GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	Detection of Optical Signals, PG_00048684						
Field of study	Electronics and Telecommunications						
Date of commencement of studies	February 2023		Academic year of realisation of subject	2022/2023			
Education level	second-cycle studies		Subject group	Optional subject group Subject group related to scientific research in the field of study			
Mode of study	Full-time studies		Mode of delivery	at the university			
Year of study	1		Language of instruction	Polish			
Semester of study	1		ECTS credits	2.0			
Learning profile	general academic profile		Assessment form	exam			
Conducting unit	Department of Metrology and Optoelectronics -> Faculty of Electronics, Telecommunications and Informatics						
Name and surname of lecturer (lecturers)	Subject supervisor		dr hab. inż. Paweł Wierzba				
	Teachers		dr hab. inż. Paweł Wierzba				
Lesson types and methods of instruction	Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
	Number of study hours	15.0	0.0	0.0	15.0	0.0	30
	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	30		4.0	16.0		50
Subject objectives	Provision of knowledge on advanced detectors of optical radiation. Further extension of analysis and design abilities of circuits working with discussed detectors.						

Learning outcomes	Course outcome	Subject outcome	Method of verification
	[K7_U06] can analyse the operation of components, circuits and systems related to the field of study; measure their parameters; examine technical specifications; interpret obtained results and draw conclusions	Student can analyse the operation of electronic circuits working with detectors of optical radiation. Student can analyse the operation of selected circuits for analog signal processing.	[SU2] Assessment of ability to analyse information
	[K7_W03] Knows and understands, to an increased extent, the construction and operating principles of components and systems related to the field of study, including theories, methods and complex relationships between them and selected specific issues - appropriate for the curriculum.	Student knows and understands the operation of selected circuits for analog signal processing.	[SW1] Assessment of factual knowledge
	[K7_W02] Knows and understands, to an increased extent, selected laws of physics and physical phenomena, as well as methods and theories explaining the complex relationships between them, constituting advanced general knowledge in the field of technical sciences related to the field of study	Student knows and understands external and internal photoelectric effect, avalanche multiplication. Student knows and understands the operation of thermal and photon detectors. Student knows and understands the operation of single-photon detectors.	[SW1] Assessment of factual knowledge
	[K7_U03] can design, according to required specifications, and make a complex device, facility, system or carry out a process, specific to the field of study, using suitable methods, techniques, tools and materials, following engineering standards and norms, applying technologies specific to the field of study and experience gained in the professional engineering environment	Student can design electronic and optoelectronic circuits working with detectors of optical radiation and implementing selected measurement and control functions.	[SU1] Assessment of task fulfilment [SU4] Assessment of ability to use methods and tools
	[K7_W06] Knows and understands, to an increased extent, the basic processes taking place in the life cycle of devices, facilities and technical systems.	Student knows manufacturing methods of selected thermal and photon detectors.	[SW1] Assessment of factual knowledge

Subject contents	1. Schottky photodiodes internal structures, characteristics, applications 2. Photodiodes with heterostructures and quantum wells internal struc-tures and characteristics 3. Typical structures of Avalanche Photodiodes (APDs), materials used in their manufacturing 4. Characteristics of APDs, requirements for application circuits 5. Operation of APDs in linear mode. Noise model Geiger mode operation of APDs. 6. Passive quenching of APDs, circuits, multi-pixel APDs 7. Active quenching of APDs, circuits 8. Operation principles of thermal detectors. Spectral characteristics of responsivity 9. Bolometers classification, characteristics, internal structures 10. Thermopiles classification, internal structures 11. Photomultiplier Tubes (PMTs). Basic configuration, principles of op-eration. Photocathode types and their spectral characteristics of responsivity 12. Review of specific PMT configurations 13. Characteristics of PMTs 14. CCD detector matrices, charge transfer, detectors architectures 15. Read-out circuits and signal processing techniques 16. CMOS detector matrices. Internal structures and characteristics 17. Mid-infrared detector matrices 18. Advanced detection techniques: correlated double sampling, the use of integrators 19. Methodology of optoelectronic circuits design 20. Estimation of received power level 21. Design considerations for printed circuit boards of optoelectronic equipment 22. Maximization of signal-to-noise ratio in detector preamplifiers 23. Maximization of bandwidth in detector preamplifiers 24. Design of preamplifiers for bolometer detectors 25. Design of preamplifiers for thermopile detectors 26. Noise analysis of circuits using bolometer and thermopile detectors 27. Selection of operation amplifiers for circuits interfacing to thermal detectors 28. Design of preamplifiers for photomultiplier tubes 29. Design of preamplifiers for avalanche photodiodes 30. Requirements for applying phase sensitive detection 31. Example solutions of detection circuits
Prerequisites and co-requisites	No requirements

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<tr><td>Assessment methods and criteria</td><td colspan="2"><table>
<tr><th>Subject passing criteria</th><th>Passing threshold</th><th>Percentage of the final grade</th></tr>
<tr><td>Midterm colloquium</td><td>51.0%</td><td>50.0%</td></tr>
<tr><td>Project</td><td>51.0%</td><td>50.0%</td></tr>
</table></td></tr>
<tr><td rowspan="3">Recommended reading</td><td>Basic literature</td><td>1. T. H. Wilmshurst, Signal recovery from noise in electronic instrumentation, Taylor and Francis, 1990
2. P.Horowitz, W. Hill, The art of electronics, 3rd ed, Cambridge university press, 2015
3. S.O. Kasap, Optoelectronics and Photonics, Pearson Education, 2nd ed., 2013
4. Photomultiplier Handbook. Burle Industries 1989
5. Z. Bielecki, A. Rogalski, Detekcja sygnałów optycznych, WNT Warszawa 2019</td></tr>
<tr><td>Supplementary literature</td><td>No requirements</td></tr>
<tr><td>eResources addresses</td><td>Adresy na platformie eNauczanie:</td></tr>
<tr><td>Example issues/ example questions/ tasks being completed</td><td colspan="2">Discuss the structure of an avalanche photodiode

Discuss the operation of an avalanche photodiode in the Geiger mode with active quenching

Estimate the input-referred signal-to-noise ratio of a current-to-voltage converter</td></tr>
<tr><td>Work placement</td><td colspan="2">Not applicable</td></tr>
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