National Technical University of Ukraine
gor Sikorsky Kyiv Polytechnic Institute "

Department of Electromechanical Systems Automation and Electrical Drives

Control Of Energy Conversion In Renewable Sources And Electric Vehicles

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	*Discipline of professional practical training, mandatory*
Form of education	*Daytime*
Year of training, semester	*4th year, spring semester*
Scope of the discipline	*36 hours of lectures / 18 laboratory works / 4 ECTS credits*
Semester control/ control measures	*Exam*
Class schedule	*http://rozklad.kpi.ua*
Language of teaching	*Ukrainian*
Information about the course leader / teachers	Lecturer: *Ph.D., Assoc. Mykola Vasyliovych PUSHKAR, 0675088258*
Placement of the course	

Program of educational discipline

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

The program of the educational discipline "Control Of Energy Conversion In Renewable Sources And Electric Vehicles" was compiled in accordance with the educational program "Electromechanical systems of automation, electric drive and electric mobility" of bachelor's training in specialty 141 - Electric power, electrical engineering and electromechanics.

The purpose of the educational discipline *is to study the basics of the theory and principles of electromechanical energy conversion in renewable energy sources and electric transport and the technical implementation of semiconductor converters intended for work with renewable energy sources, electric transport and charging installations. As well as the issue of protecting such systems from the effects of weather conditions (moisture, lightning, temperature).*

The content of *the credit module includes theoretical information on the principle of electromechanical energy conversion in renewable sources, electric vehicles and chemical energy sources, a description of the designs and technological schemes of the main types of*

semiconductor converters used for this, as well as the features of the operation of these devices and their application in real conditions and at enterprises.

***The subject of the academic discipline** is advanced technologies in electromechanical systems and electric drives, which include modern and engineering developments in the field of semiconductor and conversion technology in electric transport and renewable energy sources and energy storage systems, including methods of selecting equipment and designing such electromechanical systems.*

Program learning outcomes:

PR04. Know the principles of bioenergy, wind energy, hydropower and solar energy installations.
PR06. Apply application software, microcontrollers and microprocessor technology to solve practical problems in professional activities. PR07. To carry out the analysis of processes in electric power, electrotechnical and electromechanical equipment, relevant complexes and systems.
PR08. Choose and apply suitable methods for the analysis and synthesis of electromechanical and electric power systems with specified indicators.
PR09. To be able to evaluate the energy efficiency and reliability of electric power, electrotechnical and electromechanical systems.
PR16. Know the requirements of regulatory acts related to engineering, intellectual property protection, occupational health and safety, safety and industrial sanitation, take them into account when making decisions.
PR20. Know and understand the principles of control of linear, non-linear and discrete automatic control systems; mathematical methods in electromechanics.
PR23. Be able to apply the laws of algebra-logic, code conversion, Carnot maps, the basis of transition tables, graph transitions, cyclograms and multiplexers-selectors for the synthesis of logic control schemes for automation systems
PR26. Know and understand the laws of transformation of structural diagrams, typical control laws, methods of studying the stability of linear automatic control systems; typical libraries of Simulink blocks, basics of programming in M-files.
PR27. To 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.

Professional competences:

K05. Ability to search, process and analyze information from various sources.
K06. Ability to identify, pose and solve problems.
K07. Ability to work in a team. K08. Ability to work autonomously.
K09. The ability to realize one's rights and responsibilities as a member of society, to realize the values of a civil (free democratic) society and the need for its sustainable development, the rule of law, the rights and freedoms of a person and a citizen in Ukraine.
K10. The ability to preserve and multiply moral, cultural, scientific values and achievements of society based on an understanding of the history and patterns of development of the subject area, its place in the general system of knowledge about nature and society and in the development of society, technology and technologies, to use various types and forms of motor activity for active recreation and leading a healthy lifestyle. Professional competences (FC)
K16. The ability to solve complex specialized tasks and practical problems related to the problems of production, transmission and distribution of electric energy.
K20. Awareness of the need to constantly expand one's own knowledge of new technologies in electric power, electrical engineering and electromechanics.
K23. Ability to use modeling software packages for analysis, synthesis and research of electromechanical automation systems and electric drives.

K26. The ability to solve complex problems related to the control of automated electric drives of various technological applications with electric drives of direct current and alternating current.
K27. Ability to solve complex practical problems related to energy conversion in renewable sources and electric transport

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, a student must have basic knowledge of the theory of structural materials, electric machines and devices, theoretical electrical engineering, theory of automatic control, theory of electric drive, control of electric drives. Competences, knowledge and skills obtained in the process of studying the credit module enable students and future specialists to independently solve complex practical problems related to the transformation of energy in renewable sources and electric transport.

3. Content of the academic discipline

The discipline is structurally divided into 2 ***sections*** *, namely:*

Chapter 1 THEORETICAL BASICS OF ELECTROMECHANICAL ENERGY CONVERSION IN RENEWABLE SOURCES AND ELECTRIC VEHICLES

Topic 1 Renewable and alternative energy sources.
Topic 2 Conversion of solar energy into electrical energy. Solar energy.
Topic 3. Solar charging stations for charging electric cars.
Topic 4. Wind energy. The main types of generators for wind energy installations.
Topic 5. Systems of storage and accumulation of electrical energy.
Topic 6. Chemical current sources and supercapacitors.
Topic 7. High-voltage traction battery and traction battery parameters
Types of rechargeable batteries.
Topic 8 Charging systems for automobile electric transport. Modes and types of electric vehicle charging. Standards for charging stations
Topic 9 Lightning protection of solar power plants and charging stations for electric vehicles Classification and level of lightning protection of objects. Effect of lightning discharge on industrial objects. Structural elements of lightning conductors and the concept of the protection zone

Chapter 2 MODERN PROCESSING TECHNIQUES FOR RENEWABLE SOURCES AND ELECTRIC VEHICLES

Topic 10 Power converters for production, storage and transmission to the local or general electrical network of energy from renewable sources.
Topic 11 Power semiconductor converters in solar power plants.
Topic 12 Power semiconductor converters in wind generators.
Topic 13 Power generation systems based on a dual power machine.
Topic 14 Application of power semiconductor converters in networks with distributed energy sources (Micro-Grid).
Topic 15 Ensuring the quality of electricity with the help of power converters in renewable energy sources and electric vehicles.
Topic 16 Power semiconductor converters in electric vehicles.
Topic 17 Wireless chargers.

4. Educational materials and resources

Main information resources:

1. *Renewable energy sources / In general. ed. S.O. Curls Kyiv: Institute of Renewable Energy of the National Academy of Sciences, 2020, 392 p.*
2. *Basics of wind energy: a textbook / H. Pivniak, F. Shkrabets, N. Neuberger, D. Tsyplenkov; Ministry of Education and Science of Ukraine, National mountain Univ. - D.: NSU, 2015. 335 p.*
3. *Power generation complexes with the functions of reactive power compensation and active filtering based on a double power machine. Monograph / Shapoval I.A., Mikhalskyi V.M., Artemenko M.Yu., Polishchuk S.Y., Chopyk V.V. Kyiv, Institute of Electrodynamics of the National Academy of Sciences of Ukraine, 2020, 241 p.*
4. *Autonomous converters and frequency converters: training. manual / M.M. Kazachkovsky; Ministry of Education and Science of Ukraine, National mountain Univ. - Electron. text. data. - 2nd ed., ed. and added -Dnipro.: NSU, 2017, 324 p.*
5. *Power electronics: study guide / O.O. Shavyolkin, K.: KNUTD, 2017, 396 p.*
6. *Islam, Md Rabiul. Emerging Power Converters for Renewable Energy and Electric Vehicles: Modeling, Design, and Control. CRC Press, London 2021, 419 p.*
7. *Reliability of Power Electronics Converters for Solar Photovoltaic Applications, Edited by Ahteshamul Haque, Frede Blaabjerg, Huai Wang, Yongheng Yang, Zainul Abdin Jaffery. The Institution of Engineering and Technology, London, 2021, 400 p.*
8. *Remus Teodorescu, Marco Liserre and Pedro Rodríguez. Grid Converters for Photovoltaic and Wind Power Systems. John Wiley & Sons, 2011, 416 p.*
9. *Iqbal Husain. Electric and Hybrid Vehicles Design Fundamentals. CRC Press, London 2021, 498 p.*
10. *Ashok Kumar L., Albert Alexander S. Power Converters for Electric Vehicles. CRC Press, London 2021, 273 p.*

Supporting literature

1. *Electronic and microprocessor equipment of cars: training. manual / Yu.I. Pindus, R.R. A whirlwind – Ternopil: TNTU, 2016. – 209 p.*
2. *Rashid MH Alternative Energy in Power Electronics. Butterworth-Heinemann, 2014, 378 p.*
3. *Myhalsky V.M. Means of improving the quality of electricity at the input and output of frequency and voltage converters with pulse width modulation. Kyiv, Institute of Electrodynamics of the National Academy of Sciences of Ukraine, 2013, 340 p.*
4. *Hnatov, A. V. Progressive technologies in automobile transport: lecture notes [Electronic resource] / A. V. Hnatov ; Ministry of Education and Science of Ukraine, Kharkiv. national automobil.-dor. Univ. - Kharkiv, 2020. - 185 p.*
5. *Hnatov, A. V. Electric vehicle infrastructure: lecture notes [Electronic resource] / A. V. Hnatov, Sh. V. Argun; Ministry of Education and Science of Ukraine, Kharkiv. national automobil.-dor. Univ. - Kharkiv, 2021. - 142 p.*

Educational content

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

Lecture classes

No s/p	The name of the topic of the lecture and a list of main questions (a list of didactic tools, references to the literature and tasks on the SRS)
1	***Chapter 1 THEORETICAL BASIS OF ELECTROMECHANICAL ENERGY CONVERSION IN RENEWABLE SOURCES AND ELECTRIC VEHICLES*** *Topic 1 Renewable and alternative energy sources*
2	*Topic 2 Conversion of solar energy into electrical energy. Solar energy.*
3	*Topic 3 Solar charging stations for charging electric cars.*
4	*Topic 4 Wind energy. The main types of generators for wind energy installations*
5	*Topic 5 Systems of storage and accumulation of electric energy.*
6	*Topic 6 Chemical current sources and supercapacitors.*
7	*Topic 7 High-voltage traction battery and parameters of traction battery Types of rechargeable batteries.*
8	*Topic 8 Charging systems for automobile electric transport. Modes and types of electric vehicle charging. Standards for charging stations*
9	*Topic 9 Lightning protection of solar power plants and charging stations for electric vehicles Classification and level of lightning protection of objects. Effect of lightning discharge on industrial objects. Structural elements of lightning conductors and the concept of the protection zone*
10	***Chapter 2 MODERN PROCESSING TECHNIQUES FOR RENEWABLE SOURCES AND ELECTRIC VEHICLES*** *Topic 10 Power converters for production, storage and transmission to the local or general electrical network of energy from renewable sources.*
11	*Topic 11 Power semiconductor converters in solar power plants.*
12	*Topic 12 Power semiconductor converters in wind generators.*
13	*Topic 13 Power generation systems based on a dual power machine.*
14	*Topic 14 Application of power semiconductor converters in networks with distributed energy sources (Micro-Grid).*
15	*Topic 15 Ensuring the quality of electricity using power converters in renewable energy sources and electric vehicles.*
16	*Topic 16 Power semiconductor converters in electric vehicles.*
17	*Topic 17 Wireless chargers.*
18	*MODULAR CONTROL WORK*

Laboratory work

No s/p	List of laboratory works
1	***Laboratory work #1. STUDY OF THE WORK OF AN AUTONOMOUS GENERATOR BASED ON A DUAL SUPPLY MACHINE***
2	***Laboratory work #2. STUDY OF OPERATION OF ASYNCHRONOUS GENERATOR ON FUNDAMENTALS OF ASYNCHRONOUS MACHINE WITH SHORT-CIRCUITED ROTOR WITH VECTOR CONTROL***
3	***Laboratory work #3. STUDY OF STATIC CHARACTERISTICS OF AN AUTONOMOUS***

	ASYNCHRONOUS GENERATOR
4	***Laboratory work #4. RESEARCH OF THE DYNAMIC CHARACTERISTICS OF AN AUTONOMOUS ASYNCHRONOUS GENERATOR***

Student's independent work

No. z/p	*Type of independent work*	*Number hours of SRS*
1	*Preparation for classroom classes*	*6*
2	*Preparation for laboratory work*	*11*
2	*Preparation for MKR*	*4*
3	*Preparation for the exam*	*30*
	Together	*51*

Policy and control

6. 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 "Control Of Energy Conversion In Renewable Sources And Electric Vehicles";*
- *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.*

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

Current control *: MKR .*
Calendar control *: carried out twice a semester as a monitoring of the current state of fulfillment of the syllabus requirements.*
Semester control: *exam*

Conditions for admission to the semester control *: a semester rating of more than 25 points, all 4 laboratory works have been worked out and defended, and an essay submitted for a positive evaluation.*

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

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 exam have not been met	*Not allowed*

overall rating *for work in the semester consists of points obtained for:*

1 Performance and protection of laboratory work.

The weighted point is equal to 5. The maximum number of points for all 4 laboratory works is 20 ***.*** *Laboratory work, depending on the type, is performed on a laboratory stand by a team of students or in the form of a demonstration. In any case, the protocol for laboratory works is made in full, one per student!*

Criteria for evaluating laboratory works:

- "excellent" (5 points) - the protocol was prepared without errors, the answers to the questions were clear and meaningful.

- "good" (4 points) - the report is prepared with some inaccuracies, the answers to the questions have minor errors.

- "satisfactory" (3 points) - the protocol is prepared with errors, the answers to the questions are unclear and have significant errors.

- "unsatisfactory" (0 points) - the protocol is prepared with errors, the answers to the questions are incorrect. Laboratory work requires additional practice.

2. Modular control work.

The number of MKR is 1 with a duration of 2 academic hours. The maximum number of points for the MKR is 15. The criterion for evaluating the MKR is as follows:

- "excellent", complete answer (at least 90% of the required information) - 13-15 points;

- "good", a sufficiently complete answer (at least 75% of the required information), or a complete answer with minor inaccuracies - 10-12 points;

- "satisfactory", incomplete answer (at least 60% of the required information) and minor errors - 7-9 points;

- "unsatisfactory", unsatisfactory answer or absence during the work - 0 points.

4. Abstract. *5 weeks are given to complete the essay. After that, the student submits the essay for review, receives points for the design and is admitted to the defense. For each day of late submission of the essay for review, 0.5 points are deducted from the maximum number of points that can be obtained for the essay, but not more than 10 . The abstract is checked for plagiarism, no more than 30% plagiarism is acceptable for admission.*

The maximum number of points per essay is 15. Scoring

- "excellent", completely original work that fully reveals the content of the given topic, and submitted on time - 14-15 points;

- "very good", a work that contains up to 30% plagiarism or borrowing, or discloses the content with minor inaccuracies, or a completely original work, but submitted for review late. – 10-13 points;

- "good", The work has more than 30% borrowings, but contains a complete answer with minor inaccuracies - 7-9 points;

- "satisfactory", the work has more than 30% borrowings, but contains an incomplete answer with significant inaccuracies - 4-6 points;

Form of semester control – Exam

The condition for admission to the exam is that all 4 laboratory works have been worked out and defended, and the essay passed for a positive evaluation and a rating score of not less than 25 points.
At the exam, students perform a written test. Each task contains 2 theoretical questions. The maximum score for the exam is 50. Each theoretical question is valued at 25 points.
The sum of starting points and points for the examination control work is transferred to the examination grade according to the table of correspondence of rating points to grades on the university scale.

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 Igor Sikorskyi of learning outcomes acquired in non-formal/informal education*

Working program of the academic discipline (syllabus):

Compiled by M.V. Pushkar, associate professor of the Department of Automation of Electromechanical Systems and Electric Drives of the FEA.

Approved by the Department of Automation of Electromechanical Systems and Electric Drives of the FEA (protocol No. 15 dated 13.06.2024)

Agreed Agreed by the Methodical Commission of the Faculty of Electrical Power Engineering and Automation (protocol No. 10 dated 06/20/2024)