**Syllabus**
Course Program

# Simulation of microprocessor electric drives of robotic and mechatronic systems

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
Master's level

Course type
Optional

Semester
1

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

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 (linear and nonlinear, in continuous and discrete time, deterministic and stochastic, using graph and matrix representation methods). Detailed lecture discussions on the principles of construction, circuits, and characteristics of modern industrial electric drives and automation tools are required for modeling in the first part. The second part is dedicated to the synthesis methods of electromechanical systems using matrix techniques with continuous and digital controllers and root locus methods. This theoretical part is presented at the level of principles, formulas, and diagrams, with the instructor demonstrating their operation on pre-developed models in a computer environment.

### Course objectives and goals

To develop in the student theoretical concepts and practical skills in the methods and tools of mathematical and computer modeling, laying the theoretical foundations for the synthesis of control systems using matrices in continuous and discrete time. This includes elucidating the ideas behind modeling and synthesizing stochastic control systems and demonstrating the corresponding modeling tools in a computer environment.

### Format of classes

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

### Competencies

Ability to utilize the entire spectrum of mathematical models for dynamic systems to solve tasks within the specialty. Proficiency in applying fundamental knowledge of physics, higher mathematics, and theoretical foundations of electrical engineering to address practical challenges in the fields of electrical power engineering, electrical engineering, and electromechanics through both mathematical and computer modeling. Competence in applying knowledge of metrology and electrical measurements, control theory, electric drive theory, digital signal processing, and automation to address optimization and control tasks, including the synthesis of modern controllers, in the domains of electrical power engineering, electrical engineering, and electromechanics. Capability to conduct experimental computer investigations into the operation modes of electrical power, electrical engineering, and electromechanical equipment. Proficiency in developing and calculating models of electrical installations for various purposes, determining their equipment composition, and calculating their operating modes.

### Learning outcomes

Learning outcomes: Ability to identify the principles of construction and operation of elements in control and automation systems for electrical power, electrical engineering, and electromechanical complexes. Solving professional tasks related to the modeling of electrical power, electrical engineering, and electromechanical complexes and systems. Analyzing processes in electrical power, electrical engineering, and electromechanical equipment, as well as corresponding complexes and systems. Improving skills in working with modern equipment and software when performing calculations for dynamic operating modes of electrical engineering, electrical power, and electromechanical equipment, as well as relevant complexes and systems.

### Student workload

The total volume of the course is 150 hours (5 ECTS credits): lectures - 32 hours, practical studies - 16 hours, laboratory classes - 16 hours, self-study - 86 hours.

### Course prerequisites

To successfully complete the course, it is necessary to have a qualification of the 1st (bachelor's) level in the educational programs of the specialty "Electric Power Engineering, Electrical Engineering and Electromechanics.".

### 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 and practical studies involve 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. Representation of models in continuous time.
Topic 2. Representation of models in discrete time.
Topic 3. Discretization of continuous objects.
Topic 4. Numerical differentiation of signals.
Topic 5. Modeling of discrete-continuous systems.
Topic 6. Fundamental issues in modeling and synthesis of control systems with random input signals.
Topic 7. Modeling of static nonlinearities.
Topic 8. Methods for calculating dynamic processes in continuous systems.

### Topics of the workshops

Topic 1. Matrix form and continuous transfer functions in models.
Topic 2. Discrete transfer functions in models.

Topic 3. Static and dynamic nonlinearities in models.
Topic 4. Structural diagram of models.

### Topics of the laboratory classes

Topic 1. Modeling of a linear control object.
Topic 2. Modeling of a control object with nonlinearities.
Topic 3. Modeling of a control system with a simplified representation of the control object.
Topic 4. Modeling of nonlinear robotic and mechatronic systems.

### Self-study

Processing of lecture materials. Preparation for laboratory work and practical studies. Independent study of topics and questions not covered in lectures. Creating of the course work.

## Course materials and recommended reading


1. Wilhelm Lehmann. Die Elektrotechnik und die elektrischen Antriebe Lehr- und Nachschlagebuch für Studierende und Ingenieure. — 6th ed. — Springer-Verlag, 1962. — 433 p. — ISBN: 978-3-662-00241-4.
2. Aizerman M. A. Theory of Automatic Control. — Pergamon, 1963. — 519 p. — ISBN: 978-3-642-97648-3.
3. Koziol R., Sawicki J., Szklarski L. Digital Control of Electric Drives. — Elsevier, 1992. — 206 p. — ISBN: 0-444-41713-3.
4. Beaty H.W., Kirtley J. Electric Motor Handbook. — McGraw Hill, 1998. — 398 p. — ISBN: 978-0070359710.
5. Krishnan R. Electric Motor Drives. Modeling, Analysis, and Control. — Pearson, 2001. — 650 p. — ISBN: 978-0130910141.
6. Leonhard W. Control of Electrical Drives. — 2nd ed. — Springer, 1996. — 680 p. — ISBN: 978-3540418207.
7. Krishnan R. Electric Motor Drives. Modeling, Analysis, and Control. — Pearson, 2001. — 652 p. — ISBN: 0-13-091014-7.
8. Austin Hughes. Electric Motors and Drives. — 3rd ed. — Newnes, 2006. — 410 p. — ISBN: 978-0750647182.
9. Stan Gibilisco. Electricity and Electronics. — 4th ed. — McGraw-Hill/TAB Electronics, 2006. — 699 p. — ISBN: 978-0071459334.
10. Chapman Stephen J. Electric Machinery Fundamentals. — 5th ed. — McGraw-Hill, 2012. — 680 p. — ISBN: 978-0-07-352954-7.


## 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 (20%), course work (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

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| Approved by | Date, signature | Head of the department<br>Bohdan VOROBIOV |
| | Date, signature | Guarantor of the educational program<br>Vira SHAMARDINA |