Syllabus
Course Program

THEORY OF AUTOMATIC CONTROL

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
Special (professional), Mandatory

Semester
4

Language of instruction
English

Lecturers and course developers

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PhD, Assistant Professor, Assistant Professor of the Department of Automated Electromechanical Systems of NTU "KhPI"

Experience – 22 years. An author is over 40 scientific works. A leading lecturer is from courses: English course of «Design of Control Systems in Mechatronics», Ukrainian course of «Automated Electric Drive for General Industrial Installations», Ukrainian course of «Power Supply of Industrial Enterprises and Energy Saving», Ukrainian course of «Design of Control Systems in Mechatronics»
More about the lecturer on the department's website
http://web.kpi.kharkov.ua/aems/uk/staff-uk/

General information

Summary

The course provides knowledge and basic understanding of the automatic control theory, modern mathematical tools and methods of mathematical and computer simulation for synthesis and study of steady-state and dynamic operation modes for the general purpose electromechanical systems.

Course objectives and goals

Develop students' theoretical, practical skills and knowledge in the field of component elements and automatic control systems (ACS) functioning of electrical power, electrical engineering and electromechanics technical objects, as well as the ability to calculate ACS parameters and analyze their influence on system properties, to synthesize systems with desired quality performance, to analyze the properties of separate elements and ACS as a whole.

Format of classes

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

Competencies

GC 7. Skills of using information and communication technologies.
PC 5. Ability to use knowledge in metrology and electrical measurements, the theory of automatic control and electronics to solve problems of measurement, design, control and control in power engineering, electrical engineering and electrical engineering.
PCs 18. Ability to conduct appropriate calculations for the analysis of transient and steady-state operation of electric drives.
PRT 17. To define the principles of construction and functioning of elements of control, control and automation systems of electric power, electrical and electromechanical complexes.
PRT 20. To analyze processes in electric power, electrotechnical and electromechanical equipment and corresponding complexes and systems.
PRT 22. To possess methods of synthesis of electric power, electrotechnical and electromechanical installations and systems with given parameters.
PRTs 38. To be able to carry out calculations for the analysis of transient and steady-state operation modes of electric drives.

Learning outcomes

Knowledge of mathematical and structural modelling methods, classical methods of automatic control systems synthesis with set quality parameters, study of software used for automatic control systems computer simulation

Student workload

The total volume of the course is 180 hours (6 ECTS credits): lectures - 48 hours, laboratory classes - 16 hours, practical studies - 16 hours, self-study - 100 hours.

Course prerequisites

For successfully passing the course, you must have knowledge and practical skills in the following disciplines: Higher Mathematics, Physics, Technical Mechanics, Theoretical Foundations of Electrical Engineering.

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

Lectures use multi-media, and students have material to study in advance, which allows them to consider problem issues in more detail, have discussions and take blitz tests.
During practical studies and laboratory classes, students solve problems of analyzing the characteristics of component parts and electromechanical systems as a whole, as well as problems of synthesizing high-quality control systems for working mechanisms. Computer modelling of the characteristics of individual blocks and dynamic processes in electromechanical systems by using the MATLAB..

Program of the course

Topics of the lectures

Topic 1. Basic terms, definitions and concepts.
Cybernetics, its main tasks and specific features. Information and control concepts. Automation advantages. Some historical information about the development of automation. Today's tasks in the field of automatic control systems. The problem of automatic control. Automatic control system general structure. Automatic control system classification.
Topic 2. Automatic control system design principles.
Fundamental control principles: control in open-loop control systems, deviation control, disturbance control, combined control, adaptation principle. Automatic control basic types: stabilisation, tracking, software, optimal, extreme. Creating functional diagrams of automatic control systems. Examples.
Topic 3. Continuous linear automatic control systems mathematical description.
Statics and dynamics equations. Linearization. Basic forms of automatic control systems mathematical description. Vector-matrix equation of systems in state space. Operator method for solving equations of system dynamics. Laplace transform. Concept of automatic control system transfer functions. Graphic interpretation of automatic control systems mathematical description: block diagrams and graphs.

Structural transformation rules. Open-loop and closed-loop transfer functions of automatic control systems according to setting and disturbance signals. Transfer function zeros and poles.
Topic 4. Time and frequency responses of automatic control systems and their components.
Input signals as standard. Transient and impulse transition functions, their relationship to the transfer function. Complex transfer function. Frequency responses of automatic control systems and their components. Passband, cut-off frequency. Connection between frequency responses. Study of time and frequency responses of automatic control systems and their components. Typical dynamic control actions, their time and frequency responses. Determination of the typical dynamic control actions parameters by their time and frequency responses.
Topic 5. Continuous linear automatic control systems stability.
Stability of differential equation solutions. Concept of stability using solutions of differential equations. Automatic control systems stability: necessary and sufficient conditions. Stability criteria: algebraic and frequency. Stability regions build. Automatic control systems structural unstable. Comparative assessment of stability criteria. Define the automatic control system stability factor by amplitude and phase.
Topic 6. Quality analysis of linear continuous systems in steady-state mode.
Defining the control error in automatic control systems. Error factors. Ways to improve accuracy in automatic control systems. Structural features of system astatism, ways to improve its order. Static accuracy and stability conflicts in automatic control systems. The principle of invariance is implemented. Increasing quality in combined automatic control systems and systems with variable block diagram.
Topic 7. Dynamic analysis of control quality in continuous linear automatic control systems.
Quality parameters for automatic control systems in transient mode. Oscillation factor. Control quality assessment with a harmonic input signal. Quality assessment root methods. Root hodograph. Integral assessments of control quality.
Topic 8. Automatic control system correction.
Series and parallel correction devices. Standard regulators (P-regulator, PI-regulator, PID-regulator). Regulators' influence on the quality of control in transient and steady-state modes of automatic control systems.
Topic 9. Automatic control system synthesis by classical methods.
Standard coefficients method. Synthesis of a serial correction device using logarithmic amplitude-frequency responses. Correction devices synthesis based on the root hodograph. Parallel correction devices. The influence of local feedback on the automatic control system quality. Combination of serial and parallel correction (systems with subordinate coordinate). Standard optimum settings (technical and symmetrical optimum).

Topics of the workshops

Topic 1. Drawing up block diagrams of the automatic control system. Examples
Topic 2. Linearization. For example, linearization of the electric machine magnetization characteristic.
Topic 3. Math description of electromechanical system components.
Topic 4. Block diagrams transformation in algorithmic circuits.
Topic 5. Frequency and time responses of typical dynamic control actions.
Topic 6. The logarithmic amplitude and frequency responses of open-loop systems.
Topic 7. Automatic control systems stability. Algebraic and frequency stability criteria.
Topic 8. Determining the control error in automatic control systems. Improving the accuracy of automatic control systems.

Topics of the laboratory classes

Topic 1. Introduction to the features of working with Simulink/MATLAB blocks.
Topic 2. Creating a model for the study in Simulink/MATLAB.
Topic 3. To study of the time responses of typical first-order linear control actions.
Topic 4. To study of the time responses of typical second-order linear control actions.
Topic 5. To study of the frequency responses of typical first-order linear control actions.
Topic 6. To study of the frequency responses of typical second-order linear control actions.

Self-study

Individual work includes completion of an individual calculation task "Static and dynamic properties analysis of components and automatic control systems".
Using the block diagram, do:
To identify the type of components of dynamic control actions.
To draw the time and frequency responses of one of the control actions.
To perform block diagram transformations of the algorithmic scheme and to determine the transfer functions of the automatic control system by the setting and disturbance signals.
To determine the steady-state value of the output coordinate according to the principle of superposition in linear automatic control systems.
According to one of the criteria, to study the stability of the open-loop and closed-loop automatic control systems, to determine the stability factor.
To determine the control error in the automatic control systems in steady-state and dynamic modes of operation.

Course materials and recommended reading

1. Richard C. Dorf and Robert H. Bishop Modern control systems. 12t edition. PrenticeHall, 2011. – 1071 p.
2. Karl Johan Astr and Richard M. Murray Feedback Systems An Introduction for Scientists and Engineers, DRAFT v2.7a (17 July 2007). – 412 p.
3. Rao V. Dukkipati Analysis and Design of Control Systems Using MATLAB. New Age Science, 2009. – 449 p.
4. Asmolova L.V., Shamardina V.M., Chudovska T.S. Fundamentals of Studying Typical Dynamic Control Actionsin MATLAB: Study Guideto LabClassesare for students of specialty 141 «Electric Power Engineering, ElectricalE ngineeringand Electromechanics» learning the discipline «Theory of Automatic Control. Part 1» on Educational Programin English. – Kharkiv: PromArtLtd., 2022. – 56p.
5. Kattan P. MATLAB forBeginners: A GentleApproach. – 2010. – 300 p. https://www.researchgate.net/publication/301358471_MATLAB_for_Beginners_A_Gentle_Approach

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 VOROBIOV
	Date, signature	Guarantor of the educational program Mykola ANISHCHENKO