National Technical University of Ukraine
Igor Sikorsky Kyiv Polytechnic Institute "

Department of
Electromechanical Systems
Automation and Electrical
Drives

CONTROL OF ELECTRIC DRIVES. COURSEWORK

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	*Mandatory*
Form of education	*Daytime*
Year of training, semester	*4th year, autumn semester*
Scope of the discipline	*60 hours / 2 ECTS credits*
Semester control	*Test*
Class schedule	*rozklad.kpi.ua*
Language of teaching	*Ukrainian/English*
Information about the course leader	*Ph.D. Prof. Transfer Serhiy Mykhailovych* *assistant Nikonenko Evgeny Oleksiyovych*
Placement of the course	https://do.ipo.kpi.ua/course/view.php?id=4885

Program of study discipline

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

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

The goal of the educational discipline *is to develop the following abilities in students:*
perform original research, achieve scientific results that create new knowledge in electrical engineering; orally and in writing to present and discuss the results of scientific research and/or innovative developments in Ukrainian and English; identify, pose and solve problems of a research nature in the field of electrical engineering, evaluate and ensure the quality of performed research; the ability to search for information from various sources; ability to apply knowledge in practical situations; the ability to learn and master modern knowledge; the ability to identify and assess risks.

The subject of the educational discipline *is alternating current electromechanical systems based on asynchronous or synchronous electric drives , which include new electromechanical converters, power electronics, methods of control and signal processing, as well as issues of modern scientific research in the field of alternating current electromechanical systems .*

Competencies: (ZK02) ability to apply knowledge in practical situations; (ZK03) ability to communicate in the state language both orally and in writing; (ZK05) ability to search, process and

analyze information from various sources; (ZK06) ability to identify, pose and solve problems; (ZK08) ability to work autonomously; (FK01) the ability to solve practical problems using automated design and calculation systems (CAD); (FK02) the ability to solve practical problems involving the methods of mathematics, physics and electrical engineering; (FK05) the ability to solve complex specialized tasks and practical problems related to the operation of electric machines, devices and automated electric drives; (FK07) the ability to develop projects of electric power, electrotechnical and electromechanical equipment in compliance with the requirements of legislation, standards and specifications; (FK09) awareness of the need to increase the efficiency of electric power, electrotechnical and electromechanical equipment; (FC10) awareness of the need to constantly expand one's own knowledge about new technologies in electric power, electrical engineering and electromechanics; (FC12) the ability to use mathematical methods and methods of the theory of automatic control in the study of linear and nonlinear systems, to analyze quality indicators, to synthesize regulators, to compile and analyze structural diagrams of automatic control systems; (FC13) ability to use simulation software packages for analysis, synthesis and research of electromechanical automation systems and electric drives; (FC15) the ability to perform calculations of the mechanical part of the electric drive, mechanical transient processes, calculate the parameters of direct and alternating current 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.

Ability: (PRN03) to 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 activities; (PRN06) apply application software, microcontrollers and microprocessor technology to solve practical problems in professional activities; (PRN07) to 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; (PRN09) to be able to evaluate the energy efficiency and reliability of electric power, electrotechnical and electromechanical systems; (PRN10) Find the necessary information in scientific and technical literature, databases and other sources of information, evaluate its relevance and reliability; (PRN11) communicate freely about professional problems in national and foreign languages orally and in writing, discuss the results of professional activity with specialists and non-specialists, argue their position on debatable issues; (PRN17) solve complex specialized problems in the design and maintenance of electromechanical systems, electrical equipment of power stations, substations, systems and networks; (PRN18) to be able to learn independently, acquire new knowledge and improve the skills of working with modern equipment, measuring equipment and application software; (PRN19) apply suitable empirical and theoretical methods to reduce losses of electrical energy during its production, transportation, distribution and use ; (PRN20) to know and understand the principles of control of linear, non-linear and discrete automatic control systems; (PRN22) to know and understand the basics of coordinate transformation and the principles of frequency and vector control of electromechanical systems; (PRN25) to know ways to improve the efficiency of algorithms for controlling electric drives, electromechanical systems, the basics of electromobility theory ; (PRN26) to know and understand the laws of transformation of structural schemes, typical control laws, methods of studying the stability of linear automatic control systems; typical libraries of Simulink blocks , basics of programming in M-files; (PRN27) to know the equation of motion of the 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) to 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)

For the successful implementation of the project, the student must complete training in the educational components "Higher mathematics", "General physics", "Theoretical foundations of electrical engineering", "Theory of automatic control", "Electric machines", "Electric drive", "Automated electric drive" of the first (undergraduate) level, since the methods and approaches to the development and control of alternating current electromechanical systems are based on the main provisions of these disciplines.
Competences, knowledge and skills acquired in the process of completing the course project are necessary for further completion of pre-diploma practice and successful writing of the bachelor's diploma project.

3. Content of the academic discipline

The discipline "Course project on control of electric drives " consists of the following stages :

1. *Obtaining a topic and task for a course project. Formulation of the task for the course project and its detailing .*
2. *Calculation of nominal mode parameters and engine replacement scheme.*
3. *Design of classical and robust AD/SDPM speed vector control systems. Development of structural schemes of control algorithms AD/SDPM.*
4. *Practical implementation of the AD/SDPM vector control system: development of the functional scheme of the electric drive, determination of the purpose of its main elements, calculation and selection of equipment.*
5. *Study of dynamic and static characteristics of designed systems. Study of robustness properties in AD/SDPM speed control systems. Research of energy characteristics of vector control systems.*
6. *Performance of an individual task.*
7. *Designing a course project. Submission of a course project for review.*
8. *Protection of course project.*

4. Educational materials and resources

1. *Zahirnyak M.V., Klepikov V.B., Kovbasa S.M., Mikhalskyi V.M., Peresada S.M., Sadovoy O.V., Shapoval I.A. Energy-efficient electromechanical systems of a wide technological purpose. Kyiv: NAS of Ukraine, 2018. 310 p.*
2. *A. Emadi Handbook of Automotive Power Electronics and Motor Drives. – CRC Press. 2005. – 668p.*
3. *Electric drive theory / Edited by M.G. Popovicha. - K.: V ischa shkola, 1993.-494 p.*
4. *Methods of robust adaptive control of electromechanical systems with increased dynamic and energy indicators : a report on the NDR. NTUU "KPY". No. DP 0115U000381. Kyiv, 2017. 506 p.*
5. *M. Ehsani, Y. Gao, S. Longo, KM Ebrahimi Modern Electric, Hybrid Electric, and Fuel Cell Vehicles. Third edition. - CRC Press, 2018, -573p.*
6. *Development of an energy-efficient electromechanical system of an electric bus based on an adaptive vector-controlled asynchronous electric drive with a battery-supercapacitor power supply: a report on NDR / NTUU "KPY". No. DP 0117U004284. Kyiv, 2018. Volume 1. 472 p.*
7. *S.-K. Sul, Control of electric machine drive systems. John Wiley & Sons, 2011.*

8. *K. Dąbała, MP Kazmierkowski, Converter-Fed Electric Vehicle (Car) Drives–A Critical Review // Przeglad Elektrotechniczny , 2019, vol. 95, no. 9, 12 p.*
9. *DSTU 8302:2015. Bibliographic reference. General provisions and rules of drafting. Kyiv, 2016. 16 p.*
10. *Order of the Ministry of Education, Culture, Sports and Science of Ukraine "On Approval of Requirements for Dissertations" dated January 12, 2017 No. 40.*

Educational content

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

Each student is given a technical assignment to design and research an electromechanical alternating current system with a pre-selected mechanism.

In the course project implementation process, students must:

1. *Choose a motor (asynchronous (AD) or synchronous (SDPM)), calculate its nominal mode and calculate the parameters of the L-shaped substitution scheme.*
2. *To develop a system of vector speed control AD/SDPM.*
3. *Modify the management system with additional robustifying connections.*
4. *Develop two structural diagrams for control algorithms at the speed of AD/SDPM.*
5. *Determine the purpose of all the main elements of the functional scheme, calculate and select each element of equipment.*
6. *Develop a functional diagram of the electric drive, which includes the motor and a detailed diagram of the electric drive.*
7. *Conduct research using mathematical modeling of dynamic and static characteristics of designed systems.*
8. *To investigate the properties of robustness in AD/SDPM speed control systems to the variation of the active resistance of the rotor/stator circuit.*
9. *Investigate the energy characteristics of vector control systems depending on the value of the variation of the specified parameters.*
10. *Complete an individual task.*

6. Student's independent work

Semester week	*Type of independent work*	*Number hours of SRS*
1	*Obtaining the topic and task for the course project. Formulation of the task for the course project and its detailing.*	*1*
2	*1. Calculation of nominal mode parameters and engine replacement scheme. Design of classical and robust AD/SDPM speed vector control systems. Development of structural schemes of control algorithms at the speed of AD/SDPM.*	*6*
4	*2. Practical implementation of the AD/SDPM vector control system: development of the functional scheme of the electromechanical system, determination of the purpose of its main elements, calculation and selection of equipment.*	*14*
6	*3. Study of dynamic and static characteristics of designed systems. Study of robustness properties in AD/SDPM speed control systems.*	*14*
7	*4. Research of energy characteristics of vector control systems.*	*7*

8	*5. Performance of an individual task.*	*8*
10	*Designing a course project.*	*10*
12	*Submission of the course project for review and defense.*	*2*

Policy and control

7. Policy of academic discipline (educational component)

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

- *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 "Course project on electric drive control";*
- *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, be polite and limit communication to the working hours of the teacher;*
- *students are required to attend consultations on the discipline "Course Project on Controlling Electric Drives";*
- *students are obliged to regularly view messages in the moodle course / Google class, and/or the common Telegram channel, and also respond promptly to them;*
- *in the case of distance education, students must timely download the sections of the course project of the message in the moodle course / Google class for verification.*

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

- ***Current control** : implementation and protection of points of the course project.*
- ***Calendar control** : is carried out twice a semester as a monitoring of the progress of the course project.*
- ***Semester control** : credit.*
- *Conditions **for admission to semester control** : a fully completed course project.*

The course project rating has two components.
The first (starting) characterizes the student's work on course design and its result - the quality of the explanatory note and graphic material.
The second component characterizes the quality of the student's defense of the course project.
The scale of the starting component is 60 points, and the defense component is 40 points.
The calendar plan for the implementation of the sections of the course project and the variant is issued to students in the first week and is signed by the student and the teacher. Signed calendar plans are uploaded to the appropriate section of Moodle
At consultations according to the calendar plan:
- the presence of a completed section is checked;
- the correctness of the applied methods, calculations, etc. is analyzed;
- the modernity of the decisions made.

1. *Starting ingredient:*

1.1. Calculation of nominal mode parameters and engine replacement scheme. Design of classical and robust AD/SDPM speed vector control systems. Development of structural diagrams of AD/SDPM speed control algorithms. - max . 5 points:

- *correct choice of the engine, correct calculation of its parameters (SDPM) - 1.5 points;*
- *correct choice of engine, partially correct calculation of parameters (SDPM) - 0.9 points;*
- *incorrect engine selection (SDPM) – 0 points;*

- *correct calculation of the parameters of the nominal mode and the parameters of the engine replacement scheme (AD) - 1.5 points;*
- *partially correct calculation of the parameters of the nominal mode and/or the parameters of the engine replacement scheme (AD) - 0.9 points;*
- *incorrect calculation of the parameters of the nominal mode and the parameters of the engine replacement scheme (AD) - 0 points;*

- *the developed structural schemes of AD speed control (standard and robust algorithm)/SDPM correspond to the option, are completely correct - 1.5 points;*
- *the developed structural schemes of speed control correspond to the variant, but have errors - 0.9 points;*
- *inconsistency of the developed structural schemes for controlling the speed of AD/SDPM option - 0 points;*

- the section was completed on time - 2 points;
- the section is completed no more than 1 week late - 1 point;
- the section was completed more than 1 week late - 0.5 points;
- the section was completed more than 1 month late - 0 points;

1.2. Practical implementation of the AD/SDPM vector control system: development of the functional scheme of the electromechanical system, determination of the purpose of its main elements, calculation and selection of equipment. - max . 10 points

- *the developed functional scheme of the electric drive corresponds to the variant, contains all the necessary functional blocks and is designed in accordance with the requirements of DSTU - 3.0 points;*
- *the developed functional scheme of the electric drive corresponds to the variant, designed in accordance with the requirements of DSTU, but does not contain all functional blocks - 1 , 8 points ;*
- *the developed functional scheme of the electric drive does not meet the option or the requirements of DSTU - 0 points;*

- *correct calculation of the main parameters of the converter, correct selection of all its elements, reasonableness of the choice of equipment - 3.0 points;*
- *correct calculation of the main parameters of the converter and partially correct selection of all its elements or partially incorrect justification of the choice of equipment - 2.5 points;*
- *partially correct calculation of the main parameters of the converter and partially correct selection of all its elements or partially correct justification of the choice of equipment - 1.8-2.2 points;*
- *partially correct calculation of the main parameters of the converter and incorrect selection of all its elements or incorrect justification of the choice of equipment - 1.8-2.2 points;*
- *incorrect calculation of the main parameters of the converter - 0 points;*

- the section was completed on time - 4 points;
- the section was completed no more than 1 week late - 3 points;

- the section was completed more than 1 week late - 2 points;
- the section was completed more than 1 month late - 0 points;

1.3. Study of dynamic and static characteristics of designed systems. Study of robustness properties in AD/SDPM speed control systems. - max . 18 points (8 b according to the table + 3 b design of graphic material + 7 b timely execution)

Evaluation criterion	*Compliance with the criterion*								
Version	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*0*
Physical limitations of EP	*1*	*1*	*1*	*1*	*0*	*0*	*0*	*0*	
Full volume	*1*	*1*	*0*	*0*	*1*	*1*	*0*	*0*	
Description quality	*1*	*0*	*1*	*0*	*1*	*0*	*1*	*0*	
Number of points	*8*	*7.5-7*	*6.5-6*	*5.5-5*	*4.5-4*	*3.5-2*	*1.5-1*	*1*	*0*

Abbreviations are used in the table: "Variant" - the conducted studies correspond to the student's variant; "Full scope" - the research was carried out in full; "Physical limitations of the EP" - studies correspond to the physical limitations of the electric drive; "Description quality" - each stage of the research is sufficiently well described, has justification and a comprehensive analysis of the results. Compliance with the criteria is evaluated as complete - "1" and incomplete/partial/lack of compliance - "0", depending on the completeness of which the final grade is assigned among the range of points.
Points for design of graphic material:

- *the material is designed with high quality according to the requirements - 3 points;*
- *the material is designed qualitatively with minor errors - 1.8 -2.5 points;*
- *the material is poorly designed - 0 points;*

- the section was completed on time - 7 points;
- the section was completed no more than 1 week late - 6 points;
- the section was completed more than 1 week late - 4-5 points;
- the section was completed more than 1 month late - 0 points;

1.4. Research of energy characteristics of vector control systems. - max . 7 points (4.5 b according to the table + 0.5 b design of graphic material + 2 b timely execution) (the description of the criteria is similar to item 3)

Evaluation criterion	*Compliance with the criterion*				
Version	*1*	*1*	*1*	*1*	*0*
Physical limitations of EP	*1*	*1*	*0*	*0*	
Description quality	*1*	*0*	*1*	*0*	
Number of points	*4.5*	*4.0-3.5*	*3.0-2.0*	*1.5-0.5*	*0*

Points for design of graphic material:

- *the material is designed with high quality according to the requirements - 0.5 points;*
- *the material is designed qualitatively with minor errors - 0.3 points ;*
- *the material is poorly designed - 0 points;*

- the section was completed on time - 2 points;
- the section is completed no more than 1 week late - 1 point;
- the section was completed more than 1 week late - 0.5 point;
- the section was completed more than 1 month late - 0 points;

1.5. Performance of an individual task - max . 10 points (6 b according to the table + 1 b design of graphic material + 3 b timely execution) (the description of the criteria is similar to item 3)

Evaluation criterion	*Compliance with the criterion*				
Version	*1*	*1*	*1*	*1*	*0*
Physical limitations of EP	*1*	*1*	*0*	*0*	
Description quality	*1*	*0*	*1*	*0*	
Number of points	*6*	*5.5-4.5*	*4.0-3.0*	*2.5-1.0*	*0*

Points for design of graphic material:

- *the material is designed with high quality according to the requirements - 1 point;*
- *the material is designed qualitatively with minor errors - 0.6 points ;*
- *the material is poorly designed - 0 points;*

- the section was completed on time - 3 points;
- the section was completed no more than 1 week late - 2 points;
- the section was completed more than 1 week late - 1-0.5 points;
- the section was completed more than 1 month late - 0 points;

1.6. Submission of the final version of the course project for review - max . 10 points:
- the course project is designed with high quality in compliance with the requirements for the design of technical documentation, the diagrams are made according to ANSI requirements and do not contain flaws, graphic materials are made in compliance with the requirements - 9-10 points;
- the course project is designed with high quality in compliance with the requirements for the design of technical documentation, but it contains minor remarks, the diagrams are made according to ANSI requirements and contain minor defects or graphic materials contain defects - 6.5-8 points;
- the course project is designed mainly in compliance with the requirements for the design of technical documentation, contains comments, diagrams are made mainly according to ANSI requirements and contains shortcomings, or graphic materials are made mainly according to the requirements and contain errors - 6 points;
- the course project is designed with significant flaws, contains comments, diagrams are not made according to ANSI requirements or graphic materials are not made according to requirements - it is returned for revision and is evaluated at 0 points

2. The component of the defense of the course project.
2 theoretical and 2 practical questions are submitted for defense, each of which is valued at 10 points.
2.1. The degree of mastery of the theoretical material (2 theoretical questions based on the materials of the course project) - max . 10 points each:
- "excellent", complete answer (at least 90% of the required information) - 9-10 points;
- "good", a sufficiently complete answer (at least 75% of the required information), or a complete answer with minor inaccuracies - 7-8 points;
- "satisfactory", incomplete answer (at least 60% of the required information) and minor errors - 6 points;
- "unsatisfactory", unsatisfactory answer (does not meet the requirements for 4 points) - 0 points.
2.2. The degree of mastery of practical skills (demonstration of the program, the ability to determine the correspondence of a fragment of the algorithm with the program, to explain the applied theoretical and technical solutions) - max . 10 points each:
- "excellent", complete error-free solution of the task - 10 points;
- "good", complete solution of the task with insignificant inaccuracies - 7-9 points;

- "satisfactory", the task was completed with certain shortcomings - 6 points;
- "unsatisfactory", task not completed - 0 points.

3. Additional (bonus) points

The rating system provides additional points for innovative ideas and methods of solving the tasks of individual sections of the coursework. One student cannot receive more than 10 bonus points in a semester. The amount of additional points is determined separately for each student depending on the level of innovation.

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
Less than 30	Not allowed

9. Additional information on the discipline (educational component)

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 the assistant of the Department of Automation of Electromechanical Systems and Electric Drives of the FEA, Nikonenko E.O.

Approved by the Department of Automation of Electromechanical Systems and Electric Drives of the FEA (Protocol No. 15 dated June 13, 2024).

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