Syllabus
Course Program

Theory of Electrical Circuits p.1.

Specialty
171 Electronics

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

Educational program
Electronics

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 considers the basic laws and methods of calculation of DC and AC electric circuits in steady-state and transient modes, which are based on practical calculations of electric circuits for various purposes.

Course objectives and goals

- provide students with fundamental knowledge of electric circuits with lumped parameters in steady-state and transient modes of operation up to the level necessary to study and carry out research in the field, which is determined by the specialty “Electronics”.

Format of classes

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

Competencies

- ability to apply knowledge in practical situations
- ability to integrate knowledge of fundamental sections of physics and chemistry to understand the processes of solid-state, functional, energy and biomedical electronics, electrical engineering.
- ability to identify, classify, evaluate and describe processes in electronics devices, devices and systems using analytical methods, modeling tools, prototypes and experimental results

Learning outcomes

students should be able to find solutions to practical problems of electronics by applying appropriate models and theories of electrodynamics, analytical mechanics, electromagnetism, statistical physics, solid state physics

Student workload

The total volume of the course is 150 hours (5 ECTS credits): lectures - 32 hours, laboratory classes - 16 hours, workshops - 16 hours, self-study - 86 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. Scecific modes of operation of AC circuits. Part 1.

Transient processes. The switching lows. The duration of transient processes. The time constants. The exponent’s properties (equations and graphs).

Topic 16. Scecific modes of operation of AC circuits. Part 2.

Operational method. Laplace transformation. Basic theorems of the operational method. Table of basic functions images by Laplace transformation. Ohm's Law and Kirchhoff's laws in the operational form.

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. Analysis of transient processes in electrical circuits

Classical approach for the analysis of transient processes. The Laplace transform-based analysis of transient processes.

Topics of the laboratory classes

Laboratory work 1.

Experimental study of simple linear DC circuits

Laboratory work 2.

Experimental verification of Kirchhoff's laws in DC circuits.

Laboratory work 3.

Experimental study of modes of operation of DC power sourses

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.
Transient processes in RLC 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.
7. M. M. Rezynkina, I. A. Kostiukov, S. A. Lytvynenko " The Laplace transform analysis of transient processes in linear electrical circuits " Kharkiv: NTU "KhPI", 2020. – 44 p.
8. M. M. Rezynkina, I. A. Kostiukov, S. A. Lytvynenko " Guidelines of calculation and graphical performing of theindividual assignment on the topic " The analysis of transient processes in the linear electrical circuits " Kharkiv: NTU "KhPI", 2022. – 48 p.

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

Head of the department
Ivan KOSTIUKOV

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Olga BUTOVA