alternating current.
2	Synthesis and study of an adaptive observer of the rotor flux coupling vector module.
3	Synthesis and study of an adaptive observer of the angular velocity of an induction motor.
4	Synthesis and research of an adaptive observer of a three-phase network voltage vector.
5	Investigation of robustness of indirect vector control algorithms for induction motors.
6	Investigation of robustness of observers of the modulus of flow coupling vector.
7	Investigation of robustness of direct vector control algorithms for induction motors.
8	Research of vector control algorithms for synchronous motor with permanent magnets.
9	Research of synchronous jet engine control algorithms.
10	Investigation of the frequency control system of an induction motor on an experimental setup.
11	Investigation of the system of indirect vector control of an induction motor on an experimental setup.
12	Investigation of observers of rotor flux coupling vector on experimental setup.
13	Investigation of vector control algorithms for a synchronous motor with permanent magnets on an experimental setup.
14	Investigation of asynchronous motor control processes in the presence of dead time of the inverter.
15	Research of current and voltage measurement processes.
16	Practical implementation of a real-time cycle on a digital signal processor for the implementation of control algorithms.
17	Practical implementation of pulse-width modulation on a digital signal processor.
18	Practical implementation of the frequency control system on a digital signal processor.

Calculation and graphic work

Students perform calculation and graphic work, which includes the implementation of the following points:

1. *Synthesis of the observer (flux coupling, speed, voltage) with the properties of adaptation or robustness.*
2. *Proof of the stability properties of the synthesized observer.*
3. *Research of the observer by the method of mathematical modeling.*
4. *Practical implementation of the synthesized observer on a digital signal processor.*
5. *Experimental studies of the synthesized observer.*

6. Independent work of student

№з / п	*Type of independent work*	*Number hours of CPC*
1	*Preparation for classroom classes*	*108*
2	*Preparation for MCR*	*10*
3	*Execution of RGR*	*20*
4	*Exam preparation*	*15*

6. Tests

The purpose of tests is to consolidate and test theoretical knowledge of the credit module, students gain practical skills for solving problems. Conducting MCR requires a student to have a personal computer to enable research by mathematical modeling.

One modular control work (MCR) is carried out. The main options of tasks.

1. *To synthesize an observer of the rotor flux coupling vector adaptive to the active resistance of the rotor.*
2. *Synthesize an adaptive angular velocity observer.*
3. *Synthesize an adaptive observer of the voltage vector of a three-phase network.*
4. *Gearless control of the DC motor.*
5. *Develop software for the implementation of the algorithm for vector control of the angular velocity of an induction motor.*
6. *Investigate the robustness of the vector control system of the angular speed of an induction motor.*
7. *Investigate the robustness of the vector torque control system of an induction motor.*

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 estimated 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 persons 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 the discipline "Scientific interdisciplinary research of electromechanical systems";*
- *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, work in practical classes, implementation and protection of RGR.*

Calendar control*: conducted twice a semester as a monitoring of the current state of compliance with the requirements of the syllabus.*

Semester control: *examination.*

Conditions of admission to semester control*: semester rating more than 30 points.*

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

Scores	*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*

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

- *answers during express surveys at lectures;*
- *work in practical classes;*
- *performance of modular control work (MCR);*
- *implementation and protection of RGR.*

Express survey	*Work on practical classes*	*RGR*	*MCR*
18	*18*	*14*	*10*

Answers during express surveys at lectures

*Weight point 1. The maximum number of points in all lectures - 1 point * 18 = 18 points.*

Evaluation criteria

- *correct answers to some questions from the place - 1 point;*
- *partially correct answer - 0.5 points;*

- *wrong answer - 0 points;*

Work on practical classes

*Weight score -1. The maximum number of points in all classes - 1 point * 18 = 18 points.*

Evaluation criteria

- *independent problem solving, free possession of the topic of lesson -1;*
- *problem solving with the help of a teacher, possession of separate sections of the lesson topic - 0.5;*
- *unsatisfactory work in class - 0.*

Modular control work

Weight score MKR - 10.

The maximum score for MCR is 28.

Evaluation criteria

- *complete answer to the question (more than 90% of the material) 8 - 10 points;*
- *incomplete answer to the question (from 50 to 90% of the material) - 5 - 7 points;*
- *the answer contains less than 50% of the required information - 0 points;*

Calendar control is based on the current rating. The condition of positive attestation is the value of the current student rating not less than 50% of the maximum possible at the time of attestation.

Calculation and graphic work

RGR weight score - 14.

The maximum number of points for RGR - 14.

Evaluation criteria

execution and design

- *the results of the research are correct and properly designed - 8 points;*
- *questionable research results and / or poor design 3 - 7 points;*
- *incorrect research results - 0 points.*

protection of RGR

in defense of the student are asked three questions, the correct answer to each of which is evaluated in 2 two points.

The form of semester control is an exam

The maximum amount of points is 100. A necessary condition for admission to the exam is a complete syllabus of lectures, completed and defended RGR.

Exam work consists of two theoretical questions, one of which can be replaced by a problem.

Credit evaluation criteria

- "excellent", complete answer, not less than 95% of the required information (complete, error-free solution of the problem) - 38 - 40 points;

- "very good", a fairly complete answer, at least 85% of the required information or minor inaccuracies (complete solution of the problem with minor inaccuracies) - 34-37 points;

- "good", a fairly complete answer, at least 75% of the required information or minor inaccuracies (complete solution of the problem with minor inaccuracies) - 30-33 points;

- "satisfactory", incomplete answer, not less than 65% of the required information and some errors (the task is performed with certain shortcomings) - 26-29 points;

- "enough", incomplete answer, but not less than 60% of the required information and some errors (the task is performed with certain shortcomings) - 24 - 25 points;

- "unsatisfactory", the answer does not meet the conditions for "satisfactory" - 0 points.

9. Additional information on the discipline (educational component)

Certificates of distance or online courses on the subject can be credited subject to compliance with the requirements set out in Order № 7-177 of 01.10.2020 On approval of the provisions on recognition in the KPI. Igor Sikorsky learning outcomes acquired in non-formal / informal education

Work program of the discipline (syllabus):

FoldedprofessorDepartment of Automation of Electromechanical Systems and Electric Drive FEA Doctor of Technical Sciences, Sergei Peresada ; Associate Professor of Automation of Electromechanical Systems and Electric Drive FEA, Doctor of Technical Sciences Serhii Kovbasa

ApprovedDepartment of Automation of Electromechanical Systems and Electric Drive FEA (protocol № 12 dated 30.06.2021)

Agreed Methodical commission of the faculty[1] (Minutes № __ of _____)

[1]Methodical council of the university - for general university disciplines.