Syllabus
Course Program

Electric drive of mechatronic systems with microprocessors control

Specialty
141 – Electric power engineering, electrical engineering and electromechanics

Institute
Educational and Scientific Institute of Energy, Electronics and Electromechanics

Educational program
Electric drive, Mechatronics and Robotics

Department
Department of Automated Electromechanics Systems (129)

Level of education
Master's level.

Course type
Special (professional)

Semester
10

Language of instruction
English

Lecturers and course developers

Yaroslav Kyrylenko
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Assistant at Department of Automated Electromechanics Systems of NTU "KhPI".

Author and co-author of more than 9 scientific publications.
Courses: "Embedded control systems in mechatronics", "Programming in the C language", "Вбудовані системи керування в мехатроніці", Industrial Robots, Digital circuits.
More about the lecturer on the department's website

General information

Summary

The discipline is aimed at mastering the theoretical foundations and practical skills in the field of mathematical and computer modeling of elements and control systems of modern electric drives of mechatronic systems with microprocessors control (linear and nonlinear, in continuous time and discrete, deterministic and stochastic, using the method of graphs and matrix description)..

Course objectives and goals

1.The method of reliable modeling of complex modern electric drives and automation systems using the package, conducting research into their operation using modern computing equipment and generalizing the obtained results in the process of scientific work.
2.Evaluation of the possibility of synthesizing regulators of complex electric drive control systems with programmable controllers and built-in computer boards.

Format of classes

Workshops, laboratory classes, consultations, self-study. Final control in the form of a Lab reports.

Competencies

"Physics", "Electric machines and devices", "Theory of electric drive", "Theory of automatic control", "Elements of automated electric drive", "Industrial electronics", "Fundamentals of microprocessor technology", SKEP, MEMS, bachelor's project..

Learning outcomes

1. Learn construction methods and learn to work with virtual computer models.
2. To learn to work with microprocessor drives with microprocessor control on laboratory stands.
3. Learn to compare the results of computer modeling, design and laboratory experiments, being aware of them close connection and disagreements.
4.Initiate students' ability to conduct their own scientific research on electric drive control systems at a level sufficient for successful completion of the next master's degree without the intervention of the project manager.

Student workload

The total volume of the course is 90 hours (3 ECTS credits): workshops classes - 16 hours, laboratory classes - 32 hours, self-study - 42 hours.

Course prerequisites

Knowledge, skills, and previous courses that are necessary for successful course completion.

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

Here you can describe the specific features of teaching and learning and, in particular, the teaching methods that distinguish the course: project work, peer-to-peer, teamwork, gamification, case studies, the use of certain software, LMS (learning management systems), etc. Use red sub-headers if necessary.

Program of the course

Topics of the lectures

No lectures classes in this course

Topics of the workshops

Topic 1. Learning of The Concept of a Control System
1.1 Control Systems
1.2 Feedback Control
1.3 The Time-Domain and Frequency-Domain
Topic 2. Learning of Differential Equations and Laplace Transforms
2.1 Differential Equations
2.2 The Relationship between Differential Equations and Control Systems
2.3 Laplace Transform
Topic 3. Learning of Modeling of Dynamic Systems
3.1 Modeling of Dynamic Systems using Differential Equations
3.2 Transfer Function
3.3 Block Diagrams
3.4 Signal Flow Graph
3.5 State Equation
3.6 Modeling of Dynamic Systems using State Equations
3.7 Linearization of Nonlinear Systems
Topic 4. Learning of Control System Performances
4.1 Basic Concepts of Control System Performances
4.2 Transient performance of Control Systems
4.3 Transient Responses

4.4 Stability of Control Systems
4.5 Steady-State Performance
Topic 5. Learning of The Root Locus Method
5.1 The Basic Concept of the Root Locus
5.2 Properties of the Root Loci and Rules for Plotting
5.3 Effects of Poles and Zeros on the Root Locus
5.4 Controller Design and the Root Locus
Topic 6. Learning of The Root Locus Method
6.1 Frequency Response
6.2 Bode Plot
6.3 Nyquist Stability Criterion
6.4 Stability Margin
6.5 Bode's gain and phase relationship
6.6 Frequency Response of the Closed-loop Transfer Function
Topic 7. Learning of Controller Design in Frequency Domain
7.1 PD Controller Design
7.2 Lead Controller Design
7.3 PI Controller Design
7.4 Lag Controller Design
7.5 PID Controller and Lead-Lag Controller
7.6 Digital Implementation of Controller
Topic 8. Learning of Control System Analysis in State-Space
8.1 Relationship between State-Equation and Transfer Function
8.2 Stability of State Equations
8.3 State Equations and System Responses
8.4 Controllability
8.5 Observability
8.6 State Variable Transformation
8.7 Relationship between Transfer Functions and Controllability/Observability
8.8 State Feedback Controller
8.9 State Estimator
8.10 State Estimator Based Controller
8.11 Integral State Feedback Controller

Topics of the laboratory classes

Lab 1.
1.1 The Digital Control System
1.2 Timer Interrupts and D/A Conversion
Lab 2
2.1 A/D Conversion
2.2 Real-Time Simulation of First-Order Dynamic Systems
Lab 3
3.1 Encoder for Motor Control
3.2 Measurement of DC Motor Model Parameters
Lab 4
4.1 Real-Time Simulation of a Second-Order Dynamic System
4.2 Feedback Control of an Analog Dynamic Simulator
Lab 5
5.1 PD Control of an Analog Dynamic Simulator
5.2 Position Control of a DC Motor
Lab 6
6.1 Lead Controller for an Analog Dynamic Simulator
6.2 Lead Controller for a Magnetic Levitation System
Lab 7
7.1 State Feedback Controller for an Analog Dynamic Simulator

7.2 State Estimator Based Controller for an Analog Dynamic Simulator
7.3 State Estimator Based Controller for a Magnetic Levitation System

Self-study

Information on self-study and individual assignments (reports, course projects, etc.), if it is necessary according to the plan. Also, methods of control and assessment of self-study.

Course materials and recommended reading

1. C-T Chen. Linear System Theory and Design. Oxford University Press, 1984.
2. Richard C. Dorf and Robert H. Bishop. Modern Control Systems. 8th ed. Addison Wesley, 1998.
3. Gene F. Frankin, David Powel, and Abbas Emami-Naeini. Feedback Control of Dynamic Systems. 7th ed. Pearson, 2014.
4. William H. Hayt, Jack E. Kemmerly, and Steven M. Durbin. Engineering Circuit Analysis. 8th ed. McGraw-Hill, 2012.
5. T. Kailath. Linear Systems. Prentice-Hall, 1980.
6. Erwin Kreyszig. Advanced Engineering Mathematics. 10th ed. JohnWiley & Sons, 2011.
7. Benjamin C. Kuo and Farid Golnaraghi. Automatic Control Systems. 9th ed. JohnWiley & Sons, 2010.
8. Feedback Instruments Ltd. Control in a MATLAB Environment Magnetic Levitation System 33-006. Feedback Instruments Ltd., 2003.
9. S.J. Mason. “Feedback Theory-Further Properties of Signal Flow Graphs”. In: Proc. IRE 44 (1956–7), pp. 920–926.
10. S.J. Mason. “Feedback Theory-Some Properties of Signal Flow Graphs”. In: Proc. IRE 41 (1953–9), pp. 1144–1156.
11. Mathworks. Control System Toolbox. Mathworks, Inc., 2018.
12. Mathworks. MATLAB. Mathworks, Inc., 2018.
13. K. Ogata. Modern Control Engineering. 4th ed. Prentice-Hall, 2002.
14. Bruce O. Watkins. “A Partial Fraction Algorithm”. In: IEEE Trans. Automatic Control AC-16 (1971–10), pp. 489–491.

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 practical reports (50%) and laboratory reports (50%)

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