National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute"

Automation of electrical and mechatronic complexes

SYSTEMS FOR AUTOMATING ENGINEERING CALCULATIONS OF ELECTRIC DRIVE

Work program of the discipline (Syllabus)

Details of the discipline	
Level of higher education	***Second (Master degree)***
Field of knowledge	*G Engineering, Manufacturing and Construction*
Specialty	*G3 Electrical Engineering*
Educational program	*Engineering of intellectual electrotechnical and mechatronic complexes*
Discipline status	*Elective*
Form of study	*Full-time (daytime)/full-time (evening)/part-time/remote/mixed*
Year of preparation, semester	*2 year, spring semester*
Scope of discipline	*4 credits 120 hours (30 lectures, 14 practices, MCW)*
Semester control / control measures	*Final test/ practice works, MCW*
Timetable	*http://schedule.kpi.ua/*
Language of instruction	*English*
Information about Course Leader / Instructors	Lecturer*: Ph.D., Associate Professor, Anton V. Toropov, tel. +38 066-736-54-53, email: toropovtosha@ukr.net* Practical / Seminar: *Ph.D., Associate Professor, Anton V. Toropov, tel. +38 066-736-54-53, email: toropovtosha@ukr.net*
Course Placement	https://classroom.google.com/c/ODQyMDI3ODkzMzk4?cjc=drty4jpx

The program of the discipline

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

The discipline acquaints students with the software and means of constructing electromechanical systems of alternating current by methods that are based on the theory of electric drive and the principles of building control systems for electric drives.

The purpose of studying the discipline is to get acquainted with the state and prospects of the development of modern computer systems for the design of electromechanical systems using the bases of modern inverter devices from leading manufacturers of electric drives. Much attention is paid to the peculiarities of the implementation of the design procedure using the Drive Solution Designer (CAE system) software from Lenze company.

The subject of the discipline is systems of engineering design of electromechanical systems and electrotechnical complexes.

Competencies: (FC1) Ability to solve practical problems using computer-aided design and calculation (CAD) systems; (FC5) Ability to solve complex specialized tasks and practical problems related to the operation of electrical machines, apparatus and automated electric drive.

Skills: (PRN6) Apply application software, microcontrollers and microprocessor technology to solve practical problems in professional activities; (PRN7) Analyze processes in electric power, electrical

and electromechanical equipment, relevant complexes and systems; (PRN17) Be able to solve complex specialized problems in the design and maintenance of electromechanical systems, electrical equipment of power plants, substations, systems and networks; (PRN21). To use, calculate and investigate digital and non-linear process controllers using modern electrical equipment.

2. Prerequisites and post-requisites of the discipline (place in the structural and logical scheme of training in the relevant educational program)

The academic discipline "Systems for automating engineering calculations of electric drive" is taught on the basis of knowledge and skills gained by students during the study of credit modules of such disciplines as "Fundamentals of electromechatronics", "Electric drive", "Theoretical mechanics", "Electrical machines", etc.

The knowledge and skills gained in the process of studying the credit module " Systems for automating engineering calculations of electric drive" are necessary for every specialist of this specialty who solve engineering problems in the field of automation of electrical engineering and mechatronics.

3. The content of the discipline

The discipline " Systems for automating engineering calculations of electric drive" consists of 5 chapters:

- **Chapter 1. CAE systems of electric drive tasks.**

Topic 1.1. General concepts of computer-aided engineering systems.

Topic 1.2. Design of electric drives for pumps and fans.

- **Chapter 2. Design of electric drive systems with soft starters**

Topic 2.1. Methods of starting of induction motors.

Topic 2.2. Methods of braking of induction motors.

- **Chapter 3. Design of electric vertical lift drives:**

Topic 2.1. Differences between counterweight and non-counterweight systems in terms of electric drive modes.

Topic 2.2. Design of a hoisting system with angular or linear velocity stabilization.

Topic 2.3. Tachogram of hoisting mechanisms.

- **Chapter 4. Selection of parameters of the elements of the electric drive system**

Topic 3.1. Selection of the type of motor, gearbox, frequency inverter.

Topic 3.2. Frequency inverter safety modules.

- **Chapter 5. Selection of additional elements of the electric drive system**

Topic 4.1. Selection of braking devices, filtering devices.

Topic 4.2. Feedback sensors in the electric drive.

4. Training Materials & Resources

Basic literature:

1. Drive Solutions Mechatronics for production and logistics. Edited by E. Kiel. –Berlin: Springer Verlag, 2008. – 542 p.

2. Johan Rees, Magnus Kjellberg and Sören Kling. Soft starter hand book ABB. Available at https://library.e.abb.com/public/6b4e1a3530814df0c12579bb0030e58b/1SFC132060M0201.pdf

3. Induction motors fed by PWM frequency inverters: technical quide. Available at https://esrmotors.com/Literature/WEG/Manuals/WEG-induction-motors-fed-by-pwm-frequency-converters-technical-guide-028-technical-article-english.pdf

4. Holodnyi, I. M., Lavrinenko, Y. M., Kozyrskyi, V. V., Chervinskyi, L. S., Abduramanov, D. A., Toropov, A. V., and Sanchenko, O. V. Regulated electric drive. Kyiv: Komprint Publishing House, 2015. - 509 p. (in Ukrainian)

Supporting Literature:

5. Global drive automation. Engineering inside. Lenze GmbH & Co KG. Available at http://www.lenze.org.ua/pdf/Automation.pdf

6. Adjustable electric drive. Theory. Modeling. Textbook./I.M. Holodnyi, Yu.M. Lavrynenko, M.V. Syniavsky, V.V. Kozyrsky, L.S. Chervinsky, V.M. Reshetnyuk, V.V. Savchenko; Edited by I.M. Hungry. – 2nd ed.- K.Agrarian Media Group. 2012-513p.

Educational content

5. Methods of mastering the discipline (educational component)

Active learning strategies are used, which are determined by the following methods and technologies: problem-based learning methods (research method); student-centered technologies based on such forms and methods of teaching as visualization and information and communication technologies, in particular electronic presentations for lectures. Teaching is carried out in the form of lectures, practical classes. When performing calculation work, the problem-search method is used.

No.	*The content of the educational work*
1-2	**Lecture 1.** Topic 1.1. General concepts of computer-aided design systems. General concepts and definitions of computer-aided engineering systems. **References: [1].** **Lecture 2.** Topic 1.1. General concepts of computer-aided design systems. Electric drive systems of municipal and industrial enterprises are widespread. **References: [2].**
3-4	**Lecture 3.** Topic 5.1. Methods of starting induction motors. Start by changing the voltage. Start by changing the stator current. Start of pumps with an induction motor. Start of synchronous motors. **References: [4].** **Lecture 4.** Topic 5.2. Methods of braking induction motors. AC and DC braking. **References: [3].**
5-6	**Lecture 5.** Topic 1.2. Design of electric drives for pumps and fans. Features of the design of turbo mechanisms. **References: [2].** **Lecture 6.** Topic 2.1. Differences between counterweight and non-counterweight systems in terms of electric drive modes of operation. Choosing a counterweight and its impact. **References: [3].**
7-8	**Lecture 7.** Topic 2.2. Design of a hoisting system with angular or linear velocity stabilization. Design of a hoisting system with angular velocity stabilization. **References: [1].** **Lecture 8.** Topic 2.2. Design of a hoisting system with angular or linear velocity stabilization. Design of a hoisting system with linear velocity stabilization. **References: [3].** **Module test (part 1).**
9-10	**Lecture 9.** Topic 2.3. Tachogram of movements of lifting mechanisms. The difference between simple and complex movement tachograms. **References: [2].** **Lecture 10.** Topic 3.1. Selection of the type of motor, gearbox, frequency inverter. Selection of parameters of the elements of the electric drive system. **References: [3].**
11-12	**Lecture 11.** Topic 3.1. Selection of the type of motor, gearbox, frequency inverter. Selection of the type of installation of frequency inverters, depending on the operating conditions. **References: [4].**

	Lecture 12. Topic 3.2. Frequency inverter safety modules. Basic motion control functions from frequency inverters with safety modules. **References: [1].**
13-14	**Lecture 13.** Topic 4.1. Selection of braking devices, filtering devices. Selection of brake resistors. Choice of brake choppers. **References: [1].** **Lecture 14.** Topic 4.2. Feedback sensors in the electric drive. Functionality of incremental and absolute encoders. **References: [1].**
15	**Lecture 15.** Topic 4.2. Feedback sensors in the electric drive. Speed feedback sensors with Hyperface interface. Feedback sensors in the electric drive. Speed feedback sensors with industry-wide interfaces. Feedback sensors in the electric drive. Speed feedback sensors with SSI interface. **References: [1].** **Module test (part 2).**

Practical classes

Salary No.	***The content of the educational work***
Practical lesson 1.	Calculation of a soft starter with two adjustable phases to start the pump.
Practical lesson 2.	Calculation of a soft starter with three adjustable phases to start the fan.
Practical lesson 3.	Calculation of a soft starter to start the fire pump.
Practical lesson 4.	Calculation of a servo motor for a rotating table.
Practical lesson 5.	Calculation of servo motor for lathe.
Practical lesson 6.	Selection of an electric drive for a conveyor.
Practical lesson 7.	Selection of an electric drive for a rotating table with precise positioning.

6. Student's independent work

Student's independent work involves:
preparation for classroom lessons – 62 hours;
preparation for modular tests – 8 hours;
Preparation for the final test – 6 hours.

Policy & Control

7. Academic discipline policy (educational component)

At the time of each lesson, both lecture and practical, the student must have the Zoom application installed on the device from which he works (in the case of distance learning), as well as open the course "Automation Systems of Engineering Calculations" on the "Google Classroom" platform (the access code to the course is provided at the first lesson according to the schedule). syllabus; lecture material; tasks for each practical lesson; options for modular tests; tests, which need to be completed by lectures; methodical recommendations for the implementation of practical work and calculation and graphic work; Variants of the test are posted on the "Google Classroom" platform and in the "KPI Electronic Campus" system.

During the course " Systems for automating engineering calculations of electric drive", students are required to adhere to the general moral principles and rules of ethical behavior specified in the Code of Honor of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute".

The deadlines for each task are specified in the course "Systems for automating engineering calculations of electric drive " on the Google Classroom platform.

The presence of higher education students in practical classes is mandatory. Classes missed for valid reasons must be worked out.

All students, without exception, are obliged to comply with the requirements of the Regulations on the System for the Prevention of Academic Plagiarism at the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute".

8. Types of control and rating system for assessing learning outcomes (CRO)

Current control: performance of practical tasks (10 points per task), MCW (which have to carried out directly at the lecture, in the presence of the teacher, 30 points). The MCW is divided at two parts and performed in the form of an answer to two theoretical questions from the lecture material of the first half of the semester and at the second part of semester. The student performs the MCW directly at the lecture, 15-20 minutes before its end. At the end of the lesson, the work on the MCW ends and is not subject to rewriting.

Each practical task is evaluated at 10 points according to the following criteria:

– "excellent" – correctly formatted results and formulation of the relevant conclusion (at least 90% of the required information), appropriate justifications provided – 9 – 10 points;

– "good" – correctly formatted results and formulation of the relevant conclusion (at least 75% of the required information), which is made in accordance with the requirements for the level of "skills" or contains minor inaccuracies in the answer – 7-8 points;

– "satisfactory" – contains inaccuracies in the design of the results or formulates an inappropriate conclusion (at least 60% of the required information), made in accordance with the requirements for the "stereotypical" level and contains some errors – 6 points;

– "unsatisfactory" – incorrectly formatted results of the assessment or unsatisfactory answer during the defense – 0 points.

Each part is worth 15 points according to the following criteria:

– "excellent" – complete answers (at least 90% of the required information), appropriate justifications and personal opinion – 13-15 points;

– "good" – a sufficiently complete answer (at least 75% of the required information), which is completed in accordance with the requirements for the level of "skills" or contains minor inaccuracies – - 11-12 points;

– "satisfactory" – an incomplete answer (at least 60% of the required information), made in accordance with the requirements for the "stereotypical" level and containing some errors – 9 – 10 points;

– "unsatisfactory" – unsatisfactory answer – 0 points.

Calendar control: it is carried out twice a semester as a monitoring of the current state of fulfillment of the requirements of the syllabus. The condition for a positive first and second calendar control is to obtain at least 50% of the maximum possible rating at the time of the relevant calendar control.

Semester control: Final test. Conditions for admission to semester control: completed and credited practical tasks and MCW.

Students who have fulfilled all the conditions for admission to the test and have a rating score of 60 or more points receive a grade corresponding to the scored rating without additional tests. The sum of the rating points received by the student during the semester is transferred to the final grade according to the table.

If the sum of points is less than 60, but practical tasks are completed and credited, the student performs a test work. In this case, the sum of points for practical and test work are transferred to the final grade according to the table.

A student who received more than 60 points in the semester, but wants to improve his result, can take part in the test. In this case, the final result consists of the points obtained on the test and the points for practical and MCW.

At the test, students complete a written test.

The test work is estimated at 30 points. The control task of this work consists of three theoretical questions from the list provided in the appendix to the syllabus.

Each part is worth 15 points according to the following criteria:

– "excellent" – complete answers (at least 90% of the required information), appropriate justifications and personal opinion – 26-30 points;

– "good" – a sufficiently complete answer (at least 75% of the required information), which is completed in accordance with the requirements for the level of "skills" or contains minor inaccuracies – - 22-25 points;

– "satisfactory" – an incomplete answer (at least 60% of the required information), made in accordance with the requirements for the "stereotypical" level and containing some errors – 18 – 21 points;

– "unsatisfactory" – unsatisfactory answer – 0 points.

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

Score	Grade
100-95	Excellent
94-85	Very Good
84-75	Good
74-65	Satisfactory
64-60	Pass
Less than 60	Failed
Admission conditions are not met	Not allowed

9. Additional information on the discipline (educational component)

The list of questions that are submitted for semester control is given in the appendix to the syllabus.

A higher education applicant has the opportunity to take an online course(s) on one or more topics provided for by the curriculum of the discipline. The applicant can choose an online course independently or on the recommendation of a teacher. 1 hour of the course is estimated at 0.83 points. The maximum number of hours that can be counted based on the results of non-formal education is 12 hours, respectively, the maximum number of points for such results is 10 points.

Work program of the discipline (syllabus):

Compiled by: Associate Professor of the Department of Automation of Electrical and Mechatronic Complexes, Ph.D., Anton V. Toropov

Approved by the Department of Automation of Electrical and Mechatronic Complexes. Protocol No. 15 of 04.06.25.

Approved by: Methodical Commission of Educational and Research Institute of Energysaving and Energy management (Protocol No. 30 of 25.06.25)

Questions for credit in the discipline «Systems for automating engineering calculations of electric drive».

1. Basic terms and definitions of CAD and CAE
2. Motion profiles implemented in frequency inverters.
3. Goals and objectives of CAE
4. Drive tasks. Procedure for finding a zero label. Electronic shaft.
5. Types of supply voltages for electric drive systems
6. Configuration of the electromechanical part of the electric drive of hoisting installations. Description of the main elements
7. Resolver. Principle of operation. Advantages and disadvantages
8. Design of a hydraulic system in CAE. Basic selection options
9. Devices and methods of locking the motor shaft in hoisting installations. Their influence on the characteristics of the drive.
10. Methods of starting induction motors using soft starters.
11. Design of a pneumatic system in CAE. Basic selection options.
12. Additional electric motor configuration options.
13. Methods of starting induction motors for open-loop systems.
14. Methods of starting induction motors for closed-loop systems.
15. Drive solution Catalog. Basic electric drive systems
16. Modes of operation with constant linear and angular velocities. Application features.
17. Analog speed/position sensors in electric drives.
18. Incremental speed sensors. Main characteristics, advantages and disadvantages.
19. HiperFACE. Schematic implementation. Basic parameters.
20. Configuration of the electromechanical part of the electric drive of turbo mechanisms. Description of the main elements.