Syllabus
Course Program

Photoelectric Converters

Specialty
141 – Electric Power, Electrical Engineering and Electromechanics

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

Educational program
Electric Power Industry

Department
Engineering Electrophysics (135)

Level of education
Master's level

Course type
Special (professional)

Semester
1

Language of instruction
English

Lecturers and course developers

Mykyta Petrenko

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Ph. D., Associate Professor at the Engineering Electrophysics Department of NTU "KhPI".
Authored 6 publications in the domain of strong magnetic field calculations, computation of strong magnetic fields, electromagnetic forming and related areas. Lecturer on “Modelling of Electro-Physical and Electric Power Equipment and Processes”, “High Voltage Measurements”, “High Voltage Equipment”, “High Voltage Pulse Equipment”, etc.
More about the lecturer on the department's website

Levchenko Olena

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Candidate of Technical Sciences, Senior Lecturer at the Department of Engineering Electrophysics, NTU "KhPI".
20 years teaching experience. Main disciplines:
"Electrical Equipment in Renewable Energy Installations"
"Основи інформаційних технологій в ТВН та відновлюваній енергетиці", ect.
More about the lecturer on the department's website

General information

Summary

The "Photoelectric Converters" course is designed to provide students with a solid foundation in the principles of solid-state physics, with a special focus on semiconductors, which are pivotal in the functioning of photoelectric systems. This course is based on prior knowledge in higher mathematics, physics, electrical engineering, and electronics. It explores the application of photoelectric systems in diverse industrial and agricultural fields, equipping students with both theoretical knowledge and practical skills.

Course objectives and goals

The objective of the "Photoelectric Converters" course is to instill in students a comprehensive understanding and ability to apply fundamental concepts of semiconductor physics in the realm of

photoelectric systems. The goal is to prepare students for qualified participation in the multifaceted activities of energy specialists, particularly in the development, production, and operation of non-traditional energy sources. This course aims to enable students to make informed choices in selecting photoelectric converters and to proficiently use these converters, evaluating their efficiency and applying methods for their control and management. The teaching methods include lectures, practical and laboratory works, supplemented by self-study and regular consultations.

Format of classes

Lectures, workshops, laboratory classes, consultations, self-study. Final control in the form of an examination.

Competencies

GC 3. The ability to apply knowledge in practical situations
GC 7. Skills of using information and communication technologies.
GC 8. The ability to learn and master modern knowledge.
GC 14. Ability to demonstrate basic knowledge in the field of natural sciences and readiness to use the methods of fundamental sciences for solving general engineering and professional problems.
PC 3. Ability to use basic knowledge of general physics, higher mathematics, theoretical foundations of electrical engineering and electrical materials for solving practical problems in the field of electric power engineering, electrical engineering and electromechanics.
PC 11. Ability to observe the requirements of the rules of safety and occupational safety and norms of industrial sanitation when working at the enterprises of electrical and electromechanical complexes.
PC 12. Ability to study and analyze scientific and technical information in the field of electric power engineering, electrical engineering and electromechanics.
PC 15. Understanding the principles of organizing electricity generation processes based on traditional and renewable energy sources, meeting the specified technological parameters of power plants and the quality of electricity.

Learning outcomes

PRT 2. Discuss professional topics
PRT 12. Know and use the methods of fundamental sciences to solve the general engineering and professional tasks.
PRT 16. To define principles of construction and normal functioning of elements of electric power, electrotechnical, electromechanical complexes and systems.
PRT 18. To evaluate the parameters of the electrical, electrical and electromechanical equipment and related complexes and systems work and to develop measures to increase their energy efficiency and reliability.
PRT 19. Solving professional tasks in the design, installation and operation of electric power, electrical engineering, electromechanical complexes and systems.
PRT 26. Understand and explain the importance of traditional and renewable energy for successful economic development of the country.
PRT 31. Combine the methods of empirical and theoretical research to find ways to reduce the loss of electric energy in its production, transportation, distribution and use.

Student workload

The total volume of the course is 150 hours (5 ECTS credits): lectures - 32 hours, workshops - 16 hours, laboratory classes - 16, self-study - 86 hours.

Course prerequisites

Physics, Theoretical Foundations of Electrical Engineering p.1, Theoretical Foundations of Electrical Engineering p.2

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

Lectures employ modern multimedia tools to enhance the learning experience. Laboratory classes are structured around a mix of student preparatory self-study and collaborative team activities. Experiential learning is also an integral part of the coursework, allowing students to learn from real-world scenarios. Knowledge and skills cultivated during practical sessions are further reinforced as students tackle individual computational tasks.

Program of the course

Topics of the lectures

Topic 1. Introduction to Photoelectric Converters and Solar Energy
Understanding the role of photoelectric converters in harnessing solar energy and their integration into conventional power systems.
Topic 2. Solar Radiation and its Characteristics
Examining the nature of solar radiation and the sun as an absolute black body emitter, crucial for photoelectric converters.
Topic 3. Semiconductors – The Foundation of PECs
Exploring the solid-state zone theory and the properties of key semiconductor materials in photoelectric converters.
Topic 4. Conductivity in Semiconductors: Intrinsic and Doped
Analyzing electron and hole concentrations in intrinsic and doped semiconductors and the concept of the Fermi level.
Topic 5. The P-N Junction and Its Formation
Understanding the formation of p-n junctions and carrier movement in equilibrium states, foundational for PEC operation.
Topic 6. Principles of Photoelectric Converters Operation
Studying the generation of photo-EMF in illuminated p-n junctions and the spectral photosensitivity of semiconductors.
Topic 7. Efficiency Limits of Photovoltaic Cells
Investigating methods to enhance photovoltaic cell efficiency and the application of solar batteries.
Topic 8. Voltage Stabilizers in Consumer Power Supply
Delving into the characteristics and schematics of various types of voltage stabilizers in power supply systems.
Topic 9. Current Sources: Types and Operations
Exploring the operational principles and applications of different current sources, including current mirrors.
Topic 10. Inverters and Converters: Varieties and Functioning
Covering the types and functioning of inverters and converters, focusing on transistor and thyristor inversion methods.
Topic 11. Power Supply Components: Key and Regulating Elements
Examining key elements in power supplies, including transistors, thyristors, and energy storage components.
Topic 12. Protection of Key Elements from Overvoltage and Surge Current
Addressing the causes and protection methods for overvoltages and current overloads in inverter systems.
Topic 13. Control and Protection Systems in Power Converters
Overview of the general characteristics, requirements, and types of control and protection systems in power converters.
Topic 14. Circuitry of Main Nodes in Control Systems
Detailed examination of the circuitry in control systems, focusing on various integral components.
Topic 15. Advanced Topics in Photoelectric Converters
An exploration of recent advancements and innovative practices in photoelectric conversion technology.
Topic 16. Future Trends and Developments in Photoelectric Conversion
Investigating future prospects and potential developments in the field of photoelectric energy conversion.

Topics of the workshops

Topic 1. Exploring Photoelectric Converter Systems
Practical exploration of the integration of photoelectric converters in solar energy systems and their functionality in traditional power setups.
Topic 2. Semiconductor Materials in PECs
Hands-on analysis of semiconductor materials and their properties relevant to photoelectric converters.
Topic 3. P-N Junction Analysis
A focused session on understanding the dynamics of p-n junctions through practical examples and case studies.
Topic 4. Photovoltaic Cell Efficiency Enhancement
Exploring innovative methods to enhance the efficiency of photovoltaic cells, including solar battery applications.
Topic 5. Voltage Stabilizer Design and Analysis
Practical design exercises and analysis of continuous-action and pulse voltage stabilizers used in power supply systems.
Topic 6. Inverter and Converter Systems
Hands-on session on designing and analyzing various types of inverters and converters, with a focus on their operational mechanisms.
Topic 7. Circuit Design and Protection in Power Systems
Design and simulation of key and regulating elements in power supply systems, focusing on protective measures against overvoltage and surge currents.
Topic 8. Control Systems in Photoelectric Converters
Detailed examination and design of control and protection systems in photoelectric converters, emphasizing practical applications.

Topics of the laboratory classes

Topic 1. Solar Radiation Characterization
Practical exercises and simulations to understand the characteristics of solar radiation and its impact on photoelectric converters.
Topic 2. Conductivity in Semiconductors
Laboratory experiments focused on measuring and analyzing conductivity in different types of semiconductors.
Topic 3. Operational Dynamics of P-N Junctions
Experiments to understand the operational dynamics of p-n junctions under various conditions.
Topic 4. Power Supply System Components
Laboratory exercises on the components of power supply systems, including transistors, thyristors, and energy storage elements.
Topic 5. Current Source Applications
Practical exercises on the use and application of different types of current sources, including current mirrors.
Topic 6. Building and Testing Inverters and Converters
Constructing and testing different types of inverters and converters to understand their functioning and efficiency.
Topic 7. Designing Protective Circuits for Power Converters
Designing and testing protective circuits for key elements in power converters to mitigate the risk of overvoltages and surge currents.
Topic 8. Advanced Control Systems for Photoelectric Converters
Developing and testing advanced control systems for photoelectric converters, focusing on real-world applications and efficiency.

Self-study

This course invites students to link solar energy theory with practical application by analyzing a real-world case study from their region. This deepens understanding of solar energy's impact on sustainable solutions. Students will engage in computational exercises to design and optimize solar energy systems, considering various technical factors. Materials will be provided to guide these tasks.

Additionally, a research project will explore solar energy's current landscape, challenges, and future in the students' home country, covering policy, technology, and development areas.
Supplemental resources, including articles and webinars, will support a deeper dive into specific topics, rounding out the learning experience. This self-study approach not only broadens knowledge but also sharpens practical skills in solar energy.

Course materials and recommended reading

1. Markvart, Tom, ed. Practical handbook of photovoltaics: fundamentals and applications. Elsevier, 2003.
2. Quaschning, Volker. Understanding renewable energy systems. Routledge, 2014.
3. Peake, Stephen. Renewable energy-power for a sustainable future. No. Ed. 4. OXFORD university press, 2018.

Assessment and grading

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

The final score for this course is calculated based on a combination of evaluations from exam, workshop and laboratory class achievements, and the execution of individual assignments.
1. Final Examination.
Students can earn up to 40 points from the final module tests. The tests evaluate the student's comprehension and knowledge retention from the lecture material.
2. Workshop and Laboratory Class Assignments.
Engaging and participating in workshops, including quizzes and tasks, can earn students up to 30 points.
3. Individual Assignments.
For the completion of individual assignments students can receive up to 30 points.

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
2023

Head of the department
Serhii MOSTOVYI

Date, signature
2023

Guarantor of the educational program
Halyna OMELIANENKO