Syllabus
Course Program

Electromagnetic transient processes

Specialty
141 – Electric Power Engineering, Electrical Engineering and Electromechanics

Institute
Institute of Education and Science in Power Engineering, Electronics and Electromechanics

Educational program
Electrical Power Engineering. Electric Power Stations

Department
Electric Power Stations (130)

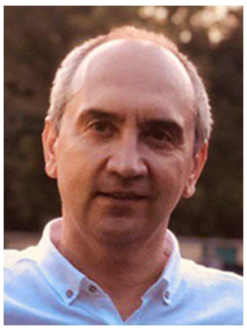
Level of education
Bachelor's level

Course type
Special (professional), Optional

Semester
5

Language of instruction
English, Ukrainian

Lecturers and course developers



Melnikov Heorhii Ihorovych

Heorhii.Melnykov@khpi.edu.ua
Candidate of Technical Sciences, associate professor at the Department of Electric Power Stations, NTU "KhPI"
Author of more than 50 scientific publications and educational works. Leading lecturer in the disciplines: "Modeling of electric power and electromechanical devices and systems", 'Electricity quality and quality management', 'Design of electric power systems and devices', 'Modern energy efficient technologies'.
More about the lecturer on the department's website

Fedorchuk Stanislav Olegovich

stanislav.fedorchuk@khpi.edu.ua
Candidate of Technical Sciences, Senior Lecturer at the Department of Electric Power Stations, NTU "KhPI"
Author and co-author of more than 20 scientific and methodological works. Courses: "Energy Management", 'Energy Management and Audit', 'Fundamentals of Energy Management', 'Fundamentals of Electric Power Engineering', 'Open Source Microprocessor Systems', 'Virtual Power Plants'.
More about the lecturer on the department's website

General information

Summary

The discipline covers the core range of issues related to the description and study of transients in electrical systems under changing operating conditions, mastering the methods and means of calculating transients under symmetrical and asymmetrical disturbances of electrical systems. Considerable attention is paid to the formation of skills and acquisition of skills by students in calculating the parameters of transient modes in electrical systems and the study and analysis of transients in electrical systems.

Course objectives and goals

Objective.
Development of knowledge of physics and mathematical description of electromagnetic transients in electrical systems under changing conditions of its operation, mastering the methods and means of calculating transients in case of violations of the operating modes of electrical systems, developing skills in the study and analysis of electromagnetic transients in case of short circuits in electrical systems.
Goals.
To know:
physics and mathematical description of transients in simple three-phase electric circuits and circuits with magnetic coupling;
physics of transients in a synchronous machine and their mathematical description.
practical methods for calculating transients under symmetrical and asymmetrical disturbances of electrical systems;
software and simulation complexes that allow to study transients in electrical systems.
To be able to:
calculate the parameters of transients in electrical systems;
investigate transients in electrical systems using virtual computer models;
predict quantitative changes in the system parameters based on changes in system parameters, propose the necessary measures for control)

Format of classes

Lectures, practical classes, laboratory work, independent work, calculation and defense of term papers, consultations. Final control - exam

Competencies

GC 1. Ability to apply knowledge and understanding in practice in a way that indicates a professional approach to problem solving in the field of electrical engineering.
GC 4. Ability to use information and communication technologies.
PC 1. Ability to use computer-aided design (CAD), manufacturing (CAM) and engineering calculations (CAE) systems and related application packages.
PC 2. Ability to theoretically substantiate the decisions made in the process of performing design and development and research work within the framework of a kind of occupation at the level of a specialist with a first-cycle higher education qualification in the field of electrical engineering.
PC 3. Ability to use basic knowledge of general physics, higher mathematics, theoretical foundations of electrical engineering and electrical materials to solve practical problems in the field of electricity, electrical engineering and electromechanics.
PC 8. Ability to use modern methods of calculation, modeling and analysis of operating modes of electric power, electrical and electromechanical equipment and design of electric power and electromechanical systems.
PC 13. Ability to perform experimental (model) studies of operating modes of electric power, electrical and electromechanical equipment.

Learning outcomes

PRT 12. To know and use the methods of basic sciences to solve general engineering and professional problems.
PRT 16. Determine the principles of construction and normal functioning of elements of electric power, electrical and electromechanical complexes and systems.
PRT 18. Evaluate the parameters of electrical, electrical and electromechanical equipment and related complexes and systems and develop measures to improve their energy efficiency and reliability.
PRT 20. Analyze processes in electrical, electrical and electromechanical equipment and related complexes and systems.
PRT 21. Collect and analyze information on abnormal modes and emergencies in the electrical industry to prevent their recurrence in the future.
PRT 30. Improve skills in working with modern equipment and software when performing calculations of operating modes of electrical, electrical power and electromechanical equipment, relevant complexes and systems

Student workload

Content of the discipline: 6 ECTS credits 180 hours.
Lectures: 48 hours.
Laboratory classes: 16 hours.
Practical classes: 32 hours.
Final control: Examination.
Individual assignment: term paper.

Course prerequisites

Previous courses:
Theoretical fundamentals of electrical engineering;

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

Lectures are conducted interactively with the use of multimedia technologies. Practical tasks are performed using open source software and the Microsoft 365 platform. Learning materials are available to students in OneNote Class Notebook.

Program of the course

Topics of the lectures

Module 1. Symmetric modes.
Topic 1: Introduction to the course.
Brief history of the origin and development of the problem of transients in electrical systems. The main objectives of the course and its connection with related general theoretical and special disciplines. Familiarization with the educational literature.
Topic 2. Basic definitions.
Causes of transients in electrical systems. Dangerous manifestations of transients in the operation of an electrical system and its individual elements. The purpose of practical calculations of electromagnetic transients and the requirements for them.
Topic 3. Basic assumptions used in the calculation of electromagnetic transients.
Selection of design conditions. Application of the system of relative units. Calculation by the formulas of exact and reduced reduction.
Topic 4. Parameters of elements of the design scheme.
Arrangement of the substitution scheme and determination of its parameters in named and relative units. Accurate and approximate accounting of transformation factors.
Topic 5. Conversion of substitution schemes.
Distribution of currents and voltages in an electrical circuit.
Topic 6: Three-phase short circuit in a circuit powered by an unlimited power source.
Influence and accounting of initial conditions. The nature of the current change in time. Determination of the maximum instantaneous and current values of the total current and its individual components. An approximate estimate of the equivalent time constant of the free current change in a branched circuit that does not contain a capacitor.
Topic 7. A three-phase short circuit in a circuit powered by a source of limited power.
The effect of the presence of an automatic excitation regulator on the short-circuit current.
Topic 8. Methods for calculating short-circuit currents.
Calculation of the effective value of the periodic component of the short-circuit current for any given time. Method of calculation curves.
Topic 9. Method of typical curves.
The essence and basic assumptions of this method. Calculation by total and individual change.
Topic 10. The method of directional characteristics.
Basic prerequisites and principles of this method. Setting design parameters for different moments of time.
Topic 11. Calculation of the steady-state mode of a three-phase short circuit in the absence and presence of automatic excitation control (AEC) in generators.
Critical current and critical reactance for generators with automatic excitation control. Influence and consideration of preload.

Topic 12: Calculation of short-circuit currents in electrical installations up to 1 kV.
Calculation of short-circuit currents using computers. Modular control №1

Module 2. Asymmetric modes.
Topic 13. Asymmetric modes.
The method of symmetrical components. Basic assumptions when using the method of symmetric components.
Topic 14. Formation of higher harmonics.
Physical picture of the formation process.
Topic 15. Parameters of system elements for reverse and zero sequence currents.
Circulation of zero-sequence currents.
Topic 16. Schemes of substitution of direct, reverse and zero sequences.
Longitudinal and transverse asymmetry in the system. Application of the theory of symmetric components to the study of transients.
Topic 17. Boundary conditions for the main types of single-phase asymmetry (short circuits between two phases, one phase and two phases to ground, open circuits).
Relationship between individual symmetrical components of currents and voltages. Expressions for currents and voltages at the point of asymmetry. Vector diagrams of currents and voltages at the point of asymmetry for different types of asymmetry.
Topic 18. The rule of equivalence of the direct sequence in application to different types of single asymmetry.
Determination of additional resistances for different types of asymmetric short circuits.
Topic 19. Complex substitution schemes.
Comparison of different types of short circuits and determination of the limiting ratios between the sizes of currents in them. The influence of load in case of asymmetric short circuits.
Topic 20. Distribution of currents and voltages in case of asymmetric short circuits.
Transformation of symmetrical components of currents and voltages.
Topic 21. Vector diagram of a synchronous generator.
Main characteristics, parameters and ratios. The influence of the generator's apparent polarity.)

Topics of the workshops

Topic 1. The system of relative units. Accurate and approximate accounting of transformation factors when organizing substitution schemes in relative and named units.
Topic 2. Preparation and transformation of substitution schemes on the basis of calculation schemes.
Topic 3. Calculation of supertransient, shock and aperiodic currents of a three-phase short circuit at zero time.
Topic 4. Calculation of three-phase short-circuit current by the method of design and typical characteristics.
Topic 5. Calculation of steady-state short-circuit mode in complex circuits.
Topic 6. Drawing up replacement circuits for direct, reverse and zero sequence in the calculation of the current of an asymmetric short circuit.
Topic 7. Calculation of an asymmetric short circuit by the method of straightened curves.
Topic 8. Calculation of short-circuit current in a given section and voltage at a given point.

Topics of the laboratory classes

Topic 1: Study of transients in a simple three-phase circuit with an infinite power source
Topic 2. Investigation of transients in a simple three-phase system powered by a generator of limited power (in the absence of an excitation regulator) under symmetrical short circuits.
Topic 3. Investigation of transients in a simple three-phase system powered by a generator of limited power (in the presence of an excitation regulator), with symmetrical short circuits
Topic 4. Research on the computer model of the influence of the parameters of the elements of the design scheme and its structure on the magnitude of the current of a three-phase short circuit
Topic 5. Investigation of transients in a simple three-phase system powered by a source of limited power under asymmetric short circuits.
Topic 6. Investigation of symmetrical components of voltages and currents under transverse asymmetry.
Topic 7. Investigation of symmetrical components of voltages and currents under transverse asymmetry.

Topic 8. Investigation of the distribution of symmetrical components of currents and voltages at asymmetrical short circuits

Self-study

1. Study the lecture material.
2. Preparation for practical and laboratory classes.
3. Processing of results and preparation of a report on laboratory work.
4. Carrying out calculations for the course work according to the individual task.
5. Registration of the course work.

Scope of work: 25-30 c.
Submission deadline: 16th week.

Course materials and recommended reading

Main literature:
1. Transient processes in power supply systems: textbook for universities / G.G. Pivnyak, I.V. Zhezhelenko, Y.A. Papaika, L.I. Nesen, edited by G.G. Pivnyak; Ministry of Education and Science of Ukraine, National Mining University - 5th edition, revised and supplemented - Dnipro: NSU, 2016. - 600 p.
2. Methodical instructions for laboratory work in the course "Electromagnetic transients" for students of full-time, part-time and distance learning in the specialty "Electric power engineering, electrical engineering and electromechanics" / comp. Rudevych N.V. - Kh.: NTU "KhPI", 2021. - 59 p.
3. DSTU IEC 60909-0:2007 Short-circuit currents in three-phase alternating current systems. Part 0. Calculation of current strength. - Kyiv: State Consumer Standard of Ukraine. - 2009.
4. Bukovych N.U., Mirkevych G.N. Calculation of short-circuit currents - Kyiv: NMK V0, 1991. - 222 c.

Additional literature
1. Methodical instructions for the course work "Calculation of short-circuit currents and stability of the electrical system" in the course "Transients in electrical systems" for students of specialties 7.000008 - "Energy Management" / comp. Piskurev M.F., Danilova O.A. - Kharkiv: NTU "KhPI" - 2005. - 56 p.
2 Sustainability of power systems. Guidelines. SOU-N MEV 40.1 - 00100227-68:2012. - Kyiv: Ministry of Energy and Coal Industry of Ukraine, 2012.
3. Teptya, V.V. Electromechanical transients in electric power systems: electronic lecture notes for combined (local and network) use [Electronic resource] / V. Teptya, V. Kulyk: VNTU, 2021. 183 p.

Assessment and grading

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

Scores are awarded according to the following ratio:
- practical classes: 20% of the semester grade;
- module tests: 20% of the semester grade;
- laboratory work: 20% of the semester grade;
- independent work: 20% of the semester grade for completing the course work according to the individual assignment;
- exam: 20% of the semester grade

The exam consists of a written assignment (two theoretical questions and one practical question) and an oral report.

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	Date, signature	Head of the department Oleksandr LAZURENKO
	Date, signature	Guarantor of the educational program Galina OMELIANENKO