Syllabus
Course Program

Automated AC Electric Drive

Specialty
141 Electric Power Engineering, Electrical Engineering and Electromechanics

Institute
Institute of Power Engineering, Electronics and Electromechanics

Educational program
Electric Drive, Mechatronics and Robotics

Department
Automated Electromechanical Systems (129)

Level of education
Bachelor's level

Course type
Optional

Semester
8

Language of instruction
English

Lecturers and course developers

Oleksii Semikov
oleksii.semikov@khpi.edu.ua
Candidate of technical sciences, senior lecturer at the Department of “AEMS”.

Experience is 8 years. An author is over 20 scientific works.
More about the lecturer on the department's website

General information

Summary

In the discipline, modern control systems for electric drives are examined, including their static and dynamic characteristics, methods of analysis and synthesis, and methods for calculating alternating current automated electric drive systems.

Course objectives and goals

The formation of theoretical and practical skills in the fundamentals of designing modern automated electric drive systems and their operation in future specialists.

Format of classes

Lectures, practical studies, consultations, self-study. Final control in the form of an exam.

Competencies

Ability to use knowledge of the basics of electromechanics: the theory of electric machines, apparatus and automated electric drive for solving practical problems in the field of electric power engineering, electrical engineering and electromechanics. Ability to determine and provide optimal, energy-efficient and economic modes of operation of electric power, electrical and electromechanical equipment. Ability to carry out experimental (model) research of operating modes of electric power, electrotechnical and electromechanical equipment. The ability to collect and interpret the necessary data and on this basis to

put forward and defend arguments regarding the characteristics of electric drives, as well as the trends of their development, in particular with the use of modern information and computer technologies.

Learning outcomes

To evaluate the parameters of the electrical, electrical and electromechanical equipment and related complexes and systems work and to develop measures to increase their energy efficiency and reliability. To analyze processes in electric power, electrotechnical and electromechanical equipment and corresponding complexes and systems. To possess methods of synthesis of electric power, electro-technical and electromechanical installations and systems with given parameters. Assess the reliability of electrical, electrical and electromechanical systems. To be able to apply modern technical means to measure electric power, electrical and electromechanical installations and the processes that occur in them, analyze the results of measurements for monitoring and control.

Student workload

The total volume of the course is 90 hours (3 ECTS credits): lectures - 30 hours, practical studies - 10 hours, self-study - 50 hours.

Course prerequisites

Previous courses (that are necessary for successful course completion): Higher Mathematics, Physics, Theoretical Foundations of Electrical Engineering, Fundamentals of Electronics, Theory of Automatic Control, Electric Machines, Theoretical Basic of Electric Drive.

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

Lectures are conducted interactively using multimedia technologies. Distributed lecture texts are utilized during lectures. During practical studies, the project method is applied using physical and simulation models in a computer environment.

Program of the course

Topics of the lectures

Topic 1. Speed Control Systems for AC Electric Drives.
Classification of AC electric drive control systems. Control system of a synchronous electric drive. Powering a synchronous motor with permanent magnets from a controlled voltage inverter. Characteristics of a valve electric drive when powered by sinusoidal voltage.

Topic 2. Automatic Regulation Systems for AC Electric Drives.
2.1. Vector control of a permanent magnet synchronous motor. Current regulation in the vector control system of a permanent magnet synchronous motor. Flux weakening in the vector control system of a permanent magnet synchronous motor. Vector control systems of a permanent magnet synchronous motor with state observers.
2.2. Methods of controlling an asynchronous electric drive. Scalar control. Speed and torque stabilization in the scalar control system of an electric drive. Vector control of an asynchronous electric drive. Observer models for the sensor-based vector control system. Methods of adjusting observer parameters during electric drive operation. Speed regulation of an asynchronous electric drive with sensorless vector control.
2.3. Direct torque control. Mechanical and electromechanical characteristics in the Direct Torque Control system. Obtaining information about the controlled process. State observers in the direct torque control system.

Topic 3. Discrete Control Systems for AC Electric Drives.
3.1. Pulse models of a thyristor rectifier and pulse converter of constant voltage with unidirectional PWM in continuous current mode. Influence of the pulsating component of the output voltage of the converter on the dynamics of the closed-loop system. Mathematical description of the pulse system. Stability of the pulse system. Finite duration process. Calculation of transient processes.

3.2. Analysis of the dynamics of the armature current regulation loop with an impulse model of the converter.

Topics of the workshops

Topic 1. Analysis of the parameters of the equivalent circuit of an asynchronous motor. Calculation of parameters for the simplified model of an asynchronous motor.
Topic 2. Analysis of the speed control system in the VFD-Asynchronous Motor system.
Topic 3. Analysis of the torque control system in the VFD-Asynchronous Motor system.
Topic 4. Selection of elements for the power section of a variable frequency drive.
Topic 5. Synthesis of the pulse control system.

Topics of the laboratory classes

Laboratory classes are not included in the curriculum.

Self-study

Processing of lecture materials. Preparation for practical studies. Independent study of topics and questions not covered in lectures. The calculated task includes the analysis of static and dynamic characteristics of the excitation current regulation loop of an AC motor. Analysis of dynamic processes in the torque loop of the motor. Synthesis of a modal regulator for the regulation system of an AC motor.

Course materials and recommended reading

1. Die Elektrotechnik und die elektrischen Antriebe Lehr- und Nachschlagebuch für Studierende und Ingenieure. Wilhelm Lehmann. 6th ed. 1962. 433 p.
2. Theory of Automatic Control. M. A. Aizerman. 1963. 519 p.
3. Electric Motor Handbook. Beaty H.W., Kirtley J. 1998. 398 p.
4. Electric Motor Drives. Modeling, Analysis, and Control. R. Krishnan. 2001. 650 p.
5. Control of Electrical Drives. Leonhard W. 3rd ed. 2003. 460 p.
6. Electric Motors and Drives. Austin Hughes. 3rd ed. 2006. 410 p.
7. Electricity and Electronics. Stan Gibilisco. 4th ed. 2006. 699 p.

Assessment and grading

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

The final grade consists of the results of the evaluation of control task (20%), individual works (20%), calculated task (30%), and exam (30%).

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 VOROBIOV
	Date, signature	Guarantor of the educational program Mykola ANISHCHENKO