Syllabus
Course Program

Power Elements of Mecharronics and Robotics Systems

Specialty
141 – Electric power engineering, electrical engineering and electromechanics

Institute
Institute of Education and Science in Power Engineering, Electronics and Electromechanics

Educational program
Electric drive, mechatronics and robotics

Department
Department of Automated Electromechanics Systems

Level of education
Bachelor's level

Course type
Special (professional), Mandatory

Semester
5

Language of instruction
English

Lecturers and course developers

Tetiana Kunchenko

Tetiana.Kunchenko@khpi.edu.ua
Candidate of technical sciences, associate professor, associate professor of the department of automated electromechanical systems of NTU "KhPI"

Work experience - 27 years. Author of more than 50 scientific and educational and methodological works. Leading lecturer in the disciplines: "Electric drive", "Fundamentals of electric drive".
More about the lecturer on the department's website

General information

Summary

The object of study in this course is the power elements of mechatronics and robotics systems designed to convert electrical energy and control this process. The subject of the discipline is the acquisition of theoretical and practical knowledge about the components of an automated electric drive, which will further allow designing mechatronics and robotics systems.

Course objectives and goals

To form students' concepts and provide knowledge about the basic elements that make up mechatronics and robotics systems. To develop the ability to determine the principles of construction and normal functioning of elements of electrical engineering complexes and systems. Develop the ability to develop and calculate schemes of electrical installations for various purposes, determine the composition of their equipment and calculate operating modes, the ability to use reference literature, equipment catalogs, modern methods of calculation, design and analysis of the operation of components of electric drives.

Format of classes

Lectures, practical classes, calculations, self-study and consultations. Final control – exam.

Competencies

The ability to solve complex specialized tasks and practical problems related to the operation of electric machines, devices and automated electric drives. Obtaining and using professional knowledge and

understanding related to the process of using and consuming electricity by means of an electric drive in compliance with the specified parameters of technological processes and the quality of electricity. The ability to perform appropriate calculations for the analysis of transient and steady modes of operation of electric drives and mechatronic modules and systems. The ability to draw up and calculate diagrams of electrical installations for various purposes, determine the composition of their equipment and optimize their operating modes.

Learning outcomes

Solve professional tasks related to the design, installation and operation of electric power, electrotechnical, electromechanical complexes and systems. To know and understand the processes of using and consuming electricity by means of an electric drive in compliance with the specified parameters of technological processes and the quality of electricity. To be able to perform calculations for the analysis of transient and steady modes of operation of electric drives and mechatronic modules and systems. Know and understand the principles of drawing up and calculating schemes of electrical installations for various purposes, determine the composition of their equipment and optimize their operating modes.

Student workload

The total volume of the course is 120 hours (4 ECTS credits): lectures – 48 hours, practical classes – 16 hours, self-study – 56 hours.

Course prerequisites

Physics, Theoretical basics of electrical engineering, Electric machines, Electrical devices, Basics of circuit engineering, Basics of electronics

Features of the course, teaching and learning methods, and technologies

The learning process in this discipline involves lectures, practical classes, performance of calculation tasks, independent work and consultations. When conducting lectures, the text of lectures prepared and distributed to students in advance is used. At the same time, there is an opportunity to consider some sections of the lecture material in more detail and to carry out ongoing control with the help of test control works. Practical classes are related to the calculation of mathematical models of the generator, parameters of the main elements of thyristor converters, static and dynamic characteristics of converters. During independent work, the student must study sections, topics according to the recommended literature, specified by the work program of the academic discipline.
The quality control system of students' education includes ongoing control and final control in the form of an exam. Current control is implemented in the form of a survey, performance of individual (calculation) tasks, conducting test control works. Control of the component of the work program, which is mastered during the student's independent work with additional lecture material, is carried out by checking notes. Semester control is conducted orally based on exam tickets in the amount of educational material determined by the curriculum and in the terms established by the curriculum. A student is considered admitted to the semester exam in the academic discipline, provided that he completes all the practical classes, completes the calculation work and tests provided by the educational program in the discipline.

Program of the course

Topics of the lectures

Topic 1. Goals and objectives of the discipline. Concept and classification of elements. Main coordinates of elements.
Topic 2. Generalized mathematical model of an element. Regulatory and external characteristics.
Topic 3. Formation of characteristics of elements using feedback on the initial coordinate.
Topic 4. Direct current generators.
Topic 5. Means of forcing generator excitation.
Topic 6. Thyristor voltage converters. Their advantages and disadvantages. Classification and main schemes of non-reversible converters.
Topic 7. Classification and main circuits of reversing converters.
Topic 8. Physics of the rectification process in beam and bridge circuits.

Topic 9. Physics of the inversion process.
Topic 10. Dependence for the EMF of the converter and its characteristics in the continuous current mode.
Topic 11. Characteristics of the converter in the intermittent current mode.
Topic 12. Nature of static equalizing current. Selection of equalizing reactors.
Topic 13. Nature of dynamic equalizing current and methods of its limitation.
Topic 14. Selection of smoothing reactors and reactors for limiting the intermittent current zone.
Topic 15. Dynamic properties of the power circuit of the thyristor converter.
Topic 16. Calculation of the transfer function of the power circuit of the converter.
Topic 17. System of pulse-phase control (SPPC) of a thyristor converter.
Topic 18. Classification and typical schemes of SPPC.
Topic 19. Dynamic properties of a thyristor converter.
Topic 20. Calculation of the transfer function of the converter.
Topic 21. Energy indicators of a thyristor converter.
Topic 22. Emergency modes of the thyristor converter.
Topic 23. Means and schemes of thyristor converter protection.
Topic 24. Reducing the impact of the thyristor converter on the power supply network.

Topics of the laboratory classes

Laboratory classes are not scheduled

Self-study

The course involves calculation work. Based on the results of the calculations, a written report is drawn up. After checking the report, the student must defend the calculation task.

Course materials and recommended reading

1. Тукалов І.О., Кунченко Т.Ю. Елементи автоматизованого електропривода. Частина перша. Керовані перетворювачі електричної енергії для електроприводів – Харків.: НТУ «ХПІ», 2022 р.-204 с.
2. Калінов А. П., Мельников В. Елементи автоматизованого електропривода : навч. посібник / А. П. Калінов, В. О. Мельников. – Кременчук : Видавництво ПП Щербатих О. В., 2014. – 276 с.
3. Зімін Е. Н .Електрообладнання промислових підприємств і установок: підручник / Е. Н. Зимін, В.І.Преображенський, І. І. Чувашев. - 2-е вид., Перероб. і доп. - К.: Вища школа, 1981. - 552 с.
4. Теорія електропривода: Підручник / М.Г. Попович, М.Г Борисюк, В.А. Гаврилюк та ін.; За ред. М.Г. Поповича. – К.: Вища школа, 1993 – 494 с.
5. Erickson, Robert W. Fundamentals of Power Electronics. New York, NY: Chapman& Hall, 1997. ISBN: 9780412085413.
6. Електроніка і мікросхемотехніка : Підручник для вищ. навч. закл. освіти : У 4-х т./ В.І. Сенько, М.В. Панасенко , Є.В. Сенько та ін.; Під ред. В.І. Сенька. – К.: ТВО «'Видавництво Обереги'», 2000. – Т.1. Елементна база електронних пристроїв.– 309 с
7. Krein, Philip T. Elements of Power Electronics. New York, NY: Oxford University Press, 1998. ISBN: 9780195117011.
8. Попович М.Г., Лозинський О.Ю., Клепіков В.Б. та ін. Електромеханічні системи автоматичного керування та електроприводи. Навч. посіб. / М.Г. Попович, О.Ю. Лозинський, В.Б. Клепіков та ін. – К.: Либідь, 2005. – 680
9. Richard Crowder. Electric Drives and Electromechanical Systems: Applications and Control / Richard Crowder. – Newnes, Published Date: 2006. – 312 p.
10. Перетворювальна техніка. Підручник : Ч. 2/ Ю.П. Гончаров , О.В. Будьонний, В.Г. Морозов та ін., За ред.. В.С. Руденка. – Харків: Фоліо, 2000. – 360 с.
11. Островерхов М. Я. Промислова електроніка: Напівпровідникові перетворювачі змінної напруги в постійну навч. посіб. / М. Я. Островерхов, В.І. Сенько, В.І. Чибеліс; КПІ ім. Ігоря Сікорського. – Київ: КПІ ім. Ігоря Сікорського, 2021. – 341 с.
12. Казачковський М.М. Комплектні електроприводи. Навч. посібник. Дніпропетровськ: НГУ, 2003. – 266 с.
13. Чехет Е.М., Мордач В.П., Соболев В.М. Безпосередні перетворювачі частоти для електропривода. – К.: Наук. думка, 1988. – 224 с.

14. Шавьолкін О.О. Силові напівпровідникові перетворювачі енергії: навч. посібник / О.О. Шавьолкін; Харків, над. ун-т. міськ. госп-ва ім. О.М. Бекетова. -– Харків : ХНУМГ ім. О.М. Бекетова, 2015. – 403 с.
15. Михальський В.М., Соболєв В.М., Чехет Е.М. Векторна широтно-імпульсна модуляція в матричних перетворювачах. Навчальний посібник. – К.: Ін-т електродинаміки НАН України, 2003. – 74с
16. Rashid, Muhammad H. SPICE for Power Electronics and Electric Power. 2nd ed. Boca Raton, FL: CRC Press, 2006. ISBN: 9780849334184.
17. Blaschke F. "The Principle of Field Orientation as Applied to the NEW Transvector Closed-Loop System for Rotating-Field Machines," Siemens Review, Vol. 39, No. 5, 1972, pp. 217-220
18. Malesani L., Rossetto L., Tenti P. Tomasin P.,"AC/DC/AC PWM Converter with Reduced Energy Storage in the DC Link". IEEE Trans. Ind. Appl., No2,1995, pp.287-292.
19. Malinowski M., Kazmierkowski M., Hansen S., Blaabjerg F., MarquesG., "Virtual-flux-based direct power control of three-phase PWM rectifiers". IEEE Trans. Ind. Appl., No4,2001, стр.1019-1027.
20. Попович Н.Г. Елементи автоматизованого електропривода /Н.Г.Попович, В.А.Гаврилюк, О.В.Ковальчук, В.І.Теряєв . К.: УМК ВО, 1990. – 260 с
21. Руденко В.С. Промислова електроніка: Підручник / В.С. Руденко, В.Я. Ромашко, В.В. Трифонюк, К.: – Либідь, 1993. – 432 с
22. Казачковський М.М. Керовані випрямлячі. – Дніпропетровськ: НГА України, 1999. – 228 с.
23. Тукалов І.О., Кунченко Т.Ю Методичні вказівки до виконання розрахункових робіт з дисципліни «Елементи автоматизованого електроприводу». Учбово-методичне забезпечення самостійної роботи студентів. –Харків: НТУ ХПІ, 2022 г.

Assessment and grading

Criteria for assessment of student performance, and the final score structure

Description of the final score structure, course requirements, and necessary steps to earn points, especially paying attention to self-study and individual assignments.

Grading scale

Total points	*National*	*ECTS*
90–100	*Excellent*	*A*
82–89	*Good*	*B*
75–81	*Good*	*C*
64–74	*Satisfactory*	*D*
60–63	*Satisfactory*	*E*
35–59	*Unsatisfactory (requires additional learning)*	*FX*
1–34	*Unsatisfactory (requires repetition of the course)*	*F*

Norms of academic integrity and course policy

The student must adhere to the Code of Ethics of Academic Relations and Integrity of NTU "KhPI": to demonstrate discipline, good manners, kindness, honesty, and responsibility. Conflict situations should be openly discussed in academic groups with a lecturer, and if it is impossible to resolve the conflict, they should be brought to the attention of the Institute's management.
Regulatory and legal documents related to the implementation of the principles of academic integrity at NTU "KhPI" are available on the website: http://blogs.kpi.kharkov.ua/v2/nv/akademichna-dobrochesnist/

Approval

Approved by	*Date, signature*	*Head of the department* *Bohdan VOROBYOV*
	Date, signature	*Guarantor of the educational program* *Mykola ANISHCHENKO*