



Національний технічний університет України
«КИЇВСЬКИЙ ПОЛІТЕХНІЧНИЙ ІНСТИТУТ
імені ІГОРЯ СІКОРСЬКОГО»



Department of
Electromechanics FEA

BRUSHLESS AND SWITCHING SYSTEMS IN ELECTROMECHANICS

Work program of the discipline (Syllabus)

Details of the discipline

Level of higher education	<i>Second (master's)</i>
Branch of knowledge	<i>14 "Electrical Engineering"</i>
Specialty	<i>141 "Electric power, electrical engineering and electromechanics"</i>
Educational program	BRUSHLESS AND SWITCHING SYSTEMS IN ELECTROMECHANICS <i>(ELECTRICAL LOW VOLTAGE SWITCHING DEVICES)</i>
Discipline status	<i>Selective</i>
Form of study	<i>Full-time (day) / correspondence / remote / mixed</i>
Year of preparation, semester	<i>1 course, spring semester</i>
The scope of discipline	<i>165 hours / 5.5 ECTS credits</i>
Semester control / control measures	<i>Offset / MCR</i>
Timetable	http://rozklad.kpi.ua/Schedules/ViewSchedule.aspx?v=9f535d05-ccd4-4f3a-983e-966c052418db
Language of instruction	<i>Ukrainian</i>
Information about course leader / teachers	Lecturer: <i>Ph.D. Kovalenko Mykhailo Anatoliiovych, 0676563651</i> Practical: <i>Ph.D. Kovalenko Mykhailo Anatoliiovych, 0676563651</i>
Course placement	https://do.ipk.kpi.ua/course/view.php?id=740

Program of academic discipline

1. Descriptive discipline, its purpose, subject of study and learning outcomes

The curriculum of the discipline "Brushless and switching systems in electromechanics" is compiled in accordance with the educational and professional training program for masters in the field of knowledge 14 "Electrical Engineering" in the specialty 141 "Electrical Engineering, Electrical Engineering and Electromechanics".

The purpose of the discipline is the formation of students' theoretical and practical knowledge about electrical devices of their choice, and the effective application in modern electrical networks.

The subject of the discipline - parameters and characteristics of Brushless and switching systems in electromechanics.

Program learning outcomes:

Competencies: (LC1-10) Ability to apply knowledge in practice; Ability to communicate in the state language both orally and in writing; Ability to communicate in a foreign language; Ability to use information and communication technologies; Ability to search, process and analyze information from various sources; Ability to identify, pose and solve problems; Ability to make informed decisions; Willingness and ability to perform high quality work both independently and collectively and to make decisions within their professional knowledge and competencies; Ability to communicate with representatives of other professional groups of different levels; The ability to act socially responsibly and consciously.

(FC 2, 4-6, 10-13, 17) Ability to solve practical problems with the involvement of higher mathematics,

general physics and theoretical electrical engineering; Ability to solve practical problems related to the problems of metrology, electrical measurements, the operation of automatic control devices, relay protection and automation; Ability to solve practical problems related to the operation of electric machines, devices and automated electric drive; Ability to solve practical problems related to the problems of production, transmission and distribution of electricity; Awareness of the need to increase energy efficiency of electrical, electrical and electromechanical equipment; Awareness of the need to constantly expand their knowledge of new technologies in power engineering, electrical engineering and electromechanics; Ability to identify, obtain and place the necessary data, plan and conduct analytical and experimental research and modeling of electrical machines and devices, critically evaluate data and draw conclusions; Ability to effectively use new technologies in the process of modernization and reconstruction of electrical equipment, electrical machines and apparatus, electric transport, electrical devices, systems and complexes.

Knowledge: design and principle of operation of circuit breakers, ELVs, differential circuit breakers, starters and auxiliary devices to them; methods of calculation of short circuit in the network of an industrial enterprise.

Skills: to choose electric switching devices for specific practical conditions; to create mathematical models of electric power networks, adequate to the task; perform calculations of the main modes of operation of transformers and electrical machines; to give the analysis and the description of the established and transient processes in systems in which there are electric cars and devices and to draw the corresponding conclusions.

Experience: experimental research of electric switching devices in laboratory conditions; technical calculations in the networks of the industrial enterprise and the choice of electrical switching devices; gaining skills in working with electrical switching devices, to master the methods of their experimental research, to get acquainted with some technological means of production of electrical devices, as well as with the achievements and problems in the field of modern electrical engineering. Experience of technical calculations in the networks of an industrial enterprise and the choice of electrical switching devices

2. Prerequisites and postrequisites of the discipline (place in the structural and logical scheme of education according to the relevant educational program)

To successfully master the discipline the student must have: higher mathematics, physics, theoretical foundations of electrical engineering, electric machines. Discipline "Brushless and switching systems in electromechanics", using the known laws of electrical engineering, creates a method of calculation and selection of switching devices for the protection of electric motors and other electrical equipment in power supply networks. When studying the design and modes of operation of electrical switching devices also require knowledge of electrical materials, applied mechanics, electronics, basics of metrology and electrical measurements. General education issues are considered in the analysis of emergency transients in electrical networks.

3. The content of the discipline

The discipline is structurally divided into 6 sections, namely:

1. **Introduction, basic provisions and concepts of low voltage electrical switchgear**, which included questions about the subject and objectives of the course "Electrical switching devices". Electrical switching devices in circuits for protection of electric motors of alternating current. Classification of electrical switching devices. Radial-main power supply circuit of an industrial enterprise (fitting). Emergency modes are possible during engine operation.
2. **Operating modes of electrical devices in 0.4 kV networks**, which included questions about the features of 0.4 kV networks. Short circuit in the mains. Modes of operation of electrical devices. Coordination of protective characteristics of protection devices with maximum allowable current and time loads of different consumers.
3. **Elements of the theory of switching devices**, which included questions about losses in electrical appliances. The main types of electrical contacts. Transient resistance of contact, its dependence on

force of a press, material of the conductor. Dwight Forces. Switching of an electric circuit with active-inductive loading. Electric arc and methods of its extinguishing.

4. **Circuit breakers**, which included questions about the regulatory framework, technical requirements, purpose, principle of operation, classification, technical characteristics of modern modular switches. Time-current characteristics. Calculation of short circuit currents. Selection of modular circuit breakers. Additional devices (additional contacts, independent splitter, splitting of maximum and minimum voltage, etc.) on the DIN-rail. Features of high current switches. Load switches and other types of switches. Protective circuit breakers (RCDs) and differential circuit breakers. Purpose, concept of differential current, principle of operation, classification, technical characteristics, areas of application.
5. **Magnetic starters, contactors**, which included questions about the design and principle of operation of the magnetic starter, operating modes, basic technical characteristics. Thermal relays, additional contacts, time switches and other additional devices to contactors.
6. **Other electrical switching devices for motor protection**, which included questions about the relay to control the magnitude and symmetry of phase voltages. Devices for temperature control of windings of electric machines. Fuses.

4. Training materials and resources

Main information resources:

1. Electrical and electronic devices: Textbook of universities / Ed. YK Rozanova. - 2nd ed. ispr. and add.- M.: Informelectro, 2001.-420 p.
2. Klimenko BV Electrical devices: Switching, control and protection equipment. General course: Textbook - Kharkiv: Publishing House "Point", 2012. - 266 p.
3. Klimenko BV Switching equipment, control equipment, fuses. Terms, interpretations, comments. Textbook.-Kharkiv: Talent, 2008.- 208p.
4. Distance course "Electric low voltage switchgear"
<https://do.ipk.kpi.ua/course/view.php?id=740>

Additional:

1. Methodical instructions for laboratory work in the discipline "Electrical switching devices". Sections: "Electric devices for starting and protection of electric motors". Kyiv: KPI named after Igor Sikorsky, 2017. - 29 p.
2. Belyaev AV "Choice of equipment, protections and cables in 0.4 kV networks." - St. Petersburg: Energoatomizdat, 1988.
3. Voldek AI Electric machines - L., Energy, - 1974, 782 p.
4. Rules devices of electrical installations .. - Moscow: Energoatomizdat, 1986.
5. Akimov EG, Chunikhin A.A. "Selection of electrical protection devices for power semiconductor devices: Course manual: Selection and application of electrical control and protection devices." - Moscow: MEI Publishing House, 1993.
6. Akimov EG, Korobkov Yu. S., Savelyev AV, etc. "The choice of electrical devices for electric drive, electric transport and power supply of industrial enterprises: Textbook for the course: Electrical devices." - Moscow: MEI Publishing House, 1990.
7. AA Chunikhin, EG Akimov, Yu.S. Boxes, etc. "The choice of electrical devices for industrial plants." - Moscow: MEI Publishing House, 1990.

Educational content

5. Methods of mastering the discipline (educational component)

Lectures

No	The title of the lecture topic and a list of key issues
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s / n	(list of teaching aids, links to information sources)
1	<p>Subject and tasks of the course "Brushless and switching systems in electromechanics". Low-voltage electrical switching devices in the protection circuits of AC electric motors. Classification of electrical switching devices. Radial-main power supply circuit of an industrial enterprise (fitting). Emergency modes are possible during engine operation.</p> <p>literary sources: [2, p. 9 - 12], [1, p.157 - 159].</p> <p>distance course "Brushless and switching systems in electromechanics" lecture 1https://do.ipk.kpi.ua/course/view.php?id=740</p>
2	<p>Operating modes of electrical devices in 0.4 kV networks. Features of 0.4 kV networks. Short circuit in the mains. Modes of operation of electrical devices. Coordination of protective characteristics of protection devices with maximum allowable current and time loads of different consumers.</p> <p>literary sources [1, p. 158 - 166], [5];</p> <p>distance course "Brushless and switching systems in electromechanics" lecture 2https://do.ipk.kpi.ua/course/view.php?id=740</p>
3	<p>Elements of the theory of switching devices. Losses in electrical appliances. The main types of electrical contacts. Transient resistance of contact, its dependence on force of a press, material of the conductor. Dwight Forces. Switching of an electric circuit with active-inductive loading. Electric arc and methods of its extinguishing.</p> <p>literary sources [1, p. 9 - 26, c. 70 - 75], [2].</p> <p>distance course "Electric low voltage switchgear" lecture 3https://do.ipk.kpi.ua/course/view.php?id=740</p>
4	<p>Automatic switches (general questions). General questions (regulatory framework, technical requirements, purpose, principle of operation, classification, technical characteristics) of modern modular switches. Time-current characteristics.</p> <p>literary sources [1, p. 31 - 46, p. 76 - 78], [2].</p> <p>distance course "Electric low voltage switchgear" lecture 4 https://do.ipk.kpi.ua/course/view.php?id=740</p>
5	<p>Selection of circuit breakers and additional devices. Calculation of short circuit currents. Selection of modular circuit breakers. . Additional devices (additional contacts, independent splitter, splitting of maximum and minimum voltage, etc.) on the DIN-rail.</p> <p>literary sources [1, p. 47 - 52, p. 78 - 82], [2];</p> <p>distance course "Electric low voltage switchgear" lecture 5https://do.ipk.kpi.ua/course/view.php?id=740</p>
6	<p>High current circuit breakers. Features of high current switches. Load switches and other types of switches.</p> <p>literary sources [1, p. 52 - 58, p. 83 - 87], [2];</p> <p>distance course "Electric low voltage switchgear" lecture 6https://do.ipk.kpi.ua/course/view.php?id=740</p>
7	<p>Protective circuit breakers (RCDs) and differential circuit breakers. Purpose, concept of differential current, principle of operation, classification, technical characteristics, areas of application.</p> <p>literary sources [1, p. 118 - 126, 175 -179], [2, 4, 6, 7, 8, 9].</p> <p>distance course "Brushless and switching systems in electromechanics" lecture 7https://do.ipk.kpi.ua/course/view.php?id=740</p>
8	<p>Magnetic starters, contactors. Design and principle of operation of the magnetic starter, operating modes, main technical characteristics. Thermal relays, additional contacts, time switches and other additional devices to contactors.</p> <p>literary sources [1, p. 106 - 110, 113 - 118, 170 - 174], [7, 8, 9].</p> <p>distance course "Electric low voltage switchgear" lecture 8https://do.ipk.kpi.ua/course/view.php?id=740</p>

9	<p><i>Other Electric switching devices of low voltage of protection of motors. Relay for controlling the magnitude and symmetry of phase voltages. Devices for temperature control of windings of electric machines. Fuses.</i></p> <p><i>literary sources [1, p. 106 - 113].</i></p> <p><i>distance course "Electric low voltage switchgear" lecture</i></p> <p><i>9https://do.ipk.kpi.ua/course/view.php?id=740</i></p>
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Laboratory work

<i>№ s / n</i>	<i>The name of the topic of the lesson and a list of main questions</i>
1	Introductory lesson. Instruction on the rules of safety and behavior during laboratory work. Features of research schemes. Familiarity with laboratory and demonstration stands of the laboratory distance course "Electric low voltage switchgear" https://do.ipk.kpi.ua/course/view.php?id=740
2	Laboratory work №1. Examination of the circuit breaker. Familiarity with the design of the circuit breaker and additional devices. Experimental determination of the main parameters and characteristics of the modular circuit breaker, determination of losses on the contacts of the switch. distance course "Electric low voltage switchgear" https://do.ipk.kpi.ua/course/view.php?id=740
3	Laboratory work №2. Research of the differential automatic switch (DAV). Familiarity with the design of DAV. Check of working capacity, experimental definition of time of operation of DAV from size of supply voltage. Experimental determination of DAV operation time from the value of differential current at rated voltage. Measurement of time of operation of DAV at current overload in a working circuit. distance course "Electric low voltage switchgear" https://do.ipk.kpi.ua/course/view.php?id=740
4	Laboratory work №3. Investigation of magnetic starter (contactor) and thermal relay. Familiarity with the designs of the magnetic starter (MP), additional contacts (DC), thermal relay (RT), voltage relay (PH), experimental study of time-current characteristics of RT, determination of power losses in the winding MP. Experimental study of voltage relays when voltage changes and supply voltage asymmetry BP. distance course "Electric low voltage switchgear" https://do.ipk.kpi.ua/course/view.php?id=740
5	Laboratory work №4. Research of the automatic switch of protection of the alternating current motor. Acquaintance with designs of the automatic switch of protection of the motor of alternating current, additional devices, experimental research of time-current characteristics depending on current of the switch setpoint. distance course "Electric low voltage switchgear" https://do.ipk.kpi.ua/course/view.php?id=740

6. Independent work of student

<i>№3 / n</i>	<i>Type of independent work</i>	<i>Number hours of CPC</i>
1	Preparation for classroom classes	12
2	Problem solving	8
3	Preparation for MCR	6
4	Preparation for the test	10

Policy and control

7. Course policy (educational component)

The system of requirements that the teacher puts before the student:

- rules for attending classes: in accordance with Order 1-273 of 14.09.2020, it is prohibited to assess the presence or absence of the applicant in the classroom, including the accrual of incentive or penalty points. According to the RSO of this discipline, points are awarded for the relevant types of educational activity in lectures and laboratory work.
- rules of conduct in the classroom: the student has the opportunity to receive points for the relevant types of educational activities in lectures and practical classes provided by the RSO discipline. The use of means of communication to search for information on the teacher's Google

drive, on the Internet, in a distance course on the Sikorsky platform is carried out under the guidance of the teacher;

- rules for assigning incentive and penalty points: incentive and penalty points are not included in the main scale of the RSO, and their amount does not exceed 10% of the starting scale. Incentive points are awarded for participation in faculty and institute competitions in the discipline of "Brushless and switching systems in electromechanics", participation in faculty and institute scientific conferences. Penalty points are awarded for late performance of laboratory work.
- policy of deadlines and rearrangements: untimely performance of practical tasks involves accrual of penalty points. If a student does not pass or does not appear at the MCR, his result is estimated at 0 points. Reassignment of protection of laboratory works and results of MCR is not provided;
- Academic Integrity Policy: Code of Honor of the National Technical University of Ukraine "Kyiv Polytechnic Institute" <https://kpi.ua/files/honorcode.pdf> establishes general moral principles, rules of ethical conduct of individuals and provides a policy of academic integrity for people who work and study at the university, which they should be guided in their activities, including the study and preparation of control measures in the discipline of "Low voltage electrical switchgear";
- when using digital means of communication with the teacher (mobile communication, e-mail, correspondence on forums and social networks, etc.) it is necessary to adhere to generally accepted ethical norms, in particular to be polite and limit communication during the teacher's working hours.

8. Types of control and rating system for evaluation of learning outcomes (RSO)

Current control: express survey, MCR, problem solving

Calendar control: conducted twice a semester as a monitoring of the current state of compliance with the requirements of the syllabus.

Semester control: credit

Conditions of admission to semester control: minimum positive assessment for work in laboratory and lecture classes, modular control, semester rating more than 40 points.

Table of correspondence of rating points to grades on the university scale:

Scores	Rating
100-95	Perfectly
94-85	Very good
84-75	Fine
74-65	Satisfactorily
64-60	Enough
Less than 60	Unsatisfactorily
Admission conditions are not met	Not allowed

The overall rating of the student after the end of the semester consists of points obtained for:

- answers during express surveys at lectures;
- performance and defense of four laboratory works;
- performance of two control works within the framework of modular control work (MCR).

Express survey	Laboratory work	MCR	Rs	Rzal	R
6	24	30	60	40	100

Answers during express surveys at lectures

Weight score - 3. The maximum number of points in all lectures is: 3 points * 2 = 6 points.

Evaluation criteria:

- 3 points - a complete reasonable answer,
- 1... 2 points - insufficiently substantiated answer,
- 0 points - no or incorrect answer

Laboratory work

Weight score - 6. The maximum number of points for all laboratory work is: 6 points * 4 = 24 points.

Evaluation criteria:

- 1 points - preparation for work,
- 2 points - laboratory work,
- 3 points - defense of laboratory work.

Modular control work

Weight score - 15. The maximum number of points for all tests is: 15 points * 2 = 30 points. Evaluation criteria:

- 15 points - a complete reasonable answer,
- 8... 10 points - insufficiently substantiated answer,
- 6... 7 points - the presence of 1-2 errors,
- 3 points - unreasonable answer with errors.

Calendar control is based on the current rating. The condition of positive attestation is the value of the current student rating not less than 50% of the maximum possible at the time of attestation.

Form of semester control - credit

The test consists of theoretical questions performed in the form of tests.

Credit evaluation criteria

Rating $R_c \geq 0.6 * R$, ie 60 points - is credited automatically.

Rating R_c in the range $(0.4 - 0.59) * R$, ie 40 - 59 points - students take the test.

Maximum credit rating $R_s = 40$ points.

Score $R_3 = 33 - 40$ points - the student gave comprehensive answers to all questions (if necessary - and additional), gives clear definitions of all concepts and values, the answers are logical and consistent.

Score rating $R_3 = 25 - 32$ points - answering the questions, the student makes some mistakes, but can correct them with the help of the teacher; knows the definition of basic concepts and values of the discipline, in general understands the physical essence of electromagnetic processes in the objects studied.

Score rating $R_3 = 16 - 24$ points - the student partially answers the exam questions, shows knowledge, but does not sufficiently understand the physical essence of electromagnetic energy conversion processes. The answers are inconsistent and vague.

Credit rating $R_z \leq 15$ points - in response, the student makes significant mistakes, shows a lack of understanding of the physical nature of electromagnetic processes, can not correct mistakes with the help of the teacher. The answers are incorrect, and in some cases do not correspond to the essence of the question.

9. Additional information on the discipline (educational component)

The list of topics that are submitted for semester control

1. Purpose and principle of operation of modular AV.
2. The main structural elements of the modular AV type VA 47-29. What is a DIN rail?
3. The main technical characteristics of AB.
4. What is the nominal and maximum switching current AB.
5. Time-current characteristic of AB, and its types.
6. For which types of consumers are AB with characteristics B, C and D used?
7. Which releases provide protection in the area of current overloads and short circuits? The mechanism of free disengagement.
8. What additional equipment is available to expand the functions of the AB?
9. Purpose of modular DAV.
10. The principle of operation of modular DAV.
11. The main structural elements of the modular DAV type AD-12.
12. The main technical characteristics of DAV.

13. What is the rated and rated differential current of the DAV?
14. Time-current characteristic of DAV.
15. What are category A and AC safety cut-outs?
16. How to check the efficiency of DAV.
17. What is the difference between DAV for human protection and fire protection?
18. What is the difference between safety shut-off devices and DAV?
19. Purpose and principle of operation of contactors.
20. Purpose and principle of operation of RN.
21. Purpose and principle of operation of the Republic of Tatarstan.
22. The main technical characteristics of contactors.
23. The main technical characteristics of PH.
24. The main technical characteristics of RT.
25. Time-current characteristic of RT, and its types.
26. Purpose and principle of operation of modular AVZD
27. The main structural elements of the modular AVZD type VA 2005. What is a DIN-rail?
28. The main technical characteristics of AVZD.
29. What is the nominal and maximum switching current of the AVZD.
30. Time-current characteristic of AVZD.

Certificates of distance or online courses on the subject can be credited subject to compliance with the requirements set out in Order № 7-177 of 01.10.2020 On approval of the provisions on recognition in the KPI. Igor Sikorsky learning outcomes acquired in non-formal / informal education

Work program of the discipline (syllabus):

Folded Associate Professor of Electromechanics FEA, Ph.D. Kovalenko MA

Approved Department of Electromechanics FEA (protocol № 11 dated 24.06.2021)

Agreed Methodical commission of the faculty¹ (Minutes № 11 of June 25, 2021)

¹Methodical council of the university - for general university disciplines.