Syllabus
Course Program

Automated DC 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
7

Language of instruction
English

Lecturers and course developers

Oleksii Semikov

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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 direct 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, laboratory classes, 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 120 hours (4 ECTS credits): lectures - 32 hours, laboratory classes - 16 hours, self-study - 72 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. Laboratory work involves the use of laboratory stands and a project method with the application of physical and simulation models in a computer environment.

Program of the course

Topics of the lectures

Topic 1. Principles of Building Control Systems for DC Electric Drives.
1.1. Classification of Electric Drive (ED) Control Systems. Architecture of ED Control System. Open-loop and closed-loop ED control systems. Typical elements of ED control systems.
1.2. Static and dynamic characteristics of ED. Correction methods for closed-loop ED control systems. Methods of analysis and synthesis of ED control systems.
Topic 2. Automatic Regulation Systems for DC Electric Drives.
2.1. Mathematical model of a DC motor. Static and dynamic characteristics of a thyristor rectifier and pulse converter of constant voltage with PWM. Continuous dynamic models of a thyristor rectifier and a pulse converter of constant voltage. Influence of the type of reference signal of the thyristor rectifier on the control characteristic. Methods of linearizing the control characteristic of the thyristor rectifier. Influence on the control characteristic of the converter of the E.R.S. motor.
2.2. Technical (modular) and symmetric optimization criteria. Optimization of the current control loop for a stalled motor powered by a thyristor rectifier or a pulse converter of constant voltage. Analysis of the impact on the current loop dynamics of the E.R.S. motor.
2.3. Speed control of ED. Transfer functions of closed structures by speed and static load. Dynamics of the speed control loop with P, PI regulators. Subordinate control system of ED. Principle of time distribution of dynamic processes. Structure of the subordinate control system of ED. Methods for limiting the motor armature. Dynamics of the subordinate control system of ED. Two-zone speed control.
2.4. ED systems with reversible converters. Methods for forming the control characteristic of a reversible converter. Common control of thyristor rectifiers. Influence of the insensitivity zone on the dynamics of ED. Dynamics of the ED system with common control of thyristor rectifiers with a step and linearly increasing speed reference signal. Separate control of thyristor rectifiers. Current-free pause. Linearization of the control characteristic by scanning logic. Dynamics of ED with separate control of thyristor rectifiers with a step and linearly increasing speed reference signal.
Topic 3. Modern Methods of Electric Drive Control.

3.1. Principles of constructing modal control systems for ED. Representation of the electric drive control system in state-space form. Controllability of the system. Synthesis of a modal regulator. Structural diagram of a modal regulator. Dynamics of the electric drive control system.
3.2. Sensorless control systems for electric drives (model-based control). State observers, open-loop, with relay feedback, with PI regulator, for a DC motor, two-loop, and combined systems. Structural and schematic diagrams of observers.

Topics of the workshops

Workshops are not included in the curriculum.

Topics of the laboratory classes

Topic 1. Research of the armature current regulation system.
Topic 2. Research of the subordinate speed control system.
Topic 3. Investigation of a modal regulator.
Topic 4. Exploration of a sensorless system.
Topic 5. Time function of the resistive start of a direct current motor.

Self-study

Processing of lecture materials. Preparation for laboratory work. 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 a DC motor. Analysis of dynamic processes in the armature current regulation loop of the motor. Synthesis of a modal regulator for the regulation system of a DC 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%), laboratory works (30%), calculated task (20%), 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