Syllabus
Course Program

Design of Control System in Mechatronics

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), Optional

Semester
4

Language of instruction
English

Lecturers and course developers

Asmolova Larysa Valeriivna

Larysa.Asmolova@khpi.edu.ua
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 « Theory of Automatic Control», 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 is directed on fixing the basic provisions of the automatic control theory, skills of using modern mathematical methods and PC modelling for synthesis and study of steady-state and dynamic operating modes of general-purpose mechatronic systems.

Course objectives and goals

Developing students' practical skills and knowledge to study the operation of complex elements and mechatronic automatic control systems, the ability to calculate the parameters of the automatic control system and analyze their influence on the properties of the system. To make synthesis of mechatronic systems with set quality parameters, analyze their properties for individual element and automatic control system.

Format of classes

Laboratory classes, practical studies, self-study, individual tasks Course work. Final control in the form of a tests.

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 mechatronic 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 120 hours (4 ECTS credits): laboratory classes – 16 hours, practical studies – 32 hours, self-study – 72 hours.

Course prerequisites

For successfully passing the course, you must have knowledge and practical skills in the following disciplines: Theory of Automatic Control, Fundamentals of Metrology and Electrical Measurements, Fundamentals of Electronics, Theoretical Basics of Electrical Engineering.

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

Explanatory-illustrative method: Students receive knowledge during lectures, from educational or teaching materials, multi-media.
Reproductive method (students apply the knowledge they have learnt using a template, rules or when performing laboratory works and practical studies, study algorithms for doing typical tasks, repeatedly repeat the knowledge they have learnt during testing and self-control.
The problem presentation method (When presenting the material, a problem is set, a task is formulated. Ways of solving the problem, systems of evidence, comparison of points of view, different approaches of analysis, synthesis, comparison, generalization, concretization, singling out the main point are provided).
Partial-search or heuristic (active search is conducted at practical studies and laboratory classes, the solution of tasks is step-by-step directed and controlled using software and teaching materials).
Research method (The material is analyzed, problems and tasks are formulated, corresponding information sources and solutions are found. Students independently study the literature, make observations and measurements, perform any actions of search character in order to make correct scientific conclusions. Computer simulation of processes in technical systems is used to create, verify, measure, as well as to determine the principles and regularities of synthesis, functioning of systems and their prediction).

Program of the course

Topics of the lectures

Lectures are not provided in the curriculum.

Topics of the workshops

Topic 1. Creation of automatic control systems.

Control fundamentals: open loop control, deviation control, disturbance control, combined control, adaptation control. The basic types of automatic control: stabilization, tracking, programming, optimal, extreme. To create functional block diagrams of automatic control systems. Examples.

Topic 2. Mathematical description of automatic control system elements.

Studying the functioning principles of the basic components of the automatic control system, obtaining the transfer functions of the elements.

Topic 3. Oriented graph of the automatic control system.

Construction of the oriented graph of the automatic control system. Automatic control system transfer functions determination by Mason's formula.

Topic 4. Automatic control system mathematical description in the state space.

Defining the differential equations of the automatic control system in Cauchy form. Matrices A, B, C, D are defined.

Topic 5. Linear automatic control systems stability.

Construction of stability regions using Vishnegradsky criterion. Structural instability of automatic control systems. Comparative assessment of stability criteria. Calculation of modulus and phase stability reserve in the automatic control system. Calculation and construction of the stability zone of the automatic control system (D-division method) in the plane of one and two regulated parameters of the system.

Topic 6. Analyzing the control quality of linear automatic control systems in steady-state mode.

Defining control error in automatic control systems. Error coefficients. Structural features of systems astatism, ways to increase its order. Determining the desired transfer coefficient of an open loop automatic control system given its accuracy.

Topic 7. Control quality analysis of linear automatic control systems in dynamics.

Quality assessment parameters of automatic control system in transient mode. Root methods of quality assessment. Root hodograph.

Topic 8. Automatic control systems correction.

Series and parallel correction devices. Typical regulators (P-regulator, PI-regulator, PID-regulator, PID-regulator). Influence of regulators on the control quality in transient and steady-state modes of automatic control system operation.

Topic 9. Automatic control systems synthesis by classical methods.

Standard coefficient method. Serial corrective device synthesis using logarithmic amplitude-frequency characteristics. Corrective device synthesis by root-mean-square hodograph.

Topics of the laboratory classes

Topic 1. Creating a model for the study in Simulink/MATLAB.

Topic 2. To study of dynamic behavior of a DC motor with independent excitation by MATLAB.

Topic 3. To study of the automatic control system on stability by the Routh-Hurwitz and the Hurwitz stability criteria by MATLAB.

Topic 4. To study of the automatic control system on stability by the Mikhailov's and the Nyquist stability criteria by MATLAB.

Topic 5. Construction of the stability zone of the automatic control system (D-division method) in the plane of one and two regulated parameters of the system by MATLAB.

Topic 6. To study of the control quality of uncorrected and corrected automatic control systems in steady-state mode by MATLAB.

Self-study

The student performs the course work, which aimed at improving consolidate knowledge of the course. He argues the assumptions, finds information and makes calculations in the process of solving the problems and gains skills in simulation electromechanical systems and analyzing the behavior of their transients.

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