

Identification	Subject	ETR 466 Power Electronics 6 ECTS credits
	Department	Physics and Electronics
	Program (Undergraduate, Graduate)	Undergraduate
	Term	Fall 2026
	Instructor	M.Sc. Muhammad Alizada
	Email:	malizada@khazar.org
	Classroom/hours	11 Mehseti Street, Baku, Azerbaijan (Neftchilar campus), Monday-Friday, 09:00-18:00
Prerequisites	None	
Language	English	
Compulsory/Elective	Compulsory	
Textbooks and course materials	Textbooks: 1.Power Electronics: Devices, Circuits, and Applications, 4th ed., by Muhammad H. Rashid, 2014. Optional Reference Texts: 2. Power Electronics: Circuit Analysis and Design, 2nd ed., by Issa Batarseh and Ahmad Harb, 2018. 3. Power Electronics Handbook, 4th ed., by Muhammad H. Rashid, 2017. 4. Power Electronics and Motor Drives, 1st ed., by Bogdan M. Wilamowski and J. David Irwin, 2017. 5. Power Electronics, International Edition, 1st ed., by Daniel W. Hart, 2013.	
Course description	This course provides a comprehensive introduction to the fundamental principles, devices, circuits, and applications of power electronics, with an emphasis on their role in electrical energy conversion and modern electrical and electronic systems. It explores the key concepts and processes associated with power semiconductor devices and power electronic converters, including diodes, thyristors, MOSFETs, IGBTs, and other controlled switching devices, providing students with a structured framework for understanding the operation and control of power electronic systems. The course combines theoretical concepts with systematic circuit analysis and problem-solving methods, enabling students to examine power semiconductor devices, analyze power electronic circuits, and apply fundamental principles to practical engineering applications. The main topics include controlled and uncontrolled rectifiers, AC voltage controllers, DC-DC converters, DC-AC inverters, switching techniques, gate and triggering circuits, and protection of power semiconductor devices. Particular attention is given to the analysis of power electronic circuits under different operating conditions and the principles of controlled power conversion. Together, these topics provide a strong theoretical and practical foundation for the analysis, design, selection, and application of power electronic converters and systems in motor drives, renewable energy systems, power supplies, and electrical energy conversion applications.	
Course objectives	The main objective of this course is to provide undergraduate students in Electrical and Electronics Engineering with a strong foundation in the	

	fundamental principles, devices, analysis, and applications of power electronics and power electronic converter systems. The course aims to: • Develop a clear understanding of the characteristics, operating principles, and switching behavior of power semiconductor devices, including power diodes, thyristors, MOSFETs, and IGBTs. • Introduce the fundamental principles of power conversion and the operation of controlled and uncontrolled rectifiers, AC voltage controllers, DC-DC converters, and DC-AC inverters. • Develop students' ability to analyze and design power electronic converter circuits under different operating conditions. • Provide students with an understanding of PWM and other switching techniques, gate drive circuits, and control methods used in power electronic systems. • Develop students' ability to analyze power losses, efficiency, and harmonic effects in power electronic converters. • Introduce appropriate techniques for the protection and reliable operation of power semiconductor devices and converter systems. • Strengthen students' analytical, design, and problem-solving skills through theoretical and practical activities involving power electronic circuits and systems. • Provide students with the essential theoretical and practical background necessary for the analysis, design, selection, and application of power electronic devices and converter topologies in motor drives, regulated power supplies, renewable energy systems, and electrical energy conversion.
Learning Outcomes	By the end of the course, students will be able to: • Describe the role, importance, and applications of power electronics in modern electrical, electronic, industrial, and energy systems. • Explain the operating principles, characteristics, and switching behavior of power semiconductor devices, including power diodes, thyristors, MOSFETs, and IGBTs. • Describe the fundamental principles of power conversion, switching circuits, gate and triggering circuits, and protection techniques for power semiconductor devices. • Explain the operating principles and characteristics of uncontrolled and controlled rectifiers, AC voltage controllers, DC-DC converters, and DC-AC inverters. • Explain the principles of PWM and other switching techniques used for controlling power electronic converters. • Analyze the effects of switching losses, power losses, efficiency, harmonics, and power quality on power electronic systems. • Analyze and calculate the main electrical parameters of rectifiers, AC voltage controllers, DC-DC converters, and DC-AC inverters.

	• Design and analyze basic triggering, gate drive, switching, and protection circuits for power electronic devices. • Apply PWM and other control techniques to regulate the output voltage, current, and power of power electronic converters. • Analyze and troubleshoot basic power electronic circuits using theoretical calculations, simulation software, and practical measurements. • Evaluate and select appropriate power semiconductor devices and converter topologies for specific electrical and electronic applications. • Apply theoretical knowledge and analytical methods to solve practical problems related to power electronic converters and systems. Demonstrate an integrated understanding of the fundamental principles, devices, circuits, control techniques, and applications of power electronics through laboratory activities, problem-solving exercises, quizzes, midterm assessment, and final examination.		
Teaching methods	Case analysis		☒
	Group discussion		x
	Lecture		☒
	Simulation		x
Evaluation Criteria	Methods	Date/deadlines	Percentage (%)
	Midterm Exam	TBA	30
	Quizzes	2 quizzes during the semester	10
	Practical Assignments	5 lab works during the semester	15
	Activity	-	0
	Attendance	At each lesson	5
	Final Exam	TBA	40
	Total		100
Class Policy	Preparation for class The pedagogical structure of this course necessitates diligent individual study and external preparation. Course sessions are designed to emphasize the primary theoretical frameworks introduced in the text. Pre-class engagement with assigned chapters is essential to facilitate a comprehensive understanding of the material. Subsequent to each session, students should synthesize their notes and resolve pertinent problems, case studies, and sample examination questions located at the conclusion of each chapter. Withdrawal (pass/fail) This course strictly adheres to the grading ordinances of the School of Science and Engineering. Consequently, students are required to achieve a minimum threshold of 60% to secure a passing grade. In the event of an unsatisfactory result, the student will be mandated to repeat the course in the following academic term or year. Cheating/plagiarism Any instance of academic dishonesty or plagiarism during Quizzes, Midterms, or Final Examinations will result in the immediate nullification of the		

assessment. In such cases, the student will automatically be assigned a score of zero (0) without further consideration. Generative AI Policy The use of Generative Artificial Intelligence (GAI) tools is partially permitted in this course. Students may use GAI tools for learning purposes, such as obtaining explanations of course concepts, organizing information, generating practice questions, and supporting their understanding of the course material. GAI tools may not be used to complete or generate answers for quizzes, midterm examinations, final examinations, or other assessed work unless explicitly authorized by the instructor. Students are responsible for the accuracy of any information obtained through GAI tools and must ensure that their submitted work reflects their own understanding, analysis, and intellectual contribution. Any use of GAI in accordance with the permitted purposes should be appropriately acknowledged by the student. Professional behavior guidelines Students are expected to conduct themselves in a manner that fosters a constructive academic and professional environment during instructional hours. Unauthorized discourse and unethical behavior are strictly prohibited. Attendance Students who maintain full attendance for the duration of the course will be awarded 5 marks. Conversely, for every four absences recorded, the student will incur a deduction of 1 mark. Quizzes Two quizzes will be administered throughout the semester, with formal announcements made in class two weeks prior to each assessment date. The content of each quiz will be based on assigned homework problems, which are curated from the questions and problems at the end of each chapter. Practical Assignments Students will complete 5 practical assignments during the semester. Each assignment will be evaluated based on the quality of the work, accuracy of the results, and understanding of the practical concepts. Each assignment is worth 3 points, for a total of 15 points.			
Tentative Schedule			
Week	Date/Day (tentative)	Topics	Textbook/Assignments
1		Introduction to Power Electronics. Applications and history of power electronics, types of power electronic circuits, design considerations, RMS values of waveforms, characteristics and specifications of switches <i>Questions and Exercises</i>	[1], p. 3-30
2		Power Diodes and Switched RLC Circuits. Semiconductor basics, diode characteristics, reverse recovery, power diode types, series and parallel diode connections, switched RC, RL, LC and RLC loads, freewheeling diodes.	[1], p. 59-97

		<i>Questions and Exercises, Practical Assignment 1</i>	
3		Diode Rectifiers. Performance parameters, single-phase full-wave rectifiers, rectifiers with RL and highly inductive loads, multiphase and three-phase bridge rectifiers, output filters and effects of source/load inductance. <i>Questions and Exercises</i>	[1], p. 103-154
4		Power Transistors. Power MOSFETs, JFETs, BJTs, IGBTs, switching characteristics, power derating, series and parallel operation, di/dt and dv/dt limitations, gate-drive circuits and isolation techniques. <i>Questions and Exercises</i>	[1], p. 158-232
5		DC–DC Converters. Principles and performance parameters of DC–DC converters, step-up operation, converter classification, switching-mode regulators, buck, boost, buck-boost and Cúk converters. <i>Questions and Exercises, Practical Assignment 2</i>	[1], p. 234-276
6		Advanced DC–DC Converter Analysis and Design. Multi-output boost converters, averaging models, state-space analysis, input filters, converter design considerations and drive ICs. <i>Questions and Exercises, Quiz 1</i>	[1], p. 277-303
7		DC–AC Converters and Inverters. Operating principles and performance parameters of inverters, single-phase bridge inverters, three-phase inverters, 120° and 180° conduction, voltage control and PWM techniques. <i>Questions and Exercises, Practical Assignment 3</i>	[1] – p. 306-344
		Midterm exam	
8		PWM and Advanced Inverter Techniques. Sinusoidal PWM, modified PWM, phase-displacement control, three-phase PWM, space-vector modulation, harmonic reduction, current-source inverters and inverter circuit design. <i>Questions and Exercises</i>	[2], p. 340-380
9		Resonant and Multilevel Inverters. Series and parallel resonant inverters, frequency response, Class-E converters, zero-current switching (ZCS), zero-voltage switching (ZVS), multilevel inverter concept and applications. <i>Questions and Exercises</i>	[1], p. 385-465
10		Thyristors. Thyristor characteristics, thyristor types, series/parallel operation, protection, DIACs and related semiconductor devices. <i>Questions and Exercises</i>	[1], p. 467-525
11		Controlled Rectifiers. Single-phase full converters, dual converters, three-phase full converters, PWM-controlled rectifiers, twelve-pulse converters, converter design and effects of source/load inductances. <i>Questions and Exercises</i>	[1], p. 527-570

12		AC Voltage Controllers and Cycloconverters. Single-phase and three-phase AC voltage controllers, resistive and inductive loads, transformer connection changers, cycloconverters, harmonic reduction and PWM control. <i>Questions and Exercises, Practical Assignment 4</i>	[1], p. 576-608
13		Power Supplies and Power Electronic Applications. DC and AC power supplies, switched-mode power supplies, flyback, forward, push-pull, half-bridge and full-bridge converters, resonant and bidirectional power supplies, control circuits. <i>Questions and Exercises, Quiz 2</i>	[1], p. 658-695
14		Power Electronics Applications and Protection. DC and AC motor drives, snubber circuits, transient protection, current protection and electromagnetic interference <i>Questions and Exercises, Practical Assignment 5</i>	[1], p. 699-760, 864-927, 931-968
15		Advanced Applications of Power Electronics. Motor Drives, Renewable Energy Systems, Power Supplies, Converter Control, and System Performance Analysis. <i>Questions and Exercises.</i>	[1], p. 699–857 [4], p. 397–464
	TBC	Final exam	

