GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	Power Electronics Systems, PG_00048263		
Field of study	Electrical Engineering		
Date of commencement of studies	February 2023	Academic year of realisation of subject	2023/2024
Education level	second-cycle studies	Subject group	
Mode of study	Full-time studies	Mode of delivery	at the university
Year of study	1	Language of instruction	Polish
Semester of study	2	ECTS credits	3.0
Learning profile	general academic profile	Assessment form	assessment
Conducting unit	Department of Power Electronics and Electrical Machines -> Faculty of Electrical and Control Engineering		
Name and surname of lecturer (lecturers)	Subject supervisor	prof. dr hab. inż. Ryszard Strzelecki	
	Teachers	prof. dr hab. inż. Ryszard Strzelecki	

Lesson types and methods of instruction	Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
	Number of study hours	30.0	0.0	30.0	0.0	0.0	60
	E-learning hours included: 0.0						

Learning activity and number of study hours	Learning activity	Participation in didactic classes included in study plan	Participation in consultation hours	Self-study	SUM
	Number of study hours	60	5.0	10.0	75

Subject objectives	*Objectives of this course is a introduce to advanced power electronic systems, design principles and methods of their control in different application areas.*

Learning outcomes	Course outcome	Subject outcome	Method of verification
	K7_U07	The competence to modelling and simulation of complex power electronics systems using standard simulation packages as well as analysis and evaluation of results	[SU4] Assessment of ability to use methods and tools [SU2] Assessment of ability to analyse information [SU1] Assessment of task fulfilment [SU3] Assessment of ability to use knowledge gained from the subject [SU5] Assessment of ability to present the results of task
	K7_K03	Ability to cooperate and organize group activities in the realization of problematic tasks	[SK2] Assessment of progress of work [SK1] Assessment of group work skills [SK4] Assessment of communication skills, including language correctness [SK3] Assessment of ability to organize work [SK5] Assessment of ability to solve problems that arise in practice
	K7_K02	Ability to evaluate the possibilities and effects of using power electronic devices in environmental and social aspects	[SK5] Assessment of ability to solve problems that arise in practice [SK4] Assessment of communication skills, including language correctness
	K7_U02	Ability to analyze results and to select, evaluate and present the most important results of realized tasks in the area concerning power electronics systems	[SU5] Assessment of ability to present the results of task [SU3] Assessment of ability to use knowledge gained from the subject [SU2] Assessment of ability to analyse information [SU1] Assessment of task fulfilment [SU4] Assessment of ability to use methods and tools
	K7_W10	Knowledge of the principles of operation, design and control of selected modern power electronic converter topologies. Characterizes the design and operation of converters - distinguishes topological aspects of system and application control methods	[SW1] Assessment of factual knowledge [SW3] Assessment of knowledge contained in written work and projects [SW2] Assessment of knowledge contained in presentation
	K7_U07	The competence to modelling and simulation of complex power electronics systems using standard simulation packages as well as analysis and evaluation of results	[SU1] Assessment of task fulfilment [SU2] Assessment of ability to analyse information [SU3] Assessment of ability to use knowledge gained from the subject [SU4] Assessment of ability to use methods and tools [SU5] Assessment of ability to present the results of task
	K7_U02	Ability to analyze results and to select, evaluate and present the most important results of realized tasks in the area concerning power electronics systems	[SU1] Assessment of task fulfilment [SU2] Assessment of ability to analyse information [SU5] Assessment of ability to present the results of task [SU3] Assessment of ability to use knowledge gained from the subject [SU4] Assessment of ability to use methods and tools
	K7_W04	Knowledge and understanding of capability and characteristics of application of power electronic converters in various electromechanical devices	[SW1] Assessment of factual knowledge [SW3] Assessment of knowledge contained in written work and projects [SW2] Assessment of knowledge contained in presentation

Course outcome	Subject outcome	Method of verification
K7_U06	Ability to comprehensively analyze, model, and simulate electrical systems with power electronic converters, using standard cyber-physical simulation software packages.	[SU1] Assessment of task fulfilment [SU2] Assessment of ability to analyse information [SU3] Assessment of ability to use knowledge gained from the subject [SU4] Assessment of ability to use methods and tools [SU5] Assessment of ability to present the results of task
K7_W13	Understanding and qualitative analysis of power electronic converters in the scope of concerning quality of conversion electrical energy, efficiency, compatibility electromagnetic compatibility and reliability.	[SW1] Assessment of factual knowledge [SW2] Assessment of knowledge contained in presentation [SW3] Assessment of knowledge contained in written work and projects
K7_U06	Ability to comprehensively analyze, model, and simulate electrical systems with power electronic converters, using standard cyber-physical simulation software packages.	[SU4] Assessment of ability to use methods and tools [SU3] Assessment of ability to use knowledge gained from the subject [SU2] Assessment of ability to analyse information [SU1] Assessment of task fulfilment [SU5] Assessment of ability to present the results of task
K7_W04	Knowledge and understanding of capability and characteristics of application of power electronic converters in various electromechanical devices	[SW3] Assessment of knowledge contained in written work and projects [SW1] Assessment of factual knowledge [SW2] Assessment of knowledge contained in presentation
K7_W13	Understanding and qualitative analysis of power electronic converters in the scope of concerning quality of conversion electrical energy, efficiency, compatibility electromagnetic compatibility and reliability.	[SW2] Assessment of knowledge contained in presentation [SW1] Assessment of factual knowledge [SW3] Assessment of knowledge contained in written work and projects

Subject contents

LECTURE*: Analytical Basics of Power Electronics Systems: General Direct Converter Model, Coordinate Transformation, Spectral Analysis and Power Theory in Power Electronic Systems. Modern PE semiconductor devices (including SiC and GaN switches). Element Modulation Pulse Techniques: Scalar and vector control, Current regulation methods. Multilevel and other Special Converters: Multilevel Inverter Topologies, Multilevel Inverter Modulation Methods, Rectifiers for Multilevel Inverter, other Special Converters; PE Smart Transformers: DAB Topology, Control, Applications. Power Electronics Arrangements in EE Network: Power Conditioning Problems, Arrangements for Mitigation of Power Disturbances, Active PQ Controllers, Hybrid Arrangement of PQ Controllers. Predictive Control of the PE Systems: Hysteresis Based Predictive Control, Model Based Predictive Control. Power Converters with a Input Impedance Sources: Z-converters, qZ-converters, T-converters, multilevel topology. Soft Switching and Resonant Converter : Principle, Overview*

LABORATORY: *Introduction to Matlab simulation tools: the S-function and Simscape Electrical software which operates in the Simulink environment. Implementation of the control system of PWM rectifier in simulation environment and converter operation analysis. Implementation and commissioning of the PWM rectifier control algorithm in a laboratory workbench consisting of a controller unit with the TMS320F28379D microcontroller and a three-phase voltage inverter based on GaN transistors.Simulation and laboratory tests of the system, comparison of results, final report with conclusions*

Prerequisites and co-requisites

Basic knowledge in the field: Electrical engineering, electronics, circuit theory, automation, power electronics in accordance with the subject programs for the first degree studies. Additionally, it is desirable to complete the course Electrical Circuits conducted on the II degree studies.

Assessment methods and criteria

Subject passing criteria	Passing threshold	Percentage of the final grade
Laboratory practice	50.0%	40.0%
Lecture	60.0%	60.0%

Recommended reading	Basic literature	1. Nowak M., Barlik R. Poradnik inżyniera energoelektronika. Tom1 Wydawnictwo WNT, Warszawa 2014, wyd. II , 400 pp. 2. Nowak M., Barlik R, Rąbkowski J. Poradnik inżyniera energo-elektronika. Tom 2, Wyd.WNT, Warszawa 2015, wyd.II 523 s 3. Akagi H., Watanabe E., H., Aredes M., Instantaneous Power Theory and Applications to Power Conditioning. J.Willy&Sons Inc Pub. - IEEE Press, New Jersey, 2007, 379 pp 4. Strzelecki R., Supronowicz H., Współczynnik mocy w systemach zasilania prądu przemiennego i metody jego poprawy: Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa, 2000, 452 pp. 5. Rodriguez J. (Author), Cortes P., Predictive Control of Power Converters and Electrical Drives . Wiley IEEE Series 41, New Jersey, 246 pp.212
	Supplementary literature	1. Ericson R.W., Maksimovic D., Fundamentals of Power Electronics: Springer; 3rd ed., London, 2020, 1075p. 2. Hartman M.: Wielopoziomowe falowniki napięcia, Akademia Morska w Gdyni, Gdynia,2006, 144 pp 3. Wu B., Narimani M., High-Power Converters and AC Drives (2nd Edition): Wiley-IEEE Press, New York, 2017, 480 pp 4. M. Kazmierkowski, R. Krishnan, and F. Blaabjerg, Control in Power Electronics Selected Problems. Academic Press, 2002 5. Du S., Dekka A., Wu B., Zargari N., Modular Multilevel Converters: Analysis, Control, and Applications: Wiley-IEEE Press, New York, 2018, 368 pp. 6. Piróg S., Energoelektronika. Układy o komutacji sieciowej i o komutacji twardej: Uczelniane Wydawnictwa Naukowo-Dydaktyczne, Kraków, 2006, 1011p 7. Strzelecki R., Supronowicz H.: Filtracja harmonicznych w sieciach zasilających prądu przemiennego. Wyd. Adam Marszałek, Toruń 1999. 8. R. Strzelecki, G. Benysek (Eds.) Power electronics in smart electrical energy networks. Springer-Verlag 2008. 9. Du S., Dekka A., Wu B., Zargari N., Modular Multilevel Converters: Analysis, Control, and Applications: Wiley-IEEE Press, New York, 2018, 368 pp. 10. 10.Geyer T., Model Predictive Control of High Power Converters and Industrial Drives , Wiley, 2016, 576 pp. 11. 11.Liu F., Abu-Rub H., Ge B., Blaabjerg B., Ellabban O., Loh P. Ch., Impedance Source Power Electronic Converters, Wiley-IEEE Press, New York, 424 p. 12. 12.D. G. Holmes and T. Lipo, Pulse Width Modulation for Power Converters, Principles and Practice. New York: IEEE Press, 2003. 13. Du S., Dekka A., Wu B., Zargari N., Modular Multilevel Converters: Analysis, Control, and Applications: Wiley-IEEE Press, New York, 2018, 368 pp
	eResources addresses	Adresy na platformie eNauczanie:
Example issues/ example questions/ tasks being completed	1. *Properties of modern commercial power electronic devices, including SiC and GaN.* 2. *Basic topologies and features of multi-level converters and their typical applications in the power engineering and high power drive industry.* 3. *Properties, construction and application of soft-switched converters.* 4. *Start up the uP controller of the AFE rectifier based on a commercial 3-phase inverter module with GaN transistors*	
Work placement	Not applicable	