Syllabus

Course Program

Reliability and Diagnostics

Specialty
141 Electrical Power Engineering, Electrical Engineering, Electromechanics

Institute
Institute of Energy, Electronics, and Electromechanics

Educational program
Electrical Power Engineering, Electrical Engineering, and Electromechanics

Department
Electric Power Transmission (131)

Level of education
Master's level

Course type
Special (professional), Mandatory

Semester
2

Language of instruction
English, Ukrainian

Lecturers and course developers

Olena Fedoseienko

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Candidate of Technical Sciences, Associate Professor at the Department of Electric Power Transmission

Work Experience: 17 years. Author of over 40 scientific and educational-methodical works. Main courses: "Reliability and Diagnostics," "Operation Conditions of Electrical Power Engineering," "Power Plants."
More about the lecturer on the department's website

General information

Summary

The course "Reliability and Diagnostics" addresses essential aspects of ensuring the reliability and uninterrupted operation of power systems. This course provides students with a profound understanding of reliability concepts in the field of electric power engineering and diagnostic methods to timely detect and rectify malfunctions in power systems.

Course objectives and goals

The aim of this discipline is to provide students with a deep understanding of the fundamental concepts and principles of reliability and diagnostics in electric power engineering. Additionally, it aims to prepare students for effective problem-solving tasks related to maintaining the reliability and uninterrupted operation of power systems.
Key Objectives of the Discipline:
Comprehend the concepts of reliability, safety, and diagnostics in electric power engineering.
Familiarize with common faults and failures in power systems and their consequences.
Study methods for ensuring the reliability of power system operation.
Master diagnostic techniques for equipment condition assessment and preventive maintenance planning.

Format of classes

Lectures, workshops, self-study, consultations. Final control in the form of an exam

Competencies

К01. The ability to search, process, and analyze information from various sources.
К05. The capability to make informed decisions.
К11. The application of theoretical knowledge, scientific, and technical methods to solve problems in the fields of electric power engineering, electrical engineering, and electromechanics.
К14. The ability to develop and implement measures to enhance the reliability, efficiency, and safety in the design and operation of equipment and facilities in the fields of electric power engineering, electrical engineering, and electromechanics.
К18. The ability to investigate and identify problems, including those related to environmental protection, sustainable development, human health and safety, and risk assessment in electric power engineering, electrical engineering, and electromechanics.
К21. Evaluation of reliability and performance indicators of electric power, electrical, and electromechanical equipment and systems.

Learning outcomes

ПР02. Develop a plan for enhancing the reliability, safety, and lifespan of electric power, electrical, and electromechanical equipment and relevant systems.
ПР10. Justify the choice of direction and research methodology, taking into account contemporary issues in the fields of electric power engineering, electrical engineering, and electromechanics.
ПР14. Identify ways to improve energy efficiency and reliability of electric power, electrical, and electromechanical equipment and relevant systems.
ПР15. Recognize problems and constraints related to environmental protection, sustainable development, human health, and safety, and risk assessment in the field of electric power engineering, electrical engineering, and electromechanics.
ПР17. Adhere to the principles and rules of academic integrity in educational and scientific activities.

Student workload

The total volume of the course is 150 hours (5 ECTS credits): lectures - 32 hours, workshops - 32 hours, self-study - 86 hours.

Course prerequisites

To successfully complete the course, it is necessary to have knowledge and practical skills in the following disciplines: : ЗП 9 "Higher Mathematics", СП 7 "Technical Mechanics", ЗП 10 "Physics",СП 4 "Theoretical Foundations of Electrical Engineering", СП 11 "Electric Power Stations and Substations", and СП 9 "Electrical Systems and Networks".

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

Lectures are conducted interactively using multimedia technologies. *Problem-oriented lectures* are one of the most important elements of problem-based learning for students. They involve, alongside the presentation of the main lecture material, the identification and discussion of a set of problem-based, debatable issues that are insufficiently developed in science and have practical relevance. Problem-oriented lectures feature in-depth material argumentation, fostering independent creative thinking in students and imparting cognitive skills. Students become participants in scientific research and problem-solving situations.
Discussions involve the exchange of opinions and views among participants on the given topic (question). They also stimulate critical thinking, help in shaping perspectives and convictions, develop the ability to formulate and express thoughts, and teach the assessment of other people's suggestions.
The case method is an approach for analyzing specific situations, which brings the learning process closer to the practical activities of professionals. It involves the consideration of problem situations during the study of educational material.
Presentations are speeches delivered to an audience and are used for presenting specific achievements, results of group work, reports on the completion of individual tasks, and project work. Presentations can be either individual, such as a presentation by one audience member, or collective.

Program of the course

Topics of the lectures

Topic 1. Basic Concepts and Reliability Characteristics
1.1. General principles and definitions of reliability.
1.2. Elements of probability theory in the analysis of energy equipment reliability.
1.3. Fundamental properties defining an object's reliability and the indices characterizing these properties.
Topic 2. Methods of Determining Reliability Indices for Technical Systems
2.1. Methods for representing the structural-functional relationships of system elements when determining reliability.
2.2. Boolean algebra and basic rules of logic expression transformation. Functionality and non-functionality of the system.
2.3. General method for calculating reliability indices.
2.4. Calculating changes over time in state probabilities for a two-element system (initial probabilities and final probabilities).
2.5. Logical-probabilistic method. Tabular method.
2.6. Determining reliability indices for simple systems using the general and logical-probabilistic methods.
2.7. Determining conditional shutdown probabilities for busbars in a distribution substation (four-corner scheme) when calculating reliability indices using the tabular method.
2.8. Statistical testing method.
Topic 3. Reliability Problems of Electric Power Systems and Their Solutions
3.1. General statement of the electric power system (EPS) reliability problem and its resolution strategy. Systematic approach (system analysis).
3.2. Models of equipment reliability in the reliability calculations of an EPS.
3.3. Accounting for the control system in the reliability models of electric power equipment.
3.4. Determining reliability indices for 110 kV electrical network components.
3.5. Structural system reliability model. Distribution network structure model. System-forming network structure model.
3.6. Developing a reliability model for the 110 kV electrical network structure and its analysis.
3.7. Reliability design problems for distribution electrical networks. Design stage tasks. Mathematical system model. Accounting for planned maintenance.
3.8. Determining the reliability indices of a 110/10 kV distribution network in relation to the 10 kV substation busbars.
3.9. Main means of ensuring EPS subsystem reliability.
3.10. Determining the reliability indices of the distribution substation (four-corner scheme) – resolution algorithm.

Topics of the workshops

Topic 1. Basic Concepts and Reliability Characteristics
1.1. Statistical assessment of reliability indicators for energy facilities under operational conditions.
1.2. Average electricity curtailment during partial failure of the Electric Energy System (EES) and the economic loss incurred. Resolution algorithm for determining the loss.
Independent Student Assignments:
1.3. Calculating the loss due to electricity curtailment during a partial EES failure.
Topic 2. Methods for Determining Reliability Indices of Technical Systems
2.1. General method for calculating reliability indices.
2.2. Method for calculating reliability indices based on Markov processes. Calculating changes in state probabilities over time for a two-element system (initial and final probabilities).
2.3. Logic-probabilistic method. Tabular method.
2.4. Determining reliability indices for simple systems using both general and logic-probabilistic methods.
2.5. Determining conditional shutdown probabilities for busbars in a distribution substation (four-corner scheme) using the tabular method.
2.6. Method of statistical testing.
Independent Student Assignments:

2.7. Calculating the reliability indices of the Operational Information Complex of the EES, consisting of two servers, using a method based on Markov processes.

Topic 3. Reliability Problems of Electric Power Systems and Their Solutions

3.1. Determining the reliability indices of 110 kV electrical network components.
3.2. Model of the reliability of the system structure. Model of the distribution network structure. Model of the system-forming network structure.
3.3. Forming the reliability model of the 110 kV electrical network structure and analyzing it.
3.4. Design problems for the reliability of distribution electrical networks. Design stage tasks. Mathematical system model. Accounting for planned maintenance.
3.5. Determining the reliability indices of the 110/10 kV distribution network concerning the 10 kV substation busbars.
3.6. Main means of ensuring the reliability of EES subsystems.
3.7. Calculating the reliability indices of the distribution substation (four-corner scheme).

Topics of the laboratory classes

Laboratory work within the discipline is not envisaged.

Self-study

Processing of lecture material. Self-study of topics and questions not covered during lectures. Completion of an individual assignment.

Course materials and recommended reading

1. Marko Cepin. Assessment of Power System Reliability. Methods and Applications. Springer : London. – 2011. – 300 p. ISBN 978-0-85729-687-0, e-ISBN 978-0-85729-688-7, DOI 10.1007/978-0-85729-688-7
2. Ali A. Chowdhury. Don O. Koval. POWER DISTRIBUTION SYSTEM RELIABILITY. Practical Methods and Applications. – IEEE Press. – John Wiley & Sons, Inc., Hoboken, New Jersey. – 2009. – 531 pp.
3. P.E. William, H. Smith. Electric Power System Reliability. – Paperback Alphagraphics-Roswell GA. – 2018. – 300 pp. ISBN-10 : 069294589X.
4. R. Medjoudj, H. Bediaf, and D. Aissani, 'Power System Reliability: Mathematical Models and Applications', System Reliability. InTech. – 2017. – doi: 10.5772/intechopen.71926.
5. Chanan Singh; Panida Jirutitijaroen; Joydeep Mitra, "Introduction to Power System Reliability," in *Electric Power Grid Reliability Evaluation: Models and Methods*, IEEE, 2019, pp.185-191, doi: 10.1002/9781119536772.ch7.

Assessment and grading

Criteria for assessment of student performance, and the final score structure

100% of the final grade consists of assessment results in the form of an exam (40%) and ongoing assessment (60%). Exam: 2 theory questions - oral presentation. Ongoing assessment: individual assignment (60%).

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

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