Syllabus
Course Program

Theoretical Foundations of Electrical Engineering p.1.

Specialty
141 Electric power engineering, electrical engineering and electromechanics

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

Educational program
Electric power engineering

Department
Theoretical Electrical Engineering (137)

Level of education
Bachelor's level

Course type
Mandatory

Semester
3

Language of instruction
English

Lecturers and course developers

Ivan Kostiukov

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Candidate of sciences, head of the department of theoretical electrical engineering

Author of more then 50 scientific publications, lecturer on courses "Theoretical Foundations of Electrical Engineering P.1", " Theoretical Foundations of Electrical Engineering P.2", "Theory of Electrical Circuits", "Theory of Electric and Magnetic Field
More about the lecturer on the department's website

General information

Summary

The course is focused on basic laws and methods of calculation of DC and AC electric circuits in steady-state mode of operation

Course objectives and goals

- provide students with fundamental knowledge about the electromagnetic circuits with lumped and distributed parameters in steady-state mode of operation.
- enhance students capacity to analyze DC and AC circuits up to the level necessary to study and carry out research in the field determined by the specialty “Electric power engineering, electrical engineering and electromechanics”

Format of classes

Lectures, workshops, laboratory works, consultations. The course ends with a final exam.

Competencies

K01. Ability to abstract thinking, analysis and synthesis.
K02. Ability to apply knowledge in practical situations.
K03. The ability to communicate in the national language both orally and in writing

K05. Ability to search, process and analyze information from
different sources.
K06. Ability to identify, pose and solve problems.
K07. Ability to work in a team.
K08. Ability to work autonomously.
K12. The ability to solve practical problems involving the methods of mathematics, physics and electrical engineering.
K20. Awareness of the need to constantly expand one's own knowledge of new technologies in electric power, electrical engineering and electromechanics

Learning outcomes

PR01. Know and understand the principles of operation of electrical systems and networks, power equipment of electrical stations and substations, protective grounding and lightning protection devices and be able to use them to solve practical problems in professional activities.
PR03. Know the principles of operation of electric machines, devices and automated electric drives and be able to use them to solve practical problems in professional activities.
PR04. Know the principles of bioenergy, wind energy, hydropower and solar energy installations.
PR05. Know the basics of electromagnetic field theory, methods
calculating electric circuits and being able to use them for
solving practical problems in professional activity.
PR07. To carry out the analysis of processes in electric power, electrotechnical and electromechanical equipment, relevant complexes and systems.
PR08. Choose and apply suitable methods for the analysis and synthesis of electromechanical and electric power systems with given indicators.
PR10. Find the necessary information in scientific and technical literature, databases and other sources of information, evaluate its relevance and reliability.
PR11. Communicate freely about professional problems in national and foreign languages orally and in writing, discuss the results of professional activity with specialists and non-specialists, argue one's position on debatable issues.
PR15. Understand and demonstrate good professional, social and emotional behavior, follow a healthy lifestyle. PR18. Be able to learn independently, acquire new knowledge and improve skills in working with modern equipment, measuring equipment and application software.
PR18. Be able to learn independently, acquire new knowledge and improve skills in working with modern equipment, measuring equipment and application software. PR19. Apply appropriate empirical and theoretical methods to reduce losses of electrical energy during its production, transportation, distribution and use.
PR26. Know and understand the processes of creating and using safe and effective electrical insulation, cable and fiber optic systems.
PR28. Know and understand the working processes of electrophysical high-voltage installations for scientific research and industrial technologies, as well as installations of renewable energy.

Student workload

The total volume of the course is 180 hours (6 ECTS credits): lectures - 48 hours, laboratory classes - 16 hours, workshops - 16 hours, self-study - 100 hours.

Course prerequisites

Within their program students are supposed to master the courses "Introduction to specialty", "Mathematics" and "Physics".

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

Students gain their knowledge by listening lectures with presentations and participating in discussions, workshops, laboratory classes, as well as by taking part problem-based learning.

Program of the course

Topics of the lectures

Topic 1. Introduction

Basic concepts of the electrical circuits' theory: voltage, potential, potentials difference, electric current, current density, electromotive force - EMF. Series and parallel connection of elements. Ohm's law for circuits (in absence and presence of EMF). Power balance. Ideal and real energy sources. Equivalent transformation of sources.

Topic 2. Kirchhoff's current law

Kirchhoff's voltage law (for loops). The number of independent equations and variables. Advantages and disadvantages of Kirchhoff's laws usage for currents and voltages calculation.

Topic 3. Mesh currents method

Mesh currents method (example and generalization). Principle of superposition.

Topic 4. Nodal potentials method

Equivalent circuit transformations with presence of parallel active branches.

Topic 5. Tevenen's theorem.

The applying of Tevenen's theorem for the analysis of DC circuits

Topic 6. Transmition of power.

Power transmission from the power source.

Topic 7. Analysis of AC circuits.

Features of AC circuits (EMF of inductance, displacement currents). Magnetic field. Flux and flux coupling. Faraday's law of electromagnetic induction. Principle of continuity of magnetic field. Inductance. Magnetic field energy. Magnetic field strength. Magnetic permeability.

Topic 8. Parameters of AC circuits.

RMS and average values of current and voltage. Representation of a harmonic function by a phasor . Phasor diagrams. Equations of the elementary AC circuit. Ohm's law for amplitudes and RMS values in a steady-state mode.

Topic 9. The applying of phasors for the analysis of AC circuits.

Triangles of voltages, resistances, currents, conductivities. Basic operations with complex numbers (addition, subtraction, multiplication, division, exponentiation). Rotation operator. Conjugate complex numbers. Theorem of differentiation and integration. Ohm's and Kirchhoff's laws in complex form.

Topic 10. Power in AC circuits.

Power oscillations in AC circuits. Instantaneous and average power. Active and reactive processes in AC circuits. Equations for power determination. Triangle of power.

Topic 11. Resonance phenomena in AC circuits.

Resonance in an electric circuit at series connection (resonance frequency, characteristic impedance, Q-factor, attenuation, energy processes). Frequency characteristics and resonance curves. Practical applications of resonance phenomena.

Topic 12. Types of resonance in AC circuits

Resonance at parallel connection (resonance frequency, resonance condition, ideal circuit, frequency characteristics).

Topic 13. Circuits with magnetic coupling.

Circuits with mutual inductance. Own and mutual magnetic flux. Coefficient of magnetic coupling. Peculiarities of writing Kirchoff's laws for circuits with mutual inductance. Series connection.

Topic 14. Analysis of circuits with magnetic coupling

Parallel connection at mutual inductance presence. Method of decoupling. Air-core transformer. Equations, vector diagram. Equivalent scheme. Ideal transformer.

Topic 14. Multiphase circuits.

Concepts of three-phase (poly-phase) circuits. Basic definitions and properties of symmetric systems of voltages, currents, EMFs instant values. Complex form. Rotation operator. The principle of obtaining a three-phase system of EMFs (electromechanical generator). Relationship between linear and phase magnitudes at wye- and delta-connections. Advantages of three-phase circuits over a single-phase.

Topic 15. Three-phase circuits with a load.

Calculation of a three-phase circuit with a delta-connected load.

Topic 16. Scecific modes of operation of AC circuits.

Cases of significant asymmetry in three-phase circuits. Measurement of power in three-phase circuits

Topic 17.Circuits with four terminals.
Classification: passive and active, linear and nonlinear. Basic equations in a steady harmonic mode. Systems of primary parameters.
Topic 18. Scecific questions of operation of four terminal circuits.
Types of the connection of circuits with four terminals and the application of various parameter systems.
Topic 19. Physical basics of electrical engineering.
Physical basics of electrical engineering. Electrical field in dielectric and conducting mediums.
Topic 20.Electrical capacitance.
Main factors which affect the electrical capacitance. Calculation of electrical capacitance for a simple system of electrodes
Topic 21. Characteristics of electric field.
Voltage and scalar potential of electric field. Gauss's theorem.
Topic 22. Characteristics of electric field.
Calculation of electric and magnetic fields in a simple systems of electrodes and conductors.
Topic 23.Magnetic inductance.
Main factors which affect the inductance.
Topic 24. Calculation of inductance for a simple system of conductors.
Inductance of a coil, inductance of a loop.

Topics of the workshops

Topic 1. Basic parameters of electrical circuits
Calculation of equivalent resistances in linear circuits of direct current. Calculation of electric circuits (currents and voltages finding) with the help of equivalent transformation of electric circuits and Kirchhoff's current and voltage laws.
Topic 2. Methods of analysis of DC circuits
Analytical study of lumped DC circuits using Kirchhoff's laws. Calculation of electric circuits (currents and voltages finding) with the mesh currents method and the method of nodal potentials. Calculation of electric circuits (currents and voltages finding) using the equivalent generator method. Principle of superposition.
Topic 3. Superposition in DC circuits
Analytical methods of complex circuits studying using the principle of superposition in DC circuits.
Topic 4. Analysis of AC circuits
Analytical study of lumped AC circuits using Kirchhoff's laws
Topic 5. Resonance phenomena in electrical circuits
Calculation of electrical circuits (currents and voltages finding) of electrical circuits in resonance mode.
Topic 6. Phasor diagrams
Building of phasor diagrams for AC circuits
Topic 7. Electrical circuits with mutual inductance
Methods of analysis of AC circuits with mutual inductance
Topic 8. Three-phase electrical circuits
Methods of analysis of three-phase electrical circuits

Topics of the laboratory classes

Laboratory work 1.
Experimental study of simple linear DC circuits
Laboratory work 2.
Experimental verification of the principle of superposition in DC circuits.
Laboratory work 3.
Experimental study of modes of operation of a source of electric energy in DC circuits
Laboratory work 4.
Method of equivalent generator in DC circuits
Laboratory work 5.
Kirchhoff's circuit laws
Laboratory work 6.
Resonance phenomena in AC circuits

Laboratory work 7.
Electrical circuits with mutual induction
Laboratory work 8.
Three-phase electrical circuits

Self-study

Individual assignments on the analysis of DC and AC circuits. Preparation for workshops and laboratory works

Course materials and recommended reading

1. Md. Abdus Salam, Quazi Mehbubar Rahman. Fundamentals of Electrical Circuit Analysis Springer Nature Singapore Pte Ltd. 2018,
2. Bird J. Electrical Circuit Theory and Technology Newnes / J. Bird, 2003. - 1008 P.
3. Ergul Ozgur. Introduction to Electrical Circuit Analysis / Ozgur Ergul, Wiley, 2017. — 425 p.
Rahmani-Andebili M. DC Electrical Circuit Analysis: Practice Problems, Methods, and Solutions Springer, 2020. — 267 p.
4. M. M. Rezynkina, O. H. Kiessaiev, O. L. Rezynkin, S. A. Lytvynenko " Guidelines of calculation and graphical performing of the task on the topic "Linear electric circuits of harmonic current" Kharkiv: NTU "KhPI", 2020. – 44 p.
5. M. M. Rezynkina, O. H. Kiessaiev, O. L. Rezynkin, S. A. Lytvynenko " Guidelines of calculation and graphical performing of the task on the topic "Calculation of DC electrical circuits" Kharkiv: NTU "KhPI", 2020. – 48 p.
6. Теоретичні основи електротехніки: зб. задач для підготовки до І етапу Всеукр. студ. олімпіади : для студентів електротехн. спец. / Л. В. Казаковцева, І. О. Костюков, О. Ю. Кропачек, О. В. Лавріненко, С. А. Литвиненко; Нац. техн. ун-т "Харків. політехн. ін-т". – Електрон. текст. дані. – Харків, 2023. – 48 с. – Укр. та англ. мовами.

Assessment and grading

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

Students get their final exam mark after the complete fulfillment of their individual assignments and laboratory works

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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