SYLLABUS OF THE ACADEMIC DISCIPLINE
Control Systems of Electric Drives

Academic degree	Bachelor
Academic program	141 Electric Power Engineering, Electrical Engineering and Electromechanics
Period of study	7th, 8th semester
Delivered in	Falls and spring semesters
Lectures per week	3 academic hours
Laboratory classes per week	3 academic hours
Language	English

Link to the remote courses	https://do.nmu.org.ua/course/view.php?id=4007
Department	Electric Drives

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1. Abstract

The course is meant to provide practical skills in engineering control systems for industrial applications, particularly electric drives.

An electric drive is also called electromechanical system, or mechatronic system. It cn be found in any mechanism or appliance which performs controlled mechanical motion – robots, vehicles, 3D-printers, various industrial machinery. In order to provide necessary movement, controllers and feedbacks have to be tuned properly.

The courses is based on practical examples – you will learn to design relay-based control systems for AC and DC motors, develop systems with variable frequency drives and parametrize them. Special section of the course is dedicated by simulation and system modelling.

2. The purpose and objectives

The purpose of the course is to provide competences for design, commissioning and maintenance of electric drives' control systems.

Course objectives:

- deriving the knowledge on fundamental concepts of electric drives' control systems, getting familiar with nomenclature of control engineering;
- learning to design relay- and contactor-based control systems for electric drives;
- learning to represent the components of electromechanical systems as dynamic elements in structural diagrams (signal graphs);
- getting skills in designing variable frequency drives – dimensioning and selection of the components, plotting electric connection diagrams;
- learning to parametrize the frequency converters and tune the overall systems;
- getting skills in predicting the behavior of AC and DC electric drives;
- understanding the purpose and structure of modern AC drives – field-oriented control systems, direct-torque control systems;
- being able to calculate parameters of flux and speed observers for the field-oriented control systems.

3. Learning outcomes:

Applying modern methods for calculation, design and analysis of automated control systems. Developing control systems for AC and DC electric drives, optimizing controllers, understanding and analysis transients in the system.

4. The structure of the course

LECTURES

1. **The basic concepts of control engineering for electric drives**
   - Fields of knowledge and needed competences for an electromechanical engineer
   - Classification of electric drives in industry and basic requirements
   - Control quality criteria
   - Basic concepts and components of electric drives' control systems
2. **AC electric drives in the static operation modes**
   - Asynchronous motor as a control plant in static modes: parameters, characteristics, modes
   - Methods and systems for speed control of induction motors
   - Variable frequency drive for induction motors. The concept of scalar control
   - Volt-herz characteristics for different systems
   - IR-compensation, control of the electric drive at a minimum of current

- Load capacity of an induction motor in a variable frequency drive

3. **Control systems with variable frequency drives**
    - Design and principle of operation of modern frequency converters
    - Dimensioning and selection criteria
    - Load capacity of the inverter
    - Electromagnetic compatibility of systems with inverters
    - Methods of braking in the electric drive with the frequency converter. Calculation of brake resistors
    - Software and parameterization of the inverter. Special functions
    - Variable frequency drive systems for turbomechanisms. PID regulation
    - Variable frequency drive systems for lifting mechanisms
    - Special solutions in inverter systems (torque control, multi-motor systems, common DC bus, recuperative inverters)
    - Outdated and forecoming frequency control systems
4. **Control engineering methods in electric drive applications**
    - A controller. Feedback. Error and perturbation control. Control loops.
    - Offset of mechanical characteristics of the induction motor and the resulting characteristics of the closed-loop control system
    - Dynamic and static control quality criteria
    - Composition of the multiloop cascade control system
    - Proportional and proportional-integral controller. Static and astatic systems. Influence of regulators parameters on the behavior of transients
5. **Field-oriented control of induction motors**
    - Differential equations of induction motors. Coordinate systems (reference frames)
    - Space-vector modulation (SVM)
    - Classic vector control system
    - Flux observers
    - Direct torque control
6. **DC electric drive control systems**
    - Methods of speed control of DC motor
    - Power semiconductor DC converters. Principle of operation, functionality
    - Motor-Generator system (Ward Leonardo setup) and its characteristics
    - Thyristor converter system its characteristics
    - Components of the DC electric drive system as dynamic elements
    - Frequency optimization criteria for DC electric drive system. Modular and symmetric criterion
    - Synthesis of armature and speed controllers based on frequency optimization criteria
    - Single-zone DC electric drive. Transients during start-up on a step reference. Influence of EMF on dynamics
    - Dual-zone DC electric drive
    - Positional electric drive

Laboratory classes

1. Studying and designing relay-contactor control systems of electric drive
2. Working with Altivar variable frequency drive from Schneider Electric
3. Investigation of dynamic properties of single-zone DC electric drive
4. Analysing DC drive with indirect speed control
5. Research of the dual-zone DC electric drive
6. Simulation of an induction motor in different reference frames
7. Investigation of dynamic properties of vector-controlled asynchronous electric drive

5. Tools, equipment and software

The following setups (test stands) are used for the laboratory trainings

- Stands for construction of relay and contactor based control systems in the room 1/47;
- Stands for studying pattern solutions of relay and contactor control systems in the room 1/179;
- Variable frequency drives 'Altivar Process' in the Schneider Electric Authorized Training Centre (room 5/34);
- Models of DC and AC electric drives in MatLAB;

6. Evaluation systems and educational requirements

Certification of student achievement is accomplished through transparent procedures based on objective criteria in accordance with the University Regulations "On Evaluation of Higher Education Applicants' Learning Outcomes".

The level of competencies achieved in relation to the expectations, identified during the control activities, reflects the real result of the student's study of the discipline.

6.1. Grading scales:

Assessment of academic achievement of students of the Dnipro University of Technology is carried out based on a rating (100-point) and institutional grading scales. The latter is necessary (in the official absence of a national scale) to convert (transfer) grades for mobile students.

The scales of assessment of learning outcomes of the NTUDP students

Rating	Institutional
90 ... 100	Excellent
74 ... 89	Good
60 ... 73	Satisfactory
0 ... 59	Failed

6.2. Diagnostic tools and evaluation procedures

The content of diagnostic tools is aimed at controlling the level of knowledge, skills, communication, autonomy, and responsibility of the student according to the requirements of the National Qualifications Framework (NQF) up to the 6th qualification level during the demonstration of the learning outcomes regulated by the work program.

During the control activities, the student should perform tasks focused solely on the demonstration of disciplinary learning outcomes (Section 2).

Diagnostic tools provided to students at the control activities in the form of tasks for the intermediate and final knowledge progress testing are formed by specifying the initial data and a way of demonstrating disciplinary learning outcomes.

Diagnostic tools (control tasks) for the intermediate and final knowledge progress testing are approved by the appropriate department.

Type of diagnostic tools and procedures for evaluating the intermediate and final knowledge progress testing are given below.

Diagnostic and assessment procedures

<table>
<tr><th colspan="3">Intermediate control</th><th colspan="2">Final assessment</th></tr>
<tr><th>Training sessions</th><th>Diagnostic tools</th><th>Procedures</th><th>Diagnostic tools</th><th>Procedures</th></tr>
<tr><td>Lectures</td><td>Control tasks for each topic</td><td>Task during lectures</td><td rowspan="3">Comprehensive reference work (ccw)</td><td rowspan="3">Determining the average results of intermediate controls;

Ccw performance during the examination at the request of the student</td></tr>
<tr><td rowspan="2">Practical</td><td>Control tasks for each topic</td><td>Tasks during practical classes</td></tr>
<tr><td>Or individual task</td><td>Tasks during independent work</td></tr>
</table>

During the intermediate control, the lectures are evaluated by determining the quality of the performance of the control specific tasks. Practical classes are assessed by the quality of the control or individual task.

If the content of a particular type of teaching activity is subordinated to several descriptors, then the integral value of the assessment may be determined by the weighting coefficients set by the lecturer.

Provided that the level of results of the intermediate controls of all types of training at least 60 points, the final control can be carried out without the student's immediate participation by determining the weighted average value of the obtained grades.

Regardless of the results of the intermediate control, every student during the final knowledge progress testing has the right to perform the CDF, which contains tasks covering key disciplinary learning outcomes.

The number of specific tasks of the CDF should be consistent with the allotted time for completion. The number of CDF options should ensure that the task is individualized.

The value of the mark for the implementation of the CDF is determined by the average evaluation of the components (specific tasks) and is final.

The integral value of the CDF performance assessment can be determined by taking into account the weighting factors established by the department for each NLC descriptor.

7. Course policy

7.1. Academic Integrity Policy

Academic integrity of students is an important condition for mastering the results of training in the discipline and obtaining a satisfactory grade on the current and final tests. Academic integrity is based on condemnation of the practices of copying (writing with external sources other than those allowed for use), plagiarism (reproduction of published texts by other authors without indication of authorship), fabrication (fabrication of data or facts used in the educational process). The policy on academic integrity is regulated by the Regulation "Regulations on the system of prevention and detection of plagiarism at the Dnipro University of Technology (http://www.nmu.org.ua/ua/content/activity/us_documents/System_of_prevention_and_detection_of_plagiarism.pdf.)

In case of violation of academic integrity by a student (copying, plagiarism, fabrication), the work is evaluated unsatisfactorily and must be repeated. The teacher reserves the right to change the topic of the task.

7.2. Communication policy

Students must have activated university mail.

It is the student's responsibility to check the mailbox at Office365 once a week (every Sunday).

During the weeks of independent work, it is the student's responsibility to work with the distance course "Higher Mathematics" (www.do.nmu.org.ua)

All written questions to teachers regarding the course should be sent to the university e-mail.

7.3. Reassembly policy

Works that are submitted in violation of deadlines without good reason are evaluated at a lower grade. Relocation takes place with the permission of the dean's office if there are good reasons (for example, sick leave).

7.4. Attending classes

Full-time students are required to attend classes. Good reasons for not attending classes are illness, participation in university events, business trips, which must be confirmed by documents in case of prolonged (two weeks) absence. The student must inform the teacher either in person or through the headmaster about the absence from class and the reasons for absence. If a student is ill, we recommend staying home and studying with a distance platform. Students whose health is unsatisfactory and may affect the health of other students will be encouraged to leave the class (such absence will be considered an absence due to illness). Practical classes are not repeated; these assessments cannot be obtained during the consultation. For objective reasons (for example, international mobility), learning can take place remotely - online, in agreement with the teacher.

7.5 Evaluation Appeal Policy

If the student does not agree with the assessment of his knowledge, he may appeal the assessment made by the teacher in the prescribed manner.

7.6. Bonuses

Students who regularly attended lectures (have no more than two passes without good reason) and have a written syllabus of lectures receive an additional 2 points to the results of the assessment to the final grade.

7.7. Participation in the survey

At the end of the course and before the session, students will be asked to fill out anonymously questionnaires (Microsoft Forms Office 365), which will be sent to your university mailboxes. Completing the questionnaires is an important component of your learning activity, which will allow you to assess the effectiveness of the teaching methods used and take into account your suggestions for improving the content of the discipline "Higher Mathematics".

8 Recommended bibliography

1. Werner Leonard. Control of Electric Drives. Springer Science & Business Media, 2001.
2. Bose Bimal K. Power Electronics and Motor Drives: Advances and Trends. –Elsevier, 2006. – 917 p.
3. Vas, Peter. Sensorless Vector and Direct Torque Control / Peter Vas – New York: Oxford University Press Inc, 1998. – 367 p.
4. Перельмутер В.В. Прямое управление моментом и током двигателей переменного тока. Научное издание, Харьков: Основа, 2004 -210с.
5. Спеціальні питання теорії електропривода: навч. посібник (3 частини) /І.С. Шевченко, Д.І. Морозов. – К.: Кафедра, 2014.
6. Попович М.Г., Лозинський О.Ю., Клепіков В.Б. та інш. Електромеханічні системи автоматичного керування та електроприводи. Навч. посіб. за напрямом «Електромеханіка» / М.Г. Попович, О.Ю. Лозинський, В.Б. Клепіков та інш. – К.: Либідь, 2005. Ч1.– 397 с.; Ч2. – 680 с.