Vinnytsia National Technical University
Faculty power industry and electromechanics
Department power stations and systems

AUTOMATIC CONTROL SYSTEMS FOR POWER PLANTS

Mandatory
Professional
II (master's) level higher education

Field of knowledge **14 – Electrical engineering**
Specialty **141 – Electricity, electrical engineering and electromechanics**

Educational programs: **Electric stations**

Teacher: **Komar Vyacheslav, Sikorska Olena**
Language teaching: **Ukrainian**

Semester - **2**
Credits EPSTS – **4**
Lectures – **18 hours**
Practical - **18 hours**
Laboratory – **9 hours**
Course work - 1.5 credits / **45 hours**
Independent work - **30 hours**
Type of control: **exam**

Prerequisites for studying the discipline: the discipline "Automatic control systems for power plants " is based on the study of the methodological and theoretical foundations of automated control systems (ACS) of electric stations, the structure and structure of the sectoral ACS, methods of optimizing the modes of electric stations in the power system. This discipline is related to and complements such disciplines as " Computer engineering and CAD in power engineering", " Electrical part of stations and substations", "Electrical systems and networks", "Electric machines", "Electrical devices", "Transient processes", " Mathematical problems of power engineering", "Theory of automatic control".

The purpose of teaching the educational discipline is to master the methods of optimal management of the process of production and distribution of electricity in conditions of widespread use of modern computer technology. Familiarize yourself with the methodological and theoretical foundations of ACS, with the basics of construction and structure of sectoral ACS in energy, with the features of ACS TP EPS operation in normal, start-up and emergency modes, with methods of

optimizing EPS modes in the power system.

Competencies that the applicant must master as a result of studying the discipline

The study of an academic discipline involves the formation and development of students' competencies:

Integral: The ability to solve complex problems and tACSs during professional activity in the field of electric power, electrical engineering and electromechanics or in the learning process, which involves conducting research and/or implementing innovations and is characterized by uncertainty of conditions and requirements.

General:

GC03. Ability to use information and communication technologies.

GC 06. Ability to make informed decisions, apply best practices in professional activities.

GC 08. Ability to identify and assess risks.

Special (professional):

SC02. The ability to apply existing and develop new methods, techniques, technologies and procedures for solving engineering tasks of electric power and electrical engineering.

SC04. The ability to develop and implement measures to increase reliability, efficiency and safety in the design and operation of equipment and facilities of the electric power industry.

SC05. Ability to carry out analysis of technical and economic indicators and examination of design and construction solutions in the field of electric power and electrical engineering.

SC06. Ability to demonstrate knowledge and understanding of mathematical principles and methods required for use in electrical power, electrical engineering, and electromechanics.

SC11. The ability to evaluate indicators of reliability and efficiency of the functioning of electric power systems, electrotechnical and electromechanical objects.

SC13. Ability to demonstrate awareness and ability to use regulatory and legal acts, norms, rules and standards in electric power.

SC14. Ability to use software for computer modeling, automated design, automated manufacturing and automated development or construction of elements of power systems.

SC16. The ability to solve complex specialized tasks and practical problems related to the operation of information systems in electric power engineering, electrical engineering and electromechanics.

Program results of studying the discipline

PR1. Find options for increasing energy efficiency and reliability of electric power, electrotechnical and electromechanical equipment and corresponding

complexes and systems.

PR2. Reproduce processes in electric power, electrotechnical and electromechanical systems when simulating them on a personal computer.

PR3. Master new versions or new software designed for computer modeling of objects and processes in electric power, electrotechnical and electromechanical systems.

PR5. Analyze processes in electric power, electrotechnical and electromechanical equipment and corresponding complexes and systems.

PR7. To have the methods of mathematical and physical modeling of objects and processes in electric power, electrotechnical and electromechanical systems.

PR27. Identify the main factors and technical problems that may hinder the implementation of modern methods of controlling electric power, electrotechnical and electromechanical systems.

1. Description of the academic discipline

<table>
<tr><td rowspan="2">Name of indicators</td><td rowspan="2">Field of knowledge, specialty, educational programs, level of higher education</td><td colspan="2">Characteristics of the academic discipline</td></tr>
<tr><td>full-time education</td><td>external form of education</td></tr>
<tr><td>The number of credits is 4</td><td>Branch of knowledge
14 Electrical engineering</td><td colspan="2">Mandatory professional</td></tr>
<tr><td>Modules - 2</td><td rowspan="5">Specialty

141 Power engineering, electrical engineering and electromechanics

Educational program:

Electric stations</td><td colspan="2">Year of training (course):</td></tr>
<tr><td>Content modules – 2</td><td>1</td><td>1</td></tr>
<tr><td>Individual scientific and research task — course work and reports at the annual scientific and technical conference of VNTU divisions</td><td colspan="2">Semester</td></tr>
<tr><td rowspan="2">The total number of hours is 120</td><td>2nd</td><td>2nd</td></tr>
<tr><td colspan="2">Lectures</td></tr>
<tr><td rowspan="10">Weekly hours for full-time education: classrooms - 2.8 student's independent work - 4.7</td><td rowspan="10">Level of higher education: second (master's)</td><td>18</td><td>10</td></tr>
<tr><td colspan="2">Practical, seminar</td></tr>
<tr><td>18</td><td>5</td></tr>
<tr><td colspan="2">Laboratory</td></tr>
<tr><td>9</td><td>5</td></tr>
<tr><td colspan="2">Coursework</td></tr>
<tr><td>45</td><td>45</td></tr>
<tr><td colspan="2">Independent work</td></tr>
<tr><td>30</td><td>55</td></tr>
<tr><td colspan="2">type of control</td></tr>
<tr><td colspan="2">Type of control: exam</td></tr>
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2. Program of educational discipline

Information volume of the academic discipline

Content module 1. Methodological and theoretical foundations of the construction of ACS of electric stations.

Topic 1. Methodology for creating ACS in energy. Structure of ACS.

Introduction. Literature. Study subject and course ACSs. Definition - system, automated control system, ACS, optimization, classification of ACS. Basic principles of ACS management. Functional subsystems of ACS.

Functional ACS. ACS with integrated information systems. Structure and parameters of ACS. Providing subsystems and hierarchy of the ACS. The main types of ASA. The structure of ACS subsystems of production, distribution and sale of electricity (VRRE).

Topic 2. Optimal control. Observability, controllability, identification, adaptation.

Conditions of identification processes. Conditions of identifiability, identification of processes in time. Controllability of nonlinear systems. Setting the tasks of adaptive management. Definition and classification of types of adaptability. Adaptability criteria. Control optimization criteria. Modern problems of optimization of dynamic systems. Human-machine interaction in ACS. Classification of ASA by place and role of man in them.

Topic 3. Basics of construction of ACS EPS and their operation

Principles of building control systems for a technological facility (TO). The main stages of maintenance management. Signs of ACS TP. The purpose and ACSs of ACS TP EPS. The degree of achievement of the set goal is a criterion of optimality. Restrictions when choosing management actions. Information and management functions of ACS TP EPS. Functional structure of ACS TP EPS. Types of ACS TP.

The main phases of TP management. Functions of automatic calculation of TEI and technical indicators. Determination of energy characteristics. Optimization of the combustion process, steam pressure, vacuum. Exchange of information with other ACSs. Functional structure of ACS TP nuclear unit.

Structural diagram. Functional groups (FG) of executive mechanisms (VM). Logical devices for individual and group management of VMs. The main data of the computing complex (OK) for various blocks - 300, 500, 800, 1000 MW. Main FG and their characteristics. Examples of FG.

Content module 2. Optimization of EPS operating modes.

Topic 4. Methods and means of optimizing EPS operating modes.

Determination and analysis of TEI in ACS TP. Operational, variable and reporting TEIs. TEI calculation periods. Structure of definition of TEI. Algorithm for determining operational TEIs. Requirements for TEI determination programs.

Characteristics of power plants. Energy characteristics of the equipment. Maneuvering characteristics. Equivalent characteristics and their definition in ACS

TP EPS. Construction of equivalent EPS characteristics by the method of dynamic programming. Average interval characteristics. Statistical characteristics.

The most profitable load distribution between EPS and EPS units Load distribution between TPPs. Distribution of the load in the UES with hydroelectric power stations, nuclear power plants and hydroelectric power plants. Distribution of reactive power between EPSs. Selection of the optimal composition of aggregates on the EPS.

Implementation of calculations of the most favorable load distribution between EPS and aggregates. Group management. GRAM and GRRM type devices. Individual control of EPS units. Management of EPS as part of ASDC power systems. Automation of optimal control. Use of microprocessors, programmable controllers in the control circuit.

Topic 5. Complex of technical devices of ACS EPS.

Computing equipment for ACS TP. Principles of computer construction and their adaptation in ACS. Peripheral devices. Multisystem properties of computers. Computer operating modes. Computer operation in the network. Computer communication devices with the control object.

Microprocessors and microprocessor systems. The principle of construction. Central processor. Internal and external highways. Elements of memory. devices for communication with the operator. Interface modules. Programmable controllers.

Means and systems of communication, transmission and display of information. Communication channels. Telemechanic devices. Information sensors. data transmission equipment. Means of displaying information for individual use. Means of displaying information for collective use. Means of display and dialogue.

Topic 6. Informational and special mathematical support.

Information basics of computing. The concept of information support - language and its characteristics. Database. Data bank. Database and knowledge management systems. Coding and display of alphanumeric information in a computer.

Algorithmic foundations of information processing. Stages of preparation and solving problems on a computer. Typical structures of algorithms. Data search and sorting algorithms. Organization of computer memory. Organization of transmission, management and output of information. Interface.

Technology for managing the quality of ACS functioning. Problems of ensuring the reliability of ACS. Reliable specificity of ASA. Methodology of managing the quality of ACS functioning. TACSs of managing the quality of functioning. Technology for managing the quality of ACS functioning.

Topics of laboratory classes

No s/p	Topic name
1	Selection of the functional structure of the ACS of the TP block and EPS. Determination of the volume of information of the ACS of the TP block and EPS.

2	Determination and analysis of TEI in ACS TP.
3	Transport problem. The method of potentials.
4	Determination of operating characteristics of the station.
5	Calculation of the economic effect of the implementation of the ACS EPS.

Topics of practical classes

No s/p	Topic name
1	Microprocessors in TP control.
2	Management of stabilization of TP parameters.
3	Software control of TP.
4	Regulation of voltage on EPS busbars.
5	Study of the optimal composition of aggregates and load distribution between EPS units.
6	Calculation of steady-state EES
7	The most profitable load distribution between stations in the power system.
8	Analysis and making of optimal decisions, determination of control laws of automated control systems.
9	Development of a system of optimal control of TP..

Independent work

No s/p	Topic name
1	Microprocessors and microprocessor systems
2	Means and systems of communication, transmission and display of information
3	Algorithmic foundations of information processing
4	Organization of transmission, management and output of information
5	The concept of expert systems

Individual tasks

The working curriculum provides for course work by full-time and part-time students.

The task of the course work is to consolidate knowledge and practical skills in determining the optimal distribution of active power between aggregates and power plants; construction of equivalent characteristics of an electric station.

According to the decision of the department, students prepare essays on separate topics of the discipline and reports for the annual scientific and technical conference of the VNTU divisions.

The subject of the course work

The course work is a calculation of the optimal distribution of active power between aggregates and power plants.

The settlement and explanatory note consist of the following sections:

Introduction.

1. General characteristics of optimization problems that are solved by ACS TP.

2. Preparation of initial data for the optimization of EEC modes.

2.1. Prediction of daily UES load schedules for active power.

2.2. Calculation and construction of cost characteristics of aggregates and power plants as a whole.

3. Optimum distribution of active power between power plant units.

4. Construction of equivalent characteristics of an electric station.

5. Construction of the dependence of active power losses on generation power.

6. Optimal distribution of active power between stations according to the criterion of equality of relative increases in conventional fuel consumption.

Conclusion

List of references

Teaching methods

The main teaching methods are: lecture-visualization; story-explanation; briefing; illustrating; demonstration, in particular, using multimedia learning tools; oral survey; testing; educational discussion; conversation-dialogue; performance of laboratory work; group work; a report on topics assigned to independent study; solution of practical tasks; consultations; independent work at home; individual assignments (course work, abstracts, essays, etc.), preparation of reports of a scientific and research nature, in particular, for the annual scientific and technical conference of VNTU divisions.

Control methods

Current control is carried out during practical and laboratory classes and is aimed at checking the level of the student's readiness to perform specific work. Current control can be carried out with the help of electronic tests in the local network or in the global network (JetIQ , Google) and conducting an oral or written survey.

Distribution of points received by students

Table 1 – Distribution of points for mastering content modules during the 2nd semester for full-time students

Current testing and independent work		Final test (exam)	Sum
Content module 1	Content module 2	25 points	100

T1	T2	T3	T4	T5	T6		
35 points			40 points				

T1, T2 ... T6 – topics of content modules.

Table 2 – Evaluation of students' knowledge, abilities and skills in certain types of work and in general by modules (in points)

Type of work	Module 1	Module 2	Together
1. Practical lessons (1 exam – 1 point)	9	9	18
2. Laboratory works (1 lr - 2 points)	10	8	18
3. Control work	8	5	13
4. Colloquium	8	8	16
5. Solving test tACSs	-	10	10
In total	35	40	75

Table 3 – Evaluation of the results of the coursework defense

Implementation of section 1	10
Implementation of section 2	10
Implementation of Section 3	10
Implementation of Section 4	10
Implementation of Section 5	10
Implementation of Section 6	10
Protection of term paper	40
In total	100 points

Methodical support

1. Work program of the educational discipline "Automatic control systems for power plants ".
2. Synopsis of lectures.
3. Methodical instructions for practical classes.
4. Methodical instructions for performing laboratory work.
5. Questions for colloquiums.
6. Questions for the control work.
7. Current knowledge control tests.
8. A set of examination tickets.
9. A set of complex control works.

Course policy

Applicants and teachers must adhere to the norms of ensuring honor, dignity, mutual respect and trust, equality and tolerance of all participants in the educational process by observing the principles of academic integrity set forth in the "Regulations on Academic Integrity **at VNTU**".

In order to prevent and detect plagiarism in academic works, to develop the skills of correct work with sources of information and to implement the practice of proper citation, compliance with the requirements of scientific ethics and respect for intellectual property, and activation of independence and individuality when creating an author's work and responsibility for violations of generally accepted rules of citation should be observed of norms **"Regulations on the prevention of academic plagiarism and the procedure for its detection in educational, scientific, qualification and scientific-methodological works at VNTU".**

In order to recognize the learning results obtained during non-formal and/or informal education (which was obtained according to educational programs and did not involve the awarding of state-recognized educational qualifications by education level, but could end with the awarding of professional and/or partial educational qualifications, as well as education that was carried out in the manner of self-education), applicants can use the relevant procedures specified in the **"Regulations on the procedure for recognizing learning results obtained through informal and/or informal education at VNTU".**

Applicants have the right to appeal the results of intermediate and final control measures, but only on the basis of reasoned explanations, in accordance with the **"Procedure for the organization and conduct of assessments, differentiated assessments, examinations at VNTU"**, as well as by directly contacting the educational ombudsman, according to the **"Regulations on the educational ombudsman on the rights of VNTU students"**.

In order to resolve conflict situations that may arise between applicants and other participants of the educational process and/or to prevent the occurrence of conflict situations, one should be familiar with the norms of the **"Code of Ethics of VNTU".**

VNTU applicants must be guided by the principle of "zero tolerance" to any manifestations of corruption and must take all measures provided by law to prevent, detect and counter corruption and related actions (practices), in accordance with the VNTU Anti-Corruption Program **.**

These documents are published on the VNTU website: https://vntu.edu.ua/uk/public-info/zag.html .

Recommended Books

1. Lezhnyuk P.D., Lukyanenko Yu.V., Kulyk V.V. ACS of electrical systems: Laboratory workshop. - Vinnytsia: VDTU, 2001. - 102 p.
2. Optimization of modes of electric power systems: training. a guide for universities / A.V. Zhurahivskyi - Lviv: Publishing House of Lviv Polytechnic, 2010.
3. Reliability of electric power systems and electric networks [Electronic resource]: a textbook for students majoring in "Electropower, electrical engineering and electromechanics" / A. V. Zhurahivskyi , S. V. Kazanskyi, Y. P. Mateyenko , O.

R. Pastukh ; KPI named after Igor Sikorsky. – Kyiv: KPI named after Igor Sikorskyi, 2017. – 457 c.

4. Telemechanics and automated control systems in electric power: training. help _ / [P. H. Pleshkov , S. V. Serebrennikov , K. G. Petrova]; Ministry of Education and Science of Ukraine, Kirovohrad. national _ Tech. Univ. – Kirovohrad: KNTU, 2016. – 163 p.

5. Technical operation of electrical stations and networks. Rules. - Kyiv: Industry, 2010. - 608 p. 17. Electricity of Ukraine. Structure, management, innovations: monograph / I. V. Khomenko, O. A. Plakhtiy, V. P. Nerubatskyi , I. V. Stasyuk. - Kharkiv: NTU "KhPI", LLC "Planeta- Print ", 2020. - 132 p.

6. Automatic regulation of frequency and flows of active power in energy systems. O.S. Yandulskyi , A.O. Stelyuk , M.P. Lukash; under the general editorship of O.S. Yandulskyi , K.NTUU "KPI", 2010.-88p.

7. Duel, M.A. Automated control of objects and technological processes of thermal and nuclear power plants / M.A. Duel. - Kharkiv, PP " KiK ", 2010. - 448 p.

8. Automated control system for technological processes of the 750 kV substation / B.S. Stognii, M.F. Sopel // Proceedings of the Institute of Electrodynamics of the National Academy of Sciences of Ukraine: Collection. of science pr. — K.: IED NANU, 2009. — Issue 23. — P. 33-38.

9. Distance course on the JetIQ platform "Automated power plant control systems" VNTU.

10. National Library of Ukraine named after Academician V. I. Vernadskyi: [site]. Access mode: http://nbuv.gov.ua/

11. Energy: [site]. Access mode: http:// LEONARDO.ENERGY.ORG /