RĪGAS TEHNISKĀ UNIVERSITĀTE

RTU Course "Microwave Photonics Devices and Systems"

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General data

Code	RDE716
Course title	Microwave Photonics Devices and Systems
Course status in the programme	Compulsory/Courses of Limited Choice; Courses of Free Choice
Responsible instructor	Sandis Spolītis
Academic staff	Vjačeslavs Bobrovs Oskars Ozoliņš
Volume of the course: parts and credits points	1 part, 6.0 Credit Points, 9.0 ECTS credits
Language of instruction	LV, EN
Annotation	Microwave photonics is an emerging interdisciplinary field where the microwave and photonic technologies join forces. Microwave photonic systems are proposed and designed to realize certain functions and solve certain problems that are difficult to be achieved solely with either the microwave or the photonic technologies. Particularly, as the fast evolution of the mobile networks towards beyond the fifth generation (5G), microwave photonic technologies are becoming increasingly important to bridge the fibre-optic systems and the radio frequency systems and achieve seamless convergence between the two. Therefore, the knowledge of operation, characterization and optimization of microwave photonic devices and systems is expected to be highly demanded for researchers and engineers in the coming decades. Within the study course, students will gain knowledge about microwave photonic devices, systems and applications, optical modulation techniques, analogue and digital radio-over-fibre transmission technologies, noise and nonlinearity sources in the analogue radio-over-fibre system, and the possible engineering infrastructure of the future millimetre-wave and terahertz communications.
Goals and objectives of the course in terms of competences and skills	The aim of the study course is to provide knowledge about optoelectronic components that are used in microwave photonic systems, modulation techniques, noise and nonlinear impairments in the systems, key system metrics and characterization methods, and their applications in broadband radio-over-fibre systems. Tasks of the study course: • to provide basic knowledge and principles about microwave photonic systems; • to teach developing and applying basic numerical models for microwave photonic system simulations; • to provide students with the concepts about the actual analogue radio-over-fibre links in the laboratory; • to develop skills to analyse and characterize the broadband analogue radio-over-fibre systems for the further implementation of high-speed data transmission and processing.
Structure and tasks of independent studies	Within the study course, students' independent work will be organized as follows: - to solve the tasks defined by the academic personnel, showing the use of the knowledge acquired in the lectures; - applying the acquired knowledge in developing simple numerical models of typical microwave photonic devices and integrating them in the system-level simulation environment; - analyse the state-of-the-art from latest published research works on microwave photonic systems and applications; - a basic analogue radio-over-fibre transmission system should be developed based on the equipment available in the laboratory.
Recommended literature	Obligātā/Obligatory: 1. V. J. Urick, K. J. Williams, and J. D. McKinney, Fundamentals of Microwave Photonics. Wiley, 2015. 2. C. H. Lee, Microwave Photonics, Second Edition ed. CRC Press, 2013. 3. J. Capmany and D. Novak, "Microwave photonics combines two worlds," Nature Photonics, vol. 1, no. 6, pp. 319-330, 2007/06/01 2007. 4. J. Yao, "Microwave Photonics," J. Lightwave Technol., vol. 27, no. 3, pp. 314-335, 2009. 5. D. Marpaung, J. Yao, and J. Capmany, "Integrated microwave photonics," Nature Photonics, vol. 13, no. 2, pp. 80-90, 2019. Papildu/Additional: 1. T. Nagatsuma, G. Ducournau, and C. C. Renaud, "Advances in terahertz communications accelerated by photonics," Nature Photonics, vol. 10, no. 6, pp. 371-379, 2016. 2. S. Jia, X. Pang, O. Ozolins, X. Yu, H. Hu, J. Yu, P. Guan, F. Da Ros, S. Popov, G. Jacobsen, M. Galili, T. Morioka, D. Zibar, and L. K. Oxenlowe, "0.4 THz Photonic-Wireless Link With 106 Gb/s Single Channel Bitrate," J. Lightwave Technol., vol. 36, no. 2, pp. 610-616, 2018. 3. Ostrovskis, A., Kurbatska, I., Salgals, T., Spolītis, S., Bobrovs, V. The architecture of hybrid mm-wave ARoF Super-PON system for 5G implementation. Optical Fiber Technology, 2021.
Course prerequisites	Telecommunication theory, transmission systems, fibre optic transmission systems.

Course contents

Content	Full- and part-time intramural studies		Part time extramural studies	
	Contact Hours	Indep. work	Contact Hours	Indep. work
Introduction to microwave photonics.	4	6	0	0

Basic optoelectronic components and devices.	8	12	0	0
Optical modulation techniques: directly modulation and external modulation.	8	12	0	0
Optical modulation techniques: amplitude modulation and phase modulation.	8	12	0	0
Analog and digital radio-over-fibre links.	4	6	0	0
Performance metrics for analogue microwave photonic systems.	8	12	0	0
Noise sources in microwave photonic systems.	8	12	0	0
Nonlinear distortions and dynamic range in microwave photonics.	8	12	0	0
Broadband millimetre-wave and terahertz signal generation, transmission and detection.	16	24	0	0
Practical and experimental works in analogue radio-over-fibre system characterizations in a teaching-scientific laboratory.	24	36	0	0
Total:	96	144	0	0

Learning outcomes and assessment

Learning outcomes	Assessment methods
Able to competently explain basic working principles of the optoelectronic components and devices in microwave photonic systems and describe the general applications of microwave photonics.	Test, exam
Able to create simple numerical models for microwave photonic components and incorporate them into radio-over-fibre subsystem simulation platforms.	Test, practical works, and exam
Can evaluate the impact of noise and nonlinear signal distortions in analogue radio-over-fibre links.	Practical works, exam
Able to perform system-level characterization and optimization in a teaching-scientific laboratory. Able to use different types of modulation techniques for specific applications, as well as to evaluate the performance of the chosen modulation technique in system-level studies.	Test, practical and laboratory work, exam

Evaluation criteria of study results

Criterion	%
Tests	30
Laboratory and practical works	40
Exam	30
Total:	100

Study subject structure

Part	CP	Hours per Week			Tests			Tests (free choice)		
		Lectures	Practical	Lab.	Test	Exam	Work	Test	Exam	Work
1.	6.0	2.0	2.0	2.0		*			*	