



## COURSE UNIT (MODULE) DESCRIPTION

Course unit (module) title	Code
<b>Radio interface in mobile communication systems</b>	

Lecturer(s)	Department(s) where the course unit (module) is delivered
<b>Coordinator:</b> doc. Rimvydas Aleksiejūnas	VU FF, TETI
<b>Other(s):</b>	

Study cycle	Type of the course unit (module)
Second	Mandatory

Mode of delivery	Period when the course unit (module) is delivered	Language(s) of instruction
Classroom	1-semester	English

Requirements for students	
<b>Prerequisites:</b> Must have taken a “Basics of Telecommunications” or similar course	<b>Additional requirements (if any):</b>

Course (module) volume in credits	Total student’s workload	Contact hours	Self-study hours
5	144	64	80

Purpose of the course unit (module): programme competences to be developed		
The aim is to provide knowledge about radio communication systems, their operating principles, physical phenomena occurring in the radio channel, and the optimal use of the fading channel.		
Learning outcomes of the course unit (module)	Teaching and learning methods	Assessment methods
Be able to understand and explain the structure of GSM / GPRS / EDGE / UMTS / LTE network and the principles of operation of this network radio interface.	Lectures, independent work	Control test and written exam
Be able to understand and explain various physical phenomena occurring in a real radio channel, ways to increase the capacity of the radio interface, using special software to calculate the coverage areas of transmitters.	Lectures, laboratory works, independent work	Laboratory work defence, control test and written exam
Be able to explain the general structure of a digital communication system, the principles of operation of the most important components of receivers and transmitters, the characteristics of modulated signals, the advantages and disadvantages of various modulations.	Lectures, laboratory works, independent work	Laboratory work defence, control test and written exam
Be able to explain the principles of cellular network formation, calculate the interference of overlapping channels in such a network, network load intensities, channel utilization efficiencies, etc.	Lectures, laboratory works, independent work	Laboratory work defence, control test and written exam
Be able to explain multiple access technologies, understand the principles of operation of various	Lectures, laboratory works, independent work	Laboratory work defence, control test and written exam

types of spread spectrum systems, UTRAN, WIFI, etc. the structure and performance characteristics of modern radio communication systems.		
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Content: breakdown of the topics	Contact hours						Self-study work: time and assignments		
	Lectures	Tutorials	Seminars	Exercises	Laboratory work	Internship/work placement	Contact hours	Self-study hours	Assignments
1. General principles of mobile communication systems. Historical overview of cellular communication systems. Structure of mobile networks. GSM / GPRS mobile network radio interface. GSM mobile station. Base station. GSM / GPRS network extension EDGE and EDGE Evolution. UMTS, HSDPA, HSUPA and HSDPA +, HSUPA + extensions. LTE and LTE Advanced Network. Basics of modelling with SEAMCAT software during seminars.	6						6	10	Read and learn literature on the specified topics
2. Propagation of electromagnetic waves through a mobile communication channel. Direct view radio channel. Fading radio channels. Signal attenuation. Hata, Lee, and other models for describing the attenuation curve. Near fading. Time and frequency scattering. Classification of fading channels. Signal statistics in the near-fading channel. Rice fading. Long distance fading. Mitigation and application of the fading effect in modern systems. Diversification. Diversification of reception and its types. Diversification of shipment and its types. Principles of using multiple antennas. Spatial compaction. MIMO systems and their types. Basics of modelling with SEAMCAT software during seminars. Laboratory works: • Planning the layout of GSM base stations on a map using the Cellular Expert software package; • Planning the network connecting the base stations RRL using the Cellular Expert software package;	6				8		14	20	Read and learn literature on the indicated topics, perform the laboratory works and defend them
3. General principles of digital communication systems. Digital radio communication systems. Pulse signals and their types. Signal-to-noise ratio in digital communication systems. Receivers: matched filters, correlators, equalizers. Basics of modelling with SEAMCAT software during seminars.	2						2	6	Read and learn literature on the specified topics
4. Modulation in mobile communication systems. Dual Phase Manipulation (DFM): signal shape, spectrum, error rate. DFM transmitter and receiver. Four-level phase manipulation (KFM) and its forms. Gaussian minimum and Gaussian frequency manipulation, their applications. Multilevel phase and quadratic modulation. Orthogonal frequency-division multiplexing (OFDM). Inter-symbolic and own character interference. OFDM modulator -	4				8		12	14	Read and learn literature on the indicated topics, perform the laboratory works and defend them

demodulator. OFDM signal peak-to-average power ratio and ways to reduce it. Reference (pilot) symbols in the OFDM signal. Basic OFDM signal parameters. OFDM and application of this modulation in LTE system. Single frequency network. Laboratory works: • Modelling of four-level phase manipulation (KFM) and minimal manipulation (MM) in Matlab; • Comparison of minimum (MM) and Gaussian minimum (GMM) manipulations and investigation of simulated signals.									
5. Cellular communication. Interference and ways to reduce it. Interference tuning. Sectoral, macro- and micro-cages. Information flows, their modelling. Basics of modelling with SEAMCAT software during seminars.	2						2	4	Read and learn literature on the specified topics
6. Compression in mobile access. Multiple access technologies FDMA, TDMA and CDMA. OFDM multiple access. Flexible multiple access and its application in LTE. Code access densification. Extended spectrum signals. Direct Sequence Extended Spectrum Systems. Principles of Direct Sequence Extended Spectrum Receivers. Receiver - rake. Hopping frequency spread spectrum systems. Fast and slow frequency hopping. Efficiency of frequency, time and code compression systems. Radio access on 5G networks.	2						2	6	Read and learn literature on the specified topics
7. Modern telecommunication systems. Examples of spread spectrum systems: Bluetooth, 3G, wireless LAN 802.11 b. Examples of OFDM systems, wireless LAN 802.11 a, g and n standards, DVB-T and DVB-C, LTE and 5G and Wimax. Global Positioning System, their structure, operation. Operation of radio relay lines. Basics of modelling with SEAMCAT software during seminars. Laboratory works: • Investigation of radio interface signals of various communication systems in the 80-3000 MHz band; • Research on the use of 2.4 and 5 GHz WLAN devices at VU Faculty of Physics; • Investigation of radio interface signals of DVB-T and DVB-S systems.	8			12			20	16	Read and learn literature on the indicated topics, perform the laboratory works and defend them
8. 8. Methods of measuring electromagnetic radiation. Laboratory work: • Investigation of electromagnetic radiation	2			4			6	4	Read and learn literature on the indicated topics, perform the laboratory works and defend them
<b>Total</b>	<b>32</b>			<b>32</b>			<b>64</b>	<b>80</b>	

Assessment strategy	Weight, %	Deadline	Assessment criteria
Defence of laboratory works	20*	During the semester	Laboratory the work is defended when a report is submitted and questions are answered in the laboratory work theme.
Control tests (2 pcs.)	(20+20)*	During the semester	Each test presents questions in the form of a test (10 questions). Each question is worth 1 point.
Exam	40	During the	The exam provides questions in the form of a test (10

		session	questions). Each question is worth 1 point.
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\* It is allowed to take the exam only after defended the laboratory works and passed two control tests.

<b>Author</b>	<b>Year of publication</b>	<b>Title</b>	<b>Issue of a periodical or volume of a publication</b>	<b>Publishing place and house or web link</b>
<b>Compulsary reading</b>				
John S. Seybold	2005	Introduction to RF propagation	330	John Wiley & Sons, Inc., Hoboken, New Jersey Published simultaneously in Canada
Erik Dahlman, Stefan Parkvall, Johan Sköld and Per Beming	2007 or 2010	3G EVOLUTION: HSPA AND LTE FOR MOBILE BROADBAND.	448 p. (first edition) 651 p (second edition)	Academic Press
Keysight Technologies	2014	LTE-Advanced: Technology and Test Challenges, 3GPP Releases 10, 11, 12 and Beyond. Application Note	92 p.	<a href="http://literature.cdn.keysight.com/litweb/pdf/5990-6706EN.pdf">http://literature.cdn.keysight.com/litweb/pdf/5990-6706EN.pdf</a>
<b>Optional reading</b>				
P.Mohana Shankar	2002	Introduction to wireless systems.	336 p.	John Wiley & sons
Mohinder S. Grewal, Angus P. Andrews, Chris G. Bartone	2013	Global Navigation Satellite Systems, Inertial Navigation, and Integration.	608 p.	John Wiley & Sons,
Agilen Technologies	2008, 2009	3GPP Long Term Evolution: System Overview, Product Development and Test Challenges, Application Note	92 p.	<a href="http://www.ccontrols.ch/cms/upload/applikationen/LTE/5989-8139EN.pdf">http://www.ccontrols.ch/cms/upload/applikationen/LTE/5989-8139EN.pdf</a>
Guowang Miao and Jens Zander	2016	Fundamentals of Mobile Data Networks	322 p.	Cambridge University Press